### 2,4-Dichlorophenoxyacetic acid

<table>
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<tr>
<th>IUPAC name</th>
<th>(2,4-dichlorophenoxy)acetic acid</th>
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<tbody>
<tr>
<td>Other names</td>
<td>2,4-D hedonol trinoxol</td>
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#### Identifiers

<table>
<thead>
<tr>
<th>CAS number</th>
<th>[94-75-7]</th>
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<tr>
<td>SMILES</td>
<td>OC(COC1=CC=C(C1)C=C1C1)=O</td>
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2,4-Dichlorophenoxyacetic acid (2,4-D) is a common systemic herbicide used in the control of broadleaf weeds. It is the most widely used herbicide in the world, and the third most commonly used in North America.[1] 2,4-D is also an important synthetic auxin, often used in laboratories for plant research and as a supplement in plant cell culture media such as MS medium.

### History

2,4-D was developed during World War II by a British team at Rothamsted Experimental Station, under the leadership of Judah Hirsch Quastel, aiming to increase crop yields for a nation at war. [citation needed] When it was commercially released in 1946, it became the first successful selective herbicide and allowed for greatly enhanced weed control in wheat, maize (corn), rice, and similar cereal grass crop, because it only kills dicots, leaving behind monocots.
Mechanism of herbicide action

2,4-D is a synthetic auxin, which is a class of plant growth regulators. It is absorbed through the leaves and is translocated to the meristems of the plant. Uncontrolled, unsustainable growth ensues causing stem curl-over, leaf withering, and eventual plant death. 2,4-D is typically applied as an amine salt, but more potent ester versions exist as well.

Major uses

2,4-D is sold in various formulations under a wide variety of brand names. 2,4-D can be found in lawn herbicide mixtures such as "Weed B Gon MAX", "PAR III", "Trillion", "Tri-Kil", "Killex" and "Weedaway Premium 3-Way XP Turf Herbicide". All of these mixtures typically contain three active ingredients: 2,4-D, mecoprop and dicamba. Over 1,500 herbicide products contain 2,4-D as an active ingredient.

2,4-D is most commonly used for:

- Weed control in lawns and other turf
- No-till burndown
- Control of weeds and brush along fences and highway and railroad rights of way
- Conifer release (control of broad-leaf trees in conifer plantings)
- Grass hayfields and pastures
- Cereal grains
- Corn and sorghum (occasionally)
- As a synthetic auxin analogue

2,4-D continues to be used, where legal, for its low cost. However, where municipal lawn pesticide bylaws exist, such as in Canada,[2] alternatives such as corn gluten meal and vinegar based products are increasingly being used to combat weeds.

Toxicity

The LD$_{50}$ determined in an acute toxicity rat study is 639 mg/kg.[3] Single oral doses of 5 and 30 mg/kg body weight did not cause any acute toxic effects in human volunteers.

The amine salt formulations can cause irreversible eye damage (blindness); ester formulations are considered non-irritating to the eyes.

One study found that occupational exposure to 2,4-D caused male reproductive problems, including dead and malformed sperm.[4]

Cancer risk
Different organizations have taken different stances on 2,4-D's cancer risk. On August 8, 2007, the United States Environmental Protection Agency issued a ruling which stated existing data does not support a conclusion that links human cancer to 2,4-D exposure. However, the International Agency for Research on Cancer (IARC) has classified 2,4-D among the phenoxy acid herbicides MCPA and 2,4,5-T as a class 2B carcinogen - possibly carcinogenic to humans. A 1995 panel of 13 scientists reviewing studies on the carcinogenicity of 2,4-D had divided opinions, but the predominant opinion was that it is possible that 2,4-D causes cancer in humans.

A 1990 study of farmers in Nebraska, even when adjusting for exposure to other chemicals, found that 2,4-D exposure substantially increased the risk of Non-Hodgkin's lymphoma (NHL). A 2000 study of 1517 former employees of Dow Chemical Company who had been exposed to the chemical in manufacturing or formulating 2,4-D found no significant increase in risk of mortality due to NHL following 2,4-D exposure, but did find an increase in risk of mortality due to amyotrophic lateral sclerosis.

