Cover Your Acres

Winter Conference

January 14 & 15, 2020

Gateway Civic Center
Oberlin, KS

K·STATE
Research and Extension

2020 Proceedings, Vol. 17

Table of Contents

To provide a positive experience for presenters and attendees, please silence your wireless device.

Session Summaries

Alternative Crops: We will take a look at alternative crops: field peas, industrial hemp, canola, spring wheat, dry edible beans, and more. We'll discuss what we know, don't know, and should be thinking about.

Beyond Grain: The Value Wheat in the Production Chain:
The continued decline of wheat acres in Kansas has many asking "Does wheat have a future". This session will examine the challenges and opportunities ahead of wheat and how value in the production chain will evolve in the future.

Cover Crops as a Weed Management Tool: As weed management with herbicides becomes more difficult many producers are asking about the role cover crops could play. This session will cover the potential opportunities and the lessons learned from research projects located across Kansas.

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.

Insect Management in Dryland Corn: Increasing acres of continuous dryland corn may require changes in insect management, often a new practice in dryland production. This session will cover performance of Bt trait technologies and how to chose a trait technology. Additionally, economic thresholds for spider mites in dryland corn will be discussed due to increased pressure in recent seasons.

Planter Technology: A look at various planter technologies on the market and results from on-farm experiments with downforce technologies and how they can influence seed placement and emergence.

War on Weeds: Control of troublesome weeds like Palmer amaranth and tumble windmill grass will be discussed. The optimal time in a rotation to control as well as the use of overlapping residuals will be discussed.

What drives efficiency and profitability in irrigated corn?: The TAPS program is a competition amongst teams of growers to strive for maximum input efficiency and profitability. What lessons have been learned in the past 3 years?

Why Does a Food Company Care About Soil?: General Mills committed to advancing regenerative agriculture on 1 million acres through working with producers. The why and how of that process will be discussed.

Soil Testing—Interpretations Matter: While many are familiar with using soil tests for N and P, how do you read the rest of your test and what does it mean? This session will also present new findings on the value of various "soil-health" soil test methods.

Proceedings from prior years of the Cover Your Acres
Winter Conference can be found online:
www.northwest.ksu.edu/coveryouracres

Presenters

Luke Chism- Luke is from Beloit, Kansas. He graduated from Fort Hays State University with a bachelor's degree in Agronomy in 2017. He is currently pursuing a master's degree in Agronomy-Weed Science at Kansas State University. Luke's research focuses on utilizing cover crops for weed control in corn and soybean systems. His specific areas of study include determining weed control efficacy provided by cover crops in comparison with a residual herbicide, as well as identifying the optimal cover crop termination timing to both suppress weeds and maximize yields. Luke will graduate from KSU in May 2020 and plans to work as an agronomist in Kansas, supporting farmers by waging the war on weeds.

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 5^{th} 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.

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 intensification of dryland cropping systems.

Aaron Harries- Aaron Harries has been with Kansas Wheat since July 2006. Prior to joining Kansas Wheat he was employed by the Kansas Grain and Feed Association in Topeka for 10 years. While at KGFA, he also had responsibilities with the Kansas Agribusiness Retailers Association, the Kansas Certified Crop Adviser Program and the Kansas Association of Ethanol Processors. Harries was raised on a diversified crop and dairy farm in Marshall County in Northeast Kansas. He graduated with a degree in agriculture communications from Kansas State University.

Malynda O'Day- Malynda O'Day grew up working with local farmers in northwest Missouri, which gave her a passion for agriculture and serving farmers at an early age. From there, she attended the University of Missouri where she completed her Bachelor of Science degree in Plant Science in 2018. Upon graduation, Malynda joined the Agronomy department at Kansas State where she is pursuing a Master's degree in Weed Science. Her research focuses on using cover crops to suppress weeds and manage nutrients in corn, with a primary goal of creating better integrated management techniques for farmers.

Steve Rosenzweig- Steve is a Soil Scientist at General Mills, where he researches the effects of regenerative agriculture on soil health, biodiversity, and farm profitability, and leads programs within General Mills' sourcing regions to enable farmers to implement regenerative management systems. Steve started at General Mills in 2017 after receiving his PhD in Soil and Crop Sciences from Colorado State University, where he researched the effects of dryland crop rotations on soil health and farmer profitability in no-till systems. He also applied social science to understand the social and psychological factors influencing dryland cropping system management, and used satellite imagery to map changes in agricultural practices on the landscape scale.

Presenters

Daran Rudnik- Daran Rudnick is an assistant professor of Biological Systems Engineering at the University of Nebraska-Lincoln, specializing in irrigation/water management. His appointment consists of developing and conducting relevant and responsive irrigation/water management research and extension programs for crops grown in the Central High Plains. His specific research interests include: full and limited irrigation management, precision water management, fertigation, concurrent management of irrigation and nitrogen fertilizer, economic feasibility of irrigation practices, and plant and soil water monitoring technologies. Daran has an active extension program that engages growers, industry, regulatory agencies, and university personnel. Most notably, he co-developed the University of Nebraska-Lincoln Testing Ag Performance Solutions (TAPS) program that engages a diverse group of stakeholders around efficient and profitable crop production.

