January 17 & 18, 2012

The Gateway in Oberlin, KS

Joint Effort of:
Kansas State University
Northwest Kansas Crop Residue Alliance
# Table of Contents

Crop Rotations with Limited Irrigation  
*Alan Schlegel, K-State Agronomist - Tribune*  

Enhanced Fertilizer Products  
*Kent Martin, K-State Agronomist - Garden City*  

Kochia: Growth Regulator Resistance  
*Phil Westra, Colorado State Weed Scientist*  

Kochia History, Biology & Implications of Glyphosate Resistance  
*Phil Stahlman, K-State Weed Scientist - Hays*  

Kochia Recommendations for Row Crops  
*Curtis Thompson, K-State Weed Scientist*  

Kochia Recommendations for Wheat & Fallow  
*Phil Stahlman, K-State Weed Scientist - Hays*  

Palmer and Marestail Control  
*Dallai Peterson, K-State Weed Scientist*  

Sprayer Set-up  
*Bob Klein, University of Nebraska Agronomist*  

Trends in Crop Leases  
*Troy Dumler, K-State Agriculture Economist*  

Utilizing Yield Monitor Data  
*Lucas Haag, K-State PhD Student in Crop Production*  

Utility of Cover Crops  
*John Holman, K-State Agronomist - Garden City*  

Vertical Tillage and Corn Production  
*DeAnn Presley, K-State Environmental Soil Scientist*  

Useful Agronomy Websites  

Sponsors  
*Platinum Sponsors*  
*Gold Sponsors*  
*Silver Sponsors*  

Notes Pages  

Schedule for the day  

Back Cover

K-State Research and Extension is an equal opportunity provider and employer.

Crop Rotations with Limited Irrigation

Alan Schlegel, Loyd Stone, and Troy Dumler
Kansas State University

Abstract. Research was initiated in 2001 and conducted through 2010 under sprinkler irrigation in western Kansas to evaluate limited irrigation in several no-till crop rotations on grain yield, water use, and profitability. Crop rotations were 1) continuous corn, 2) corn-winter wheat, 3) corn-wheat-grain sorghum, and 4) corn-wheat-grain sorghum-soybean. Irrigation was limited to 10 inches annually with 5 inches applied to wheat, 15 inches to corn (when in rotation with wheat), and 10 inches to grain sorghum, soybean, and continuous corn. Crop water productivity and yield of corn was greater when grown in rotation than with continuous corn. The length of the rotation did not affect grain yield or crop water productivity of grain sorghum or winter wheat. Continuous corn was generally the most profitable cropping system. However, relatively small changes in prices or yields could result in multi-crop rotations being more profitable, indicating the potential for alternate crop rotations to reduce risk under limited irrigation.

Introduction

Irrigated crop production is an important component of agriculture in western Kansas. However, with declining water levels in the Ogallala Aquifer and high energy costs, optimal utilization of limited irrigation water is required. Precipitation is limited and sporadic in the region with annual precipitation supplying about 60-90% of the seasonal water requirement for grain sorghum and only 50-75% for corn (Doorenbos and Kassam, 1979). While crop rotations have been used extensively in many dryland systems, the most common crop grown under irrigation in western Kansas is corn (about 50% of the irrigated acres), often in a continuous corn system. While corn responds well to irrigation, it also requires substantial amounts of water to maximize production. Almost all of the groundwater pumped from the High Plains (Ogallala) Aquifer is used for irrigation (97% of the groundwater pumped in western Kansas in 1995 [Kansas Department of Agriculture, 1997]) with 57% applied to corn (Kansas Water Office, 1997). This amount of water withdrawal from the aquifer has reduced saturated thickness in some areas up to 150 ft. Although crops other than corn are grown under irrigation, they have not been grown as extensively because of relatively inexpensive water and a ready market for corn to the livestock feeding industry in the area. The trend in western Kansas during the 1990s has been towards increasing acreage of irrigated corn (665,000 acres in 1990 compared with 1.2 million acres in 2000) with corresponding reductions in grain sorghum (326,000 acres in 1990 compared with 71,000 acres in 2000) and winter wheat (692,000 acres in 1990 compared with 455,000 acres in 2000) (Kansas Farm Facts, 1991 and 2001). Although corn is expected to remain the dominant irrigated grain crop (especially in areas with abundant groundwater), the need exists to develop strategies to more effectively utilize limited irrigation water for corn. While there have been increases in irrigated soybean acreage (71,000 acres in 1990 compared with 134,000 acres in 2000), there has been limited research on water use characteristics in western Kansas.

Alternative crop management practices are needed to reduce the amount of irrigation water required while striving to maintain economic returns sufficient for producer sustainability. To prepare for less water available for irrigation in the future, whether from physical constraints
(lower well capacities and declining water tables) or from regulatory limitations, information on crop productivity and profitability with less irrigation water will be beneficial for agricultural sustainability.

Materials and Methods

A field study was conducted at the Kansas State University Southwest Research-Extension Center near Tribune, KS from 2001 to 2010 on a deep silt loam soil (Ulysses silt loam [fine-silty, mixed, superactive, mesic Aridic Haplustolls]). Only data collected beginning in 2003 are presented to allow time for establishment of the crop rotations. The region is semi arid with a summer precipitation pattern and an average annual precipitation of 440 mm. The study consisted of four crop rotations; continuous corn (CC), corn-winter wheat (CW), corn-winter wheat-grain sorghum (CWS), and corn-winter wheat-grain-sorghum-soybean (CWSB). Each phase of each rotation was present each year and replicated four times. The plots were approximately 60 ft wide and 120 ft long. Irrigations were scheduled to supply water at the most critical stress periods (near flowering) for the specific crop and were limited to 1.5 inches per week. If precipitation was sufficient within a week, then irrigation was postponed. In some years, the maximum amount of irrigation was not applied because of above normal precipitation. The average first irrigation was 14 June for corn in rotation, 23 June for continuous corn, and 4 July for sorghum and soybean. The final irrigation averaged 28 August for corn in rotation, 15 August for continuous corn, and 22 August for sorghum and soybean. If needed to aid emergence of wheat, irrigation was initiated in the fall (four years) otherwise irrigation was reserved for spring application with average final irrigation on 6 June.

Average plantings dates were 3 May for corn, 20 May for soybean, and 27 May for grain sorghum. Winter wheat was planted after corn harvest (average of 1 October). Cultural practices (e.g., pesticides, tillage, and fertilization) typical for the region were used in all years of the study. The center portion of all plots was machine harvested with grain yields adjusted to 15.5% moisture (wet basis) for corn, 13% for soybean, and 12.5% for sorghum and wheat. Plant densities were determined along with the other yield components (kernels/ear and kernel mass).

The plots were irrigated with a linear move sprinkler irrigation system which had been modified to allow for water application from different span sections as needed to accomplish the randomization of plots. Soil water measurements (8-ft depth in 1-ft increments) were taken throughout the growing season using neutron attenuation. Available soil water was calculated by subtracting unavailable water from measured soil water. All water inputs, precipitation and irrigation, were measured. Crop water use was calculated by summing soil water depletion (soil water near emergence less soil water at harvest) plus in-season irrigation and precipitation. Non-growing season soil water accumulation was the increase in soil water from harvest to the amount at emergence the following year. Precipitation storage efficiency was calculated as non-growing season soil water accumulation divided by non-growing season precipitation. Crop water productivity (WP) was calculated as grain yield (bu acre⁻¹) divided by crop water use (inches).

Statistical analyses were performed using the GLM procedure from SAS version 9.1 (SAS Institute, Cary, North Carolina).

Local crop prices and input costs were used to perform an economic analysis to determine net
return to land, management, and irrigation equipment for each treatment. Custom rates were used for all machine operations. Harvest prices and input costs were kept uniform for all years based on 2010 prices.

The objectives of this research were to determine the effect of limited irrigation on crop yield, water use, and profitability in several crop rotations.

Results and Discussion

All rotations were limited to an average of 10 inches of irrigation annually; however, corn following wheat received 15 inches because the wheat received only 5 inches. This extra 5 inches of irrigation water increased the level of irrigation to nearly full and increased corn yields about 40 bu acre\(^{-1}\) compared with continuous corn (Table 1). Thus, limited irrigated corn yielded about 80% of full irrigation. Klocke et al. (2007) reported that limited irrigation (no more than 6 in water) yields were 80 to 90% of fully irrigated yields. Corn yields in the multi-crop rotations were similar regardless of length of rotation. Wheat and grain sorghum yields were similar in all rotations.

Table 1. Average grain yields of four crops as affected by crop rotation, KSU South-west Research-Extension Center, Tribune, KS, 2003-2010.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Crop rotation(\d)</th>
<th>CC</th>
<th>CW</th>
<th>CWS</th>
<th>CWSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>163 b(\d)</td>
<td>203 a</td>
<td>202 a</td>
<td>203 a</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td></td>
<td>35 a</td>
<td>36 a</td>
<td>37 a</td>
</tr>
<tr>
<td>Sorghum</td>
<td></td>
<td></td>
<td></td>
<td>134 a</td>
<td>138 a</td>
</tr>
<tr>
<td>Soybean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>43</td>
</tr>
</tbody>
</table>

\(\d\) CC = continuous corn; CW = corn-wheat; CWS = corn-wheat-grain sorghum; CWSB = corn-wheat-grain sorghum-soybean.

\(\d\) Means within a row with different letters are significantly different \((P\leq0.05)\).

Crop water productivity was in the order of corn>sorghum>wheat=soybean (Table 2). Crop water productivity of corn was increased when irrigation was increased to 15 inches and grown in rotation with other crops. Grain sorghum grown in 4-yr rotations had slightly greater crop water productivity than grown in 3-yr rotations. The length of rotation had no effect on crop water productivity of wheat.
Table 2. Average crop water productivity of four crops as affected by crop rotation, KSU Southwest Research-Extension Center, Tribune, KS, 2003-2010.

<table>
<thead>
<tr>
<th>Crop</th>
<th>CC</th>
<th>CW</th>
<th>CWGS</th>
<th>CWSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>377 b†</td>
<td>411 a</td>
<td>398 a</td>
<td>410 a</td>
</tr>
<tr>
<td>Wheat</td>
<td>—</td>
<td>115 a</td>
<td>125 a</td>
<td>122 a</td>
</tr>
<tr>
<td>Sorghum</td>
<td>—</td>
<td>—</td>
<td>314 b</td>
<td>326 a</td>
</tr>
<tr>
<td>Soybean</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>110</td>
</tr>
</tbody>
</table>

† CC = continuous corn; CW = corn-wheat; CWS = corn-wheat-grain sorghum; CWSB = corn-wheat-grain sorghum-soybean.
‡ Means within a row with different letters are significantly different (P≤0.05).

An economic analysis (based on grain prices and input costs in 2010 with average crop yields) found that the most profitable crop was corn in rotation with other crops (Table 3). Profitability was similar for grain sorghum and soybean in the 3- and 4-yr rotations. The least profitable crop was wheat, primarily because of reduced yields caused by hail and spring freeze injury in about 50% of the years. However, the most profitable crop rotation was continuous corn. All multi-crop rotations had net returns of $57-69 acre⁻¹ less than CC. Lower returns in the multi-crop rotations were due to low returns from wheat.

Table 3. Net return to land, irrigation equipment, and management from four crop rotations, KSU Southwest Research-Extension Center, Tribune, KS, 2003-2010.

<table>
<thead>
<tr>
<th>Crop</th>
<th>CC</th>
<th>CW</th>
<th>CWS</th>
<th>CWSB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>237</td>
<td>332</td>
<td>326</td>
<td>321</td>
</tr>
<tr>
<td>Wheat</td>
<td>—</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Sorghum</td>
<td>—</td>
<td>—</td>
<td>189</td>
<td>198</td>
</tr>
<tr>
<td>Soybean</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>198</td>
</tr>
<tr>
<td>Net for rotation</td>
<td>237</td>
<td>168</td>
<td>172</td>
<td>180</td>
</tr>
</tbody>
</table>

† CC = continuous corn; CW = corn-wheat; CWS = corn-wheat-grain sorghum; CWSB = corn-wheat-grain sorghum-soybean.

Conclusions

With limited irrigation (10 inches annually), continuous corn has been more profitable than multi-crop rotations including wheat, sorghum, and soybean primarily because of spring freeze and hail damage to wheat in the multi-crop rotations. In multi-crop rotations, relatively poor results with one crop (in this case wheat) can reduce profitability compared with a monoculture, especially when the monoculture crop does well. However, the multi-crop rotation can reduce economic risk when the monoculture crop does not perform as well. All multi-crop rotations had
net returns only $12-24$ acre$^{-1}$ less than continuous corn. Therefore, relatively small changes in prices or yields could result in any of the rotations being more profitable than continuous corn, indicating the potential for alternate crop rotations under limited irrigation.

**Acknowledgements**

This research was supported in part by the Ogallala Aquifer Program, a consortium between USDA Agricultural Research Service, Kansas State University, Texas AgriLife Research, Texas AgriLife Extension Service, Texas Tech University, and West Texas A&M University. This paper was originally presented at Innovations in Irrigation Conference, San Diego, CA 6 Nov. 2011.

**References**


Nitrogen Extenders and Additives

D.W. Franzen
NDSU Extension Soil Specialist
NCERA-103 Committee
North Dakota State University

Nitrogen management continues to be difficult due to transformations of nitrogen fertilizers that are possible when applied to soil and the uncertainties of weather (Cabral et al., 2008). Nitrogen (N) fertilizer in the form of urea is subject to ammonia volatilization through the activity of the urease enzyme found ubiquitously in soil (Kissel et al., 2008). Nitrate fertilizer is subject to leaching (Randall et al., 2008) or denitrification (Coyne, 2008), depending on the water content of the soil and water movement through the soil. Ammonium forms of N can be fixed (Kissel et al., 2008) or transformed to nitrate through the activities of specific soil bacteria (Norton, 2008). Because of these and other processes, nitrogen use efficiency is low.

Nitrogen often is applied to crops in the north-central region of the U.S. before planting. During the first four to six weeks after planting, corn will require only about 5 percent of the N applied. The following two to four weeks of growth require a large proportion of the total seasonal N requirement.

In winter wheat, very low levels of N are required for overwintering. However, once wheat breaks dormancy, a large proportion of N is required during the next few weeks. In spring wheat, a small amount of N is required to establish the crop during the first two to four weeks after seeding; however, most of the remaining N is required during the next 30 days.

To address some of the delayed N requirement issues of winter wheat, much of the crop is top-dressed in the spring. In corn, some growers use side-dress applications; however, spring preplant application is most common, with fall application preferred by growers in some Northern states. In spring wheat in the northern Plains, some post-N applications are made.

Because of the lack of rain during the growing season in many years, post-N applications as a source of most of the N requirement are discouraged except under irrigation. To increase nitrogen use efficiency and thereby increase yields or decrease N rates, a number of products have been developed to delay an N transformation process so that the period of time in which the N source is available for uptake is closer to the time the crop needs the available N. These products can be classified into the following groups: nitrification inhibitors, urease inhibitor additives, and nitrification and urease inhibitors.

Nitrification Inhibitors

Nitrapyrin

N-Serve, or nitrapyrin (2-chloro-6-[trichloromethyl] pyridine) has been studied and commercially used since the late-1960s. Work by Janssen (1969), summarized by Hergert and Wiese (1980), showed that nitrapyrin was active as a nitrification inhibitor and that the degree of nitrification was influenced by the nitrapyrin rate as a ratio of nitrapyrin to anhydrous ammonia. Greater N recovery with nitrapyrin than anhydrous ammonia alone was measured in April (190 days after application), June (230 days) and July (280 days) when anhydrous ammonia was applied from late October to early November.

Illinois studies in the mid-1970s showed that when injected into anhydrous ammonia or applied with urea, the rate of nitrification decreased (Figures 1 and 2) (Touchton et al., 1976a, 1976b; Touchton et al., 1979a); however, rainfall during the years of the experiments did not result in consistent increases in corn N uptake or corn yield in Illinois (Touchton et al., 1979b). Lack of yield response from the use of nitrapyrin also was reported in Iowa by Blackmer and Sanchez (1988); however, Stehouwer and Johnson (1990) reported higher corn yield from fall-applied N, with nitrapyrin related to higher N availability later in the season.

Higher corn yield with nitrapyrin in fall-applied N also was reported by Randall et al. (2003) and Randall and Vetsch (2005) in Minnesota; however, spring-applied N was highest yielding with greatest N-use efficiency. N-Serve is labeled for immediate incorporation or injection and not as a surface-applied product. Yield increases during the seven Minnesota study years were 15 bushels per acre more for fall anhydrous ammonia + N-Serve versus fall anhydrous ammonia alone, and 27 bushels per acre more for spring anhydrous ammonia compared with fall anhydrous ammonia (Randall et al., 2008).

A Wisconsin study (Hendrickson et al., 1978) found that on May 6, 1976, following an
Oct. 6, 1975, application of anhydrous ammonia, 53 percent of the recoverable N was ammonium-N with nitrapyrin (0.5 pound/acre active ingredient) compared with 11 percent ammonium-N without nitrapyrin. Nitrapyrin also increased the ammonium-N concentration in Minnesota research (Malzer, 1977) through June 8 of the following spring. In North Dakota (Moraghan and Albus, 1979), greater ammonium-N following fall anhydrous ammonia application was present through July 5 of the following spring.

Grain yield increases with the use of a nitrification inhibitor have been inconsistent due to the variability of rainfall necessary to lead to nitrate leaching in sandier soils or denitrification in high-clay soils. Malzer et al. (1979) recorded a corn yield increase with the optimum N rate in fall anhydrous ammonia application with nitrapyrin, but a split application of N resulted in similar yield with nitrapyrin as without it. Hergert et al. (1978) showed that the benefit of nitrapyrin use under irrigated sands increased as the irrigation water as a percent of evapotranspiration increased.

Instinct is an encapsulated nitrapyrin formulation that can be applied to fertilizer left on the soil surface for up to 10 days for delay of ammonium fertilizer nitrification. It received its label in 2009. Research is ongoing at a number of universities. University of Nebraska studies in 2008 and 2009 (Ferguson et al., 2008, 2009) showed no yield benefits to the use of nitrapyrin (CF-2017, Instinct); however, the plots were hampered by heavy rainfall in June (2008) and spatial variability (2009).

In Wisconsin, two years of work with Instinct resulted in corn yield increases in 2008 but not in 2009 (Laboski, unpublished data). In Illinois, yield did not increase due to the use of Instinct with urea ammonium nitrate (UAN) during six site-years (Fernandez, 2010). Iowa (Killorn, unpublished data) and Minnesota (Randall, unpublished data) research also showed no yield increase with Instinct compared with N fertilizer alone.

Field and laboratory studies show that nitrapyrin effectively reduces the rate of nitrification. However, these same studies show an inconsistency in yield increases due to the use of the product. The inconsistency is related to rainfall patterns within the experiment. Predicting the profitability of the use of nitrapyrin is therefore very difficult. The use of nitrapyrin to reduce N losses “needs to be considered at the scale of a sensitive region, such as a watershed, over a prolonged period of use as well as within the context of overall goals for abatement of N losses from the agroecosystem to the environment.” (Walt, 2004).

![Figure 1](image1.png)

**Figure 1.**

Ammonium-N concentration in soil after 120 pounds/acre of N as anhydrous ammonia was applied Oct. 14, 1975, with and without 1 pound/acre of active ingredient (two times labeled rate) N-Serve®/nitrapyrin (N-S). Differences between treatments were significant at all sampling dates through day 239 (Touchton et al., 1978).

