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Author Young, A. L.

Corporate Author

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MILITARY HERBICIDES and INSECTICIDES

by

A.L. YOUNG, 1st Lt, USAF

B.C. WOLVERTON

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NON-EXPLOSIVE MUNITIONS DIVISION

AIR FORCE ARMAMENT LABORATORY

AIR FORCE SYSTEMS COMMAND • UNITED STATES AIR FORCE

EGLIN AIR FORCE BASE, FLORIDA

MILITARY HERBICIDES
AND INSECTICIDES

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INTRODUCTION

This pamphlet has been compiled by the Assessments Branch of the Non-Explosive Munitions Division, Air Force Armament Laboratory, to acquaint Air Force personnel with information on military herbicides and insecticides. The herbicides mentioned in this pamphlet are those currently in use in military programs. The insecticide information incorporated herein pertains to those insecticides in the Air Force inventory and those having potential application in military pest control programs.

Requests for additional pesticide information should be directed to AFATL (ATMA), Eglin Air Force Base, Florida.

ABBREVIATIONS

A	acre or acres
ai	active ingredient
bp	boiling point
ft	foot or feet
g	gram or grams
gal	gallon or gallons
hr	hour or hours
inch	inch or inches
l	liter
lb	pound or pounds
LC ₅₀	lethal concentration which kills 50% of the test organisms
LD ₅₀	lethal dose, given as mg/kg of body weight, which kills 50% of the test animals
μ	micron or microns
mg	milligram or milligrams
min	minute or minutes
ml	milliliter or milliliters
mp	melting point
oz	ounce or ounces
ppb	parts per billion
ppm	parts per million
ppmw	part per million by weight
psi	pounds per square inch
pt	pint
w	weight

DEFOLIANT NOMENCLATURE

<u>Military Code</u>	<u>Trade Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Orange or Purple	Brush Killer	2,4-D, 2,4,5-T	2,4-dichlorophenoxyacetic acid, 2,4,5-trichlorophenoxyacetic acid
Pink	2,4,5-T	2,4,5-T	2,4,5-trichlorophenoxyacetic acid
White	Tordon 101	picloram, 2,4-D	4-amino-3,5,6-trichloropicolinic acid, 2,4-dichlorophenoxyacetic acid
Blue	Phytar 560 G	cacodylic acid, sodium cacodylate	dimethylarsinic acid, sodium salt of dimethylarsinic acid

MILITARY DEFOLIANTS

<u>Military Designation</u>	<u>Type</u>	<u>Weight of Formulation</u>
Orange 50-50 mixture of 80% n-butyl esters of 2,4-D and 2,4,5-T	Herbicide	8.6 lb ai/gal
Purple 50% n-butyl ester of 2,4-D, 30% n-butyl ester of 2,4,5-T and 20% isobutyl ester of 2,4,5-T	Herbicide	8.6 lb ai/gal
Pink 60% n-butyl ester and 40% isobutyl ester of 2,4,5-T	Herbicide	8.6 lb ai/gal
White 10.2% of the triisopropanolamine salt of picloram, 39.6% of the triisopropanolamine salt of 2,4-D, and 50.2% inert ingredients	Herbicide	0.54 lb ai/gal picloram, 2.0 lb ai/gal 2,4-D
Blue 22.6% sodium cacodylate, 3.9% dimethylarsinic acid, 73.5% inert ingredient (NaCl), and 5.0% surfactant	Fast-acting desiccant	2.48 lb ai/gal containing 12.7% arsenic

DEFOLIANT ORANGE

Chemical Composition

Orange is a 50-50 mixture (V/V) of n-butyl esters of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T).

Origin

Dow Chemical Co., Amchem Products, Inc., Monsanto.

Type

Orange is an effective defoliant and herbicide used on a wide variety of woody and broadleaf plants.

Properties and Formulations

Orange is a reddish-brown to tan colored liquid soluble in diesel fuel and organic solvents, but insoluble in water. It has a mp of 7 C and a bp of 146 C (295 F). The specific density is 1.282 at 25 C. The viscosity is 940 centipoises at 20 F and 43 centipoises at 75 F. Orange is considered noncorrosive to most metals but deleterious to paints, natural rubber, and neoprene. The vapor pressure of Orange is <1 mm Hg at 35 C. Thus, it is considered a volatility defoliant, and the vapors (drift) are toxic to broadleaf plants.

Orange is formulated to contain 8.6 lb ai/gal or a total ester weight of 10.7 lb/gal.

Toxicology

The acute oral LD₅₀ of Orange for white rats is 566 mg/kg. Orange is characterized by low toxicity to fish and wildlife in the target areas during or after spray applications.

Slight irritation may be caused by prolonged exposure to the skin. Orange is not absorbed by the skin.

Rates

Orange is used at the rate of 3 gal/A when applied to dense tropical canopy. It is applied at the rate of 1-1 1/2 gal/A on vegetation in temperate regions.

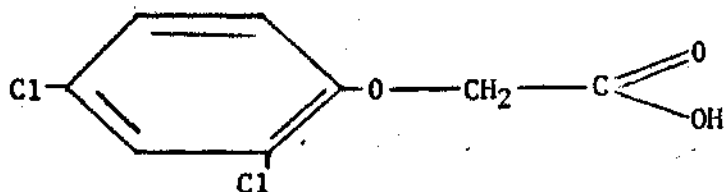
Application

When Orange is applied at the heavier rates, it is applied undiluted. When applied at lower rates, it is diluted with diesel fuel.

2,4-D HERBICIDE

Chemical Structure

2,4-Dichlorophenoxyacetic acid



Origin

Amchem Products Inc., 1942

Type

2,4-D is a selective, translocated, phenoxy herbicide used mainly in post-emergence applications.

Properties and Formulations

When pure, 2,4-D is odorless and crystalline. It has a mp. of 136 C and a bp of 160 C at 0.4 mm Hg. The crystals are soluble in dioxane (78.5 g/100 g), acetone (45 g/100 g), but not in water (0.06 g/100 g).

The specific density of 2,4-D acid is 1.565 at 30 C, while the oil-soluble amine salt (Dacamine) has a specific density of 1.0305 at 20 C.

The pure acids and salts are nonflammable. However, commercial formulations of the acid have a flash point minimum of 88 C, and some esters have a flash point minimum of 190 C.

Most formulations may be used in relatively hard water; some amines are inhibited against the precipitation of hard water salts in water containing 1,000 ppm of dissolved salts. Free-acid formulations have been used in combination with liquid fertilizers, but amine salt formulations should not be mixed (as the concentrate) with soluble fertilizers or other solutions of highly soluble salt content, or in diluted solutions containing heavy metal ions. In the case of 2,4-D esters, an emulsion compatibility test should be made before mixing with other pesticides or fertilizers.

Most formulations are noncorrosive to spray equipment, although some of the concentrates (esters) may be deleterious to painted surfaces.

Most formulations have no shelf-life limitations and are insensitive to light and temperature.

Formulations include:

a. Free acid.

b. Sodium and ammonium salts - The salt formulations are usually water soluble. The ammonium salts are rarely found on the market, while the sodium salts are usually marketed only for use by homeowners.

c. Amine salts - The alkylamines include monomethylene, dimethylamine, isopropylamine, triethylamine, and others. The alkanolamines include diethanolamine, triethanolamine, and mixed triisopropanolamines.

d. High-volatile esters - High volatile esters include methyl, ethyl, butyl, isopropyl, octylamyl, and pentyl esters containing various lb ai/gal.

e. Low-volatile esters - Low-volatile ester formulations contain esters that suppress volatility. These formulations include butoxyethanol, polyethylene glycol butyl ether esters, propylene glycol, tetrahydrofurfuryl, propylene glycol butyl ether, butoxy ethoxy propyl, ethylhexyl, and isooctyl ester.

f. Other formulations - Other formulations include 10-20% granules, emulsifiable concentrate of 3-6 lb ai/gal, 6 lb oil-soluble concentrate/gal, 95% wettable powder, and solids mixed with oil solutions, 2,4,5-T, and fertilizers.

Toxicology

The acute oral LD₅₀ of the various formulations fall in the range of 300-1,000 mg/kg for rats, guinea pigs, and rabbits on a weight basis. The toxicity to cattle appears to be quite similar to that of laboratory animals. The toxicity of 2,4-D to albino rats will vary with the formulation.

<u>Formulation</u>	<u>LD₅₀ (mg/kg)</u>
Acid	375
Sodium salt	666
Mixed butyl esters	620
Isopropyl ester	700

Recent information suggests that 2,4-D (or a contaminant in the formulation) may cause teratogenic (malformation) effects in fetuses of pregnant mice and rats when used at high dosage rates. However, statistical data have not been available to confirm this.

Some formulations may cause skin irritation. Possible dangers through inhalation are not known, but are thought to be minimal.

Pure 2,4-D acid at 100 ppm caused slight mortality to fingerling bream and largemouth bass. This is well above the rate used in practical applications. It is not harmful to wildlife under use conditions.

Rates

2,4-D is commercially applied at 1/4-4 lb ai/A in 40-100 gal of water. The military use of 2,4-D involves its formulation with 2,4,5-T in Orange. It is applied at the rate of 4.3 lb ai/gal or 12.9 lb ai/A as a defoliant for brush and tree defoliation.

Important Plants Controlled

2,4-D is widely used for control of broadleaf weeds in cereal crops, turf, pastures, and non-crop land. Most dicot crops are susceptible at herbicidal rates. The esters are particularly effective on deep-rooted perennial species. The salt and heavy ester formulations are of sufficiently low volatility so that with care, they may be used near fairly susceptible crops if spray drift is prevented.

Some of the important plants controlled include bindweed, chickweed, cocklebur, goldenrod, ivy, hoary cress, Jimsonweed, lambsquarters, locoweed, mustards, pigweed, plantain, Russian thistle, purslane, sunflower, willows, and most other broadleaf weeds. In addition, 2,4-D is used on aquatic weeds, for brush control, and as a growth stimulator.

Application

1. General usage, broadleaf plants - When 2,4-D is applied for general use, the foliage should be wet to the point of runoff on perennials and hard-to-kill plants. It is most effective on young, rapidly growing plants. A wetting agent may be added if desired. Higher rates should be used on perennial plants. The temperature during application should be between 50 and 90 F.

2. Carriers - The usual carriers include water, diesel oil, or oil-water emulsion, depending upon formulation used. Low volumes (e.g., 3-10 gal/A) are generally used for aerial applications, and higher volumes (up to 200 gal/A) are used for various ground applications. Surfactants have enhanced activity in many cases, and are particularly desirable when 2,4-D is carried in an oil-water emulsion. Agitation is needed with some formulations.

3. Aquatics - Granules are mainly used for aquatic weed-control. They are applied evenly to the water surface (not to be applied to choppy water). Results should be visible in 4-6 weeks with control lasting 1-3 years. The granules can be applied in winter on ice surfaces just before the spring thaw. 2,4-D is harmless to fish at recommended rates. It should be applied when weeds are actively growing but prior to the formation of dense mats.

4. Foliar spray and basal bark treatment of brush - Bases of trees and shrubs should be sprayed to a height of 12-15 inch from the ground line. The area at the ground line should be completely watered. A delayed response can be expected. Certain woody plants will form new growth after treatment, and repeated applications may be necessary for complete control.