Dorivar Ruiz-Diaz– Dr. Dorivar Ruiz Diaz is a soil fertility and nutrient management specialist at Kansas State University. He holds a Ph.D. in soil fertility from Iowa State University and MS in soil fertility from the University of Illinois at Urbana-Champaign. He does research and extension work on the efficient use of fertilizers, phosphorus and micronutrient management, and land application of by-products with an emphasis on crop–available nitrogen.

Ajay Sharda– Dr. Ajay Sharda is an Associate Professor in the department of Biological and Agricultural engineering at Kansas State University. He received his Ph.D. in Biosystems engineering from Auburn University. At K-State, Ajay research focuses on the development and evaluation of control systems for large agricultural equipment including planting, and spray systems; developing autonomous system for intelligent sense and spray; and developing sUAS sensing system for spatial crop health monitoring. His extension efforts have been devoted to ways precision ag technology can help improve in-season decisions on input management for sustainable food production.

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.

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.

The Gateway Oberlin, Kansas

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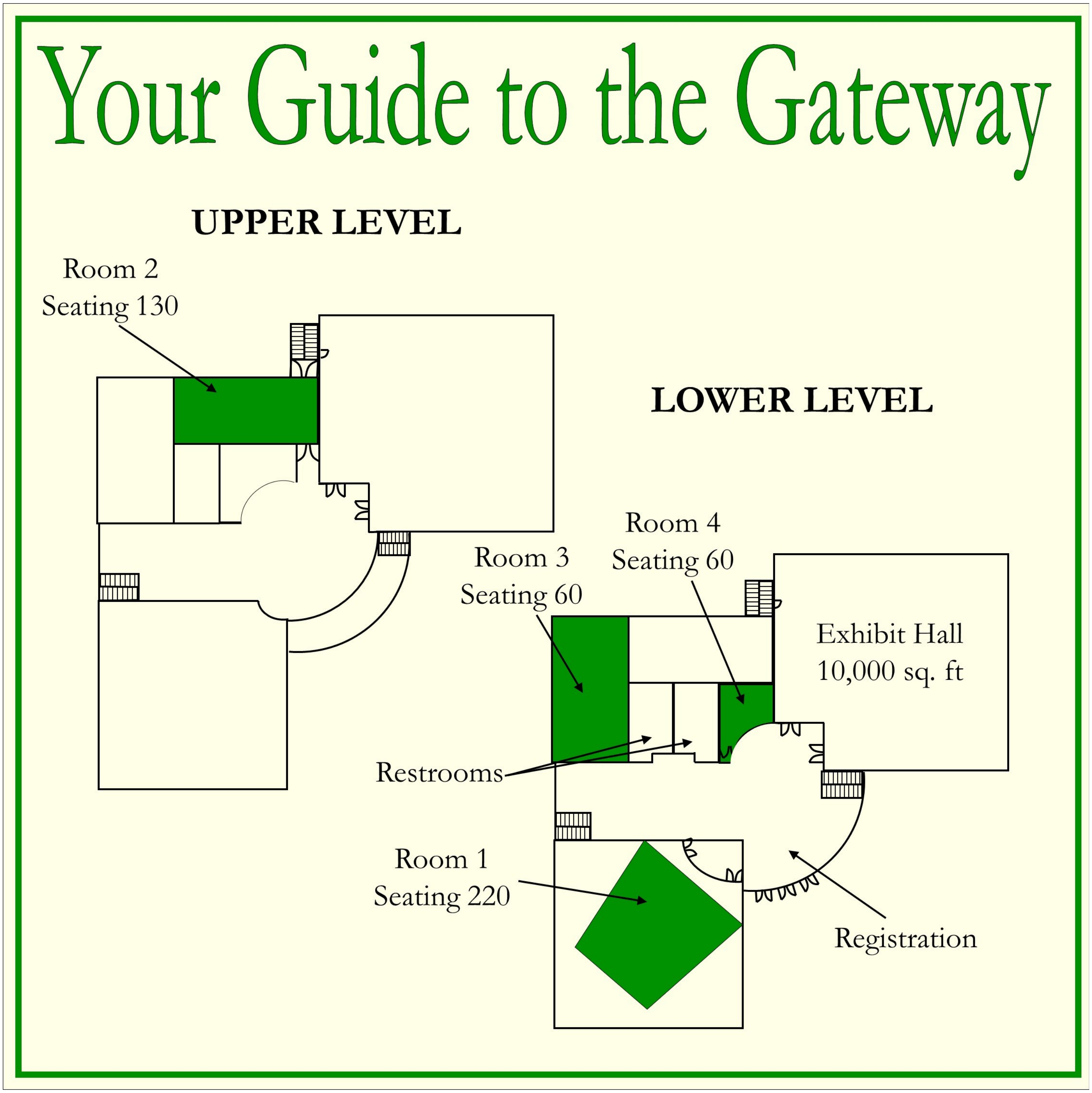

