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EC730

# Protecting Surface Water Quality

## Adoption of Agricultural Best Management Practices in the Lower Big Blue River Basin

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Agriculture is a constantly changing industry. New technologies and research findings continuously provide farmers with new methods to control pests, cultivate soil, control erosion, and protect water resources.

UNL Extension, industry, and many local, state, and federal agencies promote adopting best management practices so agricultural producers can increase yield potential, reduce costs, or minimize environmental impact. Some practices UNL Extension promotes include no-till, conservation buffers, and integrated pest management, all of which protect surface water quality.

Between 1996 and 2006, new technologies and market pressures for reducing production costs caused changes in how farmers operate in southeast Nebraska. This Extension Circular reports how producer practices in the lower Big Blue River Basin have changed over a 10-year period and illustrates dramatic changes in corn and sorghum production practices.

## Introduction

The Big Blue River and Little Blue River Basins cover about 9,690 square miles in southeast Nebraska and northeast Kansas (*Figure 1*). Land use is primarily agricultural, with over 70 percent of land dedicated to row crops, including corn, grain sorghum, and soybeans (*Figure 2*).

Inputs such as pesticides, plant nutrients (fertilizers), and irrigation are used to maintain high crop production levels across the basin. However, the Nebraska Department of Environmental Quality reported in 2004, that runoff of soil, pesticides, and nutrients has caused water quality concerns in most of the basin's primary streams, including the Big and Little Blue rivers, the West Fork of the Big Blue River, Lincoln Creek, Turkey Creek, and Big Sandy Creek.

Surface water from the basin drains to Tuttle Creek Reservoir in Kansas, a source of drinking water for two major municipalities in Kansas. Maintaining high water quality in the basin is important to both states.

In the mid- to late 1990s, education efforts by UNL Extension, local, state, and federal agencies, and private industry promoted using best management practices (BMPs) to reduce atrazine runoff in the basin. Since 2000, continued efforts to promote BMPs have focused

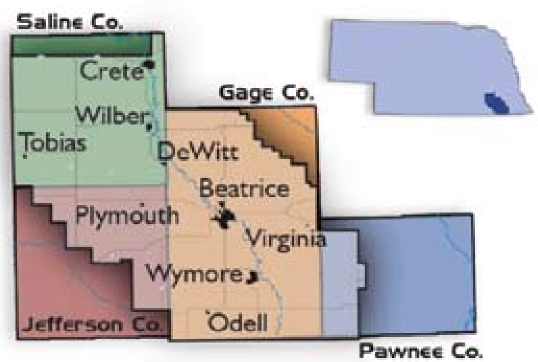


Figure 1. Map of Lower Big Blue NRD, subset of Nebraska

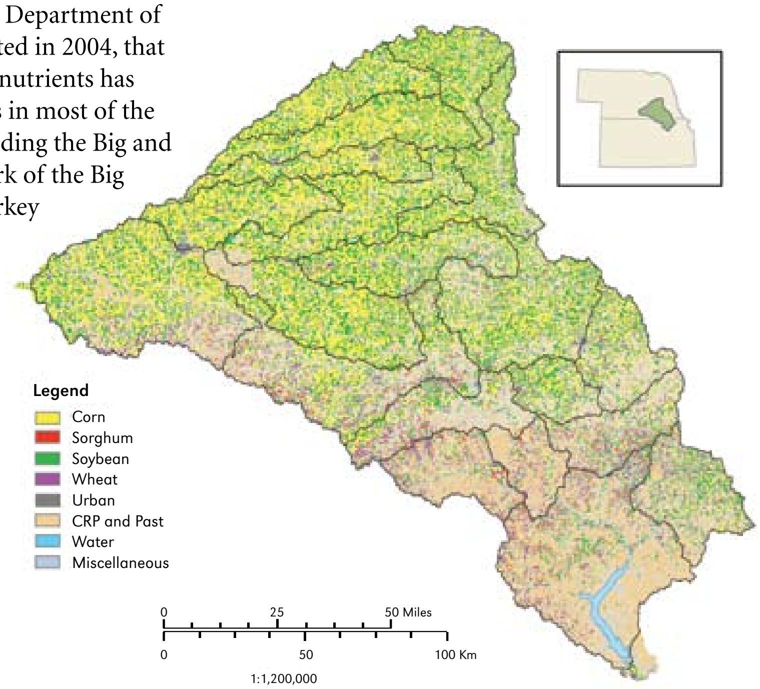


Figure 2. Land cover map of Blue River Basin (2006)

## Tillage Definitions

### No-till

No-till uses a systems approach to crop production where crops are grown with minimal soil disturbance and the soil is kept covered with crop residue to conserve soil and water. Tillage is essentially eliminated with a no-till system. **Continuous no-till** is no-till used for all crops in all years of a rotation.

### Strip-till

Strip-till is a system in which residue-free strips of soil, approximately 6 to 8 inches wide and 4 to 10 inches deep, are tilled ahead of planting using a shank, fluted coulters, or a combination of similar devices. The soil is usually lifted slightly while loosening and shaped to shed rainfall to the residue covered row middles.

### Ridge plant

The ridge plant system uses annual ridges to provide soil warming and internal drainage in the seedbed, making it well suited for poorly drained soils. Planting takes place on top of the ridges with devices on the planter to move some of the surface residue and weed seeds to the row middles.

### Chisel plow

The chisel plow uses narrow points to dig, stir, and break up the soil, leaving a rough surface with about half of the residue remaining. Operating depth is typically 8 to 12 inches. Wide sweeps may be used instead of the chisel points, operated about 6 inches deep, to undercut weeds and leave more residue on the soil surface.

### Disk and field cultivate

Though traditionally a secondary tillage tool, heavy tandem disks, especially those with larger diameter blades, can be used for primary tillage. The disk, typically operated about 6 inches deep, uses rolling blades to loosen the soil surface, kill emerged weeds, and cut up residue and mix it into the soil. A second pass with a disk or a field cultivator can smooth rough soil surfaces.

on conservation buffers, including riparian forest buffers, no-till cropping, and improved nutrient management.

The introduction of glyphosate-resistant soybean and corn varieties along with improvements in no-till planter technology have made it easier for farmers to adopt many of these BMPs. The combined impact of these educational efforts and new technologies has been dramatic, and resulted in greater use of production practices that protect surface water quality.

In 1996, and again in 2006, a producer survey was conducted in the Lower Big Blue Natural Resources District (NRD) (*Figure 1*) to document changes in agronomic practices in the basin during that period.

## Survey Methods

The first survey was the *1996 Big Blue/Little Blue River Basin Farming Practices Study* which surveyed farmer practices across three Nebraska NRDs: Upper Big Blue NRD, Lower Big Blue NRD, and Little Blue NRD. Carried out by the Nebraska Agricultural Statistics Service (NASS), it asked questions regarding production practices used in 1996.

The second survey was the *2006 Blue River Basin Producer Practices Survey* which asked questions regarding production practices used in 2006. It was conducted by UNL Extension only in the Lower Big Blue NRD (Gage and Saline counties, Nebraska). Approximately 85 percent of the survey questions in 2006 were identical to those in 1996 to allow direct comparison of changes in management practices.

Survey methods were the same for both years — randomly selected participants were interviewed in person by trained survey takers. Survey questions specific to in-field practices asked about one randomly selected field with either corn or grain sorghum grown in 2006.

Approximately 100 surveys were completed in the Lower Big Blue NRD in 1996, and 88 surveys were completed in 2006.

In 2006, 69 corn and 19 sorghum fields were selected. More respondents (92 percent) used written records to report survey answers in 2006 than in 1996 (30 percent). The margin of error for a 90 percent level of confidence in 2006 is approximately 9 percent for all responses, 10 percent for corn only, and 19 percent for sorghum only.

