# Atrazine Herbicide Best Management Practices for the Little Arkansas River Watershed

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Atrazine herbicide has been used for more than 40 years in the Little Arkansas River watershed for selective control of broadleaf and grass weeds in corn and grain sorghum. It is a widely used herbicide, applied annually to the majority of corn and grain sorghum in the watershed. Atrazine can be successfully applied using a broad range of application timings and tillage practices. It is one of the lowest-cost herbicides on a per-acre basis. It can be applied early preplant, preplant incorporated, preemergence, or postemergence. Kansas State University studies have shown it to be one of the most effective soil-applied herbicides for season-long weed control in corn and grain sorghum. In many postemergence herbicide tank mix programs, it is an essential herbicide for cost-effective control.

## Water Quality Concerns

**Atrazine is a low-cost per-acre herbicide, but there may be environmental costs that should be considered when using atrazine**. In recent years, monitoring of surface waters in the Little Arkansas River watershed has raised concerns about the levels of atrazine runoff entering surface waters (Table 1). Frequently, the concentration of atrazine in surface waters during spring and summer is above drinking water maximum contaminant level (MCL) and the aquatic life standard for atrazine of 3 parts per billion (ppb). Most municipal water treatment plants do not remove atrazine and other pesticides unless the water treatment system adds an activated carbon treatment system to the treatment process. Adding this treatment process increases the cost of the treatment facility and the day-to-day cost of water treatment.

**Table 1.** *Atrazine concentrations in the Little Arkansas River, 1996–2003.*

| Location | # of Atrazine Detections/ Samples Collected | Average Concentration When Atrazine Detected (parts per billion) |
|---|---|---|
| Alta Mills | 6/44 | 4.8 |
| Halstead | 37/68 | 10.0 |
| Sedgwick | 104/212 | 8.6 |
| Valley Center | 7/44 | 4.6 |

*Source: Kansas Department of Health and Environment, 2004.*

## WRAPS

In 2004, a local watershed stakeholders group developed a plan to restore and protect the surface water and groundwater of the Little Arkansas River watershed. One of the goals of the Watershed Restoration and Protection Strategy (WRAPS) is to encourage farmers to minimize atrazine loss from crop fields, thereby reducing atrazine runoff to surface waters to levels that meet water-quality standards. This publication discusses the best management practices for achieving weed control and reducing movement of atrazine to surface waters.

## How Atrazine is Lost From Crop Fields

The movement of atrazine from crop fields is determined by the chemical properties of atrazine; soil and site characteristics; tillage practices; and rainfall duration, intensity, and timing. When atrazine runoff occurs, it begins in the top ½ inch of soil, called the "mixing zone."

**Chemical Characteristics of Atrazine.** The most important chemical characteristics that affect atrazine runoff are adsorption and persistence. The solubility of atrazine is also important, but it plays a lesser role. Adsorption is a term that describes a chemical's tendency to bind or stick to soil particles, primarily clay and organic matter. Some herbicides are tightly adsorbed by soil particles and only leave the field with eroding soil particles and not with the runoff water. Atrazine, however, is weakly adsorbed. Atrazine leaves the field mostly with the runoff water and not with the eroding soil particles. K-State researchers found that approximately 90 percent of atrazine loss occurs in the water portion of runoff and only 10 percent with the eroding soil particles.

Persistence refers to how long it takes for a herbicide to degrade in the soil following application. The longer the herbicide lasts before degrading, the longer the period of weed control and the greater the opportunity for herbicide loss. Atrazine applied in April or May has a half-life of approximately 60 days, which means that by 60 days following application, half the atrazine will be broken

*Little Arkansas River in McPherson County, Kansas*

down. **Atrazine's fairly long half-life, combined with its adsorption characteristics, is the major reason atrazine appears regularly in surface water samples collected in the Little Arkansas River watershed.**

**Soil and Site Characteristics**. Soil and site characteristics are important factors when determining whether atrazine runoff will be a problem. Soils in most fields can absorb a light rainfall, but heavy rain over a short period of time can saturate the soil surface and lead to runoff. **In general, the greater the slope and the higher the clay content in the surface soil, the greater the potential atrazine runoff.**

**Tillage Practices.** Reducing tillage may reduce atrazine runoff in some situations but may increase atrazine runoff in other situations. Runoff depends on soil characteristics and moisture conditions before atrazine application.

K-State has examined the effects of adopting no-tillage compared to reduced-tillage or conventional-tillage at several locations and soils in Kansas. Results have been mixed. At times, atrazine runoff has been greater with no-tillage than with tilled fields.