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Alternative Crops
What we know, don't know, and should probably think about

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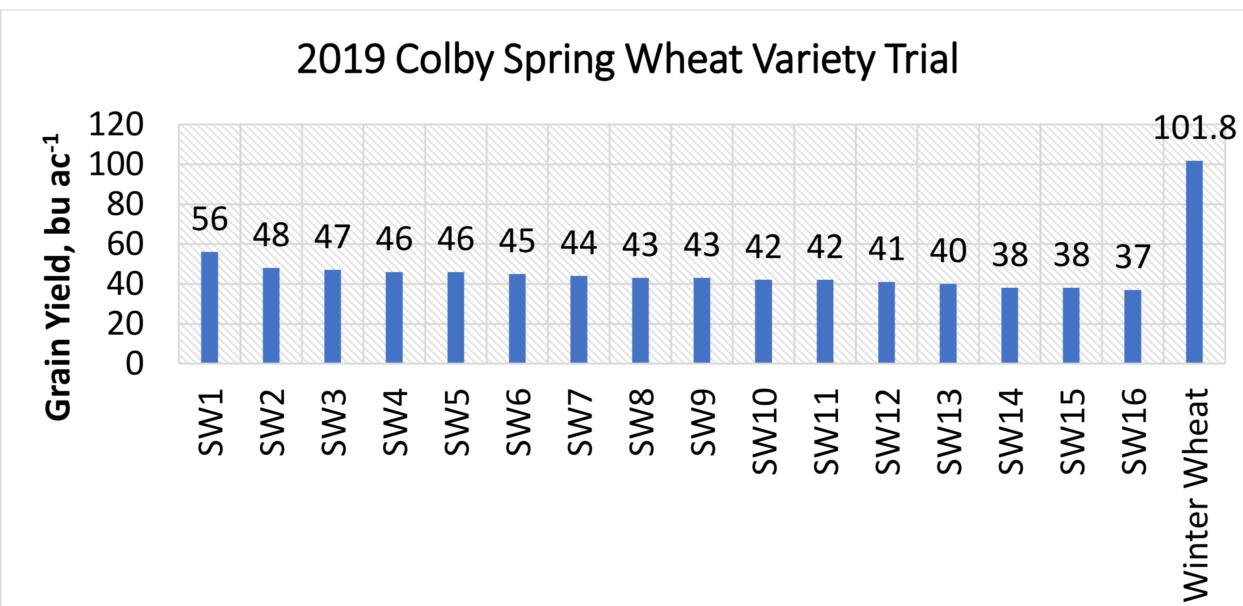
Spring Wheat

Spring wheat has been evaluated several times at the Northwest Research-Extension Center in Colby. It was evaluated continuously from 1915 through 1950. In the 1970's, early 2000's, and again starting in 2018. In the 1915-1950 study spring wheat yield averaged less than half of winter wheat. The highest spring wheat yield was 2 bu/ac less than the lowest winter wheat yield over the same time period. From 2001 through 2005, spring wheat was dormant seeded in December. Over that time period spring wheat yields averaged 49% of winter wheat with a range of 28 to 56%. In 2019, the average spring wheat yield was 43% of winter wheat, while the top spring wheat variety evaluated was 55% of winter wheat.

Colby Kanas Spring Wheat and Winter Wheat, 2001-2005

Year	Winter Wheat Mean of Top LSD Group	Spring Wheat Mean
	-- Grain Yield, bu ac^{-1} --	
2001	82.1	46.0
2002	43.2	12.1
2003	78.7	42.4
2004	60.1	30.3
2005	78.2	37.5
Average	68.5	33.7

R. Aiken, 2008. unpublished data.



Why Spring Wheat? – Spring wheat could work as a fallow replacement option for seeding into fresh row-crop stalks. There may be some limited direct marketing opportunities for marketing spring wheat due to a freight advantage over the Northern Great Plains where most spring wheat is grown.
What's the Catch? – Spring is likely to yield approximately 50% of winter wheat yields. The biggest unknown is if adequate quality can be maintained so that the spring wheat is a marketable product. An adequate supply of nitrogen and sulfur, and the level of heat stress received during grain fill are going to be key factors in final grain quality. Samples from the 2019 spring wheat variety trials are currently undergoing protein and mill and bake testing. The variety trial will be conducted again in 2020.

Production Practices – Little data exists to support production practice recommendations in the Central High Plains, however several key things should be kept in mind.

> **Seeding Rate –** Spring planted, spring wheat, has a much shorter opportunity for the initiation of tillers. In our environment, where heat stress is likely to be a terminating stress, late formed tillers are likely to be insignificant in grain production and what grain they do produce is likely to be low quality. In our testing we are current utilizing a seeding rate of 1.3 million seeds/ac.
> **Planting Date –** As with any spring sown crop, heat stress at flowering and grain fill is likely to be our most yield limiting factor. We anticipate starting planting date studies in 2020. In the meantime, a reasonable recommendation is to seed as soon as practical in last week of February and into March. Previous work at Colby in the early 2000's showed that even dormant seeding in December can be successful in obtaining productive stands.

