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1993

G93-1158 Questions and Answers about Atrazine

Fred Roeth
University of Nebraska - Lincoln, fwroeth41@gmail.com

S.D. Comfort
University of Nebraska - Lincoln, scomfort1@unl.edu

G93-1158-A

NebGuide
Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

Questions and Answers about Atrazine*

This NebGuide addresses some of the current concerns about atrazine and water quality. Included are some questions and answers about atrazine regarding toxicity, EPA guidelines, presence in water supplies, weed resistance and best management practices.

S. D. Comfort, Soil Environmental Chemist
F. W. Roeth, Extension Weed Specialist

What Is Atrazine?

What is atrazine?

Atrazine is a herbicide that selectively controls broadleaf (dicot) weeds, such as pigweed, cocklebur, velvetleaf and certain grass weeds in fields of corn and sorghum. Selective control means that the target weeds are controlled, with little or no injury to the crop. Atrazine is well tolerated by actively growing corn and sorghum, which absorb and metabolize the herbicide and thereby detoxify it.

In 1959, atrazine was registered as an approved herbicide in Nebraska. Atrazine is still widely used today because it is economical and effectively reduces crop losses due to weed interference. Its use can also reduce or eliminate the need for inter-row cultivation in corn and sorghum fields.

Why is there so much attention on atrazine and drinking water?

Atrazine is one of the most widely used herbicides in the United States. In Nebraska, approximately 15 million pounds are applied annually.

Once atrazine is applied, it begins to degrade through the action of soil microbes that use it as an energy source, and through chemical reactions with water. Half-life is defined as the length of time required for half of a pesticide to degrade. Under moist and warm conditions, the half-life of atrazine in topsoil is about 60 days. In subsurface soils or in water, atrazine's half-life is generally longer. The combination of widespread use and relative persistence in the environment help account for its frequent detection in surface and ground waters.

The EPA has set the drinking water health limit for atrazine at 3 parts per billion (ppb). Some surface and ground water supplies in Nebraska may exceed the 3 ppb standard. A recent survey of over 2,000 wells in Nebraska found that 13.5 percent of the wells had atrazine contamination, but only 1 percent had concentrations above the 3 ppb standard. The detection of atrazine in ground and surface waters has increased public concern about atrazine contamination.

How Toxic Is Atrazine?

How toxic is atrazine to humans and other animals?

Toxicity is measured in different ways. Acute oral toxicity is a measure of how poisonous or toxic a substance is when swallowed as a single dose. The **acute oral toxicity** of atrazine in laboratory rats is 5100 mg/kg. If we assume the acute oral toxicity in humans is the same as that in laboratory rats, then a 150-pound person would have a 50 percent probability of dying from ingesting about 0.75 pound of atrazine in a single dose. By comparison, one-half pound of table salt or 2.5 ounces of aspirin would produce the same probability of death by acute poisoning.

The reason atrazine is effective for weed control, but relatively non-toxic to animals, is that it inhibits photosynthesis in susceptible plants. Photosynthesis is the process that occurs in green leaves and stems of plants, whereby light energy is converted to chemical energy (carbohydrates). This process is not present in animals.

Chronic toxicity is an estimate of how a substance would affect an organism over a long period of time -- a life span, for example -- at very low levels of exposure. In practice, measuring chronic effects on a population of laboratory animals is not feasible. Therefore, much higher concentrations of the substance are administered to laboratory animals for up to several generations, with the results extrapolated to trace level exposures to the human population. Whereas the methodology for determining acute toxicity is rather straightforward, the methodology to estimate chronic toxicity is much more subjective, and heavily influenced by public policy.

How does the EPA determine Health Advisory Levels?

Long term -- chronic -- toxicology studies on animals are used to determine the "maximum tolerated level" and the "no observable effect level" for pesticides and other substances. Additional safety factors are applied to the "no observable effect" level in order to establish the EPA's drinking water limit, also called the "maximum contaminant level," or MCL. Normally a 100-fold safety factor is applied to the "no observable effect" level. For atrazine, however, a mammary tumor in a two-generation rat study triggered an additional safety factor. This resulted in an MCL for atrazine of 3 ppb, which has a 5000-fold safety factor. This is the concentration of atrazine that the EPA considers safe to consume in drinking water over an average 70-year human life span.

