I. SIGNAL WORDS AND WARNING SIGNS

Signal words are required on nearly all pesticide products registered and labeled for sale in the United States. The signal word gives a pesticide user a way to quickly assess the relative hazard level associated with using a product. There are three signal words in use today:

CAUTION, WARNING and DANGER.

<table>
<thead>
<tr>
<th>Depiction</th>
<th>Colour of lower triangle</th>
<th>Toxicity class</th>
<th>Oral LD₅₀ value (mg/kg)</th>
<th>Signal words (Upper half)</th>
<th>Warning words (Outside the diamond)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POISON</td>
<td>Bright red</td>
<td>Extremely toxic</td>
<td>&lt;50</td>
<td>POISON (In red)</td>
<td>Keep out of reach of children. If swallowed or symptoms of poisoning occur, call doctor.</td>
</tr>
<tr>
<td>POISON</td>
<td>Bright yellow</td>
<td>Highly toxic</td>
<td>51-500</td>
<td>POISON (In red)</td>
<td>Keep out of the reach of children.</td>
</tr>
<tr>
<td>DANGER</td>
<td>Bright blue</td>
<td>Moderately toxic</td>
<td>501-5000</td>
<td>DANGER</td>
<td>Keep out of the reach of children.</td>
</tr>
<tr>
<td>CAUTION</td>
<td>Bright green</td>
<td>Slightly toxic</td>
<td>&gt;5000</td>
<td>CAUTION</td>
<td>---</td>
</tr>
</tbody>
</table>

note: The value “Oral LD50” (Low Dose 50) is a measurement of amount of pesticide (mg/kg) that kills 50 out of 100 laboratory animals that are force fed the pesticide under study.
These three signal words are associated with toxicity categories established by the U.S. Environmental Protection Agency (EPA). These four categories can be roughly described as:

- Toxicity category I is Highly toxic and Severely irritating,
- Toxicity category II is Moderately toxic and Moderately irritating,
- Toxicity category III is Slightly toxic and Slightly irritating,
- Toxicity category IV is practically non-toxic and not an irritant.

LD50/LC50: A common measure of acute toxicity is the lethal dose (LD50) or lethal concentration (LC50) that causes death (resulting from a single or limited exposure) in 50 percent of the treated animals. LD50 is generally expressed as the dose in milligrams (mg) of chemical per kilogram (kg) of body weight. LC50 is often expressed as mg of chemical per volume (e.g., liter (L)) of medium (i.e., air or water) the organism is exposed to. Chemicals are considered highly toxic when the LD50/LC50 is small and practically non-toxic when the value is large. However, the LD50/LC50 does not reflect any effects from long-term exposure (i.e., cancer, birth defects or reproductive toxicity) that may occur at levels below those that cause death.

Although there is no requirement by law for Category IV products to carry a signal word, many manufacturers assign a “Caution” label above the mandatory KEEP OUT OF REACH OF CHILDREN statement.

Consumers should look for the signal word on the very front of any pesticide label. It is generally printed next to the mandatory KEEP OUT OF REACH OF CHILDREN statement that is found on all pesticides.
<table>
<thead>
<tr>
<th>TOXICITY CATEGORY (Signal Word)</th>
<th>Primary Skin Irritation</th>
<th>Primary Eye Irritation</th>
<th>Dermal LD₅₀</th>
<th>Inhalation LC₅₀</th>
<th>LD₅₀</th>
<th>Acute Oral LD₅₀</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Toxicity (DANGER) Category I</td>
<td>Corrosive tissue destruction into the dermis and/or scarring</td>
<td>Corrosive irreversible destruction of ocular tissue or corneal involvement of irritation persisting for more than 21 days</td>
<td>Up to and including 200 mg/kg</td>
<td>Up to and including 0.05 mg/L</td>
<td>Up to and including 50 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Moderate Toxicity (WARNING) Category II</td>
<td>Severe skin irritation at 72 hours (severe erythema or edema)</td>
<td>Corneal involvement or other eye irritation clearing in 8 - 21 days</td>
<td>Greater than 200 through 2000 mg/kg</td>
<td>Greater than 0.5 through 2.0 mg/L</td>
<td>Greater than 50 through 500 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Low Toxicity (CAUTION) Category III</td>
<td>Moderate skin irritation at 72 hours (moderate erythema)</td>
<td>Corneal involvement or other eye irritation clearing in 7 days or less</td>
<td>Greater than 2000 through 5000 mg/kg</td>
<td>Greater than 0.5 - 2.0 mg/L</td>
<td>Greater than 50 through 500 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Very Low Toxicity (Optional Signal Word = CAUTION) Category IV</td>
<td>Mild or slight irritation at 72 hours (no irritation or erythema)</td>
<td>Minimal effects clearing in less than 24 hours</td>
<td>Greater than 5000 mg/kg</td>
<td>Greater than 2.0 mg/L</td>
<td>Greater than 5000 mg/kg</td>
<td></td>
</tr>
</tbody>
</table>
Some examples of common signal word labels:
GHS PICTOGRAMS

The Globally Harmonized System of Classification and Labeling of Chemicals (GHS) is an internationally agreed-upon system, created by the United Nations. It is designed to replace the various classification and labeling standards used in different countries by using consistent criteria for classification and labeling on a global level.

THE GHS or HARMONIZED CLASSIFICATION SYSTEM PICTOGRAMS:
Note:
The United States published the final rule on March 26, 2012 for implementation of GHS. The final rule requires product manufacturers to adopt the standard by June 1, 2015 and product distributors to adopt the standard by December 1, 2015.
Workers must be trained by December 1, 2015
(https://www.osha.gov/dsg/hazcom/HCSFactsheet.html)

Products without signal words

If you find a product being sold without a signal word there are several possible explanations. The product could be illegally labeled, in violation of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). Some imported pesticides show up in U.S. retail outlets without an EPA-registered label. Such products may be unsafe and should be reported to your state pesticide regulatory agency.

[ where to report found here: http://npic.orst.edu/reg/state_agencies.html ]
A pesticide without a signal word may also be one of the so-called **exempt or minimum risk** products, allowed under a section in FIFRA known as 25(b). These 25(b) exempt products are limited to a few active ingredients that the EPA determined could be generally regarded as safe. (See Appendix A)

A **minimum risk** product must meet the five conditions listed below. A product that meets all of these five conditions is then exempted from regulation under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), i.e., the pesticide product does not need to be registered with EPA.

**Conditions that must be met for 25(b) classification:**

- **Condition 1:** The product's active ingredients must only be those that are listed in 40 CFR 152.25(f) (1).
- **Condition 2:** The product's inert ingredients may only be those that have been classified by EPA as:
  - List 4A “Inert Ingredients of Minimal Concern;”
  - commonly consumed food commodities, animal feed items, and edible fats and oils as described in 40 CFR 180.950(a), (b), and (c); and
  - certain chemical substances listed under 40 CFR 180.950(e).
- **Condition 3:** All of the ingredients (both active and inert) must be listed on the label. The active ingredient(s) must be listed by name and percentage by weight. Each inert ingredient must be listed by name.
- **Condition 4:** The label cannot include any false or misleading statements.
- **Condition 5:** The product must not bear claims either to control or mitigate organisms that pose a threat to human health, or insects or rodents carrying specific diseases.

Finally, it could be one of a very few products labeled since a recent ruling by the EPA allowing certain newer Category IV insecticides to be labeled without a signal word. One of the first such products, from DuPont, is the turf insecticide Acelepryn, registered in 2008.
Using signal words

One of the best uses of a signal word is when selecting a pesticide product for specific use. If you have a choice between comparable products, it’s best to choose the one with the lowest hazard rating. Most consumer products these days are sold with Caution signal words, but it’s still important to check first. If you are considering purchasing a product with a Danger or Warning signal word, be especially careful to read the safety precautions on the label, especially those regarding protective clothing and where the product may be safely used.

In every instance, the Board of Health strongly urges residents to avoid products that carry the Danger or Warning signal label. These products are rarely necessary and should be used and applied by registered and certified professionals

1. [http://www2.epa.gov/minimum-risk-pesticides/conditions-minimum-risk-pesticides](http://www2.epa.gov/minimum-risk-pesticides/conditions-minimum-risk-pesticides)

II. COMPOUNDS DEFINED AS PESTICIDES

A pesticide is a chemical meant for attracting, seducing, and then destroying, or mitigating any pest. They are a class of biocide.
The term pesticide includes all of the following: herbicides, insecticides, insect growth regulators, nematicides, termiticides, molluscsicides, piscicides, avicides, rodenticides, predacides, bactericides, insect repellents, animal repellents, antimicrobials, fungicides, disinfectants (antimicrobial), and sanitizers.

Most pesticides contain chemicals that can be harmful to people, animals, or the environment. For this reason the Office of Pesticide Programs of the Environmental Protection Agency regulates pesticides in the United States to protect public health and the environment.

Examples of pesticide products commonly used in homes:

- Cockroach sprays and baits
- Mosquito sprays
- Rat poisons
- Flea and tick sprays, powders, and pet collars.

The term pesticide also includes these substances:

**Defoliants:** Cause leaves or other foliage to drop from a plant, usually to facilitate harvest

**Desiccants:** Promote drying of living tissues, such as unwanted plant tops.

**Insect growth regulators:** Disrupt the molting, maturity from pupal stage to adult or other life processes of insects

**Plant growth regulators:** Substances (excluding fertilizers or other plant nutrients) that alter the expected growth, flowering, or reproduction rate of plants

Additionally, these common products are considered pesticides by the EPA:

- Cleaners used to disinfect the kitchen floor.
- Cleaning products used to remove the mildew on bathroom tiles.
- Household plant sprays.
- Lawn and garden products to kill insects and weeds.
- Some swimming pool chemicals.
**TYPES OF PESTICIDES**

Pesticides are often referred to according to the Type of Pest they control. Another way to think about pesticides is to consider those that are Chemical Pesticides or are derived from Natural or Common Source or production method.

**Pest Types**

Pesticides that are related because they address the same type of pests include:

- **Algicides**
  Control algae in lakes, canals, swimming pools, water tanks, and other sites.

- **Antifouling agents**
  Kill or repel organisms that attach to underwater surfaces, such as boat bottoms.

- **Antimicrobials**
  Antimicrobials
  Kill microorganisms (such as bacteria and viruses).

- **Attractants**
  Attract pests (for example, to lure an insect or rodent to a trap). (However, food is not considered a pesticide when used as an attractant.)

- **Biocides**
  Kill microorganisms.

- **Biopesticides**
  Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals.

- **Disinfectants and sanitizers**
  Kill or inactivate disease-producing microorganisms on inanimate objects.

- **Fungicides**
  Kill fungi (including blights, mildews, molds, and rusts).

- **Fumigants**
  Produce gas or vapor intended to destroy pests in buildings or soil.

- **Herbicides**
  Kill weeds and other plants that grow where they are not wanted.

- **Insecticides**
Kill insects and other arthropods.

**Miticides** (also called acaricides)
Kill mites that feed on plants and animals.

**Microbial pesticides**
Microorganisms that kill, inhibit, or out compete pests, including insects or other microorganisms.

