ADDENDUM

2019 Cover Your Acres Proceedings – Electronic Format

Remediation of Eroded High pH Hill-Top Soils with Manure

Due to the federal government shutdown at the time of the conference, Merle Vigil, the scientist who led the study, was under direct order to not attend. His proceedings paper is published in this book. In place of this talk Lucas Haag delivered a presentation on Dryland Tillage and Crop Rotation Studies at Tribune.

Long-Term Dryland Tillage and Crop Rotation Studies at Tribune, Kansas

This presentation was made in place of “Remediation of Eroded High pH Hill-Top Soils with Manure” The presentation was delivered by Lucas Haag, K-State Northwest Research-Extension Center. The slides presented in this talk can be found at the end of this electronic version of the proceedings

Dryland Corn Hybrids, Seeding Rates, and Planting Dates

The slides presented in this talk can be found at the end of this electronic version of the proceedings
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To provide a positive experience for presenters and attendees, please silence your wireless device.
Session Summaries

A Fresh Look at High Plains Irrigated Soybean Management: Recent field-scale trials in Southwest Nebraska has evaluated seeding rates, row spacing, and in-season nitrogen applications. Information from these trials will be shared along with considerations for management.

Adjuvants and Their Effects on Herbicides and Tank Mixes: Many products are on the market. This session will focus on placement of those products to maximize herbicide and tank-mix efficacy.

Current Financial Status of NW Kansas Farms: Using data from northwest Kansas farms, we take a look at opportunities for profitability and where producers should be alert for possible concerns.

Dryland Corn Hybrids, Seeding Rates and Planting Dates: Research in northwest Kansas has evaluated over 30 hybrids for optimal seeding rate and differences in ear flex. Additionally, hybrid maturity x planting date combinations have been evaluated in another study. This session will discuss the results and their implications for dryland corn management.

Getting Peak Performance From Paraquat - Rates, Adjuvants, Droplets and More: Paraquat is a valuable tool in management of resistant weeds such as Kochia and Palmer Amaranth. This session will look at how environment, application methods, and various other factors play a role in the efficacy of Paraquat.

Land Values and Rental Rates - Where are we going?: There are a lot of moving pieces in the land market and the many factors that drive rental rates. We’ll take a look at the most recent data and discuss potential future direction and what it might mean to your business.

Managing Insect Resistance in Corn: This session will address the current resistance situation and discuss the various management options to control resistant insect populations and minimize the development of additional resistance.

Palmer Amaranth Management: A discussion of what makes Palmer Amaranth different than many of the weed species we face, the latest performance results from western Kansas herbicide trials, and recommendations for developing an overall weed control strategy.

Remediation of Eroded High pH Hill-top Soils with Manure: A long-term study in eastern Colorado, started in 2006 to evaluate using beef manure at various rates, timings of application, and incorporation methods. Results and management recommendations will be shared.

Top 3 Mistakes in Northwest Kansas Wheat Production: We’ll step through the growing season and discuss the most common production problems observed in the field and consider the management practices that can improve yields and profitability in wheat production.

Producer Panel Discussion: A producer panel will discuss various alternative crop options in the region. Crops discussed may include winter canola, dry edible beans, field peas, barley, and triticale.

Proceedings from prior years of the Cover Your Acres Winter Conference can be found online:
www.northwest.ksu.edu/coveryouracres
Lucas Haag- Lucas Haag was raised on a diversified dryland farming and ranching operation near Lebanon, Nebraska along the Kansas/Nebraska line. He received his B.S. in Agricultural Technology Management in 2005 and a M.S. in Agronomy (crop ecophysiology) in 2008 from K-State. Lucas completed his Ph.D. in Agronomy in 2013. He is an associate professor of agronomy and Northwest Area Agronomist stationed at the Northwest Research-Extension Center in Colby, Kansas. He has extension agronomy responsibilities for 29 counties in northwest and north-central Kansas. He conducts research and extension activities in a variety of areas but specializes in precision ag and dryland cropping systems. Lucas remains actively tied to production ag as a partner with his brothers in Haag Land and Cattle Co.

Marshall Hay- Marshall Hay is a PhD candidate in the Department of Agronomy at Kansas State University under the direction of Dr. Dallas E. Peterson. Marshall’s dissertation is on integrated pigweed management in dryland soybean and grain sorghum with additional research on improving Paraquat efficacy on pigweed and grasses with droplet size, tank mixes, and adjuvants. Marshall’s interest in agronomy and weed science stems from his family’s farm and crop protection retail business in Iowa. After completing his B.S. at Iowa State University, he moved to K-State for his M.S. which upon completion transitioned into his doctoral work. During his spare time, Marshall enjoys helping on the farm and restoring antique tractors.

Jeanne Falk Jones- Jeanne Falk Jones is a multi-county agronomy specialist with K-State Research and Extension. She is the product of two century farm families and grew up as the 5th generation on the Falk family farm in northeast Kansas near Atchison. Jeanne is a graduate of Kansas State University with a B.S. degree in Agronomy and M.S. degree in Agronomy (weed physiology). Her programming focus is on wheat production, herbicide resistant weeds, and other crop production challenges in northwest Kansas. Jeanne is active in her family’s farm near Atchison. She and her husband Adam, ranch in Cheyenne County and own Crooked Creek Angus.

Randall Currie- Dr. Currie was born in Plainville and raised in Stockton, KS. Randall worked as a youth on local small grains farm and hog operation. Randall graduated from KSU in 1980 with a BS in Agronomy. He worked in central Kansas as a crop consultant scout and crop production chemical and fertilizer sales man from 1980 to 1985. He graduated with a Master’s Degree in Weed Science from Oklahoma State University in 1983 and a PhD from Texas A&M in Herbicide Physiology in 1990. He has worked for the last 28 years as a research scientist for Kansas State at Garden City, KS. His primary focus has been on management of herbicide resistance and weed control in irrigated corn, sorghum and fallow. During this period, he has conducted over 250 trials with over 2000 herbicide combinations for weed control in these crops.

Jordan Steele- Jordan Steele is an Extension Agricultural Economist with Kansas Farm Management Association, NW assisting members with accurate record keeping and financial analysis. Jordan grew up on a Wyoming cattle ranch then attended the University of Wyoming to obtain a Bachelor’s Degree in Agricultural Business in 2010 and a Master’s Degree in Agricultural Economics in 2012. Steele enjoys working with NW Kansas farm families to develop and maintain profitable agri-businesses.
Mykel Taylor—Mykel Taylor is a native of Montana with extensive experience in production agriculture. Mykel earned her B.S. in Agricultural Business Management from Montana State University in 2000. She went on to complete a M.S. in Applied Economics at Montana State and a Ph.D. in Economics at North Carolina State University. Mykel joined Kansas State University in 2011 as assistant professor of agricultural economics with a major appointment in extension. Her areas of focus include agricultural leases and land values, grain marketing, farm policy, and many other areas of farm management. She earned her Ph.D., Economics in 2008.

Merle Vigil—Dr. Vigil, a Colorado native, earned a B.S. in Crop Science in 1980 and an M.S. in Agronomy from Colorado State University in 1983. He earned his Ph.D. in soil science at Kansas State University in 1989. Dr. Vigil’s interests reside in the development of sustainable dryland cropping systems for the Central Great Plains region with a focus on maximizing precipitation use efficiency and fertilizer use efficiency. Dr. Vigil has authored or co-authored 180 research and technical publications and is a Fellow of the American Society of Agronomy and a Fellow in the Soil Science Society of America. He has worked as a soil scientist for the last 27 years at the USDA-ARS Central Great Plains Research Station in Akron, Colorado. He has served as research leader since 2001 and is now also serving in that capacity for the Soil Management and Sugar Beet Research Unit in Ft. Collins, Colorado.

Rich Zollinger—Rich Zollinger is a Professor Emeritus, Department of Plant Sciences, at North Dakota State University, Fargo, ND. Rich was raised on a family farming operation with livestock and crop production farms in Utah, Idaho, Montana, and an 18,000-acre farm in the Peace River Region of British Columbia, Canada. He earned his Ph.D. in Weed Science from Michigan State University in 1988; and his M.S. and B.S. degrees from Utah State University in 1985 and 1983, respectively. Zollinger retired from NDSU at the end of 2017 after 28 years of service as state Extension Weed Specialist. Dr. Zollinger conducted weed control and herbicide research primarily in corn, soybean, dry edible beans, and sunflower. His weed science project conducted over 70 field trials each year in these areas in addition to extensive greenhouse work. His main research interest was in adjuvants and formulations.

Sarah Zukoff—Dr. Sarah N. Zukoff is a field crop entomologist who has a dual role in research and extension. She specializes in integrated pest management of key pests of corn, sorghum, wheat, alfalfa and cotton. Her extension efforts focus on providing farmers with sustainable, environmentally sound insect and mite pest management strategies to provide the highest yielding crops possible to feed an ever growing population. Her current research includes characterizing resistance levels among corn feeding pests to Bt toxins and insecticides as well as quantifying the effect of Bt toxin cross pollination on resistance development among major lepidopteran pests of corn.
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Continuous corn is the most common irrigated crop sequence in southwest Nebraska. Although rotating to other crops, such as soybeans, can mitigate some production issues of continuous corn and often boost the next year’s corn yield, larger adoption of soybean has not readily occurred in this area. According to USDA Farm Service Agency planted acreage data, on average southwest Nebraska farmers plant irrigated soybean every fifth year.

The culture of farming in southwest Nebraska evolves around corn, which often prevents growers from raising soybeans under more ideal conditions. For example, priority is often given to planting corn first, soybeans are planted strip-till in 30-inch rows, and seeding rates of 160,000 seeds/ac are common. In addition, late season chemigation with nitrogen (N) is widespread without a full understanding of when and where it’s warranted (Stepanovic et al., 2018a)

The objective of this study was to investigate the impact of planting date, row spacing, seeding rates, and N management on yield and yield components of irrigated soybean in southwest Nebraska. *Cover photo: Irrigated soybean in Perkins County, NE (2019).*
Characteristics of the Two Research Sites

The study was conducted at two locations in Perkins County (the Kemling and Stumpf farms) in 2018. The predominant soil type at the Kemling Farm was Rosebud loam; at the Stumpf farm it was Kuma silt loam. At the Kemling Farm, the whole field was disked prior to planting; at the Stumpf farm, soybeans were seeded no-till. At both locations the previous crop was corn. Besides study treatments, soybeans were grown following UNL agronomic and irrigation recommendations.

The 2018 seasonal precipitation (May-Oct) was 6.5 inches higher than the 30-year average, especially early in the season (Figure 1), leading to issues with crusting and soybean germination. In addition, two hail events occurred at both sites. The first hail event occurred May 25, causing stand reduction in early planted soybeans. The second hail event occurred in mid-August, causing 20% hail injury at the Stumpf Farm and 5% at the Kemling Farm.

Data We Collected

The study evaluated four practices, each at two different levels, for a total of 16 treatments:

- Planting dates (May 1 vs June 5)
- Row spacing (15 inch vs 30 inch rows)
- Seeding rates (90,000 vs 140,000 live seeds/ac)
- N management – two fertility differed between the sites:
  - Stumpf Farm – control vs chemigation 50 lbs of N/ac @ R5 (beginning seed)
  - Kemling Farm – control vs pre-plant compost @ 5 tons/ac

Each treatment was replicated four times and each replication was divided into blocks by N management (fertility regime). Seeding practices (planting date, row spacing, and seeding rates) were randomized within each fertility N management block. The study treatments were planted into strips 40 ft by 180 ft. The middle 30 ft of each strip was harvested for yield using a John Deere 6000 series combine.

In addition, harvest population (plants/ac) was counted in each strip right before the harvest and five plant subsamples were taken to evaluate yield components, including nodes/plant, branches/plant, pods/plant, seeds/pod, and seed weight.

Figure 1. Weather conditions including total monthly precipitation and maximum and minimum temperatures at Grant, NE (2018 vs 30-year average)
Grain Yield Results

Overall, grain yield was lower at the Stumpf Farm compared to the Kemling Farm, mostly due to greater impact of soil compaction and hail injury. A cool wet spring in combination with direct seeding (no-till) of soybean at the Stumpf farm caused issues with sidewall compaction, soil crusting, and early season growth and development. Disked soil at the Kemling Farm dried out quicker, creating better seeding conditions, less sidewall compaction, and consequently fewer issues with crusting and early season plant growth (Jasa, 2010).

At both locations the best soybean yields were observed at the early planting date (May 1) and in narrower row spacing (15 inches), while higher seeding rates did not have any measurable yield increase regardless of location and practices used.

At the Kemling Farm, early planted soybeans benefited from pre-plant application of compost at 5 ton/ac, yielding as much as 107 bu/ac. This trend, however, was not observed at late planting dates as yields dropped to 28-41 bu/ac. At the Stumpf Farm, chemigation of 50 lbs of N/ac at R5 (beginning seed) did not result in a yield increase.

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**Figure 2.** Impact of planting date (May 1 vs June 5), row spacing (15 inch vs 30 inch), seeding rates (90,000 vs 140,000 live seeds/ac) and fertility regimes at Kemling Farm and Stumpf Farm during 2018 growing season in Grant, NE.
What are Soybean Yield Components and Why do They Matter?

Grain yield is comprised of several components that, when analyzed separately, can allow us to better understand their individual contribution to overall grain yield. Despite differences in grain yield, the relationship between grain yield and yield components was similar at the two sites. Table 1 summarizes correlation coefficients averaged across sites. The sign of correlation coefficient (r) indicates the nature of the relationship (either positive or negative) while the magnitude of coefficient (ranging from 0 to 1) represents the strength of the linear relationship.

Correlation between grain yield and plants/ac, seeds/pod, and seed weight was not significant (Table 1), suggesting that:

1. changes of plant population had no impact on grain yield, and
2. differences observed in grain yield had no impact on seeds/pod and/or seed weight.

On the other hand, significant positive correlation was observed between grain yield and nodes/plant (r=0.58), branches/plant (r=0.50) and pods/plant (r=0.42) suggesting that the best seeding and N management practices are those that facilitate node, branch, and pod development.

Table 1. Correlation (r) between soybean grain yield, planting date, plants/ac (at harvest), branches/plant, nodes/plant, pods/plant, seeds/pod, seed weight (1000 seeds) in field experiments at Kemling Farm and Stumpf Farm in Perkins County, NE (2018)

<table>
<thead>
<tr>
<th>Terms</th>
<th>Grain yield (bu/ac)</th>
<th>Planting date</th>
<th>Plants/acre</th>
<th>Nodes/plant</th>
<th>Branches/plant</th>
<th>Pods/pod</th>
<th>Seeds/pod</th>
<th>Seed weight</th>
</tr>
</thead>
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<tr>
<td>Planting date</td>
<td>-0.83*</td>
<td>-0.01</td>
<td>0.32*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plants/acre</td>
<td></td>
<td></td>
<td></td>
<td>0.58*</td>
<td>-0.58*</td>
<td>0.52*</td>
<td>-0.30*</td>
<td>-0.62*</td>
</tr>
<tr>
<td>Nodes/plant</td>
<td>0.50*</td>
<td>-0.52*</td>
<td>-0.30*</td>
<td>0.41*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Branches/plant</td>
<td>0.42*</td>
<td>-0.62*</td>
<td>-0.62*</td>
<td>0.54*</td>
<td>0.61*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pods/plant</td>
<td></td>
<td>-0.14</td>
<td>0.21</td>
<td>0.07</td>
<td>0.04</td>
<td>0.00</td>
<td>-0.30*</td>
<td></td>
</tr>
<tr>
<td>Seeds/pod</td>
<td>0.19</td>
<td>-0.10</td>
<td>0.02</td>
<td>0.09</td>
<td>0.28</td>
<td>0.14</td>
<td>0.14</td>
<td></td>
</tr>
</tbody>
</table>

* Correlation coefficient significant at 5% level. The sign of coefficient indicates the nature of relationship (either positive + or negative -) while the magnitude of coefficient (ranging from 0 to 1) represents the strength of the linear relationship.
Why Planting Date Matters

Previous UNL research on soybean in eastern Nebraska has demonstrated that for each day that soybean planting is delayed after May 1, yield penalties of 0.25-0.63 bu/ac can occur, depending on the year. (Elmore et al., 2014; Specht et al., 2012.) In our one-year study in southwest Nebraska, we found much larger daily yield penalties of 1.40 bu/ac/day at the Kemling Farm and 0.64 bu/ac/day at the Stumpf Farm (Figure 3).

Among yield components, nodes/plant, branches/plant and pods/plant were all negatively correlated with planting date (Table 1) suggesting that each soybean plant produced less nodes, branches and pods as planting date was delayed (Figure 3).

Figure 3. Effects of planting date on soybean yield at Kemling Farm and Stumpf Farm in a study conducted near Grant, NE in 2018
Why Row Spacing Matters

Overall, soybeans yielded better when planted in narrower rows. At the Kemling Farm a yield advantage of 8 bu/ac was observed with 15-inch rows at early planting, while there was no yield advantage with narrower rows at late planting date (Figure 4). At the Stumpf Farm, there was a yield advantage of 11 and 6 bu/ac with narrower rows at early and late planting, respectively. This is largely in agreement with our previous on-farm research studies that showed 3-13 bu/ac increases with 15-inch as compared to 30-inch rows (Stepanovic et al., 2018b).

Narrower seeding did not influence soybean node development; however, we did observe enhanced branching and consequently a greater number of pods per plant. The additional pods located on the side branches contributed greatly to the yield increase in narrower rows (data not show).

