

Prodiamine In Brief

Prodiamine is an herbicide that works by preventing cells in plants' roots and shoots from dividing. It is low in toxicity to people. It does not dissolve well in water and binds tightly to the soil. It breaks down slowly in soil, but rapidly if exposed to sunlight or if it is in water. Prodiamine is low in toxicity to bees and other beneficial insects but moderately toxic to earthworms. It is toxic to some aquatic animals. The U.S. Environmental Protection Agency (U.S. EPA) considers prodiamine a "possible human carcinogen."

What is prodiamine?

Prodiamine belongs to a group of human-made **herbicides** called dinitroanilines. Prodiamine is used in non-crop areas, nurseries, golf courses, and residential land.¹ It was first registered for use in 1992.² Prodiamine is used to control annual grasses and broadleaf weeds.^{3,4} Prodiamine is a selective herbicide that can be used before planting or emergence.^{4,5}

What are some products that contain prodiamine?

There are over 500 pesticide **products** that contain prodiamine.⁶ Prodiamine is sometimes used in products with other herbicides. Some products with prodiamine might also contain fertilizers. Prodiamine is used as a dust, emulsifiable concentrate, soluble concentrate, water dispersible granule, dry flowable, flowable concentrate, granular, or ready-to-use product.^{6,7}

Prodiamine is not used in organic horticulture.⁸

How does prodiamine work?

Prodiamine interferes with cell division to stop root and shoot growth.⁹

How might I be exposed to prodiamine?

You could be exposed to prodiamine while using a product or if you are too close to an application. You could breathe it in, get it on your skin, or get it in your eyes. You could be exposed if you eat or smoke after making an application without washing your hands. Granules could be mistaken for food crumbs by pets or children. Prodiamine is not used on any food crops, so it is not expected to be a residue on food.^{7,10} Prodiamine may occur at low concentrations in drinking water.⁷



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IMPORTANT: Always **follow label instructions** and take steps to **minimize exposure**. If any exposures occur, follow the First Aid instructions on the product label carefully. For additional treatment advice, contact the Poison Control Center at 800-222-1222. If you wish to **discuss a pesticide problem**, please call NPIC at 800-858-7378.

Technical Grade Prodiamine: This fact sheet refers to the technical grade, or "pure" prodiamine only. Products you buy from the store include other ingredients as well. While many of the chemicals used as other ingredients may not pose environmental or health risks, some of them can be toxic. In some cases, the other ingredients can pose greater risks than the active ingredient itself.

What are some signs and symptoms from a brief exposure to prodiamine?

If **inhaled**, prodiamine is low in toxicity.⁷

- People who have been exposed to enough prodiamine had headaches, dizziness, respiratory irritation, skin irritation, eye irritation, chest pain, coughing, stomach pain, twitching, and nausea.¹¹

If **eaten**, prodiamine is very low in toxicity.⁷

- No information was found on symptoms people experienced after being exposed to prodiamine by mouth. People who swallowed another dinitroaniline herbicide called pendimethalin experienced symptoms of nausea, vomiting, and sore throat. More severe cases included seizures, and vomiting blood.¹³ As with any pesticide, more exposure may lead to more harm.

When it gets **on the skin**, prodiamine is low in toxicity.⁷

- When researchers tested prodiamine on the skin of laboratory rabbits, it was non-irritating.³
- A formulated herbicide product containing prodiamine was found to be a skin sensitizer in guinea pigs.¹²

If prodiamine gets **in your eyes**, it can cause mild eye irritation and redness.¹¹

Based on numerous studies and data, it is unlikely that prodiamine is neurotoxic.^{7,12} However, in one rat study, rats fed 2000 mg/kg of prodiamine were less alert and had reduced movements 5 hours after exposure.¹²

For more information about how NPIC finds scientific studies, see our page on [Writing NPIC Fact Sheets](#).

What happens to prodiamine when it enters the body?

When prodiamine enters the body, it is rapidly excreted. After 24 hours, rats eliminated around 70% of the total dose. Most of the prodiamine was detected in the feces. The amount found in tissue 4 days later was 0.5-1.4% of the initial dose.¹³

Researchers gave rats a single dose of either 10 mg/kg or 400 mg/kg prodiamine. They also fed the rats daily with 10 mg/kg prodiamine for 2 weeks. In all cases, the rats had eliminated the prodiamine within 4 days after feeding had stopped. Female rats had higher tissue levels of prodiamine. The residues were found throughout the body. Most of the dose was eliminated in the feces and urine.⁷



photo credit: USDA NRCS Montana, flickr

What is a mg/kg?