5. Soil sterilant - Soil sterilant applications are applied in the late fall when the rains will carry the herbicide into the soil. In low rainfall areas (less than 6 inch annual rainfall), irrigation should follow treatment. The treatments are longer lasting in areas of limited rainfall.

Precautions

When spraying 2,4-D, drift should be avoided. Very susceptible plants include cotton, tomatoes, grapes, fruit trees, and ornamentals. Low-volatile esters may become volatile at 90 F and above. Excessive 2,4-D salts in the soil may temporarily inhibit seed germination and plant growth. Application equipment must be thoroughly cleaned before applying other pesticides. When used as an aquatic herbicide, decaying weeds may off-flavor water for a short period. Agitation is required during spraying of this compound, except for the water-soluble forms.

Additional Information

Plant roots absorb polar (salt) forms of 2,4-D most readily. Leaves absorb nonpolar (ester) forms most readily. In most cases a rain-free period of 6-12 hr is adequate for effective plant control. The esters of 2,4-D tend to resist washing from the plant.

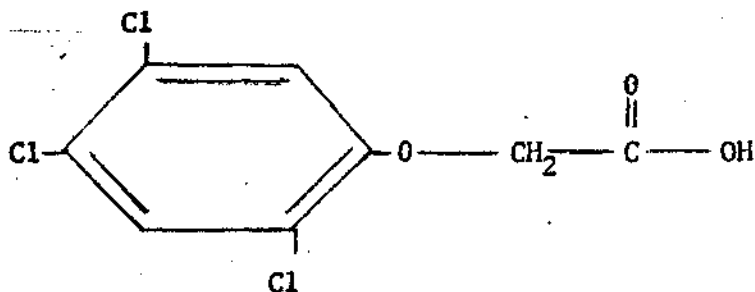
Following foliar absorption, 2,4-D translocates within the phloem, probably moving with food material. Following root absorption, it may move upward in the transpiration stream. Translocation is influenced by moisture and nutrient status of the plant. Accumulation of the herbicide occurs principally at the meristematic regions of the shoot and root.

Low rates of 2,4-D undergo microbial breakdown in warm, moist soil. Rate of breakdown depends upon temperature, moisture, organic matter, and other soil characteristics. There is minor loss of 2,4-D from photodecomposition. Volatilization depends upon the formulation. The resultant average persistence of a 2,4-D application applied at recommended rates is generally 1-4 weeks.

2,4,5-T HERBICIDE

Chemical Structure

2,4,5-Trichlorophenoxyacetic acid



Origin

Anchem Products Inc., 1944

Type

2,4,5-T is a translocated, selective, phenoxy herbicide applied post-emergence and is effective on woody plants.

Properties and Formulations

The pure chemical is a white solid with a specific gravity of 1.80 at 20 C and a mp of 154 C. It has a low vapor pressure and is soluble in ethyl or isopropyl alcohol (590 ppmw) and water (238 ppmw). The technical material is nonflammable; however, flammability will vary with formulation. When mixed with hard water, formulations do not clog spray nozzles. In general, 2,4,5-T is considered noncorrosive, but some formulations are deleterious to painted surfaces. The shelf-life of 2,4,5-T is excellent.

Numerous commercial concentrates are available in either the sodium, ammonium, or amine salt formulations, or in various ester formulations. Salts are soluble in water and insoluble in petroleum oils. Esters are insoluble in water and soluble in petroleum oils. "Brush killers" containing 2,4,5-T and 2,4-D are available commercially. The military defoliants Orange and Purple contain n-butyl esters of 2,4,5-T.

Toxicology

The toxicity (acute oral LD₅₀ mg/kg) of 2,4,5-T to albino rats will vary with formulation.

Formulation

LD₅₀

Acid
Mixed butyl esters
Isopropyl esters

500
481
495

When 2,4,5-T is used at recommended rates, it is suggested that hazards to wildlife are negligible. There is little or no biological activity of 2,4,5-T on insects, nematodes, or fungi.

Recent information suggests that 2,4,5-T (or a contaminant in the formulation), when used at high dosage rates, may cause teratogenic (malformation) effects in fetuses of pregnant mice and rats; however, statistical data have not been available to confirm this.

Rates

2,4,5-T is commercially applied at rates of 1-6 lb ai/A or 1-3 lb ai/100 gal of spray carrier.

The military use of 2,4,5-T involves its formulation with 2,4-D in Orange and Purple. It is applied at the rate of 4.3 lb ai/gal or 12.9 lb ai/A as a brush and tree defoliant.

Important Plants Controlled

2,4,5-T is one of the most potent brush killers available. It effectively controls mixed species of susceptible woody plants growing on rights-of-way, fence rows, industrial sites, ditches, and similar non-crop areas. Specific plants that 2,4,5-T will control include ash, wild blackberry, hawthorne, oak, ivy, maple, chokeberry, mesquite, birch, elm, brambles, wild grape, honeysuckle, poison ivy, sumac, willow, and many other woody plants as well as most non-woody broadleaf plants.

Application

2,4,5-T is used mainly on established plants (post-emergence), and is sprayed via conventional ground and aerial equipment.

1. Usual carrier - The usual carriers are water, diesel or fuel oil, or an oil-water emulsion; it is applied at volumes of 3-40 gal/A. The lower volumes, applied by aerial equipment, are generally most effective when at least some oil is present. Additional surfactants often enhance activity, particularly at low herbicide rates.

2. Foliage treatment - Foliage treatments are made during the growing season and after the foliage is well developed. All plant parts should be thoroughly wet with the herbicide. The best time for treatment is when the soil moisture is favorable for growth. Foliage should not be treated during periods of severe drought or in early fall when leaves have lost their healthy green color. To selectively take undesirable woody plants out of conifer trees, the stand should be sprayed immediately after annual growth is completed to avoid injury to the tender new growth. For best results 2,4,5-T is usually applied to mesquite 45-90 days after it first begins to leaf out.

3. Basal bark treatment - Basal bark treatment may be done any time of the year. The herbicide should be mixed with oil and applied to the basal parts of stems or trees having a diameter of less than 6 inch. It is applied from ground line to 12-16 inch up the trunk. The trunk should be wet on all sides. Best results are obtained when the plants are not cut for 1 year. A delayed response can be expected.

4. Stump treatment - This treatment is used to prevent regrowth. It is usually applied with oil. The cut surface of the stump should be thoroughly wet and the sides of the trunk left exposed to the point of runoff. The treatment may be applied at any time of the year. Best results are obtained when applied to freshly cut stumps.

5. Frill treatment - Frill treatment is used on trees 6 inch in diameter or larger. The chemical should be mixed with oil and applied to the cut surfaces. Treatment may be at any time during the year.

Precautions

Drift must be avoided since non-target plants may be damaged. Highly susceptible crops include cotton, tomatoes, ornamentals, grapes, and fruit trees; however, almost all broadleaves are injured. Contamination of irrigation ditches should be avoided. The same equipment should not be used to apply other pesticides to crop lanes. The recommended method of cleaning glassware and spray equipment is thorough washing with detergent followed by repeated flushings with water.

Additional Information

2,4,5-T is relatively harmless to monocotyledonous plants (e.g., grasses). It is less effective than 2,4-D on many broadleaf plants, but more effective on woody plants.

2,4,5-T is absorbed through roots and foliage of plants. The esters of 2,4,5-T are more resistant to the washing action of rain.

The translocation and persistence in plants of 2,4,5-T is similar to 2,4-D; however, the microbial degradation of 2,4,5-T is slower than 2,4-D due to the addition of another chlorine atom.

PHENOXY HERBICIDES

Formulation

The phenoxy herbicides (e.g., 2,4-D and 2,4,5-T) are usually formulated as acids, salts, and esters. Salt and ester formulations usually are supplied as liquid concentrates. The salt concentrates form solutions (i.e., they are water soluble) when mixed with water. The ester concentrates form solutions when mixed with oil; they form milky-white emulsions when mixed with water.

At temperatures below 90 F, the low-volatile esters are less likely to damage susceptible plants than high-volatile esters. However, if there are susceptible plants near, the salt formulations are the safest since they do not release enough vapors to cause damage.

High-volatile esters are less expensive than low-volatile esters and can be used effectively and safely if no susceptible plants are growing nearby.

Ester formulations are more effective than salts for killing plants that are growing slowly because of drought or cold weather. Esters usually are best for controlling plants in areas of low humidity; esters are formulated in oils and remain in moist contact on foliage longer and penetrate better than salts, which are mixed with water. Because they are oily, esters are less likely than salts to be washed off foliage if rain falls soon after their application.

Types Available

Salts

Amine (triethanolamine, diethylamine, and triisopropanolamine)

Sodium

Potassium

Ammonium

Esters

High-volatile (methyl, ethyl, isopropyl, butyl, and amyl)

Low-volatile (butoxyethanol, butoxyethoxy-propanol, isooctyl, and propylene glycol butyl ether)

DEFOLIANT WHITE

Chemical Composition

White is a 1:4 mixture of the triisopropanolamine salts of 4-amino-3,5,6-trichloropicolinic acid (picloram) and 2,4-dichlorophenoxyacetic acid (2,4-D).

Origin

Dow Chemical Company has the proprietary formulation for White.

Type

White is a systemic defoliant effective against broadleaf plants and brush.

Properties and Formulation

White is a dark brown, viscous liquid that is soluble in water but insoluble in organic solvents and diesel fuel. It has a bp of 95 F and a specific gravity of 1.12 at 25 C. It has a viscosity of 343 centipoises at 50 F and 95 centipoises at 100 F. White is noncorrosive to metals and other materials used in spray equipment.

White is formulated to contain 10.2% picloram, 39.6% 2,4-D, and 50.2% inert ingredients. White has 0.54 lb picloram/gal and 2.0 lb 2,4-D/gal.

Toxicology

The acute oral LD₅₀ of defoliant White for white rats is 3,080 mg/kg. White, applied directly to the eyes of rabbits, caused moderate transient eye irritation but no significant corneal injury. Studies on the lethal effects of White to three kinds of fish indicated that median tolerance limits ranged from 64 to 240 ppm.

Rates

For defoliation of dense vegetation, White is used at the rate of 3 gal/A.

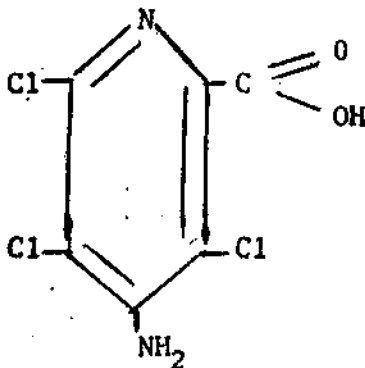
Application

Because of its persistence in soils, White should never be applied on or near broadleaf crop species. Herbicidal action of White when applied to woody plants is slow, and full defoliation may not occur for several months after application. Most grass species are resistant to applications of White.

PICLORAM HERBICIDE
(Tordon)

Chemical Structure

4-Amino-3,5,6-trichloropicolinic acid



Origin

Dow Chemical Company, 1963

Type

Picloram is a somewhat selective, translocated, pre- and post-emergence herbicide.