**Molluscicides**
Kill snails and slugs.

**Nematicides**
Kill nematodes (microscopic, worm-like organisms that feed on plant roots).

**Ovicides**
Kill eggs of insects and mites.

**Pheromones**
Biochemicals used to disrupt the mating behavior of insects.

**Repellents**
Repel pests, including insects (such as mosquitoes) and birds.

**Rodenticides**
Control mice and other rodents.

---

**Chemical Pesticides**

Many pesticides can be grouped into chemical families. Prominent insecticide families include:

**Organochlorines, Organophosphates, Carbamates, and Pyrethroids**
(For further details on Chemical Pesticides see Section III. Method of Action)

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**Natural or Common Source**

**Biopesticides** are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and
baking soda have pesticidal applications and are considered biopesticides. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products. Biopesticides fall into three major classes:

**Microbial pesticides** consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds, and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of Bacillus thuringiensis, or Bt. Each strain of this bacterium produces a different mix of proteins, and specifically kills one or a few related species of insect larvae. While some Bt's control moth larvae found on plants, other Bt's are specific for larvae of flies and mosquitoes. The target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve

**Plant-Incorporated-Protectants (PIPs)** are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the gene for the Bt pesticidal protein, and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

**Biochemical pesticides** are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances, such as insect sex pheromones, that interfere with mating, as well as various scented plant extracts that attract insect pests to traps.
Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.

1. Data taken from: http://www.epa.gov/kidshometour/pest.htm

III. METHOD OF ACTION

INSECTICIDES

Pesticides work in a variety of ways and are designed for use depending on the target pest, purpose for eradication, time of year, and area to be treated. The most common commercially available pesticides are chemical pesticides. For the control of insect pests, the most popular chemical pesticides in use today fall into one of four major classes of chemicals:

Organochlorines, Organophosphates, Carbamates, and Pyrethroids

Organochlorines  An organochloride is an organic compound containing at least one covalently bonded atom of chlorine as the dominant functionality. Their wide structural variety and divergent chemical properties lead to a broad range of names and applications. Many such compounds are controversial because of the effects of these compounds on the environment and on human and animal health.
The two main groups of organochlorine insecticides are the **DDT-type** compounds and the chlorinated alicyclics. Their mechanism of action differs slightly: The DDT like compounds work on the peripheral nervous system. At the axon's sodium channel, they prevent gate closure after activation and membrane depolarization. Sodium ions leak through the nerve membrane and create a destabilizing negative "afterpotential" with hyperexcitability of the nerve. This leakage causes repeated discharges in the neuron either spontaneously or after a single stimulus.\(^1\)

**Chlorinated cyclodienes** include aldrin, dieldrin, endrin, heptachlor, chlordane and endosulfan. A 2- to 8-hour exposure leads to depressed central nervous system (CNS) activity, followed by hyperexcitability, tremors, and then seizures. The mechanism of action is the insecticide binding at the GABA\(_A\) site in the gamma-Aminobutyric acid (GABA) chloride ionophore complex, which inhibits chloride flow into the nerve. \(^1\)

Other examples include dicofol, mirex, kepone and pentachlorophenol.

Organochlorine pesticides were used extensively from the 1940s through the 1960s in agriculture and mosquito control. Representative compounds in this group include DDT, methoxychlor, dieldrin, chlordane, toxaphene, mirex, kepone, lindane, and benzene hexachloride. As **neurotoxicants**, many organochlorine pesticides were banned in the United States, although a few are still registered for use in this country. Their toxicities vary greatly, but they have been phased out because of their persistence and potential to bioaccumulate.

Many organochlorines have been banned in the U.S. and other countries because of concerns about environmental impacts and human health effects.

In addition to DDT, the United States has banned aldrin, dieldrin, arochlor, chlordane, heptachlor, mirex hexachlorobenzene, oxychlordane, toxaphene and others.
However, several organochlorines are still registered for use, including lindane, endosulfan, methoxychlor, dicofol and pentachlorophenol.

Some organochlorines have been targeted for global elimination under the recently signed Stockholm Convention on Persistent Organic Pollutants (POPs). The treaty is an international effort to phase out harmful chemicals that persist in the environment and can be transported around the world. Many organochlorines fall into this category. The initial list of 12 chemicals targeted by the treaty includes nine organochlorine pesticides, all of which have already been banned in the U.S. ²

Great care should be taken when using Organochloride pesticides due to their serious adverse health effects

Organophosphates An organophosphate or phosphate ester is the general name for esters of phosphoric acid. Many of the most important biochemicals are organophosphates, including DNA and RNA as well as many cofactors that are essential for life. Organophosphates are the basis of many insecticides, herbicides, and nerve agents. The United States Environmental Protection Agency (EPA) lists organophosphates as very highly acutely toxic to bees, wildlife, and humans. ³ Recent studies suggest a possible link to adverse effects in the neurobehavioral development of fetuses and children, even at very low levels of exposure. ⁴ ⁵ ⁶ ⁷ ⁸

Most organophosphates are insecticides. They were developed during the early 19th century, but their effects on insects, which are similar to their effects on humans, were discovered in 1932. German chemist Gerhard Schrader at company IG Farben in the 1930s to experiment with these compounds as insecticides. Their potential use as chemical warfare agents soon became apparent. Some are very poisonous. However, they usually are not persistent
in the environment. After World War II, American companies gained access to some information from Schrader's laboratory, and began synthesizing organophosphate pesticides in large quantities. Parathion was among the first marketed, followed by malathion and azinphosmethyl. The popularity of these insecticides increased after many of the organochlorine insecticides like DDT, dieldrin, and heptachlor were banned in the 1970s.

Their method of operation is by inhibiting the enzyme acetylcholinesterase, allowing acetylcholine to transfer nerve impulses indefinitely and causing a variety of symptoms such as weakness or paralysis. Organophosphates are quite toxic to vertebrates, and have in some cases been replaced by less toxic carbamates.

Organophosphate pesticides degrade rapidly by hydrolysis on exposure to sunlight, air, and soil, although small amounts can be detected in food and drinking water. Their ability to degrade made them an attractive alternative to the persistent organochloride pesticides, such as DDT, aldrin, and dieldrin. Although organophosphates degrade faster than the organochlorides, they have greater acute toxicity, posing risks to people who may be exposed to large amounts.

Commonly used organophosphates have included parathion, malathion, methyl parathion, chlorpyrifos, diazinon, dichlorvos, phosmet, fenitrothion, tetrachlorvinphos, azamethiphos, and azinphos-methyl. Malathion is widely used in agriculture, residential landscaping, public recreation areas, and in public health pest control programs such as mosquito eradication. In the US, it is the most commonly used organophosphate insecticide. There are 38 basic producers of malathion and it is used in approximately 1,953 products worldwide. Of those approximately 174 products are registered for use in the U.S.

They are of concern to both scientists and regulators because they work by irreversibly blocking an enzyme that's critical to nerve function in both insects and humans. Even at relatively low levels, organophosphates may be most
hazardous to the brain development of fetuses and young children. The EPA banned most residential uses of organophosphates in 2001, but they are still sprayed agriculturally on fruits and vegetables. They’re also used to control pests like mosquitoes in public spaces such as parks. They can be absorbed through the lungs or skin or by eating them on food.\textsuperscript{11}

**Great Care should be taken when using Organophosphate pesticides due to their serious adverse neurological effects**

**Carbamates**. These insecticides kill insects by reversibly inactivating the enzyme acetylcholinesterase. *The organophosphate pesticides also inhibit this enzyme, although irreversibly, and cause a more severe form of cholinergic poisoning.*

A **carbamate** is an organic compound derived from carbamic acid (NH\textsubscript{2}COOH). There are many forms of carbamates, each different in the way they work and in their poisonous effects. Carbamates break down in the environment within weeks or months. The carbamate insecticides contain a carbamate ester functional group. Included in this insecticide group are aldicarb (Temik), carbofuran (Furadan), carbaryl (Sevin), ethienocarb, fenobucarb, oxamyl and methomyl. Thiocarbamate and dithiocarbamates are subclasses of carbamates.

The N-methyl carbamate (NMC) pesticides -- aldicarb, carbaryl, carbofuran, formetanate hydrochloride, methiocarb, methomyl, oxamyl, pirimicarb, propoxur, and thiodicarb -- have been identified by EPA as a common mechanism group. They affect the nervous system by reducing the ability of cholinesterase, an enzyme, to function properly in regulating the neurotransmitter acetylcholine. Acetylcholine helps transfer nerve impulses from a nerve cell to a muscle cell or another nerve cell. If acetylcholine is not properly controlled by cholinesterase, the nerve impulses or neurons remain active longer than they should, over-
stimulating the nerves and muscles and causing symptoms such as weakness or paralysis of the muscles. 12.

The first carbamate, carbaryl, marketed under the brand name SEVIN was introduced commercially in 1959. Currently, over 300 products containing carbaryl are registered with the EPA. It remains the third-most-used insecticide in the United States for home gardens, commercial agriculture, and forestry and rangeland protection, and more of it has been used throughout the world than all other carbamates combined. 13. Because of carbaryl's relatively low mammalian oral and dermal toxicity and broad control spectrum, it has had wide use in lawn and garden settings. Most of the carbamates are extremely toxic to Hymenoptera, and precautions must be taken to avoid exposure to foraging bees or parasitic wasps. Some of the carbamates are translocated within plants, making them an effective systemic treatment.

Carbamates are used as sprays or baits to kill insects by affecting their brains and nervous systems. They are used on crops and in the home to kill cockroaches, ants, fleas, crickets, aphids, scale, whitefly, lace bugs and mealy bugs. Some carbamates control mosquitoes. Some carbamates have been found in groundwater at levels high enough to cause concern. 14. Today, there are over 40 different carbamate insecticides that are registered and patented.

Care should be taken when using carbamate insecticides due to their neurological effects on humans and animals.

Pyrethroids  Pyrethroids are axonic excitoxins, the toxic effects of which are mediated through preventing the closure of the voltage-gated sodium channels in the axonal membranes. The sodium channel is a membrane protein with a hydrophilic interior. This interior is a tiny hole which is shaped precisely to
strip away the partially charged water molecules from a sodium ion and create a favorable way for sodium ions to pass through the membrane, enter the axon, and propagate an action potential. When the toxin keeps the channels in their open state, the nerves cannot repolarize, leaving the axonal membrane permanently depolarized, thereby paralyzing the organism.  

Pyrethroid insecticides are a very common and special chemical class of active ingredients found in many of the modern insecticides found on store shelves and used by pest management professionals. The name pyrethroid means “pyrethrum-like” and refers to the origin of this class of pesticides. The term pyrethroid is derived from the natural insecticide mixture known as pyrethrum or pyrethrins. Pyrethrum is one of the oldest known insecticides and comes from the dried and crushed flowerheads of two species of asters: Chrysanthemum cinerariifolium and C. coccineum.

Purified pyrethrum, called pyrethrins, has been very useful in insect control. It kills a variety of insects and mites, knocking them off plants very quickly. For this reason, and because of its relatively low toxicity to people, pyrethrins remain very popular today (e.g. Raid Flying Insect Killer and some Spectracide types). Many Pyrethrins also have the desirable environmental characteristic that they break down quickly (minutes to hours) in the outdoor environment (from a pest control perspective, this may not be an advantage).

Since the 1960s a number of new, “second-generation” pyrethroids were patented, including tetramethrin, resmethrin, bioallethrin permethrin, cyfluthrin or esfenvalerate, and phenothrin. These new compounds were many times as toxic to insects as natural pyrethrum and still have many uses today, including household insecticides.

Pyrethroids became popular as consumer insecticides in the 1990s as replacements for older pesticides, like diazinon and Dursban that were phased out for environmental and human health reasons. Some pyrethroid insecticides
last days or weeks in the environment, especially when protected from sunlight. Others, such as allethrin and resmethrin, break down within a few minutes to a few hours after application.