![Figure 2](image2.png)

**Figure 2.**

Ammonium-N concentration in soil after 120 pounds/acre of N as anhydrous ammonia was applied April 5, 1976, with and without 1 pound/acre of active ingredient (two times labeled rate) N-Serve®/nitrapyrin (N-S). Differences between treatments were significant at all sampling dates through day 114 (Touchton et al., 1978).
Research on DCD (dicyandiamide or cyanoguanidine) has shown that it can be used as a nitrification inhibitor, although research generally has shown that its activity is shorter than nitrapyrin (Bronson et al., 1989). Products that contain DCD in the U.S. include Super-U (IMC Phosphate Co., licensed exclusively to Agrotain International LLC) and Guardian fertilizer additive (Conklin Co. Inc.). DCD contains about 67 percent N and was examined as an N source early in the last century (Reeves and Touchton, 1986). It was found to decrease crop yield when rates exceeded about 36 pounds/acre (Cowie, 1918). The Guardian label recommends a 2 percent addition to fertilizer. The content of DCD in Super-U is not stated. Growers likely would not overapply either product to the point of crop phytotoxicity.

A review of north-central states' research on DCD was published by Malzer et al. (1989). The review concluded that DCD was similar to nitrapyrin in its nitrification inhibition. Yield differences between fertilizer treated with DCD and fertilizer alone were inconsistent and limited to those soils and conditions where nitrate was lost through leaching or denitrification. The greatest value of either nitrification inhibitor would be in soils where nitrate loss through leaching or denitrification is more likely. A summary by Malzer et al. (1989) is reproduced in Table 1.

In contrast to the relatively low frequency of corn responses in the Midwest, potato responses were more consistently positive (Table 2).

The ammonium-N remaining in the soil following ammonia application with both nitrapyrin and DCD treatments was explored at four Illinois locations by Sawyer (1985). Within 30 days of a fall application, no differences were found between the control and the DCD and nitrapyrin treatments in the percentage of remaining ammonium-N. In the spring, the DCD and nitrapyrin treatments provided a greater percentage of remaining ammonium-N compared with the control at three of four locations. The differences are presented in Figure 3 for the Urbana and Dekalb locations. Spring application of DCD and nitrapyrin were even more effective at some sites (Figure 4).

The use of nitrification inhibitors with liquid manure applications has generated considerable interest. In response to reports of poor corn growth due to injected liquid manure in Illinois, placement studies with and without nitrapyrin were conducted on similar soils. The results of one study showed that the use of nitrapyrin increased corn plant and grain N concentrations but did not translate into a yield increase (Sawyer et al., 1991). In another study, the use of nitrapyrin was useful in lowering soil nitrate levels in the liquid manure band, which was one reason why poor corn growth was observed in the banded liquid manure fields (Sawyer et al., 1990).

### Table 1. Summary of corn grain yield responses to DCD and nitrapyrin at N rates equal to or less than optimum for fine-textured Midwest soils. (From Malzer et al., 1989.)

<table>
<thead>
<tr>
<th></th>
<th>DCD</th>
<th>Nitrapyrin</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of comparisons</td>
<td>With significant advantage</td>
<td>Average response</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>4</td>
<td>1</td>
<td>+1.6</td>
</tr>
<tr>
<td>Spring</td>
<td>15</td>
<td>3</td>
<td>+3.4</td>
</tr>
<tr>
<td>Sidewash</td>
<td>3</td>
<td>1</td>
<td>+1.4</td>
</tr>
<tr>
<td><strong>N Source</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>2</td>
<td>0</td>
<td>-1.0</td>
</tr>
<tr>
<td>Anhydrous ammonia</td>
<td>6</td>
<td>1</td>
<td>+3.6</td>
</tr>
<tr>
<td>Urea</td>
<td>4</td>
<td>4</td>
<td>+2.2</td>
</tr>
</tbody>
</table>

### Table 2. Relative effect of dicyandiamide (DCD) used with three nitrogen sources on potato yield, % Grade A US1A tubers, and apparent N recovery in tubers at Hancock, Wis., 1984-1986. (From Malzer et al., 1989.)

<table>
<thead>
<tr>
<th>N Source</th>
<th>Number of comparisons</th>
<th>Yield</th>
<th>% Grade A</th>
<th>Tuber N Recovery</th>
<th>Yield</th>
<th>% Grade A</th>
<th>Tuber N Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium nitrate</td>
<td>9</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>+2.0</td>
<td>-3.6</td>
<td>+6.5</td>
</tr>
<tr>
<td>Urea-ammonium sulfate</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>+5.1</td>
<td>-10.8</td>
<td>+23.7</td>
</tr>
<tr>
<td>Urea-ammonium nitrate solution</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>6</td>
<td>+4.0</td>
<td>-6.1</td>
<td>+27.6</td>
</tr>
</tbody>
</table>

### Urease Inhibitors

The compound that most consistently has decreased urea volatilization when mixed with urea or urea-ammonium nitrate solutions is NBPT (N-(n-butyl) thiophosphoric acid triamide). NBPT is marketed as Agrotain (Agrotain International LLC). The mechanism for NBPT is to lock onto the urease enzyme-binding sites, preventing the enzyme from reacting to the urease (Manunza et al., 1999). Agrotain has at least two possible uses in crop production:

- One is to protect against seed injury for growers, especially in the northern Plains, who apply urea with small-grain seed at planting. Use of Agrotain has increased the rate of urea that can be applied safely with small-grain seed in some studies (Table 3).

Agrotain also decreases the rate of ammonia volatilization from urea applied to the surface as dry urea or urea-ammonium nitrate solutions (Brouder, 1996; Table 4). Ammonia volatilization losses from urea at Brandon, Manitoba, decreased from 40 milligrams (mg) to 2 mg and from 88 mg to 12 mg with Agrotain in two separate studies for a seven-day period after application (Grant, 2004).

In a recent Kansas study (Weber and Mengel, 2009), urea was applied in three site-years to the soil surface after corn emergence using a number of nitrogen-extending additives, including Agrotain. The Agrotain treatment was superior to urea alone by 25 bushels per acre in one of the three site-years. The two locations that received significant rainfall immediately
following applications did not receive a yield benefit from the Agrotain treatment. In sorghum, urea + Agrotain and urea + SuperU were 11 and 12 bushels per acre, respectively, greater in yield than with urea broadcast alone (Weber et al., 2009a). At two drier locations, no yield differences occurred between urea + Agrotain and urea alone.

A 14-year study in southern Illinois (Ebelhar et al., 2010) showed a 3-bushel corn yield advantage of urea + Agrotain compared with urea broadcast in conventional till surface and incorporated during 12 years of treatments. In no-till, urea + Agrotain held an 11 bushel/acre advantage over urea surface applied during four years of treatments. Similar results were demonstrated by Varsa et al. 1995 (Table 5).

In Kentucky, 50 pounds of N/acre was applied preplant to all corn plots (Schwab and Murdock, 2009). Side-dress applications of urea and UAN with several additives or formulations were applied to the soil surface at the six-leaf stage. Higher yields than urea alone were achieved with urea + Agrotain and SuperU. Higher yields than UAN alone were achieved with UAN + Agrotain and UAN + Agrotain Plus (combination of NBPT and DCD formulated for use with UAN) (Table 6). Also notable: The ammonium nitrate treatment was the highest yielding treatment, suggesting that some loss of N was realized with the Agrotain treatments.

**Nitrification and Urease Inhibitors**

Ammonium thiosulfate (ATS) and several additional commercial thiosulfates have nitrification- (Goos, 1985; Janzen and Bettany, 1986) and soil urease-inhibiting properties (Goos, 1985). In the process of identification of thiosulfates as nitrification and soil urease inhibitors, researchers noted that the compounds would not be expected to perform as well as some other alternative nitrification and urease inhibitors due to the shorter decomposition period for ATS compared with nitrapyrin (Goos, 1985).

One study was unable to duplicate urease inhibition results, but it used different methods than originally presented at
Table 3. Effect of seed-placed urea with and without Agrotain on stand density and grain yield of barley on a fine sandy loam soil, 1994-96. (From Grant, 2004.)

<table>
<thead>
<tr>
<th>N rate</th>
<th>Yield, bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Agrotain</td>
</tr>
<tr>
<td>lb/acre</td>
<td>No Agrotain</td>
</tr>
<tr>
<td>0</td>
<td>7.6</td>
</tr>
<tr>
<td>18</td>
<td>7.9</td>
</tr>
<tr>
<td>36</td>
<td>7.3</td>
</tr>
<tr>
<td>54</td>
<td>6.0</td>
</tr>
<tr>
<td>72</td>
<td>5.7</td>
</tr>
<tr>
<td>89</td>
<td>4.7</td>
</tr>
</tbody>
</table>

Table 4. Mean corn yield from Purdue Agronomy Farm, SEPAC, Pinney Purdue and Kosciusko locations with urea and UAN alone and treated with NBPT. (From Brouder, 1996, citing work by Phillips, Mengel and Walker, 1989, unpublished work, Purdue University.)

<table>
<thead>
<tr>
<th>Fertilizer treatment</th>
<th>Yield, bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (20 lb N/acre in starter only)</td>
<td>99</td>
</tr>
<tr>
<td>Urea broadcast, surface</td>
<td>130</td>
</tr>
<tr>
<td>Urea + NBPT broadcast, surface</td>
<td>143</td>
</tr>
<tr>
<td>UAN broadcast, surface</td>
<td>135</td>
</tr>
<tr>
<td>UAN + NBPT broadcast, surface</td>
<td>140</td>
</tr>
<tr>
<td>UAN dribbled, surface</td>
<td>139</td>
</tr>
<tr>
<td>UAN spoke injected</td>
<td>142</td>
</tr>
<tr>
<td>UAN coulter injected</td>
<td>147</td>
</tr>
<tr>
<td>UAN knife injected</td>
<td>145</td>
</tr>
</tbody>
</table>

Table 5. No-till corn yield as affected by N fertilizer sources, Agrotain and placement in Illinois. (From Varsa et al., 1999.)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Belleville</th>
<th>Dixon Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (ON)</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>Urea + Agrotain</td>
<td>134</td>
<td></td>
</tr>
<tr>
<td>UAN, surface</td>
<td>123</td>
<td></td>
</tr>
<tr>
<td>UAN + Agrotain, surface</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>UAN, dribble</td>
<td>139</td>
<td></td>
</tr>
<tr>
<td>UAN + Agrotain, dribble</td>
<td>143</td>
<td></td>
</tr>
<tr>
<td>UAN injected</td>
<td>172</td>
<td></td>
</tr>
<tr>
<td>Anhydrous ammonia</td>
<td>158</td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Yield for side-dressed no-till corn in Hardin County, Ky. (From Schwab and Murdoch, 2009.)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield, bushels per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check (50 lb N/acre preplant N only)</td>
<td>1174*</td>
</tr>
<tr>
<td>Urea</td>
<td>158c</td>
</tr>
<tr>
<td>Urea + Agrotain</td>
<td>201b</td>
</tr>
<tr>
<td>SuperU</td>
<td>201b</td>
</tr>
<tr>
<td>UAN</td>
<td>150c</td>
</tr>
<tr>
<td>UAN + Agrotain</td>
<td>179bc</td>
</tr>
<tr>
<td>UAN + Agrotain Plus</td>
<td>175bc</td>
</tr>
<tr>
<td>Ammonium nitrate</td>
<td>293a</td>
</tr>
</tbody>
</table>

* Numbers followed by the same letter are not significantly different (5%)

rates of ATS from 3.3 to 33 times the rates of Goos, 1985 (McCarty et al., 1990). Thiosulfate activity is regulated by its concentration (effective at 5 rates of 25 rig kg⁻¹, Goos and Johnson, 2001).

Thiosulfate readily breaks down rapidly in temperatures of 15 C. In a laboratory study at 15 C, ATS essentially was mineralized in about a week. Under cooler temperatures, however, significant thiosulfate remained after two weeks in two of three soils, with mineralization complete in all soils by week 13. When thiosulfate was placed in a band with aqua ammonia in the fall in North Dakota (Oct. 3, 1996), thiosulfate resulted in similar spring (May 12, 1997) ammonium and nitrate levels as aqua ammonia treated with nitrapyrin (Goos and Johnson, 1999). Spring wheat yields of aqua ammonia treated with thiosulfate and nitrapyrin were similar, and both were greater than aqua ammonia alone.

Janzen and Bettany (1986) expressed concerns at high rates of banded ATS (in excess of 100 parts per million, or ppm) due to nitrite accumulation from ATS inhibition of not only the ammonium to nitrite process, but the nitrite to nitrate process. The rate used by Goos (1985) was about 43 ppm if expressed as a band with a radius of 2 inches, which did not accumulate nitrite in the Janzen/Bettany (1986) study.

Recently, the use of thiosulfate has been re-examined. In Kansas, the application in the spring of a 5 and 10 percent calcium thiosulfate by volume solution with UAN had similar yield as urea broadcast in no-till (Tucker and Mengel, 2007).

Nutrisphere-N is a product marketed by SFP (Specialty Fertilizer Products) LLC, Leawood, Kan. The formulation for dry fertilizer is a 30 to 60 percent maleic itaconic co-polymer calcium salt. The pH of the dry formulation is between 2.5 and 5, according to the label. The maximum rate of use is 0.5 gallon per ton of urea/ammonium sulfate. The formulation for a liquid fertilizer is a 40 percent minimum maleic-itaiconic co-polymer. The pH of the liquid product is between 2 and 4, according to the label. The maximum rate of mixing with liquid N products is 0.5 gallon Nutrisphere-N per 99.5 gallons of fertilizer solution. A gallon of Nutrisphere-N liquid or dry formulation weighs 9.6 pounds per gallon.

Nutrisphere-N is marketed as both a urease inhibitor and a nitrification inhibitor. Marketing literature explains that the activity of Nutrisphere-N on nitrification is related to its binding to copper ions necessary for the nitrification process in soil bacteria. The activity of the product on urease is based on its binding to nickel ions necessary for the formation and function of the enzyme. Also, the product Avail, which is marketed as a phosphate-enhancing product by SFP, contains the same active ingredient as Nutrisphere-N.

The Avail activity is attributed to binding of calcium or iron ions in the soil that normally might bind phosphate. Based on the mode of action of the active ingredient of Nutrisphere-N/Avail, the compound is highly negatively charged and would tend to bind with any compound with a positive charge, not distinguishing one ion from another.

The most consistent yield increases and crop uptake of N from the use of Nutrisphere-N has been through work by Gordon (2008). In two years of corn at Scandia, Kan., and two years of grain sorghum at Belleville, Kan., yield increases...
from the use of Nutrisphere-N were similar to those achieved with urea-Agrotain and ESN (Environmentally Smart Nitrogen, Agrium Inc.) (Tables 7 and 8).

The consistent results from Gordon (2008) are very curious, considering that careful laboratory experiments by Coos (2008) and Norman (Franzen et al., 2011) have shown that Nutrisphere-N has no nitrification or urease inhibitor ability (Figures 5 and 6, Table 9).

Laboratory experiments clearly show that no nitrification inhibition or urease inhibition occurs by Nutrisphere when used at label rates. Goos has observed some small nitrification inhibition when the Nutrisphere for liquid fertilizer is applied in a concentrated band. He attributes this to the strong acidity of the liquid formulation and not to the Nutrisphere itself (Goos, personal communication, 2010). Acid conditions are known to inhibit nitrification bacteria (Schmidt, 1982).

Table 7. Effects of N additive, averaged over source (UAN and urea) and N rate on corn grain yield, earleaf-N and grain-N, Scandia, Kan. (2-year average). (From Gordon, 2008.)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
<th>Earleaf N</th>
<th>Grain N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bu/acre</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Check</td>
<td>152</td>
<td>1.72</td>
<td>1.13</td>
</tr>
<tr>
<td>Urea/UAN</td>
<td>168</td>
<td>2.57</td>
<td>1.28</td>
</tr>
<tr>
<td>ESN</td>
<td>185</td>
<td>2.96</td>
<td>1.33</td>
</tr>
<tr>
<td>Nutrisphere-N</td>
<td>183</td>
<td>2.98</td>
<td>1.35</td>
</tr>
<tr>
<td>Agrotain</td>
<td>183</td>
<td>2.98</td>
<td>1.36</td>
</tr>
<tr>
<td>LSD 5%</td>
<td>6</td>
<td>0.09</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Table 8. Effects of N source and rate on grain sorghum yield, Belleview (2-year average). (From Gordon, 2008.)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>N-Rate</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb/acre</td>
<td>bu/acre</td>
</tr>
<tr>
<td>Check</td>
<td>0</td>
<td>71</td>
</tr>
<tr>
<td>Urea</td>
<td>40</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>128</td>
</tr>
<tr>
<td>ESN</td>
<td>40</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>130</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>132</td>
</tr>
<tr>
<td>Urea + Agrotain</td>
<td>40</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>133</td>
</tr>
<tr>
<td>Urea + Nutrisphere</td>
<td>40</td>
<td>120</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>132</td>
</tr>
<tr>
<td>LSD 5%</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

Table 9. Cumulative ammonia volatilization losses for urea, ammonium sulfate, urea + NBPT and urea + 0.25% Nutrisphere (NSN) from a Dewitt silt loam soil during a 15-day laboratory incubation at 25 C. Norman data, University of Arkansas, Fayetteville. (From Franzen et al., 2011.)

<table>
<thead>
<tr>
<th>N sources</th>
<th>Days after N source application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Urea</td>
<td>14.5</td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>0.1</td>
</tr>
<tr>
<td>Urea + NBPT†</td>
<td>0.006</td>
</tr>
<tr>
<td>Urea + 0.25% NSN</td>
<td>17.6</td>
</tr>
<tr>
<td>LSD(0.05)†</td>
<td>12.2</td>
</tr>
<tr>
<td>LSD(0.05)§</td>
<td>9.6</td>
</tr>
</tbody>
</table>

† NBPT = N-(n-butyl) thiophosphoric triamide
‡ LSD to compare means between N sources within the same sampling time.
§ LSD to compare means between sampling time within the same N source.
In the field, consistently finding yield or quality responses to the use of Nutrisphere at the labeled rate is uncommon. In North Dakota studies on spring wheat at eight locations, no yield increases or grain N uptake increases were found with Nutrisphere compared with urea (Franzen et al., 2011). In Kansas (Tucker and Mengel, 2008), no increases occurred due to Nutrisphere with UAN versus UAN surface banded or injected in grain sorghum in 2007.

In two years of corn in Kansas, no yield increases were found from the use of Nutrisphere-N UAN compared with surface-applied UAN at three total sites (Weber and Mengel, 2009). In 2009, no response was found to Nutrisphere + UAN broadcast on grain sorghum compared with broadcast UAN alone in Kansas at three locations (Weber and Mengel, 2010).

One sorghum yield increase occurred with surface-banded Nutrisphere + UAN compared with UAN surface banded alone, and two sites were nonresponsive. The yield increase with surface band but not broadcast suggests that perhaps the acidity of the Nutrisphere may have delayed nitrification at this site (Schmidt, 1982).

At Waseca, Minn., in 2009, no corn yield difference was found between urea and urea with Nutrisphere applied in the fall (Randall and Vetsch, 2009). Grain and stover N between urea and urea with Nutrisphere were similar. In Illinois at two locations in 2008, Nutrisphere-urea was lower in yield than urea and similar in yield at the two locations with UAN and Nutrisphere-UAN (Ebelhar and Hart, 2009). At Dixon Springs in 2009, Nutrisphere urea, UAN and ammonium sulfate treatments did not result in higher corn yield than the N sources with Nutrisphere-N (Ebelhar and Hart, 2010), although the main effects for Nutrisphere-N on corn yield were significant.

In Arkansas and Mississippi, Nutrisphere-N had no effect on rice yields in three field studies compared with urea (Franzen et al., 2011). In South Dakota, Nutrisphere-N did not result in higher corn yield in 2007 (Bly and Woodard, 2007), 2008 (Bly et al., 2008) or 2009 at two sites (Bly et al., 2009).