Properties and Formulations

Picloram is a white powder with a chlorine-like odor. It decomposes before melting (215 C) and is moderately resistant to ultraviolet irradiation. The vapor pressure is 6.16×10^{-7} mm Hg at 35 C. The solubility of the pure chemical is 10,500 ppm for ethanol and 430 ppm for water.

The estimated shelf life of picloram concentrate in storage is 3 years. Picloram is noncorrosive, nonvolatile, and nonflammable.

The formulations include a 2 lb ai/gal emulsifiable concentrate (Tordon 22K), 10% granules (Tordon 10K pellets), and 2% beads. White contains the water soluble triisopropanolamine salt in combination with 2,4-D (Tordon 101 mixture). This formulation consists of a 4:1 ratio (2 lb ai/gal to 0.54 lb ai/gal) of 2,4-D and picloram.

Toxicology

The acute oral toxicity of picloram is low. The LD₅₀ values range from approximately 2,000 mg/kg of body weight for rabbits to more than 8,000 mg/kg for rats.

In long term feeding studies, albino rats and beagle dogs were fed picloram in their rations at daily levels of 15, 50, and 150 mg/kg of body weight. At the end of 2 years of continuous feeding, no observable adverse effect was noted in any of the animals of either species as measured by body weight, food consumption, behavior, mortality, hematological and clinical blood chemistry studies, and urine analyses.

Japanese quail, Bobwhite quail and Mallard ducks were fed picloram at rates from 100 to 10,000 ppm or more in their diets without reaching the LC₅₀. Japanese quail were fed 100-1,000 ppm over a period of 8-20 weeks for each of 3 successive generations without effect on mortality, body weight gain, egg production, fertility or hatchability, and without post-treatment withdrawal effects.

A triisopropanolamine salt formulation of picloram was tested against 5 species of fish at 50-82 F for periods of 24-96 hr. The LC₅₀ values were between 63 and 300 ppm of the formulation, equivalent to 20-94 ppm acid equivalent. In tests with White in 5 species of fish, the LC₅₀ values ranged from 75-241 ppm of the formulation (containing a 4:1 ratio of 2,4-D and picloram, as their triisopropanolamine salts).

Formulations containing the triisopropanolamine salts of 2,4-D and picloram are more toxic to ramshorn snails than those without 2,4-D; however, none appear to be toxic at concentrations below 100 ppm in water. In a reproductive study lasting 10 weeks in a solution containing 1 ppm picloram, many generations of Daphnia were produced without reduction of numbers. Analysis of Daphnia tissues showed no buildup of the compound above that occurring in the surrounding water.

Rates

For thick stands of brush, the pellets or beads are applied at the rate of 6-8 lb ai/A distributed evenly over the entire area.

The liquid formulations are used at rates of 0.5-3.0 lb ai/A. Rates for controlling deep-rooted perennial weeds such as field bindweed and Canada thistle are usually 2-3 lb ai/A. However, for annual weed control, rates as low as 0.25 oz ai/A have been effective, particularly in combination with 2,4-D.

The liquid potassium salt formulation is applied in water sprays in sufficient volume for uniform distribution.

Important Plants Controlled

This herbicide is excellent for general woody plant control and control of most perennial broadleaved plants. Most grasses are resistant and broad-leaf weed control in grass crops is feasible. Most broadleaf crops are

sensitive to picloram except cruciferous crops (e.g., cucumbers, squash and melons). The major broadleaves controlled are field bindweed, Canada thistle, perennial kelp, leafy spurge, and Russian knapweed.

Application

Picloram may be applied with ground sprayers as a low-pressure spray. It should be used with enough water to wet the foliage and soil thoroughly, and should be applied when plants are growing actively and rainfall can be expected soon after treatment. It is used at higher rates when either a very heavy or a very light rainfall is expected. It should be applied over the roots of woody plants to be controlled. Aircraft applications may be used up to 3 weeks before frost. Granules are most effective for spring or early summer application.

Precautions

When picloram is used, drift should be avoided. It should not be applied under the drip line of desired trees. The same equipment should not be used to apply other pesticides on desired plants. Contamination of irrigation water should be avoided. In some states it may be applied only by licensed pest control operators. Very minute quantities of picloram will injure many broadleaf crop plants. Picloram leaches readily with water.

Additional Information

Grasses will be the first to reappear in the treated areas. Maximum results are not obtained until the material is carried by moisture into the root zone. The higher rates should be used to control brush on very sandy, rocky, or gravelly soils. At lower rates of picloram, grasses are considered resistant. The pellet formulations are intended more for woody plants, while the liquid is intended for perennial broadleaf control. Picloram is being experimented with as a plant growth regulator at extremely low rates. The half-life in soil at use dosages varies from 1-11 months.

DEFOLIANT BLUE

Chemical Composition

Blue is a mixture of the herbicides dimethylarsinic acid (cacodylic acid) and sodium cacodylate.

Origin

Ansul Company has been the major producer of Blue; however, the Chapman Chemical Company, Diamond Shamrock Corporation, and Vineland Chemical Company also produce the Blue formulation.

Type

Blue is a rapid-acting desiccant or contact herbicide that causes browning and dehydration of treated portions of plants.

Properties and Formulations

Blue is a clear yellowish-tan liquid that is soluble in water but insoluble in organic solvents or diesel fuels. It has a mp of -22 F and is nonflammable. The specific gravity of Blue is 1.324 at 25 C, and it has a viscosity of 27 centipoises at 50 F and 10 centipoises at 95 F. It is corrosive to zinc and mild steel and considered mildly corrosive to aluminum. Copper, brass, and tin are not affected by Blue.

Blue is formulated to contain 3.9% dimethylarsinic acid, 22.6% sodium cacodylate, 0.5% antifoam agent, 73.0% inert ingredient (NaCl) and 5.0% surfactant. It contains 2.48 lb ai/gal with an arsenic content of 12.7%. The weight of Blue per gal is 10.9 lb.

Toxicology

The acute oral LD₅₀ of Blue for white rats is 2,600 mg/kg. Dairy cattle fed Blue for 60 days at the rate of 24.5 mg/kg gave no residue of arsenic in the milk and no storage of arsenic on a cumulative basis.

Rates

When Blue is applied at the rate of 3 gal/A to broadleaf herbaceous, woody or grass vegetation, it is an effective, rapid defoliant. For control of most grass species Blue can be applied at the rate of 1 gal/A.

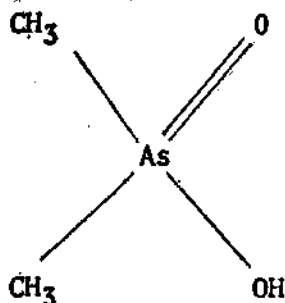
Application

When Blue is applied at lower rates it should be diluted with water. Applications of Blue should not be made during or following precipitation.

DIMETHYLARSINIC ACID HERBICIDE
(Cacodylic Acid)

Chemical Structure

Dimethylarsinic acid



Origin

Dimethylarsinic acid is an old compound recently being used as a herbicide. It is produced by a number of manufacturers; however, the Ansul Company is the basic producer.

Type

Dimethylarsinic acid is a non-selective, post-emergent, foliar-contact herbicide.

Properties and Formulations

Dimethylarsinic acid is a colorless, crystalline solid. It has a mp of 200 C and is soluble in water (66.7 g/100 ml) and alcohol (20.6 g/100 ml), but insoluble in ethyl ether. It is nonflammable, compatible with hard water, mildly corrosive, and completely stable in storage.

The most important formulations of dimethylarsinic acid are in combination with sodium cacodylate (the sodium salt of dimethylarsinic acid). For military use, the most important formulation is Phytar 560 G (Blue). This formulation contains 22.6% sodium cacodylate, 3.9% cacodylic acid, 73.5% inert ingredient (NaCl), and 5.0% surfactant. One gal contains 2.48 lb ai/A having 12.7% arsenic.

Other formulations include emulsifiable concentrate containing 65% formulation and 5.7 lb ai/gal.

Toxicology

The methyl-arsenic bond in organic arsenical compounds such as dimethylarsinic acid lowers the acute toxicity much below that which is

normally associated with inorganic arsenic compounds. Dimethylarsinic acid and its sodium salt have acute LD₅₀ values on rats between 1,000 and 2,000 mg/kg. Most inorganic arsenic compounds have acute oral LD₅₀ values of 10-100 mg/kg. In commercial use of organic arsenicals, a hesitant attitude has often been noted. This is an unfortunate result of guilt by association with the scare word "arsenic."

A subacute dose of 280 mg/kg (in rats) showed evidence of reduced activity of spermatogonia cells with some atrophic changes of the seminiferous tubules. It has a primary dermal irritation index to rabbits of 0.3 mg/kg. In general, the organic arsenicals cause very mild or no skin irritation, depending on the acidity or alkalinity of each preparation and the skin sensitivity of the exposed individual. It is essentially non-irritating to the eye.

Rates

Dimethylarsinic acid is a contact herbicide which will defoliate or desiccate a wide variety of plant species. When used for defoliation, it is applied from 5-22 lb ai/A. When it is used for control of cereal crops and grasses (and in the formulation Blue), it can be effective at rates of 1/4-1/2 lb ai/A.

Important Plants Controlled

Current experimental uses of dimethylarsinic acid include cotton defoliation, weed control in citrus orchards, pre-commercial thinning of conifers, and control of undesirable hardwood. Commercial uses include control of such weeds as nutgrass, Dallisgrass, crabgrass, Johnsongrass, Bermudagrass, spurge, pigweed, purslane, lambsquarters, morningglory, Russian thistle, puncture vine, and dodder.

Application

1. General weed killer - For general use, 2 quarts of a non-ionic surfactant are added per each 100 gal to get maximum spreading of the material. The foliage is thoroughly sprayed. Younger plants are more susceptible to the herbicide. Directed sprays are used around trees and shrubs. For best results, the herbicide should be sprayed when the temperatures exceed 70 F.
2. Turf - Turf should be mowed closely before application and the foliage covered thoroughly. The turf will be dead within 2-4 days. With thorough watering, reseeding may be accomplished within 5 days of treatment.
3. Defoliation - For defoliating, the foliage should be covered thoroughly. A second application is rarely necessary.
4. The following comments are applicable to Blue:

a. Provided that reasonable climate conditions prevail, the rate of Blue per acre required to give effective plant control has been determined as 1.5-2.0 gal, which is equivalent to an approximate range of 3 1/2-5 lb ai/A of dimethylarsinic acid (and its sodium salt).

b. It should be emphasized that one application of Blue will not give a permanent kill on deep-rooted perennial grasses. Several applications are necessary to control deep-rooted perennial species.

c. Blue usually begins to show a pronounced effect in 2 days, and desiccating activity continues to a maximum in 8-10 days, depending on climatic conditions. In some circumstances, however, effects take even longer.

d. Temperature appears to be a factor in the performance of Blue. Warm temperatures during and following application accelerate the action of this herbicide. Excellent results have been obtained under conditions of cool nights and warm days coupled with low humidity, but the action appears to be much slower. On the other hand, slow herbicidal action appears to yield a longer-lasting effect with Blue.

e. Because Blue is extremely water-soluble, rain, overhead irrigation, or even overnight dew tends to dilute and wash off the herbicide if such conditions exist soon after spraying.

f. High levels of light intensity and long periods of illumination appear to intensify both the speed of herbicidal activity and the permanence.

g. Although thorough coverage of vegetation is absolutely necessary for maximum effect of Blue, this does not mean that substantial runoff should occur. There is no effect on plants once the spray solution has contacted the soil; therefore, material applied to the soil is wasted.

h. Laboratory tests have also shown that a threshold phytotoxic effect exists when Blue is applied to many species. This level is usually between 100 and 500 ppm. Therefore, spray solutions cannot be indefinitely diluted and still retain maximum effectiveness. On the other hand, very concentrated spray solutions have been applied at low volumes with excellent results.

