● HERBICIDE FACTSHEET

ORYZALIN

Oryzalin is an herbicide used to control weeds in turf, in orchards and vineyards, around ornamental plants, and along rights of way. At least 2 million pounds of oryzalin are used annually in the U.S.

Many oryzalin-containing herbicides cause eye irritation and also can cause skin allergies.

In laboratory tests, oryzalin causes anemia. In addition, exposure of pregnant animals caused embryo loss, a reduction in the number of offspring in each litter, and a decrease in the weight of offspring. In a test of oryzalin's ability to cause cancer, exposed animals had more breast tumors, skin tumors, and thyroid tumors than unexposed animals. The U.S. Environmental Protection Agency (EPA) classifies oryzalin as a "possible human carcinogen."

Oryzalin can persist in soil up to three years after application, and, according to EPA, is a "moderately mobile" herbicide in soil. Therefore it is not surprising that it often contaminates water. The U.S. Geological Survey found oryzalin in rivers, streams, or wells in almost half (16 of 36) of the river basins that the agency has tested nationwide.

Animals can be adversely affected by oryzalin. Birds fed oryzalin gained weight more slowly than unexposed birds. It is also moderately toxic to freshwater fish, particularly juvenile fish, and is highly toxic to oysters.

Oryzalin can have unexpected effects on plants that are not a target of the herbicide. For example, oryzalin increases the virulence of a rust that attacks flax plants. At concentrations that occur in soil after applications at typical rates, it decreases the growth of mycorrhizal fungi, beneficial fungi that grow in association with the roots of many plants.

BY CAROLINE COX

The herbicide oryzalin (see Figure 1), a member of the dinitroaniline chemical family, is commonly marketed under the brand name Surflan. It was first registered in the U.S. in 1974 and its primary manufacturer is DowAgrosciences LLC, formerly called DowElanco.[1]

Use

Agricultural use of oryzalin, according to U.S. Environmental Protection Agency (EPA) estimates, is almost 2 million pounds per year. This includes use on turf (800,000 pounds per year), in almond orchards (350,000 pounds per year), and in vineyards (200,000 pounds per year). EPA believes that a "significant amount"[2] of oryzalin is also used around ornamental plants and along rights of way, but says that estimates of these uses are not readily available.[2] In addition, an estimated 1,800,000 applications are made annually around U.S. homes.[3]

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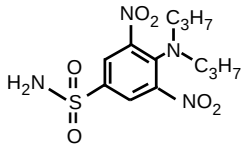
Figure 1
Oryzalin



3,5,-dinitro-N4, N4-dipropylsulfanilamide

How Does Oryzalin Kill Plants?

Oryzalin is a preemergence herbicide, meaning it kills seedlings as they germinate.[4] It kills young, growing plants by inhibiting the division of cells in the plant. Normally when cells divide, molecules of a protein called tubulin link together to form microtubules, long fiber-like structures that play critical roles in cell division. Oryzalin blocks the linking of tubulin, disrupting cell division.[5]

"Inert" Ingredients

Oryzalin products contain many ingredients other than oryzalin, and most of these, the so-called inert ingredients, are not identified on product labels.[6] Neither are they included in most of the toxicology tests required for registration.[7] For example, tests to determine whether oryzalin causes cancer, birth defects, other reproductive problems, and genetic damage have all been done just with oryzalin alone. For details about toxicological problems associated with some of the inert ingredients in oryzalin products, see "Hazards of Inert Ingredients," p.17.

All of the toxicology tests discussed in this article, with the exception of tests of eye irritation and skin allergies, were conducted on oryzalin alone.

Hazards to Eyes

Most oryzalin-containing herbicides cause eye irritation. NCAP surveyed labels from the 29 commercial oryzalin

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products whose labels are available on EPA's web site and found that 25 (over 85 percent) of them caused eye irritation.[8]

