

E X T O X N E T

Extension Toxicology Network

A Pesticide Information Project of Cooperative Extension Offices of Cornell University, Michigan State University, Oregon State University, and University of California at Davis. Major support and funding was provided by the USDA/Extension Service/National Agricultural Pesticide Impact Assessment Program.

Pesticide
Information
Profile

2,4-D

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TRADE OR OTHER NAMES

2,4-D is used in many commercial products. A few commercial names for products containing 2,4-D include Weedtrine-II, Aqua-Kleen, Barrage, Plantgard, Lawn-Keep, Planotox and Malerbane.

INTRODUCTION

2,4-D, a chlorinated phenoxy compound, functions as a systemic herbicide and is used to control many types of broadleaf weeds. There are many forms or derivatives (esters, amines, salts) of 2,4-D and these vary in solubility and volatility. Unless otherwise specified, this document will refer to the acid form of 2,4-D. This compound is used in cultivated agriculture and in pasture and rangeland applications, forest management, home and garden situations and for the control of aquatic vegetation. 2,4-D was a major component (about 50%) of the product Agent Orange used extensively throughout Vietnam. However most of the problems associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2,4,5-T component of the defoliant. The association of 2,4-D with Agent Orange has prompted a vast amount of study on the herbicide.

TOXICOLOGICAL EFFECTS

ACUTE TOXICITY

While the LD50 of 2,4-D suggests that it is only moderately toxic, the product carries the DANGER signal word on the label indicating that it is highly toxic. This is because 2,4-D has produced serious eye and skin irritation among agricultural workers ([15,16](#)).

The oral LD50 of 2,4-D in the rat ranges from 375 to 666 mg/kg; 370 mg/kg in the mouse; and less than 320 to 1,000 mg/kg in the guinea pig. The rat and rabbit have dermal LD50 values of 1,500 mg/kg and 1,400 mg/kg, respectively. In humans, prolonged breathing of 2,4-D causes coughing, burning, dizziness, and temporary loss of muscle coordination.

Symptoms of poisoning can be fatigue and weakness with perhaps nausea. On rare occasions there can be inflammation of the nerve endings with muscular effects following high levels of exposure

(6). Symptoms vary with the different commercial products because of the specific amounts and types of additives such as surfactants and solvents.

CHRONIC TOXICITY

Rats given moderate amounts (50 mg/kg) of 2,4-D in the diet for two years had no adverse effects. Some dogs fed lower amounts of the compound in their food for two years died, probably because dogs do not excrete organic acids efficiently. A human given a total of 16.3 grams in 32 days as "desperation therapy" lapsed into a stupor, showed signs of incoordination, weak reflexes, and urinary incontinence.

Reproductive Effects

Administration of drinking water dosed with moderate levels of 2,4-D (about 50 mg/kg) to pregnant rats did not result in any adverse effects on birth weights, or litter size. Rats fed higher levels (188 mg/kg) had fetuses with abdominal cavity bleeding and increased mortality. DNA synthesis in the testes was significantly inhibited when mice were fed large amounts (200 mg/kg) of 2,4-D (8). While there is some conflicting evidence about the reproductive effects of the compound in animals, most of the evidence suggests that 2,4-D causes reproductive effects at moderate doses in animals. This indicates that humans may be at risk with 2,4-D exposure though no direct evidence of reproductive problems associated with 2,4-D exposure exists.

Teratogenic Effects

2,4-D has a very limited ability to cause birth defects. However, rats fed 150 mg/kg on days 6-15 of pregnancy had an increase in skeletal abnormalities such as delayed bone development and wavy ribs (10) which are a function of general toxicity. The same conclusions may be drawn for 2,4-D's potential to cause teratogenic effects in humans as was noted above.

Mutagenic Effects

2,4-D has been very extensively tested for mutagenicity and found to be non-mutagenic in most systems. However, significant increases of damage occurred in chromosomes in cultured human cells at low exposure levels (17). 2,4-D did not damage DNA in human lung cells. The evidence is too equivocal to draw any conclusions.

Carcinogenic Effects

Low doses fed to rats for two years caused an increase in malignant tumors (10). There was some question about whether the tumors were associated with specific organs or were non-specific. Female mice given a single injection of 2,4-D developed cancer (reticulum-cell sarcomas) (10).

The studies of 2,4-D carcinogenicity mentioned above are considered to be inadequate by IARC (International Agency for Research on Cancer). New studies, completed in 1986, show a low incidence of brain tumors at moderate exposure levels (45 mg/kg/day) over a lifetime.

In humans, a variety of studies give conflicting results. Several studies in Sweden and the United States (Kansas (1) and Nebraska (21)), suggest an association of 2,4-D exposure with cancer. An increased occurrence of non-Hodgkin's lymphoma was found among a Kansas and Nebraska farm population associated with the spraying of 2,4-D. Other studies done in New Zealand, Washington, New York, Australia, and on Vietnam veterans from the United States were all

negative. There remains considerable controversy about the methods used in the various studies and thus with the results of the various studies ([20](#)). Investigations are continuing.

Organ Toxicity

Most symptoms disappear within a few days but there is a report of liver dysfunction from long term exposure ([6](#)).