In Idaho, no spring wheat yield increases were found with Nutrisphere during two years (Jeffrey Stark, personal communication, Aug. 23, 2010). In barley, however, yield increases occurred in 2008 and 2009 with Nutrisphere, but no increase occurred in grain protein versus similar rates of urea. Plant N uptake with Nutrisphere was similar to urea without Nutrisphere, suggesting that the yield increase in barley came from some response other than enhanced N nutrition (Stark, 2008; 2009).

Laboratory studies with Nutrisphere-N show no effect on nitrification or urease activity. Therefore, the findings that the great majority of studies with Nutrisphere show no yield effects are not surprising. What is surprising is that some studies show yield effects, but not from increased N nutrition. The results from Gordon (2008) suggest that under some conditions, Nutrisphere may have some effect on plant growth and development, and even N nutrition not related directly to urease inhibition or nitrification. However, the company may need to re-examine its label as a nitrification inhibitor and urease inhibitor.

Summary

Certain nitrogen additives provide growers with options for extended activity of nitrogen nutrition for their crops. Their economics depends on rainfall following application, application methods, timing and soil characteristics, especially soil texture. Nitrapyrin has been effective in delaying nitrification. Dicyandiamide also has been shown to be effective in delaying nitrification. Thiosulfates have been shown to delay nitrification, but the body of literature to support their use is much smaller than that of nitrapyrin. NBPT (Agrofin) is an effective urease inhibitor. Thiosulfates have shown some urease inhibition characteristics, but again, the body of literature that supports their use is small.

Nutrisphere has been shown to be ineffective as both a nitrification and urease inhibitor. The data that support the use of Nutrisphere is small in comparison with the data that does not support its use. If one accepts that the laboratory studies, conducted in a similar manner to those used to evaluate products such as Agrofin, show that Nutrisphere is not a nitrification or a urease inhibitor, then the small number of field studies that show a yield benefit to the use of the product, and in some circumstances even show an accumulation of N, must have other explanations. The very acidic nature of the liquid formulation of Nutrisphere suggests that in banded applications, the nitrification delay may be associated with the acidity of the solution more than the Nutrisphere itself.

References


For more information on this topic, please visit: www.ag.ndsu.edu

NDSU encourages you to use and share this content, but please do so under the conditions of our Creative Commons license. You may copy, distribute, transmit and adapt this work as long as you give full attribution, don't use the work for commercial purposes and share your resulting work similarly. For more information, visit www.ag.ndsu.edu/agcomm/creativecommons.

North Dakota State University does not discriminate on the basis of age, color, disability, gender expression/identity, genetic information, marital status, national origin, public assistance status, sex, sexual orientation, status as a U.S. veteran, race or religion. Direct inquiries to the Vice President for Equity, Diversity and Global Outreach, 205 Old Main, (701) 231-7708.

County Commissioners, NDSU and United States Department of Agriculture Coopertors. This publication will be available in alternative formats for people with disabilities upon request, (701) 231-7981.


SAA-9-11
Kochia – Growth Regulator Resistance
Dr. Phil Westra – Colorado State University

One of the most common weeds in all major crops in the Central Great Plains is kochia which has proven to be a potent adversary for sustainable crop production for crop producers. As a C4 plant, it is not surprising that kochia is heat and drought tolerant, but what is surprising is its ability to germinate and begin growth as early as February when nights are cold and snow is still likely. Kochia is highly competitive in a wide variety of crops causing yield reductions of 90% or more if not controlled. Well watered and fertilized kochia plants along the edge of corn fields can grow 8’ tall with woody stems over 1” in diameter. Since kochia seeds exhibit little dormancy, most seeds germinate the year following their production on a mother plant. In addition, as a tumble weed, kochia plants rolling across the landscape in strong winds shed their seeds as they bounce along, thus spreading their genes across long distances.

Anecdotal evidence from senior weed scientists suggest that when 2,4-D was first released as an herbicide, it did exhibit moderate to good control of kochia. Today, most weed scientists, crop consultants, and growers would rate 2,4-D as poor to ineffective for kochia control, although 2,4-D is still a frequent tank mix partner because it is cheap and it still controls many other broadleaf weeds. It is hard to determine if the current general poor kochia control with 2,4-D is a result of resistance that is wide spread, or if kochia was never controlled very well by 2,4-D. Some more recent research suggests that new acid forms of 2,4-D can be effective for kochia control.

For more than 25 years, growers have frequently turned to dicamba to control kochia in crops or field situations where dicamba is labeled. When applied at higher labeled rates, dicamba provides the added benefit of a moderate amount of soil residual activity for several weeks. Beginning in the 1980s, however, evidence began to mount that some central great plains accessions of kochia had developed resistance to dicamba. Scientists at Montana State University documented dicamba resistant kochia that exhibited some unusual growth characteristics. In Colorado, research focused on kochia collected from “lack of control” (LOC) sites primarily in irrigated corn fields. Kochia in these fields were frequently heavily damaged by dicamba with the damage often manifest as death of the primary kochia growing points. After some time, however, axillary buds would begin to grow and the plants would survive and produce seed even at the highest labeled rates for dicamba. Detailed genetic research at CSU suggested that dicamba resistance in kochia appears to be controlled by a single allele with a high degree of dominance. In spite of this discovery, it has always been a mystery as to why dicamba resistance never seem to rise to a very high level in any part of the central great plains. It has been speculated that this resistance trait was rapidly swamped out by pollen from the many susceptible plants still present in most ecosystems.

Perhaps the development and labeling of fluroxypyr indirectly helped in the management of dicamba resistant kochia since there appears to be little if any cross resistance in kochia to these two herbicides. Fluroxypyr became a popular kochia herbicide due to its effectiveness and to the generally good crop safety exhibited by fluroxypyr. The one drawback for fluroxypyr was its sometimes poor level of control of many other broadleaf weeds commonly found growing with kochia. There have been sporadic reports of fluroxypyr resistance in kochia, but once again, this has never blown up to be a major issue. New herbicides such as Huskie, Laudis, Calisto, and Impact have shown good to excellent kochia control when used in labeled crops based on extensive research over the past several years. Although these products are sometimes more expensive, they at least offer reasonable alternatives for kochia control.
Finally, it must be emphasized that since the introduction of herbicides a major weed control tools used by most crop producers, kochia has demonstrated an amazing ability to develop resistance to 1) 2,4-D 2) triazine herbicides 3) ALS herbicides 4) Dicamba 5) Fluroxypyr 6) Glyphosate. It is incumbent on all of us; scientists, crop consultants, growers, etc. to be vigilant when scouting for kochia problems in fields and possible new resistance issues as they develop. Contact your extension agents or state weed scientists if you suspect an herbicide resistance problem with kochia.
Kochia History, Biology, and Implications  
Phil Stahlman\textsuperscript{1} and Anita Dille\textsuperscript{2}  
\textsuperscript{1}Agricultural Research Center-Hays and \textsuperscript{2}Department of Agronomy  
Kansas State University

Origin, Biology, and Distribution

\textit{Introduction and spread.} Kochia (\textit{Kochia scoparia} L.) is an annual forb (broadleaf plant) with a deep taproot typically penetrating to depths of 6 to 8 ft (as deep as 16 ft during severe drought) and many erect branched stems extending upward 2 to 3 ft in dry or infertile conditions but may reach up 7 ft under favorable conditions. Leaves are simple with alternate arrangement along stems; linear to lanceolate in shape and typically range from about 3/16-inch to 5/16-inch wide and 2 to 3 inches long; and lime-green to grayish-green in color, but often change to shades of yellow, red, and brown as plants mature. Stems usually are similarly colored as the leaves but stem color may be solid or striped. Kochia is highly adaptable, drought tolerant, and grows on many soil types including saline/alkaline soils, but does not tolerate spring flooding.

Other common names for kochia include fireweed, Mexican fireweed, burning bush, summer-cypress, and tumbleweed. The species is native to southern and eastern Russia and was introduced to North American from Europe in the late 1800's for use in ornamental plantings. Kochia naturalized in the central and northern Great Plains where it flourished during periods of drought during the 1930's. It spread rapidly westward and currently is a competitive weed in cropland, rangeland and pastures, road sides, and waste areas throughout the western United States and Canada. It is one of the top 10 most-abundant agricultural weeds in the Canadian prairies and western United States. It is present throughout Kansas but is far more common and troublesome in the dry western half of the state.

The nutritional level of kochia in early vegetative growth stages is sufficient to satisfy the requirements of most livestock. However, nutritional content decreases with age. During periods of drought and shortages of grass and cultivated forage, kochia has been used for livestock feed as a portion of the diet, but plants contain high levels of oxalates, alkaloids, and nitrates that can be toxic if large amounts are consumed. A related but improved perennial semi-shrub species (\textit{Kochia prostrata}) is promoted as a drought tolerant, high-quality forage kochia for winter livestock grazing in intermountain and semi-desert habitats. This species lacks weedy characteristics and should not be confused with the annual, weedy species.

\textit{Reproduction.} Kochia reproduces by seed that disperse as mature plants break off at the base and are blown by wind as tumbleweeds scattering seed and resulting in a high rate of spread over long distances. In the Pacific Northwest, plants were observed moving nearly 2.5 miles in 6 weeks. Plants typically produce about 15,000 seed per year; however, plants have extreme reproductive plasticity. Severely stressed plants may produce few seed and plants growing under favorable conditions may produce as many as 50,000 seeds. Seed is produced in clusters of small green flowers lacking petals located in the axis of upper leaves and terminal spikes in late summer (Aug-Sept). Flowering is temperature sensitive and does not occur until mean temperature is greater than \textasciitilde60°F. Kochia will self-pollinate but flower stigmas (female structure) mature sooner and are receptive to pollen from other flowers on the same or different plants in advance of pollen shed from anthers (male structure) of the same flower. This helps ensure cross pollination and genetic diversity within the population. Pollen can move up to 500 ft.
Seedling emergence. Kochia seeds have a dormancy period of 2 to 3 months, but once dormancy is broken seeds will germinate over an extremely wide range of temperatures (~40 to 100°F). Few annual weeds emerge in spring as early as kochia. Seedlings are frost tolerant and frequently can be found along edges of melting snow in fence rows and other non-disturbed areas. Emergence in cultivated fields typically occurs several days later than in non-tilled areas. Studies indicate that fewer growing-degree days (cumulative heat units) are needed to initiate germination and cumulative growing-degree-days for the entire period of emergence are fewer in colder northern latitudes compared to warmer southern latitudes. At multiple sites in Kansas in 2010, emergence began after March 15, whereas emergence in western Nebraska and eastern Wyoming began after the first week of April. Approximately 70 to 90% of seedlings emerged within the first two weeks after first emergence, but at most sites a few seedlings continued to emerge as late as mid-July. The same general trend also occurred in 2011, but with longer periods of peak emergence, probably because of dryer spring conditions than in 2010. This and other evidence indicates that current farming practices are selecting or favor plants capable of germinating at higher temperatures, thus extending the period of usual emergence. Seeds have little or no seedbank viability; they either germinate or decay in 1 year.

Seedlings emerging in early spring frequently emerge in great density and form dense mats of vegetation. Before plant internodes begin to elongate, multiple ranks of compressed leaves form compact rosettes. Overlapping hairs on the margins of leaves intercept spray droplets and interfere with wetting of leaf surfaces from herbicide applications. Plants are more easily wetted and susceptible to most herbicides when they are about 2 to 6 inches tall and become more difficult to control as they grow larger, especially when stressed.

Intraspecific diversity. Kochia morphology is highly variable, likely due to high genetic variation and phenotypic plasticity. Within-population genetic diversity may equal or exceed levels of genetic diversity seen among kochia populations. Natural selection coupled with cross pollination, prolific seed production, and profuse seed dispersal over long distances contributes to the genetic diversity of kochia. Adaptation to agronomic practices including selection of herbicide-resistant variants has added to this diversity. Hybridization with related Kochia species does not appear to be a source of genetic diversity due to genomic differences that prohibit introgression.

Response to Herbicides

The genetic diversity within kochia populations contributes to the presence of biotypes with mutant alleles known to confer herbicide resistance. Few weed species have developed resistance to as many herbicide families as kochia. Populations of kochia resistant to triazine and acetolactate-synthase (ALS)-inhibiting herbicides are widespread, there are documented cases of resistance to synthetic auxin herbicides (2,4-D and dicamba), and resistance to glyphosate occurs throughout western Kansas and eastern Colorado. These four herbicide modes-of-action are among the most widely used herbicide groups in agricultural production systems in the United States and Canada. Loss of the use of each of these herbicide groups, especially glyphosate, for kochia control poses significant challenges in one or more major field crops and will require less simple and cost effective management strategies.

The first case of triazine resistance in kochia was documented in Idaho in 1976 and ALS herbicide resistant kochia was discovered in 1987 in wheat fields in Kansas and North Dakota, and in a non-crop area in Colorado. Triazine and ALS resistance is caused by a a single amino acid change in the protein target site. The mutation changes the shape of the binding site so the herbicide can no longer bind. Plants with the mutation are not affected by any rate of the herbicide. Lack of kochia control with dicamba in
eastern Colorado and western Nebraska in the early 1990’s prompted studies at Colorado State University that confirmed the presence of dicamba-resistant kochia. See Phil Westra’s report for more information on dicamba-resistant kochia.

Lack of kochia control with glyphosate not due to application or abiotic reasons was first observed in southwest Kansas in 2005. Studies indicated slightly elevated tolerance to glyphosate, but could not yet be called a resistant population. However, glyphosate resistance was confirmed in four geographically-dispersed kochia populations in 2007. By 2011, glyphosate resistance was common throughout the western one-third of Kansas and present in bordering counties of Colorado and Nebraska.

Glyphosate resistance is unlike triazine or ALS resistance in that it is not due to an altered target site and plant response to glyphosate is rate dependent. This type of resistance is often called “creeping resistance” and refers to the fact that the level or degree of resistance increases in successive generations with continued selection (spraying with glyphosate). The main mechanism of resistance appears to be a process called gene amplification, in which resistant plants have multiple copies of the gene that produces an enzyme to which glyphosate binds and prevents production of essential amino acids, thereby causing plant death. Resistant plants are simply able to produce more enzyme than glyphosate can disrupt.

Major implications of glyphosate resistance in kochia are that growers must use more costly and often less effective herbicides to control kochia in crops and fallow than previously possible using glyphosate. Also, there is evidence that growers in western Kansas used more tillage than normal in 2011 to control kochia after wheat harvest. Research is ongoing to evaluate alternative (to glyphosate) kochia management strategies. Refer to contributions of other conference presenters for the latest updates.
**Topics in presentation**

- Control Kochia
  - Ahead of planting
  - In Corn
  - In Sorghum
  - In Soybean
  - In Sunflower

---

**Thinking outside the box**

- Conventional methods including herbicide selection and timing of application may no longer be successful due to glyphosate and possibly growth regulator resistant kochia.
- The larger kochia get, the more difficult it is to control.
- Dense/solid stands of little kochia may not be controlled.
- Herbicides very early PRE may be required?!

---

**Cumulative GDD and Date for Start (10%), End (90%), and Duration of Kochia Emergence, Dille et al., 2010**

| Location & Site | State | GDD to Start | Date | GDD to End | Date | GDD Duration | Days to 50% ECP | ECP
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingalls, KS</td>
<td>ND</td>
<td>3/21</td>
<td>345</td>
<td>3/21</td>
<td>575</td>
<td>56</td>
<td>12/23</td>
<td>96</td>
</tr>
<tr>
<td>illustration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitchell, NE</td>
<td>ND</td>
<td>3/17</td>
<td>456</td>
<td>3/17</td>
<td>372</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>illustration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monticello, IA</td>
<td>ND</td>
<td>3/15</td>
<td>309</td>
<td>3/15</td>
<td>309</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>illustration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hays, KS</td>
<td>ND</td>
<td>3/18</td>
<td>362</td>
<td>3/24</td>
<td>127</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>illustration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ness City, KS</td>
<td>ND</td>
<td>3/11</td>
<td>472</td>
<td>4/18</td>
<td>361</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>illustration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garden City, KS</td>
<td>ND</td>
<td>3/22</td>
<td>1054</td>
<td>3/26</td>
<td>774</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### EPP herbicides for kochia control, Tribune 2011.

- **Control**
  - Claris 26 BV E. 2 oz: 56
  - Claris 26 BV E. 3 oz: 62
  - Claris 26 BV O. 2 oz: 56

### Postemergence control of kochia in fallow, Tribune 2011.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>%</th>
<th>May 10, 16D 6/13</th>
<th>June 11, 20D 6/13</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% CO2 + MNS + IPS</td>
<td>44</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>12% CO2 + MNS + IPS</td>
<td>38</td>
<td>71</td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>25% CO2 + MNS + IPS</td>
<td>32</td>
<td>65</td>
<td>65</td>
<td>65</td>
</tr>
</tbody>
</table>

*Ideally, DON'T WAIT UNTIL MAY to begin controlling kochia!!!*

### Herbicides applied 6 days before planting for control of kochia in corn, Tribune 2011.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (oz)</th>
<th>3</th>
<th>May 26, 18D 6/13</th>
<th>June 1, 20D 6/13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarity + 2.4-0</td>
<td>0.5</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Verdict</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Traxx 2.5</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Traxx 4.5</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Traxx 7.5</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Traxx 10</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Traxx 15</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Traxx 20</td>
<td>3</td>
<td>85</td>
<td>85</td>
<td>85</td>
</tr>
</tbody>
</table>

*Includes custom application (55.13) but not preplant burnoff. 71.5D = 68.*

**Treatment Cost and Kochia Control in Corn 50 ± 3 DA PRE Across Three Trials, Phil Stahlman et al.**

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Cost</th>
<th>Effectiveness</th>
<th>Cost/acre</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verdict</td>
<td>$34.89</td>
<td>85%</td>
<td>$22.27</td>
<td>85%</td>
</tr>
<tr>
<td>Traxx 4.5</td>
<td>$24.79</td>
<td>85%</td>
<td>$20.27</td>
<td>85%</td>
</tr>
<tr>
<td>Traxx 7.5</td>
<td>$24.79</td>
<td>85%</td>
<td>$20.27</td>
<td>85%</td>
</tr>
<tr>
<td>Traxx 10</td>
<td>$24.79</td>
<td>85%</td>
<td>$20.27</td>
<td>85%</td>
</tr>
<tr>
<td>Traxx 15</td>
<td>$24.79</td>
<td>85%</td>
<td>$20.27</td>
<td>85%</td>
</tr>
<tr>
<td>Traxx 20</td>
<td>$24.79</td>
<td>85%</td>
<td>$20.27</td>
<td>85%</td>
</tr>
</tbody>
</table>

Cover Your Acres Winter Conference. 2012. Vol. 9, Oberlin, KS
### Treatment Cost and Kochia Control in Corn 50 ± 3
**DA PRE Across Three Trials**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (qts)</th>
<th>Cost ($)</th>
<th>S</th>
<th>June 2</th>
<th>July 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumax 2.5</td>
<td>2.5</td>
<td>2.5</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Lexar 3</td>
<td>3.0</td>
<td>3.0</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Degree Xtra 2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Guardmax 4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Guardmax 4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Including custom application (5.13) but not preplant burndown.