![Figure 4](image_url)

**Figure 4.** Impact of planting dates (May 1 vs June 5) and row spacing (15 inch vs 30 inch) on grain yield (bu/ac), node development (nodes/plant), branching (branches/plant) and pod set (pods/plant) of soybeans at Kemling Farm and Stumpf Farm during 2018 growing season at Grant, NE.
Why Seeding Rate Matters Less than Other Factors

Soybean yield at both the Kemling and Stumpf farms did not respond to changes in plant populations. Although soybeans were seeded at 90,000 and 140,000 live seeds/ac, actual harvest population (plants/ac) ranged between 30,000 and 120,000 plants/ac at the Kemling Farm and between 20,000 and 110,000 plants/ac at the Stumpf Farm. The stand reduction at both sites was due to early season crusting issues and hail injury.

Lack of soybean yield response to increasing populations may be explained by increased competition among the soybean plants themselves. Increasing plant population causes individual soybean plants to produce fewer branches, pods, and seeds, and consequently less yield (Figure 5).

Figure 5. Impact of harvest population (plants/ac) on soybean grain yield (bu/ac) and yield components (nodes/plant, branches/plant, pods/plant, seeds/plant) in field experiments conducted at Kemling Farm and Stumpf Farm during 2018 growing season.
It’s All About Being More Profitable

In summary, soybean yield potential is increased when the crop is seeded earlier (0.64–1.40 bu/ac/day) and in narrower rows (up to 11 bu/ac yield advantage). This yield potential was achievable at lower seeding rates and without late season N supplementation.

It is not uncommon in western Nebraska to see soybean seeding delayed until after irrigated corn is planted, and to do it in 30-inch rows and at 160,000 seeds/ac. Assuming that yield penalties for late planting are lower for corn than for soybean, that typically there are fewer soybean acres to plant, and that market prices of soybean ($8.00/bu) are higher than corn ($3.30/bu), we outline potential savings from incorporating the following practices:

- Seeding soybeans 10 days earlier than as traditional and before corn – $48 to $112/ac;
- Seeding soybean in 15-inch rather than 30-inch rows with modest 3 bu/ac yield increase – $24/ac;
- Reducing seeding rates from 160,000 to 120,000 seeds/acre – $15/ac; and
- Eliminating late season chemigation with 50 lbs of N/ac – $20/ac.

Among these four production factors, early planting is the one factor that soybean growers in the region most often overlook and therefore lose the opportunity to increase their profit margins substantially. Therefore, the real question is what should we plant first in southwest Nebraska: corn or soybeans? The answer is: soybeans.

We can look to Iowa State University research for supporting data (Klein, 2009). Corn planted between April 20 and May 5 achieved 100% yield potential. Depending on year-to-year variability 99% of yield potential could still be achieved with corn planted before May 20. In the three-year study, significant yield reductions occurred only once and that was when corn planting dates were extended to late May or June. In southwest Nebraska research in 2018, we observed daily yield penalties of 0.5–1.0 bu/ac/day for corn planted after May 1 (Stepanovic, 2018; one year data).

We strongly recommend soybean farmers in western Nebraska evaluate their seeding and fertility practices and consider implementing changes that could lead to a more profitable crop.

Acknowledgements

I would like to thank my interns Nemanja Arsenijevic and Zaim Ugljic as well as our part-time technician Justin Richardson for their hard work on this project. We also thank Jim and Troy Kemling who allowed us to do this research on their farm. Lastly, we thank the Nebraska Soybean Board. Without their financial support, this project would not have been possible.
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Stepanovic Strahinja. 2018c. Impact of Hybrid Selection, Planting Date, and Seeding Rates on Dryland Corn in Western Nebraska. Nebraska Extension Crop Watch, link: https://cropwatch.unl.edu/2018/dryland-corn-western-nebraska


Introduction

Adjuvants and spray water quality influence POST herbicide efficacy. PRE herbicides do not require adjuvants for activity unless weeds have emerged and labels include POST application. Questions about adjuvant selection are common. EPA and other regulatory agencies do not regulate adjuvants allowing no standards for quality or activity. Adjuvants are composed of a wide range of ingredients which may or may not contribute to herbicide phytotoxicity. Results vary when comparing specific adjuvants, even within a class of adjuvants. POST herbicide effectiveness depends on spray droplet retention, deposition, and herbicide absorption by weed foliage.

Spray adjuvants generally consist of surfactants, oils and fertilizers. The most effective adjuvant will vary with each herbicide and the need for an adjuvant will vary with environment, weeds, and herbicide used. Follow adjuvant label directions for optimum herbicide enhancement and adequate crop safety. An adjuvant may increase weed control from one herbicide but not from another. Differences in adjuvant activity are observed on marginally controlled species when comparing adjuvants and determining adjuvant enhancement. Effective adjuvants will enhance herbicides and provide consistent results under adverse conditions. Reducing herbicide rates when using effective adjuvants exempts herbicide manufacturers from liability for nonperformance.

**Surfactants** (nonionic surfactants = NIS) are used at 0.25 to 1% v/v (1 to 8 pt/100 gal of spray solution) regardless of spray volume. NIS rate depends on the amount of active ingredient in the formulation, plant species and herbicides used. The main function of a NIS is to increase spray retention, but to a lesser degree influence herbicide absorption. When a range of surfactant rates is given, the high rate is for use with low herbicide rates, drought stress and tolerant weeds, or when the surfactant contains less than 90% active ingredient. Surfactants vary widely in chemical composition and in their effect on spray retention, deposition, and herbicide absorption.

**Silicone surfactants** reduce spray droplet surface tension, which allow the liquid to run into leaf stomata (“stomatal flooding”). This entry route into plants is different from adjuvants that aid in absorption through the leaf cuticle. Rapid entry of spray solution into leaf stomata from use of silicone surfactants may not improve weed control. Silicone surfactants are weed and herbicide specific just like other adjuvants.
Oil adjuvants were used at 2 pt/A and in past years have been recommended at a reduced rate of 1% v/v (1 gal/100 gal of spray solution). Oil adjuvants rate of 2 pt/A enhances herbicides at all spray volumes. Using oil adjuvants 1% v/v may not provide sufficient oil concentration if using less than ~15 gpa. Oil additives increase droplet retention on leaf foliage and increase herbicide absorption. Oil adjuvants contain petroleum oil (COC) or methylated vegetable/seed oils (MSO) plus an emulsifier for dispersion in water. The term crop oil concentrate (COC) designates a petroleum oil concentrate but is misleading because the oil type in COC is petroleum and not a crop vegetable oil. The emulsifier, the oil class (petroleum, vegetable, etc.), and the specific type of oil in a class all influence effectiveness of an oil adjuvant. Oil adjuvants enhance POST herbicides more than NIS and are effective with all POST herbicides, except Liberty, Cobra, paraquat, and Roundup.

MSO adjuvants enhance most POST herbicides more than NIS and PO adjuvants. MSO adjuvants are more aggressive in dissolving leaf wax and cuticle resulting in faster and greater herbicide absorption. The greater herbicide enhancement from MSO adjuvants may occur more in low humidity/low rainfall environments where weeds develop a thicker cuticle. MSO adjuvants cost significantly more than NIS and PO adjuvants. The added cost of MSO and increased risk of crop injury when used at high temperatures have deterred people from using this class of adjuvants. Using reduced MSO adjuvant rates may enhance weed control while lowering risk of crop injury to an acceptable level.

Some herbicide labels restrict use of oil adjuvants and recommend only NIS alone or combined with nitrogen based fertilizer solutions. Follow label directions for adjuvant selection and if PO or MSO adjuvants may be used.

NDSU research has shown wide difference in adjuvant enhancement of herbicides. However, in many studies, no or small differences occur depending on environmental conditions at application, growing conditions of weeds, rate of herbicide used, and size of weeds. For example, under warm, humid conditions with actively growing weeds, NIS + nitrogen fertilizer may enhance weed control to the same level as oil adjuvants. The following are conditions where MSO type additives may give greater weed control than other adjuvant types:

1. Low humidity, hot weather, lack of rain, and drought-stressed weeds or weeds not actively growing due to stress conditions.
2. Weeds larger than recommended on the label.
3. Herbicides used at reduced rates.
4. Target weeds that are somewhat tolerant to the herbicide.
5. When university data supports reduced herbicide rates. Most herbicides, except Roundup, give greater weed control when used with MSO type adjuvants.

Oil adjuvant applied on a volume or area basis
Labels of many POST herbicides recommend oil adjuvants at 1% v/v. At a spray volume of 15-20 GPA, 1% oil adjuvant (COC/PO) will provide a minimum adjuvant concentration (1% v/v in 17
The optimum rate of a PO is 2 pt/A. State surveys show common spray volumes are 10 gpa or lower. PO at 1% v/v in 8.5 gpa = 0.68 pt/A and does not provide sufficient volume oil adjuvant or the area covered. Further, aerial applications containing 1% v/v of oil adjuvant in 3-5 GPA will not provide oil adjuvant volume. For example, Pursuit and Raptor labels require oil adjuvants to be added at 1.25% v/v or 1.25 gal/100 gal water for aerial application at 5 GPA.

Some herbicide labels contain information on adjuvant rates for different spray volumes. To insure sufficient adjuvant concentration, add oil adjuvant at 1% v/v but no less than 1.25 pt/A at all spray volumes. Surfactant at 0.25 to 1% v/v water is sufficient across all water volumes.

**High surfactant oil concentrates (HSOC)** were developed to enhance lipophilic herbicides without antagonizing glyphosate. HSOC adjuvants contain at least 50% w/w oil plus 25 to 50% w/w surfactant, are PO or MSO based, and are usually applied at ½ the oil adjuvant rate (area basis). Glyphosate must be applied with other herbicides to control glyphosate tolerant weeds and crops and to delay resistant weeds. Glyphosate is highly hydrophilic, is enhanced by NIS and nitrogen fertilizer surfactant type adjuvants, and is antagonized by oil adjuvants. Most POST herbicides mixed with glyphosate to increase weed control (Select, Banvel, Laudis, Flexstar, others) are lipophilic and require oil adjuvants for optimum herbicide enhancement. Surfactants are less effective in enhancing lipophilic herbicides. Oil adjuvants, including PO and MSO adjuvants, may antagonize glyphosate. NDSU research has shown wide variability among PO based HSOS adjuvants (POMOC) with many performing no different than common PO adjuvants. However, MSO based HSOC adjuvants (HSMOC) enhance both glyphosate and the lipophilic herbicide. HSMOC adjuvants when used at optimum rates enhance lipophilic herbicides more than HSPOC, MSO and PO adjuvants.

**Some water pH modifiers** are used to lower (acidify) spray solution pH because many insecticides and some fungicides degrade under high water pH. Most solutions are not high or low enough in pH for important herbicide breakdown in the spray tank. A theory has long been postulated that acidifying the spray solution results in greater absorption of weak-acid-type herbicides. pH-reducing adjuvants (water conditioners/AMS-replacement) were developed under this belief. However, low pH is not essential to optimize herbicide absorption.

Many herbicides are formulated as various salts, which are absorbed as readily as the acid. Salts in the spray water may antagonize formulated salt herbicides. In theory, acid conditions would convert the herbicide to an acid and overcome salt antagonism. However, herbicides in the acid form are less water soluble than in salt form. An acid herbicide with pH modifiers may precipitate and plug nozzles when solubility is exceeded, such as with high herbicide rates in low water volumes. Antagonism of herbicide efficacy by spray solution salts can be overcome without lowering pH by adding AMS or, for some herbicides, 28% UAN.

Acidic AMS replacement (AAR) adjuvants (see page 130) contain adjuvants including monocarbamide dihydrogensulfate (urea and sulfuric acid) and some adjuvants in this class are similar to NIS + AMS in enhancing glyphosate and other weak-acid herbicides. The sulfuric acid
forms sulfate when reacting with water and can prevent herbicide antagonism with salts in water. The conversion of urea to ammonium is slow but the ammonium formed can partially enhance herbicides. AAR adjuvants must be applied at 1% v/v or greater to achieve the same level of herbicide enhancement as AMS.

**Basic pH blend adjuvants** are blends of nonionic surfactant, fertilizer, and basic pH enhancer and are used at 1% v/v regardless of spray volume. Data indicate basic blend adjuvants at 1% v/v from 5 to 20 GPA will provide adequate adjuvant enhancement for similar weed control.

Basic pH blend adjuvants are surfactant based, increase spray solution pH, and contain nitrogen fertilizer to enhance herbicide activity. They contain a surfactant to aid in spray retention, spray deposition, and herbicide absorption, and a buffer to increase water pH. Basic pH blends adjuvants increase water pH to near pH 9 which increases water solubility of some herbicides and can increase herbicide phytotoxicity. Within the sulfonylurea chemistry the magnitude of solubility from high spray solution pH can increase from 40 fold (Harmony GT) to 3,670 fold (UpBeet). The solubility of herbicides in other chemical families increase with high pH: Achieve (1-Dim), florasulam (2-TPS), Everest (2-SACT), Sharpen (14), and diflufenzopyr (19), Callisto and Laudis (27-triketone), and pyrasulfatole and Impact (27-pyrazolone) (numbers represent herbicide mode of action).

Some herbicides degrade rapidly in high pH spray solution. Cobra (diphenylether), Resource and Valor (N_phenylphthalimide), and Sharpen (pH 9) degrade within a few minutes in high pH water but are stable for several days at low pH. Optimum use of pH adjusting adjuvants requires some knowledge of herbicide chemistry or experience. Research has shown that basic pH blend adjuvants may enhance weed control similar to MSO adjuvants and can be used in situations where oil adjuvants are restricted.

**Spray carrier water quality**

Minerals, clay, and organic matter in spray carrier water can reduce the effectiveness of herbicides. Clay inactivates paraquat, diquat, and glyphosate. Organic matter inactivates herbicides. Hard water cations or micronutrients such calcium, magnesium, manganese, sodium, and iron reduce efficacy of all weak-acid herbicides. Cations antagonize glyphosate efficacy by binding with glyphosate to form salts (e.g. Glyphosate-Ca) that are not readily absorbed by plants. Antagonistic minerals can inactivate the activity of most POST herbicides, including glyphosate, growth regulators (not esters), ACCase inhibitors, ALS inhibitors, HPPD inhibitors, and Ignite. The antagonism is related to the salt concentration. At low salt levels, loss in weed control may not be noticeable under normal environmental conditions but will occur when weed control is marginal because of drought or partially susceptible weeds. The precise salt concentration in water that causes a visible loss in weed control is difficult to establish because weed control is influenced by other factors.

ND water often contains a combination of sodium, calcium, magnesium, and iron and these cations generally are additive in the antagonism of herbicides. Water in ND, SD, and MT is often high in sodium bicarbonate which does not normally occur in other areas of the U.S. Calcium
levels above 150 ppm and sodium bicarbonate levels above 300 ppm in spray water can reduce weed control in all situations. Water with 1600 ppm sodium bicarbonate can occur in ND, but total hardness levels can exceed 2,500 ppm.

Ammonium nitrogen increases effectiveness of most weak-acid herbicides formulated as a salt. Fertilizers should always be used with herbicides unless prohibited by label. Ammonium ions greatly enhance herbicide absorption and phytotoxicity even in the absence of antagonistic salts in the spray carrier. However, enhancement of Roundup and most other POST herbicides from ammonium is most pronounced when spray water contains large quantities of antagonistic cations. Herbicide enhancement by nitrogen compounds appears in most weed species but is most pronounced in species like volunteer corn and species that accumulate antagonistic salts on or in leaf tissue (lambsquarters, velvetleaf, and sunflower).

AMS enhances phytotoxicity and overcomes salt antagonism for weak-acid herbicides formulated as a salt including glyphosate, growth regulators (not esters), ACCase inhibitors, ALS inhibitors, HPPD inhibitors, and Ignite. The antagonism may be overcome by increasing the glyphosate concentration relative to the cation content or by adding AMS and some water conditioners to the spray solution. Effective water conditioners include EDTA, citric acid, AMS, and some acidic AMS replacements. Of these, AMS has been the most widely adopted. When added to a spray solution, the ammonium (NH$_4^+$) ion complexes with the glyphosate molecule and reduces glyphosate interaction with the hard-water cations, and the sulfate (SO$_4^{2-}$) ion complexes with the hard-water cations (e.g. calcium sulfate), causing the salt to precipitate from solution. This combined effect increases absorption and efficacy. Natural sulfate in water can be disregarded but can reduce antagonism if the sulfate concentration is at least three times the calcium concentration.

Antagonism of Roundup by calcium in a spray solution was overcome by sulfuric but not nitric acid, indicating that the sulfate ion was important, but not the acid hydrogen ion. The importance of the sulfate ion explains the effectiveness of ammonium sulfate, and not 28% UAN, in overcoming calcium antagonism of glyphosate. Other herbicides that become acid at a higher pH than Roundup may realistically benefit from a reduced pH as has been shown for Poast. However, Poast does not require a low pH for efficacy. pH of 4 has overcome sodium antagonism of Poast, but nitrogen fertilizer or AMS also will overcome sodium antagonism of Poast without lowering the pH. The ammonium ion provided by these fertilizers is apparently the important ion.

AMS is recommended at 8.5 to 17 lb/100 gal spray volume (1 to 2%) on most Roundup* labels. However, AMS at 4 lb/100 gal (0.5%) is adequate to overcome most salt antagonism but more than 4 lb/100 gal may be required to fully optimize herbicides. AMS at 0.5% has adequately overcome antagonism of glyphosate from 300 ppm calcium. Use at least 1 lb/A of AMS when spray volume is more than 12 gpa. The amount of AMS needed to overcome antagonistic ions can be determined as follows:
Lbs AMS/100 gal = (0.002 X ppm K) + (0.005 X ppm Na) + (0.009 X ppm Ca) + (0.014 X ppm Mg) + (0.042 X ppm Fe)

This does not account for antagonistic minerals on or in the leaf tissue in species like lambsquarters, sunflower, and velvetleaf which may require additional AMS.

