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G96-1299 Agricultural Management Practices to Reduce Atrazine in Surface Water

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Agricultural Management Practices to Reduce Atrazine in Surface Water

Ways to reduce atrazine availability, reduce the amount of water runoff, and reduce the impact of the first runoff are covered here.

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Each year growers face many decisions when planning for a new growing season, including selection of an economical weed control program. Because of their ease of use and effectiveness, many producers use preemergence herbicides to control weeds. Because of its low cost, corn and sorghum growers often select atrazine or an atrazine combination. Nebraska corn growers annually apply an estimated 6.3 million pounds of atrazine.

Atrazine is an effective and low-cost herbicide, but there is a hidden cost to its use. Atrazine is appearing in both surface water and groundwater.

Balancing economic and production gains against atrazine's potential environmental impacts is important for continued use of this valuable weed control product.

Best management practices can reduce the risk of atrazine and other herbicide runoff to surface water while still meeting production and profit goals. This NebGuide aims to provide a description of how various management practices affect atrazine runoff from a farm field to a waterway, drainage ditch, stream or lake. Not all practices can be adopted on every field, nor do they need to be. Producers should select practices that are economical, fit within their management plan, and can reduce atrazine runoff.

This NebGuide will aid producers in selecting practices that reduce the potential for atrazine loss in runoff.

Atrazine is usually mixed with water, then sprayed on soil, crop residue and weeds. Atrazine that reaches the soil surface is in the "mixing zone" (*Figure 1*). The mixing zone is the top one-half inch of the soil where atrazine adsorbs to soil or dissolves in water from irrigation or rainfall.

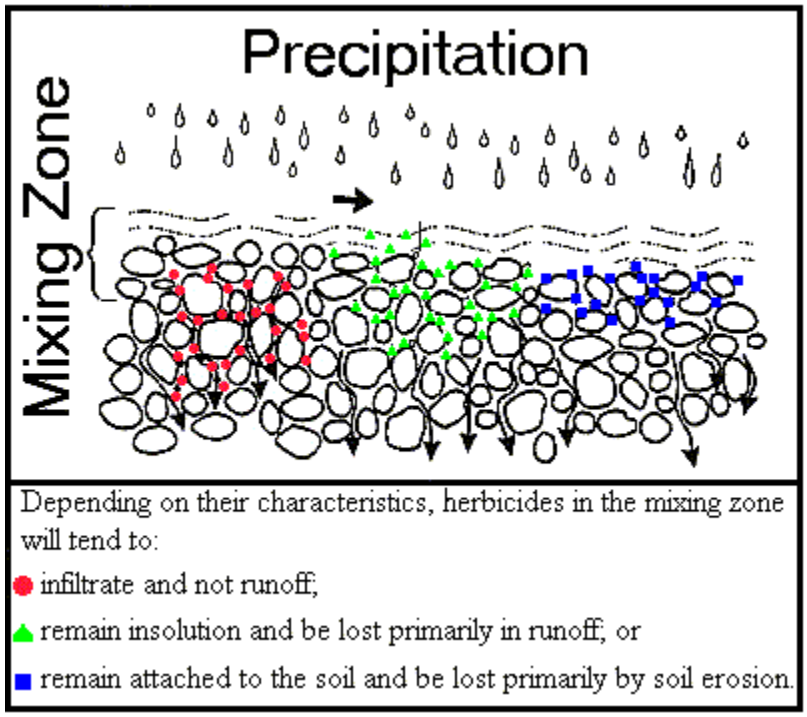

Figure 1. Diagram illustrating the mixing zone, usually the top 1/2 inch of soil. Atrazine in the mixing zone tends to remain in solution and is lost primarily with runoff.

As rainfall occurs, the water can either infiltrate into the soil or run off. Dissolved atrazine will move with water. Soil erosion removes atrazine attached to soil particles. Typically, annual runoff losses of atrazine are 2-5 percent of the total applied. Of this, 80-90 percent is lost in runoff water, with the remainder lost with eroded soil.

The three primary factors that determine the amount of atrazine lost in runoff are: 1) atrazine availability; 2) water runoff amount; and 3) runoff timing. Atrazine in the mixing zone, whether dissolved in water or attached to soil, is *available* for potential runoff in surface water. The *amount* of runoff water leaving a field will determine the total loss of atrazine. The *timing* of the first major runoff event after application can significantly affect atrazine loss. Heavy rainfall and runoff immediately following application generally will result in the greatest loss of atrazine.

Management practices to reduce atrazine loss are those that: 1) reduce atrazine's availability in the mixing zone; 2) reduce the amount of runoff water leaving the field; and 3) reduce the impact of the first runoff following application.

The management practices described below have been divided into those that: 1) reduce atrazine availability; 2) reduce the amount of water runoff; and 3) reduce the impact of the first runoff event.