Atrazine runoff loss is directly correlated to the amount of water runoff from a field, and atrazine application methods and timing. The soil's surface moisture at the time of herbicide application is important. Higher surface soil moisture leads to greater runoff when a storm occurs. Many times there is more moisture storage in no-till than in tilled fields, particularly near the soil surface and in the spring at planting time. In addition, tilling the soil may dry the soil surface temporarily, increasing water permeability and increasing herbicide binding to loose soil particles. **Regardless of tillage system, a series of atrazine best management practices are necessary to minimize atrazine runoff.**

**Rainfall Duration, Intensity, and Timing.** The surface soil moisture at time of herbicide application, length of time from herbicide application until first rainfall, intensity and duration of the first rainfall, and the total amount of the first rainfall all influence atrazine runoff. The wetter the soil surface at application, the sooner runoff begins during a rain and the greater the potential for atrazine runoff. If the soil surface is dry at the start of the storm, more water (and atrazine) infiltration will occur at the start of the storm and less will be available for runoff. Generally, soil moisture levels are greatest in April, May, and June, the time when most atrazine is applied. Approximately two thirds of the total atrazine runoff occurs from the first rain following application. The longer the time between application and first runoff event, the less atrazine runoff that can be expected. Rainfall that soaks into the soil before runoff will move some of the atrazine below the mixing zone, reducing the atrazine loss.

**Field Distance to Surface Water.** The greater the distance from the field to a stream or lake, the less likely it is that atrazine running off the field will enter surface waters. The longer the runoff is retained in grass waterways, vegetative filter strips, roadside ditches, or other fields, the greater the chance the atrazine laden runoff water will either infiltrate the soil or degrade.

## Recommendations for Atrazine Best Management Practices

K-State researchers have investigated atrazine runoff and found that annual atrazine runoff losses are 1 to 3 percent of the total applied. This is a small loss and in most instances, only requires fine tuning of atrazine-management strategies. K-State researchers have studied the effect of various management practices on atrazine runoff and determined those BMPs that, when adopted by farmers, will minimize atrazine runoff. The greatest reduction will be achieved by using a combination of BMPs. Those listed in this publication are not suited for every field. Farmers should select practices that fit within their management system, are economical, and are most effective in reducing atrazine runoff.

## Recommended Atrazine Best Management Practices

### 1. Incorporate atrazine into the top 2 inches of soil.

This is an excellent BMP if you are planning to use tillage prior to planting corn or grain sorghum. Apply preplant atrazine alone or as part of a tankmix and incorporate it into the top 2 inches of soil with a field cultivator, tandem disc, or other appropriate tillage implement. Avoid deep incorporation, which will reduce weed control. Incorporation will reduce the amount of atrazine in the mixing zone of the soil, where it is most vulnerable to runoff. Incorporation will reduce atrazine runoff by 60 to 75 percent compared to a surface application without incorporation. Incorporation will improve weed control if rainfall does not occur within 7 days of herbicide application.

**Caution***: Use only if tillage is already planned and the atrazine incorporation is part of a planned tillage operation. Using tillage unnecessarily can lead to increased soil erosion and soil loss to surface water. Suspended solids (sediment) in Kansas surface waters is considered to be a major environmental concern.*

### 2. Use early preplant applications.

Atrazine runoff can be reduced by 50 percent by applying between November 1 of the previous year and April 15 of the current cropping year. Rainfall intensity, duration, and amount is typically lower between November and mid-April than in late April, May, and June, resulting in less water and atrazine runoff. This is an excellent BMP for fields where preplant incorporation and other practices may not be appropriate.

Rain in late fall, winter, and early spring is normally of less intense, allowing the atrazine to be moved into the soil and out of the mixing zone before to runoff. The fall atrazine application will also control winter annual weeds, which may reduce the number of tillage operations necessary before planting.

K-State recommends that fall atrazine applications be made on fields that will be no-tilled with significant crop residues present. Under no-till conditions, a fall atrazine application should be followed by a soil-applied treatment at planting time or a postemergence herbicide application for season-long control.


*An atrazine BMP research/demonstration site in the Little Arkansas River watershed.*

**Caution***: Fall, winter, and early spring applications may require another herbicide application at planting time or postemergence. Higher total rates will be needed when applying atrazine in the fall, winter, or early spring, which will increase weed control costs. Higher-than-normal winter and spring precipitation may dilute the atrazine and result in poor weed control.*

### 3. Use postemergence atrazine applications.

Postemergence herbicide applications that contain low rates of atrazine in mixtures with other herbicides are widely used by Kansas farmers. Postemergence applications typically contain atrazine at rates of ½ pound applied ingredient per acre, approximately 60 to 70 percent lower than typical soil-applied atrazine application rates.