AMS may contain contaminants that may not dissolve resulting in plugged nozzles. Use spray grade AMS to prevent nozzle plugging. Commercial liquid solutions of AMS are available and contain approximately 3.4 lbs of AMS/gallon. For 8.5 lbs of AMS/100 gallons of water add 2.5 gallons of liquid AMS solution.

28% UAN fertilizer is effective in enhancing weed control and overcoming mineral antagonism of most POST herbicides, but not calcium antagonism of Roundup. Sodium bicarbonate antagonism of Poast is overcome by 28% UAN and AMS. AMS or 28% UAN does not preclude the need for an oil adjuvant with lipophilic herbicides. Generally, 4 gal of 28% UAN/100 gal of spray has been adequate. AMS and 28% UAN enhance herbicide control of most weeds even in water without antagonistic salts. Nitrogen fertilizer/surfactant blends may enhance weed control of most herbicides formulated as a salt.

The analysis may report salt levels in ppm or grains. To convert from grains to ppm, multiply by 17 (Example: 10 grains calcium X 17 = 170 ppm calcium). AMS at 2% (17 lb/100 gallons water) will overcome antagonism from the highest calcium and/or sodium concentrations in water. However, AMS at 4 lb/100 gal is adequate for most water sources. Iron is the most antagonistic salt to many herbicides but is not abundant in water.

**Water conditioner adjuvants** are liquid for user preference, applied at low use rates, may contain no or very little AMS, may lower spray solution, and are advertised to replace AMS, and thus are called AMS replacement adjuvants. Pesticide applicators prefer the convenience of low use rate water conditioners, but performance has been inconsistent. Glyphosate plus commercial water conditioner products that included AMS at the equivalent rate of 1% w/w can give similar control to 1% w/w (8.5 lbs/100 gal) AMS. Commercial water conditioners that do not provide an equivalent amount of AMS give less control than glyphosate with 1% or 2% w/w AMS and are often no better than glyphosate alone.

**Acidic AMS replacement (AAR) adjuvants** have been developed for use with glyphosate and other weak acid herbicides. Claims have been made to enhance herbicide activity, and negate the effects of antagonistic salts in spray water and the antagonism from micronutrient solutions added for crop health. Most adjuvants in this class contain monocarbamide dihydrogen sulfate or AMADS (urea plus sulfuric acid) which lowers spray solution pH to 1.4 to 3. The low pH is below the pKa of postemergence herbicides causing most herbicide molecules to be in the acid state which results in fewer molecules binding to positively charged salts.

Some water conditioner adjuvants and acidic AMS replacement adjuvants (AAR) are marketed to modify spray water pH, but low pH is not required for herbicide efficacy. The type of acid or
components of buffering agents and the specific herbicide all need to be considered before using pH-modifying agents. Several commercial AAR adjuvants applied with glyphosate in distilled water were tested and ranked as follows: surfactant + AMS > AMS > NIS = AAR. A commercial AAR adjuvant composed primarily of sulfuric acid was much less phytotoxic than most AAR adjuvants which support the concept and use of ammonia to enhance weak acid herbicides. Generally, AAR adjuvants applied with glyphosate in 1000 ppm hard water (Ca and Mg) gave similar weed control as when applied in distilled water supporting the theory of non-binding herbicide molecules when pH is below the pKa of the herbicide. Clearly, commercial adjuvants vary greatly in function, use, and chemical and biological effect.

**Low spray volumes** (5 to 10 gpa) have been equally or more effective than higher spray volumes for many herbicides. Low spray volume originally was considered important to glyphosate efficacy because it would reduce the ratio of glyphosate and antagonistic cations in the spray solution. However, low spray volumes have enhanced glyphosate efficacy because of higher glyphosate concentration in the spray deposit. Greater efficacy from higher concentrated droplets has been shown with many other herbicides but is logical that the highly concentrated droplets with low volume would be positive for translocated herbicides (NDSU Pile Theory). Contact herbicides (Cobra, Cadet, Ignite, Flexstar/Reflex, paraquat, Sharpen) require higher spray volume for adequate and thorough coverage to enhance control.

Low spray volumes usually imply use of low-volume nozzles that produce small droplets which can increase off-target movement. However, drift-reducing nozzles have been developed that produce large droplets at low volume. In low spray volumes, larger droplets produced by drift-reducing nozzles have been equally effective as small droplets with several translocating herbicides. However, coarse or larger droplets may be less phytotoxic than fine and medium size droplets for most POST herbicides. Limited research is available about efficacy based on droplet size although will become important as regulation requires larger droplet size to mitigate drift from small droplets.
Financial Status of Northwest Kansas Farms

Jordan Steele, Agricultural Economist
Kansas Farm Management Association, NW
Email: jordanraysteele@ksu.edu, Office: (785) 462-6664

Economic Overview:

Northwest Kansas farms are trudging through some of the hardest financial times in almost 70 years of KFMA, NW data even while producing record yields over the past few years. Looking back over the past 10-12 years, 2007 was the first peak in accrual net farm income followed by an enormous double peak in 2011. Following those highly profitable times has been five years of meager breakeven years with most operations not generating enough profit to cover family living and debt payments. KFMA, NW economists will be working on the 2018 analysis in the upcoming months but 2018 does not appear to have much change from the recent years.

Figure 1

Figure 1 shows Value of Farm Production (VFP) and Total Expense (TE) for KFMA, NW member farms since 2000. Notice the VFP above the TE line showing positive Net Farm Income (NFI) in those years. Many factors in the background led to those highly profitable years.
including the ethanol mandate providing a high demand for corn then a Corn Belt drought limiting supply. NW Kansas had favorable yields and could take advantage of the high market prices. Even through the drought of 2012, crop insurance APH’s were high leading to large crop insurance claims adding to net farm income.

Behind the crop scene, cattle numbers and markets were adding to overall farm profitability. As crop incomes came down in 2013, cattle markets were soaring in 2014 and 2015 extending most farms good years. The Texas drought during this time liquidated breeding livestock creating a cattle-cycle favorable to whoever could keep their herd numbers stocked. One last factor helping farm cash flow was oil leases and royalties sweeping through the area with high crude oil prices.

However basic economics kicked in leading to inflated land, machinery, breeding stock, and input costs. Profit margins tightened up quickly and positive cash flow diminished. Also, family living is still lingering around $100,000 for the average KFMA, NW family and has little room to budget. Figure 2 shows family living and income taxes paid during the same time period as Figure 1’s value of farm production. Family living and income taxes are generally lagged from net farm income but increased after the good years and has decreased during the poor years. Unless there is sufficient off farm income to cover family living and income taxes, the farm business must provide all the funds or the family is living on borrowed money.

![Family Living Cost](image)

**Figure 2**
Regardless of past years’ performance, there are still many farms with a positive net farm income. Farm size and profit margin are both critical to net farm income; large farms do not necessarily have an advantage over small farms. If the total expense ratio is greater than one (meaning it costs more than one dollar to generate one dollar of revenue), then large farms will lose more money. Farm size does help but only if profit margins are acceptable. Figure 3 shows the relationship between total expense ratio and value of farm production. The larger farms are shown to the right of the graph and the more efficient farms are shown lower on the graph. Three groups are important to note on this graph. First are the group of diamonds around $4,000,000 VFP with total expense ratio of $1.20 showing a net farm LOSS of $800,000 and proving the importance of profit margin with large farms. Second are the two farms at $5,000,000 and $6,000,000 VFP and under $0.75 total expense ratio showing net farm incomes nearing $2,000,000. The third group to consider are all farms under $2,000,000 VFP and under $0.75 total expense ratio; these are family owned farms with enough profitability to provide for a comfortable family living.

![Figure 3](image-url)
Going forward, important pieces for farm business managers to remember is the difference between the accrual income, cash flow, and tax return numbers. First, farms must be showing positive accrual income which includes grain and livestock inventories, prepaid expenses, and accounts receivable at each year end. Second, cash flow and timing of sales, purchases, and loan payments must be planned and communicated with bankers and other lenders. Last, profitable farms will have income tax liabilities and successful managers will pay them as needed. Although it is not as easy as the good years, the current market situations still have opportunity for farms to find income and profitability, ensure cash flow and liquidity, and improve net worth and solvency.

Income Tax Update:

The new tax law for 2018 has many changes that will affect agricultural businesses, here are some highlights:

- Individual rates decreased to 10, 12, 22, 24, 32, 35, and 37% brackets
- C Corporate rates are 21% flat
- Personal exemptions are eliminated
- Standard deduction is doubled
  - Or itemized deductions (medical, donations, mortgage interest, property taxes)
  - Does not impact deduction of business farm real estate or property taxes!
- Child tax credit doubled and AGI phase-out increased
- Estate exclusion increased to $11.2 million (inflation adjusted until 2025)
- Excess Business Losses over $500,000 carried forward
- Farm Net Operating Losses back 2 years or elect forward, offsets 80% taxable income
- Employer meals 50%, 0% after 2025
- Depreciation
  - Like-kind exchanges not allowed, trade is sale then full value purchase
  - Section 179 still available with limits
  - Bonus 100% until 2022 then phases down
  - 200DB method and 5-year life for some machinery
  - Impacts tax return and self-employment tax
- Section 199A Qualified Business Income Deduction
Materials were unavailable at the time of printing for:

Dryland Corn Hybrids, Seeding Rates, and Planting Dates

These materials will be distributed in the session and also posted online as part of an updated proceedings at:

www.northwest.ksu.edu/CoverYourAcres

Then click on “Past Proceedings” and select 2019
Getting Peak Performance from Paraquat

Marshall M. Hay and Dallas E. Peterson
Kansas State University, Department of Agronomy
mmhay@ksu.edu / dpeterso@ksu.edu

Executive Summary

1. Paraquat is a contact herbicide that requires coverage to ensure maximum efficacy.
2. Select spray nozzles that deliver medium to coarse spray droplets for the best efficacy.
3. Use an appropriate drift reduction agent that is compatible with your spray nozzle, and be aware of shifts in droplet size with the addition of tank mix partners.
4. Use a PSII-inhibiting herbicide whenever possible to synergize paraquat efficacy.
5. Apply paraquat with other effective herbicide sites of action and as part of an integrated strategy to reduce the risk of paraquat resistance.

Introduction to Paraquat

Paraquat was first synthesized in 1882 for use in bench chemistry; however, it was not recognized as an herbicide until 1955 with its commercial launch in 1962. Contrary to the myth, paraquat is not “Agent Orange” or a known carcinogen. Paraquat is a non-selective contact herbicide. When applied in sunny conditions, symptomology usually appears on treated plants within 1-2 hours after application. The Weed Science Society of America (WSSA) recognizes paraquat as a Group 21 herbicide site of action (SOA). After paraquat is absorbed through the cell membrane, it enters the chloroplast and binds to a protein on the photosystem I (PSI) light reaction center. Here it diverts electrons to reduce oxygen.

Reduced oxygen destroys cell membranes which appears as the necrotic symptoms on plants. Paraquat has no activity in the dark or on cloudy days because the light reaction centers are not active. Generally, plants can be assessed for control or regrowth within 14 days after an application.

Before paraquat can cause plant death, it must be absorbed through the leaf cuticle and the cell membrane. All herbicides can be classified as either oil or water-loving. Because paraquat is a water-loving molecule, it is usually applied with 0.25% v/v NIS; however, oil-activator adjuvants and ammonium nitrogen sources such as UAN at 2.5% v/v can increase absorption, especially in hot, dry environments when plants can have thick and waxy cuticles. Different results were observed with various adjuvants with a sublethal rate of paraquat at Franklin and Reno Counties (Table 1). Differences are likely due to the significantly warmer temperatures before and after application at Reno County (Figure 1). In most situations, 0.25% v/v NIS is suitable; however, in hot, dry environments, UAN at 2.5% v/v may be beneficial.

Figure 1. Daily high temperature before and after herbicide application for paraquat adjuvant trials. X denotes the day of application.
Paraquat has a unique molecular structure (divalent cation). Because of this, paraquat can bind with dust or turbid water. Therefore, only clean water should be used, and consideration should be given to dust on plant leaves or from sprayer tires that could bind with the paraquat and reduce herbicide activity.

**Application Technology**

Often paraquat is criticized as an herbicide that is prone to drift; however, paraquat is no more driftable than other herbicides and may even be less because it is not volatile. It is common for paraquat to speckle leaves on nearby corn for example (Figure 2). Corn is extremely sensitive to paraquat, and many paraquat applications are made with small droplet sizes which are more prone to drift.

Each nozzle produces a spectrum of spray droplet sizes ranging from small to large (Figure 3). Any spray droplet smaller than 150 µm (about the diameter as a sewing thread) are classified as driftable fines. Driftable fines are easily moved off-target because of the greater time they are suspended in the air before reaching the target (Table 2). Focusing on droplet size, paraquat drift can be mitigated by reducing the number of driftable fines.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Adj. Rate</th>
<th>Franklin County</th>
<th>Reno County</th>
</tr>
</thead>
<tbody>
<tr>
<td>paraquat</td>
<td>-</td>
<td>46 a-c</td>
<td>43 c</td>
</tr>
<tr>
<td>para + NIS</td>
<td>0.25% v/v</td>
<td>74 a</td>
<td>53 bc</td>
</tr>
<tr>
<td>para + MSO</td>
<td>1 % v/v</td>
<td>50 a-c</td>
<td>50 bc</td>
</tr>
<tr>
<td>para + HSOC</td>
<td>0.5 % v/v</td>
<td>42 b-d</td>
<td>61 ab</td>
</tr>
<tr>
<td>para + surfactant + acidifier</td>
<td>0.5 % v/v</td>
<td>71 a</td>
<td>54 bc</td>
</tr>
<tr>
<td>para + UAN 28</td>
<td>2.5 % v/v</td>
<td>30 cd</td>
<td>75 a</td>
</tr>
<tr>
<td>para + AMS</td>
<td>8 lb/100 gal</td>
<td>43 b-d</td>
<td>65 ab</td>
</tr>
<tr>
<td>para + UAN 28 + HSOC</td>
<td>2.5 + 0.5 % v/v</td>
<td>66 ab</td>
<td>54 bc</td>
</tr>
<tr>
<td>para + AMS + HSOC</td>
<td>8 lb/100 gal + 0.5 % v/v</td>
<td>18 d</td>
<td>55 bc</td>
</tr>
</tbody>
</table>

Table 1. Pigweed control at Franklin and Reno County with a sublethal rate of paraquat to expose the effect of an adjuvant. Better control would be expected with the field use rate. Letters indicate significant differences.

This can be influenced by increasing the droplet VMD (volume mean diameter) for the spray nozzle. Based on the VMD, each spray nozzle at a given operating pressure can be placed into one of seven categories (Table 3). Selecting a nozzle with a larger VMD would result in more larger droplets and a lesser number of driftable fines. Another option is to utilize a drift treatment.

<table>
<thead>
<tr>
<th>Droplet Classification</th>
<th>Diameter (µm)</th>
<th>Time to fall 10 ft (seconds)</th>
<th>Travel distance in 3 mph wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Fine</td>
<td>5</td>
<td>4.2 min.</td>
<td>1,100 ft</td>
</tr>
<tr>
<td>Fine</td>
<td>20</td>
<td>10</td>
<td>44 ft</td>
</tr>
<tr>
<td>Medium</td>
<td>240</td>
<td>6</td>
<td>28 ft</td>
</tr>
<tr>
<td>Coarse</td>
<td>400</td>
<td>2</td>
<td>8.5 ft</td>
</tr>
</tbody>
</table>

Table 2. Small spray droplets take longer to reach the ground. Because of this, even a slight breeze can move the droplet further off-target. Minimizing driftable fines, lowering boom heights, and not applying in windy conditions can help reduce the risk of drift. Adapted from NSDU Ext.
reduction agent (DRA) to decrease the number of driftable fines by tightening or shifting the droplet size spectrum for a given nozzle.

Unfortunately, this is easier said than done. By switching to a nozzle that produces larger droplets, paraquat coverage and efficacy could be reduced. If the incorrect DRA is utilized with certain nozzle types, more driftable fines could be produced. Nozzles that produce a Medium (M) to Coarse (C) droplet size (236 to 403 µm VMD) at 20 GPA will achieve the greatest efficacy on pigweed (Figure 4). Control will

**Table 3. Droplet size classification, symbols, and VMD ranges according to the ASABE standards.**

<table>
<thead>
<tr>
<th>Category</th>
<th>Symbol</th>
<th>VMD Range (µm)</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Fine</td>
<td>XF</td>
<td>&lt; 60</td>
<td></td>
</tr>
<tr>
<td>Very Fine</td>
<td>VF</td>
<td>61 - 105</td>
<td></td>
</tr>
<tr>
<td>Fine</td>
<td>F</td>
<td>106 - 235</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>M</td>
<td>236 - 340</td>
<td></td>
</tr>
<tr>
<td>Coarse</td>
<td>C</td>
<td>341 - 403</td>
<td></td>
</tr>
<tr>
<td>Very Coarse</td>
<td>VC</td>
<td>404 - 502</td>
<td></td>
</tr>
<tr>
<td>Extremely Coarse</td>
<td>XC</td>
<td>503 - 665</td>
<td></td>
</tr>
<tr>
<td>Ultra Coarse</td>
<td>UC</td>
<td>&gt; 665</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3.** Droplet size distribution curves for four different spray nozzles ranging from Fine to Ultra Coarse.