"Mg/kg" is a way to measure a chemical dose. This can tell us how toxic a chemical is. "Mg" means milligrams of a chemical. "Kg" means one kilogram of an animal's body weight. Something that is highly toxic may kill a person with a very small amount of chemical. If something is very low in toxicity, it may take much more for that same person to become very sick or die. Regardless of how toxic something is, there must be an exposure for there to be harm. For more information, see the [Pesticide Hazard vs. Risk Fact Sheet](#).

There are no studies available on dermal absorption, or how well prodiamine passes through the skin. However, the U.S. EPA used a related chemical to estimate dermal absorption. Based on that, they expect 3% would be absorbed by the skin into the body.⁷

TOXICITY CLASSIFICATION - PRODIAMINE⁷ (see the text box about mg/kg)

	High Toxicity	Moderate Toxicity	Low Toxicity	Very Low Toxicity
Acute Oral LD ₅₀	≤ 50 mg/kg	> 50 – 500 mg/kg	> 500 – 5000 mg/kg	> 5000 mg/kg
Inhalation LC ₅₀	≤ 0.05 mg/L	> 0.05 – 0.5 mg/L	> 0.5 – 2.0 mg/L	> 2.0 mg/L
Dermal LD ₅₀	≤ 200 mg/kg	> 200 - 2000 mg/kg	> 2000 – 5000 mg/kg	> 5000 mg/kg
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or other eye irritation clearing in 8 - 21 days	Corneal involvement or other eye irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	Mild or slight irritation at 72 hours (no irritation or erythema)

The shaded boxes reflect the signs and symptoms from a brief exposure discussed in this fact sheet. Modeled after the U.S. Environmental Protection Agency, Office of Pesticide Programs, Label Review Manual, Chapter 7: Precautionary Statements. <https://www.epa.gov/sites/default/files/2018-04/documents/chap-07-mar-2018.pdf>.

You may be wondering why the “High Toxicity” column has smaller numbers than the “Low Toxicity” column. This is because if a smaller amount of the pesticide caused a health effect, it’s more toxic. If it takes a larger amount of the pesticide to cause a health effect, it’s less toxic.

Is prodiamine likely to contribute to the development of cancer?

The U.S. EPA classifies prodiamine as a “Group C - Possibly Carcinogenic to Humans” based on thyroid tumors in male and female rats.⁷ Prodiamine did not cause cancer in mice.^{3,7,14} Prodiamine was negative for mutagenicity in all available studies. However, the U.S. EPA determined that it is plausible two of the breakdown products of prodiamine are carcinogens and mutagens.⁷

Has anyone studied non-cancer effects from long-term exposure to prodiamine?

The target organ of prodiamine in animals is the thyroid.⁷ This means the thyroid is the organ most likely to be harmed if an animal is exposed. Researchers have not identified a specific target organ in humans. However, prodiamine can affect the liver, thymus gland, and thyroid gland.¹⁵

When researchers fed rats prodiamine at 0, 400, 1200, or 4000 parts per million (ppm) for 13 weeks, the rats had effects at the highest dose of 4000 ppm in their food. At that dose, the rats gained less body weight, had increased cholesterol, and had increased urinary protein content.³ Rats eating 4000 ppm prodiamine for 13 weeks also ate less than rats in the other groups and their kidneys and livers were heavier. No effects were observed at 1200 ppm (80 mg/kg body weight) based on the effects seen at the highest dose of 4000 ppm.¹³

When beagle dogs ate prodiamine at either 0, 200, 600, or 2000 ppm for 13 weeks, dogs that were fed 600 ppm had changes in their blood. Dogs fed the highest dose of 2000 ppm had changes in their blood, heavier livers, liver damage, and their reproductive organs weighed less. Researchers did not see any changes in the dogs fed 200 ppm (5 mg/kg body weight).¹³

The thymus glands weighed less in male dogs fed 600 or 2000 ppm prodiamine than dogs who ate clean diets. Also, male thymus weights were significantly lower than controls in dogs who ate diets with 600 and 2000 ppm prodiamine.¹³

No human studies were found on the long-term effects of prodiamine.