Most pyrethroid insecticides share the following characteristics:

- Low in toxicity to mammals and birds;
- High in toxicity to fish if applied directly to water;
- Require very low doses to kill insects (high arthropod toxicity);
- Fast-acting;
- Especially effective against chewing insects, though many pyrethroid insecticides can be absorbed by the insect pest when it merely walks over the dry residue;
- Bind tightly to soil and organic matter (therefore not as effective in penetrating soil to kill underground pests);
- Dissolve very poorly in water.

Pyrethrins and pyrethroids are less acutely toxic than the organophosphate and carbamate pesticides they have largely replaced. Accidental poisonings from professional applications are very rare, though personal use of aerosol and fogging product formulations have been associated with acute exposures, poisonings and fires. Some pyrethroids may be respiratory allergens for sensitized people, including asthmatics. Though these chemicals have lower acute toxicity, there is some emerging concern over the chronic neurotoxicity of pyrethrins, pyrethroids, and their synergists. EPA has classified pyrethrins, their synergists, and several pyrethroids as suspected human carcinogens. Pyrethrins and pyrethroids break down relatively quickly when used outdoors, but persist longer when applied indoors.
Common pyrethroid active ingredients are cypermethrin, cyfluthrin, esfenvalerate, and deltamethrin. Pyrethrin and pyrethroid products used by agencies in 2013 include Whitmere Optem ME PT 600®, Steri-Fab®, Demand CS Insecticide®, Tempo SC Insecticide®, Suspend SC Insecticide® and Evercide Esfenvalerate 6.4% CS.

**NOTE:** Many organic gardeners accept the use of pyrethrins on their crops because this product is organically derived, but there is nothing natural about pyrethroid insecticides. *If you wish to garden organically, don’t confuse pyrethroids with pyrethins (or the older term, pyrethrum).*

**Caution:** Although generally considered relatively safe when used correctly, recent epidemiological studies in California suggest the pyrethroids may be detrimental to fetal development.

**CHOOSING THE RIGHT FORMULATION**
The first decision to make when selecting a pesticide is what formulation to use. A formulation is the way the pesticide active ingredient is mixed with inert ingredients to make it convenient and effective to use. Factors that influence the choice of formulation include cost, convenience in mixing and use, effectiveness against your target pest and safety.

There are 6 (six) types of formulations: Dust, Granular, Aerosol, Baits, Ready to use Spray, and Spray Concentrate. See TABLE 1 for some examples of the 6 different types.

**LOW IMPACT PESTICIDES**

Low impact products include those that are low in toxicity to people and pets (i.e., meets EPA Category IV standards) and have minimal impact on the environment, including beneficial insects. This classification is somewhat subjective, but still provides a useful way to select pesticides that meet most people’s definition of green or safer. Some, but not all, low-impact pesticides may be classified as "organic." Some organic products may not be considered low-impact if they are highly toxic. See TABLE 2 for a few examples of common low-impact insecticides that are widely available in hardware stores and garden centers.
TABLE 1. Types and uses of Pesticide formulations

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DESCRIPTION</th>
<th>WHERE AND HOW TO USE</th>
<th>RELATIVE SAFETY</th>
</tr>
</thead>
<tbody>
<tr>
<td>DUST</td>
<td>The pesticide active ingredient is sprayed onto a finely ground dust</td>
<td>Dusts are best used to deliver an insecticide to difficult-to-reach areas. Common uses include treatment of ants in a wall, or wasps in the ground. Ants and other social insects will track the applied dust deeper into a nest. Dusts are often sold for garden use, but application there is inefficient and much of the insecticide is likely to be blown or washed off the intended target. Best to apply with a crank duster or squeeze bottle designed for applying dusts.</td>
<td>Low to moderate risk. Easy to inhale, may drift from the intended target site.</td>
</tr>
<tr>
<td>(low cost)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRANULAR</td>
<td>Insecticide is sprayed onto an inert, absorptive granule; usually consisting of clay, ground corn cob, or nut husks.</td>
<td>Granular insecticides are designed to provide control of soil dwelling insects. They are less effective against surface crawling pests, unless these also spend much time underground in the treatment zone. Commonly used for control of ants, grubs, millipedes, etc. Easy to apply with a rotary, drop, or hand-held seed spreader.</td>
<td>High safety. Because insecticide is impregnated inside an inert carrier, spills are easily contained and little exposure risk to exposed skin.</td>
</tr>
<tr>
<td>(low cost)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AEROSOL</td>
<td>Insecticide mixed with gas in a metal can. Can be designed to produce a various particle sizes from fine aerosol to liquid stream.</td>
<td>Easy to use and apply, designed for application of residual sprays for crawling insects as well as for aerosol fogs for flying insects, depending on product. Commonly sold for ant and roach control, or flying insect control. Despite the impression given by advertisements, aerosol fogs do not penetrate well into cracks and crevices where pests hide.</td>
<td>Low to moderate risk. Some formulations are flammable. Solvents may add to toxicity, and exposure risk to skin is higher.</td>
</tr>
<tr>
<td>(high cost)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BAITS (low to moderate cost)</strong></td>
<td>Consist of an insecticide mixed with a food or attractant to entice the insect to ingest. Come in various forms including pellets, dusts, gels, liquids and granules.</td>
<td>One of the most effective control methods for controlling social insects, like ants and termites. Also very effective on cockroaches and crickets. Various ways to apply.</td>
<td>High safety due to the low percentage active ingredient needed to produce control. Containerized baits are exceptionally safe.</td>
</tr>
<tr>
<td><strong>Spray – Ready to Use (RTU) (moderate to high cost)</strong></td>
<td>Premixed liquid, usually in a pump spray bottle or as a hose-end attachment.</td>
<td>Designed for convenience, RTU sprays require the user to just point and pump or attach to a garden hose. No mixing required. Usually designed for tree, lawn and garden sprays, flea sprays.</td>
<td>Moderate risk Because there is no mixing, risk of exposure to the concentrate is eliminated. User should avoid exposure to spray drift.</td>
</tr>
<tr>
<td><strong>Spray – Concentrate (low cost)</strong></td>
<td>Concentrated active ingredient in an emulsion or solution. Designed to be mixed with water before application.</td>
<td>Wide range of uses include both indoor and outdoor sprays, lawn and garden sprays and soil drenches.</td>
<td>High risk because of need to mix concentrated product and potential for exposure to spillage, drift or splashing.</td>
</tr>
</tbody>
</table>
TABLE 2. Classification of Low Impact insecticides with examples 16.

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
<th>Examples (Trade Name)</th>
<th>Pest target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insect Growth Regulators</td>
<td>halofenozone</td>
<td>Scott’s Grub-Ex, Ortho Grub-B-Gone, Mach 2</td>
<td>white grubs</td>
</tr>
<tr>
<td></td>
<td>methoprene</td>
<td>Precor, vIGRen, Extinguish, others</td>
<td>fleas, fire ants</td>
</tr>
<tr>
<td></td>
<td>pyriproxifen</td>
<td>Nylar, Spectracide</td>
<td>fleas, fire ants</td>
</tr>
<tr>
<td>Microbially-derived</td>
<td>Bacillus thuringiensis</td>
<td>Dipel, Thuricide, Mosquito Dunks, others</td>
<td>caterpillars, mosquitoes</td>
</tr>
<tr>
<td></td>
<td>spinosad</td>
<td>Fertilome Bagworm and Tent Caterpillar spray, others</td>
<td>caterpillars, thrips, fire ants</td>
</tr>
<tr>
<td>Contact insecticides</td>
<td>soap</td>
<td>Safer’s Soap, others</td>
<td>small, soft-bodied pests (aphids, mites, caterpillars, mealybugs)</td>
</tr>
<tr>
<td>(kill only when sprayed directly on the pest)</td>
<td>horticultural oil</td>
<td>GreenLight Dormant Oil, Sunspray, Neem oil, Rose Defense, others</td>
<td>small, soft-bodied pests (aphids, mites, caterpillars, mealybugs, scale insects)</td>
</tr>
<tr>
<td>Botanical (plant derived products)</td>
<td>pyrethrum, synergized pyrethrins</td>
<td>Raid Flying Insect Killer, Schulz’s Plant Spray, many others</td>
<td>quick acting killer for many garden and house plant pests, flying and crawling insects</td>
</tr>
<tr>
<td></td>
<td>d-limonene</td>
<td>Citrus oil spray, Citrex, others</td>
<td>fire ants, others</td>
</tr>
<tr>
<td></td>
<td>azadirachtin</td>
<td>Neem concentrate, others</td>
<td>aphids, whiteflies, spider mites, scale insects, others</td>
</tr>
<tr>
<td>Baits</td>
<td>Active Ingredient</td>
<td>Brands</td>
<td>Target Pests</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------</td>
<td>---------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>hydramethylnon</td>
<td></td>
<td>Amdro, MaxForce, others</td>
<td>fire ants, cockroaches, other ants</td>
</tr>
<tr>
<td>sulfluramid</td>
<td></td>
<td>Combat Roach Killing Gel, Raid Ant Bait</td>
<td>ants, cockroaches</td>
</tr>
<tr>
<td>sulfur</td>
<td></td>
<td>dusting sulfur, various brands</td>
<td>mites, chiggers</td>
</tr>
<tr>
<td>boric acid and derivatives</td>
<td></td>
<td>Roach Pruf, Boracare, various baits</td>
<td>roaches, ants, termites, other crawling indoor pests</td>
</tr>
<tr>
<td>diatomaceous earth</td>
<td></td>
<td>DE, various brands of diatomaceous earth</td>
<td>crawling insects, fleas, indoor pests only</td>
</tr>
</tbody>
</table>

**CONVENTIONAL INSECTICIDES**

*Conventional insecticides* include pesticides that are not considered low-impact because they are more likely to be hazardous to humans or pets (without careful attention to standard safety practices and following the label), or because they may impact beneficial insects or the environment even when used according to the label. Most of the products listed below have the potential to harm at least some beneficial insects and for this reason **should be used very sparingly**, and only when cost-effective, low-impact products will not adequately control the pest. See **TABLE 3.** for a list of conventional pesticide types, active ingredients and brands.
### Table 3. Classification of Conventional Pesticides with examples

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Name</th>
<th>Examples (Trade Names)</th>
<th>Pest target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemics (water-soluble</td>
<td>acephate</td>
<td>Orthene, others</td>
<td>chewing and sucking insects, mites and lacebugs</td>
</tr>
<tr>
<td>insecticides that can be</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>be taken up by plants)</td>
<td>imidacloprid</td>
<td>Bayer Advanced Garden</td>
<td>sucking insects, beetle larvae, white grubs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>dinotefuran</td>
<td>Spectracide Systemic</td>
<td>sucking insects including armored scale, beetle larvae, some borers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tree and Shrub Insect</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control + Fertilizer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>disyston</td>
<td>Bayer Advanced Garden</td>
<td>sucking and chewing insects (moderate-high toxicity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rose Insect Killer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Granules</td>
<td></td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>permethrin</td>
<td>Conquest, Spectracide,</td>
<td>sprays and granules for chewing and crawling insects, borers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>others</td>
<td></td>
</tr>
<tr>
<td></td>
<td>resmethrin,</td>
<td>Wasp and Hornet spray,</td>
<td>short residual sprays for flying insects, spiders, household insects,</td>
</tr>
<tr>
<td></td>
<td>allethrin</td>
<td>others</td>
<td>mosquitoes</td>
</tr>
<tr>
<td></td>
<td>esfenvalerate,</td>
<td>Ortho Home Defense,</td>
<td>these newer pyrethroids generally provide longer residual and higher</td>
</tr>
<tr>
<td></td>
<td>cyfluthrin,</td>
<td>Bayer Advanced Garden,</td>
<td>activity on chewing and crawling insects</td>
</tr>
<tr>
<td></td>
<td>bifenthrin,</td>
<td>Zep, others</td>
<td></td>
</tr>
<tr>
<td></td>
<td>deltamethrin,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>lambda-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cyhalothrin,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>tralomethrin,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>cypermethrin,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other residual</td>
<td>carbaryl</td>
<td>Garden Tech Sevin,</td>
<td>chewing and crawling insects, slugs, snails</td>
</tr>
<tr>
<td>insecticides</td>
<td></td>
<td>others</td>
<td></td>
</tr>
<tr>
<td>(leave a killing residue</td>
<td>malathion</td>
<td>Malathion, others</td>
<td>short-lived residual treatment for a variety of chewing, crawling insects,</td>
</tr>
<tr>
<td>on surfaces)</td>
<td></td>
<td></td>
<td>mosquitoes</td>
</tr>
<tr>
<td></td>
<td>fispronil</td>
<td>Over N Out, MaxForce</td>
<td>long-residual granular product for fire ant control, termites, general</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ant baits, others</td>
<td>treatment for crawling insects, especially ants</td>
</tr>
</tbody>
</table>
ORGANIC VS SYNTHETIC PESTICIDES