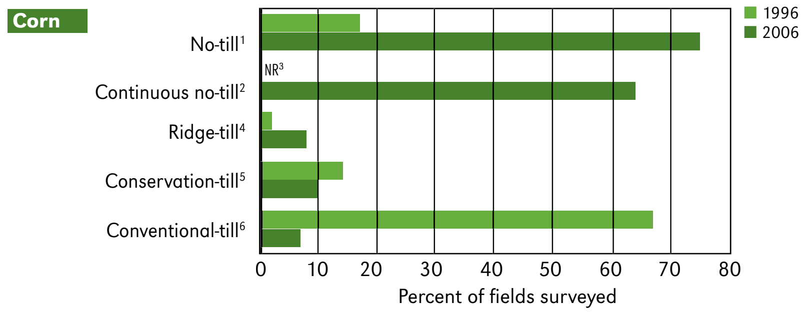


**Figure 3A. Tillage practices in corn in 1996 and 2006.**

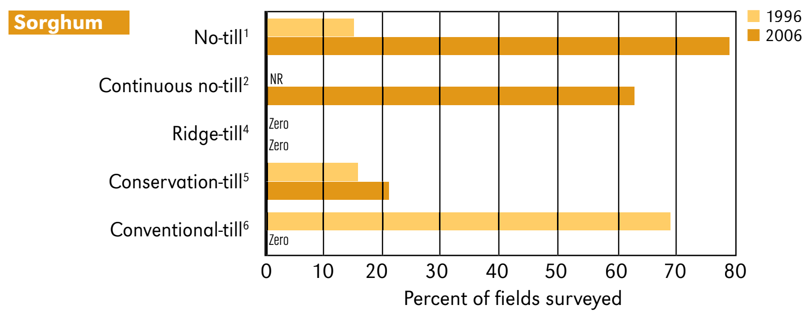


**Figure 3B. Tillage practices in sorghum in1996 and 2006.**

1 No-till as defined as minimal soil disturbance and the soil is kept covered with crop residue.
2 Continuous no-till means that tillage implements are not used for multiple crops within a rotation.
3 Not reported
4 Ridge-till systems use annual ridges to provide soil warming and internal drainage in the seedbed.
5 Conservation-till was defined as >30 percent residue cover at planting.
6 Conventional-till was defined as < 30 percent residue cover at planting.

## Conservation Buffer Definitions

### Grass Filter Strips

Grass filter strips are vegetative buffers that are located along the banks of water courses or at the edge of agricultural fields to filter runoff water, anchor soil particles, and protect banks against scour and erosion. Filter strips keep sediment out of streams, and improve water quality by filtering out fertilizers, pesticides, and microorganisms that otherwise might reach waterways. They provide valuable food, cover, and travel ways for some wildlife species.

### Riparian Forest Buffer

A riparian forest buffer is an area of trees and shrubs located adjacent to streams, lakes, ponds, and wetlands. Riparian forest buffers of sufficient width intercept sediment, nutrients, pesticides, and other materials in surface runoff and reduce nutrients and other pollutants in shallow subsurface water flow. Woody vegetation in buffers provides food and cover for wildlife, stabilizes stream banks, and slows out-of-bank flood flows. Riparian forest buffers are often used in association with a grass filter strip.

## Tillage and Conservation Practices

The use of no-till increased dramatically from 17 percent of corn fields in 1996 to 74 percent in 2006 (*Figure 3A*). The average number of years a field was in no-till increased from 2.1 years in 1996 to 8.5 years in 2006.

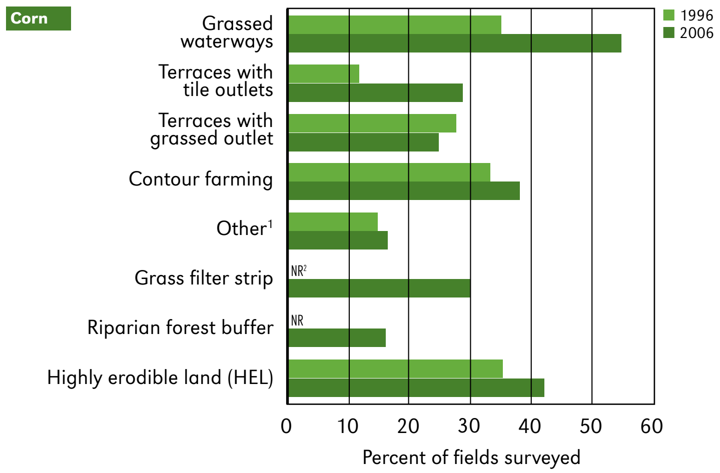


**Figure 4A. Conservation practices used and land classification of corn fields.**

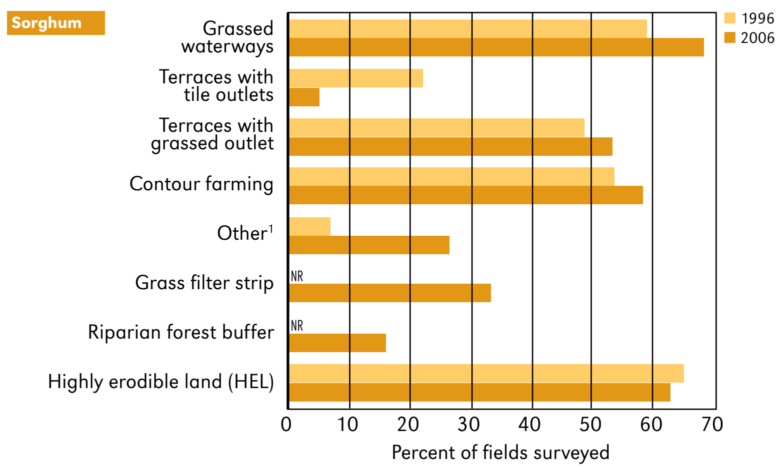


**Figure 4B. Conservation practices used and land classification of sorghum fields.**

1 Other practices include drainage channels, diversions, or sediment basins.
2 Not reported.

The 2006 survey tracked both continuous no-till (no-till every year) and no-till for 2006 only (where the field was tilled for the previous crop), and 64 percent of the fields were in continuous no-till. The increase in no-till came at the expense of conventional-till (less than 30 percent residue cover on the soil surface at planting). The use of ridge-till (plant on ridge with residue moved to furrow) and conservation-till (greater than 30 percent residue on the soil surface at planting) changed little between 1996 and 2006 in corn.

Similar shifts in tillage were observed in sorghum (*Figure 3B*). In 2006, 79 percent of fields were no-tilled compared to only 15 percent in 1996. The average number of years a field was in no-till increased from 2.1 in 1996 to 7.9 in 2006, and 63 percent of the fields were in continuous no-till. There was no appreciable change in the percentage of fields using conservation-till.

The percentage of fields on highly erodible land (HEL), as defined by the Natural Resource Conservation Service, was similar in both surveys and represented about 40 percent of corn and 65 percent of sorghum fields (*Figures 4A* and *4B*).

Since 1996, numerous state and nonprofit agencies, including UNL Extension, have promoted the adoption of structural practices, conservation buffers, and filter strips to prevent or reduce the impacts of soil erosion.

The percent of fields surveyed that had terraces with grassed outlets or contour farming was similar between 1996 and 2006, but the percent of fields surveyed with terraces with tile outlets increased for the corn fields and decreased for the sorghum fields in 2006 (*Figures 4A* and *4B*).

The percent of surveyed fields with grassed waterways increased from 1996 to 2006 for both corn and sorghum fields. Some of these differences in structural practices resulted from sampling individual fields. If a field was on a slope compared to level ground, it likely had some structural practice in place. The results are confounding as to whether a trend existed for increased use of tile outlet terraces.

The 1996 survey did not ask about grass filter strips or riparian buffer strips because they were not promoted extensively before 2000. By 2006, grass filter strips had been installed on 30 percent of corn and 32 percent of sorghum fields surveyed. Riparian forest buffer strips had been installed on 17 percent of corn and 16 percent of sorghum fields surveyed.

The Nebraska Department of Agriculture (NDA) documents adoption of buffers in each NRD through the Nebraska Buffer Strip Program. Overall, adoption of buffers was high in the Lower Big Blue NRD (as of July 2007) compared to the remainder of the state, with 1,339 acres adopted, representing 12 percent of statewide acres in this NDA program. Similarly, the Farm Services Agency (FSA) reports buffer adoption by county through the USDA Continuous Conservation Reserve Program. For Gage and Saline counties combined (representing most of the Lower Big Blue NRD) there were 1,798 acres of grass filter strips and 221 acres of riparian forest buffers installed as of August 2007.

## Cropping Systems

Between 1996 and 2006 there was a reduction in the planting of continuous corn (*Figure 5A*) or continuous sorghum (*Figure 5B*). In 1996, 13 percent of the fields had been in continuous corn for four years, but in 2006 only 1 percent was in continuous corn (*Figure 6A*). Soybeans, either in a corn-soybean or corn-corn-soybean rotation, appear to have replaced some of the continuous corn.

In 1996, 17 percent of sorghum fields were in continuous sorghum for four years, but in 2006 no fields were in continuous sorghum (*Figure 6B*). The data analysis used in 1996 precludes a direct comparison with 2006, but it is likely that the continuous sorghum acres were replaced by rotations that included soybean and wheat. Wheat was used in about 20 percent of the corn rotations and in 60 percent of the sorghum rotations. The percent of fields in a sorghum-soybean rotation remained constant.