For most growers, many of the management practices that reduce atrazine availability can be adopted with little or no change to normal operations. Decisions on atrazine application rates and methods should be aimed at reducing the amount of atrazine in the mixing zone. Runoff management practices may require farm operation changes.

There are multiple reasons for considering management changes, and as growers begin to assess them, reducing atrazine runoff may provide an additional basis for a management change. Reducing the impact of the first runoff will require reducing atrazine application when the potential for runoff is greatest.

Reducing Atrazine Availability

Integrated pest management--Integrated pest management (IPM) involves the application of a variety of management practices to control pests and weeds. Herbicides are used only when weed populations exceed an economic threshold level that justifies their application. Field scouting is required to monitor weed populations.

Nonchemical weed control methods, such as crop rotation, cultivation, competitive hybrids, rotary hoeing and altered planting dates, are emphasized as management practices that can reduce the need for herbicides. IPM may reduce the need for atrazine in some cases, saving both time and money and reducing the potential for atrazine runoff to surface water.

Reduced application rates--Reducing application rates will reduce potential loss in runoff. Consider applying less than the label rates if weeds can be controlled. Or use combinations with reduced rates of atrazine (see below).

Atrazine combinations--Combining atrazine with other herbicides will reduce the atrazine application rates compared to atrazine alone. Preemergence mixes often contain atrazine plus a herbicide for grasses and small-seed broad leaves. Postemergence applications usually include atrazine plus another broadleaf herbicide. Many pre-packaged atrazine combinations are available, or a grower can mix the separate ingredients if they are labeled for mixing.

Incorporate atrazine--Because most atrazine loss is in the solution or water phase, and not with soil particles, mechanical incorporation of atrazine will help reduce atrazine runoff by placing it below the mixing zone. Increased availability of field cultivators that can retain residue on the soil surface makes incorporation compatible with minimum tillage. On erodible land leave at least 30 percent residue cover after planting to reduce soil erosion. A light irrigation also may be effective for atrazine incorporation (see below).

Band application--Applying atrazine in a narrow band in crop rows is an effective method of reducing the total amount of atrazine applied. One or more well-timed cultivations is necessary to prevent inter-row weeds from establishing and competing with the crop. Both preemergence and postemergence herbicides may be banded.

Atrazine alternatives--Atrazine, mainly a broadleaf herbicide, can be replaced either partially or totally in some cropping systems. The alternatives are usually higher in price.

Avoid repeated use of herbicides with similar modes of action to reduce the potential development of herbicide resistance. Refer to the *Herbicide Use Guide for Nebraska (EC96-130)* for atrazine alternatives.

Rotary hoe and cultivation for weed control--Mechanical methods for weed control are effective when timed correctly. The rotary hoe should be used before weed emergence, but after the weed seed has germinated. Usually this will be within a week or 10 days after planting. The cultivator will uproot weeds and cover in-row weeds if used when weeds are small. Neither implement is as effective after weeds become established. These implements usually will complement a banded herbicide application and may reduce the need for a postemergence herbicide.

Match rates to weed infestation levels--In many fields most weeds are clustered, with as much as 70-90 percent of the land having very few weeds. At harvest it is possible to map these areas so herbicide can be applied only where needed. Rate and site specific technology, although in the developmental stages, will enable adjustment of herbicide rates according to soil organic matter, soil pH, soil texture,

and weed type and location within a field.

Crop rotation--When using a crop rotation, total atrazine use can be reduced by 50 percent or more compared to continuous corn production because atrazine is not used on the rotated crop. Weed control also may be improved because different cultural practices and herbicides are used in the rotated crops. Crop rotation spreads the planting and herbicide application season, reducing the risk of encountering widespread herbicide runoff during a single runoff event.

Light irrigation after application--A light sprinkler irrigation following application will incorporate atrazine and reduce runoff by moving some of the atrazine below the soil surface away from the mixing zone. However, saturating the soil surface increases the potential for runoff. Usually, one-half inch of irrigation water will sufficiently incorporate and activate a herbicide on a dry silt loam soil. Do not irrigation if the soil surface is near saturation or if rainfall is imminent.

Setback areas--No-spray setback distances of 50 feet from wells, 66 feet from outlets to streams or rivers, and 200 feet from lakes or reservoirs are label requirements for atrazine. Farm ponds may be excluded from the setback requirement if they are wholly on one property, not used for drinking water, and do not convey water directly to a stream or river. For tile-terrace systems, the 66-foot setback should be applied either at the subsurface outlet if it does not drain directly to a ditch, stream or other surface water, or applied at each terrace riser pipe. A 50-foot setback from wells for mixing or loading is also a label requirement. The positive impact of setbacks will be greatest if the setback area is planted to a perennial grass.