**Figure 4.** Pigweed control modeled across various nozzle droplet size spectrums and carrier volumes with a sublethal rate of paraquat.
decrease and become less consistent with larger VMDs. Therefore, a nozzle should be selected that produces a M to C droplet size at the target application pressure; high pressures should be avoided as these tend to produce a greater percentage of driftable fines.

DRA’s have the potential to shift a nozzle’s VMD or tighten the distribution of droplets around the VMD. While either will reduce the risk of drift, consideration must be given to the VMD after the DRA is added to ensure that it is still within the M to C range.

For example, if a DRA is added and the VMD is shifted to the Very Coarse range, the risk of drift will have been reduced but so will the efficacy of the paraquat. DRA’s that are oil-based should not be used in combination with Turbo-Tee, TTI, TTJ, or similar style nozzles as these have been shown to decrease droplet VMD rather than increase it; surfactant-based DRA’s should be used instead with these nozzle designs (Table 4). If a different style nozzle is used, either type of DRA will increase the VMD, especially with Turbo-Tee, TTI, TTJ, or similar style nozzles.

Because it is nearly impossible to test all tank mix combinations with all nozzles, it is imperative for applicators to continuously observe the nozzle spray pattern when the tank mix partners or rates are changed. An experienced observer can notice a change in 50 µm VMD which could have drastic performance implications for paraquat efficacy and drift.

When controlling dense stands of pigweed or kochia, it is critical to make the application to weeds smaller than 4-inches in height. Control will decrease when applying to large weeds. Inconsistent results for pigweed control with paraquat have commonly been observed at lower carrier volumes with more consistent results at higher carrier volumes (> 15 GPA). In addition to selecting a nozzle that produces the correct droplet size at the target pressure, preference should be given to a nozzle that orients droplets straight down for maximum canopy penetration. Dual angle nozzles have not been shown to increase pigweed control, possibly due to the increased distance that the droplet must travel to reach the leaf. Sprayers equipped with pulse-width-modulation (PWM) are becoming more common and can help keep droplet VMD more consistent across a range of travel speeds. Only non-venturi-type nozzles should be used with PWM, and duty-cycles should be above 40%.

**Table 4.** VMD for various nozzles with the addition of an oil-based DRA. VMD was decreased for Turbo-Tee style nozzles. Color indicates VMD classification from ASABE standards in Table 3. Adapted from Creech et al. 2009

<table>
<thead>
<tr>
<th>Nozzle</th>
<th>DRA</th>
<th>VMD (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>AITTJ11005</td>
<td>509</td>
<td>602</td>
</tr>
<tr>
<td>AIXR11005</td>
<td>645</td>
<td>803</td>
</tr>
<tr>
<td>TTI11005</td>
<td>319</td>
<td>252</td>
</tr>
</tbody>
</table>

**Tank Mix Partners**

PSII-inhibiting herbicides (atrazine, metribuzin, linuron, or diuron) should be tank mixed with paraquat whenever rotational restrictions allow to increase weed control. Synergistic effects are commonly observed when these two SOA are combined because they work in tandem on the two types of light reaction centers in the chloroplast. Delayed necrosis should be expected with these tank mixes (Figure 5).
While most of the pigweed and kochia populations in Kansas are resistant to atrazine, even reduced rates of PSII-inhibiting herbicides with paraquat still provide a synergistic effect on these resistant populations (Table 5).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Reno County Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>paraquat</td>
<td>sublethal</td>
<td>45 c</td>
</tr>
<tr>
<td>atrazine</td>
<td>0.66</td>
<td>0 d</td>
</tr>
<tr>
<td>mesotrione</td>
<td>0.19</td>
<td>78 ab</td>
</tr>
<tr>
<td>para + ATZ</td>
<td>0.09 + 0.66</td>
<td>68 b</td>
</tr>
<tr>
<td>para + ATZ + mesotrione</td>
<td>0.09 + 0.66 + 0.19</td>
<td>89 a</td>
</tr>
</tbody>
</table>

**Table 5.** Atrazine-resistant pigweed control at Reno County with a reduced rate of paraquat plus atrazine and mesotrione. A sublethal rate of paraquat was used to unmask the benefits of various tank mix partners. Letters indicate significant differences.

Rotational restrictions for atrazine and metribuzin must be given special consideration, especially in high pH soils in which they become less adsorbed to the soil and are more available for plant uptake. In these situations, linuron or diuron may be better options since they are not influenced by soil pH. Whenever a PSII-inhibiting herbicide is utilized, an oil-activator adjuvant such as 1 pt/ac COC or MSO should be substituted for NIS since PSII-inhibiting herbicides generally require an oil-activator for foliar absorption.

Other herbicide SOA such as flumioxazin, glufosinate, mesotrione, and 2,4-D have been shown to offer joint activity on pigweed when tank mixed with paraquat. Tank mixing additional effective sites of action that complement paraquat could result in more consistent weed control, residual weed control, and facilitate resistance management.

While most paraquat applications are focused on controlling glyphosate-resistant driver weeds such as pigweed or kochia, there are often other weeds that would ideally be controlled with the same application. Unfortunately, paraquat offers inconsistent control at best of many grass species. Tank mix partners such as PSII-inhibiting herbicides, glufosinate, or clethodim have been shown to increase grass weed control; however, mixed results are often observed. When trying to control grasses in addition to glyphosate-resistant driver weeds,
the best grass control is almost always achieved with a sequential application of glyphosate followed by paraquat. The tank mix of glyphosate plus paraquat has achieved poor grass control across numerous trials (Figure 6). Antagonism with paraquat plus glyphosate has been consistently observed, and therefore, this tank mix is not recommended. The antagonism is likely due to a combination of two aspects: 1) because paraquat has a positive charge, it could bind with glyphosate in the spray tank thus making it difficult for foliar absorption or 2) the desiccation of tissue by the paraquat is limiting the translocation of glyphosate in the plant.

**Resistance Management**

With the increase in glyphosate-resistant pigweed and kochia combined with the reduction in price of paraquat, more selection pressure is placed on paraquat each year. No resistance to paraquat has been confirmed in kochia or pigweed; however, resistance to paraquat has been documented in some grass species as well as marestail outside of Kansas. According to the WSSA, herbicide resistance is the inherited (genetic) ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. Repeated applications of paraquat will inevitably select for a population of pigweed or kochia that is resistant (Figure 7).

**Scenario 1:** Apply 0.75 lb ai/ac paraquat to 4-inch pigweed.

**Scenario 2:** Apply 0.75 lb ai/ac paraquat + 0.5 lb ai/ac metribuzin to 4-inch pigweed.

**Figure 7.** After repeat applications of the same herbicide, a resistant population will develop (purple plants in lower picture). In the above picture, only one resistant individual emerged. If a different approach had been used, this one individual could have been controlled. Over time, the producer selected for a resistant population.

**Figure 8.** Scenario 1 demonstrates how applying paraquat alone would not provide control of a resistant biotype. Because of the failed control of this biotype, resistant seeds will be added to the soil (red dots). In Scenario 2, MESA is utilized, and metribuzin provides control of the paraquat-resistant biotype and no resistant individuals enter the seed bank.

To extend the life of paraquat as an effective herbicide in the Great Plains, multiple effective herbicide sites of action (MESA) should be used in tank mix to limit the selection pressure on paraquat (Figure 8). It is important to understand which SOA are carrying the load in herbicide recommendations.
Many premixes are available that contain numerous SOA, but they only count toward MESA if the population does not contain resistance to that SOA and are applied at the correct rate. Tank mixing MESA has been proven to be more effective than rotating herbicide SOA because in a rotation, all the selection pressure is placed on only one SOA in each application (Figure 8).

One example of effective SOAs that should be considered are the PSII-inhibiting herbicides for pigweed control with paraquat. While most populations of pigweed in Kansas are resistant to atrazine, a member of the triazine family, atrazine-resistant pigweed populations are susceptible to metribuzin, linuron, and diuron. These other PSII-inhibiting herbicides are from different families than atrazine, and because of the non-target site metabolic resistance mechanism, they still offer excellent control (Table 6). Therefore, to implement MESA resistance management, they should be applied at a labeled rate to ensure that they could control a paraquat-resistant biotype as opposed to a low rate that might be used only for synergistic purposes.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate lb ai/ac</th>
<th>Pigweed Control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>metribuzin</td>
<td>0.75</td>
<td>99 a</td>
</tr>
<tr>
<td></td>
<td>0.375</td>
<td>96 ab</td>
</tr>
<tr>
<td></td>
<td>0.188</td>
<td>76 bc</td>
</tr>
<tr>
<td>linuron</td>
<td>1.0</td>
<td>98 a</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>95 ab</td>
</tr>
<tr>
<td></td>
<td>0.25</td>
<td>71 c</td>
</tr>
<tr>
<td>atrazine</td>
<td>2.0</td>
<td>0 d</td>
</tr>
</tbody>
</table>

*Table 6. Atrazine-resistant pigweed control at Cloud County with various rates of metribuzin, linuron, and atrazine with COC in the absence of paraquat. Letters indicate significant differences.*

In kochia, resistance to the PSII-inhibiting herbicides is conferred through a target site mechanism which has cross resistance to PSII-inhibiting herbicides including metribuzin, linuron, and diuron, making them ineffective when developing a management plan with MESA, other than for paraquat synergism purposes.

Key strategies to reducing the risk of paraquat resistance include using the full use rate of paraquat (at least 0.75 lb ai/ac) and making applications to small weeds. Utilizing the correct droplet size with an adequate adjuvant package to ensure optimal paraquat absorption is key to reducing the risk of resistance as well. The use of residual herbicides to control weeds as they emerge will also help to reduce the selection pressure on paraquat in burndowns.

In addition to these herbicide management approaches, the most effective strategies to reduce the risk of paraquat resistance are to integrate cultural and mechanical options whenever possible to suppress pigweed and kochia seed production.
Kansas Land Values and Rental Rates

Mykel Taylor
Associate Professor
K-State Dept. of
Agricultural Economics
mtaylor@ksu.edu

Current Economic Conditions

Returns to Farming

Source: KFMA Enterprise Reports (http://www.agmanager.info/kfma)

Returns to Farming

Source: KFMA Enterprise Reports (http://www.agmanager.info/kfma)

Returns to Farming

Source: KFMA Enterprise Reports (http://www.agmanager.info/kfma)

Returns to Farming

Source: KFMA Enterprise Reports (http://www.agmanager.info/kfma)

Land Values

Bankruptcies Filed by KS Farms

Land Values

Where do we get information on land values?
KS Ag Stats Service
  ◦ Annual survey series
  ◦ Dropped CRD-level estimates in 2013
  ◦ Only have a state value for irrigated, non-irrigated, and pasture land in Kansas

Land Values

Affected by profitability in ag sector
But land values do not adjust as quickly as profitability to changes in commodity prices
Adjustment period due to
  ◦ Long-run reasons for buying and holding land
  ◦ Expectations of buyers/sellers

Land Value Trends
2018 Pasture Value by State
Dollars per Acre and Percent Change from 2017

Kansas Land Values

Rent-to-Land Value Ratio

Market-Based Land Values

Kansas Land Values
Source for market transaction data
- Property Valuation Department, Topeka

2014-17 sales data
- County location, population density
- Acres in sale
- Mixture of irrigated, non-irrigated and pasture in parcel
- 20-year average rainfall and water-holding capacity
- Enrollment in CRP
- Value of improvements is removed for bare land value
- Parcels under 40 acres are omitted
- Johnson and Wyandotte County parcels removed

PVD Sales Data 2014-2017

<table>
<thead>
<tr>
<th>Year</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>150.6</td>
</tr>
<tr>
<td>CRP Contracts</td>
<td>4.3%</td>
</tr>
<tr>
<td>Sales Per County</td>
<td>25.1</td>
</tr>
</tbody>
</table>

All Years

Total Sales Transactions:

<table>
<thead>
<tr>
<th>Year</th>
<th>2017</th>
<th>2016</th>
<th>2015</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>2,625</td>
<td>2,145</td>
<td>3,775</td>
<td>3,789</td>
</tr>
</tbody>
</table>

31% drop in sales over past 4 years
Land Model Results

Non-Irrigated Land

- Estimated Value ($/ac)
- 2013 2014 2015 2016 2017
- 19% decline

Irrigated Land

- Estimated Value ($/ac)
- 2013 2014 2015 2016 2017
- 17.4% decline

Pasture Land

- Estimated Value ($/ac)
- 2013 2014 2015 2016 2017
- 21.4% decline

Kansas Land Values

- Land Values ($/ac)

Long-Run Growth

- 24.9% decline
- 43.0% decline
- 12.0% decline
Summary

Other Comments

“Land prices are still based on quality land having the highest demand and poor land having few buyers and lower prices.”

- Appraiser in Central Kansas, September 2017

Farmers are the biggest buyers of farmland
- When farmers are reluctant to buy, demand falls and isn’t likely to be sufficiently supported by outside investment
- Turnaround will happen when projections for net farm income rebound

Online Resources

2017 Kansas County-Level Ag Land Values

2018 Rent Estimates: Non-Irr. & Irrigated Cropland

Pasture Rental Rate Tool

Rental Rates

2017 USDA Non-Irrigated Rents

2017 USDA Pasture Rents
Public Information

Limited public information on rental rates
- Surveys (USDA, some KS Counties)
- K-State budgeting approach: what a representative farmer could afford to pay

Comparisons need to be done carefully
- One measures what is actually being paid
- One measures what we expect could be paid

KSU Non-Irrigated Rental Rates

<table>
<thead>
<tr>
<th>NW District</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheyenne</td>
<td>66.00</td>
<td>45.30</td>
<td>30.50</td>
<td>19.80</td>
<td>6.50</td>
<td>10.20</td>
</tr>
<tr>
<td>Decatur</td>
<td>88.20</td>
<td>67.80</td>
<td>46.00</td>
<td>30.70</td>
<td>10.10</td>
<td>12.60</td>
</tr>
<tr>
<td>Graham</td>
<td>71.60</td>
<td>54.10</td>
<td>34.90</td>
<td>24.60</td>
<td>7.90</td>
<td>11.10</td>
</tr>
<tr>
<td>Norton</td>
<td>81.50</td>
<td>69.30</td>
<td>47.10</td>
<td>31.50</td>
<td>10.40</td>
<td>13.30</td>
</tr>
<tr>
<td>Rawlins</td>
<td>73.40</td>
<td>57.60</td>
<td>39.10</td>
<td>25.80</td>
<td>8.40</td>
<td>11.80</td>
</tr>
<tr>
<td>Sheridan</td>
<td>78.70</td>
<td>62.10</td>
<td>42.20</td>
<td>28.20</td>
<td>9.20</td>
<td>12.70</td>
</tr>
<tr>
<td>Sherman</td>
<td>64.80</td>
<td>44.70</td>
<td>30.20</td>
<td>19.90</td>
<td>6.50</td>
<td>10.40</td>
</tr>
<tr>
<td>Thomas</td>
<td>70.00</td>
<td>56.00</td>
<td>38.00</td>
<td>25.20</td>
<td>8.20</td>
<td>12.60</td>
</tr>
<tr>
<td>Average</td>
<td>74.28</td>
<td>57.11</td>
<td>38.50</td>
<td>25.71</td>
<td>8.40</td>
<td>11.84</td>
</tr>
</tbody>
</table>

Why are rents staying high?

Multi-year leases
- Consider signing 3-5 year leases but renegotiate rate annually

Good yields in 2017-18 in some areas
- Kept some profitability in sector to pay rents that wouldn’t be affordable with average or below average yields

People are willing to pay more than they can afford in the short run
- Length of the short run is going to vary by producer

Online Resources

2017 Kansas County-Level Ag Land Values
- www.agmanager.info/land-leasing/land-buying-valuing

2018 Rent Estimates: Non-Irr. & Irrigated Cropland
- www.agmanager.info/land-leasing/land-rental-rates

Pasture Rental Rate Tool
- www.agmanager.info/land-leasing/land-rental-rates/pasture-rental-rate-decision-tool

Leasing Relationships
Demographic Information

Not surprising that men are the dominant gender of the producer group.

D7. What is your gender? (P)

- Male
- Female

Demographic Information

Women make up a much larger percentage of the landowner group.

Does this matter for relationships?

- Conversations with their husband

Demographic Information

Aging farmer population

- Technology is allowing farmers to keep working longer
- Succession plans may have been delayed with recent economic downturn

Average age: 59.6

D7. What is your age? (P)

- <40
- 40-49
- 50-59
- 60-69
- 70-79
- 80+

Demographic Information

Average age: 72.9

Landowners

- Don’t typically have the capital to invest in farmland until later in life or...
- Inherit from parents

Implications of their age

- Communications may have to be adjusted (texting, letters, etc.)
- Fixed income – may want fixed cash lease

Demographic Information

Proximity of landowner affects

- Communication (in-person or distance)
- Ability to monitor tenant activities

Often tied to generational distance from the farm

- Perceptions of commercial agriculture
- Understanding of farm practices, farm policy, commodity markets

B9a. Approximate Age of Landowner

- <50
- 50-59
- 60-69
- 70-79
- 80-89
- 90+

B4. Where do the LL’s live?

- on the farm
- same county
- outside county, same state
- outside state
Demographic Information

Number of years in landowner/tenant relationship
Attitudes toward return on investment
Loyalty to existing leasing arrangement
  - Style of lease
  - Lease amount

Lease Information

Communication is key to relationships
  - Keep them updated on farming practices, market conditions
  - Helps with the tough talks on renegotiating

Perceptions of commercial farming
  - Understanding of farm programs, farming practices, markets
  - Likelihood of cash rent versus crop share
Lease Information

Average: 17.7 years

B13. How long have you been renting from this person/entity?