A growing number of pesticide products advertised as “organic” have become available to consumers. To be considered organic a pesticide must be composed of only naturally occurring substances. Advertisers and others commonly imply that organic pesticides are safer and more environmentally desirable than synthetic products. While this may be true in some cases, there is no guarantee that all natural substances are inherently safer than synthetic pesticides.¹⁶

Organic pesticides usually consist of plant extracts with insect-killing or repelling properties. Plants produce many chemical compounds to protect themselves from diseases, insects and other threats. From a toxicology perspective, there is no difference between plant-derived pest control compounds and man-made pesticides. Both are chemicals. Both have some effect on the physical structure, development or metabolism of insects. And both organic and synthetic pesticides can be toxic to humans.

Most commonly sold “organic” insecticides, however, are reasonably low in toxicity and break down quickly upon exposure to water and sunlight. Their ability to degrade quickly and their relatively low toxicity is why botanical insecticides are usually classified as low-impact. However, there are exceptions. Rotenone, for example, was a popular insecticide with many gardeners because it is organic, effective in controlling many chewing pests and does not leave long-lasting residues on plants. In its concentrated form, however, rotenone is more toxic than many conventional insecticide active ingredients.¹⁶
ORGANIC HERBICIDES

Most organic herbicides are nonselective, making them hard to wield against weeds in a lawn or garden but useful where eradication is the goal. Ready-to-use products that zap weeds with fatty acids (herbicidal soap), vinegar (acetic acid), or essential oils (such as eugenol, or clove oil; and d-limonene, or citrus oil) are available from various manufacturers. You can find these at online garden-supply retailers or at well-stocked garden or home centers. Most are at their weed-scorching best when applied to young weeds on a hot, sunny day.

**Straight vinegar** or vinegar with a squirt or two of dishwashing liquid will also lay weeds low, but it may take repeated applications to do the job. The more acidic the vinegar, the more effective it will be at controlling weeds, but it also becomes more dangerous for you to handle as the concentration increases.

"Regular" grocery-store vinegar typically has 3 to 5 percent acidity; you may be able to find 10 percent vinegar at a restaurant-supply store or where supplies for pickling are sold. Repeated applications of vinegar will acidify the soil, making it harder for future generations of weeds to get a roothold.

Ammonium Nonanoate / ammonium pelargonate is a non selective contact post emergent herbicide that has shown excellent weed control activity and has just recently gained clearance as an “organic herbicide”. Ammonium nonanoate occurs in nature and is formed from the biodegradation of fatty acids. It is more effective against broad leaf weeds than grasses, and smaller-younger weeds than larger mature plants. Ammonium nonanoate can be more effective at higher application amounts than acetic acid. 17.

The Fatty Acid **pelargonic acid** has recently been ruled unacceptable as an organic herbicide and a “prohibited substance for organic crop production” 17 by
the National Organic Program (NOP). Until the recent ruling, pelargonic acid had tremendous potential as an organic herbicide. It had proved very effective as a post emergent non selective contact herbicide. It provided excellent weed control at low application rates and volumes but it has not been cleared for organic garden use due to its synthetic method of manufacture.

The Board of Health urges residents not to be misled by sales claims for many so-called “natural” products. Advertising which claims that any insecticide is “safe”, “pure”, “all-natural”, “pesticide-free” and “chemical free” are at best misleading; and at worst, false and/or illegal.


3. http://www.epa.gov/pesticides/about/intheworks/clothianidin-registration-status.html#basic


8. Rauch, SA; Braun, JM; Barr, DB; Calafat, AM; Khoury, J; Montesano, AM et al. (20 Mar 2012). "Associations of prenatal exposure to organophosphate pesticide metabolites with gestational age and birth weight.". Environ Health Perspect. 120 (7): 1055–60.


IV. METHOD OF ACTION

HERBICIDES

Herbicides are pesticides that are designed to inhibit processes in plants that are essential to life. Herbicides are many and varied, there are over 150 active ingredients registered with the EPA that appear in over 4000 brand name broad spectrum (many plants effected) and narrow spectrum (single specific plant target) herbicides manufactured for household / home garden use and commercial agriculture use. ¹

The following plant processes are among those inhibited by herbicides:

- photosynthesis
- amino acid and protein synthesis
- fatty acid synthesis
- growth inhibition and regulation
- cell membrane transfer
- pigment synthesis

These processes are inhibited by two methods of herbicide application – soil applied herbicides where the herbicide is absorbed through the roots and then either effects the roots or translocates to other areas in the plant and foliar herbicides or those that are sprayed on plants and are absorbed through the foliage and either effect the leaves of the plant or translocate to other areas for their effect.

The movement of these chemicals within the plant occurs in one or both of the two components of its vascular system. The xylem carries raw materials — water and mineral nutrients, mainly — from the soil solution through the roots, up the
stems and into the leaves. Xylem-translocted herbicides are frequently soil applied. The created products of photosynthesis are taken from the leaves and distributed to the rest of the plant via the phloem. Phloem-translocated herbicides are usually applied to the emerged plant.

There is a host of herbicides with many different modes of action. This term refers to the sequence from uptake of the chemical through plant death. It also describes what plant process is affected.

Herbicides fall into one of eight modes of action, although there are several subdivisions within most of these categories. Some have an effect on grassy plants (monocots), while others are generally only effective on broadleaved ones (dicots). Some are toxic to both kinds of plants.

**GROWTH REGULATORS**  Among the oldest herbicides are growth regulators, mainly used for broadleaf weed control. These behave in plants as if they were an auxin, a plant hormone responsible for cell and stem elongation. Because they cause the contents of plant cells to grow uncontrollably, they cause a range of deformities. Frequently leaves become misshapen — elongated or cupped (up or down) — petioles swell, and stems may become swollen and twisted.

Dicamba and 2,4-D are very common growth regulators and found in many commercial preparations, although there are many more members of this class. Many of them are translocated through both the xylem and phloem.

**SEEDLING GROWTH INHIBITORS**  Shoot inhibitors affect cell growth and division. They act by killing the young plant before it breaks through the soil. They do not prevent seeds from germinating, rather they attack either the developing shoot or root, or both, underground. Obviously, they are applied to the soil before weeds emerge. Some, like dinitroanilides, are generally used to
control grasses, but others, such as EPTC, are effective on both grasses and broadleaves. If a seedling is not killed by a third type of seedling inhibitor, acetochlora, it will show some tissue deformity, but will probably survive, since herbicides of this type are only effective on seedlings.

**PHOTOSYNTHESIS REGULATORS** (e.g. atrazine, linuron, bentazon) are used both individually and in commercial mixtures. These herbicides attack the process where, in the presence of light, a plant takes carbon dioxide and water and converts it into sugar. They interfere with photosynthesis by blocking electron transfer. Without the ability to create sugars, the plant will die. First, however, it will develop interveinal chlorosis, and may look like it has an iron deficiency. There are many herbicides, from a range of different chemical families, which inhibit photosynthesis. Many are xylem-transported, hence are applied to the soil, but not all. Bromoxinil (e.g. Buctril) is applied to, and absorbed into, leaves, where it remains without translocating (contact herbicide).

Because most of these have little effect on grasses, these are applied to kill broadleaved weeds in grassy areas, although bentazon, which is also a contact herbicide, is used to control nutsedge (a monocot) foliage.

**MEMBRANE DISRUPTORS** The category of herbicide is usually foliar applied and contains two sets of herbicides, attacking two different plant systems, but resulting in the same symptoms. They act by disrupting internal cell membranes and prevent the cell from manufacturing energy. The result is the leaves appear as if they had been sunburned, and scorching is actually what happens. Most require light in order to be active, and they are used for broadleaved weeds.

One group inhibits a particular step in photosynthesis, with the result that the plant tissue accumulates oxidants, which burn it. These affect only the tissue where they are applied, although there are reports of some instances where
paraquat and diquat will move out of leaves and on to the roots of certain plants.

Another group attacks the process that manufactures cell components required for photosynthesis. The outcome here again is the build-up of oxidants, which burn the leaf tissue. Although mostly applied post emergence, and usually considered contact herbicides, some, like fomasafen, are also translocated in the xylem.

**AMINO ACID SYNTHESIS INHIBITORS**  
This group has become a very common and popular class of herbicides for both house and garden as well as commercial agricultural use. The mood of action is to interfere with protein production, causing the plant to die. Again, two different groups of chemicals, working on two different plant processes for manufacturing of amino acids come under this heading. They are used for both grassy and broadleaved weeds.

The first group works on what are called the branched-chain amino acids. The normal function of the acetolactate synthase (ALS) enzyme is blocked, inhibiting plant metabolism and cell division.² Symptoms on plants include stunted growth, followed by foliage becoming pale, yellow to white, and ultimately dying. These chemicals have names that start with "ima-" (e.g. imazaquin) or end in one of two suffixes: "sulfuron" (e.g. halosulfuron) or "sulam", (e.g. flumetsulam). Many are translocated in both the xylem and the phloem, which permits them to be applied to foliage or to the soil.