Table I. Relative effectiveness of management practices to reduce field losses of atrazine in runoff water and with eroded soil.

		Relative Impact on Reducing Atrazine Losses	
Practice	**Action**	**in Runoff Water**	**with Eroded Soil**
Reduce Atrazine Availability			
Alternative herbicides	Eliminates atrazine use	Very High	Very High
Incorporation	Reduces atrazine on soil surface	High	High
Band application	Reduces amount applied	High	Medium
Crop rotation	Eliminates atrazine use in some years	High	Medium-High
Integrated Pest Management	Reduces atrazine use	Medium-High	Medium
Atrazine combination	Reduces amount applied	Medium-High	Medium
Mechanical weed control	Reduces atrazine use	Medium-High	Medium
Match rates to weed pressure	Reduces total application	Medium	Medium
Irrigation incorporation	Moves atrazine below soil surface	Medium	Medium
Setback areas	Eliminates atrazine from small areas	Low	Low
Reduce Water and Sediment Runoff			

Terraces without outlets	Retains runoff water	High	High
Water and sediment control basins	Holds runoff water	Medium-High	High
Reduced tillage (30% residue cover)*	Retains runoff water	Medium-High	High
No-till	Improves infiltration	Medium-High	High
Ridge-till	Retains runoff water	Medium-High	High
Reuse pits	Retains irrigation runoff	Medium	Medium
Contour farming	Retains sediment and water	Low-Medium	Medium
Strip cropping	Retains sediment and water	Low-Medium	Medium
Grass filter strips	Slows runoff and increases infiltration	Low-Medium	Medium
Terraces with outlets	Slows runoff water	Low	Medium
Grass waterways	Slows runoff water	Low	Medium
Subsurface drainage	Improves infiltration	Low	Low
Reduce Impact of First Runoff			
Post emergence application	Reduces amount applied	Medium-High	Medium
Split application	Reduces amount applied at one time	Medium	Medium
No application on saturated or wet soil	Avoids high runoff risk	Medium	Medium
*If less than 10% residue cover at planting ranking would be Runoff Water: Medium-Low; Eroded Soil: Medium-Low. A 20-30 percent residue cover after planting can reduce water-caused soil erosion by 50 percent compared to clean tilled fields.			

Reducing Water and Sediment Runoff

Managing runoff potential--Identify fields or areas of fields that have the greatest potential for surface runoff. Surface water runoff from a field is dependent on soil type, land slope, land use, and topsoil moisture status. Of these factors, only land use can be managed easily. However, recognizing the influence of other factors on surface runoff can aid management decisions.

On steeper slopes and clay soils, runoff risk is greatest. Runoff can be reduced on slopes by selecting practices such as reduced tillage or ridge-till, which can increase water infiltration and reduce runoff. Saturated topsoil will increase runoff regardless of the tillage practice. Alternative weed control methods can be used to replace atrazine on high runoff risk areas.

> *No atrazine for some areas*--Areas with high runoff potential will contribute atrazine runoff disproportionate to their size, even under the best management. Avoiding atrazine use on such areas may be the best alternative. Long, steep slopes on poorly drained soils without residue cover create high risk situations. These may occur on only part of a field or on an entire field. Defining these areas and managing them to reduce atrazine availability is important for reducing atrazine runoff risk.

Reduce tillage--Crop residue should be managed to maintain cover on the soil surface year-round to reduce wind and water erosion. Residue management is accomplished with various tillage and planting systems, such as no-till, ridge-till, strip-till, and mulch-till. For additional information on residue management see NebGuide *Residue Management for Soil Erosion Control* (G81-544).

The impact of residue management on reducing runoff can be significant. By reducing erosion, residue management reduces runoff of soil-attached atrazine. Surface residue helps slow water runoff and increases infiltration, reducing total water runoff. This is especially true for no-till, which leaves maximum crop residue on the soil surface. On well-drained soils, no-till can reduce total annual atrazine runoff by up to 90 percent compared to conventional tillage.

No-till--Soil is undisturbed except for planting and fertilizer application. Soil infiltration increases, reducing runoff. However, large runoff events that occur shortly after atrazine application can result in high atrazine runoff concentrations. Total annual runoff will depend on soil type. Poorly drained clays and silts may not have as great a runoff reduction with no-till as well-drained soils.

Ridge-till--Crops are planted in ridges formed by cultivation. Residue is maintained on the soil surface to improve infiltration and reduce runoff. Cultivation is used between the rows, so herbicides normally are applied in a band on the rows.

Strip-till--Only a narrow strip of soil is tilled for planting. Advantages are similar to ridge till, but no ridges are created. Herbicide use may be reduced if cultivation is used. Positive impacts of surface residue are maintained. Strip-till should be on the contour to reduce the risk of runoff along the tilled strip that can cause severe erosion and herbicide loss.