---

### Kochia Control PRE in Sorghum
- Preemergence products—Highly recommended
  - Lumax 2.5 qts $43.75
  - Lexar 3.0 qts $42.00
  - Degree Xtra 2.0 to 3.7 qts $20.8 - 38.50
  - Guardmax Max/Gmax Litte 2.5 - 4.6 pts $18.40 - 34.00, $19 - 33
  - Bicap II Mag / Bicep Lite II Mag 1.6 to 2.1 qt 1.1 to 1.5 qt $19.60 - 25.72, 17.88 - 24.34
  - Bullet/Lariat 2.5 to 4 qt $17.30 - 27.75
  - Sharpen 2 oz $10.24 (Add to chloracetylid + atrazine)
  - Verdict 10 oz $16.40 (Add to 2 to 2.75 pts Guardman Max or 1.5 to 2 pts Gmax Lite)

---

### Kochia Control POST in Sorghum
- Treat kochia early! Remember emergence patterns!
  - Banvel, Clarity, or generics or Starane products are a key component of a post program. Adding 0.5 lb atrazine could be very beneficial.
    - atrazine $5.89 / lb at
    - Clarity 0.5 pt $5.40
    - Starane 0.67 pt
    - Starane NXT 14-21 oz $9.24 to 12.52
    - Starane Ultra 0.4 pt $14.60
    - Huskie 12.8 to 16 oz $10.15 to 12.70

### Huskie Registration in Sorghum from Bayer Crop Science, July 2011
- Huskie, pyrasufotole (HPPD) + bromoxynil
- Controls broadleaf weeds only
- Use rate: 12.8 to 16 fl oz / a ($10.15 to 12.70)
- Apply with: Atrazine (0.25 - 1 lb) and AMS
- Maximum 2 applications, 11 days apart, total not to exceed 32 fl oz
- Timing: 3 leaf to 12 inch sorghum
- Grain and forage sorghum. 7 DAT forage PHI and 60 DAT PHI for grain or stover

---

### Sorghum Injury (%), 2009.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Prod./acre</th>
<th>7 DAT</th>
<th>14 DAT</th>
<th>21 DAT</th>
<th>28 DAT</th>
<th>56 DAT</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hukkietramzine</td>
<td>13g 16g</td>
<td>1</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hukkietramzine</td>
<td>0g 16g</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Ester</td>
<td>13g 16g</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>24</td>
<td>1</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Early application injury of Huskie, 2010.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Prod./acre</th>
<th>7 DAT</th>
<th>14 DAT</th>
<th>21 DAT</th>
<th>28 DAT</th>
<th>56 DAT</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hukkietramzine</td>
<td>13g 16g</td>
<td>1</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hukkietramzine</td>
<td>0g 16g</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Ester</td>
<td>13g 16g</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>24</td>
<td>1</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sorghum Injury (%), 2009.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Prod./acre</th>
<th>7 DAT</th>
<th>14 DAT</th>
<th>21 DAT</th>
<th>28 DAT</th>
<th>56 DAT</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hukkietramzine</td>
<td>13g 16g</td>
<td>1</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hukkietramzine</td>
<td>0g 16g</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Ester</td>
<td>13g 16g</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>24</td>
<td>1</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Late application injury of Huskie, 2010.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Prod./acre</th>
<th>7 DAT</th>
<th>14 DAT</th>
<th>21 DAT</th>
<th>28 DAT</th>
<th>56 DAT</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hukkietramzine</td>
<td>13g 16g</td>
<td>1</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hukkietramzine</td>
<td>0g 16g</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Ester</td>
<td>13g 16g</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>24</td>
<td>1</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Palmer amaranth Control, 2010.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Prod./acre</th>
<th>7 DAT</th>
<th>14 DAT</th>
<th>21 DAT</th>
<th>28 DAT</th>
<th>56 DAT</th>
<th>LSD (0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hukkietramzine</td>
<td>13g 16g</td>
<td>1</td>
<td>12</td>
<td>7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hukkietramzine</td>
<td>0g 16g</td>
<td>2</td>
<td>12</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Ester</td>
<td>13g 16g</td>
<td>4</td>
<td>9</td>
<td>5</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAK24 0 Amine</td>
<td>13g 16g</td>
<td>5</td>
<td>10</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success</td>
<td>24</td>
<td>1</td>
<td>7</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Huskie Summary:

- **Huskie is an excellent tool to help control kochia.**
- **Kochia is best controlled when small, less than 4 inches tall.**
- **Would NOT skip the PRE herbicide treatment**
- **Always add 0.25 to 1.0 lb atrazine with Huskie**
Summary of kochia control in soybean

- Control kochia early before planting!
- Soil applied herbicides are essential.
- Authority (sulfentrazone) based products likely better than Valor (flumioxazin) based products for PRE kochia control.
- Postemergence control of kochia in soybean may be extremely difficult especially if kochia is ALS and glyphosate resistant.
- Depending on Ignite for post kochia control in Liberty-Link beans is very risky!

Kochia control in sunflower

- Effective early control and burndown at sunflower planting greatly reduces kochia emerging in June planted sunflower.
- If kochia are not controlled until just prior to planting sunflower, complete crop failure is very likely.
- Because of the level of ALS resistant kochia in western KS, it is very likely that Clearfield sunflower/Beyond or ExpressSun sunflower/Express will not be effective for controlling kochia.

Weed control in sunflower, Tribune 2006, Thompson/Schlegel.

Summary

- Managing kochia will be possible, however, will be expensive regardless of row crop planted.
- The traditional methods of conventional weed control practices may not be effective.
- Managing kochia will require planning ahead.
- Implementing strategies that control the huge early flushes of kochia may be critical to a successful kochia management program, regardless of crop planted.
- Timeliness of herbicide applications is essential.
- Frequency of glyphosate resistant kochia likely is going to increase.
Kochia Control in Wheat and Fallow
Phil Stahlman
Agricultural Research Center-Hays
Kansas State University

The most sustainable weed control programs integrate the use of herbicides with other crop and soil management practices that include crop and herbicide rotation, use of competitive cultivars/hybrids, precision fertilizer placement, optimum planting dates and rates, and planting arrangements that maximize crop competitiveness with weeds. These are core principles of Integrated Weed Management (IWM).

Tillage is an ancient method of weed control and has been an integral part of crop production since the beginning of farming with simple tools. The science of modern weed control began with the discovery of 2,4-D in the early 1940's and probably has advanced more in the past 70 years than in previous recorded history. Herbicides have gradually replaced, but not eliminated, tillage for the purpose of weed control to the extent that today tillage is used as much for seedbed preparation as for weed control. Herbicides have proven so effective that other aspects of IWM are not utilized as often as in the past.

Selection pressure applied to weed populations for a long enough period of time will inevitably result in changes in weed communities favoring those species best adapted to the resulting habitat. The selective force or management practice could be herbicide, tillage, crop rotation, or other agronomic factors. However, frequent use of the same herbicide program changes the spectrum of weed populations more quickly than most other selective forces because of the greater selection herbicides impose on weed populations.

Weed species have developed resistance to several herbicide families. Those of most importance in this geography include triazine, sulfonylurea (ALS-Inhibitors), and synthetic auxin herbicides (dicamba and 2,4-D) herbicides, and more recently glyphosate. The widespread presence of glyphosate-resistant kochia in the western one-third of Kansas and adjacent counties in Colorado and Nebraska pose significant challenges to current production systems throughout semi-arid regions. The purpose of this article is to briefly review various herbicide recommendations for control of kochia in winter wheat and discuss alternative herbicide options (to glyphosate) for kochia control in fallow.

Kochia control in wheat
One of the better ways to control of kochia in wheat is to establish a full stand of vigorously-growing wheat that canopies between-row spaces quickly in spring and shades kochia seedlings; they do not grow well in shaded environments. Kochia is seldom a problem in winter wheat except when wheat stand is thin, patchy, or wheat growth is slowed by disease, low fertility, or limited moisture. Narrow row spacing, optimum seeding dates, enhanced wheat seeding rates, and in-furrow starter fertilizer increase wheat competitiveness with all weeds, not just kochia. Several herbicides registered for use in wheat have both soil and foliar activity and can be applied in late-fall or early-spring before kochia seeds germinate. Many of the same and additional herbicides can be applied to wheat and weeds in spring, but the application window for crop safety is narrow for some herbicides and postemergence application may not contact seeding kochia or other weeds protected by wheat foliage. Kochia resistant to ALS-inhibiting herbicides (sulfonylurea and imidazolinone families) was found in Kansas, Idaho, and North Dakota in 1987. ALS resistance is still present throughout the state. Many regis-
tered wheat herbicides are ALS-inhibitors. Thus, numerous ALS-inhibiting herbicides including Affinity Broadspec®, Agility SG®, Ally®, Ally Extra®, Amber®, Express TS, Finesse®, Harmony Extra®, and several generic ALS-inhibiting products may not control kochia effectively unless a herbicide of another mode of action is tank mixed with those herbicides. Auxinic herbicides such as 2,4-D, MCPA, or occasionally dicamba are popular choices for tank mix partners with sulfonylurea herbicides.

Rave® is a mixture of triasulfuron (the active ingredient in Amber) and dicamba and is a popular wheat herbicide. However, Colorado State University weed scientists have documented dicamba resistance in kochia populations in eastern Colorado and southwest Nebraska and there have been numerous complaints that dicamba is not as effective as it was in the past. Most weed scientists agree that resistant weeds evolve more quickly when low, often sub-optimal herbicide rates are used than when higher rates are used. It is possible the low amount of dicamba in recommend rates of Rave may be slowly selecting for resistance to dicamba. Other herbicides that are effective on kochia that are not ALS-inhibitors include Huskie®, Pulsar®, Starane Ultra®, and Starane Plus Salvo®.

Additional information and more detailed use recommendations can be found on individual product labels and in print copies of the K-State 2012 Chemical Weed Control Guide found online at http://www.ksre.ksu.edu/library/crps12/srp1063.pdf.

**Kochia control in early spring, preplant and fallow**

Because kochia emerges as early as March there is need for control measures in early spring either prior to emergence or as preplant burndown treatments. Two standardized experiments (preemergence and postemergence applications) were conducted at several sites in Kansas and at least one site each in Colorado, Nebraska, Montana, and Wyoming to evaluate the effectiveness of various herbicide treatments for control of kochia. In preemergence experiments, atrazine was a component of only one treatment (Harness Xtra) so as not to limit cropping options.

**Preemergence experiments.** Table 1 shows the results of four experiments conducted in Kansas near Gorham, Hays, Scott City, and Tribune in which evaluation times were similar. The mean column shows the percentage weed control averaged across experiments, the median column is the percentage at which half the control ratings were greater and the other half less than the shown percentage, and the range column reports the low and high control ratings; this is a measure of variability among experiments. The approximate costs of treatments varied from $11.77 to $30.00 per acre. There was poor correlation between treatment cost and control effectiveness.

Control ratings generally were lower at Scott City (the driest location) than the three other locations. However, the two most cost-effective preemergence treatments by a wide margin at each location were the Clarity plus 2,4-D LV4 treatments. The higher rates of Clarity and 2,4-D provided no advantage over the lower rates at 5-6 weeks after treatment, but the higher rate treatment was advantageous at later evaluations (data not shown). The 6 oz/A Spartan treatment was effective at 3 of 4 locations, but was unexplainably mediocre at Hays. Verdict was effective for 3-4 weeks but control declined rapidly thereafter. Others experiment not reported here confirm that the effectiveness of Balance Flexx is considerably improved when tank mixed with atrazine. Similar enhancement of Verdict would be expected.
Table 1. Kochia control 5-6 weeks after preemergence herbicide application averaged across four experiments conducted in Kansas, 2011.

<table>
<thead>
<tr>
<th>Herbicide treatment</th>
<th>Rate/ac</th>
<th>Approximate cost/ac(^1)</th>
<th>Mean</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verdict</td>
<td>15 oz</td>
<td>$30.00</td>
<td>59</td>
<td>62</td>
<td>23 – 89</td>
</tr>
<tr>
<td>Balance Flexx</td>
<td>5 oz</td>
<td>$29.13</td>
<td>71</td>
<td>70</td>
<td>53 – 92</td>
</tr>
<tr>
<td>Harness Xtra</td>
<td>2.3 qt</td>
<td>$19.53</td>
<td>72</td>
<td>70</td>
<td>46 – 100</td>
</tr>
<tr>
<td>Warrant</td>
<td>2 qt</td>
<td>$17.00</td>
<td>23</td>
<td>23</td>
<td>20 – 25</td>
</tr>
<tr>
<td>Valor SX</td>
<td>3 oz</td>
<td>$22.23</td>
<td>29</td>
<td>29</td>
<td>16 – 40</td>
</tr>
<tr>
<td>TripleFlex</td>
<td>1 qt</td>
<td>$24.72</td>
<td>46</td>
<td>38</td>
<td>15 – 93</td>
</tr>
<tr>
<td>Spartan 4F</td>
<td>6 oz</td>
<td>$19.77</td>
<td>79</td>
<td>83</td>
<td>55 – 100</td>
</tr>
<tr>
<td>Clarity + 2,4-D LV4</td>
<td>8 oz + 8 oz</td>
<td>$11.77</td>
<td>97</td>
<td>97</td>
<td>95 – 100</td>
</tr>
<tr>
<td>Clarity + 2,4-D LV4</td>
<td>16 oz + 16 oz</td>
<td>$18.41</td>
<td>98</td>
<td>99</td>
<td>95 – 100</td>
</tr>
</tbody>
</table>

\(^1\)Includes application ($5.13) based on Kansas Custom Rates but does not reflect program discounts or rebates. Thus, most indicated costs are probably high and are intended to show approximate costs for comparative purposes.

Postemergence experiments. Mean results of eight experiments are shown in Table 2. Format of the table is the same as Table 1. The approximate costs of treatments varied from $10.93 to $25.72 per acre. Much like the preemergence experiments, there was poor correlation between treatment cost and control effectiveness.

The effectiveness of most herbicide treatments varied widely among experiments; however, not Gramoxone + Atrazine + COC at the rates indicated in the table. The effectiveness of Roundup PowerMax in individual experiments clearly indicated that kochia populations in the Nebraska, Montana, and one of two Colorado experiments were glyphosate-susceptible while populations in all four of the Kansas experiments and one Colorado experiment were glyphosate-resistant. This is reflected in the range column. Only the Gramoxone Inteon + Atrazine 4L + COC treatment controlled kochia greater than 95% when averaged across all eight locations. Other effective treatments for which control percentage in individual experiments was always 65% or higher (range column) included Sharpen + Atrazine + MSO and Laudis + Atrazine + MSO. Huskie + NIS and Impact + Atrazine + MSO were moderately effective. Linex 4L + Atrazine 4L + COC was effective at all but the Montana location, where it performed poorly. Also, the Rage D-Tech + MSO performed much worse at the Nebraska location than at other locations. Distinct and Distinct + 2,4-D performed similarly with a wide range of performance among experiments.
Table 2. Kochia control 3-4 weeks after postemergence herbicide application averaged across eight experiments conducted in Kansas (4), Colorado (2), Montana (1) and Nebraska (1), 2011.

<table>
<thead>
<tr>
<th>Herbicide treatment¹</th>
<th>Rate</th>
<th>Approximate cost/ac²</th>
<th>Mean</th>
<th>Median</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distinct + NIS</td>
<td>4 + 2%</td>
<td>$20.20</td>
<td>67</td>
<td>75</td>
<td>27 - 94</td>
</tr>
<tr>
<td>Distinct + 2,4-D LV4 + NIS</td>
<td>4 + 8 + 2%</td>
<td>$21.34</td>
<td>69</td>
<td>74</td>
<td>32 - 99</td>
</tr>
<tr>
<td>Sharpen + LV4 + MSO</td>
<td>1 + 8 + 1%</td>
<td>$15.12</td>
<td>79</td>
<td>84</td>
<td>55 - 96</td>
</tr>
<tr>
<td>Sharpen + Atrazine 4L + MSO</td>
<td>1 + 12 + 1%</td>
<td>$15.07</td>
<td>86</td>
<td>90</td>
<td>65 - 99</td>
</tr>
<tr>
<td>Laudis + MSO</td>
<td>3 + 1%</td>
<td>$24.30</td>
<td>83</td>
<td>87</td>
<td>58 - 97</td>
</tr>
<tr>
<td>Laudis + Atrazine 4L + MSO</td>
<td>3 + 8 + 1%</td>
<td>$25.72</td>
<td>89</td>
<td>93</td>
<td>65 - 100</td>
</tr>
<tr>
<td>Callisto + Atrazine 4L + COC</td>
<td>3 + 8 + 1%</td>
<td>$22.66</td>
<td>73</td>
<td>80</td>
<td>35 - 98</td>
</tr>
<tr>
<td>Impact + Atrazine 4L + MSO</td>
<td>0.75 + 8 + 1.5%</td>
<td>$14.86</td>
<td>86</td>
<td>89</td>
<td>56 - 98</td>
</tr>
<tr>
<td>Starane NXT + NIS</td>
<td>14 + 0.5%</td>
<td>$13.94</td>
<td>63</td>
<td>62</td>
<td>18 - 99</td>
</tr>
<tr>
<td>Huskie + NIS</td>
<td>15 + 1%</td>
<td>$17.87</td>
<td>82</td>
<td>88</td>
<td>59 - 97</td>
</tr>
<tr>
<td>Rage D-Tech + MSO</td>
<td>32 + 2%</td>
<td>$17.30</td>
<td>59</td>
<td>61</td>
<td>0 - 93</td>
</tr>
<tr>
<td>Gram. + Atrazine 4L + COC</td>
<td>48 + 16 + 1%</td>
<td>$20.04</td>
<td>96</td>
<td>99</td>
<td>87 - 100</td>
</tr>
<tr>
<td>Linex 4L + Atrazine 4L + COC</td>
<td>24 + 16 + 1%</td>
<td>$21.82</td>
<td>83</td>
<td>96</td>
<td>35 - 100</td>
</tr>
<tr>
<td>RU PowerMax</td>
<td>32</td>
<td>$10.93</td>
<td>49</td>
<td>34</td>
<td>14 - 96</td>
</tr>
</tbody>
</table>

¹All treatments except Gramoxone Inteon + Atrazine 4L and Linex 4L + Atrazine 4L also included dry ammonium sulfate at 17 lb/100 gal (2% w/v). NIS, non-ionic surfactant; COC, crop oil concentrate; and MSO, methylated seed oil.

²Includes application ($5.13) based on Kansas Custom Rates but does not reflect program discounts or rebates. Thus, most indicated costs are probably high and are intended to show approximate costs for comparative purposes.

It is well known that kochia plants that survive a glyphosate application are very difficult to control by respraying, even with higher rates. This is was the case in an experiment near Monument, KS in a field of failed winter wheat which was terminated in spring by spraying with glyphosate. The wheat and weeds other than kochia were killed. We established a trial in this field and applied the herbicide treatments listed in Table 3 on June 15 when kochia plants were 3-8 inches tall. Roundup PowerMax at 32 oz/A plus Banvel at 16 oz/A and 0.5% non-ionic surfactant controlled kochia less than 50% at 21 days after treatment (DAT). Roundup PowerMax at 32 oz/A plus Sharpen at 1 oz/A and 1% MSO was similarly ineffective. No treatment controlled kochia completely and few treatments provided greater than 90% kochia control at 21 DAT.
Table 3. Kochia control in failed winter wheat 7, 14, and 21 days after treatment, Monument, KS, 2011.