The second group contains Glyphosate (Roundup, Rodeo and Touchdown). Glyphosate's mode of action is to inhibit a plant enzyme involved in the synthesis of the aromatic amino acids: tyrosine, tryptophan, and phenylalanine. It is absorbed through foliage, and minimally through roots,³ ⁴ and translocated to growing points. This causes stunted or deformed growth and chlorosis before plants die. Because of this mode of action, it is only effective on actively growing
plants; it is not effective as a pre-emergence herbicide. Some crops have been genetically engineered to be resistant to glyphosate (i.e., Roundup Ready, also created by Monsanto Company). Such crops allow farmers to use glyphosate as a postemergence herbicide against both broadleaf and cereal weeds, but the development of similar resistance in some weed species is emerging as a costly problem. Roundup Ready soybean was the first Roundup Ready crop. **Glyphosate** needs to be sprayed on foliage because it is translocated in the phloem, and because it becomes tightly bound to soil particles. In March 2015 the World Health Organization's International Agency for Research on Cancer published a summary of its forthcoming monograph on glyphosate, and classified it as "probably carcinogenic in humans" (category 2A) based on epidemiological studies, animal studies, and in vitro studies.\(^5\)

Although **Glyphosate** is the active ingredient in herbicide formulations containing it, in addition to glyphosate salts, commercial formulations of glyphosate contain additives such as surfactants which vary in nature and concentration. Laboratory toxicology studies have suggested that other ingredients in combination with glyphosate may have greater toxicity than glyphosate alone.\(^6,7\)

**MERISTEMATIC LIPID SYNTHESIS INHIBITORS** These herbicides block formation of lipids in the shoot (meristem) and roots of grass plant species and are used to control grasses by interfering with fat production, essential for all membranes in plant cells. Older leaves frequently turn colors — purple, orange or red — before becoming necrotic. The central growing point becomes easy to remove from plants treated with lipid synthesis inhibitors. Those compounds with chemical names ending in "fop" (e.g. **diclofop**) are phloem translocated; hence they are applied to emerged plants. The other group of these herbicides have chemical names ending in "dim" (e.g. clethodim) these are translocated in both xylem and phloem. As a result, lipid synthesis inhibitors can be applied both pre- and post- emergence (soil or foliar).\(^2\)
NITROGEN METABOLISM INHIBITORS (glufosinate) prevent plants (both grasses and broadleaves) from using nitrogen, a nutrient involved in virtually all plant functions. When nitrogen-using processes are interrupted, ammonium accumulates within the cells and causes cell death. Other toxic events also occur, all of which result in plant death. The first symptoms are chlorosis and wilting. These proceed most rapidly when there is bright sunlight, high humidity and moist soil. Glufosinate does not translocate well in either the xylem or the phloem, hence it is used as a contact herbicide.

PIGMENT INHIBITORS These herbicides work by contributing to chlorophyll destruction by preventing plants from creating the compounds that protect from excess sunlight (carotenoids). Many of these pigments are the reds, oranges and purples, which appear in leaf tissue and they serve as antioxidants, Leaves of plants (usually broadleaved) treated with these herbicides develop interveinal chlorosis and may even become bleached white before turning necrotic. Most pigment inhibitors are soil applied and are translocated in the xylem, although some also move through the phloem. Popular brands of pigment inhibitors contain clomazone (Command) and norflurazon (Zorial)

TABLE 4.
ALPHABETICAL LIST OF HERBICIDE TRADE NAMES, MANUFACTURER, AND ACTIVE INGREDIENT 8.
<table>
<thead>
<tr>
<th>PRODUCT CODE</th>
<th>ACTIVE INGREDIENT</th>
<th>FORMULATION</th>
<th>MANUFACTURER</th>
<th>CONCENTRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALANAP-L</td>
<td>naptalam</td>
<td>2E</td>
<td>Chemtura</td>
<td>5,000+</td>
</tr>
<tr>
<td>ALLY</td>
<td>metsulfuron</td>
<td>60DF</td>
<td>DuPont</td>
<td>5,000+</td>
</tr>
<tr>
<td>AMBER</td>
<td>triasulfuron</td>
<td>75WDG</td>
<td>Syngenta</td>
<td>5,050+</td>
</tr>
<tr>
<td>ASSERT</td>
<td>imazamethabenz</td>
<td>2.5L</td>
<td>several</td>
<td>5,000+</td>
</tr>
<tr>
<td>ASSURE II</td>
<td>quizalofop</td>
<td>0.88L</td>
<td>DuPont</td>
<td>5,900</td>
</tr>
<tr>
<td>BALAN</td>
<td>benefin</td>
<td>60DF</td>
<td>UAP - Loveland</td>
<td>500</td>
</tr>
<tr>
<td>BALANCE</td>
<td>isoxaflutole</td>
<td>75WDG</td>
<td>Bayer CropScience</td>
<td>5,000+</td>
</tr>
<tr>
<td>BARRICADE</td>
<td>prodiamine</td>
<td>65WG</td>
<td>several</td>
<td>5,000</td>
</tr>
<tr>
<td>BASAGRAN</td>
<td>bentazon</td>
<td>4L</td>
<td>several</td>
<td>2,063</td>
</tr>
<tr>
<td>BEACON</td>
<td>primisulfuron</td>
<td>75WDG</td>
<td>Syngenta</td>
<td>5,050+</td>
</tr>
<tr>
<td>BETANEX</td>
<td>desmedipham</td>
<td>1.3L</td>
<td>Bayer CropScience</td>
<td>3,960</td>
</tr>
<tr>
<td>BLAZER</td>
<td>acifluorfen</td>
<td>2E</td>
<td>United Phosphorus</td>
<td>3,330</td>
</tr>
<tr>
<td>BOLERO</td>
<td>thiobencarb</td>
<td>10G, 8E</td>
<td>Valent</td>
<td>5,000+</td>
</tr>
<tr>
<td>BUCTRIL</td>
<td>bromoxynil</td>
<td>2E</td>
<td>Bayer CropScience</td>
<td>780</td>
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<td>90SP, 75G, 2L</td>
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1. [http://weedext.ifas.ufl.edu/slides/how_herbicides_work/index.html](http://weedext.ifas.ufl.edu/slides/how_herbicides_work/index.html)
4. [http://npic.orst.edu/factsheets/glyphotech.html](http://npic.orst.edu/factsheets/glyphotech.html)
5. [http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045%2815%290134-8/abstract](http://www.thelancet.com/journals/lanonc/article/PIIS1470-2045%2815%290134-8/abstract) (SEE APPENDIX B)
8. [http://www.uky.edu/Ag/Horticulture/masabni/xreflist/Chem-TradeName-List/Chem-TradeName-List.htm](http://www.uky.edu/Ag/Horticulture/masabni/xreflist/Chem-TradeName-List/Chem-TradeName-List.htm)

**Note:** For a cross referenced list of herbicides and the weeds they are designed to eradicate go to [http://www.uky.edu/Ag/Horticulture/masabni/xreflist.htm](http://www.uky.edu/Ag/Horticulture/masabni/xreflist.htm)
V. INERT INGREDIENTS AND ADJUVANTS

INERTS DEFINED

Inert ingredients serve a variety of functions in pesticide formulations, acting as solvents, surfactants, or preservatives, among many other functions. In ordinary usage, the word “inert” refers to something that is physically, chemically, or biologically inactive. The U.S. EPA recognizes that the statutory nomenclature for pesticides under FIFRA engenders public misunderstanding, stating that “many consumers have a misleading impression of the term ‘inert ingredient,’ believing it to mean water or other harmless ingredients.” In fact, an inert ingredient “may have biological activity of its own, it may be toxic to humans, and it may be chemically active” 1.

By statute or regulation in the United States and elsewhere, pesticide ingredients are divided into two categories: active and inert (sometimes referred to as other ingredients, adjuvants, or coformulants). Despite their name, inert ingredients may be biologically or chemically active and are labeled inert only because of their function in the formulated product. Most of the tests required to register a pesticide are performed with the active ingredient alone, not the full pesticide formulation. Inert ingredients are generally not identified on product labels and are often claimed to be confidential business information. 1.

Inert ingredients can increase the ability of pesticide formulations to affect significant toxicologic end points, including developmental neurotoxicity, genotoxicity, and disruption of hormone function. They can also increase exposure by increasing dermal absorption, decreasing the efficacy of protective clothing, and increasing environmental mobility and persistence. Inert ingredients
can increase the phytotoxicity of pesticide formulations as well as the toxicity to fish, amphibians, and microorganisms. ¹.

**Inadequate Assessment of the Hazards of Pesticide Formulations**

The U.S. EPA has identified almost 3,000 substances, with widely varying toxicity, that are used as inert ingredients in the United States. For example, paper is used as an inert ingredient, but so are toxic chemicals such as naphthalene and xylene. Also, about 50% of all inert ingredients are at least moderately risky. Given the toxicity of inert ingredients and their widespread use in pesticide products, formulations should be fully assessed when pesticides are registered with the U.S. EPA. This, however, is not currently the case. Of the 20 toxicologic tests required (or conditionally required) to register a pesticide in the United States, only 7 short-term acute toxicity tests use the pesticide formulation; the rest are done with only the active ingredient. The medium- and long-term toxicity tests that explore end points of significant concern (cancer, reproductive problems, and genetic damage, for example) are conducted with the active ingredient alone. The requirements for other types of tests are similar. Only half of the required (or conditionally required) tests of environmental fate use the formulated product, as do only a quarter of the tests for effects on wildlife and nontarget plants. As a result, many potential long-term effects of pesticide formulations are not assessed as part of the registration process. ¹.

There is a substantial and growing body of research that demonstrates the inadequacy of reliance on testing the active ingredient alone when assessing the exposure to pesticides, their toxic effects, and their behavior in the environment. Inert ingredients are often biologically or chemically active and can affect each of these parameters. Demonstrations of important impacts of inert ingredients have not been limited to particular classes of pesticides, types of formulations, or
toxicity end points. Instead, it appears that the effects of inert ingredients may be both common and far-reaching.

It is often unclear if inert ingredients are directly responsible for certain toxic effects or if those effects are attributable to interactions between inert and active ingredients. Because inert ingredients are rarely identified, studies comparing the effects of the active ingredient, the inert ingredients, and the formulation are not common. Additionally, full assessment of exposure to pesticide formulations is impeded by the lack of information about the concentration of individual inert ingredients.¹

1. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1764160/

[ See Appendix A for the complete report ]
### Signal words

For products containing glyphosate may range from **Caution** to **Danger**.

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<td><strong>1.6% Imazapic</strong></td>
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<td><strong>0.73% Diquat dibromide</strong></td>
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<tr>
<td><strong>79% unlisted ingredients</strong></td>
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Glyphosate is a non-selective systemic herbicide that is applied directly to plant foliage. When used in smaller quantities, glyphosate can act as a plant growth regulator. Glyphosate is a glycine derivative. The International Union of Pure and Applied Chemistry (IUPAC) name for glyphosate is N-(phosphonomethyl) glycine. Glyphosate’s potential as an herbicide was reported in 1971. Glyphosate was first registered for use by the United States Environmental Protection Agency (U.S. EPA) in 1974, and reregistration was completed in 1993. Formulations of glyphosate include an acid, monoammonium salt, diammonium salt, isopropylamine salt, potassium salt, sodium salt, and trimethylsulfonium or trimesium salt. Technical grade glyphosate is used in formulated products, as
are the isopropylamine, sodium, and monoammonium salts. Of these, the isopropylamine salt is most commonly used in formulated products.

**Mode of Action**

**Target Organisms**
In plants, glyphosate disrupts the shikimic acid pathway through inhibition of the enzyme 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase. The resulting deficiency in EPSP production leads to reductions in aromatic amino acids that are vital for protein synthesis and plant growth. Glyphosate is absorbed across the leaves and stems of plants and is translocated throughout the plant. It concentrates in the meristem tissue. Plants exposed to glyphosate display stunted growth, loss of green coloration, leaf wrinkling or malformation, and tissue death. Death of the plant may take from 4 to 20 days to occur. The sodium salt of glyphosate can act as a plant growth regulator and accelerate fruit ripening.

**Non-target Organisms**
The shikimic acid pathway is specific to plants and some microorganisms. The absence of this pathway in mammals may explain the low toxicity of glyphosate to non-target organisms. Studies indicate that the surfactant polyoxyethyleneamine or polyethoxylated tallow amine (both abbreviated POEA), used in some commercial glyphosate-based formulations, may be more toxic by the oral route to animals than glyphosate itself. The mechanism of toxicity of glyphosate in mammals is unknown, but it may cause uncoupling of oxidative phosphorylation. However, this hypothesis has been disputed.
Acute Toxicity:

Oral
Glyphosate is low in toxicity to rats when ingested.