Communication issues
- Gets harder to talk to more people
- Use a newsletter or similar communication for group

Implications for lease type
- More likely to select a fixed cash lease to reduce paperwork burden

Who has more power in negotiating lease terms?
A. Landowner
B. Tenant

Negotiating Power
Farmers tend to have better information
- Rental rates (their other leases, coffee shop)
- Market and production conditions
- Technology
- Government programs

Landowners tend to have...the land
Most corn hybrids planted in the U.S. have transgenic traits for insect management. The Handy Bt Trait Table provides a helpful list of trait names (below) and details of trait packages (over) to make it easier to understand company seed guides, sales materials, and bag tags.

### New for 2019
- Recent mergers resulted in name changes for several seed companies. While your local seed rep may have a new business card, the names of trait packages remain the same, listed alphabetically on page 2.
- **Bt Resistance** is arguably the most important issue facing growers, extension entomologists, and seed company agronomists. Problems continue to increase in regions where field failures were already found, and new cases of resistance are reported every season. To date, resistance is confirmed to all Bt toxins targeting western corn rootworm, particularly in the central corn belt. In the southern states, corn earworm and fall armyworm resistance is expanding, while Cry1F no longer controls western bean cutworm in the Great Lakes region. These species were once secondary to European corn borer in importance, but now they are of primary concern for many growers. It is critical to be up-to-date on resistance development in your local area so that you know the limitations of the Bt traits you plant.

### Field corn ‘events’ (transformations of one or more genes) and their Trade Names

<table>
<thead>
<tr>
<th>Trade name for trait</th>
<th>Event</th>
<th>Protein(s) expressed</th>
<th>Primary Insect Targets + Herbicide tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrisure CB/LL</td>
<td>Bt11</td>
<td>Cry1Ab + PAT</td>
<td>corn borer + glufosinate</td>
</tr>
<tr>
<td>Agrisure Duracade</td>
<td>5307</td>
<td>eCry3.1Ab</td>
<td>rootworm</td>
</tr>
<tr>
<td>Agrisure GT</td>
<td>GA21</td>
<td>EPSPS</td>
<td>glyphosate</td>
</tr>
<tr>
<td>Agrisure RW</td>
<td>MIR604</td>
<td>mCry3A</td>
<td>rootworm</td>
</tr>
<tr>
<td>Agrisure Viptera</td>
<td>MIR162</td>
<td>Vip3A</td>
<td>broad caterpillar control, except for corn borer</td>
</tr>
<tr>
<td>Enlist</td>
<td>DAS40278</td>
<td>aad-1</td>
<td>2,4-D herbicide detoxification</td>
</tr>
<tr>
<td>Herculex I (HXI) or CB</td>
<td>TC1507</td>
<td>Cry1Fa2 + PAT</td>
<td>corn borer + glufosinate</td>
</tr>
<tr>
<td>Herculex CRW</td>
<td>DAS-59122-7</td>
<td>Cry34Ab1/Cry35Ab1 + PAT</td>
<td>rootworm + glufosinate</td>
</tr>
<tr>
<td>(None – part of Qrome)</td>
<td>DP-4114</td>
<td>Cry1F + Cry34Ab1/Cry35Ab1 + PAT</td>
<td>corn borer + rootworm + glufosinate</td>
</tr>
<tr>
<td>Roundup Ready 2</td>
<td>NK603</td>
<td>EPSPS</td>
<td>glyphosate</td>
</tr>
<tr>
<td>Yieldgard Corn Borer</td>
<td>MON810</td>
<td>Cry1Ab</td>
<td>corn borer</td>
</tr>
<tr>
<td>Yieldgard Rootworm</td>
<td>MON863</td>
<td>Cry3Bb1</td>
<td>rootworm</td>
</tr>
<tr>
<td>Yieldgard VT Pro</td>
<td>MON89034</td>
<td>Cry1A.105 + Cry2Ab2</td>
<td>corn borer &amp; several caterpillar species</td>
</tr>
<tr>
<td>Yieldgard VT Rootworm</td>
<td>MON88017</td>
<td>Cry3Bb1 + EPSPS</td>
<td>rootworm + glyphosate</td>
</tr>
</tbody>
</table>

### Abbreviations used in the Trait Table

- **Herbicide traits**
  - GT *glyphosate tolerant*
  - LL Liberty Link - *glufosinate-tolerant*
  - RR2 Roundup Ready 2, *glyphosate-tolerant*

- **Insect targets**
  - BCW black cutworm
  - CEW corn earworm
  - CBW corn rootworm
  - ECB European corn borer
  - FAW fall armyworm
  - SB stalk borer
  - SCB sugarcane borer
  - SWCB southwestern corn borer
  - TAW true armyworm
  - WBC western bean cutworm
<table>
<thead>
<tr>
<th>Trait packages in alphabetical order (acronym)</th>
<th>Bt protein(s) in the trait package</th>
<th>Marketed for control of:</th>
<th>Insects resistant to the combination of Bt proteins in the trait package</th>
<th>Herbicide</th>
<th>Non-Bt Refuge % (cornbelt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AcreMax (AM)</td>
<td>Cry1Ab Cry1F</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>AcreMax CRW (AMRW)</td>
<td>Cry34/35Ab1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>AcreMax1 (AM1)</td>
<td>Cry1F Cry34/35Ab1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>AcreMax Leptra (AML)</td>
<td>Cry1Ab Cry1F Vip3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>AcreMax Trisect (AMT)</td>
<td>Cry1Ab Cry1F mCry3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>AcreMax Xtra (AMX)</td>
<td>Cry1Ab Cry1F Cry34/35Ab1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>AcreMax Xtreme (AMXT)</td>
<td>Cry1Ab Cry1F mCry3A Cry34/35Ab1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure 3010 and 3010A</td>
<td>Cry1Ab</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure 3000GT and 3011A</td>
<td>Cry1Ab mCry3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>Agrisure Viptra 3110</td>
<td>Cry1Ab Vip3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure Viptra 3111</td>
<td>Cry1Ab Vip3A mCry3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure 3120 E-Z Refuge</td>
<td>Cry1Ab Cry1F</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure 3122 E-Z Refuge</td>
<td>Cry1Ab Cry1F mCry3A Cry34/35Ab1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure Viptra 3220 E-Z Refuge</td>
<td>Cry1Ab Cry1F Vip3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure Viptra 3330 E-Z Refuge</td>
<td>Cry1Ab Vip3A Cry1A.105 + Cry2Ab2</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure Duracade 5122 E-Z Refuge</td>
<td>Cry1Ab Cry1F mCry3A eCry3.1Ab</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Agrisure Duracade 5222 E-Z Refuge</td>
<td>Cry1Ab Cry1F Vip3A mCry3A eCry3.1Ab</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>Herculex I (HXI)</td>
<td>Cry1F</td>
<td>B</td>
<td>C</td>
<td>E</td>
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<tr>
<td>Herculex RW (HXRW)</td>
<td>Cry34/35Ab1</td>
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<td>C</td>
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<tr>
<td>Herculex XTRA (HXX)</td>
<td>Cry1F Cry34/35Ab1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>Intrasect (YHR)</td>
<td>Cry1Ab Cry1F</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>Intrasect TRisect (CYHR)</td>
<td>Cry1Ab Cry1F mCry3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>Intrasect Xtra (YXR)</td>
<td>Cry1Ab Cry1F Cry34/35Ab1</td>
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<td>C</td>
</tr>
<tr>
<td>Intrasect Xtreme (CYXR)</td>
<td>Cry1Ab Cry1F mCry3A Cry34/35Ab1</td>
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<td>C</td>
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<tr>
<td>Leptra (VYHR)</td>
<td>Cry1Ab Cry1F Vip3A</td>
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<tr>
<td>Powercore a Powercore Refuge Advanced b</td>
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<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>QROME (Q)</td>
<td>Cry1Ab Cry1F mCry3A Cry34/35Ab1</td>
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<td>E</td>
<td>C</td>
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<tr>
<td>SmartStax a Smartstax Refuge Advanced b SmartStax RIB Complete b</td>
<td>Cry1A.105 Cry2Ab2 Cry1F Cry3Bb1 Cry34/35Ab1</td>
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<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>Trecepta a Trecepta RIB Complete b</td>
<td>Cry1A.105 Cry2Ab2 Vip3A</td>
<td>B</td>
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<td>E</td>
<td>C</td>
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<tr>
<td>TRisect (CHR)</td>
<td>Cry1F mCry3A</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
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<tr>
<td>VT Double PRO a VT Double PRO RIB Complete b</td>
<td>Cry1A.105 Cry2Ab2</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>VT Triple PRO c VT Triple PRO RIB Complete d</td>
<td>Cry1A.105 Cry2Ab2 Cry3Bb1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>YIELDgard Corn Borer (YGB)</td>
<td>Cry1Ab</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>YIELDgard Rootworm (YGRW)</td>
<td>Cry3Bb1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
<tr>
<td>YIELDgard VT Triple</td>
<td>Cry1Ab Cry3Bb1</td>
<td>B</td>
<td>C</td>
<td>E</td>
<td>C</td>
</tr>
</tbody>
</table>
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Remediation of eroded high pH hill-top soils with manure

Dr. Merle F. Vigil, David Poss, Dr. Joe Benjamin, and Dr. Maysoorn Mikha

USDA-ARS Central Great Plains Research Station
Akron, Colorado

*Dr. Vigil is the Research Leader and a soil Scientist at the ARS Research Station in Akron Colorado.*

**Introduction**

In the Dust bowl of the 1930’s, millions of farm acres were damaged by excessive tillage and erosion (Atmos. News 2012). The tillage practices used at that time made these soil particularly vulnerable to wind and water erosion. These eroded soils can still be observed while traveling through the region. They are most obvious on hilltops and side-slopes of tilled farmland. Driving across the Great Plains one can see hilltops and side-slopes that are lighter in color than the surrounding soils. The lightly colored soil indicates that most of the original (dark-colored) top soil has been eroded away. Much of the erosion is the result of the combination of both multiple years of tillage and exposure of the unprotected land to erosive forces of the regions winds.

The subsoil now at the soil surface is low in organic matter and high in pH. Often free limestone can be found at the soil surface. The limestone buffers the soil to a high pH and that high pH makes nutrients like zinc (Zn) and iron (Fe) crop unavailable. For these reasons, “pH sensitive” crops like corn, proso millet, and sorghum will exhibit classic zinc and iron deficiency symptoms (interveinal chlorosis) when growing in these eroded soils. The crop from a distance just looks bleached yellow when growing in these eroded regions of the field.

We know that organic amendments, like animal manures be that beef, poultry or swine, are good sources of plant nutrients (high in N, P, K, Zn, Fe, S and others). Also, because animal manures are high in carbon and rich in organic matter, these manures are a good amendment for mitigating organic matter depletion of an eroded soil (Arriaga and Lowery, 2003; Eghball et. al, 2004; Ferguson, et al., 2005). The question is, how do we best use manure as an amendment to fix (remediate) these soils? Specifically, we wanted to learn about reasonable rates of application and we wanted to evaluate the value of incorporation versus just applying the manure on the surface using no-till practices. A final objective was to evaluate if incorporated (tilled in), how deep should it be incorporated?

**Experimental Approach**

In 2006, we initiated an on-farm experiment (near Akron Colorado) to study the best management practices for remediating eroded hilltop soils with beef manure as the amendment. We selected a site that showed extensive top soil loss (erosion). Proso millet planted on the field in 2005 showed classic micronutrient deficiencies (interveinal chlorosis). An earlier paper Mikha et al., 2017, provides a detailed description of the study. In brief, the soil
series at the study site is a Norka-Colby very fine sandy loam (fine-silty, mixed, mesic, Aridic, Argiustolls). The site is approximately 4540 feet above mean sea level with a slope of approximately 5%. Soil texture is 35% sand, 45% silt, and 20% clay. The average annual precipitation is 16.5 inches (110 yr. average). Each experimental plots is 45 feet wide by 50 feet long. The plots are organized in randomized complete block design with four replicates. A typical dryland cropping sequence for the region was planted over a seven year period from 2006 -2013. The crops that have been planted are Corn (2006) – Proso Millet (2007) – Forage Winter Triticale (2008) – Winter Wheat (2009) – Proso Millet (2010)—Corn (2011)—Fallow (2012)—Wheat (2013). These crops are planted on all of the plots and alleys except for the eight grass and grass/legume plots. For the grass and grass/legume plots forage sorghum was planted in June 2007 as a cover crop. The grass and grass/legume seed was planted in November 2007. Due to a record breaking drought in 2012, the field was summer fallowed that year.

Manure was analyzed before each application (Olsen’s Agricultural Laboratory, Inc. McCook, NE) and N content was evaluated (Table 1). Manure was applied with the assumption that 100% of the inorganic N (NH$_4^+$ and NO$_3^-$) content was available at application time. We assumed that approximately 25% of organic N would become available through mineralization during the first season of application (Gilbertson et al., 1979). Thus, the annual M applications throughout the 6-yr study period ranged between 2.4 to 5.9 ton M ac$^{-1}$ y$^{-1}$ for the low rate and between 5.4 to 17 ton M ac$^{-1}$ y$^{-1}$ for the high rate depending on fresh M moisture content and inorganic N availability. Fertilizer P, Monoammonium phosphate (11-52-0) was applied with the seed at approximately 20 lbs of P$_2$O$_5$ per acre at the planting of wheat, triticale, and millet. No P was applied to the corn crops.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>units</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>%</td>
<td>34.2</td>
<td>12.6</td>
</tr>
<tr>
<td>pH</td>
<td>pH</td>
<td>7.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>dSm$^{-1}$</td>
<td>15.6</td>
<td>6.7</td>
</tr>
<tr>
<td>C to N ratio</td>
<td>C:N</td>
<td>21.2</td>
<td>6.5</td>
</tr>
<tr>
<td>Total N</td>
<td>%</td>
<td>1.56</td>
<td>0.32</td>
</tr>
<tr>
<td>Inorganic N (mostly NH$_4^+$-N)</td>
<td>%</td>
<td>0.23</td>
<td>0.21</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>%</td>
<td>1.09</td>
<td>0.30</td>
</tr>
<tr>
<td>K</td>
<td>%</td>
<td>1.35</td>
<td>0.30</td>
</tr>
<tr>
<td>Ca</td>
<td>%</td>
<td>1.44</td>
<td>0.78</td>
</tr>
<tr>
<td>Mg</td>
<td>%</td>
<td>0.42</td>
<td>0.16</td>
</tr>
<tr>
<td>Na</td>
<td>%</td>
<td>0.23</td>
<td>0.07</td>
</tr>
<tr>
<td>Cl</td>
<td>%</td>
<td>0.47</td>
<td>0.25</td>
</tr>
<tr>
<td>S</td>
<td>%</td>
<td>0.31</td>
<td>0.06</td>
</tr>
<tr>
<td>Zn</td>
<td>ppm</td>
<td>150</td>
<td>54.3</td>
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<tr>
<td>Fe</td>
<td>ppm</td>
<td>4412</td>
<td>2528</td>
</tr>
<tr>
<td>Mn</td>
<td>ppm</td>
<td>163</td>
<td>49.2</td>
</tr>
<tr>
<td>Cu</td>
<td>ppm</td>
<td>23.3</td>
<td>14.0</td>
</tr>
</tbody>
</table>
Manure is applied in the fall to allow for winter precipitation to restore moisture lost during tillage operations (Table 2 and Table 3). The low rate was determined by estimating the amount of nitrogen required to meet crop needs average over the next six years which was determined to be approximately 30 lb/ac. Based on past studies, we assumed that 25% of the organic nitrogen would be available to the crop the first year. The high rate is simply three times the low rate. The high rate of manure we hoped, was excessive enough to significantly increase soil organic matter content and change soil physical properties within the next six year cycle of the experiment.

Some plots had the manure plowed under using a 14 inch tumble moldboard plow (10-12 inches deep) followed by chiseling at an 8-10 inch depth for soil mixing and seedbed smoothing, others were shallowly incorporated with V-blade sweeps (3-6 inches deep), and others the manure was applied on the surface and left unincorporated (managed no-till) (Table 2 and Table 3). The moldboard plow incorporated plots were managed in two ways: 1.) as a onetime application with a calculated rate of manure heavy enough to supply N for 6 cropping seasons and then plowed under at least 20-12 inches deep and chiseled (DP-6); and 2.) manure rate applied once every two years for two cropping seasons and plowed under and chiseled for mixing and soil smoothing (DP-2). For comparison, we included three check treatments: (1) an unfertilized check; and plots that were fertilized with just chemical fertilizer N, at either 30 lbs/acre or 60 lbs/acre. Urea was used as the chemical fertilizer N source (Table 2). Chemical N fertilizer rates are 30 and 60 lb/ac. The chemical N fertilizer treatments are broadcast (as urea) on the surface annually to the un-manured lots including the deep tillage plots, just prior to planting.