In 2006, producers were asked why they selected the particular rotation crops used. Maximizing yield potential was the first or second reason most cited (*Table 1*). Increasing or maintaining soil moisture was an important consideration if sorghum or wheat was in rotation, because these crops are planted on non-irrigated ground more often than corn or soybean.

Soil conservation was cited frequently for all rotations except corn-corn-soybean.

Weed control was an important consideration for rotations that included soybean and the "sorghum with wheat" classification. Including wheat in a rotation can reduce weed pressure through weed lifecycle disruption. Glyphosate-resistant soybeans (introduced in 1996) also reduce weed pressure when used appropriately because glyphosate is highly effective in controling weeds. Soybean was part of the rotation of 94 percent of the fields, and glyphosate-resistant soybeans had been planted in 67 percent of those fields by 2006.

Disease pressure in corn and sorghum historically has not been of high concern to farmers because it is not always obvious, and it is not consistent between years. That has probably changed some since 2006 when southern rust in corn was widespread in south central Nebraska. The yield losses from this disease, coupled with increased promotion of foliar fungicides for corn and soybean, has led to an increased use of fungicides since 2006.

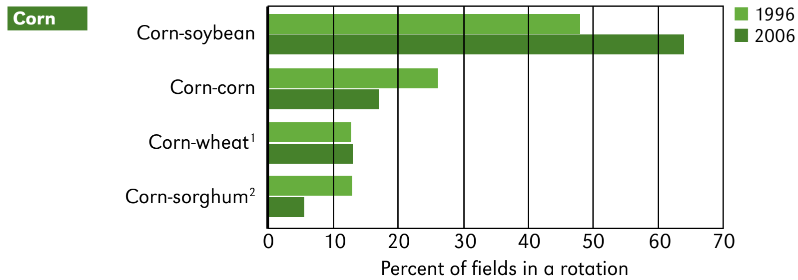


**Figure 5A. Crops used in corn rotations.**

1. In 2006, 37% of respondents reported a 3-year rotation that included sorghum, wheat, and soybean, although not necessarily in that order.
2. In 2006, 16% reported a 4-year rotation that included sorghum, corn, soybean, and wheat, and 5% reported a 3-year rotation that included sorghum, corn, and wheat.

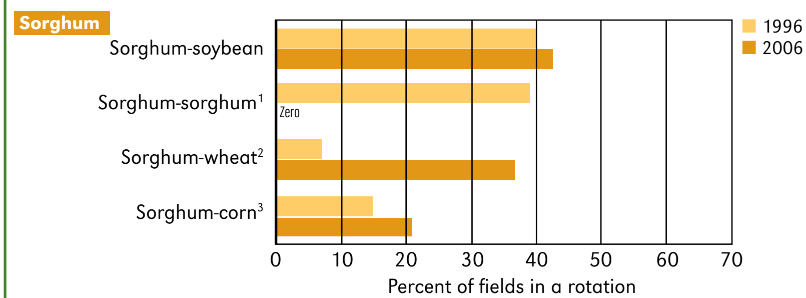


**Figure 5B. Crops used in sorghum rotations.**

1. In 2006, continuous sorghum was not reported by any survey respondent.
2. In 2006, 37% of respondents reported a 3-year rotation that included sorghum, wheat, and soybean, although not necessarily in that order.
3. In 2006, 16% reported a 4-year rotation that included sorghum, corn, soybean, and wheat, and 5% reported a 3-year rotation that included sorghum, corn, and wheat.

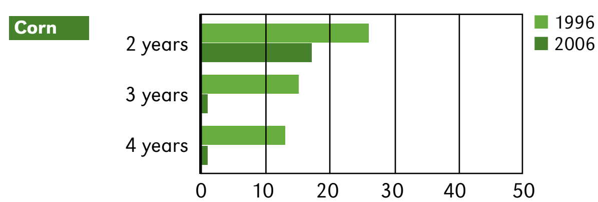


**Figure 6A. Percent of fields planted to corn for consecutive years.**

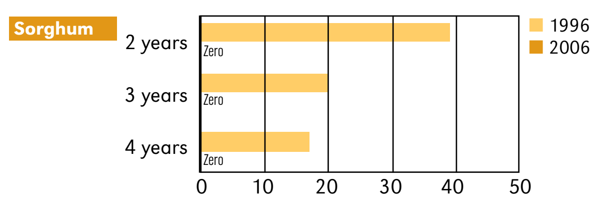


**Figure 6B. Percent of fields planted to sorghum for consecutive years.**

**Table 1. Most frequently-cited reasons for selection of particular rotation crops.** (n=#of reponses in 2006.)

Included landlord requests, more water availability (irrigation), and herbicide availability to address weed problems.

| Rotation | #1 reason (% of fields) | #2 reason (% of fields) | #3 reason (% of fields) |
|---|---|---|---|
| Corn-soy (n=44) | Weed control (91) | Increased yield (89) | Soil conservation (82) |
| Corn-corn-soy (n=7) | Increased yield (100) | Disease control (71)<br>Other (71) | Weed control (57) |
| Corn w/wheat (n=14) | Moisture savings (100) | Increased yield (93)<br>Soil conservation (93) | — |
| Sorghum-soy (n=8) | Increased yield (88)<br>Moisture savings (88) | — | Weed control (75)<br>Soil conservation (75) |
| Sorghum w/wheat (n=11) | Weed control (100) | Increased yield (91)<br>Soil conservation (91)<br>Moisture savings (91) | — |

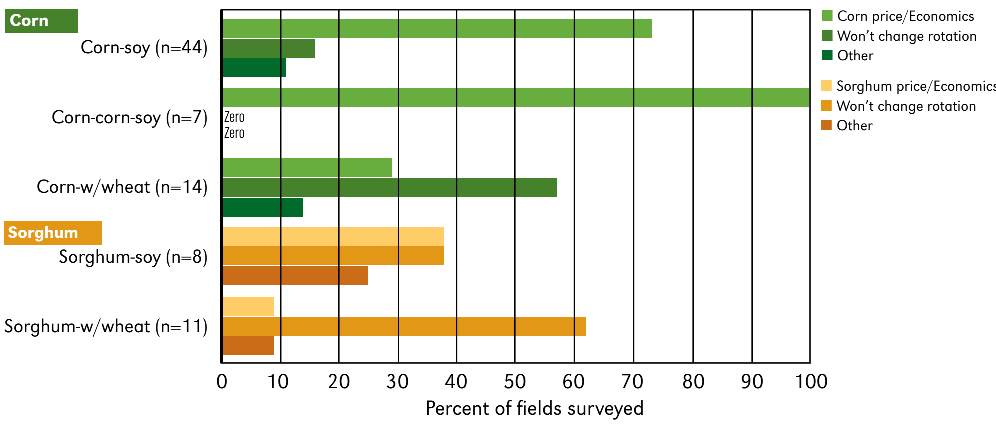


**Figure 7. Reasons to convert rotation to continuous corn.**

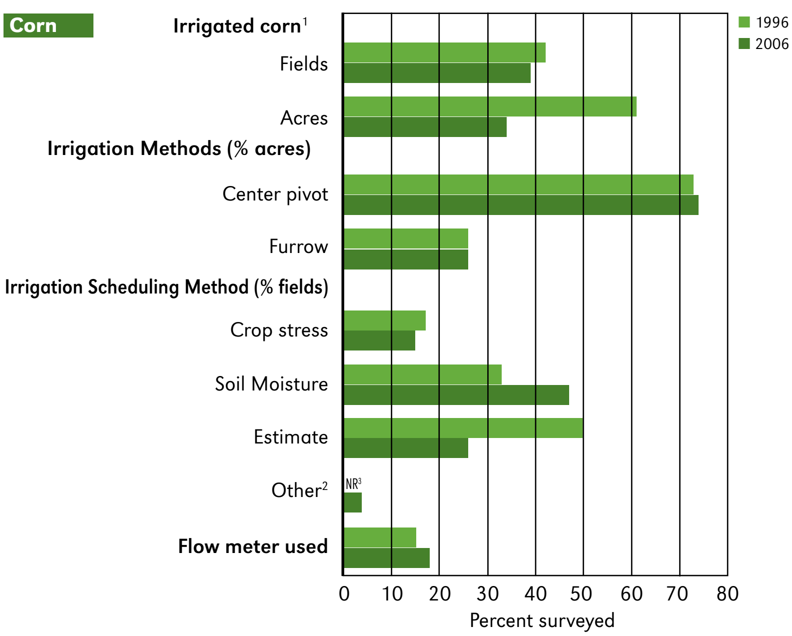


**Figure 8. Irrigation practices for corn in the Lower Big Blue NRD.**

[1] No sorghum acres were irrigated in surveyed fields in 2006, so no data is reported. In 2006, 1,682 irrigated corn acres were represented in the survey.