Doesn't the tumor finding in the female rat study suggest that atrazine causes cancer?

The tumor finding is limited to one study, in the high dose group, on a strain of rats with a high spontaneous background for mammary tumors. As a result of that study, atrazine is classified a "Group C substance," defined as: "possible human carcinogen; limited evidence of carcinogenicity in animals in the absence of human data."

Don't municipal water treatment plants take atrazine out of the water?

No, most do not. Atrazine could be readily removed by treatment with activated charcoal, but adding that treatment process to municipal water treatment facilities would be expensive and could create additional disposal problems. Activated charcoal filters are available for household treatment of drinking water (see *Water Treatment Equipment: A Buyer's Guide,* NebGuide G90-976).

What about atrazine in private water supply wells?

Atrazine is sometimes detected in groundwater. In most instances, the source of atrazine in well water may be caused by leaching near the wellhead due to atrazine loading, cleanup activities or back siphoning accidents during sprayer loading (see *Anti-Pollution Protection when Applying Chemicals with Irrigation Systems, EC 89-730*). Atrazine is not recommended for use in areas where mixing of surface and groundwater could lead to atrazine contamination of shallow aquifers. This would include areas with shallow water tables and coarse-textured soils. The atrazine label also prohibits mixing, loading or application within 50 feet of a well.

If we have an atrazine problem, why not remove the risk by banning the herbicide?

Banning atrazine would reduce the contamination problem, but could also increase other health and environmental risks. Corn and sorghum producers would likely compensate for the loss of this weed control tool by increasing reliance on cultivation and/or alternative herbicides. Increased reliance on tillage for weed control increases soil erosion by wind and water. Alternative herbicides generally provide less weed control and are more likely to cause sorghum or corn injury. Furthermore, increased use of alternative herbicides may create a different set of environmental and health concerns. Atrazine, which has been in use for over 30 years, is much better understood than newer herbicides that show promise as atrazine alternatives.

Zero risk sounds appealing, but does not reflect reality. Every aspect of human activity entails various degrees of voluntary and involuntary risk. Society has not banned jogging, electric power, x-rays or automobiles in spite of the risks they entail. Rather, we manage risk by making careful and informed choices, and consider benefits as well as risks. The same principles should apply to pest management decisions. Adoption of best management practices for atrazine on an individual field is the preferred method for reducing risks while retaining the benefits.

Resistance

Is it true that weeds have become resistant to triazine herbicides due to our dependence on them?

Triazine resistant biotypes of kochia, pigweed and other species have been confirmed, and this is largely attributable to long term reliance on these herbicides. Atrazine and other herbicides should be used only as part of an integrated weed management program.

Environmentally safe ways to use Atrazine

Are there environmentally safe ways to use atrazine?

Yes, atrazine can be used in widely different ways to help manage weeds in corn and sorghum. Some uses pose very low risk of loss from fields, whereas other uses have much higher risk for ground water or surface water pollution. The environmental risk of atrazine can be managed by altering the application rates, timing and placement of the herbicide. Atrazine should always be used in the context of integrated weed management systems that include other weed control methods.

How does atrazine move from the point of application into streams and reservoirs which may be sources of drinking water?

Atrazine can move into streams or reservoirs by either being dissolved in runoff water, the solution phase, or by adhering to eroding soil sediments, the sediment phase. The likelihood of atrazine loss in surface runoff depends on many factors, including atrazine placement, time of application, soil type, soil pH, surface residues and the amount and intensity of the first rainfall after application.

When it is used as a soil-applied herbicide, atrazine must be "activated" following application. This is the process whereby the herbicide is moved into the top few inches of soil and a portion of the herbicide is dissolved in the soil water so that it can be absorbed by weed seedlings. Mechanical incorporation can partially activate atrazine, but rainfall is required for optimum activation.

The greatest risk for potential atrazine runoff occurs shortly after application. This is the time when atrazine is still in the surface layers and has not become tightly bound to the soil. The action of raindrops, especially on bare soils, turns the surface 0.25 to 0.5 inch of soil -- the mixing zone -- into a muddy slurry. In this zone, water, soil and atrazine intermix and result in runoff. If surface runoff begins before the atrazine has had time to soak into the soil, as much as 5 percent of the applied atrazine may leave the field dissolved in runoff water, or carried on eroding soil sediments.