All treatments were replicated across the eroded slope four times. The first rep was on the most eroded soil and the other reps moved down the slope and show less erosion. Manure was applied in the fall to allow for winter precipitation to restore moisture lost during tillage operations. We measured grain and biomass yield, as well as measured changes in soil properties and nutrient uptake in the grain and biomass, every year. Weeds were controlled as needed primarily with glyphosate, [isopropylamine salt of N-(phosphonomethyl) glycine] and or with other contact herbicides in crop as needed. Beef manure (M) and urea (46-0-0) as fertilizer (F), were each applied at low and high rates (Table 2). The F was added annually within one week before crop planting at two rates. The low fertilizer rate (LF) was approximately 30 lb N ac\(^{-1}\) where the high fertilizer rate (HF) represented twice the low rate (approximately 60 lb N ac\(^{-1}\)). Manure was also added annually, before tillage operations in the fall or spring at two rates low (LM) and high (HM). The LM was added equivalent to the recommended rate of N required for crop in rotation for that specific year (approximately 30 lbs of available N per year was the target manure N rate). Where the HM rate was equivalent to the three times the recommended rate of N required for a crop planted that specific year.

Throughout the study period, soil samples, from each plot, were collected in the spring of 2006 before planting and again in the fall after harvest of each crop. Samples were collected between the crop rows to avoid the wheel-trafficked areas. A hydraulic probe (Giddings/Forestry Supplies, Inc. Jackson, MS) was used for soil sampling at 0-6 inch, 6-12 inch, 12-24, 24-36, and at the 36-48 -inch depths from each plot. Soil samples were air-dried, ground
to pass a 2-mm screen, and analyzed for different soil chemical properties (Ward Laboratory, Kearney, NE).

Table 2. Treatment description including fertilizer type, application rate, tillage and frequency of manure application of Soil Remediation Study.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Manure/ Fertilizer</th>
<th>Target Rate (lb N/ac)</th>
<th>Tillage to incorporate manure</th>
<th>Frequency of manure application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man-L-Swp</td>
<td>Manure</td>
<td>30</td>
<td>Sweep</td>
<td>Annual</td>
</tr>
<tr>
<td>Man-L-Deep6</td>
<td>Manure</td>
<td>30</td>
<td>Moldboard Plow</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Man-L-Deep2</td>
<td>Manure</td>
<td>30</td>
<td>Moldboard Plow</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Man-L-NT</td>
<td>Manure</td>
<td>30</td>
<td>No-Till</td>
<td>Annual</td>
</tr>
<tr>
<td>Man-H-Swp</td>
<td>Manure</td>
<td>90</td>
<td>Sweep</td>
<td>Annual</td>
</tr>
<tr>
<td>Man-H-Deep6</td>
<td>Manure</td>
<td>90</td>
<td>Moldboard Plow</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Man-H-Deep2</td>
<td>Manure</td>
<td>90</td>
<td>Moldboard Plow</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Man-H-NT</td>
<td>Manure</td>
<td>90</td>
<td>No-Till</td>
<td>Annual</td>
</tr>
<tr>
<td>Fert-L-Swp</td>
<td>Fertilizer</td>
<td>30</td>
<td>Sweep</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Fert-L-Deep6</td>
<td>Fertilizer</td>
<td>30</td>
<td>Moldboard Plow</td>
<td>Once at beginning of study</td>
</tr>
<tr>
<td>Fert-L-Deep2</td>
<td>Fertilizer</td>
<td>30</td>
<td>Moldboard Plow</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Fert-L-NT</td>
<td>Fertilizer</td>
<td>30</td>
<td>No-Till</td>
<td>Annual</td>
</tr>
<tr>
<td>Fert-H-Swp</td>
<td>Fertilizer</td>
<td>60</td>
<td>Sweep</td>
<td>Annual</td>
</tr>
<tr>
<td>Fert-H-Deep6</td>
<td>Fertilizer</td>
<td>60</td>
<td>Moldboard Plow</td>
<td>Once at beginning of study</td>
</tr>
<tr>
<td>Fert-H-Deep2</td>
<td>Fertilizer</td>
<td>60</td>
<td>Moldboard Plow</td>
<td>Every 2 years</td>
</tr>
<tr>
<td>Fert-H-NT</td>
<td>Fertilizer</td>
<td>60</td>
<td>No-Till</td>
<td>Annual</td>
</tr>
<tr>
<td>Control-Swp</td>
<td>None</td>
<td>0</td>
<td>Sweep</td>
<td>Annual</td>
</tr>
<tr>
<td>Control-NT</td>
<td>None</td>
<td>0</td>
<td>No-Till</td>
<td>Annual</td>
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Table 3. Manure application rates (tons/acre) and time of application to plots

<table>
<thead>
<tr>
<th>Manure application</th>
<th>Annually</th>
<th>Every other year (DP-2)§</th>
<th>One time (DP-6)¶</th>
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<tbody>
<tr>
<td>Month</td>
<td>Year</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>November</td>
<td>2006</td>
<td>5.2</td>
<td>16.3</td>
</tr>
<tr>
<td>October</td>
<td>2007</td>
<td>5.9</td>
<td>16.9</td>
</tr>
<tr>
<td>August</td>
<td>2008</td>
<td>4.6</td>
<td>13.3</td>
</tr>
<tr>
<td>November</td>
<td>2009</td>
<td>2.8</td>
<td>6.3</td>
</tr>
<tr>
<td>November</td>
<td>2010</td>
<td>3.9</td>
<td>11.7</td>
</tr>
<tr>
<td>February</td>
<td>2012</td>
<td>2.4</td>
<td>5.4</td>
</tr>
</tbody>
</table>

§ DP-2 was manure applied once every other year and then incorporated with a moldboard plow 10-12 inches deep.

¶ DP-6 was manure applied once in 2006 at the initiation of the experiment and then incorporated with a moldboard plow 10-12 inches deep.
RESULTS

Due to the drought in 2012, the study was fallowed in 2012 instead of planting a crop. Wheat was planted in the fall of 2012 and harvested in July 2013. The yields varied widely across years, ranging from a low of 7 bu/acre of corn in 2011 for the Manure-High-Deep2 treatment to a high of 74 bu/acre of corn for the Man-high-Sweep treatment (Table 4). These results are consistent across years where the treatments that were deep plowed every two years have the lowest yields and the no-till and sweep treatments have the highest yields (Table 4).

Often we get asked about not incorporating the manure in the no-till treatment and about expectations of N lost through volatilization. From Table 1, we see that ammoniacal N in the manure used in the study has is less than 0.5% of the total N applied. Therefore not much of the total N would be expected to be lost through volatilization.

Others have shown that most of the ammonia that is lost to the atmosphere is lost almost immediately after the livestock has excreted the N as ammonia in urine or manure. Most ammonia (NH\textsubscript{3} gas) is lost in the feedlot. Our source of manure was stockpiled from pen scrapings made several days before we hauled it to the site, hence low ammonia contents of 0.23% (Table 1).

The yields (as expected) were always highest with the manure treatments when compared to the urea fertilizer treatments. It is important to keep in mind that with the chemical fertilizer treatments we are only applying N fertilizer and some starter P fertilizer. On the other hand with manure, N, phosphorus (P), potassium (K), sulfur, zinc, iron, copper and several other micronutrients are being added. Furthermore, with the manure we are adding carbon, and that carbon acts like adding crop residue to the soil surface imparting improved soil water storage and improvements in soil physical properties. For the DP-6 treatment manure application in the fall of 2006, we calculated a rate of N to meet the needs of six crops. The wheat harvested in 2013 completed the six crops cycle. While all manure treatments at the low rate, received approximately the same amount of N with manure, whether it was applied all at once, biannually, or annually, some treatments did not utilize it very well due to low yields caused by the plow treatments. The DP-2 and DP-6 treatments were in this group of poor utilization. These treatments resulted in much lower yields than expected. We suspect the tillage was hard on soil physical properties and most likely caused additional water loss not seen with the no-till or sweep till treatments.

The NO\textsubscript{3}-N and NH\textsubscript{4}-N (nitrate and ammonium) distributions in the soil after 6 years of cropping (Fig. 1, Fig. 2) shows extremely high buildup of nitrate for the DP-2 and DP-6 treatments demonstrating that these were neither practical treatments from an agronomic point of view or from an environmental point of view. The N applied is not being used and is still present in the soil 6 years after application. We also can observe that all treatments show some accumulation of nitrate above the check plots (Fig. 2). Only in the manure high DP2 and DP6 treatments do we also observe a buildup of NH\textsubscript{4}-N (Fig. 1). In general the NO\textsubscript{3}-N values are at least one order of magnitude greater than the NH\textsubscript{4}-N values indicating that over time the organic N in the manure is mineralizing in the soil resulting in the NO\textsubscript{3}-N buildup.

We conclude that the most practical method for remediation of this eroded high pH hilltop soil is with either the low rate of manure applied with no incorporation or with just shallow
incorporation. Because we suspect ammonia loss was not really much of a concern because of low amounts of ammoniacal in the manure source at the time of application, incorporation is probably not necessary to improve N use. The yields of both the no-till treatments and the sweep treatments over the 6 year study gave the best yields overall. The one time application with deep incorporation DP-6, is not a recommended practice nor is the other deep tillage incorporated treatment DP-2.

Table 4. Dry Grain Yield from Soil Remediation Study from 2007 through 2013.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2007 (Proso)</th>
<th>2008 (Triticale)</th>
<th>2009 (Wheat)</th>
<th>2010 (Proso)</th>
<th>2011 (Corn)</th>
<th>2012 (Fallow)</th>
<th>2013 (Wheat)</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man-H-NT</td>
<td>39.6 ab</td>
<td>NO</td>
<td>35.8 abcd</td>
<td>37.0 ab</td>
<td>67.1 ab</td>
<td>NA</td>
<td>30.0 ab</td>
<td>41.9 a</td>
</tr>
<tr>
<td>Man-H-Swp</td>
<td>32.8 ab</td>
<td>GRAIN</td>
<td>28.8 bcd</td>
<td>37.4 ab</td>
<td>73.9 a</td>
<td>NA</td>
<td>28.5 ab</td>
<td>40.3 ab</td>
</tr>
<tr>
<td>Man-L-Swp</td>
<td>26.8 bcd*</td>
<td>44.7 a</td>
<td>41.4 a</td>
<td>50.7 cd</td>
<td>NA</td>
<td>35.0 a</td>
<td>39.7 ab</td>
<td></td>
</tr>
<tr>
<td>Man-L-NT</td>
<td>34.0 ab</td>
<td>41.5 ab</td>
<td>35.8 ab</td>
<td>56.1 bcd</td>
<td>NA</td>
<td>30.7 ab</td>
<td>39.6 ab</td>
<td></td>
</tr>
<tr>
<td>Fert-H-Swp</td>
<td>24.8 bcd</td>
<td>FORAGE</td>
<td>39.7 abcd</td>
<td>32.0 ab</td>
<td>43.8 cd</td>
<td>NA</td>
<td>24.8 abc</td>
<td>33.0 abc</td>
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<tr>
<td>Fert-L-Swp</td>
<td>26.4 bcd</td>
<td>ONLY</td>
<td>38.8 abcd</td>
<td>29.6 ab</td>
<td>42.1 cde</td>
<td>NA</td>
<td>25.3 abc</td>
<td>32.5 abc</td>
</tr>
<tr>
<td>Fert-H-Dp6</td>
<td>31.8 abc</td>
<td>29.3 bcd</td>
<td>34.6 ab</td>
<td>45.5 cde</td>
<td>NA</td>
<td>18.7 bcd</td>
<td>32.0 abcd</td>
<td></td>
</tr>
<tr>
<td>Fert-L-Dp6</td>
<td>22.8 bcd</td>
<td>27.8 cd</td>
<td>34.8 ab</td>
<td>45.4 cde</td>
<td>NA</td>
<td>20.8 bc</td>
<td>30.3 bcde</td>
<td></td>
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<tr>
<td>Control-Swp</td>
<td>26.0 bcd</td>
<td>35.8 abcd</td>
<td>28.4 ab</td>
<td>33.8 def</td>
<td>NA</td>
<td>24.0 abc</td>
<td>29.6 bcde</td>
<td></td>
</tr>
<tr>
<td>Man-H-Dp6</td>
<td>20.0 cd</td>
<td>17.5 ef</td>
<td>36.8 ab</td>
<td>53.6 bcd</td>
<td>NA</td>
<td>18.3 bcd</td>
<td>29.2 cde</td>
<td></td>
</tr>
<tr>
<td>Fert-H-NT</td>
<td>23.6 bcd</td>
<td>29.3 bcd</td>
<td>24.6 b</td>
<td>42.9 cde</td>
<td>NA</td>
<td>19.7 bcd</td>
<td>28.0 cde</td>
<td></td>
</tr>
<tr>
<td>Fert-L-Dp6</td>
<td>28.6 bcd</td>
<td>26.5 cd</td>
<td>33.6 ab</td>
<td>34.6 def</td>
<td>NA</td>
<td>14.2 cd</td>
<td>27.5 cde</td>
<td></td>
</tr>
<tr>
<td>Control-NT</td>
<td>19.8 d</td>
<td>31.7 bcd</td>
<td>29.2 ab</td>
<td>28.4 ef</td>
<td>NA</td>
<td>25.5 abc</td>
<td>26.9 cde</td>
<td></td>
</tr>
<tr>
<td>Fert-H-Dp2</td>
<td>23.2 bcd</td>
<td>31.7 bcd</td>
<td>25.4 b</td>
<td>23.4 fg</td>
<td>NA</td>
<td>11.8 d</td>
<td>23.1 cde</td>
<td></td>
</tr>
<tr>
<td>Fert-L-Dp2</td>
<td>23.8 bcd</td>
<td>31.5 bcd</td>
<td>29.4 ab</td>
<td>18.6 fg</td>
<td>NA</td>
<td>11.8 d</td>
<td>23.0 cde</td>
<td></td>
</tr>
<tr>
<td>Man-L-Dp2</td>
<td>29.0 bcd</td>
<td>28.0 dc</td>
<td>35.8 ab</td>
<td>7.1 g</td>
<td>NA</td>
<td>9.7 d</td>
<td>21.9 de</td>
<td></td>
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<tr>
<td>Man-H-Dp2</td>
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<td>24.2 de</td>
<td>34.4 ab</td>
<td>8.0 g</td>
<td>NA</td>
<td>9.2 d</td>
<td>20.4 e</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>27.1</td>
<td>30.8</td>
<td>33.1</td>
<td>39.8</td>
<td>20.9</td>
<td>30.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Means followed by the same letter are not significantly different using the SNK mean separation test with alpha = 0.10.
Fig. 1. NH$_4$-N distribution after 2012 crop, total NH$_4$-N in top 4 feet of soil profile.
Fig. 2. NO$_3$-N distribution after 2012 crop, total NO$_3$-N in top 4 feet of soil profile.

Literature references


Top 3 Missteps of Wheat Production

Jeanne Falk Jones
K-State Multi-County Agronomist

Misstep #1
Not Being On-Time for Managing Diseases

Wheat Streak Mosaic
Stripe Rust

Wheat Streak Mosaic

Wheat Streak Mosaic
**Effects to Wheat**

- **Wide range of yield reductions**
  - Year 1: 5.7 to 41.6%
  - Year 2: 5.7 to 71.2%

- **Wide range of test weight reductions**
  - Year 1: up to 9.9%
  - Year 2: up to 89.3%

- Severity depended on wheat variety and environmental conditions.

Langham et al. 2001

---

**Wheat Streak Mosaic & Wheat Curl Mites**

- Alternative Hosts
  - Barley
  - Rye
  - Oats
  - Sweet Corn
  - Field Corn
  - Sorghum
  - Millets

---

**How to Manage Around Wheat Streak Mosaic?**

- Control volunteer wheat 2 weeks prior to drilling
- Control volunteer wheat 2 weeks prior to drilling
- Control volunteer wheat 2 weeks prior to drilling
- Plant resistant wheat varieties
- Plant later
- Once infected, no remedy
- If infected, minimize stress on the wheat plant

---

**Stripe Rust**

---
Stripe Rust Disease Triangle

- Susceptible Host
- Favorable Environment
- Stripe Rust Spores

Susceptible Host

Favorable Environment

- Damp or humid conditions
- Mild temperatures

Rust Spores

Heavy stripe rust pressure in Texas

Could be a problem for western Kansas
How to Manage Around Stripe Rust?

Susceptible Host  
Plant resistant varieties

Favorable Environment  
Stop the wind; No stripe rust in Texas

Fungicide Applications

Approximately 21 days of stripe rust control

Foliar Fungicide Efficacy Ratings for Wheat Disease Management 2018

<table>
<thead>
<tr>
<th>Product</th>
<th>Rate (oz)</th>
<th>12 DAT</th>
<th>21 DAT</th>
<th>27 DAT</th>
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<tbody>
<tr>
<td>Quadris</td>
<td>9</td>
<td>1.8</td>
<td>10.6</td>
<td>26.3</td>
</tr>
<tr>
<td>Prosaro</td>
<td>8.2</td>
<td>1.5</td>
<td>14.4</td>
<td>18.8</td>
</tr>
<tr>
<td>Twinline</td>
<td>9</td>
<td>1.3</td>
<td>12.5</td>
<td>26.9</td>
</tr>
<tr>
<td>Evitea</td>
<td>4</td>
<td>1.8</td>
<td>26.9</td>
<td>30.6</td>
</tr>
<tr>
<td>Fortis</td>
<td>6</td>
<td>3.3</td>
<td>19.4</td>
<td>27.5</td>
</tr>
<tr>
<td>Stratego YLD</td>
<td>4</td>
<td>0.8</td>
<td>15.6</td>
<td>38.1</td>
</tr>
<tr>
<td>Triacon 8 + Quilt Xcel 4 + 12.5</td>
<td>4</td>
<td>1.5</td>
<td>8.1</td>
<td>19.4</td>
</tr>
<tr>
<td>Quilt Xcel</td>
<td>14</td>
<td>1.8</td>
<td>11.9</td>
<td>18.8</td>
</tr>
<tr>
<td>Vibe (late)</td>
<td>4</td>
<td>1.5</td>
<td>11.1</td>
<td>25.6</td>
</tr>
<tr>
<td>Vibe (late)</td>
<td>4</td>
<td>1.5</td>
<td>11.3</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Controlling Stripe Rust

- Applying a fungicide after flag leaf emergence, when disease is FL-1 or FL-2
- Apply fungicide on time for the most bang for your $$
- Plant stripe rust resistant wheat varieties

### Misstep #2
Not meeting the wheat’s nitrogen needs...and how that affects protein

### Nitrogen Uptake

- Most of the N used by wheat is taken up before flowering and later moved to the kernel during grain fill
- Photosynthesis occurring during grain fill largely determines kernel starch contents

### Making Protein

- Nitrogen is a basic component of amino acids
- Amino acids are the building blocks of plant growth and are stored for seedling development
- The protein in the kernel is generally considered to be laid down first before most of the carbohydrates

### Importance of Protein

- Bread rises because of yeast and gluten
- Gluten - is a “sticky” protein complex
- Proteins are made up of amino acids
- Amino acids are stored in the seed as they are the foundation of plant growth (seedlings)
Plant Use of Nitrogen

N supply effects on Grain Yield and Protein

FIGURE 1. The response of wheat yield and grain protein to increasing N supply.