[2] Other methods in 2006: consultant, probe, and ribbon.

[3] NR = Not Reported

Insect and disease control were the least important reasons for selecting a rotation, except for disease control in the corn-corn-soybean rotation. Insects may be less of a concern because of the recent introduction of Bt corn to control corn borer and corn rootworm.

At the time of the survey, corn prices were increasing. Producers were asked what would motivate them to change their rotation to continuous corn (*Figure 7*). High corn price/positive economic return was a strong motivating factor for producers in corn-soybean and corn-corn-soybean rotations. Other reasons cited for shifting towards continuous corn included landlord requests, availability of irrigation, and availability of herbicides that can address weed problems.

Producers who included wheat in their rotation said they were unlikely to shift to continuous corn, even if corn prices increased.

## Irrigation Practices

A similar percentage of corn fields were irrigated in 1996 (42 percent) and 2006 (39 percent). However, the average size of the irrigated field surveyed was smaller in 2006, and irrigation was used on 61 percent of the corn acres in 1996 compared to 34 percent of corn acres in 2006 (*Figure 8*). Center pivot irrigation was used on a similar percentage of irrigated acres in both 1996 (73 percent) and 2006 (74 percent). Gravity irrigation was used on the same percentage of irrigated acres (26 percent) in both years.

The use of soil moisture measurements to schedule irrigation increased from 33 percent in 1996 to 47 percent of irrigated acres in 2006 (*Figure 8*). The use of "eyeball estimates" to schedule irrigation declined from 50 percent to 26 percent of irrigated fields. Eight percent of fields in 2006 did not use any method to schedule irrigation. The use of flow meters, a useful tool for monitoring irrigation use, was unchanged. The average annual application rate in 2006 was 8.5 inches per acre, and the range was 4 to 21 inches per acre. In 1996, 7.1 inches per acre was the average annual application, with a range of 2 to 12 inches. The interval and intensity of storms within a growing season highly influences the irrigation rate. Estimated monthly precipitation for the region for 1996 and 2006 is shown in *Figure 9*.

## Fertilization

Nitrogen (N) was applied to 99 percent of the acres in 1996 and 100 percent in 2006. The average application rate on corn in 2006 was 132 lb/A, down from 144 lb/ac in 1996. In grain sorghum, the average application rate increased slightly, from 90 lb/ac in 1996 to 97 lb/ac in 2006. Nitrogen application methods changed little between 1996 and 2006 for both crops (*Figure 10A and 10B*). A variable-rate N application was used for at least one application on 9 percent of fields (14 percent of corn acres, 9 percent of sorghum acres). Approximately 5 percent of the acres of both corn and sorghum were treated with a slow release nitrogen fertilizer (data not shown).

The timing of N applications cannot be compared directly between years because of differences in survey wording (*Figure 11*). However, data suggest that the use of fall-applied N in surveyed fields declined dramatically in both corn and sorghum. Nitrogen applied in fall is at greater risk of loss, especially into groundwater, than N applied in spring. Despite the risk of some N loss, fall application of N is often used as a way to distribute workload more evenly throughout the year.

More producers reported using a standard soil test (nitrogen, phosphorus, potassium, pH, and organic matter) in 2006 than in 1996. In corn, it increased from 37 percent of acres in 1996 to 72 percent of acres in 2006, and in sorghum it increased from 12 percent of acres in 1996 to 67 percent of acres in 2006. Deep profile N tests are often a better predictor of crop available N than standard soil tests. In 2006, 33 percent of corn fields (39 percent of corn acres) were tested with a deep-profile nitrogen test compared to 38 percent of corn fields in 1996. Only 4 percent of sorghum fields (11 percent of sorghum acres) in 2006 were tested with a deep-profile nitrogen test compared to 12 percent in 1996.

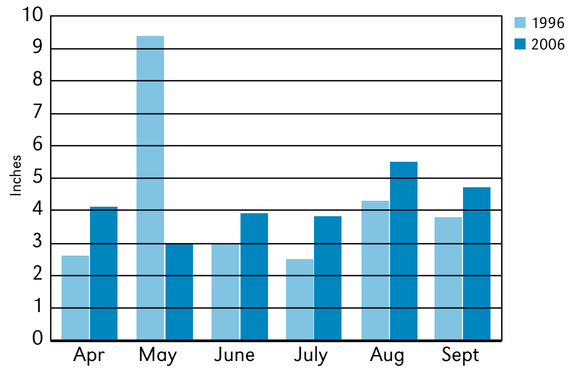


**Figure 9. Monthly precipitation averaged across four locations in Gage and Saline counties**

[1] Data was obtained from the High Plains Regional Climate Center for Crete, Western, Friend, and Virginia, Neb.

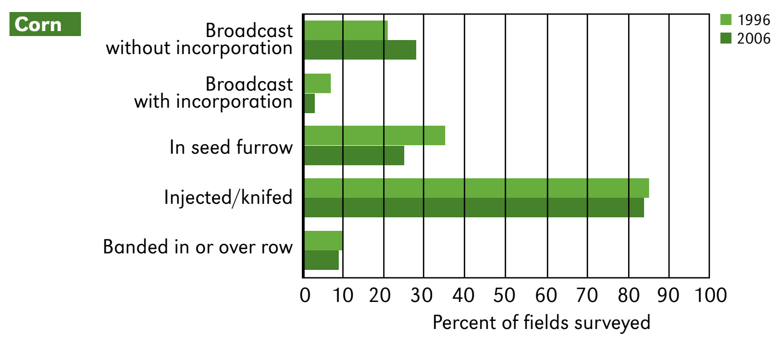


**Figure 10A. Nitrogen application method and annual application rate for corn.**

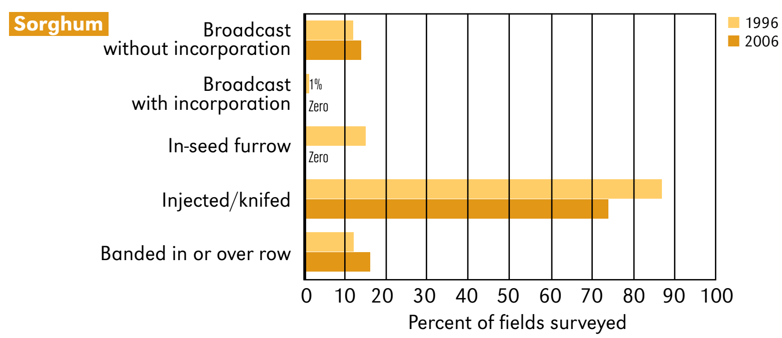


**Figure 10B. Nitrogen application method and annual application rate for sorghum.**

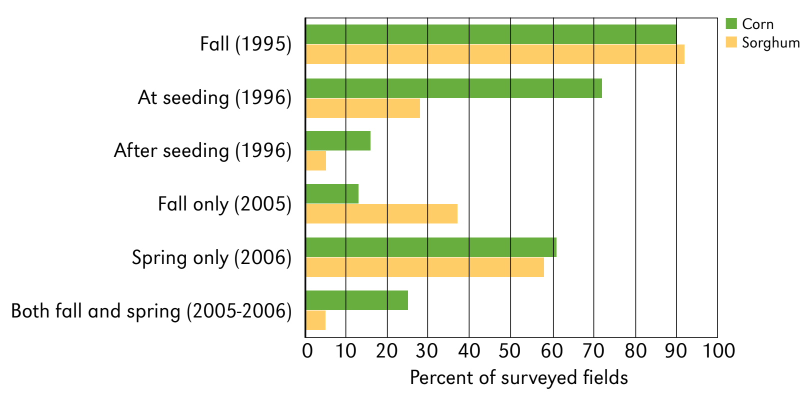


**Figure 11. Nitrogen application timing in corn and sorghum for 1996 and 2006 crops.**

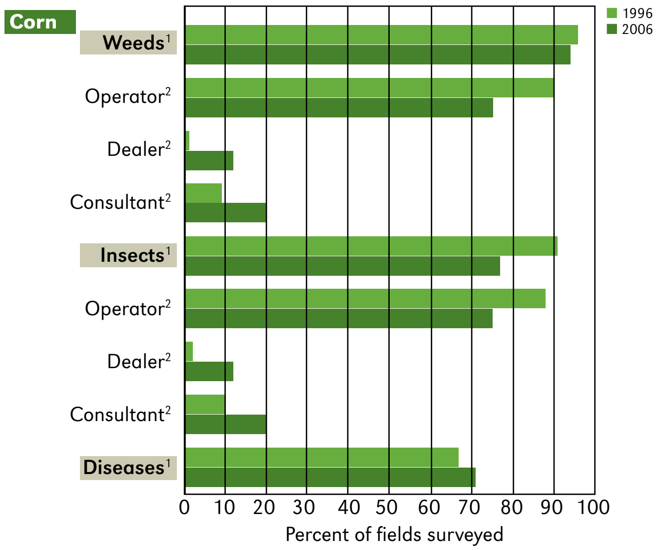


**Figure 12A. Resource used to scout and monitor weed, insect, and plant disease pressure in corn.**

[1] Data within row represents percentage of fields surveyed.
[2] Data within row represents percentage of field where scouting was reported.