Due to its moderate solubility in water and the high water to soil runoff ratio usually encountered, over 90 percent of the atrazine leaving a field is in the dissolved, or solution, phase. The risk of runoff loss is greatest from sloping fields with fine-textured soils having low water permeability and little plant residue cover. In Nebraska, the most intense rainstorms generally occur in May, June and July, so atrazine applied during this period is at greatest risk of loss through runoff. The intensity of the first 0.5 inch of rain after atrazine application is a very important factor in atrazine runoff.

What are some approaches to environmentally safe atrazine use?

Risk to both groundwater and surface runoff can be reduced by applying less atrazine per acre when feasible. It is important to remember that "across the board" rate cutting is not necessarily needed. For example, certain fallow fields with high residue cover may require over 2 lb/acre atrazine for adequate weed control, yet pose only slight risk of atrazine leaching or surface runoff. In other cases, 1 lb/acre could lead to excessive runoff.

A good way to minimize the atrazine load on the environment, and still benefit from its weed control effectiveness, is to switch from the higher soil-applied rates to the lower foliar rates. Commercially formulated herbicide mixtures such as Buctril/Atrazine, Laddok and Marksman are foliar-applied at rates that contain from 0.38 to 0.75 lb atrazine per acre.

When atrazine is foliar-applied, good weed control can be achieved with lower rates because the herbicide is absorbed directly by plant leaves. Rainfall is not required for activation, as with soil-applied atrazine. These foliar applications can provide excellent control of many broadleaf weeds, and are especially effective on large-seeded broadleaf weeds such as velvetleaf and common cocklebur. Atrazine absorbed by corn or sorghum leaves is readily metabolized and is not detrimental to those crops.

Proper application timing for foliar-applied atrazine is required for satisfactory weed control. Herbicide labels must be consulted for guidelines on weed height. Atrazine cannot be applied after corn (or sorghum) is 12 inches tall. A planned postemerge application when weeds are small is much more satisfactory than trying to control taller weeds.

Over-the-row banding of herbicides is another effective strategy to reduce application rates. The amount of herbicide can be reduced by 50 percent or more, depending on the width of the band and the crop row spacing. Using herbicides this way necessitates cultivation of weeds growing between the crop rows. Improved cultivator designs, and the development of cultivator guidance systems, can help speed up cultivation and reduce the weather risks associated with cultivation.

These low-rate approaches are most important where corn or sorghum is grown on sloping fields of fine-textured soils with high water runoff potential, and on fields with coarse-textured soils where the most serious environmental threat comes from atrazine leaching. Especially vulnerable are sandy soils with shallow groundwater aquifers, including irrigated fields with runoff collection basins in moderate to highly permeable soils, sands and gravels.

Options in Application

I'd like to switch to foliar-applied atrazine with its lower application rates, but postemergence applications just don't fit my program. Isn't there some way to continue using soil-applied atrazine?

Shallow soil incorporation is one way to greatly reduce the risk of atrazine loss in surface runoff. Because much of the herbicide is mechanically placed below the soil surface, risk of runoff loss is reduced about 70 percent compared with runoff from atrazine left on the soil surface.

In dry years especially, incorporation enhances weed control, compared with surface (preemergence) applications, by reducing the amount of precipitation needed for herbicide activation. However, too deep or uneven incorporation may result in poor weed control. Shallow incorporation can be achieved with field cultivators, rotary tillers, finishing disks or harrows. It requires care to avoid throwing atrazine treated soil out of the crop row with the planter. On irrigated fine-textured soils, a light irrigation sufficient to move atrazine below the soil surface shortly after application but not enough to produce runoff, may also reduce the chances of atrazine runoff from later intensive rain storms. Herbicide incorporation may not be an option on highly erodible fields where the conservation plan requires maintaining large amounts of plant residue.

Incorporation will not alleviate the atrazine pollution risk on coarse-textured soils, because leaching is more important than surface runoff on these soils. Minimizing the rate of atrazine applied is the key to reducing leaching potential on coarse-textured soils.