Field Peas

K-State Research has been ongoing on spring field pea production since 2009 and winter pea production since 2018. They have been shown to be a viable fallow replacement option. Ongoing research in my program involves both spring pea and winter pea. Additional details will be included in a packet handout at the talk, and can also be found at www.northwest.ksu.edu/agronomy.

	2014		2015		2016		2017		2018		2019		
Location	**Entries**	**Top Group Avg. Yield**	**Entries**	**Top Group Avg. Yield**	**Entries**	**Top Group Avg. Yield**	**Entries**	**Top Group Avg. Yield**	**Entries**	**Top Group Avg. Yield**	**Entries**	**Top Group Avg. Yield**	**Top Group Across Years**
Rawlins	6	49.2	17	40.9	18	31.4	18	29.7	20	39.5	8	19.9	35.1
Thomas	6	28.2	18	30.6	22	33.8	20	39.3	30	26.5	30	48.7	34.5
Decatur	0	-	9	47.5	18	31.7	18	-	20	34.9	17	36.1	37.6
Gove	-	-	-	-	14	27.9	18	29.6	12	23.1	9	52.3	33.2
Scott	4	4.6	-	-	-	-	-	-	-	-	-	-	4.6
Sherman IRR	-	-	11	55.2	-	-	-	-	-	-	-	-	55.2
Rooks	-	-	-	-	-	-	-	-	-	-	8	31.1	31.1
Republic	-	-	-	-	-	-	-	-	-	-	25	12.9	12.9

Dry Beans

Dry edible beans have been successfully grown in the region for a number of years. The biggest change that potentially opens up dry beans as an alternative crop has been the shift from traditional vine type beans to more upright bush type beans. These upright plant types can be direct harvested with a flex or draper head without the additional steps of knifing and windrowing. Beginning with the 2019 season, we undertook a new study looking a collecting data to fine tune recommendations for these new bush type varieties. Preliminary data shows a great deal of flexibility exists in terms of row spacing (7.5" and 30", varieties, and seeding rates, with only minor differences amongst the treatments).

Dry beans are traditionally grown on irrigated land, however with the introduction of bush type beans some producers have experienced success with dryland production as well. Starting with a good level of profile soil moisture will be important to success. Additionally, the producer should be conscious of current levels of residue cover as well as establishment of the subsequent crop due to dry beans producing low levels of lasting crop residue.

A good resource with production information is the Dry Bean Pest Management and Production book. This guide is a joint publication of University of Nebraska-Lincoln, University of Wyoming, and Colorado State University and is available through Extension.

Canola

Canola is a winter broadleaf cash crop in the brassica family. When grown in rotation with wheat it presents a unique opportunity to clean up annual weeds and disease pressure. Around 80% of the US consumption is imported, so market demand exists for domestic production. Both open pollinated and hybrid varieties of canola exist.

Winter Canola

Winter canola has been grown with some success in Northwest Kansas. Advantages include a ready and established market with processing facilities located within the region (ADM Northern Sun, Goodland).

Largest Challenges for Growing Canola in Northwest Kansas

1. Stand Establishment and Overwintering
    a. Herbicide carryover – Sensitivity to many residual herbicide products
    b. Crop Residue – Need to move residue away from the seed furrow so that the crown can develop at the soil surface. Elevated crowns are susceptible to winter kill
    c. Proper growth going into fall:
        i. For maximum survival: 6-8 true leaves before freezeup, 6-18 inches of growth
        ii. Planting too late leads to little growth and poor survival
        iii. Planting too early leads to too much growth and poor survival

1. Production Practices
    a. Several step improvements in winter hardiness of varieties in the past few years
    b. Row Spacing: Can be grown in a wide range of spacings: 7.5" up to 30"
    c. Planting Date: September 10th-15th

Spring Canola

Spring canola has been looked at experimentally at the Northwest Research-Extension Center at Colby for a number of years. Heat stress at flowering is the dominant yield limiting factor which results in reduced grain yields and oil content and quality. In general, the production of spring canola is not advisable.

Winter Canola Seeding Rate Recommendations

Open Pollinated – 90,000 to 150,000 seeds/lb			
Row Width	**Seed Size**	**lb/acre**	**seeds/acre**
7.5-in to 15-in	115,000 seeds/lb	2.0 to 4.0	230,000 to 460,000
20-in to 30-in	115,000 seeds/lb	1.0 to 2.5	115,000 to 287,500

Hybrid – 80,000 to 110,000 seeds/lb			
Row Width	**Seed Size**	**lb/acre**	**seeds/acre**
7.5-in to 15-in	90,000 seeds/lb	2.0 to 4.0	180,000 to 360,000
20-in to 30-in	90,000 seeds/lb	1.0 to 2.5	90,000 to 225,000

Seed Cost			
Type	**$/unit**	**$/lb (unit)**	**$/acre (3.5 lb rate)**
Conventional OP	$200	$4.00	$14.00
RR OP	$295	$5.90	$20.65
Hybrid**	$496	$14.17	$49.59

** 35 lb bags for hybrid seed. Priced at $15.76 per 100,000 pure live seeds.

Spring Canola, Brassica napus, Camelina, and Brassica juncea yields at Colby, Kansas, 2003-2006.