- The acute oral LD50 in rats is greater than 4320 mg/kg.
(See the text boxes on pg. 3 Toxicity Classification and LD50/LC50.)
- The acute oral LD50 for rats was also reported to be greater than 5000 mg/kg. The acute oral LD50 was greater than 10,000 mg/kg in mice and 3530 mg/kg in goats.
- The isopropylamine salt is of very low toxicity to rats, with an LD50 greater than 5000 mg/kg.
- The acute oral LD50 for the ammonium salt is 4613 mg/kg in rats.
- The acute oral LD50 in three formulated products ranged from 3860 to greater than 5000 mg/kg in rats.

Dermal
Glyphosate is low in toxicity to rabbits when applied to the skin.

- The acute dermal LD50 in rabbits is greater than 2 g/kg.

Glyphosate is low in toxicity for eye irritation and very low in toxicity for dermal irritation. In studies with glyphosate manufacturing use products, researchers observed mild eye irritation in rabbits that cleared in seven days. Glyphosate was not found to be a skin sensitizer.

- The isopropylamine and ammonium salts are also low in toxicity via the dermal route. The LD50 in rabbits was greater than 5000 mg/kg for both salts, and these salts are considered slight eye irritants but not skin irritants.

Of three formulated products tested, skin irritation varied from none to moderate, and eye irritation was rated as none, moderate, and severe.

- Dermal LD50 values in rabbits exposed to these products were greater than 5000 mg/kg.
The formulated product Roundup®, containing 41% glyphosate, was applied to the skin of 204 male and female volunteers in a modified Draize test. No sensitization was observed. The researchers concluded that exposure would not lead to photoirritation or photosensitization.

**Inhalation**

Glyphosate is very low in toxicity to rats when inhaled. The acute inhalation LC50 in rats is greater than 4.43 mg/L based on a 4-hour, nose-only inhalation study. The 4-hour LC50 for rats exposed to the isopropylamine form of glyphosate was greater than 1.3 mg/L air. The LC50 for rats exposed to the ammonium salt form of glyphosate was greater than 1.9 mg/L in a whole body exposure. Inhalation LC50 values for two formulated products were greater than 1.3 mg/L and 3.2 mg/L in rats.

http://npic.orst.edu/factsheets/glyphotech.pdf

**note:** The International Agency for Research on Cancer (IARC) Monograph Volume 112: Evaluation of five organophosphate insecticides and herbicides, as determined that Glyphosate should no longer be listed as a Class E (non-carcinogen) but as a Class 2A probable carcinogen. The evaluations were:

- The herbicide **glyphosate** and the insecticides **malathion** and **diazinon** were classified as probably carcinogenic to humans (Group 2A).
- The insecticides **tetrachlorvinphos** and **parathion** were classified as possibly carcinogenic to humans (Group 2B).
Bifenthrin is an insecticide used heavily in the control of red imported fire ants. Due to its high toxicity to aquatic organisms, it is listed as a restricted use pesticide, although it can be purchased for residential use in lower concentrations. It has a very low solubility in water and tends to bind to soil, which minimizes runoff into water sources. It may also be marketed as Talstar, Bifenthrine, Brigade, Capture, Torant, Zipak, FMC 54800, and OMS3024.

Chemical Description

Bifenthrin is chemically classified as a pyrethroid. It is a waxy solid, with a color ranging from an off-white to a pale tan, with a slightly sweet odor. It is mostly insoluble in water. Commercially, it is available as emulsifiable concentrates, wettable powders, granules, flowable concentrates, and pellets. Bifenthrin is not naturally synthesized. Bifenthrin tends to bind tightly with soil. In soil, it has a half-life of 7 days to 8 months, depending on soil type and aeration.

Uses

Bifenthrin is used regularly as an insecticide to target red imported fire ants. Other target species are aphids, worms, ants, gnats, moths, beetles, grasshoppers, mites, midges, spiders, ticks, yellow jackets, maggots, thrips, caterpillars, flies, and fleas. It is often used in orchards, nurseries, and homes. Agriculturally, it is registered for use on greenhouse ornamentals and cotton. Roughly 70% of all US-grown hops and raspberries are treated with bifenthrin.
Human Health Effects

People may be exposed to bifenthrin through ingestion or skin contact, although dermal absorption has little to no risks beyond mild discomfort. Ingestion is moderately toxic for mammals. Bifenthrin, as with other pyrethroids, overstimulates electrical signals in nerve cells. This may cause tremors and paralysis. However, in the body, bifenthrin is broken down and excreted quickly. In a seven-day study on rats, excess bifenthrin was found accumulated in high-fat tissues, including skin and ovaries of females. The EPA listed bifenthrin as a developmental toxicant in the toxics release inventory. The EPA has also identified bifenthrin as a class C carcinogen, meaning that it is a possible human carcinogen.

Symptoms associated with exposure to pyrethroid compounds include skin and eye irritation, irritability to sound or touch, abnormal facial sensation, sensation of prickling, tingling, or creeping on skin, numbness, headache, dizziness, nausea, vomiting, diarrhea, salivation, and fatigue. At very high levels of exposure, muscle twitching and fluid accumulation in the lungs may occur.

Environmental Health Effects

Bifenthrin disrupts the nervous system and causes paralysis in insects. It has a moderate toxicity to mammals.

- For rats, the LD50 of females is 54mg/kg, and in males is 70mg/kg.

Bifenthrin is also moderately toxic to birds.

- The LD50 of mallard ducks is 1280ppm, and 4450ppm for bobwhite quail.

It has a very high toxicity for fish and other aquatic species.

- The LD50 is 0.00015 mg/l for rainbow trout, 0.00035 mg/l for bluegill, and 0.0016 mg/l for Daphnia.

Bifenthrin is also toxic to non-target bees.
Although it does not pose a high risk for mammals and birds, bifenthrin may accumulate in the food chain and harm high-level predators. Bifenthrin has a low potential for ground water contamination, although bifenthrin bound to sediment could contaminate runoff. Bifenthrin is not absorbed into plants, and has a low mobility in most types of soil.

**Regulation**

Bifenthrin is a restricted use pesticide, meaning that it can only be sold and used by Certified Pesticide Applicators. However, some products for unrestricted residential use, which have lower bifenthrin concentrations, are legally sold.

**Precautionary Notes**

Although unsoluble in water, bifenthrin is highly toxic to aquatic organisms and should be used with caution near water sources. Otherwise, the risks to aquatic species are somewhat offset by the hydrophobic property of bifenthrin. It may be absorbed through skin, although this has low risk for humans.

**References**


2,4-D 2,4-dichlorophenoxy acetic acid

2,4-D (2,4-dichlorophenoxy) is a systemic phenoxy herbicide developed in the 1940s and still in use today. 2,4-D was the first widely used herbicide used to control broadleaf plants, and it has significantly contributed to modern weed control in agriculture. Different formulations vary widely in levels of toxicity, health effects, and environmental impact, leading to debate over regulations and the formation of a 2,4-D Industry Task Force. Currently, more than 46 million pounds of 2,4-D are applied annually, with the global marketplace for the herbicide accounting for more than US$300 million (EPA RED Facts, 2005 and PAN-UK, 1997).

Chemical Description
2,4-D is chemically classified as a chlorophenoxy herbicide and is an odorless, crystalline powder that is colorless or white to yellow. 2,4-D is a strong oxidizer and is a non-combustible solid; however, it can be dissolved in flammable liquids (CDC NIOSH 2005.)

In addition to 2,4-D itself, there are eight salts and esters of 2,4-D. The most common form is the acid form, which is the subject of the majority of toxicity tests (Journal of Pesticide Reform, 2005).

2,4-D has a chemical half-life in soil between seven and ten days, depending on temperature, moisture, sterility, nutrient composition, and oxygenation of the soil. Despite the short half-life, low levels of 2,4-D have been detected in groundwater supplies in at least 5 states in the United States.

Use

2,4-D is a post-emergence systemic herbicide used widely for selective control of broadleaf plants in a variety of food, forest, aquatic, and residential sites. On average, 4.6 million pounds are used annually: 66% on agriculture, 23% on pasture/ rangeland, and 11% by homeowners. In the US 2,4-D is used predominantly in the Midwest, Great Plains, and Northwest (EPA RED FACTS, 2005).

2,4-D is commonly found in lawn care products; wheat, corn, and other grass family herbicides; forestry products; treatments for roadside weeds; and aquatic weed control products (NPTN).

Application

2,4-D can be sprayed from many different applicators such as fixed-wing aircraft, truck-mounted sprayers, and backpack sprayers (EPA RED Decision, 2005).

Formulations

2,4-D can be formulated as emulsifiable concentrates, granules, soluble concentrate and solids, water-dispersable granules, and wettable powders. 2,4-D is used alone, but is commonly formulated with dicamba, mecoprop, mecoprop-p, MCPA, and clopyralid (EPA RED FACTS, 2005).
2,4-D is a High Production Volume (HPV) chemical with annual usage around 46 million pounds, making it one of the most widely used Herbicides in the world (#Scorecard and #EPA RED FACTS, 2005). Approximately two-thirds of use is for agricultural purposes and one-third is for residential purposes.

**History**

2,4-D was developed during World War II at British Rothamsted Experimental Station by Judah Hirsch Quastel and sold commercially in 1946. 2,4-D was developed by a British team during World War II and first saw widespread production and use in the late 1940s. It is easy and inexpensive to manufacture, and it kills many broadleaf plants while leaving grasses largely unaffected (although high doses of 2,4-D at crucial growth periods can harm grass crops such as maize or cereals). 2,4-D’s low cost has led to continued usage today and it remains one of the most commonly used Herbicides in the world.

**Role in Agent Orange**

The herbicide and defoliant Agent Orange, by far the most toxic of the Army’s Rainbow Herbicides, was widely used in the Vietnam War to destroy foliage in an effort to expose the enemy by destroying their cover. It was roughly a mixture of two chemicals, 2,4-D and 2,4,5-T. 2,4,5-T becomes contaminated with dioxin during its production. Though 2,4-D composed 50% of Agent Orange, the health effects of Agent Orange are related to the dioxin (EXOTOXNET, 1996).

**Routes of Exposure and Metabolism**

In humans, 2,4-D exposure can occur through inhalation, skin absorption, ingestion, and skin/eye contact. Once absorbed in the body, there is little
evidence that 2,4-D is accumulated and only a small percentage is transformed in 2,4-D conjugates with sugars or amino acids. A single dose of 2,4-D is excreted within a few days, mainly through the urine, but also in the bile and feces (International Programme on Chemical Safety, WHO Geneva, 1984).

In plants, 2,4-D affects double-leaf seeds (dicots) rather than single-leaf seeds, explaining why it is selective against broadleaf plants. 2,4-D is absorbed by the leaves of the plant and eventually enters the meristems of the plant. From the meristems, 2,4-D acts as an auxin and increases the following three characteristics of the plant: plasticity of cell walls, amount of proteins being made, and ethylene production. Collectively, this causes cells to divide and the plant to grow uncontrollably, resulting in tissue damage and ultimately death.

**Human Health Effects**

2,4-D is reported to have negative effects on the endocrine system (specifically the thyroid and gonads) and immune system.

Research in the Netherlands suggests that 2,4-D displaces sex hormones from the protein that normally transports these hormones in the blood. More specifically, a study done at the University of Missouri reported a strong correlation between low sperm counts, high numbers of abnormal sperm, and atrophy of the testes with high levels of 2,4-D (measured in urine). Additionally, a University of Minnesota study found that 2,4-D acts like estrogens in breast cancer cells (CDC NIOSH, 2005).