<table>
<thead>
<tr>
<th>Herbicides¹</th>
<th>Rate</th>
<th>Days after treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>RU PowerMax + Banvel + NIS</td>
<td>32 + 16 + 0.5%</td>
<td>26 e 30 f 48 g</td>
</tr>
<tr>
<td>Sharp + Linex 4L + MSO</td>
<td>1 + 24 + 2%</td>
<td>91 a 89 ab 86 a-c</td>
</tr>
<tr>
<td>Sharp + Atrazine 4L + MSO</td>
<td>1 + 8 + 1%</td>
<td>91 a 85 b 80 b-d</td>
</tr>
<tr>
<td>Sharp + Gram. Inteon + MSO</td>
<td>1 + 48 + 1%</td>
<td>90 a 84 b 73 de</td>
</tr>
<tr>
<td>Sharp + RU PowerMax + MSO</td>
<td>1 + 32 + 1%</td>
<td>69 bc 48 e 53 fg</td>
</tr>
<tr>
<td>Laudis + Banvel 4 + MSO</td>
<td>3 + 16 + 1%</td>
<td>45 d 58 d 83 a-d</td>
</tr>
<tr>
<td>Laudis + Banvel 4 + Sencor DF + MSO</td>
<td>3 + 16 + 12 + 1%</td>
<td>61 c 86 b 92 ab</td>
</tr>
<tr>
<td>Laudis + Starane NXT + MSO</td>
<td>3 + 14 + 1%</td>
<td>75 b 89 ab 90 ab</td>
</tr>
<tr>
<td>Impact + Atrazine 4L + MSO</td>
<td>1 + 8 + 1%</td>
<td>65 c 74 c 74 c-e</td>
</tr>
<tr>
<td>Impact + RU PowerMax + MSO</td>
<td>1 + 32 + 1%</td>
<td>45 d 55 de 65 ef</td>
</tr>
<tr>
<td>Gramoxone Inteon + Linex 4L + NIS</td>
<td>48 + 24 + 0.5%</td>
<td>88 a 85 b 84 a-d</td>
</tr>
<tr>
<td>Gramoxone Inteon + Linex 4L + Sencor DF + NIS</td>
<td>48 + 24 + 12 + 0.5%</td>
<td>91 a 95 a 95 a</td>
</tr>
</tbody>
</table>

¹All treatments included dry ammonium sulfate at 17 lb/100 gal (2% w/v).
Marestail & Palmer Amaranth Management

Dallas Peterson & Doug Shoup
Department of Agronomy
K-State Research & Extension

Marestail (Conyza Canadensis)
- Member of the Composite (sunflower) plant family
- Native to North America
- Not much of an agronomic problem prior to no-till
- Propensity to develop herbicide resistance

Marestail Biology
- Marestail is generally considered a winter annual weed that germinates in the fall, overwinters in the rosette stage, bolts in the spring and produces seed in the summer.
- Multiple flushes can occur in the fall, spring, and summer.
- Northern areas fall germination more common
- Southern areas spring germination more common
- Plants generally have single, unbranched stems until the flowering branches at the top of the plant.
- Leaves are linear with a slightly toothed margin, alternating, and attached directly to the stem.
- Mature plants can be from 1 to 5 ft tall.

Marestail Stages of Growth
- Marestail is generally a winter annual weed that overwinters in the rosette stage, bolts in the spring, and produces seed in the summer.

Marestail
- Marestail can produce up to 200,000 seeds/plant
- Relatively short seed life in soil
- Limited competition research on marestail
  - Yield loss will depend on emergence date, density, and climatic conditions
  - Study in Michigan where soybean yield reduced >80%

Most Problematic Weeds in Kansas
Kochia
Palmer amaranth
Waterhemp
Marestail
(Horseweed)
Marestail Seed Dispersal

- Seed are very small, about 1/8 the size of dandelion seed.
- Seed is attached to a pappus, which can act like a parachute to carry the seed with the wind.
- Marestail seed have been found in the upper planetary boundary layer (~450 ft above ground).
- This could allow seeds to travel up to 300 miles with a single wind event.

Herbicide Resistance

- Marestail has developed herbicide resistance to five herbicide modes of action:
  - Glyphosate
  - Paraquat
  - Atrex
  - ALS-inhibiting herbicides
  - Diuron

Management Effect on Marestail in Soybeans

Managing Marestail

- Timing, Timing, Timing!
- Utilize 2,4-D, dicamba, Sharpen and/or residual herbicides in fall and early spring burn down in no-till.
- Atrazine + 2,4-D in corn or sorghum.
- Ignite for late burn down control.
- Control marestail in the wheat crop.
- Don’t skip on rate or appropriate spray adjuvants.
- Use appropriate treatments.

Marestail control in wheat (Winfield, 2011)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate (oz)</th>
<th>Rosette (Dec-21)</th>
<th>Balled (April-8)</th>
<th>% Control (May 19%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basil</td>
<td>3.2</td>
<td>100</td>
<td>100</td>
<td>4.05</td>
</tr>
<tr>
<td>Huska</td>
<td>1.5</td>
<td>84</td>
<td>100</td>
<td>11.00</td>
</tr>
<tr>
<td>Buckthorn</td>
<td>2.2</td>
<td>52</td>
<td>82</td>
<td>19.85</td>
</tr>
<tr>
<td>Aim</td>
<td>0.5</td>
<td>24</td>
<td>88</td>
<td>3.10</td>
</tr>
<tr>
<td>Finster</td>
<td>0.4</td>
<td>20</td>
<td>88</td>
<td>8.00</td>
</tr>
<tr>
<td>Rave</td>
<td>1.5</td>
<td>100</td>
<td>88</td>
<td>3.00</td>
</tr>
<tr>
<td>Powerherb</td>
<td>3.0</td>
<td>55</td>
<td>80</td>
<td>12.00</td>
</tr>
<tr>
<td>Harmony SG</td>
<td>3.9</td>
<td>63</td>
<td>76</td>
<td>32.00</td>
</tr>
<tr>
<td>Stendane Ultra</td>
<td>6.4</td>
<td>65</td>
<td>68</td>
<td>14.60</td>
</tr>
</tbody>
</table>

LSD (0%) 24

Shloy, Zimmerman, & Peterson, 2010

Fall applied herbicides for weed control prior to no-till corn, Manhattan, KS (Thompson and Peterson 1001fall10).

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate (oz)</th>
<th>% Control</th>
<th>% Control in May 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atrazine + 2,4-D</td>
<td>32</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Atrazine + 2,4-D + COC + AMS</td>
<td>32</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Atrazine + 2,4-D + COC + AMS</td>
<td>32</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Atrazine + 2,4-D + COC + AMS</td>
<td>32</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Atrazine + 2,4-D + COC + AMS</td>
<td>32</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

LSD (0%) 18
### Burndown of rosette marestail at Manhattan, KS in 2011 (Peterson and Thompson)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date</th>
<th>Rate</th>
<th>IWA T</th>
<th>5/24</th>
<th>6/10</th>
<th>6/24</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(g/a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharpen + MSQ</td>
<td>4/12</td>
<td>1</td>
<td>95</td>
<td>55</td>
<td>.43</td>
<td>33</td>
<td>5.60</td>
</tr>
<tr>
<td>2,4-D</td>
<td>4/12</td>
<td>56</td>
<td>80</td>
<td>73</td>
<td>.63</td>
<td>32</td>
<td>2.75</td>
</tr>
<tr>
<td>Clarity</td>
<td>4/12</td>
<td>4.2</td>
<td>81</td>
<td>73</td>
<td>.59</td>
<td>2.88</td>
<td></td>
</tr>
<tr>
<td>Clarity</td>
<td>4/12</td>
<td>8</td>
<td>89</td>
<td>79</td>
<td>.98</td>
<td>2.70</td>
<td></td>
</tr>
<tr>
<td>Ignite + AMS</td>
<td>4/12</td>
<td>26</td>
<td>86</td>
<td>58</td>
<td>.43</td>
<td>38</td>
<td>13.90</td>
</tr>
</tbody>
</table>

**LSD (5%)**

|        | 4 | 5 | 4 | 3 |

### Burndown of bolted marestail at Manhattan, KS in 2011 (Peterson and Thompson)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Date</th>
<th>Rate</th>
<th>IWA T</th>
<th>5/24</th>
<th>6/10</th>
<th>6/24</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(g/a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharpen + MSQ</td>
<td>5/10</td>
<td>1</td>
<td>94</td>
<td>96</td>
<td>76</td>
<td>61</td>
<td>5.60</td>
</tr>
<tr>
<td>2,4-D</td>
<td>5/10</td>
<td>16</td>
<td>73</td>
<td>33</td>
<td>57</td>
<td>47</td>
<td>2.75</td>
</tr>
<tr>
<td>Clarity</td>
<td>5/10</td>
<td>4</td>
<td>53</td>
<td>38</td>
<td>53</td>
<td>60</td>
<td>2.65</td>
</tr>
<tr>
<td>Clarity</td>
<td>5/10</td>
<td>18</td>
<td>43</td>
<td>48</td>
<td>69</td>
<td>79</td>
<td>5.70</td>
</tr>
<tr>
<td>Ignite + AMS</td>
<td>5/10</td>
<td>29</td>
<td>81</td>
<td>57</td>
<td>88</td>
<td>88</td>
<td>13.90</td>
</tr>
<tr>
<td>Roundup + Pinox</td>
<td>5/10</td>
<td>22</td>
<td>48</td>
<td>93</td>
<td>96</td>
<td>96</td>
<td>3.60</td>
</tr>
<tr>
<td>Roundup + Sharpen</td>
<td>5/10</td>
<td>22+1</td>
<td>94</td>
<td>100</td>
<td>99</td>
<td>99</td>
<td>2.20</td>
</tr>
</tbody>
</table>

**LSD (5%)**

|        | 4 | 5 | 4 | 3 |

### Marestail Control Ahead of Soybean (Hillsboro)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Application Share</th>
<th>Herb</th>
<th>Resette (Mar-29)</th>
<th>Boiled (May-5)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(g/a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundup PMax</td>
<td>22  oz</td>
<td>84</td>
<td>63</td>
<td>1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2,4-D</td>
<td>32  lb</td>
<td>95</td>
<td>84</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classic</td>
<td>112 oz</td>
<td>59</td>
<td>59</td>
<td>5.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ignite</td>
<td>22  oz</td>
<td>97</td>
<td>90</td>
<td>10.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authority First</td>
<td>3    oz</td>
<td>57</td>
<td>61</td>
<td>16.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valor TCX</td>
<td>3    oz</td>
<td>54</td>
<td>58</td>
<td>13.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Rate</td>
<td>0.7  oz</td>
<td>71</td>
<td>71</td>
<td>29.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharpen</td>
<td>1.1  oz</td>
<td>97</td>
<td>97</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gramoxone</td>
<td>33  lb</td>
<td>86</td>
<td>78</td>
<td>9.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**LSD (5%)**

*Shrivji Rohani, & Paterson, 2010.*

### Sharpen on Marestail

- Most consistent results when tank-mixed with 2,4-D, dicamba, or glyphosate.
- Use with methylated seed oil.
- Use adequate spray volume, 15 gpa or higher.
- 2 oz/A has been more consistent than 1 oz/A when it can be used.

### Post-emergence Control of Glyphosate Resistant Marestail Control in Soybean (Manhattan)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>IWA T</th>
<th>3.WAT</th>
<th>10.WAT</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>(g/a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundup PMax</td>
<td>22  oz</td>
<td>30</td>
<td>57</td>
<td>.57</td>
<td>3.00</td>
</tr>
<tr>
<td>Roundup PMax + Cadet</td>
<td>44  oz</td>
<td>37</td>
<td>60</td>
<td>.57</td>
<td>3.20</td>
</tr>
<tr>
<td>Cadet</td>
<td>0.9 oz</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>10.70</td>
</tr>
<tr>
<td>RU PMax + Cadet</td>
<td>25.2 oz</td>
<td>80</td>
<td>.74</td>
<td>.47</td>
<td>14.30</td>
</tr>
<tr>
<td>First Rate</td>
<td>0.5  oz</td>
<td>47</td>
<td>73</td>
<td>4.3</td>
<td>12.75</td>
</tr>
<tr>
<td>RU PMax + First Rate</td>
<td>23.0 oz</td>
<td>47</td>
<td>77</td>
<td>.95</td>
<td>16.35</td>
</tr>
<tr>
<td>Classic</td>
<td>0.5 oz</td>
<td>53</td>
<td>53</td>
<td>40</td>
<td>6.20</td>
</tr>
<tr>
<td>RU PMax + Classic</td>
<td>22.0 oz</td>
<td>53</td>
<td>79</td>
<td>.77</td>
<td>11.80</td>
</tr>
</tbody>
</table>

**LSD (5%)**

|        | 6 | 10 | 6 |

### Palmer amaranth (Amaranthus palmeri) Common Waterhemp (Amaranthus rudis)

- Members of the Amaranth (pigweed) plant family
- Native to North America
- Very competitive and prolific seed producers
- Propensities to develop herbicide resistance
**Palmer Amaranth & Waterhemp Biology**

- Warm season, summer annuals
- Start to germinate in May and continue through the summer
- Palmer amaranth has ovate leaves and may reach 12 feet tall and have 3-inch diameter stems.
- Waterhemp may reach 8 feet tall, but typically has smaller stems and narrower leaves.
- Both species have smooth stems and leaves, while redroot pigweed is pubescent.
- Both species have male and female plants (dioecious).
- Genetic diversity
- Gene flow

---

**Pigweed Competition.**

- **Palmer amaranth:**
  - Height: up to 10 ft tall
  - Soybean yield losses up to 79% at 8 plants/3 ft row

- **Common waterhemp:**
  - Height: up to 7 ft tall
  - Soybean yield losses up to 50% at 8 plants/3 ft row

- **Redroot pigweed:**
  - Height: up to 3 ft tall
  - Soybean yield losses up to 38% at 8 plants/3 ft row

---

**Herbicide Resistance**

- Palmer amaranth and waterhemp have developed resistance across 6 herbicide MOA:
  - Diaminonime (Palmer)
  - Triazine Resistance (Both)
  - ALS Resistance (Both)
  - FPO Resistance (Waterhemp)
  - Glyphosate Resistance (Both)
  - HPPD Resistance (Both)
  - 2,4-D (Waterhemp)

---

**Palmer Amaranth & Waterhemp Control**

- Utilize an integrated approach incorporating residual and postemergence herbicides with different MOA

- Foundation preemergence herbicides:
  - Soybeans: Prefix, Authority, Valor, Acetanilides, Fierce
  - Corn: Atrazine/acetanilide premixes, Lannate/Lumax, Balance FLEX, Corvus, Verdict
  - Sorghum: Atrazine Premixes, Lannate/Lumax, Verdict
  - Sunflower: Spartan, Dual, Prowl

33
Palmer Amaranth & Waterhemp Control

- Utilize an integrated approach incorporating residual and postemergence herbicides with different MOA

- Postemergence herbicide options
  - Soybean: Flexstar, Cobra, Ultra Blaster, Glyphosate
  - Corn: Callisto, Laudis, Capreno, Impact, Armezon, Stifl, 2,4-D, Glyphosate
  - Sorghum: Huskie, atrazine, desmetry, 2,4-D
  - Sunflowers: Beyond or Express???

- Liberty Link programs in soybeans and corn

---

Glyphosate resistant waterhemp control at Ottawa, KS in 2011 (Peterson, Shoup, and Putman)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>6/28</th>
<th>7/20</th>
<th>9/8</th>
<th>Cost ($/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundup Power Max</td>
<td>22</td>
<td>16</td>
<td>15</td>
<td></td>
<td>3.00</td>
</tr>
<tr>
<td>Valor XLT/RUPM</td>
<td>4/22</td>
<td>91</td>
<td>91</td>
<td>66</td>
<td>21.85</td>
</tr>
<tr>
<td>Valor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XLT/RUPM+Flexstar</td>
<td>4/22+20</td>
<td>99</td>
<td>92</td>
<td>66</td>
<td>43.90</td>
</tr>
<tr>
<td>Authority XLT/RUPM+Flexstar</td>
<td>4/22+20</td>
<td>98</td>
<td>97</td>
<td>36</td>
<td>49.35</td>
</tr>
<tr>
<td>Authority+Flexstar</td>
<td>6/5/22+20</td>
<td>90</td>
<td>96</td>
<td>94</td>
<td>58.90</td>
</tr>
<tr>
<td>Fierce/RUPM+Flexstar</td>
<td>4/5/22+20</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td></td>
<td>7</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

---

Roundup Power Max

Fierce/Roundup PM+Flexstar

---

Broadleaf weed control at Manhattan, KS in 2010 with good activation (Peterson and Thompson)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Palmer amaranth (%)</th>
<th>Velvet leaf</th>
<th>Morning glory</th>
<th>Herb. Cost ($/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valor XLT</td>
<td>3 oz</td>
<td>99</td>
<td>100</td>
<td>98</td>
<td>13.70</td>
</tr>
<tr>
<td>Fierce</td>
<td>3.6X</td>
<td>99</td>
<td>99</td>
<td>87</td>
<td>?</td>
</tr>
<tr>
<td>Authority First/Stufte</td>
<td>3.2 oz</td>
<td>97</td>
<td>100</td>
<td>87</td>
<td>16.40</td>
</tr>
<tr>
<td>Authority XL</td>
<td>4 oz</td>
<td>98</td>
<td>93</td>
<td>90</td>
<td>14.60</td>
</tr>
<tr>
<td>Prefix</td>
<td>2.6X</td>
<td>100</td>
<td>53</td>
<td>50</td>
<td>14.30</td>
</tr>
<tr>
<td>OptiTill</td>
<td>2 oz</td>
<td>89</td>
<td>100</td>
<td>83</td>
<td>13.25</td>
</tr>
<tr>
<td>Broad H2O</td>
<td>2.5 pt</td>
<td>59</td>
<td>83</td>
<td>27</td>
<td>14.25</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td></td>
<td>7</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

---

Broadleaf weed control at Manhattan, KS in 2010 with delayed activation (Peterson and Thompson)

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Palmer amaranth (%)</th>
<th>Velvet leaf</th>
<th>Morning glory</th>
<th>Herb. Cost ($/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valor XLT</td>
<td>4 oz</td>
<td>99</td>
<td>87</td>
<td>73</td>
<td>16.00</td>
</tr>
<tr>
<td>Authority First</td>
<td>3.2 oz</td>
<td>73</td>
<td>70</td>
<td>77</td>
<td>16.40</td>
</tr>
<tr>
<td>Authority XL</td>
<td>4 oz</td>
<td>63</td>
<td>63</td>
<td>73</td>
<td>14.60</td>
</tr>
<tr>
<td>Authority Astra</td>
<td>5 oz</td>
<td>67</td>
<td>67</td>
<td>73</td>
<td>14.30</td>
</tr>
<tr>
<td>Fierce</td>
<td>2 oz</td>
<td>98</td>
<td>100</td>
<td>73</td>
<td>7</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td></td>
<td>8</td>
<td>13</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
Liberty Link Corn and Soybeans

- Allows the use of Ignite herbicide (newer formulation of Liberty).
- Application timing, spray coverage, temperature, humidity, light intensity, and time of day all critical to performance of Ignite.
- Works best as part of a sequential weed control program with preemergence residual herbicides.

Weed control in Liberty Link soybeans at Manhattan, KS, 2011 (Peterson and Thompson).

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Timing</th>
<th>Emergence</th>
<th>Flowering</th>
<th>Velvetleaf</th>
<th>Morningglory</th>
<th>Herb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ignite</td>
<td>46</td>
<td>EP</td>
<td>90</td>
<td>95</td>
<td>95</td>
<td>96</td>
<td>92</td>
</tr>
<tr>
<td>Ignite/Ignite</td>
<td>39/39</td>
<td>E/EP</td>
<td>94</td>
<td>93</td>
<td>92</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>Prefix/Ignite</td>
<td>32/32</td>
<td>PX/EP</td>
<td>100</td>
<td>100</td>
<td>90</td>
<td>91</td>
<td>92</td>
</tr>
<tr>
<td>Prefix/Vali</td>
<td>32/32</td>
<td>EP/EP</td>
<td>90</td>
<td>90</td>
<td>95</td>
<td>95</td>
<td>92</td>
</tr>
<tr>
<td>Vali/Ignite</td>
<td>32/32</td>
<td>EP/EP</td>
<td>97</td>
<td>95</td>
<td>90</td>
<td>95</td>
<td>93</td>
</tr>
<tr>
<td>Valor XL/Ignite</td>
<td>32/32</td>
<td>EP/EP</td>
<td>90</td>
<td>100</td>
<td>100</td>
<td>99</td>
<td>92</td>
</tr>
<tr>
<td>Aust. First/Ignite</td>
<td>42/42</td>
<td>PX/EP</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>92</td>
</tr>
<tr>
<td>Aust. XL/Ignite</td>
<td>42/42</td>
<td>PX/EP</td>
<td>100</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>99</td>
</tr>
<tr>
<td>Paraliget</td>
<td>32/32</td>
<td>PX/EP</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>95</td>
</tr>
</tbody>
</table>

| Lad (%) | 6 | 8 | 3 | 4 |

Future Technologies in Soybeans

- Crops stacked with multiple herbicide resistant traits.
- Dicamba resistant soybeans from Monsanto -- 2014?
  - Metabolism based resistance, stacked with Roundup Ready trait.
  - Monsanto and BASF developing new lower volatility formulation of dicamba.
- DHT (Enlist) resistant soybeans from Dow Ag -- 2015?
  - Resistance to 2,4-D, stacked with glyphosate resistance.
  - Metabolism based resistance.
  - Dow developing new low volatility formulation of 2,4-D that will be pre-mixed with glyphosate called Enlist Duo.
- HPPD resistant soybeans -- 2016?