Spring Oilseed Variety Trials

Northwest Research-Extension Center, Colby, KS
(lb/acre)

	Year			
Variety	2003	2004	2005	2006
Hyola 401 (check)	978	868	1,204	91
High Yield B. napus	1,294	908	1,204	325
Low Yield B. napus	431	137	183	28
Camelina	1,370	289	1,034	93
B. juncea	1,171	417	607	---

- Limited by available water, stand establishment, and heat at reproductive stage

Kansas State University

Industrial Hemp

2019 was the first year that industrial hemp was legal to grow in Kansas. There are three different target markets for industrial hemp: fiber, grain, and cannabinoids (CBD). It's important to understand the market you are targeting as the production practices vary greatly. Production information is very limited. Following are some considerations in response to problems experienced in 2019.

1. Seed quality – Hemp seed is easily damaged by handling, resulting in decreased germination and increased seedling mortality. Further compounding this situation is that hemp seed as a dormancy requirement which can make lab sampling for germination challenging. While lab procedures are standardized for germination testing, a seed pretreatment procedure has not been standardized and is an active discussion item.
2. No approved herbicides or insecticides – There are currently no herbicides or insecticides labeled for hemp production. It is critical that producers start with a clean seedbed. There may very well be an opportunity for a fall planted, high residue cover crop such as rye or winter triticale to be planted, then terminated at or prior to hemp planting. This residue may help keep weeds suppressed. In 2019, in plots with acceptable stands, once the hemp reached 10-12 inches in height, it was quite competitive with palmer amaranth, our most troublesome weed.
3. Stand establishment – Based on our 2019 experience, stand establishment is going to be a formidable challenge. The seedings have relatively low vigor compared to most adapted crops to the region. Seed must be placed shallow and crusting of the soil avoided. The ability to moisten the soil and surface crust makes irrigation high desirable. Attempting to establish hemp from planted seed under dryland conditions is a much higher risk practice.
4. Marketing – Producers should do extensive due diligence regarding potential contracts, business partners, and purchasers of their production.

Management practices have not been well defined for industrial hemp, but our current "best guesses" for the Central High Plains include:

Planting Date:	mid-May (> 50* F soil temperature)
Row Spacing:	7.5" – 10" rows for fiber or grain production A primary purpose of narrow rows is to assist in weed suppression, and in the case of fiber production, keep stalks thinner
Seeding Rate:	around 600,000 PLS/acre for grain or dual purpose Around 1.2 million PLS/acre for fiber
Fertility:	Fertilize as you would for a corn crop in that field. If producing for grain or CBD, sulfur is likely to be important for oil synthesis

Overall considerations before growing an alternative crop:

1. Agronomic Considerations
   a. Is my herbicide history a potential problem?
   b. Do I have the necessary equipment to plant and harvest in a timely manner?
   c. Do I understand the potential weed/insect/disease issues with this new crop?
2. Economic Considerations
   a. Have I identified a market for this crop?
   b. Do I have the ability to store it if need be?
   c. Will delayed marketing of an alternative crop cause me cash flow issues?
   d. If the crop does not meet market standards, have I identified a backup use (e.g. can I feed it to livestock?)
   e. Can I take on the risk in growing a crop with little or no crop insurance program?

Beyond Grain: The Value of Wheat in the Production Chain

Aaron Harries, Kansas Wheat
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Presentation Outline

Global wheat market snapshot

- Export countries 20 years ago vs. today
- Top and emerging markets for U.S. wheat

Kansas wheat trends

- Planted acres
- Yield trends
- Protein trends

Value Beyond the Kernel

- Value of straw
  - Harvested/Bailed
  - Returned nutrients to soil (not bailed)
  - Moisture conservation by residue
    - Yield gain in row crops
    - Value of no fallow in rotation
  - Weed control
- Value of cattle grazing/gain
- Breaking the disease and insect cycle
- Soil Health, Erosion Control
- Double cropping after wheat
- Wildlife habitat

New frontier of wheat research

- The genetic complexity of wheat
  - Map of wheat genome
- New wheat research tools
  - Gene editing
  - Predictive genomics
  - Agronomics for quality
  - Doubled haploids
  - Trait targets