Precautions

The following precautionary information is more applicable to the inorganic forms of arsenic than to organic arsenicals.

a. Symptoms of poisoning - The symptoms of subacute poisoning with arsenicals are usually a salty taste, a burning in the throat, and colicky pains in the stomach and intestines. A garlicky odor of the breath and skin

is frequently present. The symptoms of acute poisoning are headache, vomiting, diarrhea, dizziness, stupor, convulsions, general paralysis and death. The dose of arsenicals required to give these acute symptoms is from about 1 oz-1 lb of active material for a normal-sized adult.

b. First aid and antidotes - If liquid or dust should accidentally enter the eyes, they should be immediately washed with water. If any irritation remains after washing, a physician should be consulted. If accidental oral ingestion occurs, the stomach should be emptied by vomiting and lavage with water, followed by a saline cathartic, such as sodium sulfate. BAL (Dimercaprol) is a specific antidote; it should be administered intramuscularly at the rate of 3 mg/kg of body weight every 4 hr for the first 2 days, every 6 hr on the third day and twice daily until recovery is complete.

Additional Information

The phytotoxic properties of this herbicide are quickly inactivated on contact with the soil. It is suggested that this inactivation is a result of surface adsorption and ion exchange. There is no loss from photodecomposition and/or volatilization.

The organic pentavalent arsenicals are considerably less toxic than inorganic trivalent arsenicals. There is no evidence of metabolism of the organic arsenicals by microorganisms nor of significant buildup of toxic residues in the soil.

Dimethylarsinic acid is a very effective leaf defoliant for many species when applied in dosages considerably lower than normally recommended for desiccation. The leaf abscission layer on susceptible species is triggered by small amounts of the chemical. Many plants so affected are able to regenerate new leaves within a short time and continue their life cycle with only a slight interruption.

When dimethylarsinic acid is applied in early plant growth stages in amounts far below that required for a phytotoxic effect, this compound produces malformed inflorescences at a later growth stage on many species. Seed production is reduced, and other abnormalities, possibly including sterilization of the pollen or ova, are indicated by the responses which have been observed.

INSECTICIDE NOMENCLATURE

<u>Trade Name</u>	<u>Common Name</u>	<u>Scientific Name</u>
Dursban	Experimental No. M-3019	0,0-Diethyl-0,3,5,6-trichloro-2-pyridyl phosphorothioate
Baytex	Fenthion	0,0-Dimethyl-0-[4-(methylthio)-m-tolyl] phosphorothioate
Malaphos	Malathion	0,0-Dimethyl-S-1,2-di-(ethoxycarbamyl) ethylphosphorodithioate
Dibrom	Naled	Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate
Thimet	Phorate	0,0-Diethyl-S-(ethylthiomethyl) phosphorodithioate
Phosdrin	Mevinphos	2-Carbomethoxy 1-methylvinyl dimethyl phosphate
Dimecron	Phosphamidon	Dimethyl-2-chloro-2-diethyl carbamoyl-1-methylvinyl phosphate
Sevin	Carbaryl	N-methyl-1-naphthyl-carbamate
Mirex	Mirex	Dodecachlorooctahydro-1,3,4-metheno-2 <u>H</u> cyclobuta (<u>cd</u>) pentalene

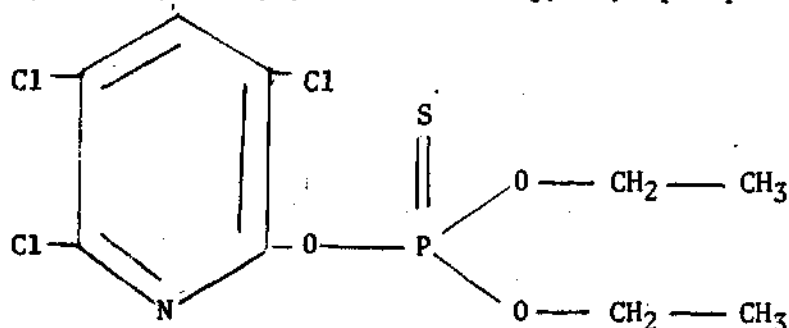
INSECTICIDE CLASSES

<u>Class</u>	<u>Insecticide</u>	<u>Principle Pests Controlled</u>
Organophosphate	Dursban	Mosquitoes, cockroaches
	Fenthion	Mosquitoes, flies
	Malathion	Mosquitoes, broad-spectrum
	Mevinphos	Cutworms, aphids
	Naled	Mosquitoes, grasshoppers
	Phorate	Mites, Hessian fly
	Phosphamidon	Aphids, moths
Carbamate	Carbaryl	Grasshoppers, fleas, mites
Chlorinated Hydrocarbon	Mirex	Fire ants

DURSBAN INSECTICIDE

Chemical Structure

O,O-Diethyl-O-3,5,6-trichloro-2-pyridyl phosphorothioate



Origin

Dow Chemical Company, 1965

Type

Dursban is an organic phosphate insecticide. It is effective insecticidally by contact, ingestion, and vapor action.

Properties and Formulations

Dursban is a white crystalline solid with a mp of 41.5-43 C. It has a molecular weight of 350.5 and a vapor pressure of 1.87×10^{-5} mm Hg at 25 C and 8.15×10^{-5} mm Hg at 35 C.

Dursban is insoluble in H₂O, but soluble in acetone, carbon tetrachloride, chloroform, methylene chloride, xylene, kerosene, and No. 2 diesel fuel oil. Under normal storage conditions, most formulations are stable for indefinite periods of time. The breakdown rate of Dursban increases as temperature and pH of the solution increases. Dursban is moderately residual on plant surfaces and quite residual on inert surfaces. In water solutions and soil, Dursban hydrolyzes at a half-life rate of 80-100 days. It is stable to ultraviolet light when in powder form, but 80% of plant application is lost to volatilization.

Formulations of Dursban include wettable powders, granules, and emulsifiable concentrates.

Toxicology

The skin absorption LD₅₀ for rabbits is 2,000 mg/kg of body weight.

The acute oral LD₅₀ for female rats is 135 mg/kg; for male rats - 163 mg/kg; guinea pigs - 500 mg/kg; chicks - 32 mg/kg; rabbits - 1,000-2,000 mg/kg.

Dursban is highly toxic to marine shrimp, chironomid larvae and Daphnia, and may be quite toxic to freshwater trout. At a rate of 0.05 lb/A, brown shrimp suffer 100% mortality and certain minnows suffer 50% mortality, while mullet and blue crabs seem to be unaffected. Dursban insecticide applied at routine use concentrations should not present any hazard to birds and other vertebrate wildlife.

Rates

Dursban is applied at rates of 0.05-1.0 lb ai/A. The higher dosage rates should not be used where loss of fish, crustaceans, and lower components of the food chain would be significant.

Phytotoxicity

Dursban is non-phytotoxic when used at the recommended rates.

Uses

Dursban is a broad-spectrum insecticide which is especially effective against mosquitoes, household pests, and soil insects.

Dursban is being tested for control of internal and external parasites of cattle and sheep, as well as experimentally on turf, crop plants, and around buildings.

Important Pests Controlled

Chinch bugs, cockroaches, houseflies, fleas, ants, earwigs, webworms, clover mites, ticks, and mosquitoes may be controlled by use of Dursban.

Application

When Dursban is applied to plant foliage or to a surface, the area should be covered thoroughly and treatment repeated when it becomes necessary. When Dursban is used for mosquito control, data which follow emphasize recommended rates:

CONDITION OF AREA TO BE TESTED	AMOUNT TO USE PER ACRE		NO. OF ACRES 1 GAL OF DURSBAN M WILL TREAT
	DURSBAN M (FL OZ)	DURSBAN INSECTICIDE (LB)	
Larval Control: None to Medium Vegetative Cover	0.4 to 0.8	0.0125 to 0.025	320 to 160
Larval Control: Medium to Heavy Vegetative Cover	0.8 to 1.6	0.025 to 0.05	160 to 80
Adult Control: Light to Medium Vegetative Cover	0.8	0.025	160
Adult Control: Medium to Heavy Vegetative Cover	1.6	0.05	80

Precautions

Dursban should not be used on any food or feed crops until registration has been granted. It should not be mixed with alkaline compounds.

Dursban is fatal if swallowed, may be absorbed through skin, and may be injurious to eyes and skin.

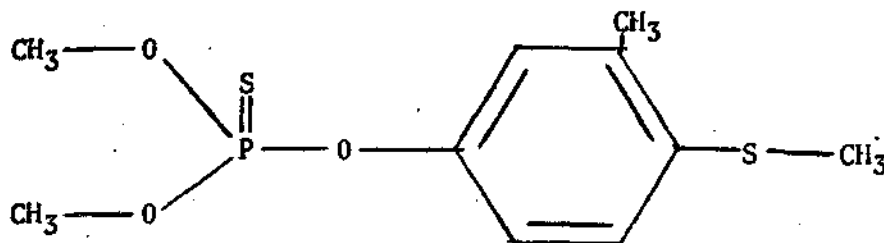
Additional Information

Dursban has a very short residual life on plant foliage; however, on soil, wood, and concrete, it is effective for several weeks. It is very resistant to leaching in the soil. It will decompose slowly in warm moist soil and does not stain. Dursban is absorbed rapidly by plants and soil particles, but metabolized slowly. Dursban is absorbed slowly by fish, but metabolized rapidly. The amount absorbed by fish is influenced by other organisms in the environment. Dursban is rapidly metabolized in mammals (it is not a cholinesterase inhibitor when in pure form), and the detoxified products are eliminated via the urine and feces.

FENTHION INSECTICIDE (Baytex)

Chemical Structure

O,O-Dimethyl-O-[4-(methylthio)-m-tolyl] phosphorothioate



Origin

Farbenfabriken Bayer A. G. in Germany, 1957. It is licensed to be sold in the United States by Chemagro Corporation.

Type

Fenthion is an organic phosphate insecticide-acaricide with a long residual activity.

Properties and Formulations

Fenthion is stable under normal conditions, but subject to hydrolysis. It is resistant to lime and can be applied to whitewash without deleterious effects; however, it is incompatible with highly alkaline pesticides.

Formulations include emulsifiable concentrates of 2, 4, and 8 lb ai/gal, 25% wettable powders, 1 and 5% granules, 3% dust, 1% aerosol, and 225 and 22.5 mg/ml injectable materials.

Toxicology

The acute oral LD₅₀ of fenthion to rats is 200 mg/kg. The dermal LD₅₀ is 330 mg/kg. Fenthion is readily absorbed through the skin. Fenthion is toxic to fish and birds (LD₅₀ of 15 mg/g for ducks) and should not be used where wildlife conservation can be easily disrupted.