Are children more sensitive to prodiamine than adults?

Children are at an increased risk to pesticides due to their smaller body size, ongoing organ development, and different behaviors. Keep all pesticides out of reach of children and pets to avoid accidental ingestion.

Young children may act in ways that put them at greater risk of being exposed. For example, they may spend more time near the floor. They may also be more likely to place their hands in their mouths after touching treated surfaces or pets. The U.S. EPA concluded that prodiamine should not be more toxic to children than adults and no additional safety factors in the risk assessments were needed.¹⁶

Researchers found a birth defect called omphalocele after feeding pregnant rats 300 mg/kg of prodiamine. This is a defect where organs stick out through the abdominal wall. Pregnant rats and rabbits fed 1000 mg/kg and 300 mg/kg respectively gained less weight than unexposed pregnant rats and rabbits.³

What happens to prodiamine in the environment?

Prodiamine is broken down quickly by sunlight.^{5,9} It is not likely to leach or reach groundwater.^{17,18} Prodiamine is not soluble in water.¹⁷ The **half-life** of prodiamine in water exposed to sunlight is very short, ranging from 2.3-7.3 hours. The half-life of prodiamine in aerobic water conditions is around 18.3-24.9 days.¹⁸

Prodiamine binds tightly to soil and breaks down slowly in soil. The half-life of prodiamine in sandy loam soil is around 69 days.⁵

Prodiamine is not very likely to become a gas based on its vapor pressure (2.50×10^{-8} mmHg @ 25°C / 77°F).¹⁸

What is parts per million (ppm)?

Parts per million (ppm) is a unit of chemical measurement. One ppm is one part of the chemical to one million parts of water, soil, or food. Although 1 ppm is equivalent to 1 mg/kg, mg/kg refers to the amount of chemical (in milligrams) per kilogram of body weight, not the concentration in food in a toxicity study. One ppm may also be written 1 mg/L if the substance is a liquid. It is a very small concentration.



photo credit: Paul Brennan, pixabay

Can prodiamine affect birds, fish, or other wildlife?

Pesticides that enter the environment can affect wild plants and animals. Prodiamine has a potential to bioaccumulate in aquatic organisms.¹⁸

Birds

Birds might be exposed to prodiamine by eating granules, feeding on exposed prey, or by contact with a pesticide product containing prodiamine. Water containing trace amounts of prodiamine is not expected to be toxic to birds.¹⁸

- Short-term feeding studies have shown prodiamine is practically non-toxic to the canary.¹⁸
- Northern bobwhite quail and mallard ducks ate up to 1000 ppm prodiamine for 21 weeks. Researchers observed no harm to their health, survival, or reproductive development.¹³

Aquatic animals

Prodiamine is practically insoluble in water. This makes it difficult for researchers to accurately measure how much is in water when they run tests and look for impacts to aquatic organisms.¹³ However, the amount that can dissolve is low in toxicity to fish. Overall, scientists saw reproductive effects in freshwater fish and invertebrates exposed to prodiamine. However, none of the animals died during tests.¹⁸

- Researchers exposed bluegill sunfish to prodiamine concentrations of 18 to 320 mg/L for 96 hours. None of the fish died, but all showed signs of excitability at 96 hours.¹³
- Fathead minnows were exposed to prodiamine in their water for 16 weeks. On average, they had fewer eggs for each spawn and fewer eggs per female per day.¹⁸
- In a long-term study, scientists exposed rainbow trout to 25 µg/L prodiamine for an unknown period of time. The fish were shorter and weighed less compared to unexposed fish. The U.S. EPA concluded that the effects occurred near the limit of solubility of prodiamine in water.¹⁸
- Researchers exposed water fleas to various concentrations of prodiamine up to 100 mg/L for 48 hours. After 24 hours, the water fleas exposed to concentrations of 18 mg/L or more had erratic behavior.¹³

Bees

Prodiamine is low in toxicity to honeybees following contact and slightly toxic following ingestion.^{13,18} More data may be needed to fully evaluate risks to pollinators, especially chronic exposure to bees.¹⁹

Worms and insects

Prodiamine is low to moderately toxic to earthworms.^{13,20}

- Scientists placed adult earthworms on discs of filter paper treated with prodiamine at five different concentrations for 48 hours. They determined that contact with the prodiamine paper was relatively non-toxic.²⁰