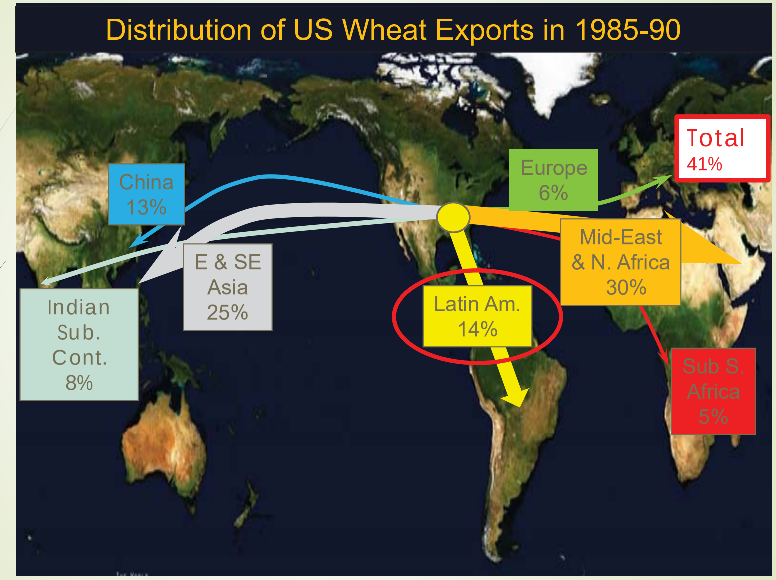
Fields Forward Campaign

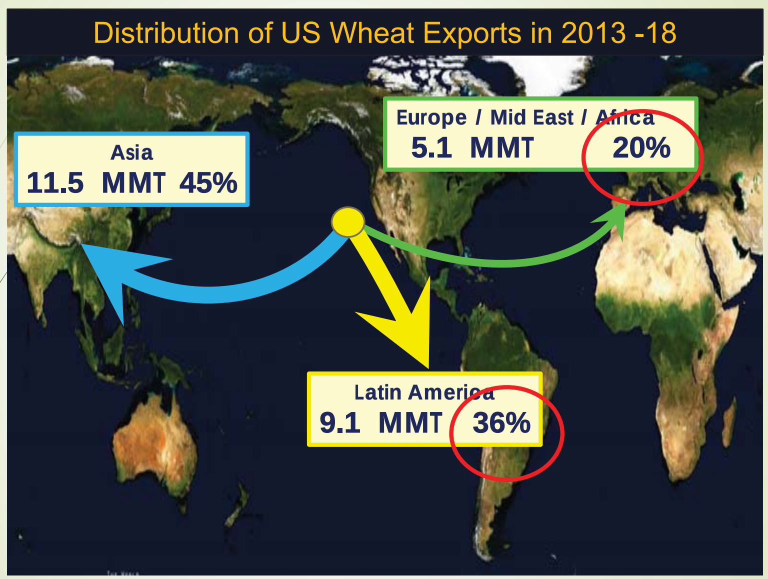
Questions

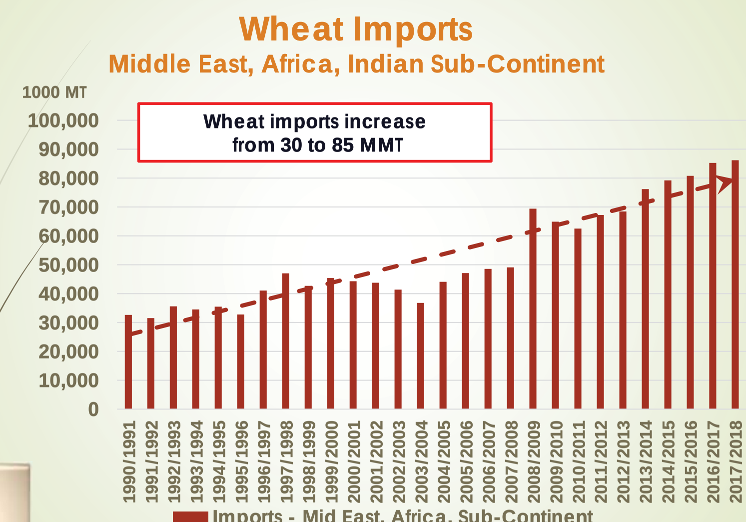
Beyond Grain: The Value of Wheat in the Entire Production Chain