Over a 96-hr period, 0.58 ppm fenthion caused 50% mortality among oysters. Over a 48-hr period, 0.06 ppb caused 50% mortality among shrimp.

Within a 48-hr period, 1.59 ppm fenthion caused 50% mortality among juvenile fish (mullet). It has been reported that, during a 4-hr exposure, 1.0 ppm decreased the productivity of a phytoplankton community by 7%. Fenthion is highly toxic to mosquito larvae.

Rates

Fenthion is applied at 0.5-1.5 lb ai/100 gal. Effective mosquito control can be obtained with rates of 0.05-0.10 lb ai/A.

Phytotoxicity

Fenthion is considered non-phytotoxic when used at the recommended rates.

Uses

Fenthion is registered for use as a mosquito larvacide, in households, on agricultural premises, and on ornamentals. It is being used experimentally on alfalfa, cotton, clovers, sugar beets, cranberries, rice, coffee, stored products, and many ornamentals. It is also being used on all types of livestock. The dust is used to control household pests.

Important Pests Controlled

Important pests that can be controlled by use of fenthion include flies, mosquitoes, ticks, lice, bedbugs, boll weevils, alfalfa weevils, crickets, armyworms, thrips, bollworms, codling moths, aphids, leaf hoppers, spittle bugs, sawflies, ants, cutworms, grasshoppers, mites, and lygus bugs.

Application

1. Foliage and premises - For foliage, fenthion is applied evenly at a uniform rate. Application should be repeated as necessary. It is resistant to lime and, therefore, may be applied to fresh whitewash without staining or losing its effectiveness.

2. Livestock - For use on livestock, it is applied as a .1-.2% concentration as an overall spray using approximately 1 gal/animal.

3. Soils - In soils (Coachella fine sand) containing 0.15% organic matter, fenthion showed residual activity at 2 months, but not at 6 months when applied at 8-16 lb/A. Fenthion showed no residual activity after 2 months of storage.

Precautions

Fenthion should not be used on food or feed crops until registration is cleared by the FDA. Only trained personnel should use fenthion in households.

Excessive wetting of plastic, tile, or rubber should be avoided. To protect bees, flowering crops should not be sprayed with fenthion.

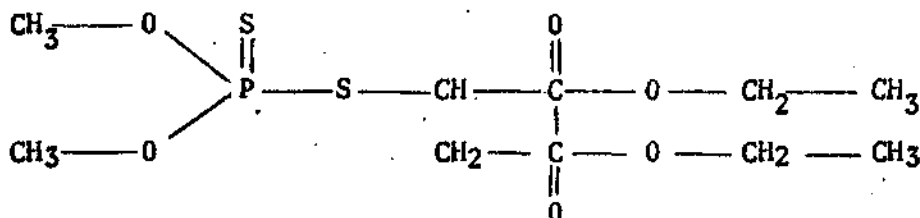
Additional Information

Fenthion is generally compatible with other pesticides except those which are highly alkaline. It is used on a no-residue basis. It has given control of insects in stored products from 4-16 months. When applied to the sides of barns, it gave 100% control of mosquitoes after 42 weeks. It is sometimes mixed with paints. Iiguvon is the trade name when it is used as a livestock insecticide. Registration on many species of domestic animals is expected in the near future. The penetrative ability of fenthion controls mining insects. It is used for treating walls made of a wide variety of materials since it does not discolor or stain colored surfaces.

MALATHION INSECTICIDE
(Malaphos)

Chemical Structure

O,O-Dimethyl-S-1,2-di(ethoxycarbonyl) ethylphosphorodithioate



Origin

American Cyanamid, 1950

Type

Malathion is an organophosphate insecticide-acaricide. It has been reported to be more effective than naled as a larvicide at rates of 0.1-0.2 lb ai/A.

Properties and Formulations

Malathion is a clear brown to colorless liquid with a slight characteristic odor. Its specific gravity is 1.2315 at 25 C. It has a bp of 156 C under 0.7 mm Hg with slight decomposition. Its viscosity is 17.57 centipoises at 40 C and 36.78 centipoises at 25 C. The refractive index at n_D^{25C} is 1.4985. The mp is 2.85 C. The weight of ultra-low-volume malathion per gal of formulation is 10.25 lb. The solubility of malathion is 145 ppm at 25 C in water. It is completely soluble in alcohols, esters, high aromatic solvents, and ketones, but exhibits poor solubility in aliphatic hydrocarbons.

Malathion is stable for an indefinite period of time when stored under proper conditions. It is stable to light, but is decomposed when heated to an excessively high temperature. Malathion liquid concentrate attacks iron, tin plate, lead and copper and may gel if kept in contact with iron or tin plate. No gelation has been observed in low concentration formulations containing approximately 5% malathion.

Malathion is broken down faster in the presence of alkali than in acid and is not residual on inert surfaces. It has a short residual life when used at low rates on field crops.

Formulations include wettable powders of 25 and 50%, emulsifiable concentrate of 4, 5, and 10 lb ai/gal, dust 4 and 5%, 1, 2, and 4% aerosols, granules 5 and 10%, and baits. It is also mixed with Captan, Methoxychlor, DDT, sulfur, Zineb, Toxaphene, BHC, TDE, and others.

Toxicology

Malathion is one of the least toxic organophosphate insecticides to man and other mammals. The acute oral LD₅₀ in female rats is 1000 mg/kg; in males it is 1375 mg/kg. The acute dermal LD₅₀ in female rats is 4444 mg/kg; in males it is 4444 mg/kg. The 24 hr LC₅₀ is 100 ppb for rainbow trout, 170 ppb for redear sunfish, 45-120 ppb for bluegill sunfish, and 100 ppm for channel catfish. A rate of 0.1-0.2 lb ai/A provides a good margin of safety for birds.

The optimal temperature for toxicity to insects is 26.7 C.

Rates

Malathion is applied at 0.1-2 lb ai/100 gal water or 0.1-3 lb ai/A.

Phytotoxicity

Injury from malathion has been reported on McIntosh and Cortland varieties of apples, as well as sweet cherries, certain European grapes, Bosc pears, cucurbits, string beans, and sorghum. Fruit spotting has resulted on nectarines.

Uses

Malathion is recommended for pest control on alfalfa, almonds, apples, avocados, apricots, asparagus, artichokes, barley, beans, beets, blackberries, blackeyed peas, blueberries, boysenberries, broccoli, Brussels sprouts, cabbage, carrots, cowpeas, cauliflower, celery, cherries, cloves, collards, corn, cotton, cranberries, cucumbers, currants, carrots, dandelion, dates, dewberries, eggplant, endive, figs, filberts, garlic, gooseberries, grapefruit, grapes, grasses, guavas, hops, horseradish, kumquats, lemons, lettuce, limes, melons, lentils, nectarines, oats, okra, onions, parsley, parsnips, oranges, peaches, peanuts, papayas, pears, peas, pecans, peppers, mint, pineapples, potatoes, plums, prunes, pumpkins, radishes, rice, rye, sorghum, soybeans, spinach, squash, strawberries, chestnuts, sugar beets, tangerines, tomatoes, turnips, walnuts, watercress, and wheat. It is also recommended for pest control on cattle, poultry, sheep, goats, swine, greenhouses, agricultural premises, and poultry ranges.

Important Pests Controlled

Insects controlled by use of malathion include aphids, mites, scale, flies, codling moths, leaf hoppers, leaf miners, thrips, loopers, pear psylla, mealy bugs, Japanese beetles, lygus bugs, spittlebugs, corn earworms, chinch bugs, grasshoppers, army worms, boll weevils, bollworms, lice, ticks, ants, spiders, and mosquitoes.

Application

1. When malathion is applied to foliage, it should be applied at a uniform rate with common application equipment. Treatment should be repeated as necessary.

2. For control of soil-borne insects, it should be disced into the top 6-8 inch of soil.

3. For treatment of livestock, individual animals or birds should be dusted or sprayed thoroughly. Malathion should not be applied to dairy animals within 5 hr of milking time.

4. Malathion should be prepared the day it is to be used.

5. Malathion is used as a mist or fog for area control of adult mosquitoes.

6. Malathion can be used as a larvicide and protectant for stored grain.

Precaution

When malathion is being used, prolonged breathing of spray mist should be avoided. Prolonged or repeated contact with skin should also be avoided. After malathion is used, skin should be washed thoroughly.

Malathion reacts with heavy metals, especially iron. It is incompatible with alkaline materials. The ultra-low-volume concentrate may cause spotting on automobile paint finish and should be washed off immediately if automobiles are accidentally sprayed.

Additional Information

Malathion can be applied on the day before harvest to some crops. It has more residual tolerances established for it than any other phosphate insecticide. When malathion is mixed with alkaline materials, the initial kills are satisfactory, but residual toxicity may be decreased. Residue tolerances of 0, 2, 4, and 8 ppm have been established depending upon the crop it is registered for use on. Residue tolerances of 0 ppm in milk have been established.

APPLICATION RATE CHART

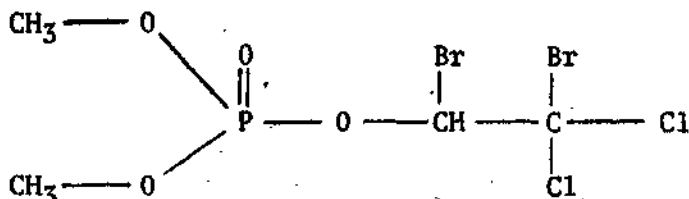
The application rates apply only to malathion ultra-low-volume concentrate.

Crop	Pests Controlled	Fluid Ounces Per Acre	Interval Between Last Application and Harvest
Alfalfa, Clover, Pasture and Range Grass, Grass, Grass Hay, Nonagricultural Land (waste-lands, roadsides, soil bank lands)	Grasshopper	8	May be applied on day of harvest or grazing. Do not apply to alfalfa and clover in bloom. Do not apply to seed alfalfa.
Cereal Crops	Cereal Leaf Beetle	4-8	Cereal Crops: 7 days of harvest or forage use. Grasses: May be applied on day of harvest or grazing.
Grain Crops	Grasshopper	8	7 days Corn: 5 days of harvest or forage use.
Cotton	Boll Weevil	8-12	0 day
		16	
	Grasshopper	8	
	Lygus Bugs	8-12	
		16	
	Early Season Insects		
Safflower	Thrips		3 days of harvesting seeds
	Fleahopper	4-8	
	Leafhopper		
	Grasshopper	8	
Soybeans	Lygus Bug		7 days of harvest or forage use
	Mexican Bean Beetle		
	Grasshopper	8	
	Japanese Beetle		
Sugar Beets	Green Cloverworm		7 days, if tops are to be used as feed
	Grasshopper	8	
Corn	Adult Corn Rootworm	4	5 days
Beans (lima, green, snap, Navy, red kidney, wax, dry, blackeye)	Mexican Bean Beetle		1 day
	Leafhopper		
	Green Cloverworm	8	
	Japanese Beetle		
	Lygus Bug		
Blueberries	Blueberry Maggot	10	0 day
Nonagricultural Lands	Beet Leafhopper (on wild host plants)	8	0 day
Beef Cattle--Feed Lots and Holding Pens	Adult Flies and Mosquitoes	6-8	0 day

NALED INSECTICIDE (DIBROM)

Chemical Structure

Dimethyl-1,2-dibromo-2,2-dichloroethyl phosphate



Origin

Chevron Chemical Company (Ortho Division of Standard Oil), 1956.