Dicamba and 2,4-D Resistant Soybeans

Potential Benefits

- Improved control of hard to control weeds.
  - Morningglory, velvetleaf.
- Improved control of herbicide resistant weeds.
  - Marestail, pigweeds, pigmyweeds, Kochia.
- Improved burndown options without preplant interval restrictions.
Spray Boom Set-up on Field Sprayers

Robert N. Klein, Extension Western Nebraska Crops Specialist
Greg R. Kruger, Extension Cropping Systems Specialist

Design attributes and expected costs of dry and wet field sprayer booms are compared and illustrated.

Field sprayer booms are an important part of the pesticide delivery system and can influence application accuracy and efficiency. Booms come in all shapes and sizes, depending on their use, and deliver the spray solution to the nozzles and tips at the desired pressure for the target. A small hand boom may be only a single nozzle while a large field sprayer could have a 120-foot or wider boom.

Nozzle Spacing

The most common nozzle spacings are 20 and 30 inches. Many sprayers are now being converted from 30 inch to 15 inch spacings. The 30-inch spacing is used for the lower application rates (7 to 10 gallons per acre) and the 15-inch spacing for the higher application rates (14 gallons per acre and higher). For most applications, the 30-inch spacing (adding 15-inch spacing if desired) works best since most row crops are in 30-inch rows. For those in 20- and 22-inch rows you may wish to have nozzle spacing the same as row width. Having nozzles spaced the same as the row width enables you to easily use drop nozzles, although with row spacing less than 30 inches it is usually difficult to use drop nozzles. The recommendation is to use 80-degree nozzles in 20-inch or narrower spacing, and to use 100-degree nozzles with 30-inch nozzle spacing. Many new nozzles are only available in 110 degrees. The 30-inch nozzle spacing also lets the applicator use a larger nozzle tip that permits use of 50 mesh nozzle screens. If possible, use 0.25 gallons per minute (GPM) nozzle tips or larger. A 0.20 GPM nozzle tip may be used with a 50 mesh nozzle screen but is just on the border of what is recommended to prevent plugging. The particle size of a 110 degree nozzle tip that is 50 percent larger (used in 30-inch spacing) and an 80-degree nozzle used in 20-inch spacing (0.3 GPM vs 0.2 GPM) is almost the same size as you do not increase the potential spray drift problem going to 30-inch nozzle spacing and 110-degree nozzles.

Stability and Strength — Boom Features

Two attributes to look for when selecting a boom are stability and strength. Stability, the most important factor, ensures that the boom maintains a constant orientation to the target. Field conditions may vary widely, but if a spray boom is expected to provide a uniform application, stability must be maintained. Also important is a boom’s strength or its ability to withstand operating conditions without becoming damaged.

Two systems are used to control boom stability. Passive systems, which include trapeze suspensions, center pivots, and dampening suspensions, all use balance. They minimize the amount...
of deflection transferred from the sprayer to the boom through various linkage designs. Active systems, on the other hand, use sensors and actuators in stabilizing the boom. An active system will usually have a sensor on the boom which is set to distinguish any fluctuation in distance between the target and the boom. If a difference in height is observed, the sensor signals the actuator on the boom linkage and it makes the appropriate adjustment. This usually means raising or lowering the boom in relation to the original setting.

**Wet and Dry Booms**

There are two types of booms: wet and dry. A boom is considered a wet boom (Figure 1, bottom) if the pipe span is not only used as a support mechanism for the spray nozzles but delivers spray solution to them as well, hence the name “wet boom.” A boom that is used merely as a span along which to space the nozzles, but which does not deliver the spray solution, is considered a dry boom (Figure 1, top). The solution is delivered to the nozzles via a separate hose line that runs along the boom span using it as a support mechanism to mount each nozzle.

The advantages of a wet boom are less plugging of nozzle tips since there is less area where particles could build up and the ease of flushing the boom. On the dry boom, hose and nozzle assemblies are much more subject to being contaminated with residues than stainless steel tubing or pipe. Some adjuvants used with pesticides provide excellent cleaning of the tank, hose, etc., and may cause the spray solution to become contaminated. Even though the tank has been cleaned, the spray booms often have not been cleaned.

As more glyphosate-resistant weeds appear, use of products with greater residual activity or different modes of action will increase. As this occurs, greater attention is going to need to be given to flushing the system before moving on to other crops or on to crops without the appropriate resistance traits. Because of this, wet booms are going to become more practical because of the ease of cleaning.

Unless the boom is really long or a small size pipe is used, the spray boom on a wet boom needs only to be fed with the spray solution on the end. Since the nozzle assemblies on a dry boom greatly restrict the flow rate, the boom must be fed every few nozzles to prevent a pressure drop.

Another advantage of a wet boom is that the angle of the boom can be changed (Figure 2) and in most situations it is easier to change the height of a wet boom than a dry boom. Additional nozzle assemblies to accommodate various row spacings on a wet boom do not restrict the flow rate (Figure 3) nearly as much as additional nozzle assemblies on a dry boom.

The two main disadvantages of a wet boom are initial cost and its potential for damage. If the boom contacts a non-moveable object, it may break or bend, destroying part of the boom.

**Table 1. Comparison of wet and dry boom costs.**

<table>
<thead>
<tr>
<th>20-foot wet boom:</th>
<th>20-foot dry boom:</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 feet of 1-inch OD 16-gauge stainless</td>
<td>20 feet of 3/4-inch braided hose - $0.95/foot</td>
</tr>
<tr>
<td>steel tubing - $6.75/foot</td>
<td>$19.00</td>
</tr>
<tr>
<td>2 nipples - $6 each</td>
<td>If 30-inch nozzle spacing, 16 stainless steel clamps - $0.80 each</td>
</tr>
<tr>
<td>Welding 2 nipples - $4 each</td>
<td>$12.80</td>
</tr>
<tr>
<td></td>
<td>To keep from losing pressure, each 10-foot section of hose is fed in the middle</td>
</tr>
<tr>
<td></td>
<td>Extra hose is 7 feet + 17 feet = 24 x $0.95 = $22.80</td>
</tr>
<tr>
<td></td>
<td>4 more clamps at $0.80 each = $3.20</td>
</tr>
<tr>
<td></td>
<td>Two fittings at approximately $7 each = $14.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>$155.00</td>
<td>$71.80</td>
</tr>
</tbody>
</table>

**Cost Comparison**

The costs of a modern wet boom design versus a dry boom are summarized in Table 1. The cost of 1-inch outside diameter 16-gauge stainless steel tubing is approximately $6.75 per foot. The ends of the tubing are compressed and 1-inch stainless steel pipe nipples are welded to each end of the stainless steel tubing. The nipples cost approximately
Figure 3. Nozzle assemblies for dry (left) and wet (right) booms.

Figure 4. The bracket to hold the wet boom. The rubber hose protects the boom and the stainless steel hose clamps hold the wet boom in place.

Figure 5. How dry boom is fed — note restriction to flow rate.

Figure 6. How wet boom is fed.

Figure 7. End cap on wet boom to drain and flush boom.

Figure 8. Wet boom nozzle body on and off boom.
$6.00 and welding each one costs about $4. The hose that feeds the boom and the plug can be attached to these nipples. Both are quick attach couplers. Holes on the boom need to be precisely drilled at the nozzle spacing being used.

This example assumes the connectors and nozzle assemblies for the hose and stainless steel tubing will be about equal to the additional hose and fittings needed on the dry boom.

If the dry boom is left outside and unprotected, the hose may need to be replaced every two or three years. The stainless steel tubing should last for many years if not damaged.

*Figures 3-10* help illustrate differences between wet and dry booms.

This publication has been peer reviewed.

UNL Extension publications are available online at [http://extension.unl.edu/publications](http://extension.unl.edu/publications).
Current Trends in Crop Leases
Troy Dumler – tdumler@ksu.edu – 620-275-3164
Kevin Dluhyoetter – krod@ksu.edu – 785-532-5577

Introduction

▶ Types of leases
▶ Principles of leases
  – Technological changes
  – Tenant/Landowner communications
▶ Information and decision tools:
  www.agmanager.info

Over the years, the majority of leasing questions received pertain to:

▶ Impact of adopting new technologies
▶ Cash renting
▶ "Non-traditional" leases
  – Net share rent
  – Flexible cash rent
  – Bushel rent
  – Combination cash/crop share
▶ Terminating leases

...regardless of topic pertaining to lease terms, method of addressing questions does not change

Types of Leases on Crop Land

▶ Crop share lease
  – Landowner receives a share annual revenues based
    (grain sales and government payments) and typically
    shares certain production costs
▶ Cash lease
  – Landowner receives a fixed annual payment in
    exchange for use of land
▶ Variations of crop share and cash leases

Non-irrigated Lease Types in Kansas

<table>
<thead>
<tr>
<th>District</th>
<th>Fixed Cash</th>
<th>Crop Share</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW</td>
<td>36.2%</td>
<td>54.9%</td>
<td>5.9%</td>
</tr>
<tr>
<td>WC</td>
<td>21.3%</td>
<td>58.5%</td>
<td>20.2%</td>
</tr>
<tr>
<td>SW</td>
<td>23.7%</td>
<td>75.1%</td>
<td>1.4%</td>
</tr>
<tr>
<td>NC</td>
<td>41.9%</td>
<td>54.9%</td>
<td>3.2%</td>
</tr>
<tr>
<td>C</td>
<td>32.6%</td>
<td>53.8%</td>
<td>13.4%</td>
</tr>
<tr>
<td>SC</td>
<td>34.0%</td>
<td>65.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>NE</td>
<td>48.7%</td>
<td>42.4%</td>
<td>8.9%</td>
</tr>
<tr>
<td>EC</td>
<td>50.6%</td>
<td>39.6%</td>
<td>9.8%</td>
</tr>
<tr>
<td>SE</td>
<td>35.9%</td>
<td>56.2%</td>
<td>8.9%</td>
</tr>
</tbody>
</table>

Rental:
55.7% 55.7% 8.9%

Source: KSU, Coltegel and Tidwell, 2011.

Determining the terms of a lease...

▶ How are cash lease rates or the terms of share
  leases established?
  – Short answer is "the market"
▶ While landowners and tenants (i.e., the market)
  ultimately determine terms of share and cash
  leases, we use the **equitable** concept to arrive at a
  starting point for negotiations.
Example of market established crop shares...

<table>
<thead>
<tr>
<th>Crop</th>
<th>Broadcast</th>
<th>Disk Share</th>
<th>Side Share</th>
<th>Center Share</th>
<th>Total Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>38.0%</td>
<td>0%</td>
<td>0%</td>
<td>38.0%</td>
<td>38.0%</td>
</tr>
<tr>
<td>Corn</td>
<td>38.0%</td>
<td>38.0%</td>
<td>12.5%</td>
<td>12.5%</td>
<td>69.0%</td>
</tr>
<tr>
<td>Soybeans</td>
<td>20.0%</td>
<td>20.0%</td>
<td>20.0%</td>
<td>20.0%</td>
<td>80.0%</td>
</tr>
</tbody>
</table>

*Representative market in this table represents the percent of the crop during the crop season. For example, 38.0% of the crop planted 38.0% of the broadcast share.

Problem:

The market equilibrium prices we observe (when they are available) often do not reflect individual situations.

That is, they reflect averages, but nobody is average...

... so what can we do to arrive at a price that reflects an equilibrium?

Principle #1: Yield increasing inputs should be shared

Example of yield increasing inputs:

- Fertilizer
- Irrigation water
- Herbicide
- Seed

A good crop share lease should follow five basic principles...

1. Yield increasing inputs should be shared
2. Share arrangements should be adjusted as technology changes
3. Total returns divided in same proportion as resources contributed
4. Compensation for unused long-term investments at termination
5. Good landlord/tenant communications

Crop Share Arrangements in Kansas

<table>
<thead>
<tr>
<th>Share</th>
<th>NW</th>
<th>NE</th>
<th>SW</th>
<th>SE</th>
<th>SW</th>
<th>NE</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Year</td>
<td>40%</td>
<td>35%</td>
<td>20%</td>
<td>6%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Second Year</td>
<td>30%</td>
<td>20%</td>
<td>50%</td>
<td>7%</td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>Total</td>
<td>70%</td>
<td>55%</td>
<td>70%</td>
<td>13%</td>
<td>10%</td>
<td>13%</td>
</tr>
</tbody>
</table>


Principle #2: Technology may affect share arrangements

Examples of technological change
- Reduced-no-till
- New crops and/or rotations
- Center pivot irrigation
- Bio-technology
- Precision agriculture (GPS)

How does technology impact relative contributions?
**Principle #3:**
 Returns divided in same proportion as resources contributed.

This requires annual contributions of both parties to be identified (budgeting type approach). Valuing inputs can depend on whether the lease being developed is a one-year lease versus multiple-year lease.

**If the goal is to have an “equitable” lease ...**

... then crops should be divided in the same proportion that inputs are provided, regardless of whether or not specific input costs are shared.

What is most important is communication.

---

**Principle #4:**
Compensation for unused long-term investments at termination.

- It is generally recommended that landowner make long-term investments such as terraces, irrigation well, lime, alfalfa seed, etc.

- However, if the tenant either pays for these investments, or shares them, he should be compensated for his share of any value that remains when the lease is terminated.

**Principle #5:**
Good communications between the landlord and the tenant.

- Because so many of the terms of the lease are based on negotiation between the landowner and the tenant, good communications are critical.

- Because a lease is a legal contract in Kansas, it is suggested that terms of the lease agreed upon by both parties be put in writing.

---

**Cash rents ...**

- Reasons to go to cash rent ...
  - Steady source of income for landowners
  - Increased planting flexibility
  - Increased simplicity
- Potential consequences
  - Land tends to change hands more often
  - Relative risks change

**Methods of Establishing Cash Rent Values**

- Market going rate (if available)
- Landowner’s cost
- Crop share (adjusted for risk?)
- Amount tenant can afford to pay
Kansas Nonirrigated Cash Rents, 2011

**Cropland Values and Rents**

<table>
<thead>
<tr>
<th>Year</th>
<th>Irrigated</th>
<th>Non-Irrigated</th>
<th>Irrigated</th>
<th>Non-Irrigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>$1,220</td>
<td>$820</td>
<td>$74.00</td>
<td>$36.00</td>
</tr>
<tr>
<td>2007</td>
<td>$1,260</td>
<td>$880</td>
<td>$82.00</td>
<td>$41.00</td>
</tr>
<tr>
<td>2008</td>
<td>$1,450</td>
<td>$880</td>
<td>$82.30</td>
<td>$42.50</td>
</tr>
<tr>
<td>2009</td>
<td>$1,500</td>
<td>$1,000</td>
<td>$89.00</td>
<td>$43.50</td>
</tr>
<tr>
<td>2010</td>
<td>$1,800</td>
<td>$1,100</td>
<td>$90.80</td>
<td>$43.50</td>
</tr>
<tr>
<td>2011</td>
<td>$1,880</td>
<td>$1,250</td>
<td>$105.00</td>
<td>$44.90</td>
</tr>
</tbody>
</table>

% Change

'06 to '11: 12.5% 13.6% 10.0% 1.1%

Source: Kansas Agricultural Statistics

**Market going rate...**

**Market going rate...**

**Using “KSU-Lease.xls” to determine equitable crop share and cash leases...**

- Information/data required:
  1. Crop rotation/mix
  2. Income information
  3. Production inputs
  4. Machinery costs
  5. Land value
  6. Irrigation costs
  7. Contributor of input
  8. Risk adjustment
Alternative Prices to Consider

2011 Estimated cash rents for Western Kansas

Non-traditional Leases

Flexible Cash Rents – WHAT?

Flexible Cash Rents – WHY?

Flexible cash rents simply refer to land rental arrangements where the amount of cash rent paid (received) can vary based upon some pre-determined formula (i.e., formalizes bonus rents)

Methods of “flexing” rental rates, i.e., formulas are based on:
- Yield (actual for producer, county average, etc.)
- Price (harvest, season average, actual)
- Revenue (yield x price, crop insurance, residue)
- Costs
- Other...

Method of allowing rents to vary from year-to-year without having to renegotiate rents annually

Trend in Kansas has been moving away from crop share leases to more cash leases

Volatility of last few years has significantly increased the risk of fixed cash rents

Way of sharing/managing risks associated with volatile markets (without hassles of crop share lease)
Flexible Cash Rents – Why Not?

- Complex
- Theory and intuition guide conceptual design, but little help with specific details
- Not needed if cash rents are renegotiated frequently
- Hard to think of everything, which means we might need to be “tweaking” arrangement regularly
- If designed wrong, might increase risk

Flexible cash rents (method of formulating bonuses)

1) Establish base cash rent

2) Flex/modify base rent based on...
   - price deviation from base (fixed bushel rent)
   - yield deviation from base
   - price and yield (revenue) deviation from base
   - cost deviation from base

> Communication and documentation are important to ensure everybody understands what it is they are agreeing to.

Bushel Rent

- Potential advantages versus fixed cash rent
  - Allows landowner to take advantage of high prices
  - Provides some protection for tenants when prices fall
- Must establish base yield and bushels landlord receives
- If landlord does not share production risk, they are ineligible for government subsidies

Net Share Rent

- Potential advantage
  - Allows landowner to take advantage of high prices
  - Provides some protection for tenants when prices fall
- Disadvantage
  - Violates 1st principle of good crop share leases (share yield increasing inputs)
  - Could result in more frequent negotiations if input costs are volatile

Other important considerations

- Written agreements are encouraged
- By law, oral leases are one-year leases that automatically renew unless notice of termination is given
- Termination requirements
  - Proper notice must given to tenant 30 days prior to March 1 for both crop and pasture land unless a written lease identifies another date for termination
- Kansas Agricultural Lease Law

Questions?
In this session we examine three areas of common questions regarding yield monitoring, including the theory and operation of yield monitoring systems, data filtering, and potential uses of yield monitor data.

**Why yield data?**

Crop yield, or yield potential is the basis of almost all agronomic decision making. Everything from nitrogen rates to seeding rates are tied to yield potential either explicitly or implicitly. Yield is the result of a combination of factors, some manageable, some not, but is the integration of everything that happens to a crop over the course of the growing season. Yield varies spatially within a field. This is recognized by all producers and yield monitor data is the only way to truly quantify spatial variability in crop yield within a field.

**Yield Monitoring Systems:**

Yield monitoring systems work by measuring mass (weight) over a given area and assign that value to a geographic location via GPS. Grain mass is measured by a mass flow sensor located at the top of the clean grain elevator. Grain moisture is obtained by a capacitance type sensor that is placed in the flow of clean grain somewhere on the combine. It is important to keep the top of the clean grain elevator chain and paddles at the proper distance to the mass flow sensor. This affects the trajectory of grain into the sensor’s strike plate. Any change in this distance must be accompanied by recalibration of the monitor; distances outside of tolerance will result in reduced accuracy. It is important that proper calibration procedures are implemented so that the system can correlate a measured force to a known mass. The type of calibration to be performed is dependent upon your yield monitoring system. A yield monitor can either be a single point or multi-point calibration. The differences between calibrations are shown in the figure.