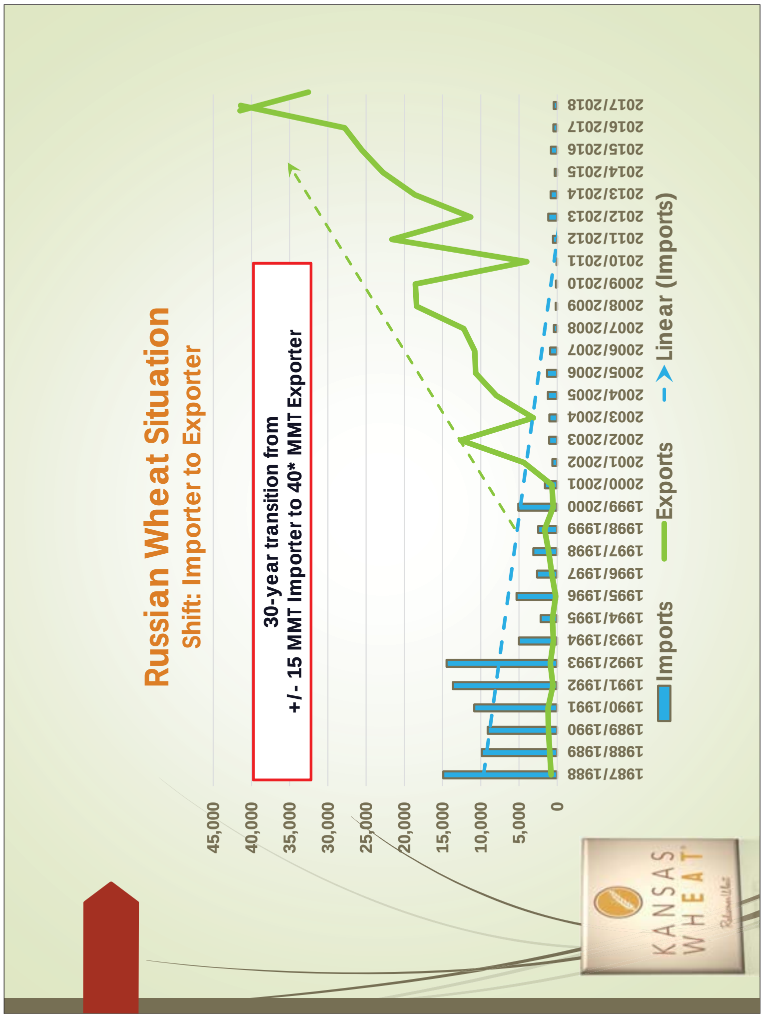
Supplemental Slides – World Market Situation

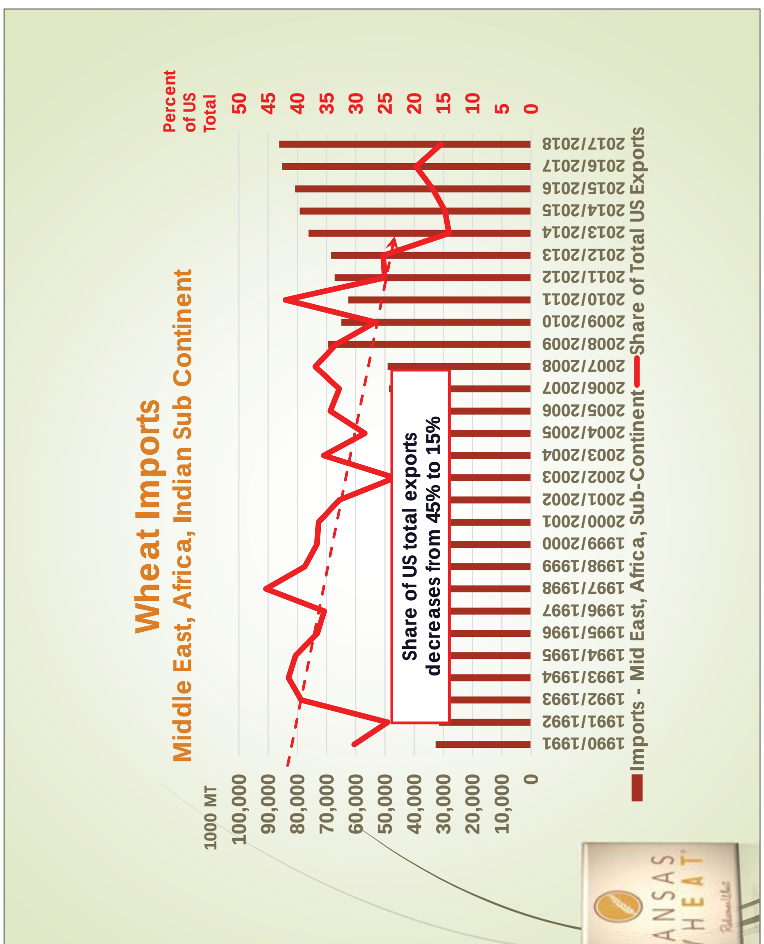
2020 Cover Your Acres Conference
Aaron Harries, Kansas Wheat