Mulch-till--The entire soil surface is tilled, but tools such as chisels, field cultivators and finishing discs are used sparingly to minimize residue burial. Generally, tillage that buries residue reduces water infiltration and increases water runoff. However, if atrazine is incorporated with a light tillage operation that maintains surface residue, mulch-till can be a very effective management practice to reduce atrazine runoff.

Contour farming--Contour farming can reduce runoff. Furrows, crop rows and wheel tracks along the contour act as miniature dams to hold water and help prevent erosion and runoff.

Strip cropping--Strip cropping is the practice of alternating crops, such as corn and alfalfa, in small strips along the contour of the field. The runoff from the corn is captured in the downhill alfalfa strip, thereby retaining sediment and water in the field.

Terraces--Terraces without outlets, such as level terraces or storage terraces, are designed to hold runoff water and allow it to infiltrate into the soil for moisture conservation. These types of terraces greatly reduce runoff.

Terraces slow the speed of runoff, reduce its soil-carrying capacity, and trap soil particles. This reduces the amount of sediment and soil-attached atrazine leaving the field. Terraces with outlets can be somewhat effective at reducing runoff by ponding water and allowing additional time for water to infiltrate. However, grassed waterways and subsurface tile drains are conduits for water and provide little advantage for runoff reduction. (see **setback areas** above).

Water and sediment control basins--Basins capture runoff water and sediment, reducing the amount of water and soil leaving a field. By capturing sediment, basins are effective at reducing losses of

atrazine attached to soil. Because most atrazine leaving a field is dissolved in water, basins that hold all the water from a runoff event, allowing it to infiltrate or evaporate, significantly reduce the amount of atrazine leaving a field. However, basins with an outlet to release water, similar to a tile-terrace system, are less effective at reducing runoff.

Reuse pits--Irrigation reuse pits reduce the amount of irrigation water leaving a field. Reuse pits allow dissolved atrazine to be recycled onto the field, and adsorbed atrazine to settle out with sediment. The bottom and sides of the pits should be sealed to reduce leaching loss.

Grass waterways--Grass waterways slow runoff water and remove sediment, thereby reducing loss of herbicides attached to soil. Grass waterways are less effective at reducing atrazine loss, which is primarily lost in runoff water. Water concentrates in grassed waterways and flows directly off the field. Some runoff reduction occurs for small runoff events when water flows slowly through the grass waterway, allowing most of the water to infiltrate.

Grass filter strips--Grass filter strips planted along watercourses, streams or ponds can remove a significant amount of sediment from runoff water. They are less effective at reducing water runoff.

Grass filter strips reduce the amount of water runoff by increased infiltration within the strip. They are effective if water is spread out evenly as it flows across the filter, not concentrated as in a grassed waterway. Filter strips could be effective at the end of rows, such as at field borders, or at the end of irrigationd furrows to filter tail-water runoff.

Subsurface drainage--Subsurface drainage may reduce water runoff potential in some situations. Subsurface drainage is used to reduce the level of soil saturation and increase the capacity for water to infiltrate, reducing runoff. Consult the Natural Resources Conservation Service before draining a field that might be considered a wetland.

Reducing the Impact of the First Runoff

Split applications--pre- and post- emergence-- Herbicide runoff is greatest when a high intensity rainfall occurs as the first rainfall following application, and is proportionally greater when high application rates are used. Split applications reduce the amount applied at one time, thereby reducing the amount of atrazine available if runoff occurs. Postemergence application may be at lower rates, or avoided if preemergence applications control weeds.

Postemergence application--Atrazine usually is applied at lower rates with postemergence applications than with preemergence applications. Postemergence applications are usually made to drier soil and often are applied when the potential for large rainfall events is less, reducing the potential for runoff.

Avoid wet soil application--Do not apply herbicide to wet soil or when rainfall is imminent. It is important that the initial rainfall after application soaks into the soil to carry atrazine below the mixing zone. Unless the top several inches of soil can absorb water readily, rainfall or irrigation water will run off rather than infiltrate into the soil. If the soil is near saturation, delay herbicide application until it drains. Also, driving on wet soil may lead to soil compaction that can reduce infiltration and increase runoff.

Related Extension Publications

EC95-143 pesticide Runoff and Water Quality in Nebraska

EC96-130 Herbicide Use in Nebraska
EC94-135 Understanding pesticides and Water Quality in Nebraska
G93-1182 Best Management Practices for Agricultural pesticides to Protect Water Resources
G93-1158 Questions and Answers about Atrazine
G82-586 Effects of Agricultural Runoff on Nebraska Water Quality
G81-544 Residue Management for Soil Erosion Control

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