Jones et al., Montana State Univ. EB0206

Fertility

Wheat grain yield, bushels/acre

Wheat grain Protein, %

protein = 17.903 - 0.082 (bu/acre) R^2 = 0.64

protein = 15.169 - 0.088 (bu/acre) R^2 = 0.40

USDA-ARS Akron Station Wheat 1996-2009

USDA-ARS Central Great Plains Research Station, Akron, Colorado

Goos et al 1982

Wheat Grain Protein, %

N insufficient for 95% of maximum yields

Wheat grain rel-yield % of maximum

40

60

80

100

120

11 12 13 14 15 16 17 18

Goos et al 1982

Wheat Grain Protein, %

N sufficient for 95% of maximum yields

Wheat grain rel-yield % of maximum

40

60

80

100

120

7 8 9 10 11 12 13 14 15 16 17 18

ARS-Akron Wheat Proteins versus Yield 1996-2009

Wheat Grain Protein %

N insufficient for 90% of maximum yields

Wheat Grain rel-yield % of maximum

40

60

80

100

120

7 8 9 10 11 12 13 14 15 16 17 18

Increasing Grain Protein

- UNL (NebGuide EC143) recommends an additional 20 lbs of spring applied N to increase protein 1% (up to 40 lbs Max)
- CSU (Bulletin 544) recommends an additional 20-30 lbs of N to increase protein 1%
- The additional applications will not increase protein if your short of N to maximize yield
- Timing of nitrogen in the root zone is very important

Key Thoughts

- Will we get the moisture to get the nitrogen into the root zone?
- Will we get paid for the protein?
- You are leaving yield on the table if you are consistently getting less than 11.5% protein.

Weed Control

- Important for in-crop
  - Winter annuals
  - Grissy weeds
  - Summer annuals in thin wheat
- Important for wheat stubble
  - Kochia
  - Palmer amaranth
- A thick wheat stand is good for weed control

Misstep #3

Skipping Weed Control
In-Crop
- Mustard
- Downy brome
- Jointed goatgrass
- Clearfield Wheat → Beyond Herbicide
- CoAXium Wheat → Aggressor Herbicide

Effectiveness of fall/spring-applied Aggressor on downy brome control in Incline AX CoAxium winter wheat at KSU Ag Research Center-Hays, Kansas in 2018abc

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate</th>
<th>Timing</th>
<th>Downy brome</th>
<th>Wheat yield</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>(oz/a)</td>
<td></td>
<td>4/11/18</td>
<td>5/6/18</td>
</tr>
<tr>
<td>Aggressor</td>
<td>8</td>
<td>FP</td>
<td>94</td>
<td>96</td>
</tr>
<tr>
<td>Aggressor</td>
<td>10</td>
<td>FP</td>
<td>94</td>
<td>96</td>
</tr>
<tr>
<td>Aggressor</td>
<td>8</td>
<td>SP</td>
<td>73</td>
<td>91</td>
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<tr>
<td>Aggressor</td>
<td>12</td>
<td>SP</td>
<td>73</td>
<td>94</td>
</tr>
<tr>
<td>Aggressor</td>
<td>8/8</td>
<td>FP/SP</td>
<td>94</td>
<td>96</td>
</tr>
<tr>
<td>Untreated</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>LSD (5%)</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

- Fall Post (FP) was applied on Nov 6, 2017, Spring Post (SP) was applied on Mar 28, 2018.
- Experimental field was under continuous winter wheat for several years.
- NIS was used in all herbicide applications per label guidelines.

Thin Wheat Stands

Weed control in wheat and wheat stubble following harvest, SWREC Tribune 2017. Thompson, Schlegel, and Peterson.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Kochia in crop</th>
<th>Kochia in fallow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lb / acre</td>
<td>1 DAT</td>
<td>21 DAT</td>
</tr>
<tr>
<td>Clarity + 2,4-D</td>
<td>0.125-0.375</td>
<td>Preempt</td>
<td>88</td>
</tr>
<tr>
<td>Clarity + 2,4-D + NIS</td>
<td>0.5-0.75</td>
<td>Preempt</td>
<td>91</td>
</tr>
<tr>
<td>Clarity + Zidua</td>
<td>0.125-0.162</td>
<td>Preempt</td>
<td>91</td>
</tr>
<tr>
<td>Clarity + Promax + 2,4-D</td>
<td>0.250-0.500</td>
<td>Preempt</td>
<td>94</td>
</tr>
<tr>
<td>Clarity + Huskie + Zidua + NIS + AMS</td>
<td>0.125</td>
<td>Preempt</td>
<td>99</td>
</tr>
<tr>
<td>Atrazine + Sharpen + MSO + UAN</td>
<td>1.0</td>
<td>Preempt</td>
<td>99</td>
</tr>
<tr>
<td>Rave + Zidua</td>
<td>0.147-0.197</td>
<td>Preempt</td>
<td>89</td>
</tr>
<tr>
<td>Atrazine + Sharpen + MSO + UAN</td>
<td>1.0</td>
<td>Preempt</td>
<td>89</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

Weed control in wheat and wheat stubble following harvest, SWREC Tribune 2017. Thompson, Schlegel, and Peterson.
Kochia control in wheat stubble with no in wheat crop treatment, SWREC Tribune 2017. Thompson, Schlegel, and Peterson. 1701whtTR

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rate</th>
<th>Applying time</th>
<th>Kochia in Fall</th>
<th>13 DAT</th>
<th>33 DAT</th>
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<tr>
<td>Clarity+Sharpen+Lines+MSO+UAN</td>
<td>0.5+0.3+0.75+1+2.5%</td>
<td>Fallow</td>
<td>84</td>
<td>87</td>
<td></td>
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<tr>
<td>Clarity+Atrazine+COC</td>
<td>0.5+1.0+0.5%</td>
<td>Fallow</td>
<td>59</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>Clarity+extra+Sharpen+MSO+UAN</td>
<td>0.5+1.0+0.45+1+2.3%</td>
<td>Fallow</td>
<td>82</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>Gramoxone SL+MS</td>
<td>0.75+0.5%</td>
<td>Fallow</td>
<td>91</td>
<td>88</td>
<td></td>
</tr>
<tr>
<td>Gramoxone SL+extra+COC</td>
<td>0.75+0.25+1%</td>
<td>Fallow</td>
<td>94</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Clarity+2,4-D+MS</td>
<td>0.5+0.3+0.125%</td>
<td>Fallow</td>
<td>70</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>85</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Weeds

Percent kochia control with and without in crop treatments

With In-Crop Treatments Without In-Crop Treatments

Take Home...

- Be ready to make a spring herbicide application to help in crop and after harvest
- Clearfield and CoAXium wheat can help clean up challenging weed situations
- Wheat stubble is great at preventing weed emergence in crop, but lose some of that cover with harvest...be ready to move fairly quickly after harvest

Final Thoughts

- An ounce of prevention is worth a pound of cure.
- Timeliness is key to preventing these missteps.
- Make a plan and be ready to roll
- Mother nature has the last say in many of these things, but we can manage around some things

Resources

- www.ramwheatdb.com
- www.plantpath.k-state.edu
- https://www.agronomy.k-state.edu/services/soiltesting/fertilizer-recommendations/index.html
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rdwai@decaturcoop.net
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Farmers Business Network
Sarah Hill
shill@farmersbusinessnetwork.com
605-770-6257

Heartland Ag
Tyson Shelley
tysons@heartlandag.com
308-380-2462

JD Skiles Company
Justin Marintzer
justin@jdskiles.com
785-626-9338

Kansas Corn
Stacy Mayo-Martinez
smartinez@ksgrains.com
785-410-5009

Kansas Grain Sorghum
Pat Damman
pat@ksgrainsorghum.org
785-556-5177

Kansas Soybean Commission
Dennis Hupe
hupe@kansassoybeans.org
785-271-1040

Leitner Enterprises
Brad Leitner
lenterprises98@hotmail.com
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Denton Bailey
denton.bailey@lgseeds.com
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308-278-2160

Shelbourne Reynolds
Daniel Morris
daniel.morris@shelbourne.com
785-462-6299

Star Seed Inc
Devon Walter
devon@gostarseed.com
785-658-7389

SW Seeds/Sorghum Partners
Larry Heier
larryheier@swseedco.com
785-673-9491

Ward Laboratories Inc
Hannah Gaebel
hgaebel@wardlab.com
308-234-2418

Woofter Construction & Irrigation Inc
Blake Arberger
blakea@woofter.com
785-462-8653
Websites

Weather:
- Kansas Mesonet
  www.mesonet.ksu.edu
- National Weather Service-Goodland
  www.weather.gov/gld
- CoCoRahs
  www.cocorahs.org
- Drought Monitor
  www.droughtmonitor.unl.edu

K-State:
- Northwest Area Agronomy
  www.northwest.ksu.edu/agronomy
- Cover Your Acres Conference
  www.northwest.ksu.edu/coveryouracres
- K-State Research and Extension
  www.ksre.ksu.edu
- K-State Department of Agronomy
  www.agronomy.ksu.edu
- K-State Ag Economics Extension
  www.agmanager.info
- K-State Department of Entomology
  www.entomology.ksu.edu
- K-State Department of Plant Pathology
  www.plantpath.ksu.edu
- K-State Department of Bio and Ag Engineering
  www.bae.ksu.edu
- K-State Mobile Irrigation Lab
  www.mobileirrigationlab.com
- K-State Western Kansas Ag Research Centers
  www.wkarc.org

Herbicide Labels:
- Greenbook
  www.greenbook.net
- CDMS
  www.cdms.net
The plan for the day...

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<thead>
<tr>
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<th>Room 3</th>
<th>Room 4</th>
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<td>Financial Status of NW KS Farms ¹ (J. Steele)</td>
<td>Managing Insect Resistance in Corn ¹, ² (S. Zukoff)</td>
<td>Remediating eroded high pH soils with manure ¹ (M. Vigil)</td>
<td>The Importance of Adjuvants (EGE Products)</td>
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<td>The When, Where, Why, and How of Spray Adjuvants ¹, ² (R. Zollinger)</td>
<td>Palmer Amaranth Management ¹, ² (R. Currie)</td>
<td>Top 3 Mistakes Made in Wheat Production ¹ (J. Falk Jones)</td>
<td>Upside Down in Farming (Sims Fertilizer &amp; Chem)</td>
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<td>Getting Peak Performance from Paraquat ¹, ² (M. Hay)</td>
<td>Land Values and Rental Rates ¹ (M. Taylor)</td>
<td>High Plains Irrigated Soybean Management ¹ (S. Stepanovic)</td>
<td>2018 Gothenburg Research Center Update (Bayer Crop Science)</td>
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<td>Hybrids, Plant Dates, and Seeding Rates for Dryland Corn ¹ (L. Haag)</td>
<td>The When, Where, Why, and How of Spray Adjuvants ¹, ² (R. Zollinger)</td>
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<td>Land Values and Rental Rates ¹ (M. Taylor)</td>
<td>Top 3 Mistakes Made in Wheat Production ¹ (J. Falk Jones)</td>
<td>Hybrids, Plant Dates, and Seeding Rates for Dryland Corn ¹ (L. Haag)</td>
<td>Creating a Drought Resilient Farm (Green Cover Seed)</td>
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<td>Producer Panel: Canola, Field Pea, Dry Beans as Alternative Crops</td>
<td>High Plains Irrigated Soybean Management ¹ (S. Stepanovic)</td>
<td>Managing Insect Resistance in Corn ¹, ² (S. Zukoff)</td>
<td>Spray Efficacy with Particle Size and Adjuvants (Corteva Agriscience)</td>
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<td>5:00</td>
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<td>Palmer Amaranth Management ¹, ² (R. Currie)</td>
<td>Financial Status of NW KS Farms ¹ (J. Steele)</td>
<td>Combine Data to Planter Decisions (Nutrien Solutions)</td>
<td>Sunflower Industry Update (National Sunflower Assoc.)</td>
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</tbody>
</table>

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 Research & Extension personnel. Lucas Haag, K-State Northwest Area Agronomist is the conference coordinator and proceedings editor. Please send your feedback to lhaag@ksu.edu

www.facebook.com/NWKSAgronomy #CYA19

www.northwest.ksu.edu/agronomy
On-Farm Hybrid Characterization

*Developing data for VRS implementation*

Lucas A. Haag Ph.D.
Assistant Professor / Northwest Area Agronomist
K-State Northwest Research-Extension Center, Colby, Kansas

Dryland Corn Hybrids – What’s Changed

- Continual decline in ASI
  *Anthesis-Silking Interval*
- Increased resistance to barrenness
- Drought Tolerant Traits/Selection
- Improved yield potential of short and mid-season hybrids

Hybrids and VRS

- Hybrid characterization is the key to effective VRS strategies
- Our ability to create VRT seeding prescriptions has exceeded our ability to characterize hybrids
  - Rapid hybrid turnover has further complicated this
- Yield components flex differently, at different rates, for different hybrids
- Fewer companies publicizing the “ear flex” scorings of products
  - Definition of ear flex, how much, what components

2016-2018 Field Trials

- Dryland trial on-farm in Decatur County
  - 38 Hybrids
  - 5 Seeding Rates:
    - 8,100
    - 14,200
    - 17,200
    - 20,700
    - 27,000/ac
  - 4 Replications in a split-plot design
- Yield, Kernel Rows, Kernels per Row, Kernel Wt.
2018 Dryland Cropping Update

5k seed/ac difference to obtain 150 bu yield

Decatur Dryland - 2016
Optimal Seeding Rate of 36 Hybrids

2017 Optimal Seeding Rate
Decatur County Dryland
Sources of Ear Flex

- Prolificacy
- Kernel Rows, Kernels per Ear Row, Kernel Weight
- What about tillers?

Grain Yield Per Plant

- What is really important is the slope, how fast to I give up yield per plant as seeding rate goes up.

What Drives Yield at Low Seeding Rates

Effect of Ears/Plant on Per Plant Grain Yield at 8,100 plants/ac

\[ y = 3.6112x - 0.3239 \]
\[ R^2 = 0.417 \]
- 121.1 bu/ac
- 85.7 bu/ac
What Drives Yield at Low Seeding Rates

- Effect of Ears/Plant on Per Plant Grain Yield at 8,100 plants/acre
- Effect of Kernels per Plant on Per Plant Grain Yield at 8,100 plants/acre
- Effect of Kernel Rows on Per Plant Grain Yield at 8,100 plants/acre
- Effect of Kernels per Ear Row on Per Plant Grain Yield at 8,100 plants/acre

K-State Research and Extension

2018 Dryland Cropping Update

Its not just about high yield/plant, but how fast do I give it up

Yield per Plant Declines Slower

Yield per Plant Declines Faster

5k seed/ac difference to obtain 150 bu yield

Hybrid 4

Hybrid 9

Hybrid 11

Hybrid 25

Hybrid 6

Hybrid 30

Knowledge for Life
Sources of Ear Flex

- Prolificacy
- Kernel Rows, Kernels per Ear Row, Kernel Weight
- What about tillers?

- Some indication in Tribune data that tillers have a negative effect on yield (18 hybrids in trial)
- But, we know that there is an interaction between plant population and tillering, for some hybrids
- Average decline in yield was 0.3 bu/ac for every 1,000 tillers/acre
- Example @ 17,000/ac, one tiller per plant reduces yield 5.3 bu/ac

On-Farm Seeding Rate Trials

- Big enough range in seeding rates, +/- 2k isn’t likely to show a response
- Treatment areas 300’ long minimum, multiple field locations
- Can I use a highly variable field to generate a lot of characterization data?

