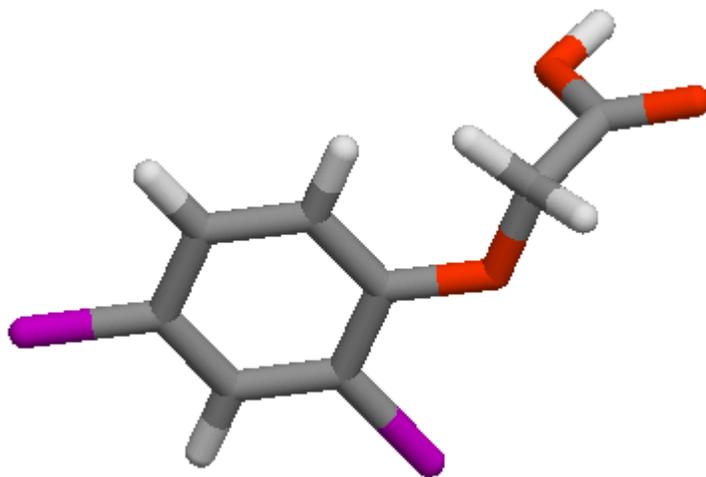
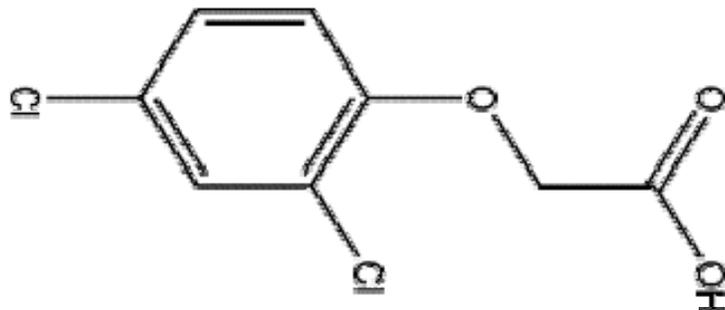


# 2,4-Dichlorophenoxyacetic acid

2,4-Dichlorophenoxyacetic acid



[IUPAC name](#)

(2,4-dichlorophenoxy)acetic acid

Other names

2,4-D  
hedonal  
trinoxol

## Identifiers

[CAS number](#)

[\[94-75-7\]](#)

[SMILES](#)

OC(COC1=CC=C(Cl)C=C1Cl)=O

<a href="#">ChemSpider ID</a>	<a href="#">1441</a>
<b>Properties</b>	
<a href="#">Molecular formula</a>	C <sub>8</sub> H <sub>6</sub> Cl <sub>2</sub> O <sub>3</sub>
<a href="#">Molar mass</a>	221.04 g mol <sup>-1</sup>
Appearance	white to yellow powder
<a href="#">Melting point</a>	140.5 °C (413.5 K)
<a href="#">Boiling point</a>	160 °C (0.4 mm Hg)
<a href="#">Solubility in water</a>	900 mg/L (25 °C)
<b>Related compounds</b>	
Related compounds	<a href="#">2,4,5-T</a> , <a href="#">Dichlorprop</a>
Except where noted otherwise, data are given for materials in their <a href="#">standard state</a> (at 25 °C, 100 kPa)	

**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.<sup>[U]</sup> 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.<sup>[*citation needed*]</sup> 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,<sup>[2]</sup> alternatives such as [corn gluten meal](#) and [vinegar](#) based products are increasingly being used to combat weeds.

## Toxicity

The [LD<sub>50</sub>](#) determined in an acute toxicity rat study is 639 mg/kg.<sup>[3]</sup> 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](#).<sup>[4]</sup>

## 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.<sup>[5]</sup> 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.<sup>[6]</sup> 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.<sup>[7]</sup>

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).<sup>[8]</sup> 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](#).<sup>[9]</sup>

## 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-dichlorodibenzo-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.<sup>[10]</sup><sup>[not in citation given]</sup> 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.<sup>[citation needed]</sup> 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 <sup>[11][12][13]</sup>

## 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."<sup>[14]</sup> Concern over 2,4-D is such that it is currently not approved for use on lawns and gardens in Sweden<sup>[15]</sup>, Denmark, Norway, Kuwait and the Canadian provinces of Québec<sup>[16]</sup> and Ontario<sup>[17]</sup>. 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.<sup>[18]</sup> 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.<sup>[19]</sup>

## References

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2. [Private Property Pesticide By-laws In Canada](#)
3. US EPA 2,4-D Reregistration Eligibility Decision, 2006
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5. [EPA: Federal Register: 2,4-D, 2,4-DP, and 2,4-DB; Decision Not to Initiate Special Review](#)
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13. [2,4-dichlorophenol - toxicity, ecological toxicity and regulatory information](#)
14. [EUROPA - Plant Health - Plant Protection - Evaluation & Authorisation - Existing active substances - Reports](#)
15. <http://sv.wikipedia.org/wiki/2,4-diklorfenoksiättiksyra>
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17. <http://www.ene.gov.on.ca/en/news/2009/030401.php>
18. [2,4-D \(2,4-dichlorophenoxyacetic acid\) | Reregistration | Regulating Pesticides | Pesticides | US EPA](#)
19. [Proposed Acceptability for Continuing Registration PACR2007-06](#)

## 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](http://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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