- The same scientists exposed 10 adult earthworms to soil containing various amounts of prodiamine. The soil exposure was moderately toxic to earthworms.²⁰
- Other scientists found that earthworms exposed to 1000 mg/kg of prodiamine in dry soil for two weeks lost weight.¹³

Prodiamine does not affect the development of other beneficial insects.¹³

- Researchers submerged aphids parasitized by wasps in levels of prodiamine that would be expected in the field. The young wasps were not affected.¹³
- The researchers also submerged ladybug larvae and green lacewing larvae in the prodiamine solution, and they also were not negatively affected.¹³

Soil microorganisms were not affected when scientists treated their soil with prodiamine for 28 days. The soil type was sandy loam.¹³

Where can I get more information?

For more detailed information about Prodiamine, call the National Pesticide Information Center, Monday - Friday, between 8:00am - 12:00pm Pacific Time (11:00am - 3:00pm Eastern Time) at 800-858-7378, or visit us on the web at npic.orst.edu. NPIC provides objective, science-based answers to questions about pesticides.

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References:

1. *BEAD Chemical Profile for Registration Review: Prodiamine*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2010.
2. *Prodiamine Summary Document Registration Review: Initial Docket*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC 2010.
3. *Prodiamine Pesticide Fact Sheet*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 1992.
4. Roberts, T.; Hutson, D. *Metabolic Pathways of Agrochemicals, Part I: Herbicides and Plant Growth Regulators-Prodiamine*; Royal Society of Chemistry: Cambridge, UK, 1999.
5. Tomlin, C. D. S. *The Pesticide Manual, A World Compendium: Prodiamine*, 14th ed.; British Crop Production Council (BCPC), 2006.
6. *NPIC Product Research Online (NPRO): Prodiamine*; National Pesticide Information Center, Corvallis, OR, 2022.

7. *Prodiamine Draft Human Health Risk Assessment for Registration Review*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2018.
8. National List of Allowed and Prohibited Substances; *Code of Federal Regulations*, Part 205.601, Title 7, 2022.
9. Dale L. Shaner. *Herbicide Handbook: Prodiamine, 10th ed.*; Weed Science Society of America: Lawrence, KS, 2014.
10. Tolerances and Exemptions for Pesticide Chemical Residues in Food; *Code of Federal Regulations*, Part 180, Title 40, 2023.
11. *Prodiamine Tier I Update Review of Human Incidents and Epidemiology for Draft Risk Assessment*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2018.
12. *Pendimethalin: Roadside Vegetation Management Herbicide Fact Sheet*; Washington State Department of Transportatio: Olympia, WA, 2006.
13. *Public Release Summary on the Evaluation of the New Active Prodiamine in the Product Barricade Turf Herbicide*; Australian Pesticides and Veterinary Medicines Authority: Kingston, Australian Capitol Territory, Australia, 2010.
14. Hurley, P. M.; Hill, R. N.; Whiting, R. J. Mode of Carcinogenic Action of Pesticides Inducing Thyroid Follicular Cell Tumors in Rodents. *Environ Health Perspect*, 106 (8), 1998.
15. Leonard, J. A.; Nelms, M.; Craig, E.; Perron, M.; Pope-Varsalona, H.; Dobreniecki, S.; Lowit, A.; Tan, Y. M. A Weight of Evidence Approach to Investigate Potential Common Mechanisms in Pesticide Groups to Support Cumulative Risk Assessment: A Case Study with Dinitroaniline Pesticides. *Regul. Toxicol. Pharmacol.*, 107:104419, 2019.
16. *Prodiamine Occupational and Residential Registration Review Exposure and Risk Assessment*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2018.
17. *Registration Review - Preliminary Problem Formulation for the Ecological Risk Assessment of Prodiamine*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2010.
18. *Ecological Risk Assessment for the Registration Review of Prodiamine*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2018.
19. *Prodiamine Interim Registration Review Decision*; U.S. Environmental Protection Agency, Office of Chemical Safety and Pollution Prevention, U.S. Government Printing Office: Washington, DC, 2019.
20. Yanhua, W.; Shenggan, W.; Liping, C.; Changxing, W.; Ruixian, Y.; Qiang, W.; Xueping, Z. Toxicity Assessment of 45 Pesticides to the Epigeic Earthworm *Eisenia Fetida*. *Chemosphere*, 88, 2012, pp 484–491.

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