Fate in Humans and Animals

The absorption of the herbicide is almost complete in mammals after ingestion and nearly all of a dose is excreted in the urine. The compound is readily absorbed through the skin and lungs also. When five men were given 5 mg/kg, they excreted most of the dose (about 82%) as unchanged 2,4-D.

Only traces of the compound have been found in the milk of lactating animals for six days following exposure. The half-life is between 10 and 20 hours in living organisms. There is little evidence to suggest that the compound accumulates to any significant level in mammals or in other organisms ([18](#)). Peak concentrations of 2,4-D were found in the blood, liver, kidney, lungs and spleen with lower levels in muscle and brain between six and eight hours after small doses (1 mg/kg) were given to rats. After 24 hours there were no detectable tissue residues. 2,4-D passes through the placenta in pigs and rats. In rats, about 20% was detected in the uterus, placenta, fetus, and amniotic fluid ([12](#)). Chickens given moderate amounts of 2,4-D in drinking water from birth to maturity had very low levels of the compound in egg yolks and only a trace in the egg whites.

ECOLOGICAL EFFECTS

2,4-D is slightly toxic to wildfowl. Mallards, pheasants, quail, and pigeons had LD50 levels of >1000, 472, 668, and 668 mg/kg, respectively.

Some formulations of 2,4-D are highly toxic to fish while others are less so. For example the LC50 ranges between 1.0 mg/l to 100 mg/l in cutthroat trout, depending on the formulation used. Channel catfish had less than 10% mortality at 10 mg/l in 48 hours. Green sunfish when exposed to 110 mg/l for 41 hours showed no effect on swimming response. Limited studies indicate a half-life of less than 2 days in fish and oysters when exposure is discontinued ([11](#)).

Brood production was severely impaired when honeybees were fed moderate doses, but, at lower levels of exposure they lived significantly longer than the controls. The honeybee LD50 is 11.5 micrograms/bee.

Concentrations of 10 mg/l for 85 days did not adversely affect the survival of adult dungeness crabs. The early immature stages had an LC50 of greater than 10 mg/l in 96 hours indicating that the compound is only slightly toxic to these organisms. Brown shrimp had a small increase in mortality at 2 mg/l over a 48 hour exposure period.

ENVIRONMENTAL FATE

2,4-D applied at 1.16 lb/acre to bluegrass turf in a laboratory experiment had a half-life of ten days. Other half-life figures for the herbicide in soil are seven days (15-25 degree C with 65% moisture) and ten days in non-sterile soil and 1.5 to 16 days in other studies. Soil microbes are primarily responsible for its disappearance in soil. Studies in Alaska and Canada failed to detect

leaching in 22 weeks or from spring to fall ([10](#)), but 2,4-D has been included on the EPA list of compounds that are likely to leach from soil.

In aquatic environments microorganisms readily degrade 2,4-D and breakdown by sunlight is not a major reason for loss. Rates of breakdown increase with increased nutrients, sediment load and dissolved organic carbon. Under oxygenated conditions the half-life can be short, in the order of one week to several weeks. 2,4-D interferes with normal plant growth processes. Uptake of the compound is through leaves, stems and roots; however, it is generally nonpersistent. In one study when 2,4-D was applied to grass, there were 80 ppm at day zero, 45 ppm at 14 days, and 6 ppm at 56 days. Breakdown in plants is by a variety of biological and chemical pathways ([11](#)).

Despite its short half-life in soil and in aquatic environments, the compound has been detected in groundwater supplies in at least five States and in Canada ([18](#)). It has also been detected in surface waters throughout the United States at very low concentrations.

DIOXIN CONTAMINATION

Although recently manufactured 2,4-D technical acids have consistently been free of dioxin contamination, the amine and ester products may have measurable levels of some forms of dioxin. According to a study of 2,4-D manufactured in Canada ([9](#)), of 26 amine samples tested, 8 were positive. The levels ranged from 5 ppb to nearly 500 ppb. Several different forms of dioxin were present in the different products. All but one of 21 ester samples were positive.

Since an earlier study had reported finding hexachlorodioxin in 2,4-D the samples were analyzed for mono- to octachlorodioxin but no other isomers were found above the detection limit of 10 ppb. A subsequent study of 2,4-D manufactured in the United States found very little dioxin contamination. Measurable amounts of one form of the compound (2,7 DCDD) were found in 3 of 30 samples, with traces of other isomers. The amounts found do not have biological significance.

Exposure Guidelines:

NOEL (rats):	1 mg/kg
ADI:	0.3 mg/kg (WHO)
MCL:	0.07 mg/l
HA:	70 ug/l (lifetime)
TLV-TWA:	10 mg/m ³
TLV STEL:	20 mg/m ³
Dangerous Exposure:	500 mg/m ³ (OSHA/NIOSH)
RfD:	0.01 mg/kg/day
LEL:	5 mg/kg/day (rat)

Physical Properties:

CAS #:	94-75-7
Chemical Name:	(2,4-dichlorophenoxy) acetic acid
Chemical class/use:	phenoxy herbicide
Solubility in water:	890 mg/l
Solubility in other solvents:	ethanol and acetone, 9.5 g/100 g; benzene, 1.07 g/100g

Melting Point: 138 degrees C
Vapor Pressure: 8 x 10⁻⁶ mm Hg
Partition Coefficient: 2.81 (octanol/water)

BASIC MANUFACTURER

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Review by Basic Manufacturer:

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