University of Saskatchewan researchers demonstrated that "environmentally realistic" amounts of 2,4-D reduce the activity of several proteins important to immune system function. Researchers at NIOSH have demonstrated a decreased production of cells responsible for making antibodies in mice bone marrow, in addition to decreased T-cells, produced in the thymus.

**Acute Toxicity**

The different formulations of 2,4-D may have different toxicities; for instance, the acid and salt formulations are severe eye irritants while the ester forms are not
(EPA RED Decision, 2005). 2,4-D is slightly toxic to humans and at high doses is a central nervous system depressant that can cause stiffness of arms and legs, incoordination, lethargy, anorexia, stupor, and coma (EPA, 2007). It is also a respiratory system irritant that can cause prolonged difficulty breathing, coughing, burning, dizziness, and temporary loss of muscle coordination (EXOTOXNET, 1996). Other symptoms of 2,4-D poisoning include irritation, inflammation, itching, and headache (CDC NIOSH, 2005). The primary target organs of the chemical are the eye, thyroid, kidney, adrenals, ovaries, and testes (EPA RED Decision, 2005).

**Chronic Toxicity**
Long-term animal studies of 2,4-D's chronic exposure have shown effects on the blood, liver, and kidneys (#EPA, 2007). Studies have also revealed slight chronic symptoms including a reduction in weight and changes in blood chemistry. It seems that long term exposure to 2,4-D can affect different animals in a wide variety of ways. Rats for example were found to be largely unaffected when fed moderately large amounts in their diet over long periods, although signs of kidney pathology were demonstrated. Dogs however died when fed smaller amounts over shorter periods. A human fed 16.3 grammes over 32 days showed severe symptoms of intoxication(13). It also seems that the various chemical forms of 2,4-D can have different toxic effects. Acid, salt and various esters differ in all their measured toxic effects to some extent, but the majority of toxicity data relates only to the acid.

**Cancer**
Phenoxy acid herbicides have been linked with soft tissue sarcomas, but the UK ACP has concluded that 'the data do not suggest a positive link with 2,4-D’14 as have the Canadian authorities(15). However, the International Agency for
Research on Cancer (IARC) has classified 2,4-D among the phenoxy acid herbicides MCPA and 2,4,5-T as a class 2B carcinogen—possibly carcinogenic to humans\(^{16}\) (concluding that there was limited evidence in humans, inadequate evidence in animals).

The US authorities have also been reluctant to declare 2,4-D as a potential human carcinogen, but the US courts decided that a forestry worker contracted cancer and died as a direct result of his exposure to 2,4-D during the course of his work\(\text{Journal of Pesticide Reform, 1987}\).

One concern about 2,4-D has related to dioxin contamination. 2,4-D was in the past frequently co-formulated with the herbicide 2,4,5-T. Production of 2,4,5-T was contaminated with the carcinogenic dioxin TCDD. Those who were exposed to the mixed formulations might therefore have been exposed to TCDD. The most notorious mixed formulation was Agent Orange, used first by the UK military in Malaysia and later extensively by the US military to defoliate jungle regions in Vietnam. In the UK, 2,4-D + 2,4,5-T formulations were in use until 1994. 2,4-D has been produced with contaminant dioxins, but not the harmful TCDD\(\text{Veterans Update, 1996}\).

**Reproductive effects**

Abnormal fetal skeletal development, increased fetal mortality and other reproductive effects are fairly conclusively associated with exposure to phenoxy-acid herbicide and their dioxin contaminants \(\text{Environmental Health, 1984}\). 2,4-D has also been classified as an endocrine disrupter\(\text{COLBURN, 1993}\), and significant chromosomal damage occurred in human cells cultured in the presence of 2,4-D. At the same time no evidence for mutagenicity has been found and 2,4-D did not damage DNA in human lung cells\(\text{EXTOXNET, 1994}\).

**Developmental Toxicity**

It is observed to be a developmental toxicant. Some observed effects are
increased gestation length, skeletal abnormalities, and effects on the thyroid and gonads (EPA RED FACTS, 2005).

**Carcinogenicity**

2,4-D is not classified as a human carcinogen, but some studies have shown it to be a carcinogen in rats that were fed high levels of 2,4-D over two years (EPA RED FACTS, 2005 and EXTOXNET, 1996). Recently, several human studies have shown an association between exposure to 2,4-D and an increased risk of tumor formation, but it is not yet clear that "this represents a true association, and, if so, whether it is specifically related to 2,4-D" (EPA, 2007). Several university studies done in the US have confirmed that rapid and repeated division of blood cells occurs in pesticide applicators using 2,4-D, in addition to increased activity of a tumor gene in the liver. It should be noted that NIOSH lists the acid, sodium salt, and dimethylamine salt formations as mutagens and that chromosomal rearrangement and breaks are both correlated with increased levels of 2,4-D in the urine (CDC NIOSH, 2005).

**Environmental Health Effects**

**Persistence in the environment**

2,4-D's persistence depends on its formulation as it enters the environment, but "under most environmental conditions 2,4-D esters and 2,4-D amines will degrade rapidly to form 2,4-D acid," which generally has a low persistence under normal conditions (EPA RED Facts, 2005). The half-life in normal soil conditions is seven days and microorganisms readily degrade 2,4-D under normal aquatic conditions (EXTOXNET, 1996).

**Effect on Animals and Organisms**

2,4-D is slightly toxic to wildfowl, moderately toxic to birds, and highly disruptive to honeybees (EXTOXNET, 1996). Several notable toxicity experiments have been conducted uniquely on animals. Important results with possible human applications include: decreased litter size in animals drinking 2,4-D contaminated water, contaminated breast milk in 2,4-D-
contaminated mothers (in both rats and goats), and effects on neurotransmitters, brain size, and development of neural connections in lab animals (CDC NIOSH, 2005).

**Regulation**

2,4-D has been in pre-Special Review status by the EPA since 1986, due to carcinogenicity concerns. The herbicide has been the subject of several Data Call-Ins (1980, 1994, 1995), requiring studies on toxicity, carcinogenicity (specifically non-Hodgkin's Lymphoma), reproduction, metabolism, re-entry, residential exposure, and chemistry to be submitted. A link could not be established between 2,4-D exposure and non-Hodgkin's Lymphoma, deferring the initiation of a Special Review. Instead, the 2,4-D Task Force agreed to risk-reduction measures in September, 1992. In 2004 the EPA concluded that there is no additional epidemiological evidence to implicate 2,4-D as a cancer-causing agent. As a result, 2,4-D has been classified as a Group D Carcinogen (not classifiable to human carcinogenicity). Risk-reduction measures, such as modified product labels and a user-education program, are still in place (EPA RED FACTS 2005).

**Precautions**

According to the EPA, 25% of samples of 2,4-D were contaminated with dioxin (2,3,7,8-TCDD), which is mutagenic, carcinogenic, and causes reproductive problems at very small doses (CDC NIOSH, 2005).

**Sources of Potential Exposure**

Exposure most likely would result from inhalation or dermal contact during 2,4-D's manufacture, formulation, or application, but it has been found in low levels in five states' groundwater supplies (#EPA, 2007 and #EXTOXNET, 1996).
References


Environmental Health Criteria 29, 2,4-Dichlorophenoxyacetic acid (2,4-D), IPCS, Geneva, 1984


Journal of Pesticide Reform, O'Brien, Mary, Jury Charges Dow $1.5 million for 2,4-D caused death of forest worker, 1987, 7: 4(30).


Dicamba

3,6-Dichloro-2-methoxybenzoic acid

Dicamba is a benzoic acid herbicide. It was registered with the EPA in 1967 (#NPIC). Dicamba mimics the plant hormone auxin, causing uncontrolled growth which eventually kills plants. It is meant for post-emergent plant control (#EPA). Dicamba is frequently formulated with other active herbicides such as 2,4-D, MCPP, and MCPA (#NPIC). Dicamba may be sold under names such as Banfel, Banvel, Banvel CST, Banvel D, Banvel XG, Dianat, Dicazin, Fallowmaster, Mediben, Metambane, Tracker, and Trooper (#EXTOXNET).

Chemical Description
Dicamba belongs to the benzoic chemical family. It is a white to brown crystalline solid. It is soluble in water (#NPIC), and it boils at 200°C (#NIOSH). Dicamba bonds with soil poorly. The half-life of dicamba in soil ranges from one to six weeks (#USDA).

Dicamba has a variety of acid and salt formulations. It is commercially available in liquids, liquid concentrates, wettable powders, granules, water dispersible granules, and sprays (#EPA).

**Uses**

Dicamba is used in the control of broadleaf plants, brush, and vines (#USDA). It is registered for use on asparagus, barley, corn, oats, millet, rye, sorghum, soybeans, sugarcane, and wheat. It is also used on pasture or rangeland grass, right-of-way areas, and golf courses. Residentially, it can be found in some lawn care products (#EPA).

**Human Health Effects**

In oral, dermal, and inhaled routes of exposure, dicamba has a low acute toxicity (#NPIC). Dicamba may have irritating or corrosive effects on the skin and eyes (#NPIC). The EPA has identified dicamba as a developmental toxin in the Toxics Release Inventory (#PANNA).

Exposing the skin and eyes to dicamba can cause redness, pain, and blurred vision. The inhalation of dicamba may cause coughing, labored breathing, vomiting, and weakness (#PANNA). Nausea and convulsions may also result from ingestion (#NIOSH).

**Environmental Health Effects**
Dicamba mimics auxin, a natural plant hormone, and causes uncontrolled cell division and growth. The plant dies as a result of damage to the vascular tissue (#EPA). With proper application, dicamba will not harm grasses. It is moderately toxic to some cacti species (#USDA). Dicamba has a low affinity for most soil types and is highly mobile (#USDA). Because of this, it has been detected in groundwater (#NPIC).

Dicamba has a low toxicity to mammals. The oral LD50 in rats is greater than 2740 mg/kg (#EPA). It also has a low toxicity to fish and bees. The oral LD50 for bees ranges from 3.6 μg/bee to greater than 10 μg/bee (#NPIC), and the LD50 in rainbow trout is 135 mg/L (#EXTOXNET). Dicamba salts are practically non-toxic to birds, although dicamba acids can be moderately toxic (#EPA). Neurological effects have been observed on rats, dogs, and hens given doses of dicamba. It is believed to affect the function of a significant enzyme (#USDA).

**Regulation**

Dicamba is registered for general use (#USDA). There are more than 400 products with dicamba (#EPA).

**Precautionary Notes**

Dicamba can be highly mobile in soil and can easily contaminate water. Take care not to harm desirable plants and be very cautious near water sources. Dispose of dicamba properly.