Type

Naled is an organophosphate insecticide-acaricide which has both contact and stomach poison activity with brief residual effects.

Properties and Formulations

Naled is a yellow liquid with an mp of 26 C. It is soluble in fuel oil and xylene, but insoluble in water. It has a short residual activity. Approximately 90% of the naled applied under field conditions will hydrolyze within 48 hr of application. It is not stable in alkaline conditions and when it is in combination with certain reducing agents and metals, it will be converted to dichlorovos (2,2-dichlorovinyl dimethyl phosphate).

Formulations of naled include emulsifiable concentrates containing 4, 8, and 14 lb ai/gal. Dusts containing 4% naled are also available.

Toxicology

The acute LD₅₀ of naled in albino rats is 430 mg/kg. The acute dermal LD₅₀ for rats is 800-1100 mg/kg. The acute LD₅₀ in quail is 500-600 mg/kg. Ducks and pheasants are more resistant than quail.

The LC₅₀ of naled for rainbow trout is 70 ppb. The 48-hr LC₅₀ for mullet is 0.55 ppm. Over a 48-hr period, 0.30 ppm caused 50% mortality among juvenile blue crabs; in the same period of time, 5.50 ppb caused 50% mortality among adult pink shrimp.

An application rate of 0.6 oz ai/A did not significantly affect either the fish or other wildlife in a mangrove area adjacent to Biscayne Bay in Dade County, Florida. Naled concentrate, applied by thermal fogging or by aerial application in concentrations normally used for marshland mosquito control, has little or no observable effects on test animals held in their natural environment.

Rates

For adult mosquito control, naled (Dibrom 14 concentrate) is aerially applied at the rate of 0.1-0.25 lb ai/A.

For insect control using ground applicators, naled is applied at the rate of 1-8 lb ai/A in 40-100 gal water.

Phytotoxicity

Some injury has been reported on apples, pears, cherries, beans, cotton, and also on ornamentals such as white butterfly rose, golden rapture, green wandering Jew, Dutchman's pipe, ornamental cherries, liquid amber, and chrysanthemums. Naled should not be applied to the Hegari variety of grain sorghum. It may also cause fruit spotting on nectarines.

Uses

Naled is used for insect control on alfalfa, apricots, beans, broccoli, Brussels sprouts, cabbage, cauliflower, celery, chard, citrus, clover, collards, cotton, cucumbers, eggplant, endive, filberts, grapes, hops, kale, lemons, lettuce, melons, mustard greens, nectarines, oranges, onions, peaches, peas, peppers, plums, potatoes, prunes, pumpkins, sorghum, soybeans, spinach, squash, rice, strawberries, sugar beets, tomatoes, turnips, vetch, walnuts, agricultural premises, and greenhouses.

Important Pests Controlled

Important pests that can be controlled by use of naled include loopers, lead miners, cabbageworms, fleahoppers, bollworms, stinkbugs, cutworms, fruit flies, peach twig borers, spittlebugs, thrips, white flies, mosquitoes, gnats, and grasshoppers.

Application

1. Fields - For control of insects in fields, naled should be applied when the insects first appear. The foliage should be thoroughly covered and treatment should be repeated only as necessary.

2. Agricultural premises - Naled can be applied to agricultural premises when animals are present. However, contamination of food containers should be avoided.

3. Adult mosquito and dog fly control - Adult mosquitoes and dog flies can be controlled by thermal fog or airplane applications of naled. Naled, as the concentrate, should be aerially applied using diesel oil or No. 2 fuel oil.

Precautions

Naled should not be applied when the temperature is over 90 F. Applications of naled should be avoided during periods of heavy bee activity (e.g., daylight).

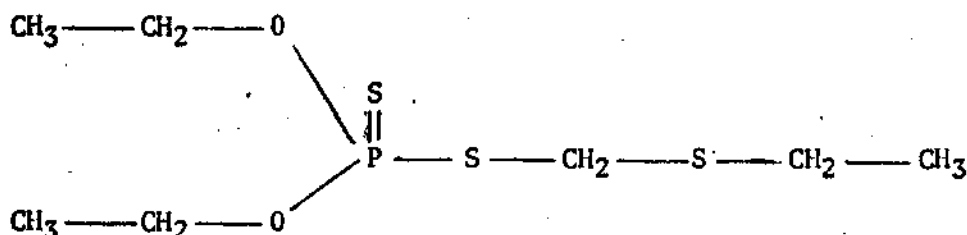
Naled is incompatible with highly alkaline materials such as lime and Bordeaux. Because it will readily corrode most metals, all spray equipment must be cleaned (or decontaminated) immediately after use.

When naled is being handled, solvent-proof gloves and face shield or goggles should be used. Naled may cause skin and eye damage.

PHORATE INSECTICIDE
(Thimet)

Chemical Structure

O,O-Diethyl-S-(ethylthiomethyl) phosphorodithioate



Origin

American Cyanamid Company, 1954

Type

Phorate is a systemic, organophosphate insecticide-acaricide with considerable contact and fumigant activity.

Properties and Formulations

Technical phorate is a clear liquid with a mp of less than -15 C. The water solubility is quite low (approximately 50 ppm). It is miscible in xylene, vegetable oils, carbon tetrachloride, alcohols, ethers and esters. At room temperature, technical phorate is known to be stable for at least 2 years. It is subject to hydrolysis under alkaline conditions. The commercial formulations have satisfactory stability. Phorate may be lost from the soil by volatilization (about 25% occurring in the first hr after treatment), strong absorption on clay and organic matter, and partial degradation to the sulfoxide and sulfone. Phorate exhibits residual activity at 2 months, but not at 6 months when applied at 8-16 lb/A to a Coachella fine sand containing 0.15% organic matter.

Formulations of phorate include emulsifiable concentrates containing 6-8 lb ai/gal, 10% granules, and 44% in carbon powder for seed treatment.

Toxicology

The acute oral LD₅₀ of technical phorate is 2-4 mg/kg for male rats. By single 24-hr skin contact, the LD₅₀ of phorate for guinea pigs is approximately 20-30 mg/kg.

In testing the dermal toxicity of the solid formulation, the solids were wet with just sufficient water to form a paste, and the paste was held in contact with the clipped trunks of guinea pigs continuously for 24 hr. Under these conditions, the LD₅₀ of a granular phorate formulation was 630 mg/kg.

Rats were not affected by a continuous 8-hr exposure to an airstream near saturated with vapor of technical phorate. This result demonstrated the low vapor pressure of the insecticide.

In general, phorate and its formulations should be considered poisonous by skin contact, inhalation or swallowing.

Rates

Phorate is applied at 1/2-3 lb ai/A. It is used at the rate of 8 oz ai/100 lb.

Phytotoxicity

Phorate-treated plants have shown apparent plant stimulation and exhibit a much darker green color than untreated plants. Crops treated with phorate generally show increased plant vigor.

A slight chlorosis and marginal spotting has been reported on seedling plants under some conditions. Extensive field trials and grower use has indicated that the phytotoxicity did not persist when phorate was used according to the label directions.

Injury may occur on tobacco and apples.

Uses

Phorate is commonly used on such crops as alfalfa, barley, beans, cotton, corn, lettuce, peanuts, potatoes, rice, sugar beets, tomatoes, wheat, and some ornamentals.

Important Pests Controlled

Important pests controlled by use of phorate include mites, aphids, thrips, leaf hoppers, leaf miners, psyllids, cutworms, rootworms, Hessian fly, foliar nematodes, flea beetles, white flies and Mexican bean beetles.

Application

Soil application - Phorate should not be used on muck soils.

Precautions

Livestock should not be grazed on phorate-treated crops, and animals should not be fed phorate-treated seed. Phorate should not be applied later than 60 days before harvest. Dosage rates higher than 4-8 oz/100 lb of seed should not be used on wheat, oats, corn, peas, cucumbers, and beans. To prevent detrimental effects on germination, excessive soil moisture should be avoided during application. Phorate is not to be sold for home-owner use on ornamentals. Accumulation in the soil, resulting in reduced stands and yields, may occur after use at high rates for a number of years consecutively. Exposure to open flames should be avoided. Phorate is not compatible with alkaline compounds.

When granules containing phorate are being used, they should be poured downwind to minimize exposure to handlers. Spillage should be removed and burned. Storage enclosures should be ventilated periodically.

Phorate spills should be covered with an absorbent such as soda ash, lime, clay, or sawdust, swept up and buried, and the area washed thoroughly with a full-strength liquid household chlorine bleach. Empty containers should be decontaminated and disposed of as follows: drain pail completely, add 1/2 gal of water, 1/4 cup of detergent, and 1/4 lb of lye, tighten closure, rotate pail to wet all surfaces and let stand for at least 15 min, drain completely and rinse several times with water. After this procedure is completed, the closure should be tightened and the pail punctured and crushed to prevent reuse. Personal safety precautions should be observed when decontaminating spills or empty containers.

CD-1 (formerly the All Purpose Decontaminant) developed by the Air Force Armament Laboratory will decontaminate phorate.

Additional Information

No tolerances have been established for phorate; therefore, it can be used on a no-residue basis.

Many studies to determine the rate of disappearance of toxic residues from crops following phorate treatment, as well as many analyses of mature crops from treated fields, have demonstrated that no residue problem exists if the insecticide is applied according to label directions. When taken up by the plant, phorate is rapidly oxidized to metabolites of increased toxicity to insects and mammals. These products gradually undergo chemical breakdown by hydrolysis to form various phosphoric and thiophosphoric acids and esters which have no appreciable mammalian toxicity. The toxic products disappear from the plants before harvest.

MEVINPHOS INSECTICIDE
(Phosdrin)

Chemical Structure

2-Carbomethoxy-1-methylvinyl dimethyl phosphate



(alpha isomer)

Origin

Shell Chemical Company, 1953

Type

Phosdrin is an organic phosphate insecticide-acaricide with contact and systemic activity.

Properties and Formulations

Phosdrin is a light yellow to orange liquid having a specific gravity of 1.24 at 14.5 C. The bp is 99-107 C at 0.03 mm Hg, and its density (1b per gal at 20 C) is 10.3. Phosdrin has a relatively high flash point (79 C, tag open cup).

Phosdrin is soluble in water and organic solvents and is relatively stable in neutral and acid solutions. The half-life at pH 11 is 14 hr. It has a short residual activity, but very rapid action.

Technical Phosdrin contains not less than 60% of the alpha isomer and not more than 40% w of insecticidally active related compounds. Other formulations include emulsifiable concentrates 2-4 lb ai/gal, wettable powders 10, 20, and 25%, granules 1-5%, dusts 1-2%, water solution 2 lb ai/gal, aerosols.

Toxicology

The oral LD₅₀ for male rats is 6.1 mg/kg and 3.7 mg/kg for female white rats. The dermal toxicity is 4.7 and 4.2 mg/kg for male and female rats respectively. Great hazards in the use of Phosdrin are absorption through the skin by contact and through the lungs by inhalation.

Rates

Phosdrin is applied at 1/8-1 lb ai/A.