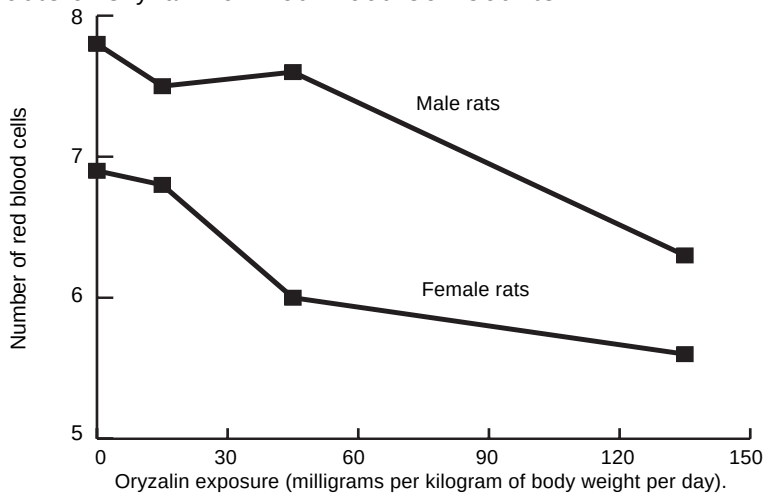
Skin Allergies

Most oryzalin-containing herbicides can cause the development of skin allergies in people who have prolonged or repeated exposures. In NCAP's survey of labels of oryzalin products, almost 80 percent had a warning statement about skin allergies.[8]

Medium- and Long-term Toxicity

Both three-month (subchronic) and two-year (chronic) feeding studies with rats and dogs found that oryzalin caused changes in blood similar to anemia. The number of red blood cells decreased (see Figure 2); hematocrit (the proportion, by volume, of blood that is made up of red blood cells[9]) decreased; and the amount of the

Figure 2
Effects of Oryzalin on Red Blood Cell Counts



Source: U.S. EPA. 1993. Oryzalin - update on decisions of RfD/Peer Review Committee - Revised DERs. Memo from Dobozy, V., Toxicology Branch, Sept. 27. See attached revised data evaluation record for MRIDs No. 26779, 44332, and 70569.

Oryzalin caused anemia in both sexes of rats.

HAZARDS OF INERT INGREDIENTS

Propylene glycol is used as an inert ingredient in six oryzalin products.[1] It causes eye and skin irritation, and affects the kidney, central nervous system, and liver. In laboratory tests of animals exposed during pregnancy, it has caused fetal toxicity and embryo death.[2]

Glycerin is used as an inert ingredient in five oryzalin products.[3] It causes headaches and nausea and also affects kidneys. Production of sperm was disrupted in male laboratory animals exposed to glycerin, and it caused embryo death in animals exposed during pregnancy.[4]

Laurel sulfate is used as an inert ingredient in five oryzalin products.[5] It is irritating to eyes and skin, and can cause drowsiness. In laboratory tests of pregnant animals, it was toxic to fetuses.[6]

Dowicil 75 is a preservative used in three oryzalin products.[7] In laboratory studies, animals exposed to Dowicil 75 weighed less than unexposed animals and had damaged livers more often than unexposed animals.[8]

Acacia gum (gum arabic) is used as an inert ingredient in two oryzalin products.[9] It causes severe eye irritation, skin irritation, and irritation of the respiratory tract. It can cause hives and asthma attacks.[10]

Xylene is used as an inert ingredient in one oryzalin product.[11] It causes severe eye irritation, is irritating to skin and the respiratory system, and affects nerves and the liver. In laboratory tests with pregnant animals it has caused miscarriages, birth defects, and is toxic to fetuses.[12]

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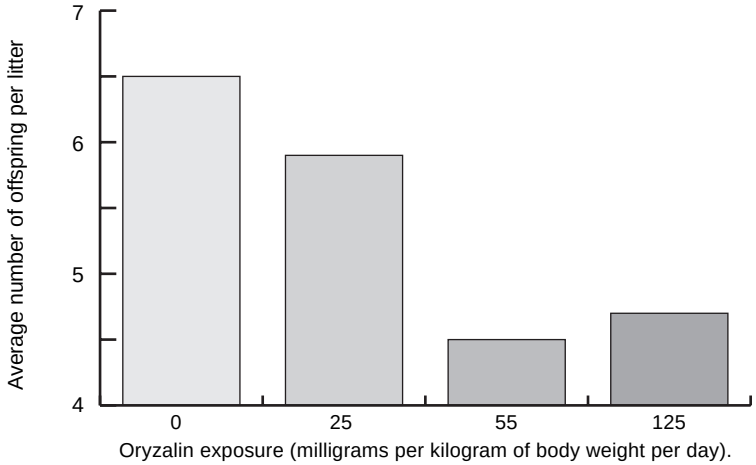
2. Fisher Scientific. 2000. Material safety data sheet: Propylene glycol. www.fishersci.com.
3. Ref. # 1. The five products containing glycerin have the following registration numbers: 62719-193, 62719-112, 62719-113, 62719-159, and 62719-158.
4. Sigma Chemical Co. 2001. Material safety data sheet: Glycerin USP. www.sigma-aldrich.com.
5. Ref. # 1. The five products containing laurel sulfate (also called sodium laurel sulfate) have the following registration numbers: 62719-193, 62719-110, 62719-106, 62719-153, and 62719-138.
6. Sigma Chemical Co. 2001. Material safety data sheet: Laurel sulfate 10% solution. www.sigma-aldrich.com.
7. Ref. # 1. The three products containing Dowicil 75 have the following registration numbers: 62719-140, 62719-112, and 62719-113.
8. U.S. EPA. Prevention, Pesticides and Toxic Substances. 1995. Reregistration eligibility decision (RED): Dowicil® CTAC. www.epa.gov/pesticides. p. 9.
9. Ref. # 1. The two products containing acacia gum (gum arabic) have the following registration numbers: 62719-153, and 62719-138.
10. Acros Organics. 2000. Material safety data sheet: Gum arabic. www.fishersci.com.
11. Ref. # 1. The product containing xylene has registration number 62719-149.
12. Riedel-de Haen. 2001. Material safety data sheet: Xylene. www.sigma-aldrich.com.