**References**


CONCLUSIONS AND RECOMMENDATIONS
(From The European Food Safety Authority)

Overall conclusions
The conclusion was reached on the basis of the evaluation of the representative uses as proposed by the applicant which comprise post-emergence applications with conventional tractor-mounted spraying devices or self-propelled hydraulic sprayers.
At the moment there is no agreed specification for the impurities in the technical material. Adequate analytical methods are available to monitor all compounds given in the respective residue definitions in food/feed of plant origin and environmental matrices. Sufficient analytical methods as well as methods and data relating to physical, chemical and technical properties are available to ensure that quality control measurements of the plant protection products are possible. In the mammalian metabolism studies, penoxsulam was rapidly and almost completely absorbed upon oral administration. There was no evidence of bioaccumulation. Excretion was rapid, but dose and sex dependent as excretion was primarily observed via feces in males and primarily excreted in urine in
females. Penoxsulam was biotransformed to a large number of metabolites; however the majority of the radioactivity was eliminated as unchanged parent compound. Plant and environmental metabolites BST and BSTCA were not identified in the rat metabolism studies. Toxicological information was lacking on the metabolite BSTCA to conclude on its relevance as a plant metabolite, moreover, it cannot be ruled out that BSTCA is also relevant according to the guidance document on the relevance of metabolites in groundwater. The acute toxicity of penoxsulam was low by the oral, dermal and inhalation route; slight skin and eye irritation were observed, but no potential for skin sensitisation. The dog was found to be the most sensitive species with the kidneys as the main target organ; the overall short-term NOAEL in dogs was 18 mg/kg bw/day. Long term toxicity reflected the same target organ observed in the short term studies: the liver in mice and the liver and kidneys in rats. The relevant long term NOAEL was the dose level of 5 mg/kg bw/day from the 2-year rat study. No potential for genotoxicity, carcinogenicity or neurotoxicity was observed. No effect was seen on the reproductive performance and parameters; no developmental effect was observed in rats. In rabbits, a slight increase in resorption rate parameters was associated with maternal toxicity, evidenced by gastro-intestinal upset and decreased body weight gain during the middle gestation. The Acceptable Daily Intake (ADI) of penoxsulam was 0.05 mg/kg bw/day; the Acceptable Operator Exposure Level (AOEL) was 0.18 mg/kg bw/day; no Acute Reference Dose (ARfD) was allocated. The level of operator exposure was below the AOEL even without the use of personal protective equipment (PPE) according to both the German and the UK POEM models. Worker and bystander exposure were considered negligible.

Name of Chemical: Penoxsulam

Reason for Issuance: Conditional Registration

Date Issued: September 27, 2004

DESCRIPTION OF CHEMICAL

Generic Name: 2-(2,2-difluoroethoxy)--6-(trifluoromethyl-N-(5,8-dimethoxy[1,2,4] triazolo[1,5-c]pyrimidin-2-yl))benzenesulfonamide

Common Name: Penoxsulam
VII ORGANIC PESTICIDES BY BRAND NAME

Organic Herbicides

Lawns

Suburban Lawns are a major focus of care and expense for the home owner. Lawn care, however, has come at a high cost to the environment. According to the U.S. National Wildlife Federation:

- 30% of water used on the East Coast goes to watering lawns; 60% on the West Coast.
- 18% of municipal solid waste is composed of yard waste.
- The average suburban lawn received 10 times as much chemical pesticide per acre as farmland.
- Over 70 million tons of fertilizers and pesticides are applied to residential lawns and gardens annually. (Read Healthy lawns, healthy lungs)
- Per hour of operation, a gas lawn mower emits 10-12 times as much hydrocarbon as a typical automobile. A weed eater emits 21 times more and a leaf blower 34 times more. Where pesticides are used, 60 - 90% of earthworms are killed. Earthworms are important for soil health.

Healthy Lawn Basics

Many gardeners are looking for natural alternatives in the landscape. The lawn can be one of the most chemically laden areas around our homes. Herbicides and chemical fertilizers are of concern, and any chemical applied to the grass affects the life below and possibly above.

There are plenty of organic products available that will give homeowners the perfect lawn without chemicals. They build the quality of the soil over time to a
point where a small application of organic fertilizer or organic matter is all that's needed for the grass to thrive.

The most often used chemical weed control is 2,4-D, which is a derivative of Agent Orange.

Grass can thrive with chemical treatments, but it also can become reliant on them. Remove the treatments and the lawn suffers.

The only way to reduce a dependence on chemical fertilizers is to develop a healthy lawn, which is naturally resistant to weeds, insects and diseases. If you need to fertilize your lawn more than once a year, consider these ways of improving the natural health of your lawn:

**Improve the Soil**
The first step is to test the soil's pH - it should read between 6.5 and 7.0, which is slightly acidic. Soil that is too acidic will need a sprinkling of lime; sulfur can be added to soil which is not acidic enough. You can buy a pH tester (see below, this page) for $40 - $60. Another solution is to have your soil tested professionally; first call your extension office - they often provide soil testing as a free service.

Lawns grow best in loamy soils that have a mix of clay, silt and sand. Too much clay in the soil mix, or heavy use, can compact the soil and prevent air and nutrient flow. Compacted soil may need aeration, a process of lifting small plugs of turf to create air spaces in the soil. For best results, rent an aerator or hire a lawn service to do the job - this will remove "finger size" plugs which improves aeration. Aeration is best done before top dressing and fertilizing.

**Choose a locally adapted grass**
Grasses vary in the type of climate they prefer, the amount of water and nutrients required, shade tolerance and the degree of wear they can withstand. Ask your local garden center to recommend grass which is best adapted to your area.


**Mow often but not too short**

Giving your lawn a "Marine cut" is not doing it a favor. Surface roots become exposed, the soil dries out faster and surface aeration is reduced. As a general rule, don't cut off more than one-third of the grass at any one time. Most turf grass species are healthiest when kept between 2.5 and 3.5" tall.

When the lawn is finished growing for the season, cut it a bit shorter to about 2". This will minimize the risk of mold buildup during winter.

**Water deeply but not too often**

Thorough watering encourages your lawn to develop deep root systems which make the lawn hardier and more drought-resistant. Let the lawn dry out before re-watering; as a rule of thumb, the color should dull and footprints should stay compressed for more than a few seconds. When watering, put a cup in the sprinkler zone; it should get at least one inch (2.5cm) water. Most healthy lawns require only 1" of water per week.

The best time for watering is early morning - less water will be lost to evaporation. Ideally, it's better to water the first half-inch or so, then wait for an hour or two before watering the second half-inch.

**Control thatch buildup**

Thatch is the accumulation of above-soil runners, propagated by the grass. This layer should be about 1/2" (1.25cm) on a healthy lawn, and kept in balance by natural decomposition, earthworms and microorganisms. Too much thatch prevents water and nutrients from reaching the grass roots. Before resorting to renting a dethatcher, however, effort should be made to improve aeration to control thatch buildup. Aeration brings microorganisms to the surface that will eat most of the thatch. If you don't aerate, the roots stay near the surface, contributing to thatch buildup. When you aerate once a year it breaks down the
thatch, allowing the roots to get deeper in the soil. This leads to thicker grass which naturally kills weeds too. While a dethatcher will reduce thatch buildup, it can strip and thin the grass so much it reduces competition for weeds allowing them to germinate easier. You can also reduce thatch with a steel rake.

**WATERING PROCEDURES FOR DIFFERENT GRASS TYPES**

How long can you wait between waterings before the lawn starts to go brown?

**12 - 21 days:** Bahia grass, Buffalo grass, Bermuda grass, St. Augustine grass, Centipede grass  
**8 - 12 days:** Carpet grass, Fine fescue, Kikuyu grass, Seashore paspalum, Tall fescue, Zoysia  
**5 - 7 days:** Ryegrass, Kentucky bluegrass, Bentgrass

The fine-leaved fescues (grass blades) as well as the "common" types of Kentucky bluegrasses, such as Park and Kenblue, require less water, fertilizer and cutting than turf-type perennial ryegrass or many of the newer "improved" types of Kentucky bluegrass.

**COMMERCIAL PRODUCTS**

**Acetic Acid** *(Vinegar)*

Vinegar contains Acetic Acid that burns the leaves and stems. Vinegar, is a non-selective, contact weed killer. This means it will kill or harm the above ground plant tissue it touches, but will not translocate (travel internally throughout the plant) into the roots. Plants that regenerate from roots, tubers, or rhizomes will not be controlled. However, you should know that the vinegar you buy at the grocery store contains only about 5% acetic acid. Studies have shown that 5% is insufficient and may not control some weeds effectively. The result is that most
weeds will come back. If you find that to be the case, there are a few commercial vinegar products available that may offer better results.

Vinegar labeled as a weed control product, in most cases, must be registered with the EPA. Many concentrated solutions are as high as 50% acetic acid and must be diluted before spraying. These are available only to licensed applicators. However, a few commercial products are available for home use without a license. They also combine citric acid for added effect.

**Trade Names**

- **Nature's Glory - Grass and Weed Killer** 6.25% acetic acid
- **Greenergy's Blackberry and Brush Block** 7.0% acetic acid
- **St. Gabriel Labs Fast Acting Burnout RTU** 6.25% acetic acid

Be advised that these products may not be available or legal to use in all states. Check with your local county extension office for advice on what is legal to use where you live.

**Corn Gluten Meal (CGM)**

CGM: An Organic Preemergent

Corn gluten meal is a by-product of corn processing and milling. It is a natural preemergent and is used as a substitute for the chemical varieties. The preemergence effect of Corn Gluten Meal was discovered by accident by Dr. Nick Christians. Dr. Christians is a professor at the University of Iowa and one of the world’s leading turf scientists. While using corn gluten meal in an unrelated experiment, he discovered its preemergent qualities.

**How CGM Works**

Corn Gluten Meal (CGM) is a fertilizer containing 9% slow release Nitrogen and is a natural preemergent for grassy and broadleaf weeds. The Nitrogen needs of
the grass must be taken into account when determining the amount of material to apply.
As a preemergent, it works by absorbing surface moisture needed by tiny germinating seeds. Established plants have developed root systems and are not affected since they can reach water below the effects of the CGM.
CGM is sometimes advertised as post-emergent weed killer. **It is important to know that corn gluten meal has no weed killing properties, except as a preemergent.**
The rate of application is from 10 to 30 lbs/1000 sq. ft. After applying, it needs to be watered in and followed by a drying period. This drying period is necessary for corn gluten’s desiccating effect. If you live in the northwestern U.S. or have an unusually wet spring, you may not get the results you hoped for.

**Avenger Weed Killer** is a citrus oil-based herbicide designed to meet the demands and needs of gardeners looking for an alternative to synthetic herbicides or less effective "natural" weed killers. Environmentally friendly, Avenger is fast becoming the organic weed killer of choice. Use along fences, foundations, sidewalks, walls, driveways, patios, mulch beds, gravel beds, lawn and garden preparation, around trees, shrubs and flowers. Active ingredient: d-limonene 70%
**Botanical Weed and Grass Herbicide.** This product is a contact, non-selective, broad spectrum herbicide. Multiple trials have demonstrated effectiveness against a wide range of weeds. Controls most annual and perennial weeds, both grasses and broadleaf. Complete coverage is required. Use of an organic surfactant is recommended, but not required. **Nu Film** Performed best in field trials. The active ingredient is d-limonene, a citrus oil extract that strips away the waxy cuticle from leaves, causing fast wilting (necrosis), dehydration and death. Other ingredients include castor oil and emulsifiers. For best results, treat weeds 6 inches or smaller. Larger plants, grasses and perennials may need repeat applications. Most economical if banded or used for spot treatment.

**Weedzap** is an all natural, broad spectrum, nonselective, contact herbicide that when foliarly applied zaps small broad leaf and grassy weeds. Best results when applied to actively growing emerged green vegetation six inches in height or less. Controls both annual and perennial plants, but does not translocate, and only affects plants actually coated with the spray solution. Contains 45% clove oil, 45% cinnamon oil and 10% inert ingredients (lactose and water). Mix 6.4 oz per gal water, or 5 gal/100 gal water per acre.
Natur’l Oil blends spreader/surfactant emulsifiers and 93% soybean oil. Often used to enhance effectiveness of **Safer's Insecticidal Soap** (1 part oil to 4 parts soap) and other foliar sprays, it reduces surface tension and evaporation and promotes absorption of materials being sprayed. It is also suitable for dormant oil applications. Use 1-5 gal/100 gal; gardeners use 2-5 TBS/gal.