Phytotoxicity

No injury has been reported from Phosdrin applications at recommended rates, and no harmful materials persist in the soil. There may be some systemic action characterized by rapid absorption into the plants and translocation throughout the foliar portions. Some crops may be sensitive to solvents used in certain formulations.

Uses

Phosdrin is commonly used on such crops as alfalfa, asparagus, apples, artichokes, barley, beets, broccoli, Brussel sprouts, cabbage, carrots, corn, cucumbers, citrus, grapes, grasses, lettuce, onions, oats, okra, peaches, potatoes, sorghum, tomatoes, watermelons and walnuts.

Important Pests Controlled

Important pests controlled by use of Phosdrin are aphids, leafrollers, orange tortrix, weevils, armyworms, loopers, corn earworms, cutworms, leafminers, chinch bugs, grasshoppers, lygus bugs, mites, and thrip.

Application

For foliar treatment, Phosdrin should be applied uniformly when insects first appear and application repeated as often as necessary to obtain control. Aerosol formulations should be applied in greenhouses, which should remain tightly closed for 2 hr after treatment.

Precautions

Streams or ponds should not be contaminated. Phosdrin is corrosive to steel and is incompatible with alkaline materials. All spray equipment must be decontaminated and cleaned immediately after use.

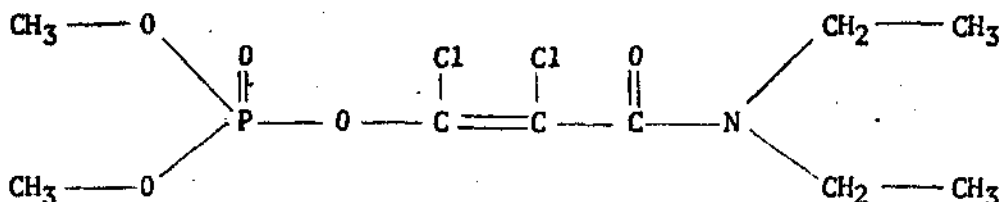
Additional Information

Phosdrin is compatible with insecticides and fungicides except strongly alkaline materials. Most crops may be harvested within 1 day after Phosdrin treatment. Phosdrin has a short residual activity and does not accumulate in soils.

PHOSPHAMIDON INSECTICIDE
(Dimecron)

Chemical Structure

Dimethyl-2-chloro-2-diethylcarbamoyl-1-methylvinyl phosphate



Origin

CIBA Ltd, 1957. Licensed to be sold in the United States by Chevron Chemical Company (Ortho Division of Standard Oil).

Type

Phosphamidon is an organophosphate insecticide-acaricide. Phosphamidon acts as a systemic toxicant and also has a relatively active contact action.

Properties and Formulations

Phosphamidon is a colorless liquid having a bp of 162 C at 1.5 mm Hg. and a specific gravity of 1.2 at 20 C. It is of low volatility.

It is relatively stable in non-alkaline solutions, but hydrolyzes quickly in alkaline solutions. It has a half-life of 1.5-2.5 days under experimental conditions and persists for short periods in plant sap.

It is soluble in water and organic solvents. It is available as a 94.3% concentrate for ultra-low-volume applications. Other formulations include emulsifiable concentrates of 4 and 8 lb ai/gal, 50% wettable powder, and 3% dust.

Toxicology

The acute oral LD₅₀ of phosphamidon is 28.3 mg/kg for albino rats. The acute dermal LD₅₀ for rats is 143 mg/kg. Phosphamidon in the daily diet of dogs at 5 mg/kg for 90 days did not cause any adverse response, function or pathogenic effect.

The acute dermal LD₅₀ for albino rabbits is 267 mg/kg. Animals placed in an atmosphere containing 0.125 mg/l of insecticide for 6 hr a day, 5 days a week for a period of 90 days did not show marked toxic effects.

In fish toxicity studies, 1000 ppm solutions of phosphamidon were required for complete kills. Short term mortality studies of young salmon and trout in streams sprayed with the insecticide showed no differences from unsprayed controlled sites. Phosphamidon applied at 1 lb ai/A did not affect oysters or the microorganisms used for food by oysters.

No mortality to Mourning dove adults or nestlings was observed in a citrus grove that was sprayed with phosphamidon at 2.5 lb ai/A.

Phosphamidon was found to be toxic to bees upon contact. The toxicity to bees was, however, only slight 24 hr after an application at 0.5 lb ai/A. The hazard to bees could be reduced by applying phosphamidon in the evening after bee activity has stopped.

Rates

Phosphamidon is applied at rates from 0.25-2 lb ai/A in 50-200 gal of water. Phosphamidon concentrate is aërially applied at rates of 0.15-0.5 lb ai/A.

Phytotoxicity

Injury following phosphamidon applications has been reported on cherries, apples, walnuts, plums, and peaches.

Uses

Phosphamidon is used for pest control on alfalfa, apples, beans, cabbage, cantaloupes, cotton, eggplant, lemons, peas, plums, grapefruit, prunes, potatoes, sugar beets, cucumbers, oranges, peppers, rice, tomatoes, watercress, walnuts, wheat, and ornamentals.

Important Pests Controlled

The most important pests controlled by using phosphamidon include aphids, lygus bugs, leaf hoppers, thrips, codling moths, grasshoppers, mites, scale, bollworms, Mexican bean beetles, whiteflies, leafminers, potato tuberworm, and stinkbugs.

Application

1. Phosphamidon is applied thoroughly when insects first appear. It is then repeated as necessary. It is recommended for fruit trees during non-bearing years, or as a post-harvest spray.

2. Phosphamidon has a particularly high aphicidal activity and is applied at 4-8 oz ai/A for aphid and thrip control.

Precautions

Standard handling precautions should be adhered to as with other organophosphorus insecticides. Treated forage or crop residue should not be fed to livestock. Phosphamidon is incompatible with alkaline materials.

Additional Information

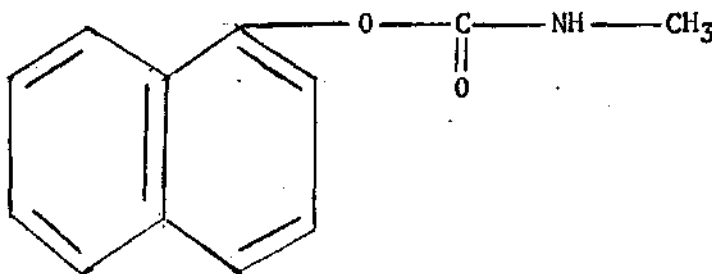
The effectiveness of phosphamidon becomes evident 1-3 days after application. The surface residual action is short and thought to be minor as a mode of action.

Phosphamidon is absorbed by all parts of the plant. The systemic activity has been demonstrated where the insecticide is translocated from roots or stems to foliage, from the lower part of plants to foliage at the top of the plants, and from foliage to fruits. It penetrates into leaf tissue quickly without leaving persistent insecticidal residues on leaf surfaces. Its effects on predators is, therefore, limited to a short time during and immediately following application. Heavy rains following treatment apparently diminish the quantity of insecticide retained in the foliage.

CARBARYL INSECTICIDE (Sevin)

Chemical Structure

N-Methyl-1-naphthyl-carbamate



Origin

Union Carbide Chemical Corporation, 1957

Type

Carbaryl is a carbamate insecticide, expressing contact and stomach poison action with long residual effects. It is a good general purpose insecticide; it is effective against many insects which have become resistant to chlorinated hydrocarbons and/or phosphates.

Properties and Formulations

Carbaryl has no odor.

The extent and rate of hydrolysis of carbaryl have not been determined, but the rate is apparently slow under most conditions. Under alkaline conditions, however, hydrolysis is rapid and complete.

Carbaryl is formulated as an emulsifiable concentrate containing 13 lb ai/gal, 5 and 10% dusts, 50 and 80% wettable powders, 5 and 10% granules, and 97.5% aerosol.

Toxicology

Oral LD₅₀ in the male rat is 850 mg/kg.

Dermal LD₅₀ is greater than 4,000 mg/kg.

The carbamates are reversible inhibitors of cholinesterase. The reversal is so rapid that, unless special precautions are taken, measurements of blood cholinesterase of people or animals exposed to carbamates are likely to be inaccurate and always in the direction of appearing to be normal.

Concentrates may cause skin irritation as well as systemic poisoning.

It is rapidly metabolized in animals and not secreted in the milk.

Carbaryl is low in toxicity to fish.

Rates

Carbaryl is applied at 1/2-1 1/2 lb ai/100 gal water or 1/2-2 1/2 lb ai/A.

Phytotoxicity

Excessive dosages of carbaryl may retard germination of grasses. Injury may occur on tender foliage in the presence of rain or high humidity for several days. Injury has been reported on McIntosh and York varieties of apples and some pears. Watermelons and Boston ivy have been injured; however, at normal rates, there is no adverse effect on plant growth or food flavor.

Uses

Uses of carbaryl include pest control in alfalfa, apples, apricots, asparagus, barley, bananas, beans, most berries, carrots, cherries, citrus, corn, cotton, cucumbers, eggplant, grapes, grasses, lettuce, melons, oats, olives, peaches, peanuts, pears, peas, pecans, peppers, plums, potatoes, prunes, pumpkins, radishes, rice, rye, sorghum, soybeans, sugar beets, tomatoes, turnips, walnuts, and wheat. It is also used on poultry, beef cattle, swine, sheep, and agricultural premises.

Important Pests Controlled

Important pests controlled include aphids, codling moths, leaf hoppers, scale, bollworms, armyworms, lygus bugs, Japanese beetles, boll weevils, peach twig borers, spittlebugs, thrips, grasshoppers, stink bugs, cucumber beetles, and ticks, fleas and mites on dogs, cats, and poultry.

Carbaryl exhibits a degree of specificity; it will not kill house flies, carpet beetles or termites and gives poor control of several species of aphids.

Application

Carbaryl may be applied with common application equipment at a uniform rate and repeated as necessary. It should be applied when insects first appear. On livestock, it should not be applied more often than every 4 days. Carbaryl is used as a dust bath on poultry.

Precautions

Carbaryl is incompatible with lime, lime sulfur, bordeaux, or other alkaline materials. It does not control spider mites. It is highly toxic to bees. Carbaryl should not be used on apples as an insecticide at blossom time if they are to be chemically thinned with other compounds, or over-thinning may occur.

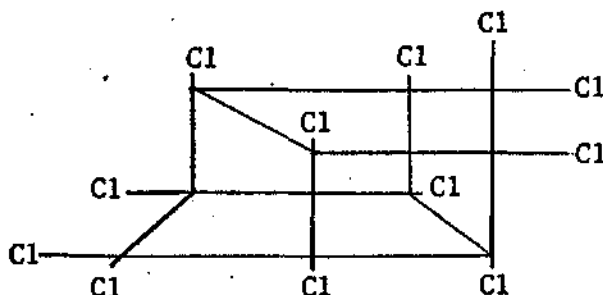
Additional Information

Carbaryl is a very safe insecticide. No off-flavor has resulted on harvested crops. It may be applied within 1 day of harvest on some crops. It is compatible with most insecticides and fungicides. Some systemic action has been shown. Carbaryl controls the eggs of some insect species. Flies are tolerant to this compound. Residual action will last 5-35 days, depending upon growing conditions. Toxicity increases as the temperature increases. Residue tolerances of 10 and 5 ppm have been established on crops for which it is registered. Control should last for 1-3 weeks.