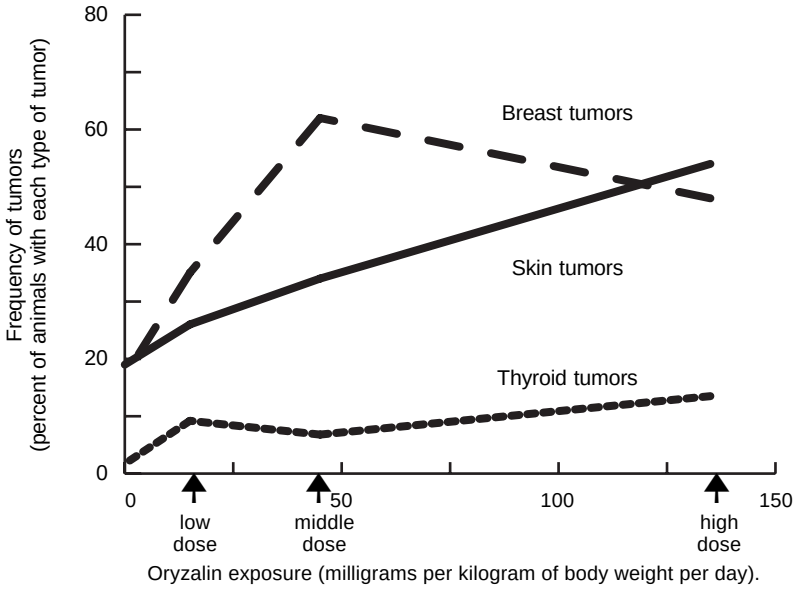
Figure 3
Oryzalin Reduces Litter Size in Rabbits Exposed during Pregnancy



Source: U.S. EPA. 1993. Oryzalin - update on decisions of RfD/Peer Review Committee - Revised DERs. Memo from Dobozy, V., Toxicology Branch, Sept. 27. See attached data evaluation record for MRIDs No. 52557, 78552, and 26785.

Oryzalin increased the frequency of embryo loss in laboratory studies of pregnant rabbits.

Figure 4
Oryzalin Causes Cancer



Sources:
U.S. EPA. Office of Pesticides and Toxic Substances. 1982. Carcinogenicity/oncogenicity assessment of oryzalin 'Surflan.' Memo from B.D. Litt, Toxicology Branch, to R. B. Jaeger, Toxicology Branch. Washington, D.C., Mar. 24.
U.S. EPA. 1981. Oryzalin, TB/HED evaluation of 2-year feeding/oncogenicity study in the rat, submitted in support of requested tolerances at 0.05 ppm on certain fruits/nuts. Memo from M.L. Quaife, Toxicology Branch, to R. Taylor, Registration Div. Washington, D.C., Jan. 7.

EPA classifies oryzalin as a "possible human carcinogen" because it caused three types of tumors, breast, skin, and thyroid, in laboratory studies of rats.

oxygen-carrying protein hemoglobin in the blood decreased. This anemia occurred at doses of approximately 50 milligrams per kilogram of body weight (mg/kg) per day.[10] Supporting evidence for this kind of effect comes from researchers at Central University in Venezuela who showed that oryzalin reduces the activity of enzymes involved in energy production in human red blood cells.[11]

Other adverse effects seen in chronic laboratory studies were increased weight of the liver and kidney as well as increased blood cholesterol levels.[10]

Effects on Reproduction

Oryzalin caused a variety of reproductive problems in laboratory tests.