In addition, the growing crop foliage helps reduce atrazine runoff potential by intercepting some of the atrazine and reducing the storm impact at the soil surface. When using postemergence applications with grain sorghum, which is planted later than corn, application can be delayed until late June or early July when the soil surface can be expected to be drier. Postemergence applications result in 50 to 67 percent less atrazine runoff compared to typical preemergence soil-applied atrazine applications. The herbicide mixture used for postemergence applications can be based on specific weed species and populations present. K-State research has found postemergence applications (containing atrazine) to provide better control than preemergence soil-applied atrazine on tough, large-seeded broadleaf weeds such

*Effectiveness of Atrazine BMPs were confirmed through research.*

as velvetleaf, common cocklebur, and common sunflower.

**Caution***: Postemergence applications containing atrazine and other herbicides are generally more expensive on a per-acre basis, and require an additional application trip across the field. In addition, wet soil conditions may prevent timely postemergence application and lead to reduced grain yields.*

## 4. Reduce soil-applied atrazine application rates.

There is a direct relationship between atrazine application rate and runoff amount. The lower the rate of atrazine applied, the less the potential runoff. Using lower atrazine rates and/or formulations with lower atrazine rates can still provide excellent control of pigweed and other small-seeded broadleaf weeds. Reducing atrazine rates by one-third potentially reduces atrazine runoff by 33 percent.

**Caution***: If atrazine is the primary broadleaf herbicide used, reducing atrazine rates may lead to unsatisfactory weed control, particularly for large-seeded broadleaf weeds, such as velvetleaf, common cocklebur, and common sunflower. Supplemental herbicides or weed management strategies may be needed to control escaped weeds.*

## 5. Use split applications of atrazine.

Apply atrazine and tankmixes as split applications. For example, apply one-half to two-thirds of the atrazine before April 15 and one-third to one-half before or immediately following planting. Using split applications reduces the amount of atrazine available for runoff at any one time. In addition, the early application is made at a less vulnerable time for atrazine runoff. This BMP has the potential to reduce atrazine runoff by 25 percent compared to applying all the atrazine at planting time.

## 6. Reduce soil-applied atrazine rates, follow with a postemergence herbicide application.

Applying atrazine at a reduced soil-applied rate of approximately 1 pound applied ingredient per acre at planting time followed by a postemergence mixture that contains low rates of atrazine results in 25 percent less atrazine runoff compared to surface applying all atrazine at planting time, while generally providing excellent broadleaf weed control. This BMP reduces the amount of atrazine applied at planting time.

This two-step approach of using preemergence herbicides followed by postemergence herbicides has consistently resulted in the best weed control over a broad spectrum of broadleaf and grass weeds in corn and grain sorghum. This program may be less costly on a per-acre basis if the initial application provides needed weed control and the postemergence application is not necessary.

**Caution***: Herbicide costs are higher for the two-step program — both in higher herbicide costs and the two application trips across the field. Wet field conditions may prevent timely postemergence application and reduce weed control.*

## 7. Use non-atrazine herbicides.

New herbicides that do not contain atrazine are available for use in corn and grain sorghum. Using non-atrazine alternatives eliminates atrazine runoff.

## 8. Use integrated pest-management strategies.

Integrated pest-management strategies combine prevention, suppression, monitoring, and pesticides to control weeds. This system maximizes profits and weed control while minimizing the amount of herbicide needed.

Crop rotation; preplant tillage; in-season cultivation; hand-roguing; changes in row spacing, planting date, or seeding rate; crop scouting; cover crops; variety/hybrid selection; and spot herbicide treatments can reduce weed infestations, improve the crop's ability to compete with weeds, and reduce the amount of herbicide needed. This program can reduce atrazine runoff by 0 to 100 percent.

**Caution***: Evaluate weed infestation levels before reducing herbicide rates.*

## 9. Band herbicides at planting or cultivation.

Banding the atrazine application over the row as a 10- or 15-inch band reduces the total amount of atrazine applied to a field by 50 to 67 percent, resulting in a corresponding reduction in atrazine runoff compared to a broadcast surface application without incorporation. Banding also reduces herbicide costs. Weeds in the untreated middle of the rows will be removed by in-season cultivation. This system works particularly well for ridge tillage and other situations where cultivation will be used.