It is important to remember that a yield monitor is only as good as the calibration performed on it. Distance should be calibrated first, followed by grain moisture, and lastly grain flow. A suggested procedure for a multipoint type monitor is demonstrated below. The full flow pass is done with full width and while “pushing” harvest speed. The resulting flows are then accomplished by traveling at a steady speed while using

![Diagram](image-url)

(a) Example “near-straight” (near-linear) grain flow calibration curve.

- Internal points that define near-linear characteristics
- Calibration point at some harvest rate to adjust the internal points
- "zero" = that portion of the flow sensor signal not due to actual grain flow

(b) Example “not-straight” (non-linear) grain flow calibration curve.

- Internal points that define non-linear characteristics
- Calibration points at various harvest rates to adjust the internal points
- "zero" = that portion of the flow sensor signal not due to actual grain flow
fractions of the available header width. After completing calibration errors should be in the range of 1.5 – 2.5% and must be less than 3% if the data is to be used for RMA yield reporting purposes.

<table>
<thead>
<tr>
<th>Blank Area</th>
<th>Full Flow</th>
<th>1/4 Full Flow</th>
<th>1/2 Full Flow</th>
<th>3/4 Full Flow</th>
<th>Blank Area</th>
</tr>
</thead>
</table>

Yield Monitor Data:

It is good practice to keep a raw copy (both binary direct from the data card and in some export format) before you perform any filtering or processing. Before filtering yield monitor data, it is important to understand the potential sources of errors. The most notable sources of error include unknown header width, grain flow delay, and rapid changes in combine speed. Unknown header width can be handled by newer yield monitors through autoswath technology if only one machine is running in the field. Advancements in software will be needed to fix swath errors in other scenarios. Most other yield data errors are caused by combine flow dynamics. The Yield Editor software offered by USDA-ARS (Google search: USDA-ARS Yield Editor Download) provides a simple way to help filter these errors from the data. The newest version 2.0 contains automated routines that greatly simplify the process and are described in more detail in the software documentation.

The processing of yield data is an important step that offers a variety of options. Regardless of the method used, yield monitor data is almost always processed into a grid of some form. In interpolation, a relatively small grid is used. Data are created from estimations to fill in grid cells that do not have actual combine data located within them. These procedures should be used with caution as they actually create data that did not previously exist and errors in the data can be amplified through the use of interpolation. Other appropriate options for yield data include point average and potential mapping. In these scenarios, a larger grid is used, perhaps 90 ft. In potential mapping, the mass flow values for points within the cell are summed and divided by the area. This procedure can provide a better representation of yield in fields where header width varies. The point yield procedure simply averages the point yield data within a cell and assigns it to the grid. When generating yield maps for visual interpretation, it’s important to make sure the ranges and color schemes are selected to appropriately represent yield variability.

Data to Decisions:

The largest challenge in the adoption of yield monitors has been the lack of clear uses for yield monitor data. However, opportunities exist to make better agronomic, economic, and machinery management decisions. Yield monitor data can be used to analyze combine performance in the field, compare harvesting methods, or the value of unloading on the go. In agronomics, yield monitor data can be utilized in a variable rate phosphorus program whereby prescriptions are based on crop removal as indicated by the previous crop yield data. Several reference points are established within the field for annual sampling. With multiple years of yield data, it is possible through analysis to determine areas of a field that are stable high or stable low yielding, and then manage these field areas differently.
Some Opportunities to Utilize Yield Monitor Data

RMA Crop Insurance Documentation

Recent changes in RMA (Risk Management Agency) procedures regarding the use of precision ag technology have opened up many opportunities. Yield monitor data can be used to document production for APH reporting. Yield monitors can be used to report production separately for different practices even when they are planted and harvested together (e.g. pivot corners and irrigated). It is important to note that in order to meet RMA requirements, the producer must have GPS technology integrated into the planter monitor, combine yield monitor, and yield mapping software. All three are required if precision ag technology is to be used to provide information for RMA. Yield monitors used for RMA reporting must be calibrated to less than 3% error and the calibration procedure be documented.

Multiple years of yield data – determining yield stability

A key component of determining spatial yield goals for a field, which could be used to drive variable rate nitrogen or seeding recommendations, involves determining areas of yield stability. By analyzing multiple years of yield data together, areas of the field can be classified into stable high yielding, stable low yielding, and unstable or average areas. These areas can be used to further guide management strategies. Multiple years of yield data can also be normalized. This process sets each year of yield data on a relative scale by using the field average. For example, if a spot in a field yielded 112 bu/ac and the field average was 100, then its normalized yield is 1.12. This process makes it easier to combine yield maps from across years and even different crops. Multiple normalized yield maps can then be averaged to generate spatial yield goals that could drive a variable rate seeding or nitrogen prescription.

A variable-rate seeding example

In this example, consider a field with a long term average of 190 bu/ac, the field has areas that are 30% above and 30% below average (would show up as 1.3 and 0.7 on a normalized yield map). The producer determines that at the high end to hit 247 bu/ac (a normalized yield of 1.3) a seeding rate of 36,000 is necessary, meanwhile, to hit a yield of 133 bu/ac (a normalized yield of 0.7) a seeding rate 20,000 would be appropriate. This would result in a population of 28,000 for the average yield of 190 bu/ac. So after the bounds have been set, a relationship can be easily be determined and put into an equation using a spreadsheet.

![Seeding Rate Equation](image)

The normalized yield layer and this equation could be used to generate a variable rate planting prescription for the example field. The average normalized yield map could also be used in a similar way to the VRT seeding example to create a variable rate nitrogen prescription.
VRT of Phosphorus based on crop removal

Crop removal rates of phosphorus are fairly well established; ex. 0.50 lb P₂O₅/bu wheat, 0.33 lb P₂O₅/bu corn, and 0.40 lb P₂O₅/bu sorghum. We know that yields vary across a field, but yet we typically blanket apply phosphorus based on average yields. Over time, this results in areas of the field that are consistently low yielding to build soil test P levels as we are applying more than we typically remove. Additionally, areas of the field that are consistently high yielding have low soil test P levels as we are applying less than removal. Multiple years of yield maps can be used to identify areas of the field for targeted sampling that may be high or low in soil test P. Once a baseline has been determined for a field, each years yield map could be used to generate a P removal map simply by multiplying yield by the P removal rates for various grains. This P removal map, or a series of removal maps, could be used to develop a VRT P application map.

Who is going to take your data to the next level?

The process of utilizing yield data may seem daunting, but the good news is that precision ag software has evolved a great deal of the past few years in terms of user friendliness. You as a producer, however, have a range of options depending on your own comfort level and computer abilities. You may decide to use your own on-farm research trials to develop your own recommendations and do all your own data analysis, or you may decide to use a completely outsourced solution from a provider. Regardless of which path you choose you must always ask yourself:

1. Does it make sense technically? - Is what I’m asking to be done physically possible by the equipment I’m using? Can I expect my yield monitor to detect a treatment strip of less than 300’ in size? Can my VRT applicator really apply that rate, or change rates that quickly? We are capable of developing many scenarios on the computer that we cannot actually accomplish in real life due to equipment constraints.

2. Does it make sense agronomically? - What is the maximum or minimum seeding or fertility rate that is acceptable or reasonable under any circumstance? Is what the map or recommendation telling me relativistic in what I know about crop production?

3. Does it make sense economically? - What is the maximum economic rate of phosphorus I can apply to short-term rented ground? Should I adjust my variable rate recommendations based on changes in crop prices or inputs? Does the time and cost involved in my precision ag program generate a positive return? How to I quantify that what I’m doing is correct and profitable?

It’s always appropriate to question, “Does this look right, do I believe that, can I test that this is the right thing to do?”.

Using Yield Monitors for Demonstration or On-Farm Research Plots
Lucas Haag, Research Assistant
K-State Research & Extension, Dept. of Agronomy
lhaag@ksu.edu

Yield monitors provide producers an excellent tool for conducting demonstration or research plots on their farm. Using a properly calibrated yield monitor allows for faster harvesting of plots and through GPS mapping provides a long-term method of storing results. However, like any tool, yield monitors must be used properly in order to provide beneficial data. Users must understand that yields differing by only several bushels, are likely not truly different as some error is inherent in data obtained from yield monitors or weigh wagons, especially in un-replicated trials. Some tips for plot preparation and harvest are outlined below.

Using Yield Monitors For Plot Harvesting - Checklist

Setting up a demonstration or on-farm research plot

- Demonstration plots are non-replicated, typically side-by-side plots, generally conducted more for observational purposes than data (a traditional seed corn strip trial)
- On-Farm Research Plots are a replicated design for the purpose of testing some factor (hybrid or variety, seeding rate, N rate, fungicide vs. untreated, etc.)
- Regardless of plot type, a plot should be of sufficient length (>300 ft., longer lengths are preferred) for harvesting with a yield monitor. Lengths should be equal for all treatments.

Make sure your yield monitor is calibrated

- With the proper size of loads (typically 3,000 – 6,000 lbs) Calibrations using semi-loads will seldom provide the accuracy needed for strip trials or on-farm research plots.

- At a typical flow rate for single point calibration monitors (Deere GreenStar and GreenStar2)

- Across several flow rates for multi-point calibration monitors (all AgLeader and Case-IH systems)

- Moisture calibration – follow manufacturer guidelines. If confident in calibration, then use dry weights as described below. If not confident, then use wet weights and your own moisture tester.

If harvesting strips plots only use total dry weight data from the yield monitor

- DO operate the combine the same for each harvest strip, i.e. consistent ground speed, do no unload on the go
- DO separate plots or strips by using different yield monitor “loads” or “tanks”
- DO NOT use bu./acre as calculated by the yield monitor
- DO calculate your own area
  Calculate your own area using traditional methods (e.g. measuring wheel or handheld GPS). Differences in timing when raising or lowering header, errors in speed sensors, or GPS errors can affect the yield calculated by your monitor over short distances. Using total dry or wet weight with measured areas will provide better data.

Remember… Bad data is WORSE than NO DATA !
Fallow Replacement in Western Kansas

John Holman
Scott Maxwell & Tom Roberts

Cover Crop Benefits

- Improve soil quality
  - Increase soil organic matter
  - Reduce soil erosion
  - Reduce soil compaction
  - Increase water infiltration
    - Decrease runoff
  - Supply nitrogen
  - Suppress weeds
  - Government programs (EQUIP & CREP)
  - Conserve soil moisture?
  - Reduce nitrate leaching?
  - Impact yield of following crop?

Increase in Soil C

- Claassen-Hesston, KS
  - Wheat/Cover-Sorghum, 2002-2010
  - Residue: Sun hemp > Soybean

- ↑ Soil C (0-3 in)
- ↑ Water infiltration
- = Soil aggregate stability w/N
- = Soil compaction (0-3 in) w/N
- ↑ Soil ag. and comp. wo/N
- ↑ crop yield @ low N rate only

Fallow Replacement Study

- Initiated in 2006 at KSU-Garden City
- Crop rotations:
  - Wheat-Fallow, Wheat-Wheat, & Wheat-Cover Crop/Forage/Grain,
  - RCB design, 4 replications, each phase of the rotation present each year
- Plots are 30’ x 135’, 224 plots total, 11 A study
- Measuring:
  - Cover crop water use
  - Forage yield and nutritive value
  - Water storage in seed zone and profile
  - Wheat yield, test weight, and protein
  - Profitability/loss of including cover crops in rotation

Fallow Treatments (Cover, Forage, Grain)

<table>
<thead>
<tr>
<th>Season</th>
<th>Cover Crop</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>Yellow sweet clover</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yellow sweet clover/Winter triticale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hairy vetch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hairy vetch/Winter triticale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter lentil</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter lentil/Winter triticale</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter pea (grain)</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter pea</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter pea/Winter triticale</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter triticale</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>Spring lentil</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring lentil/Winter triticale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring pea</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring pea (grain)</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring pea/Spring triticale</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring vetch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Winter triticale</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fallow and cont. wheat, 16 treatments total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cover and Forage Crop Termination
- Winter terminated ~May 15 (winter triticate heads)
- Spring terminated ~June 1 (spring triticate heads)
- Plots split: ½ hayed & ½ sprayed out and left standing

Winter Peas

2008-2010, Crop Biomass Average
- Winter triticate yield > spring triticate
- Legumes: spring yield > winter; winter injury
  - Spring pea > winter pea
  - Winter lentil = spring lentil
  - Hairy vetch 1 year winter kill

Residue or Forage Value?

Crude Protein (CP)
- Microbial protein and amino acid production
  - > 13% "premium" nutritive value
  - Alfalfa 18-24% CP

Total Digestible Nutrients (TDN)
- Energy available
  - Alfalfa 61-67% TDN

Cover and Forage Crop Impact on Winter Wheat

Wheat Following Low Residue, 2007

Western KS Moisture Results
- Fallow storage, 20-30% effective
- Growing cover crop used moisture
  - Improves storage and may improve stand establishment

2008 Yield Results
- Hail week prior to harvest
- Only visual difference was cont. wheat

2009 Yield Results
- Only visual difference was cont. wheat
- No effect of residue management treatment
2010 Yield Results

- Only visual difference was cont. wheat
- Cover yielded 2.9 bu/A more than hay

2009-2011 Yield Results

- 2 good years, 1 very poor year
- No effect of residue management treatment
- Winter triticate, grain pea, and cont. rv yields less

Field Pea Yields

- Australian Pea/Grain barley in VA
- Spring pea vs 2011 winter
- Field pea vs wheat forage
- Wheat yield reduction
- 1.5% yield for 18% of growers
- Additional 50% possible using 3-4" residue

Western KS Preliminary Results

<table>
<thead>
<tr>
<th>Western KS Preliminary Results</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Only visual difference was cont. wheat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Cover yielded 2.9 bu/A more than hay</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Western KS Cool-Season Crops

- Legume
  - Clover: biennial-slow growth, seed cost ($25/A)
  - Vetch: hard seed, cattle-photosensitization and muscle problems, winter injury, seed cost ($50/A)
  - Peas (W & S): winter injury, fair yield, seed cost ($25/A)
  - Lentils (W & S): hardy, low yield, seed cost ($11/A)
- Non-legume
  - Trifoliate (W & S): hardy, high yield, seed cost ($15/A)
- Mixtures
  - Legumes survive better, high yield, some N fixing, reduce seed cost

Future Direction

- Wheat-grain sorghum (fallow/fallow replacement)
- Spring oats compared to triticale
- Radishes and turnips: large taproot reduce soil compaction?
- Cocktail mixtures?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Hay</th>
<th>Cover Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring pea</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Spring pea/Spring Oat</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Spring pea/Spring Triticale</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Spring Oat</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Spring Triticale</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Daikon radish &amp; Shogoin turnip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cocktail mix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(cawl, triticale, pea, buckwheat, radish and turnip)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fallow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Daikon Radish

<table>
<thead>
<tr>
<th>3</th>
<th>244</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>280</td>
</tr>
<tr>
<td>4</td>
<td>344</td>
</tr>
<tr>
<td>5</td>
<td>458</td>
</tr>
<tr>
<td>6</td>
<td>503</td>
</tr>
<tr>
<td>7</td>
<td>575</td>
</tr>
<tr>
<td>8</td>
<td>692</td>
</tr>
<tr>
<td>9</td>
<td>793</td>
</tr>
<tr>
<td>10</td>
<td>937</td>
</tr>
<tr>
<td>11</td>
<td>432</td>
</tr>
<tr>
<td>12</td>
<td>437</td>
</tr>
</tbody>
</table>

Planting Spring Crops in the Fall

- Plant a mixture of spring and winter crops for more fall grazing
- Plant a spring crop in the fall for feed in a drought

Western KS Warm-Season Crops

- Legume
  - Oilseed: guar and soybean
  - Forage: cowpea, lablab, mungbean, pigeon pea, soybean
  - Cover: sunhemp (toxic to cattle)
- Brassicas
  - Soil & Cover: turnip, radish, and Ethiopian cabbage
- Grasses
  - Forage: forage sorghum, sorghum sudangrass, millet
- Drought, Weeds & Rabbits (2011)
  - Best: turnip, radish, guar, cowpea, lablab, Ethiopian cabbage, and grasses

Mixtures?

- A lot of interest in mixtures
- Some species more competitive
- Select a mixture based on need, more is not necessarily better
  - Spring forage: legume improving N content of forage and N fixation, and grass for high biomass (ex: spring pea and oat)
  - Spring cover crop: large taproot may help soil quality, legume for N fixation, and large biomass crop (ex: daikon radish, spring pea, and triticale)
  - Summer grazing: large taproot for soil quality and grazing, legume, and high biomass (ex: daikon radish & turnip, cowpea, sorghum sudangrass)
**Eastern KS: Cover Crop Study**
- Cover crop-grain sorghum rotation 3 site yrs (Manhattan & Hutchinson)
- Cover crop biomass

**Western KS Results**
- Impact on wheat yield and profitability?
  - In wet years, little to no impact on yield
  - In drought years, all treatments reduced yield except some of the spring crops
    - On average spring crops reduced yield (1.5 bu/A)
      - 1 ton forage @ $100/bu: not $40/A more than chem-fallow vs.
      - 1.5 bu/A @ $8.00/bu: $12.00/A ($26 less than springle forage)
    - Averaged across years:
      - Cont. WW reduced yield 37% (25% more total than W-P)
      - Winter triticale reduced yield 9% or 5.5 bu/A
      - Grain pea reduce yield 11% or 7 bu/A (11 bu/A less in drought)
      - No difference between cover or hay

**Questions?**

- Bale it, Graze it, or Combine it?
- High seed cost, offsets N contribution- grow own seed
  - More economical to apply N
- Select fallow replacement crop adapted to region
  - Winter hardness
  - Many proposed cover crops will not perform
- Terminate cover crop prior to June 1 for wheat
- If moisture is available consider double-crop after wheat
- Harvesting crop as forage or grain increased profitability
Residue Issues

- Bt corn residue: persists in the environment longer than non-Bt
- High quantities of crop residue, especially in irrigated, continuous corn (continuous wheat is not too)
- What are your options?

Estimating residue

- Harvest index: for every 1 lb of grain, 1 lb of residue for corn and sorghum
- 200 bushel corn crop
- 200 bu/acre corn
- Total grain/bushel = 56 lb of residue per acre (1,050 lb/acre)

Vertical tillage and Corn Production

DeAnn Presley, Soil Management Specialist
Kansas State University, Agronomy
deannc@ksu.edu

Options for managing heavy residue

- No-till anyway, improve planter?
- Strip-till?
- Different rotation?
- Tillage
- Removal for other uses (livestock fuel?)
- Burn

Now, how much is removed with current equipment?
What is vertical tillage?

- High speed tillage: 8-10 mph
- Disks a.k.a. coulters that cut residue
- If concave: Throw some soil laterally
  - Which causes some smoothing.
- Rolling or tine harrow: Anchors residue
- Gang angle varies between mfrs
  - More angle = more aggressive
  - Salford: Disks on springs, not gangs.
- Disk properties vary: Concavity vs. straight, smooth vs. rippled.