The offspring of rats given oryzalin during pregnancy weighed less than the offspring of unexposed rats. Decreased growth also occurred in a study in which rats were fed oryzalin during three generations. These effects occurred at doses of 37.5 and 225 mg/kg per day.[12]

Rabbits given oryzalin during pregnancy had more embryo loss than unexposed rabbits and also had smaller litters. (See Figure 3.) These effects occurred at a dose of 55 mg/kg per day.[12]

In addition, the uterus and ovaries of mice fed oryzalin for two years weighed less than these organs in unexposed mice. According to EPA, "As uterine weight is often under the influence of endocrine glands, one might suppose that oryzalin exerts a hormonal influence in these mice."[13]

Ability to Cause Cancer

EPA classifies oryzalin as a carcinogen (a chemical that causes cancer). The agency uses a "Group C" (possible human carcinogen) classification for oryzalin because three types of tumors (breast tumors, skin tumors, and thyroid tumors) occurred more frequently in a laboratory study of rats fed oryzalin than in unexposed animals.[14] (See Figure 4.)

In 1994, EPA estimated the risk of cancer in people who apply oryzalin, assuming that applicators make 1 or 10 applications every year. The

agency's calculations showed that users of most types of application equipment (low pressure handwand, backpack sprayer, and ground boom sprayer) exceeded EPA's acceptable risk for either the 1- or 10-day exposure. However, EPA believes that requiring chemical resistant footwear (rubber boots), as the agency has done since 1995, "should adequately mitigate risk."[15]

Soil Persistence

According to EPA, oryzalin often has a "biphasic" breakdown pattern in soil. This means that a portion of applied oryzalin breaks down relatively quickly, while the rest is more persistent. Oryzalin's half life (the amount of time required for one half of applied oryzalin to break down and move away from the application site) for the first breakdown phase in field studies is between 58 and 77 days. For the second phase it is between 138 and 146 days.[16]

Under some conditions, however, oryzalin can persist for much longer periods of time. On irrigated farmland in Idaho, oryzalin caused "extensive damage" to sugarbeets one year after treatment.[17] In Indiana, small amounts of oryzalin persisted for three years after application.[18]

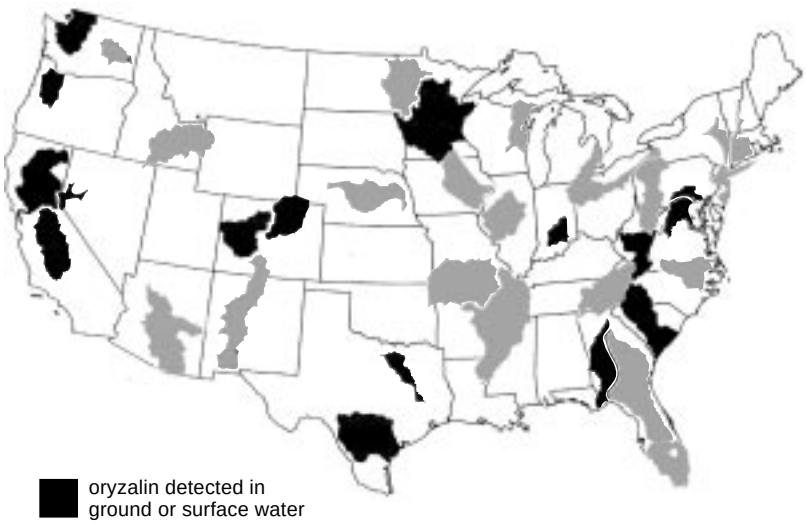
Movement in Soil

Oryzalin is categorized by EPA as "moderately mobile" in soil. Interestingly, a researcher at an Israeli agricultural research institute found that surfactants, detergent-like molecules that are used in herbicides to help the herbicide move from the surface to the inside of the plant,[19] increase the mobility of oryzalin in the soil.[20] When combined with three common surfactants, oryzalin moved deeper into the soil than it did when it was applied alone. Oryzalin alone inhibited plant growth to a depth of 12 centimeters; with a surfactant this depth increased to 20 centimeters.[20]

Water Contamination

Given its persistence and mobility in soil, it's not surprising that oryzalin often moves into wells, rivers, and streams. The U.S. Geological Survey's (USGS's) national water monitoring program found that oryzalin contaminated rivers, streams, or wells in 16 of the 36 river basins studied by USGS.[21] (See Figure 5.) Although there are no comprehensive data about which particular uses of oryzalin contaminate water, oryzalin has been found in runoff following applications of a granular oryzalin product to nursery containers,[22] and in ponds and wells on golf courses.[23,24]

Figure 5
Contamination of Water (Rivers, Streams, and Wells) in the U.S.