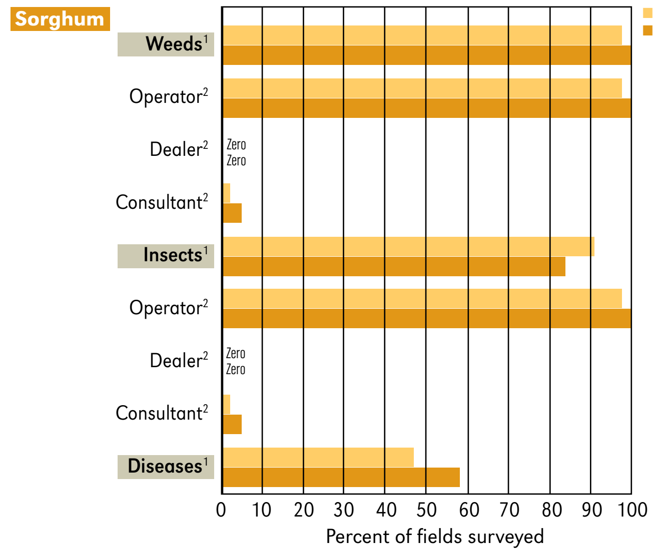


**Figure 12B. Resource used to scout and monitor weed, insect, and plant disease pressure in sorghum.**

[1] Data within row represents percentage of fields surveyed.
[2] Data within row represents percentage of field where scouting was reported.

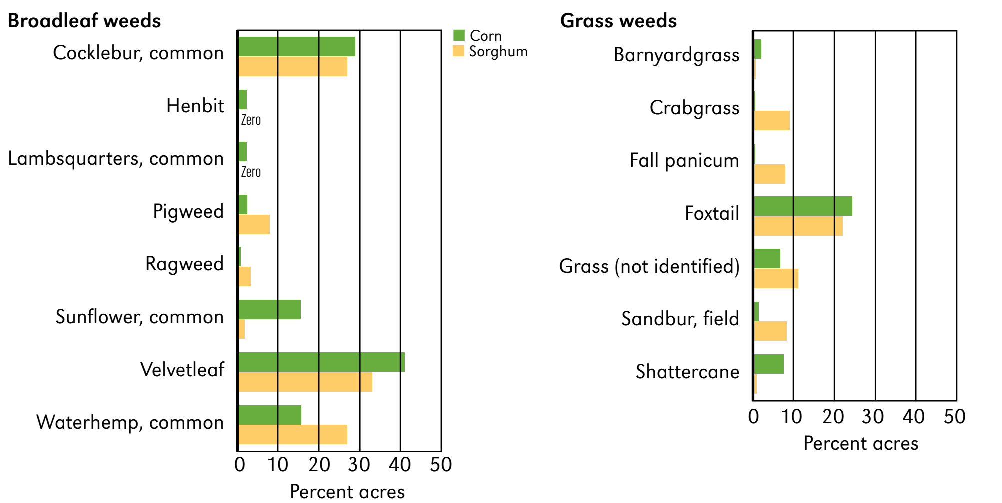


**Figure 13. Weeds[1] targeted for control by herbicide application in 2006. Data represents the percentage of acres described in the survy where the weed is a problem.[2]**

[1] Weeds present on less than one percent of acres include field bindweed, black nightshade, hemp dogbane, horsenettle, marestail (horseweed), prickly lettuce, smartweed, brome grass, Johnsongrass, and volunteer wheat.
[2] Represents 4,988 acres of corn and 785 acres of sorghum

## Pest Management

Scouting fields to measure pest pressure is a critical component of integrated pest management. Done regularly and effectively, it may increase profitability by helping a producer avoid unnecessary pesticide applications or to detect pest problems before they cause an economic yield loss.

The percentage of fields scouted for weed and disease problems was similar between 1996 and 2006 for both corn and sorghum (*Figures 12A* and *12B*). Scouting for insect pressure declined slightly in corn, possibly reflecting the adoption of Bt corn to manage corn borer or corn rootworm instead of the use of insecticides. Corn producers were more likely than sorghum producers to use consultants or dealers to assist in field scouting.

In 2006, growers were asked to list the four most common weeds present in the field and the percentage of acres infested with each weed (*Figure 13*). Velvetleaf, cocklebur, *Amaranthus* species (pigweed and waterhemp), and sunflower were the most common broadleaf weeds reported. Foxtail species were the most common grass weeds.

The spectrum of weeds present differed some between the crops. Sunflowers were more common in corn than in sorghum, and *Amaranthus* species were more common in sorghum than in corn. The percentage of acres infested with late-emerging grass species (crabgrass, fall panicum, and field sandbur) was greater in sorghum than corn. Late-emerging grass and broadleaf species (like *Amaranthus* species) are more difficult to control in sorghum than in corn because of sorghum's later planting date, and because fewer post-emergence herbicides are labeled for sorghum, especially those with activity on grasses and *Amaranthus* biotypes resistant to ALS or triazine herbicides.

Since 1996, UNL Extension pest management training sessions have emphasized practices that reduce the risk of developing pesticide-resistant weeds and insects. More farmers reported rotating herbicide and/or insecticide modes of action to avoid pesticide resistance in 2006 than did in 1996 (*Figure 14*). Farmers appeared to be more concerned with herbicide resistance than insecticide resistance in 2006, perhaps reflecting the decline in the use of insecticides because of the availability of Bt corn.

Several of the most important technological developments between 1996 and 2006 were improved seed treatments and genetically engineered Bt and herbicide resistance traits (*Figure 15A*). In 2006, 52 percent of the corn hybrids were herbicide-resistant, 22 percent were Bt corn rootworm-resistant, and 70 percent were Bt corn borer-resistant.

In 2006, all sorghum seed was treated with Concep II safener to increase tolerance to the chloroacetamide herbicides (metolachlor, alachlor, and dimethenamid). Insecticide-treated corn and sorghum seed was used in more than 75 percent of fields. Use of gray leaf spot-resistant corn hybrids also increased (*Figure 15B*).

The percentage of fields treated with soil-applied insecticides to control corn rootworm declined dramatically, from 32 percent in 1996 to 9 percent in 2006 (data not shown). The soil-applied insecticide treatments applied in 2006 were targeted at corn rootworm and grubs.

No grower reported applying foliar fungicides in 2006. However, given the major yield losses caused by corn diseases in 2006, and industry's promotion of foliar fungicides, the percentage of fields receiving foliar fungicide applications for disease control has undoubtedly increased since 2006. Most corn and sorghum seed comes pretreated with fungicides to protect the seed until it emerges, and no questions were asked about fungicide seed treatments.

There were significant changes in the weed control methods used between 1996 and 2006. These changes correspond to:

1. the shift towards less tillage and the increased reliance on herbicides for weed control,
2. the availability of new herbicide-active ingredients, and
3. the adoption of glyphosate-and glufosinate-resistant crops.