Vertical Tillage Research

- YouTube video: www.youtube.com/benvidrace
- Parts:
  - Coulters cut the residue and
  - Notes lift some soil so the leveling tiller can work.
  - The rolling harrow behind that does some minimal leveling around and breaks up any clods that might have made their way through.
- $2000/ per foot
- Requires 5-10 ply-rip per foot
- Produces dust (even some no-tillers)
  - Residue to break down faster (lift corn)
  - Anchor so it doesn’t wash or blow
  - Some leveling capability—improves “plantability”
  - Seedbed preparation

Objectives of study:

- Evaluate effects of vertical tillage versus farmer practices at multiple times during growing season on:
  1. Residue % coverage and mass
  2. Disease incidence and severity
  3. Crop vegetative properties
  4. Soil properties
  5. Soil- and residue-born pathogens

Results: Vegetative and Disease
### 2010 Results: Meade Co.
**Continuous, Irrigated Corn**

<table>
<thead>
<tr>
<th></th>
<th>Stand *1000/ac</th>
<th>Disease % pop</th>
<th>Severity lesions/plt</th>
<th>Yield bu/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>29.9</td>
<td>90.0</td>
<td>78.5</td>
<td>195</td>
</tr>
<tr>
<td>Case</td>
<td>30.3</td>
<td>89.5</td>
<td>83.8</td>
<td>204</td>
</tr>
<tr>
<td>Landoll</td>
<td>29.7</td>
<td>91.8</td>
<td>96.0</td>
<td>190</td>
</tr>
<tr>
<td>Great Plains</td>
<td>29.8</td>
<td>89.3</td>
<td>89.8</td>
<td>204</td>
</tr>
<tr>
<td>LSD*</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

High levels of disease on all treatments: *0.05 level, all sites

### 2010 Results: Jefferson Co.
**Continuous Corn**

<table>
<thead>
<tr>
<th></th>
<th>Stand *1000/ac</th>
<th>Disease % pop</th>
<th>Severity lesions/plt</th>
<th>Yield bu/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>35.7</td>
<td>26.0 a</td>
<td>71.8 a</td>
<td>154</td>
</tr>
<tr>
<td>Case</td>
<td>37.6</td>
<td>17.0 b</td>
<td>46.3 b</td>
<td>176</td>
</tr>
<tr>
<td>Disk</td>
<td>38.2</td>
<td>16.0 b</td>
<td>42.8 b</td>
<td>154</td>
</tr>
<tr>
<td>LSD</td>
<td>--</td>
<td>1.9</td>
<td>6.4</td>
<td>--</td>
</tr>
</tbody>
</table>

Difference in disease didn't translate into significant difference in yield

### 2010 Results: Wilson Co.
**Corn after soybeans**

<table>
<thead>
<tr>
<th></th>
<th>Stand *1000/ac</th>
<th>Disease % pop</th>
<th>Severity lesions/plt</th>
<th>Yield bu/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Plains</td>
<td>25.1</td>
<td>24.8 a</td>
<td>45.8</td>
<td>110</td>
</tr>
<tr>
<td>Strip-till</td>
<td>25.0</td>
<td>22.3 b</td>
<td>43.0</td>
<td>112</td>
</tr>
<tr>
<td>LSD</td>
<td>--</td>
<td>1.6</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

### 2010 Results: Marion Co.
**Corn after soybeans**

<table>
<thead>
<tr>
<th></th>
<th>Stand *1000/ac</th>
<th>Disease % pop</th>
<th>Severity lesions/plt</th>
<th>Yield bu/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>16.1</td>
<td>33.0</td>
<td>32.0</td>
<td>79.5</td>
</tr>
<tr>
<td>Great Plains</td>
<td>22.2</td>
<td>33.0</td>
<td>37.8</td>
<td>86.6</td>
</tr>
<tr>
<td>LSD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

No differences despite large difference in % residue coverage. 73% no-till, 33% vertical tillage after planting.
Results: Soil and Residue Properties

2010 Results: Meade Co.
Continuous, Irrigated Corn

<table>
<thead>
<tr>
<th></th>
<th>May 27th</th>
<th>% Residue</th>
<th>0-2&quot; BD g/cm³</th>
<th>Infiltration mm/hr</th>
<th>Moisture cm³/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 DAP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-till</td>
<td>94.8 a</td>
<td>1.21</td>
<td>0.49</td>
<td>40.53 a</td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>90.5 ab</td>
<td>1.16</td>
<td>0.36</td>
<td>37.01 ab</td>
<td></td>
</tr>
<tr>
<td>Landoll</td>
<td>89.4 ab</td>
<td>1.16</td>
<td>0.18</td>
<td>36.40 ab</td>
<td></td>
</tr>
<tr>
<td>Great Plains</td>
<td>89.3 b</td>
<td>1.13</td>
<td>0.54</td>
<td>33.17 b</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>3.7</td>
<td>--</td>
<td>--</td>
<td>4.34 b</td>
<td></td>
</tr>
</tbody>
</table>

Great Plains: Lower residue because was less anchored and more blow away, which caused lower soil moisture, trend lasted through season (not shown).

2010 Results: Jefferson Co.
Continuous Corn

<table>
<thead>
<tr>
<th>July 19th</th>
<th>% Residue</th>
<th>0-2&quot; BD g/cm³</th>
<th>Infiltration mm/hr</th>
<th>Moisture cm³/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>60.2 a</td>
<td>0.96 a</td>
<td>0.84 b</td>
<td>33.99</td>
</tr>
<tr>
<td>Case</td>
<td>40.8 b</td>
<td>0.78 b</td>
<td>2.12 a</td>
<td>29.75</td>
</tr>
<tr>
<td>Disk</td>
<td>35.6 b</td>
<td>0.80 b</td>
<td>1.30 ab</td>
<td>30.10</td>
</tr>
<tr>
<td>LSD</td>
<td>7.7</td>
<td>0.12</td>
<td>0.95</td>
<td>--</td>
</tr>
</tbody>
</table>

[At this site, tillage was done in fall, resulted in more treatment differences]

2010 Results: Wilson Co.
Corn after soybeans

<table>
<thead>
<tr>
<th>June 3rd</th>
<th>% Residue</th>
<th>0-2&quot; BD g/cm³</th>
<th>Infiltration mm/hr</th>
<th>Moisture cm³/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Plains</td>
<td>10.2</td>
<td>1.33</td>
<td>0.32</td>
<td>23.95 a</td>
</tr>
<tr>
<td>Strip-till</td>
<td>10.7</td>
<td>1.25</td>
<td>0.44</td>
<td>21.79 b</td>
</tr>
<tr>
<td>LSD</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>1.64</td>
</tr>
</tbody>
</table>

Low residue for both treatments, and spring tillage, caused few treatment differences.
2010 Results: Marion Co.
Corn after soybeans

<table>
<thead>
<tr>
<th>June 24</th>
<th>% Residue</th>
<th>0-2&quot; BD g/cm³</th>
<th>Infiltration mm/hr</th>
<th>5-28 Moisture cm³/cm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>No-till</td>
<td>72.8 a</td>
<td>1.23</td>
<td>2.29</td>
<td>37.70</td>
</tr>
<tr>
<td>Great Plains</td>
<td>32.8 b</td>
<td>1.03</td>
<td>2.24</td>
<td>35.94</td>
</tr>
<tr>
<td>LSD</td>
<td>10.8</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Large difference in % residue cover did not affect soil properties

Summary

- Fall tillage causes more treatment differences than spring tillage
  - 4 out of 5 sites tilled in fall for 2011 corn
- More treatment differences in continuous corn and in heavier residue
- 2011 data will be presented during my talk
Here are a few agronomy-related websites that you may find useful:

**Weather:**
- National Weather Service
- The Weather Channel
- Weather Underground
- Drought Monitor

**Markets:**
- Chicago Board of Trade
- Kansas City Board of Trade
- DTN
- Dow Jones

**News:**
- Ag Web (Farm Journal)
- Agriculture.com (Successful Farming)
- Farm Progress (Kansas Farmer)
- Grass and Grain
- High Plains Journal

**University:**
- K-State Research and Extension
- K-State Department of Agronomy
- K-State Ag Economics Extension
- K-State Department of Entomology
- K-State Department of Plant Pathology
- K-State Department of Bio and Ag Engineering

**Commodity Groups:**
- Kansas Corn Commission
- Kansas Grain Sorghum Producers Association
- Kansas Soybean Commission & Kansas Soybean Assoc
- Kansas Sunflower Commission
- Kansas Wheat (Kansas Wheat Commission & Kansas Assoc of Wheat Growers)

**Herbicide Labels:**
- Greenbook
- CDMS

**Discussion Boards:**
- Ag Talk

**Websites**

- www.weather.gov
- www.weather.com
- www.wunderground.com
- www.droughtmonitor.unl.edu
- www.cbot.com
- www.kcbt.com
- www.dtnprogressivefarmer.com
- www.dowjones.com
- www.agweb.com
- www.agriculture.com
- www.farmprogress.com
- www.grassandgrain.com
- www.hpj.com
- www.ksre.ksu.edu
- www.agronomy.ksu.edu
- www.agmanager.info
- www.entomology.ksu.edu
- www.plantpath.ksu.edu
- www.bae.ksu.edu
- www.ksgrains.com/kcc
- www.ksgrains.com/sorghum
- www.kansassoybeans.com
- www.kssunflower.com
- www.kswheat.com
- www.greenbook.net
- www.cdms.net
- www.newagtalk.com
HIGHLY EFFECTIVE ON STUBBORN, RESISTANT WEEDS. NOT TO MENTION YOUR ROI.

Kixor® herbicide technology is the revolutionary chemistry that drives rapid burndown of resistant broadleaf weeds, giving you cleaner, easier to manage fields. Combined with its residual activity, Kixor reduces resprays and allows you to plant quicker and operate more cost effectively. Ask your retailer or go to KixorHerbicide.com.
Brothers Equipment
Friend, Nebraska
Phone: 800-228-4582
"Serving Agriculture for Over 35 Years"

CASE II

NEW!

nutri-placer 940
60 & 65 Ft. NH3 Applicator

nutri-placer 2800-16
Liquid Applicator

Spra-Coupe 4460 & 4660
The Premier Post Sprayers
Spra-Coupe 7660

GVM Predator
Pre/Post Liquid & Dry
GVM Prowler

With the Expertise & Products for Your Equipment Needs
### AGRONOMY

**TRADITIONAL AGRONOMY PRODUCTS:**
- Custom Applied Chemicals
- Farmer Applied Chemicals (delivery available)
- Dry Fertilizer (Semiload delivery available)
- Liquid Fertilizer (Semiload delivery available)
- Custom Dry, Liquid and Application
- Mycogen, NK, Fontanelle, Dekalb, and Agrow Brand Seeds

**VALUE ADDED AGRONOMY PRODUCTS:**
- NextField Grid Sampling and Prescription Seed and Fertility Recommendations
- Variable Rate Multi Product Dry Fertilizer Applications
- MicroEssentials SZ (MESZ)
- Agronomy ProShop Plots

---

### GRAIN

**TRADITIONAL GRAIN PRODUCT CONTRACTS:**
- Cargill offers a wide variety of grain contracts for any grain operation. Choose contracts based on your desired level of control, your risk tolerance and performance factors, that best help you prosper.

**VALUE ADDED MARKETING PRODUCTS:**
- Traditional Contracting
  - Cash Contract
  - NBE+
- Cargill Risk Management Tools
  - Pacer Family
  - Min Price Contracts
  - On Farm Storage
  - Focal Points
- ProPricing
  - Pacer Pro
  - Diversi Pro
  - Market Pros

---

### CAMS

Cargill AgHorizons Marketing Services (CAMS) is the ideal place to go for professional help in managing your grain marketing:
- Access to the global resources of Cargill personal service
- Customized marketing recommendations
- Market Planning
- Action Tracking
- Freedom to deliver your grain to your chosen location

---

### Crop Insurance

- Forward market up to 85% of APH
- Yield Protection Plan
- Revenue Protection Plan
- RFP with Harvest Price Exclusion
- Group Risk Income Protection (GRIP)

---

Visit us at [www.cargillag.com](http://www.cargillag.com)
We've Got You Covered...From Start To Finish
We're Your No-Till Farming Headquarters!

SPRAYERS......Self-Propelled and Pull-Type
- Case IH Patriot 3230, 3330, & 4430 Self-Propelled with Exclusive AIM Command System
- Schaben Pull-Type Sprayers—Several sizes available

Case IH Tractors.....Get The Job Done!!
Rated #1 in University Nebraska Tractor Tests
- Puma's  130 HP-230 HP
- Magnums's  180 HP-340 HP
- Steiger 4WD  350 HP-600 HP

No-Till Planters & Drills
for uniform stands & the best yields
Case IH—Kinze—Sunflower
Great Plains—Crustbuster

Precision Fertilizer Placement
In No-Till Fields
DMI - Orthman - Yetter

And The Most Important Step...
Harvest every bushel with a Case IH Axial Flow Combine and leave your field ready for next year with a Shelbourne Stripper Header

Financing Available on All Equipment—Attractive Rates and Options!
Hoxie Implement Co., Inc. Hoxie, KS  785-675-3201 www.hoxieimplement.com
Colby Ag Center, L.C. Colby, KS  785-462-6132 www.colbyag.com
Oakley Ag Center, L.C. Oakley, KS  785-671-3264 www.oakleyag.com
Thank You for attending the Cover Your Acres Winter Conference.

We look forward to helping you with your seed, trait, and chemical needs.
With the High Plains Sunflower Committee

Enhancing sunflower production through education, research and promotion

Please take a moment and assess the financial advantages sunflowers can provide your farming operation this next growing summer. Whether it be oils or confections, outstanding opportunities are available for sunflowers this next year. To view the latest information on yield trials, revenue assurance, market prices, elevators taking sunflowers, chemical options, and other important topics, please view the National Sunflower association web site: http://www.sunflowersnsa.com/
Ag producers are discovering the benefits of using cover crops between crop rotations to
- reduce erosion
- conserve soil water
- reduce nitrate leaching

- increase water infiltration
- increase organic matter
- supply nitrogen to subsequent crops
- decrease water runoff
- reduce compaction
- suppress weeds

Through ongoing research Arrow Seed has developed and continues to develop formulations of SoilBuilder™ Cover Crop Mixes to get the most benefit out of your soil for the next crop going in.

SoilBuilder™ Cover Crop Mixes are only available from ARROW SEED dealers.
To find the one nearest you visit www.ArrowSeed.com

20125 W. 105th St.
Olathe, Kansas 66061

913-764-7766
913-764-7769 (fax)
www.evansenterprises.net

Gold Sponsors
Kugler KQ-XRN®  Come see what's new at 2012 Cover Your Acres Winter Conference.

Its reputation is growing.

Growers across the Midwest are raving about Kugler KQ-XRN — the only slow release nitrogen formulation of its type.

See and hear growers talk about Kugler fertilizers at www.KQXRN.com

Kugler KQ-XRN
www.KQXRN.com • www.KuglerCompany.com
800.445.9116 • PO Box 1748 • McCook, NE 69001

Golden Plains Ag Tech
650 E Pine
Colby, KS 67701

800-255-8280
Sims Fertilizer & Chemical

1006 Industrial Park Ave
Osborne, KS 67473

(785) 346-5681

www.simsfarm.com

SureFire Ag Systems

Fertilizer Application Solutions

SureFire Ag specializes in providing variable rate fertilizer application systems for all makes and models of planters, strip-till machines and fertilizer applicators.

Speak with a SureFire Application Control Expert to learn more.
At 10:50 a.m. in Room 4 or at 2:50 p.m. in Room 3, visit our session, “Ag Estate Planning” featuring, Mr. Ken Wasserman, Attorney-at-Law from Salina, Kansas, who will address:

*Ag Producer Succession Planning
*Ag Producer Estate Planning
Silver Sponsors

Exaptia Solutions
(785) 820-8000
www.exapta.com

J.D. Skiles
1-800-626-9338
www.jdskiles.com

Shelbourne Reynolds
(785) 462-6299
www.shelbourne.com/

Ag Valley Coop
1-800-228-1352
www.agvalley.coop/

Axis Seed/Select Seeds
(308) 340-8720
www.axisseed.com

Bayer Crop Science
www.bayercropscience.com/

Crop Quest
(620) 408-6516
www.cropquest.com

Dreamland Industries
(325) 513-4217
www.dreamlandusa.com/

DuPont
(620) 952-2807
www.dupont.com

Green Cover Seed
(402) 469-6784
www.greencoverseed.com/

Kauffman Seeds
620-465-2245

Kansas Corn Commission
www.ksgrains.com/kcc/
(785) 448-2626

Kansas Soybean Commission
www.kansassoybeans.com/
1-800-328-7390

LG Seeds
(785) 475-4447
www.lgseeds.com/

Market Data Inc
1-800-867-8289
www.marketdatainc.com/

McCook National Bank
1-800-595-9286
www.mnbl.com

Mycogen Seeds
(785) 443-1303
www.mycogen.com

Northern Sun/ADM
(785) 899-6500
www.admworld.com

Novozymes BioAg Inc
(970) 371-9651
www.bioag.novozymes.com

NuTech Seed
1-800-942-6748
www.nutechseed.com

Olsen’s Ag Laboratory
(308) 345-3670
www.olsenlab.com/

Pioneer
www.pioneer.com
(785) 675-1302

Producer Hybrids
(785) 656-0467
www.producershybrids.com

ProGreen Ag
(785) 249-5528
www.progreenag.com/

Red Willow Aviation
(308) 345-3635
www.rwaviation.com/

Schaffert Manufacturing Co Inc
1-800-382-2607
www.schaffert.com/

SFP
1-800-446-GROW (4769)
www.sfp.com/

Sharp Brothers Seed
1-800-462-8483
www.sharpsfeed.com/

United Sorghum Checkoff
1-877-643-USCP (8727)
www.sorghumcheckoff.com/

Sorghum Partners
1-800-645-7478
www.sorghum-partners.com/

Star Seed
www.gostarseed.com/
1-800-782-7311

Triumph Seed Company
(806) 253-2585
www.triumphseed.com/
### The plan for the day...

<table>
<thead>
<tr>
<th>Room 1</th>
<th>Room 2</th>
<th>Room 3</th>
<th>Room 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:45 8:15</td>
<td>Registration</td>
<td>Welcome</td>
<td>Chloride: Wheat &amp; Row Crops - Evans Enterprises (I)</td>
</tr>
<tr>
<td>8:15 8:20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8:30 9:20 Kochia History, Bio &amp; Glyph Resistance (P. Stahman)</td>
<td>Utility of Cover Crops (J. Holman)</td>
<td>Enhanced Fertilizer Products (K. Martin)</td>
<td></td>
</tr>
<tr>
<td>10:20 10:50 View Exhibits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11:50 12:40 Kochia: Growth Regulator Resistance (P. Westra)</td>
<td>Utilizing Yield Monitor Data (L. Haag)</td>
<td></td>
<td>Lunch</td>
</tr>
<tr>
<td>12:50 1:40 Trends in Crop Leases (T. Dumler)</td>
<td>Enhanced Fertilizer Products (K. Martin)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:50 2:40 Palmer and Marestail Control (D. Peterson)</td>
<td>Kochia History, Bio &amp; Glyph Resistance (P. Stahman)</td>
<td>Sprayer Set-up (B. Klein)</td>
<td>Monsanto Product Update Monsanto (I)</td>
</tr>
<tr>
<td>3:40 4:10 View Exhibits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4:10 5:00 Vertical Tillage &amp; Corn Production (D. Presley)</td>
<td>Kochia Recom for Wheat &amp; Fallow (P. Stahman)</td>
<td>Solutions for Managing Weed Resistance - BASF (I)</td>
<td>Maximizing Your Yield w/ Solutions - Cargill (I)</td>
</tr>
<tr>
<td>5:10 6:00 Utilizing Yield Monitor Data (L. Haag)</td>
<td>Trends in Crop Leases (T. Dumler)</td>
<td>Max Yields w/ KQ- XRN and KS Fert - Kugler Co (I)</td>
<td>Strategies for Weed Control - Sims Fertilizer (I)</td>
</tr>
</tbody>
</table>

6:00 Bull Session

(I) indicate industry sessions.
1 Indicate Certified Crop Advisor CEUs applied for.
2 Indicate Commercial Applicator CEUs applied for.

This conference is organized by a committee of producers and K-State Extension personnel. Chair of this committee is Jeanne Falk, K-State Agronomist.

Please send your feedback to jfalk@k-state.edu

[www.northwest.ksu.edu/coveryouracres](http://www.northwest.ksu.edu/coveryouracres)