## 10. Establish vegetative and riparian buffer areas.

Vegetative and riparian buffer areas include grass waterways, field boundaries, and areas along streams and ponds. These buffers are effective at slowing down runoff and collecting soil particles from erosion. Vegetative and riparian buffers may reduce the amount of water runoff by increasing infiltration of runoff water within the buffer. To the extent that water infiltrates into the buffer strip soils, atrazine loss also will be reduced.

Vegetative buffers are most effective at reducing water (and atrazine) runoff if the water is spread out evenly as it flows across the filter. If water infiltration in the buffer area does not occur, atrazine runoff will not be reduced as the vegetation itself will not absorb atrazine. Many grass waterways concentrate runoff and so are not highly effective for reducing atrazine runoff. Vegetative and riparian buffer areas can reduce atrazine runoff by 25 to 35 percent.

**Caution***: Vegetative and riparian buffer areas must have even water flow across the buffer to be effective.*

## 11. Use proper atrazine rates, mixing, loading, and disposal practices.

It is important that all label requirements be followed when using atrazine and other pesticides. The rate should be chosen carefully and tailored to label recommendations, water quality concerns, weed infestations, and soil type. Using higher than labeled atrazine rates is unlawful and may lead to increased atrazine runoff, crop damage, and carryover concerns.

All application equipment should be calibrated regularly to maintain accuracy of application. All pesticides should be stored in appropriate storage facilities. Be careful when mixing and loading the spray tank with atrazine and other herbicides. Mix and load in the field and away from wells and surface water. It is best to use a nurse tank rather than directly loading from a well. If a well is used, a backflow device should be used to prevent back-siphoning into the well. Follow product label recommendations on rinsing and disposing of the herbicide container. Spray-rinse water should be applied back onto the target field and not drained near wells, ponds, lakes, or streams.

## 12. Use conservation practices and structures.

Conservation practices and structures that reduce water runoff and soil erosion from a field will reduce atrazine runoff. Most conservation practices and structures reduce soil erosion more than water runoff. Conservation structures that primarily reduce soil erosion will have limited impact on atrazine runoff because the majority (more than 90 percent) of atrazine loss occurs in runoff water.

## 13. Follow label on atrazine setbacks.

The label contains requirements for how, when, and where applications can be made to prevent atrazine runoff. Key points on the label include:

**Streams and rivers**

a) Do not mix or load within 50 feet of any stream or river.
b) Do not apply within 66 feet of points where surface water enters an intermittent or perennial stream or river.
c) Do not apply within 66 feet of a tile inlet (for tile outlet terraces) unless the atrazine is incorporated and/or greater than 30 percent residue is present.

**For lakes**

a) Do not mix or load within 50 feet of the water's edge.
b) Do not apply within 200 feet of the water's edge.

## Summary.

Atrazine is used widely in the Little Arkansas River watershed for weed control in corn and grain sorghum. The herbicide provides cost-effective weed control and has wide application flexibility. In recent years there have been concerns about the levels of atrazine moving from corn and grain sorghum fields into surface waters. The movement of atrazine from crop fields is determined by the chemical properties of atrazine; soil and site characteristics; tillage practices; application timing and methods; and rainfall duration, intensity, and timing. K-State researchers have studied the effect of various management practices on atrazine runoff and have determined those BMPs that, when adopted by farmers, will minimize atrazine runoff. The greatest reduction will be achieved by using a combination of BMPs. Farmers should select the BMPs for their field that fit within their management system, are economical, and are most effective in reducing atrazine runoff.

## 12 Best Management Practices for Atrazine

1. Incorporate atrazine into the top 2 inches of soil.
2. Use fall or early spring applications.
3. Use postemergence atrazine premix products.
4. Reduce soil-applied atrazine application rates.
5. Use split applications of atrazine.
6. Use reduced soil-applied atrazine rates followed by a postemergence herbicide application.
7. Use non-atrazine herbicides.
8. Use integrated pest management strategies.
9. Band herbicides at planting or cultivation.
10. Establish vegetative and riparian buffer areas.
11. Use proper atrazine rates, mixing, loading, and disposal practices.
12. Use conservation practices and structures.

## Other K-State Research and Extension Atrazine Publications

MF-1023 *Q & A about Atrazine*
MF-2182 *Water Quality Best Management Practices for Atrazine*
MF-2208 *Managing to Minimize Atrazine Runoff*
MF-2461 *Atrazine Herbicide: A Water Quality Concern for Kansas*

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