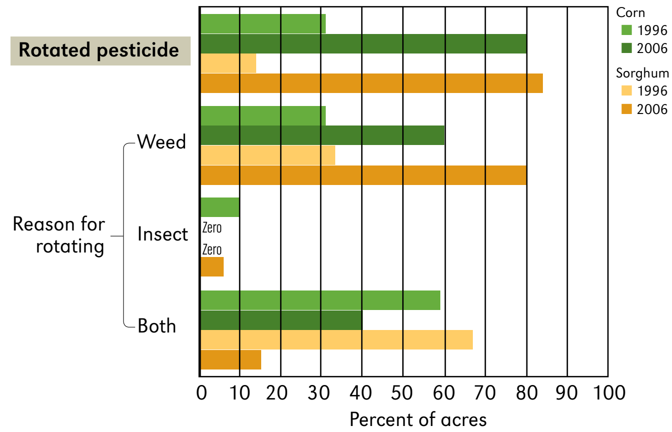


**Figure 14. Rotation of pesticide modes of action to avoid pesticide resistance in weeds or insects, and the reason for the rotation.**

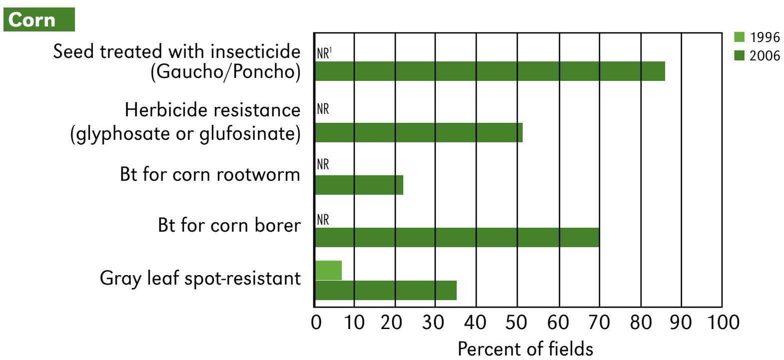


**Figure 15A. Seed treatments and genetically modified traits for corn.**

[1] NR = Not Reported

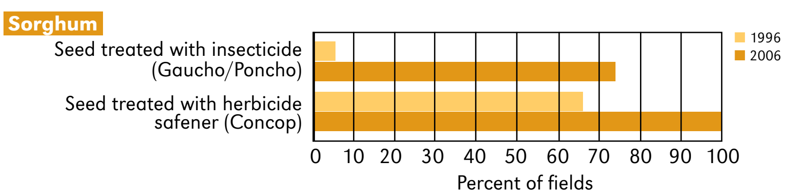


**Figure 15B. Seed treatments and genetically modified traits for sorghum.**

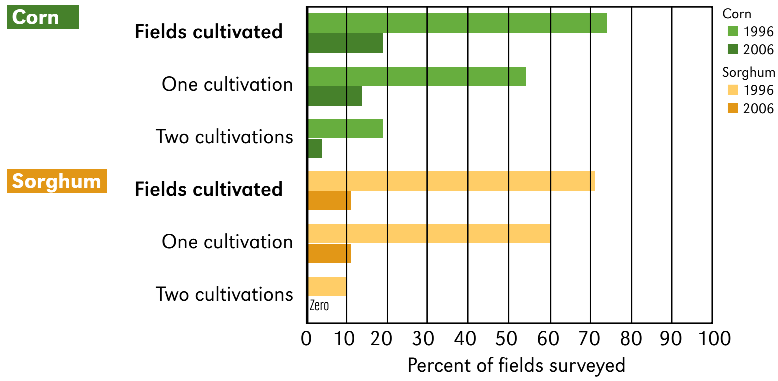


**Figure 16. Use of cultivation for weed control in crops.**

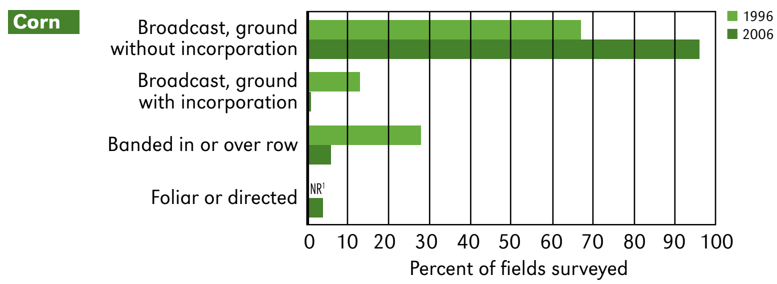


**Figure 17A. Methods used for applying herbicides in surveyed corn fields.**

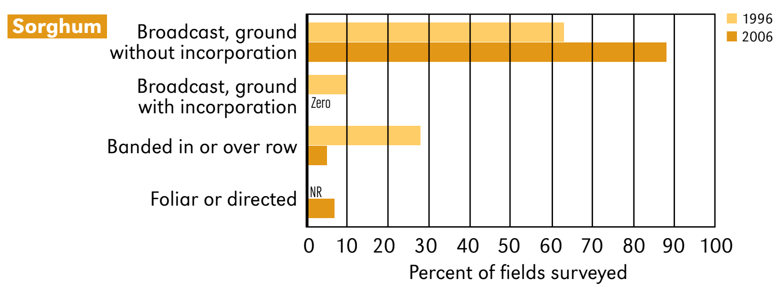


**Figure17B. Methods used for applying herbicides in surveyed sorghum fields.**

1 Not reported in 1996.

The use of three weed control practices declined due to increased no-till. First, fewer acres were cultivated in-crop to control weeds. In 1996, nearly 75 percent of corn and sorghum fields were cultivated at least once, but in 2006 less than 20 percent of fields were cultivated (*Figure 16*). Second, fewer herbicides were banded over the crop row (*Figure 17A* and *17B*). In 1996, 28 percent of corn and sorghum acres had herbicide applications banded over them, but that fell to less than 6 percent in 2006. Third, fewer herbicide applications were incorporated by tillage. No-till can have positive environmental effects by reducing soil erosion and runoff from rainstorms; however, reduced cultivation and banding can mean an increased reliance on broadcast herbicides for weed control.

Broadcast herbicide applications can be more effective at controlling weeds than the combination of cultivation and banding. But broadcasting herbicides increases the risk of herbicide runoff because a larger quantity of herbicide is applied. Using tillage to incorporate herbicides also may reduce the risk of herbicide runoff by moving the herbicides off the soil surface, but that benefit must be weighed against the increased risk of soil erosion caused by the tillage operation.

The timing of herbicide applications and the number of herbicide applications per acre changed dramatically between 1996 and 2006 (*Figure 18A* and *18B*). In both corn and sorghum, the percentage of acres receiving postemergence (after planting) herbicide applications increased.

In sorghum there was also a large increase in acres receiving herbicide applications "before planting." The increase in preemergence applications in sorghum resulted from the increased use of no-till and the need to control weeds with herbicides instead of tillage before planting the crop.

The increase in postemergence herbicide applications resulted from the increased availability of effective herbicides for both crops. Applying herbicides postemergence can be a good Integrated Pest Management (IPM) practice because it allows the producer to target only the weeds present, and moves the application window later in the year when average precipitation is less and the risk of runoff, at least in some years, is lower.

However, from a management standpoint, relying solely on postemergence weed control can be risky if weather conditions prevent timely herbicide applications and weeds are allowed to compete with the crop too long. Most herbicide applications, both preemergence and postemergence, were routine treatments (>60 percent of fields), rather than being based on field mapping of weed populations (0 percent) or scouting for the presence of weeds (<25 percent) (data not shown).

The purpose of the applications was estimated, based on the herbicides used and the timing of application (*Figure 19*) to develop an herbicide use pattern for each field (*Figure 20*). Approximately 85 percent of the corn acres and 100 percent of the sorghum acres received a preplant burndown or preemergence herbicide application that included an herbicide with soil (residual) activity (*Figure 19*).

Postemergence herbicides were applied on 85 percent of the corn acres and 70 percent of the sorghum acres (*Figure 19*). About 70 percent of both corn and sorghum acres received a combination of a preemergence and a postemergence herbicide (*Figure 20*). A little less than half of the postemergence applications included only a non-soil active or minimally soil-active herbicide like glyphosate, glufosinate, or 2,4-D (*Figure 19*). The other half included soil-active herbicides, like atrazine or mesotrione, often in a tank-mix with a non-soil active herbicide.

The strategy of a preemergence application followed by a postemergence application represents a best management practice to (1) protect against early-season yield loss from weeds and (2) reduce the risk of developing herbicide-resistant weeds, if different herbicide modes of action are used. However, the risk of herbicide runoff, especially of atrazine, may not be reduced unless the annual herbicide rate is also reduced.

Between 1996 and 2006 there was little change in who applied herbicides. Either the grower, a family member, or an employee was responsible for applications to about 67 percent of the corn acres and 80 percent of the sorghum acres. The remaining 20 to 33 percent of the acres were treated by custom applicators (data not shown). All growers who responded to the survey were licensed pesticide applicators.