Source: U.S. Geological Survey. National Water-Quality Assessment (NAWQA) Program. 1998-2000. Circulars 1144,1150, 1151, 1155-1171, 1201-1216. http://water.usgs.gov/pubs/nawqasum/.

The U.S. Geological Survey found oryzalin in rivers, streams, and wells in 16 of the 36 river basins that the agency has studied.

Effects on Birds

While perhaps not expected for an herbicide, oryzalin can harm birds. A study in which oryzalin was fed to bobwhite quail showed that oryzalin reduced food consumption and body weight gain at all doses tested. EPA calculated that the amount of oryzalin that would be present on grass following a single application at the rate recommended for lawns and turf was greater than the lowest concentration of oryzalin causing the decreased weight gain (625 parts per million, ppm).[25]

Effects on Fish

Oryzalin is classified as "moderately toxic" to fish because between 2 and 3 ppm are sufficient to kill fish. Juvenile fish are even more susceptible; less than 1 ppm caused adverse effects.[26]

Because of this toxicity the labels of all oryzalin-containing herbicides must include the warning statement, "This pesticide is toxic to fish. Do not apply this product directly to water, or to areas where surface water is present."[27]

Effects on Other Aquatic Animals

Oryzalin is classified by EPA as "highly toxic" to the Eastern oyster, one of the species used in pesticide testing to represent mollusk species that live in estuaries or the ocean. EPA's classification is based on a study showing that a concentration of less than 0.3 ppm is sufficient to

reduce the growth of the oysters' shells.[28]

Another aquatic animal affected by oryzalin at low concentrations is the water flea, *Daphnia magna*. *Daphnia* is one of the species used in pesticide testing to represent fresh water invertebrates (insects, other arthropods, etc.). An oryzalin concentration of 0.6 ppm reduced the weight of *Daphnia* offspring.[29]

Effects on Aquatic Plants

Oryzalin is toxic to aquatic plants at extremely low concentrations. For example, 15 parts per billion (ppb) reduces the growth and reproduction of duckweed, one of the species EPA uses to represent aquatic plants in testing for ecological hazards.[30]

Effects on Nontarget Plants: Runoff and Drift

Not surprisingly, small amounts of oryzalin are damaging to plants. For example, 2.2 ppb reduces root growth in oat seedlings.[31] This means that drift or runoff from fields or other areas treated with oryzalin can be sufficient to damage plants not intended as the target of the oryzalin application.

EPA estimated the amount of oryzalin in runoff assuming that just 1 percent of the oryzalin applied (by either aerial or ground applications) would be carried off by runoff and that the lowest application rate was used. The agency found that runoff under these conditions would be sufficient to damage nontarget plants on adjacent areas.[32]

For drift, EPA assumed that 5 percent of the amount of oryzalin used in an aerial application drifts onto adjacent areas. The agency's calculations showed that applications at low rates (1 pound per acre) could damage nontarget plants on adjacent areas.[32]

Effects on Plant Diseases

Oryzalin may increase the susceptibility of some crop plants to diseases caused by fungi. In a study of a flax rust conducted at the Australian National University, a race of flax rust that is normally not able to attack flax grew and developed like a virulent race when the flax was treated with oryzalin. The researchers believe this was a result of oryzalin's ability to inhibit the formation of microtubules.[33] (See "How Does Oryzalin Kill Plants?" p. 16.)

Effects on Mycorrhizal Fungi

Mycorrhizal fungi are beneficial fungi that grow in association with many plant species and increase their growth and survival. Oryzalin reduces the growth of some of these fungi. Researchers at Auburn University (Alabama) tested 8 species of mycorrhizal fungi associated with southern pines and found that oryzalin concentrations of 1 ppm reduced the growth of one species, and concentrations of 3 ppm reduced the growth of four species. While this study was done in a laboratory, these concentrations (1 and 3 ppm) are equal to concentrations found in soil after applications made at typical rates.[34]

Resistance

Weeds can develop resistance to oryzalin, the ability to survive exposure to this herbicide. Some populations of green foxtail, the most abundant weed of annual crops grown on Canada's prairies, can tolerate six times more oryzalin than normal plants. These populations are resistant to all herbicides in the dinitroaniline chemical family, as well as two other herbicides, dithiopyr and DCPA.[35] Goosegrass in cotton fields has also developed resistance to oryzalin and other dinitroaniline herbicides.[36]

References and Notes

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