Using Field Variability to Guide Plot Placement..... Learn More

0-3’ Soil EC
Recommendations

- Plant some small areas (planter width by 150’) to a WIDE range of seeding rates
  - Dryland 8,100 to 27,000 (maybe higher?)
  - Irrigated 12,000 to 50,000
- Be aware that non-prolific hybrids could leave yield on the table if your seeding rate is too low
  - Yield per plant is maxed out, and then we’re short of plants to match the environment
  - If yield/plant is the same from 8,100 to 14,00
    that’s a good sign were maxing out the plant

Recommendations

- Be aware that non-prolific hybrids could leave yield on the table if your seeding rate is too low
  - Yield per plant is maxed out, and then we’re short of plants to match the environment
  - If yield increases proportionally to seeding rate then your maxing out the plant
  - Example 8,100 to 16,000, if yield doubles we’re still plant limited
Questions / Comments?
northwest.ksu.edu/agronomy
lhaag@ksu.edu 785.462.6281
Twitter @LucasAHaag or www.facebook.com/NWKSAgronomy

Dryland Corn Hybrid Maturity x Planting Dates

Lucas Haag, Ph.D., K-State Northwest Research Extension Center, Colby
Alan Schlegel, Ph.D., K-State Southwest Research-Extension Center, Tribune
Alicia Boor, Cottonwood Extension District, Great Bend
Stacy Campbell, Cottonwood Extension District, Hays
Sandra Wick, Post Rock Extension District, Smith Center

Matching Hybrid Maturity and Planting Dates

• The only dryland corn planting date research in western Kansas was done in the early to mid 1990’s at Garden City
• We hear from a lot of producers (and I have experienced myself) improved yields from later planting
• Is this real? Is it a function of recent years? How does hybrid maturity play a role?

Different Planting Date Philosophies

• Defensive
  – Early Corn Early (beat the heat)
  – Shorter-season hybrids to reduce water use
  – Plant medium season hybrids late (get on the other side of the heat)
• Offensive
  – Always planting the longest season hybrid the environment can support (max yields)
What’s changed since we’ve started growing dryland corn?

- Improved cold vigor and emergence, especially important for no-till wheat stubble
- Yield competitiveness of mid and short season hybrids has improved
  - Chicken and egg: lots of focus from the companies on this maturity group in order to expand acres
- Some reduction of ear-flex in full season hybrids potentially reducing their adaptability to dryland production
- Climate variability?
- Machinery capacity – acres/row, acres/day
Predicting Probabilities of Success

- Implies that we should be planting the longest hybrid the season will support (might be true?)
- Utilize historical weather data to look at cumulative GDU’s from planting to freeze for various planting dates
- Assumes the book value GDU’s to blacklayer are correct and stable

Planting Date x Maturity Probabilities
St. Francis

Need to take a blended approach example: St. Francis vs. Atwood

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June 12 Planting Date - Across Locations

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<td>110</td>
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<td>2944</td>
<td>3060</td>
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“Without data you’re just another person with an opinion”

-W. Edwards Deming

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Objectives

- Evaluate a combination of hybrid maturities and planting dates across western and central Kansas.
- Is there an advantage to planting later?
- Do hybrids adjust when planted later?
- Collect a solid dataset for crop modeling

Materials and Methods

- Dryland corn planted no-tilled into wheat stubble (except Barton County, soybean stubble)
- Region appropriate seeding rates
  - Tribune and Colby, 17,400
  - Olmitz and Smith Center 19,500
### Materials and Methods – 2018 Planting Dates

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<th>Colby</th>
<th>Barton Co.</th>
<th>Smith Center</th>
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### Materials and Method - Hybrids

- Utilize multiple, genetically independent hybrids to represent each maturity class

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<th>GDU_Pollen</th>
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### GDU’s to Emergence - Tribune

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<th>Min</th>
<th>Average</th>
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<td>5/17</td>
<td>226</td>
<td>226</td>
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<td>5/31</td>
<td>188</td>
<td>165</td>
<td>172</td>
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<tr>
<td>6/14</td>
<td>406</td>
<td>207</td>
<td>260</td>
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Most guides will tell you 90 to 120 or 100 to 120 GDU.

### Planting Date affects on Phenology

<p>| Corn Hybrid x Date of Planting Study, Silking Dates, Tribune, Kansas. 2018 - PRELIMINARY DATA |
|-------------------------------------------------|---------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|</p>
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<th>Planted 5/17 Silking Date</th>
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<td>7/15 1386</td>
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<td>101</td>
<td>7/13 1357</td>
<td>7/14 1302</td>
<td>7/23 1309</td>
<td>8/2 1291</td>
<td>8/11 1111</td>
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<td>107</td>
<td>7/14 1396</td>
<td>7/16 1355</td>
<td>7/24 1333</td>
<td>8/3 1314</td>
<td>8/14 1151</td>
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<tr>
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<td>116</td>
<td>7/18 1461</td>
<td>7/19 1434</td>
<td>7/26 1377</td>
<td>8/4 1332</td>
<td>8/15 1209</td>
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<td>7/13 1331</td>
<td>7/15 1316</td>
<td>7/23 1291</td>
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<tr>
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<td>7/17 1367</td>
<td>7/25 1344</td>
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<td>7/28 1631</td>
<td>7/30 1453</td>
<td>8/6 1389</td>
<td>8/14 1291</td>
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Planting Date affects on Phenology

Planted 5/15/2018 Silking Silking GDU
Planted 5/21/2018 Silking Silking GDU
Planted 6/1/2018 Silking Silking GDU
Planted 6/16/2018

<table>
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<tr>
<th>Company</th>
<th>Hybrid</th>
<th>CRM</th>
<th>5/15 to 6/15 Reduction in GDU to Silk</th>
<th>Great Bend</th>
<th>Difference</th>
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<td>Monsanto/DeKalb</td>
<td>DKC51-20DGVT2PRIB</td>
<td>101</td>
<td>105</td>
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<td>97</td>
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<tr>
<td>Monsanto/DeKalb</td>
<td>DKC57-99RIB</td>
<td>107</td>
<td>128</td>
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<tr>
<td>Monsanto/Channel</td>
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<td>112</td>
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<td>P9998AMX</td>
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<tr>
<td>Dupont/Pioneer</td>
<td>P1751AM</td>
<td>117</td>
<td>151</td>
<td>133</td>
<td>18</td>
</tr>
</tbody>
</table>

Planted 6/16/2018

Hybrids did some adjustments due to planting date, BUT....

Also note, this was an adjustment to silking date.
We do not yet know the affects of delayed planting on reaching blacklayer
Moving Forward

• Continue searching for funding opportunities so that we can collect more data

• Field trials will not provide us the answer we need

• A given combination isn’t always going to be the right answer

Moving Forward

• A given combination isn’t always going to be the right answer

• The real question is:

What hybrid x maturity combination minimizes risk and maximizes profits over the long-term?

• Finding max yield an any individual year doesn't answer that

• Crop modeling is how we will get to that answer
Thanks for your support

Partially Funded By:

Cover Your Acres
Winter Conference

Seed Provided By:

Questions / Comments?
northwest.ksu.edu/agronomy
lhaag@ksu.edu 785.462.6281
Twitter @LucasAHaag or www.facebook.com/NWKSAGronomy
Cropping Systems Research

Alan Schlegel and Lucas Haag
Southwest Research-Extension Center – Tribune, Kansas

Annual Precipitation, Tribune, KS

Normal is 17.90”

Long-term (1913 - 2018) Annual Precipitation - 16.94 in

Large-Scale Cropping Systems
Current Rotations

- Wheat-Fallow (WF), reduced tillage.
- Wheat-Sorghum-Fallow (WSF).
- Wheat-Sorghum-Corn-Fallow (WSCF).
- Wheat-Corn-Fallow (WCF).
- Wheat-Corn-Sorghum-Fallow (WCSF).
- Continuous Sorghum (SS).

Wheat Yields from Cropping Systems

Average Wheat Yields, 2008-2018

Sorghum Yields from Cropping Systems

TAM 113 winterkilled in 2015, wheat streak mosaic in 2017
Summary

- Wheat yields similar in 2-, 3-, and 4-yr rotations.
- Corn and sorghum yields about 50% greater following wheat than row crop.
- Sorghum yields about 40% greater than corn yields in similar rotations.
- No rotation better than WSF.

Objectives

Determine effect of long-term tillage practices in a wheat-sorghum-fallow rotation

Site characteristics

- Richfield silt loam soil
- Level (<1% slope)
- Annual precipitation - 18 inches
WSF rotation

- Conventional tillage
- Reduced tillage
- No-till

Weed control during fallow

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Chemical</th>
<th># of operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>4-5</td>
<td>0</td>
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<tr>
<td>RT</td>
<td>2-3</td>
<td>2</td>
</tr>
<tr>
<td>NT</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

1991-2000

Average Wheat Yield

<table>
<thead>
<tr>
<th>Year</th>
<th>CT</th>
<th>RT</th>
<th>NT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-1995</td>
<td>45</td>
<td>50</td>
<td>60</td>
</tr>
<tr>
<td>1996-2000</td>
<td>50</td>
<td>55</td>
<td>65</td>
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</tbody>
</table>

Average Sorghum Yield

<table>
<thead>
<tr>
<th>Year</th>
<th>CT</th>
<th>RT</th>
<th>NT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991-1995</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>1996-2000</td>
<td>30</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>
### Weed control during fallow

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>4-5</td>
</tr>
<tr>
<td>RT</td>
<td>4-5 (W)</td>
</tr>
<tr>
<td>NT</td>
<td>0</td>
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</tbody>
</table>

2001 thru current

---

### Soil Water at Wheat Planting

**WSF, Tribune, 2001-2018**

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Profile water, inch</th>
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<tbody>
<tr>
<td>CT</td>
<td>b</td>
</tr>
<tr>
<td>RT</td>
<td>a</td>
</tr>
<tr>
<td>NT</td>
<td>a</td>
</tr>
</tbody>
</table>

*Knowledge for Life*
Summary
(2001-2018)

Grain yield:
- wheat: NT ~35% greater than CT
  ~20% greater than RT
- sorghum: NT ~150% greater than CT
  ~60% greater than RT

```
CONVENTIONAL TILLAGE
Y = -19.9 + 3.24X
n = 75    r² = 0.651    RMSE = 8.84    P<0.0001

WINTER WHEAT GRAIN (bu/acre)
```

```
NO TILLAGE
Y = -56.4 + 5.20X
n = 64    r² = 0.831    RMSE = 8.79    P<0.0001

WATER SUPPLY: ASW + PRECIP. (in.)
```

```
CONVENTIONAL TILLAGE
Y = -20.9 + 5.22X
n = 59    r² = 0.409    RMSE = 22.11    P<0.0001

SORGHUM GRAIN (bu/acre)
```

```
NO TILLAGE
Y = -46.0 + 7.45X
n = 28    r² = 0.834    RMSE = 14.94    P<0.0001

WATER SUPPLY: ASW + PRECIP. (in.)
```
The move toward less tillage...

- Some intended goals
  - Conserve soil moisture, improve soil health
  - Higher yields
  - Fewer tillage passes through the field

- But...
  - Do higher yields offset the higher chemical costs in reduced till / no-till systems?
  - Growing herbicide resistance in some weeds

Notes on input costs

- Use custom rates to estimate machinery costs

- Include cost of preceding fallow period with cost of crop production

- Economic comparison of systems
  - Do higher yields pay for higher chemical costs?
**Fertilizer use**

- **Nitrogen**
  - NH3 used when using tillage
  - UAN-28 liquid applied in no-till regime
  - Wheat: 2 lbs N for each bushel of average yield
  - Sorghum: 1.2 lbs N for each bushel of average yield

- **Phosphate**
  - MAP (11-52-0) for wheat, 26 lbs P per acre
  - APP (11-34-0) for sorghum, 27 lbs P per acre

**WHEAT: chemical use**

- **NO-TILL system**
  - Fallow period prior to wheat
    - Scoparia, 3 oz/a
    - Dicamba, 16 oz/a
    - Metribuzin, 8 oz/a
    - Paraquat, 48 oz/a
    - 2,4-D, 16 oz/a

- **CONVENTIONAL system:**
  - Retains only those herbicides used on wheat crop

- **REDUCED system:**
  - Fallow after sorghum: use tillage
  - Same herbicides for wheat crop

**SORGHUM: chemical use**

- **NO-TILL system**
  - Fallow period prior to sorghum
    - Glyphosate, 32 oz/a
    - 2,4-D, 32 oz/a
    - Atrazine, 0.25 lb/a
    - Paraquat, 48 oz/a
    - Metribuzin, 8 oz/a

- **CONVENTIONAL system:**
  - Retains only those herbicides used on sorghum crop

- **REDUCED system:**
  - Fallow after wheat: use no-till
  - Same herbicides for sorghum crop

**Wheat costs using 2018 input prices**

<table>
<thead>
<tr>
<th></th>
<th>NT</th>
<th>NT</th>
<th>CT</th>
<th>NT</th>
<th>NT</th>
<th>CT</th>
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<td></td>
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</tbody>
</table>

* Input costs do not include harvest costs, which vary with yield.
## Sorghum costs using 2018 input prices

<table>
<thead>
<tr>
<th>Item</th>
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<th>Conventional</th>
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<tr>
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<td>UAN</td>
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<td>0.12</td>
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<tr>
<td>NH₃</td>
<td>0.24</td>
<td>0.24</td>
<td>0.24</td>
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<tr>
<td>APP</td>
<td>0.22</td>
<td>0.22</td>
<td>0.22</td>
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<td>Actual N, P</td>
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<tr>
<td>Herbicide</td>
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<tr>
<td>Glyphosate</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>2,4-D</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
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<td>Paraquat</td>
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<td>0.23</td>
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<td>3.00</td>
<td>3.00</td>
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<td>0.47</td>
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<td>Dry/liquid</td>
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<tr>
<td>Total</td>
<td>210.51</td>
<td>196.55</td>
<td>164.50</td>
</tr>
</tbody>
</table>

* Input costs do not include harvest costs, which vary with yield.

## Cost comparison: wheat

<table>
<thead>
<tr>
<th>Item</th>
<th>No-Till</th>
<th>Reduced</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>10.00</td>
<td>10.00</td>
<td>10.00</td>
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<tr>
<td>Fertilizer</td>
<td>30.89</td>
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<td>21.53</td>
</tr>
<tr>
<td>Herbicide</td>
<td>78.91</td>
<td>1.99</td>
<td>1.99</td>
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<tr>
<td>Field operations</td>
<td>52.50</td>
<td>78.00</td>
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<tr>
<td>TOTAL</td>
<td>172.30</td>
<td>112.71</td>
<td>111.51</td>
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</table>

* Input costs do not include harvest costs, which vary with yield.

## Cost comparison: Sorghum

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<th>No-Till</th>
<th>Reduced</th>
<th>Conventional</th>
</tr>
</thead>
<tbody>
<tr>
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<td>8.40</td>
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<tr>
<td>TOTAL</td>
<td>210.51</td>
<td>196.55</td>
<td>164.50</td>
</tr>
</tbody>
</table>

* Input costs do not include harvest costs, which vary with yield.

## Wheat net returns

![Wheat net returns chart](chart.png)

**AVERAGE RETURNS**

- No Till: $-24.95/a
- Reduced: $-12.08/a
- Conventional: $-50.56/a

* Chart shows dryland outcomes for 3 tillage methods, 2001-2017.*
**Sorghum net returns**

Dryland outcomes for 3 tillage methods, 2001-2017

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional</th>
<th>Reduced</th>
<th>No Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>-$69.27/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>-$45.02/a</td>
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</tr>
<tr>
<td>2003</td>
<td>$25.16/a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Net returns over entire W-S-F rotation**

Dryland outcomes for 3 tillage methods, 2001-2017

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional</th>
<th>Reduced</th>
<th>No Till</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>-$94.24/a</td>
<td></td>
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<tr>
<td>2002</td>
<td>-$57.09/a</td>
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</tr>
<tr>
<td>2003</td>
<td>-$25.40/a</td>
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</tbody>
</table>

**Sensitivity to crop prices?**

- Drop crop prices to loan rates?
  - Wheat: $2.94/bu
  - Grain sorghum: $1.95/bu
  - RT had highest return: higher yields than CT, lower costs than NT

- Once grain sorghum prices reach $2.35/bu, NT dominates, regardless of wheat price

**SUMMARY**

- WHEAT: small yield advantage with no-till
- SORGHUM: huge yield advantage to no-till

- Entire W-S-F rotation:
  - **NO-TILL**: yield advantage to no-till sorghum more than offset no-till cost disadvantage for wheat
  - **REDUCED TILL**: better sorghum yields than conventional, but still far below no-till
  - **LOW PRICES**: prices at loan rate favor RT, but grain sorghum prices above $2.35 favored NT
Occasional tillage in a WSF rotation

Materials and Methods

- One tillage (sweep plow) every 3-yr
  - May/June in fallow or
  - July after wheat harvest

- Continuous no-till
Wheat Yields - Tribune

Grain Yield, bu/a

May fallow
July wheat stubble
No-till

ns ns

Profile available soil water at sorghum planting

Profile water, inch

May in fallow July after wheat harvest No-till


Sorghum Planting

Tillage
- May in fallow
- July after wheat harvest
- No-till

Depth, ft

Available water, inch

Sorghum Yields - Tribune

Grain Yield, bu/a

May fallow
July wheat stubble
No-till

ns ns

Occasional Tillage, Tribune, 5-yr average

<table>
<thead>
<tr>
<th>Tillage</th>
<th>May in fallow</th>
<th>July in wheat stubble</th>
<th>No-till</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
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<tr>
<td>Sorghum</td>
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</table>

Wheat Yields - Garden City

<table>
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<tr>
<th>Year</th>
<th>May fallow</th>
<th>July wheat stubble</th>
<th>No-till</th>
</tr>
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<tbody>
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<tr>
<td>Mean</td>
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Sorghum Yields - Garden City

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</tbody>
</table>

Conclusions

• A single tillage (sweep plow) every 3-yr seems to have little effect on grain yield in a wheat-sorghum-fallow rotation.
“The three-year rotation, consisting of first year, sorghum; second year, summer fallow; third year, winter wheat is especially recommended for this region as it is very practicable”.

C.E. Cassell, 1912