Ecofarming Situations

Atrazine has a vital role in ecofallow/ecofarming systems such as the winter wheat-sorghum-fallow and winter wheat-corn-fallow rotations and various no-till and ridge-till planting systems throughout Nebraska. What are the guidelines for atrazine use in these situations?

Most dryland farming systems replenish soil moisture with a fallow period between crops. Because of its residual weed control properties, atrazine is often applied to wheat stubble in late summer to control broadleaf weeds and winter annual grass weeds (including volunteer wheat) in fields to be no-till planted to corn or sorghum the following spring. The following considerations should be taken into account before using atrazine in this manner.

- Consider the amount of winter wheat or spring small grain residue present. Winter wheat and rye produce greater quantities of residue per bushel of grain than oats and barley. Atrazine may be safely applied to winter wheat, rye or spring grain stubble in the fall for control of volunteer and other weeds in preparation for no-till planting of corn or sorghum the following spring. The probability of heavy rains is low during the autumn months, so there is reduced risk of runoff losses. To enhance water infiltration and reduce runoff potential, plant residue on the soil surface should exceed 50 percent at the time of atrazine application.

- Consider the average precipitation for the area, and the risk of intense storms at different times of year. The probability of intense rainfall and high runoff is greatest from May to August. Precipitation and the potential for high runoff decrease in a westward direction across Nebraska.

- Other conservation and soil management practices such as contour farming, strip-cropping, terraces, waterways, buffer zones and ridge tillage help reduce water runoff and atrazine loss potential.

Reducing Contamination

What about the storage and handling of pesticides, and sprayer operator's responsibilities?

Improper storage, handling and sprayer loading and cleanup present a higher pollution risk than the use of pesticides in fields. This is due to much higher concentrations of the substances around storage mixing and loading sites. Point source contamination from improper storage handling and disposal is usually responsible for atrazine concentrations in groundwater which approach or exceed the maximum contamination level (MCL).

So what's the bottom line? Can atrazine be used in ways that will eliminate contamination potential?

There is no way to remove all risk of contamination from atrazine. However, steps can be taken to manage and reduce risk.

- Reduce atrazine rates on both coarse- and fine-textured soils. Lower rates of foliar-applied atrazine are often much more effective for broadleaf control than higher soil-applied rates. Also consider the crop rotation benefits of less atrazine carryover following lower application rates.

- If weed pressure is too high to risk relying on foliar-applied herbicides, consider tank mixtures and/or sequential applications with a reduced amount of atrazine applied at planting, followed by a foliar application. This spreads out atrazine use and reduces the atrazine available for a single storm runoff.

- Where fields are tilled prior to planting, consider shallow incorporation of atrazine. Springtooth, spiketooth and flexible harrows can be used to mix atrazine into the top 2 inches of soil. Many modern field cultivators have adequate clearance to perform well in fields with considerable plant residues.

- Atrazine applied to soil has considerable longevity. Consider applying it when the probability of heavy rains is reduced. Under Nebraska weather conditions, atrazine applied in early April has half the risk of surface runoff compared to that applied in late May. Thus, early preplant applications ahead of corn or well ahead of sorghum planting generally have a reduced risk of runoff. Similarly, late summer or fall applications -- after August -- to wheat stubble also have low risk of surface runoff loss. Conservation tillage systems may improve water infiltration into soils, and reduce surface runoff.

- Consider the possibility of banding preemergence herbicides over the row and following up with cultivation. This allows use of the full herbicide rate in the row and reduces herbicide costs, carryover and the herbicide load on the environment.

- Producers should ask themselves whether it's really necessary to use atrazine in their weed management program. Can they adopt crop production systems that reduce the need for herbicides in general, and atrazine in particular? Atrazine is an unusual and valuable herbicide because of the wide variety of ways it can be effectively used to help manage weeds. Knowledge of environmental risks associated with different uses will enable corn and sorghum producers to modify their management practices to assure environmentally sound decisions.

***Adapted from Kansas State University Cooperative Extension Service Publication MF-1023 (D.L. Regehr, D.E. Perterson, and J.S. Hickman).**

File G1158 under: PESTICIDES, GENERAL
B-13, Herbicides
Issued May 1993; 10,000 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.