Between 1996 and 2006, the percentage of corn acres treated with atrazine, metolachlor, acetochlor, prosulfuron, and primisulfuron was similar, but use rates of these products declined slightly (*Table 2*). Some decline in use rates may be attributable to adoption of herbicide-resistant hybrids and the availability of more effective postemergence herbicides. Because of these factors, many producers have reduced the rates of preemergence herbicides (atrazine, metolachlor, and acetochlor) compared to use rates they would have applied if they were not planning to apply a postemergence herbicide.

This is a positive change in terms of reducing the risk of atrazine runoff because less atrazine is applied. More corn acres were treated with 2,4-D in 2006 than in 1996, but the use rate in 2006 was lower (*Table 2*). The increased use of 2,4-D was primarily attributable to the need for burndown herbicide applications in no-till farming systems.

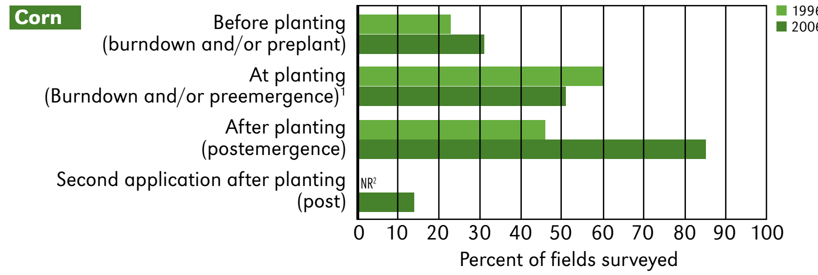


**Figure 18A. Timing of herbicide application in corn.**

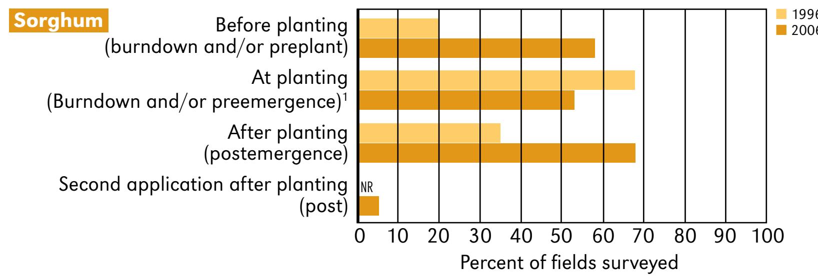


**Figure 18B. Timing of herbicide application in sorghum.**

1 In 2006, "At planting" was defined as "within three days of planting."
2 Not reported in 1996.

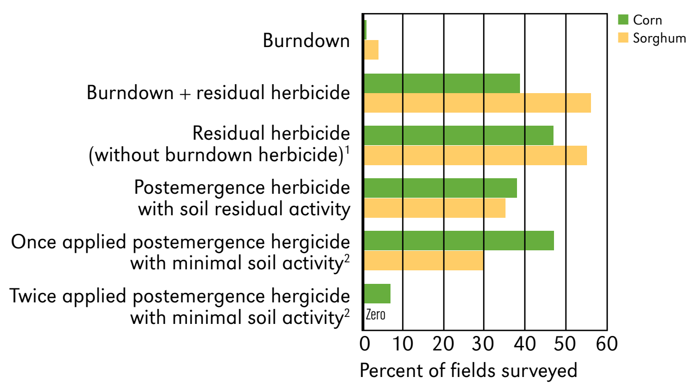


**Figure 19. Purpose of herbicide application in 2006 as estimated by herbicide active ingredients and application timing.**

1 In sorghum, some residual herbicides were split-applied, e.g., one application with the burndown, and a second application at planting.
2 Postemergence herbicides with minimal or no soil activity included 2,4-D, glyphosate, and glufosinate.

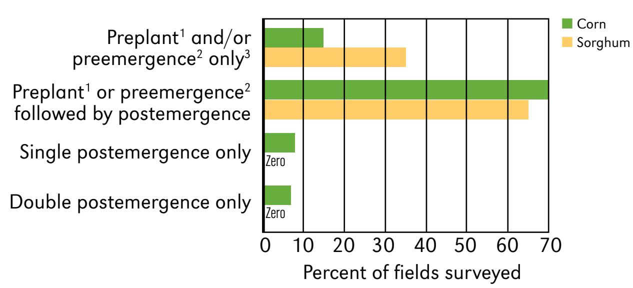


**Figure 20. Herbicide application timing pattern across the growing season in 2006.**

1 Preplant = Residual herbicide or residual herbicide plus burndown herbicide or burndown herbicide only.
2 Preemergence = Residual herbicide or Residual herbicide plus burndown herbicide.
3 In sorghum, some residual herbicides were split-applied, e.g., one application with the burndown and a second application at planting.

Table 2. Herbicide active ingredients (a.i.) and use rates on corn in 1996 and 2006. Detailed information is included only for herbicides used on more than two percent of the acres.

| | 1996[1] | | | | 2006[2] | | | |
|---|---|---|---|---|---|---|---|---|
| Herbicide a.i. | Acres | Appl's | Rate/appl | Rate/yr | Acres | Appl's | Rate/appl | Rate/yr |
| | % | #/ac | lb ai/ac | lb ai/yr | % | #/ac | lb ai/ac | lb ai/yr |
| 2,4-D | 7 | 1.00 | 0.81 | 0.81 | 20 | 1.05 | 0.26 | 0.28 |
| Acetochlor | 18 | 1.00 | 2.00 | 2.00 | 24 | 1.01 | 1.72 | 1.75 |
| Alachlor | 15 | 1.00 | 1.30 | 1.30 | 1 | 1.00 | 1.00 | 1.00 |
| Atrazine | 84 | 1.11 | 1.09 | 1.21 | 86 | 1.14 | 0.91 | 1.04 |
| Dicamba | NR[3] | – | – | – | 4 | 1.00 | 0.17 | 0.17 |
| Glufosinate | NA[4] | – | – | – | 7 | 1.00 | 0.42 | 0.42 |
| Glyphosate[5] | NR | – | – | – | 64 | 1.21 | 0.77 | 0.93 |
| Isoxaflutole | NA | – | – | – | 12 | 1.03 | 0.05 | 0.05 |
| Mesotrione | NA | – | – | – | 31 | 1.09 | 0.10 | 0.11 |
| Metolachlor | 36 | 1.02 | 1.60 | 1.63 | 32 | 1.11 | 1.06 | 1.17 |
| Nicosulfuron | 16 | 1.00 | 0.03 | 0.03 | 5 | 1.00 | 0.017 | 0.017 |
| Primisulfuron | 19 | 1.00 | 0.02 | 0.02 | 15 | 1.00 | 0.022 | 0.022 |
| Prosulfuron | 15 | 1.00 | 0.02 | 0.02 | 17 | 1.00 | 0.008 | 0.008 |
| Rimsulfuron | NA | – | – | – | 8 | 1.00 | 0.011 | 0.011 |
| Thifensulfuron | NA | – | – | – | 4 | 1.00 | 0.006 | 0.006 |

[1] Herbicides that were used on a small percentage of acres in 1996 included pendimethalin, bromoxynil, butylate, cyanazine, , EPTC, halosulfuron.
[2] Herbicides used on less than two percent of the acres in 2006 included carfenzatrone, clopyralid, dimethenamid-P, flufencet, and halosulfuron.
[3] NR = not reported. The herbicide was used in the basin, but the data was not reported because of small sample size.
[4] NA = not available for use because it had not been labeled for use, or use of the active ingredient was not reported in 1996 in the Lower Big Blue NRD.
[5] Application rate for glyphosate is in pounds of acid equivalent per acre.

Table 3. Herbicide active ingredients (a.i.) and use rates on sorghum in 1996 and 2006. Detailed information is included only for herbicides used on more than two percent of the acres.

| | 1996[1] | | | | 2006 | | | |
|---|---|---|---|---|---|---|---|---|
| Herbicide a.i. | Acres | Appl's | Rate/appl | Rate/yr | Acres | Appl's | Rate/appl | Rate/yr |
| | % | #/ac | lb ai/ac | lb ai/yr | % | #/ac | lb ai/ac | lb ai/yr |
| 2,4-D | 23 | 1.00 | 0.19 | 0.19 | 61 | 1.23 | 0.219 | 0.269 |
| Alachlor | 30 | 1.00 | 1.90 | 1.90 | 7 | 1.00 | 1.95 | 1.95 |
| Atrazine | 87 | 1.10 | 1.14 | 1.26 | 100 | 1.26 | 1.33 | 1.68 |
| Bromoxynil | NR[2] | – | – | – | 9 | 1.00 | 0.26 | 0.26 |
| Dimethenamid-P | NA[3] | – | – | – | 16 | 1.63 | 0.53 | 0.86 |
| Glyphosate[4] | NR | – | – | – | 68 | 1.15 | 0.76 | 0.87 |
| Halosulfuron | NA | – | – | – | 14 | 1.00 | 0.03 | 0.03 |
| Metolachlor | 33 | 1.20 | 1.39 | 1.66 | 78 | 1.09 | 1.16 | 1.26 |
| Propachlor | 13 | 1.00 | 2.05 | 2.05 | NA | – | – | – |
| Prosulfuron | NA | – | – | – | 7 | 1.00 | 0.009 | 0.009 |

[1] Herbicides that were used on a small percentage of acres in 1996 included paraquat.
[2] NR = not reported. The herbicide was used in the basin, but the data was not reported because of small sample size.
[3] NA = not available for use because it had not been labeled for use, or use of the active ingredient was not reported in 1996 in the Lower Big Blue NRD.
[4] Application rate for glyphosate is in pounds of acid equivalent per acre.