MIREX INSECTICIDE

Chemical Structure

Dodecachlorooctahydro-1,3,4-metheno-2H cyclobuta (cd) pentalene



Origin

General Chemical Division of Allied Chemical Corporation, 1958

Type

Mirex is a chlorinated hydrocarbon insecticide which kills by contact and as a stomach poison.

Properties and Formulations

Mirex has a long residual life, indicating excellent stability.

Mirex is noncorrosive to most metals.

Formulations include 0.075, 2, and 4% bait. The bait may be either bran or finely chopped corn cob.

Toxicology

The oral LD₅₀ is 312 mg/kg for white albino rats.

Mirex is not harmful to fish or wildlife when used as recommended.

Rates

Mirex is mixed with bait material at the rate of 2/3 g Mirex/lb bait. Mirex is applied at 1/2 lb of mixed bait per ant mound. As a broadcast treatment it is applied at the rate of 5 lb ai/A.

Phytotoxicity

Mirex is not generally used on plants, but no problems have been encountered when it is applied according to directions.

Uses

Since Mirex is used for control of ants, it is used on agricultural premises, livestock pastures, and crop lands.

Important Pests Controlled

Mirex will control most ant species, cutworms, wireworms, and earwigs.

Application

Mirex should be applied either individually to each ant mound or used as a broadcast treatment on highly infested areas. Livestock need not be removed from pastures during application. The application should be made when ants are the most active. New mounds should be treated as soon as they appear; if ants are still active after 4 weeks, the mound should be retreated.

In 1965, Mirex baits were applied to over 4,000,000 A in states from North Carolina to Texas infested with the imported fire ant. At the rate of 3.4 g/A, over 30,000 lb of technical chemical were required.

Precautions

Only 1 broadcast application of Mirex should be applied during a 12-month period. Other insecticides used on the same area may interfere with the effectiveness of Mirex.

Additional Information

Mirex expresses a delayed toxic effect to ants. This allows the worker ants to carry the bait into the colony and distribute it among the other ants. Ants will usually die within 3-4 weeks. Contamination of the bait by pesticides or fertilizers may make it unacceptable to the ants. Light rains have no apparent effects on the control obtained. Usage on crop pests is under investigation.

ULTRA-LOW-VOLUME INSECTICIDE APPLICATION

Note: The following article was taken from an information brochure published by the American Cyanamid Company, 1969. Part of the information was obtained from the Aedes aegypti Eradication Branch, CDC, U. S. Public Health Service, U. S. Department of Health, Education, and Welfare, Atlanta, Georgia.

Introduction

During 1963, a revolutionary concept in aerial insecticide application was developed. This concept was the use of ultra-low-volume aerial sprays of insecticides for insect control. In 1964, field tests were initiated to evaluate the use of low-volume aerial sprays of undiluted technical malathion for control of adult salt-marsh mosquitoes. Since then, undiluted malathion has been used effectively on millions of treatment acres for the control of various insects including mosquitoes.

The growing interest in ultra-low-volume aerial insecticide application is a direct reflection of several advantages it offers over conventional spraying techniques. Because wider swath spacings are used, fewer flights are needed to cover acreage and, therefore, costly ferry and loading times are reduced. (Time can become a crucial factor in emergency control programs.) The use of undiluted technical material eliminates the need for mixing tanks and reduces the amount of ground equipment and personnel needed. Higher flight affords the pilot a greater safety margin.

The overall effect of these advantages is to considerably reduce application costs and to eliminate some of the hazards normally associated with aerial application. These benefits, coupled with malathion's outstanding performance against mosquitoes, make the ultra-low-volume method of applying technical malathion a completely unique means of mosquito control.

Performance

The outstanding results achieved in halting encephalitis outbreaks in Dallas and Corpus Christi, Texas, have initiated worldwide interest in mosquito control with the low-volume concept in aerial application. The techniques used in these operations are unique and are described below.

City and state health departments were already involved in the detection of the epidemic when this mosquito-borne disease was brought to the attention of the U. S. Public Health Service. The U. S. Air Force

made available C-123 cargo planes equipped to apply undiluted malathion at 3 fl oz/A. Previous research and trials by the U. S. Public Health Service showed that aircraft should operate in the early morning up to 7:30 A.M. before rising temperatures and air currents interfere with the deposition of the insecticide. The aircraft spray system should produce a droplet size with a mass median diameter of 50-60 μ with no more than 10% of the droplets above 100 μ as determined by readings made from microscope slides coated with Dri-Film. Deposition of 10 particles or more per sq inch is considered necessary to achieve the desired biological effect.

To achieve this spray pattern, the C-123 aircraft operated at 150 mph on a 500-ft swath at a flight altitude of 150 ft. Each plane was equipped with 42 Spraying Systems D2-13 nozzles, or 21 nozzles per wing. The nozzles were placed on the boom at a 45° angle down and into the wind. The pressure was 39 psi.

In the Aedes aegypti programs conducted in Miami, Florida, and four South Carolina cities, a Twin Beech aircraft was employed to apply undiluted malathion at 3 fl oz/A. To achieve a droplet size spectrum similar to the one obtained in the Texas operations, the Twin Beech aircraft operated at 150 mph on a 300-ft swath. The boom was equipped with four Tee-jet 8004 nozzles set 45° down and into the wind, and the application was made at a flight height of 150 ft. The boom pressure was 100-110 psi.

Generally, spraying should not be attempted when the wind is at or above 10 mph or temperatures are above 82 F.

These programs resulted in a better than 95% control and could not have been achieved without extensive research and study of the low-volume concept in aerial application. The prerequisites for such operations are a properly equipped aircraft, and personnel with specialized training and understanding of this new concept.

DECONTAMINATION OF ORGANOPHOSPHATE INSECTICIDES

In case of insecticide spillage on aircraft or equipment, excess quantities of the new Air Force insecticide neutralizing solution* should be applied. After approximately 20-30 min of contact time, the solution should be washed off. This decontaminant is very irritating to the eyes and can be irritating to the skin upon prolonged contact; it is, however, completely water soluble and can be readily washed from the skin of personnel or from equipment.

When large quantities of concentrated mevinphos or naled are being neutralized, a high heat of reaction can be expected; therefore, precaution must be exercised. With sulfur-containing insecticides such as malathion, no heat is generated during decontamination using large quantities of the concentrate. All empty containers should be decontaminated by thorough rinsing with the new neutralizing solution and allowed to remain in contact with the mixture 30-60 min.

*This formulation contains approximately 2% lithium hydroxide hydrate dissolved in a minimal amount of water (approximately 10% by volume), added to monoethanolamine (MEA), technical grade (approximately 25% by volume), and dipropylene glycol methyl ether, technical grade (approximately 65% by volume).

TOXIC PROPERTIES AND TREATMENT OF ORGANOPHOSPHORUS INSECTICIDES

Organophosphorus insecticides are, in general, excellent organic solvents and penetrate clothing and other clothlike materials. These compounds are absorbed by the skin as well as by the respiratory and gastrointestinal tracts. Absorption by the skin tends to be slow, but, because the insecticides are difficult to remove, such absorption is frequently prolonged. Skin absorption is somewhat greater at higher temperatures and is much greater in the presence of dermatitides.

The toxic effects of carbamate and organophosphorus insecticides are due to their ability to inhibit an essential nervous system enzyme, cholinesterase. The results of inhibiting cholinesterase will thus be (a) interference with the neuromuscular junction, giving rise to rapid twitching of voluntary muscles, and finally paralysis, which is of particular importance in the respiratory system; (b) interference with the autonomic nervous system at the cholinergic site; in general, the symptoms seen are those caused by excessive parasympathetic stimulation: pupil contraction, secretion of tears and saliva, and constriction of the bronchioles. Central effects may also occur, such as incoordination and paralysis of the respiratory center.

Signs and symptoms to watch for in man are: muscle twitching, sweating, pin pointing of pupils (miosis), headache, giddiness, nervousness, blurred vision, a pulling sensation in the chest area, salivation and other excessive respiratory tract secretion. In advanced cases convulsions, coma, and loss of reflexes are normally present.

Pilots and other personnel working with concentrated organophosphorus insecticides should have their cholinesterase blood level established and occasionally checked for depression. This measurement of exposure serves as a warning of impending toxicity and is useful in prophylactic programs. The Air Force Armament Laboratory (ATMA) has the capability and approval from the USAF Hospital Eglin for conducting cholinesterase blood level determinations.

Treatment

The onset of symptoms is rapid, and maximum effects may develop within a few hours. It is thus important that medical care be obtained without delay. Since the early symptoms of headache, malaise, etc., are easily confused with other diseases, it is important that workers exposed to the organic phosphates be instructed to report any such indications.

Adequate atropinization is essential to relieve the muscarinic effects and to provide central respiratory stimulant action. An average adult may

require from 12-24 mg total dose of atropine intravenously during the first 24 hr. Since this is far in excess of the usual therapeutic dose, the physician unacquainted with the mutually antagonistic action of this drug and the organic phosphate may be hesitant to employ such large doses. A general rule is that atropine should be administered until visible effects of atropinization are observed (dryness of the mouth and skin, pupil dilation, etc.). Since, as pointed out above, the muscarinic effects are only a part of the action produced by heavy exposure, it is essential that the patient be treated symptomatically with artificial respiration, postural drainage, warmth, etc.

Esters - Chemical compounds formed by the elimination of water between a molecule of an alcohol and a molecule of an acid.

Formulation - The manner in which the active ingredient and the carrier are mixed.

Growth Regulator - Compounds that upset an organisms's growth and metabolic processes.

Herbaceous - Referring to plants with non-woody stems and which normally die back to the ground in the winter.

Herbicide - Any compound used to kill or inhibit the growth of plants.

Nonselective Herbicide - A compound that kills all plants it comes in contact with.

Parts Per Million (ppm) - The number of parts by weight or volume of a given compound in one million parts of the final mixture.

Pesticide - Any substance or mixture of substances used to control plant and animal life.

Post-Emergence Herbicide - A chemical applied to the foliage of weeds after the crop has emerged from the soil.

Pre-Emergence Herbicide (residual) - A chemical applied at time of seeding or just prior to crop emergence to kill weed seeds and germinating seedlings.

Residual Herbicide - A plant killer that persists in the soil, killing plants as they germinate.

Soil Sterilant - A compound which, when applied to the soil, prevents the growth of all vegetation for a relatively long period of time.

Surfactant - Materials used in pesticide formulations to impart emulsifiability, spreading, wetting, dispersibility or other surface-modifying properties.

Systemic - A compound which, when taken up by the plant, is made effective throughout the plant's whole system. Usually refers to insecticides that kill insects which eat the juices of treated plants.

Translocated - A chemical which is taken up by a plant and moved throughout its system.

Vapor Drift - Movement of vapors from the area of application. A problem with highly volatile materials.

Volatile - Refers to substances that evaporate or vaporize (change from a liquid to a gas) at ordinary temperatures on exposure with air.

Wettable Powder - A solid formulation which, upon the addition of water, forms a suspension used for spraying.

Wetting Agent - A material which, when added to a spray solution, causes the spray to spread over and wet the plant surfaces more readily.