### Manufacture

2,4-D is a member of the phenoxy family of herbicides, which include:

- **2,4,5-Trichlorophenoxyacetic acid** (2,4,5-T)
- **2-Methyl-4-chlorophenoxyacetic acid** (MCPA)
- 2-(2-Methyl-4-chlorophenoxy)propionic acids (mecoprop, MCPP)
- 2-(2,4-Dichlorophenoxy)propionic acid (dichloroprop, 2,4-DP)
- (2,4-Dichlorophenoxy)butyric acid (2,4-DB)

2,4-D is manufactured from chloroacetic acid and 2,4-dichlorophenol, which is itself produced by chlorination of phenol. The production process creates several contaminants including isomers, monochlorophenol, and other polychlorophenols and their acids.

The powerful defoliant and herbicide Agent Orange, used extensively throughout the Vietnam War, contained 2,4-D. The controversies associated with the use of Agent Orange were associated with a contaminant (dioxin) in the 2,4,5-T component. However, 2,4-D is still contaminated to some extent with dioxins, predominately those with 2 or 3 chlorine atoms. Another form of dioxin, 2,7-dichlorodibenz-p-dioxin (DCDD), an inevitable by-product of 2,4-D manufacturing, was found to be "equipotent" to dioxin TCDD in its toxic effect on the immunity of mice. TCDD received all the publicity while the DCDD component was largely forgotten. To this day DCDD is not regulated or monitored by the EPA and PMRA, even though DCDD levels could be at much higher levels than TCDD. The typical smell of 2,4-D is the break-down product 2,4-dichlorophenol which is a suspected endocrine disrupter and possible carcinogen. 2,4-D is toxic to the liver at small dosages. Increases in liver function tests, jaundice, acute hepatitis, lobular and portal inflammation indicative of a toxic reaction, as well as permanent damage leading to cirrhosis has been reported in exposed golfers.
Legal issues

2,4-D has been evaluated by the European Union and included on its list of approved herbicides, stating inter alia that "the review [of 2,4-D] has established that the residues arising from the proposed uses, consequent on application consistent with good plant protection practice, have no harmful effects on human or animal health."[14] Concern over 2,4-D is such that it is currently not approved for use on lawns and gardens in Sweden[15], Denmark, Norway, Kuwait and the Canadian provinces of Québec[16] and Ontario[17]. 2,4-D use is severely restricted in the country of Belize. In 2005, the United States Environmental Protection Agency approved the continued use of 2,4-D.[18] In Canada, the Pest Management Regulatory Agency (PMRA) has placed a condition of registration on 2,4-D such that the 2,4-D registrant(s) must provide the PMRA with a required developmental neurotoxicity study by September 20, 2009.[19]

References

1. 24d.org
2. Private Property Pesticide By-laws In Canada
3. US EPA 2,4-D Reregistration Eligibility Decision, 2006
5. EPA: Federal Register: 2,4-D, 2,4-DP, and 2,4-DB; Decision Not to Initiate Special Review
8. Zahm, Shelia Hoar; Weisenburger, Dennis D.; Babbitt, Paula A.; Saal, Robert C.; Vaught, Jimmie B.; Cantor, Kenneth P.; Blair, Aaron, "A Case-Control Study of Non-Hodgkin's Lymphoma and the Herbicide 2,4-Dichlorophenoxyacetic Acid (2, 4-D) in Eastern Nebraska", Epidemiology, Vol. 1, No. 5., Sep. 1990.
10. The Monsanto Investigation


13. 2,4-dichlorophenol - toxicity, ecological toxicity and regulatory information.
14. [EUROPA - Plant Health - Plant Protection - Evaluation & Authorisation - Existing active substances - Reports](http://sv.wikipedia.org/wiki/2,4-diklorfenoxiättiksyra)
17. [2,4-D (2,4-dichlorophenoxyacetic acid) | Reregistration | Regulating Pesticides | Pesticides | US EPA](http://sv.wikipedia.org/wiki/2,4-diklorfenoxiättiksyra)
18. [Proposed Acceptability for Continuing Registration PACR2007-06](http://sv.wikipedia.org/wiki/2,4-diklorfenoxiättiksyra)

**External links**

**Government and academic references:**

- 2,4-D Technical Fact Sheet - National Pesticide Information Center
- 2,4-D Pesticide Information Profile - Extension Toxicology Network
- EPA 2,4-D Reregistration Eligibility Decision
- 2,4-D RED Facts

**Industry website:**

- 24d.org

**Health and environmental references:**

- ChemicalWATCH Factsheet
- Highlights of Major Problems with PMRA's Feb. 21, 2005 Review on 2,4-D Herbicide
- Overview of the toxic effects of 2,4-D
- 2,4-D: The Wrong Symbol for Pesticides

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