Use of alachlor and nicosulfuron declined sharply from 1996 to 2006, due to a lack of marketing (alachlor) and the availability of glyphosate for postemergence grass control in corn (nicosulfuron). Glyphosate was applied on 64 percent of the acres, and was used as both a burndown and a postemergence herbicide. Four new (introduced since 1996) herbicide active ingredients — glufosinate, isoxaflutole, mesotrione and rimsulfuron — were applied to a significant percentage of acres.

In sorghum, the percentage of acres treated with atrazine, metolachlor, and 2,4-D increased from 1996 to 2006 (*Table 3*). Much of the use of 2,4-D was as a burndown herbicide.

Little glyphosate was applied to sorghum in 1996, but 68 percent of the acres were treated with glyphosate in burndown applications in 2006.

Other herbicides not widely used in sorghum in 1996 but used on a sizable percentage of acres in 2006 were bromoxynil, dimethenamid-P, halosulfuron, and prosulfuron. From 1996 to 2006 the application rates of atrazine increased, but those of metolachlor declined.

The adoption of no-till in sorghum has placed greater pressure on herbicides for weed control. Fewer herbicides are labeled for use in sorghum than for use in corn. The need for more herbicide applications (burndown, preemergence, and postemergence) compared to a conventional tillage system (preemergence and postemergence), and the inexpensive cost and effectiveness of atrazine for weed control at all three application timings has led to its increased use.

## Sources of Information Used

Farm supply outlets, UNL Extension, and consultants were the primary sources of information on pesticide control for producers (*Figure 21A* and *Figure 21B*). Growers reported greater use of the Internet and information from other growers in 2006 than in 1996. However, data collected in 2006 is not directly comparable to that collected in 1996, because growers were allowed to list multiple "primary" sources in 2006. There was increased use of Extension training — in 2006, 53 percent attended an Extension training within the previous year, compared to 25 percent in 1996.

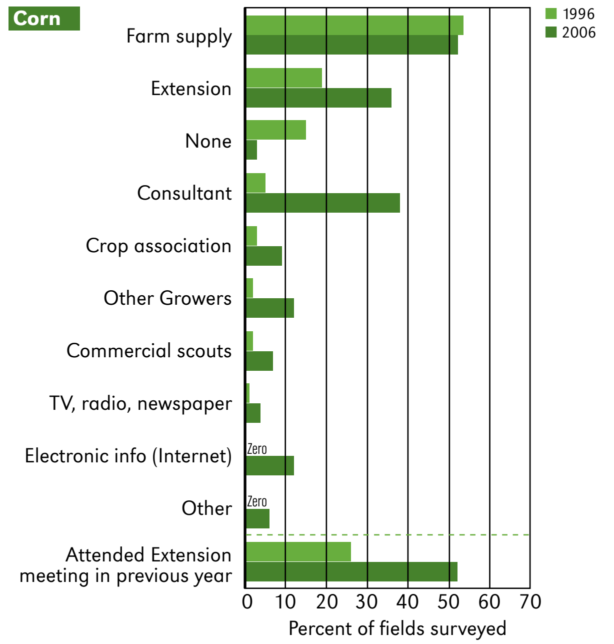


**Figure 21A. Primary sources for information on pest management for corn, and attendance at UNL Extension training sessions.**

[1] In 2006, producers listed more than one primary source, so total of all sources is greater than 100 percent. In 1996, only one primary source was listed.

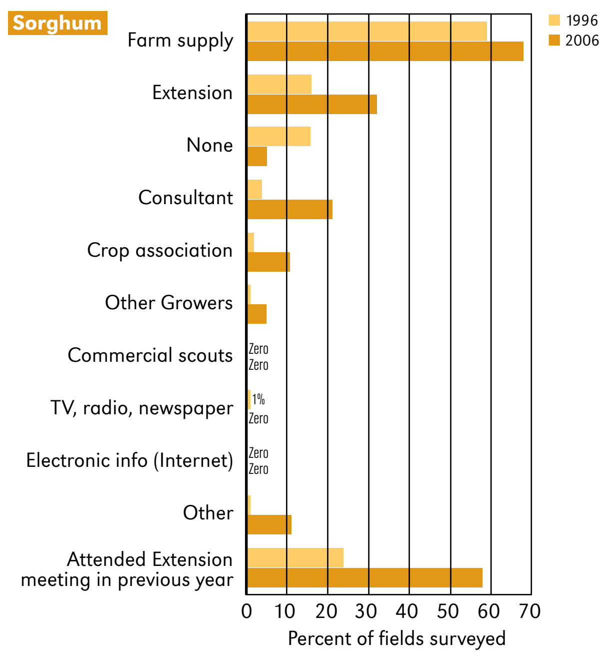


**Figure 21B. Primary sources for information on pest management for sorghum, and attendance at UNL Extension training sessions.**

## Summary

Between 1996 and 2006, corn and sorghum farmers in the Big Blue River Basin in Southeast Nebraska adopted numerous best management practices (BMPs) to help increase yield potential, reduce costs, and minimize environmental impacts.

- The use of no-till increased dramatically from 17 percent of corn fields in 1996 to 74 percent in 2006, and 64 percent of corn fields were in continuous no-till. Similar shifts in tillage were observed in sorghum.
- By 2006, grass filter strips were installed on 30 percent of corn and 32 percent of sorghum fields; riparian forest buffer strips had been installed on 17 percent of corn and 16 percent of sorghum fields.
- The use of soil moisture measurements to schedule irrigation increased from 33 percent in 1996 to 47 percent in 2006. This often enables more efficient use of irrigation water.
- More farmers reported rotating herbicide and/or insecticide modes of action to avoid pesticide resistance in 2006 than did in 1996.
- More farmers reported rotating herbicide and/or insecticide modes of action to avoid pesticide resistance in 2006 than did in 1996.
- In both corn and sorghum, the percent of acres receiving postemergence herbicide applications increased from 1996 to 2006, and in sorghum there was also a large increase in acres receiving herbicide applications before planting. Applying herbicides postemergence allows the producer to target applications only to weeds that are present, and moves the application window later in the year when the risk of runoff may be lower.
- About 70 percent of both corn and sorghum acres received a combination of a preemergence and a postemergence herbicide in 2006.
- In corn, the percent of acres treated with atrazine, metolachlor, acetochlor, prosulfuron and primisulfuron was similar between 1996 and 2006, but the use rates of these products declined slightly. The atrazine use rate in corn went down approximately 14 percent. However, the atrazine use rate in grain sorghum increased between 1996 and 2006.
- Mesotrione, isoxaflutole, glufosinate, and rimsulfuron were applied to a large percentage of corn acres in 2006, but were not available for use in 1996. Use of 2,4-D and glyphosate increased, in part, to control winter annual weeds on no-till fields and the adoption of glyphosate-resistant corn hybrids.
- Farm supply outlets, UNL Extension, and consultants were the primary sources of information on pesticide control for producers. In 2006, 53 percent of growers attended an Extension training meeting within the previous year, compared to 25 percent in 1996.

Although many producers have adopted practices that increase productivity and reduce pesticide loss, atrazine contamination of surface waters is still a frequent problem in the Blue River Basin. Greater adoption of the best management practices described above, and additional changes in how pesticides are used, are still necessary to protect the environmental quality of this region.

## References

Nebraska Department of Agriculture, Division of Agricultural Statistics. 1996. "Big Blue/Little Blue River Basin Farming Practices Study."

Nebraska Department of Environmental Quality. 2004. "2004 Surface Water Quality Integrated Report." *http://www.deq.state.ne.us/.*

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