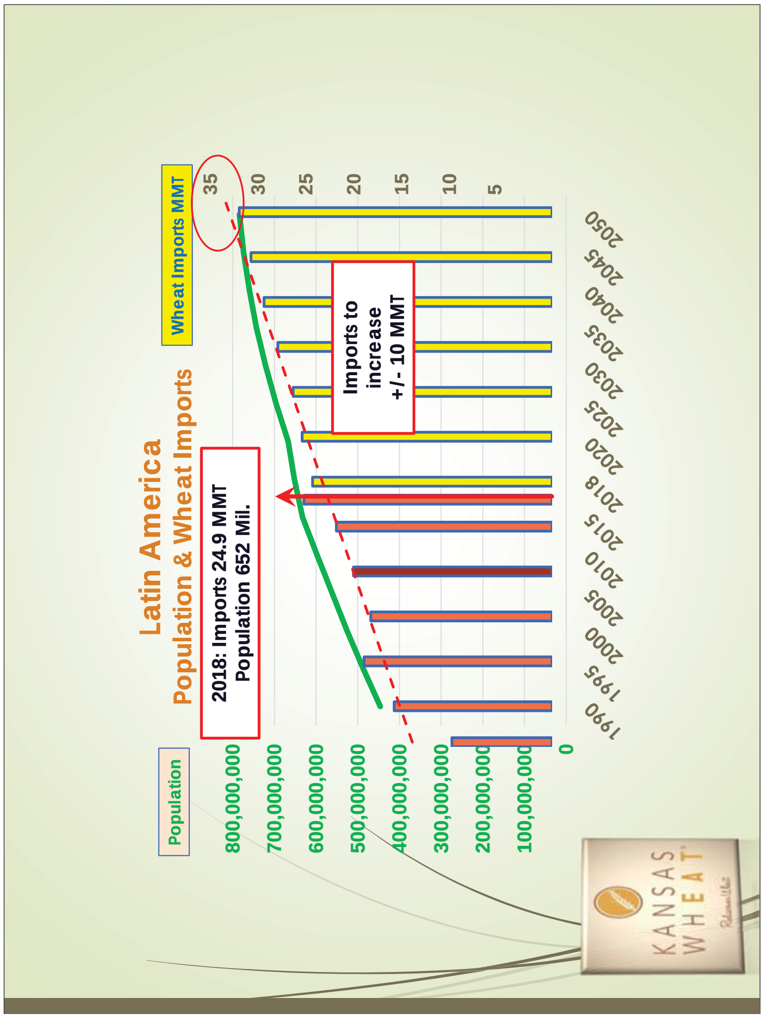

Russian Wheat Situation
Shift: Importer to Exporter
30-year transition from
+/- 15 MMT Importer to 40* MMT Exporter
45,000 40,000 35,000 30,000 25,000 20,000 15,000 10,000 5,000 0
1987/1988 … 2017/2018
Imports
Exports
Linear (Imports)
KANSAS WHEAT

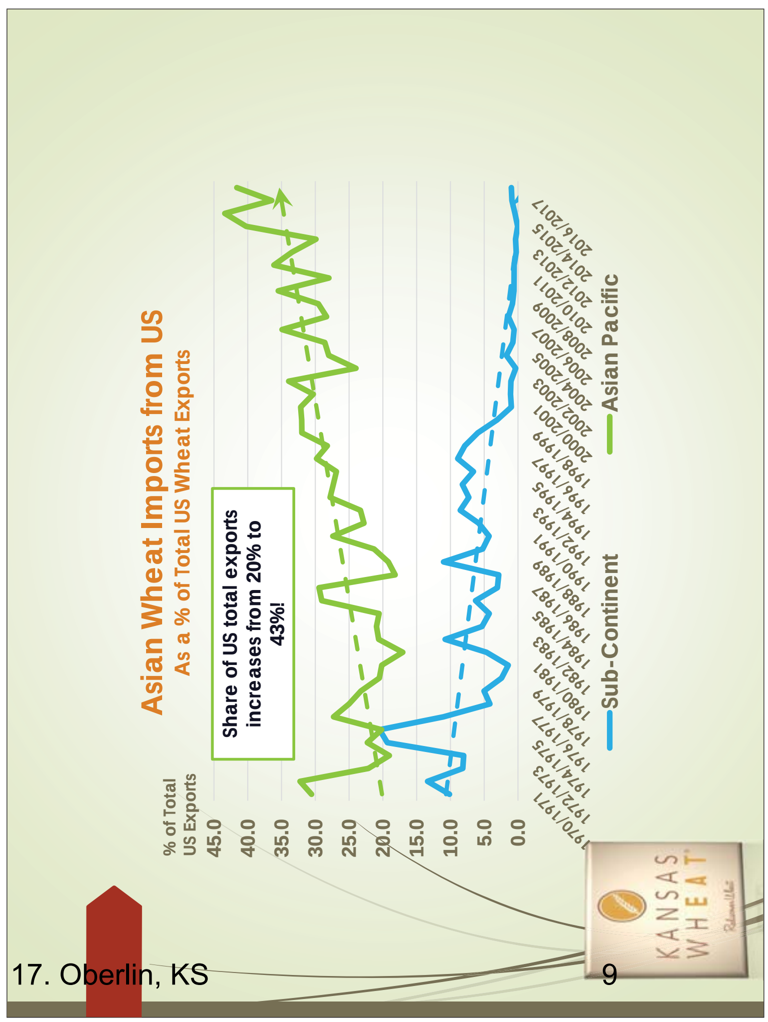

Wheat Imports
Middle East, Africa, Indian Sub Continent
1000 MT
100,000 90,000 80,000 70,000 60,000 50,000 40,000 30,000 20,000 10,000 0
Percent of US Total
50 45 40 35 30 25 20 15 10 5 0
Share of US total exports decreases from 45% to 15%
1990/1991 … 2017/2018
Imports - Mid East, Africa, Sub-Continent
Share of Total US Exports
KANSAS WHEAT

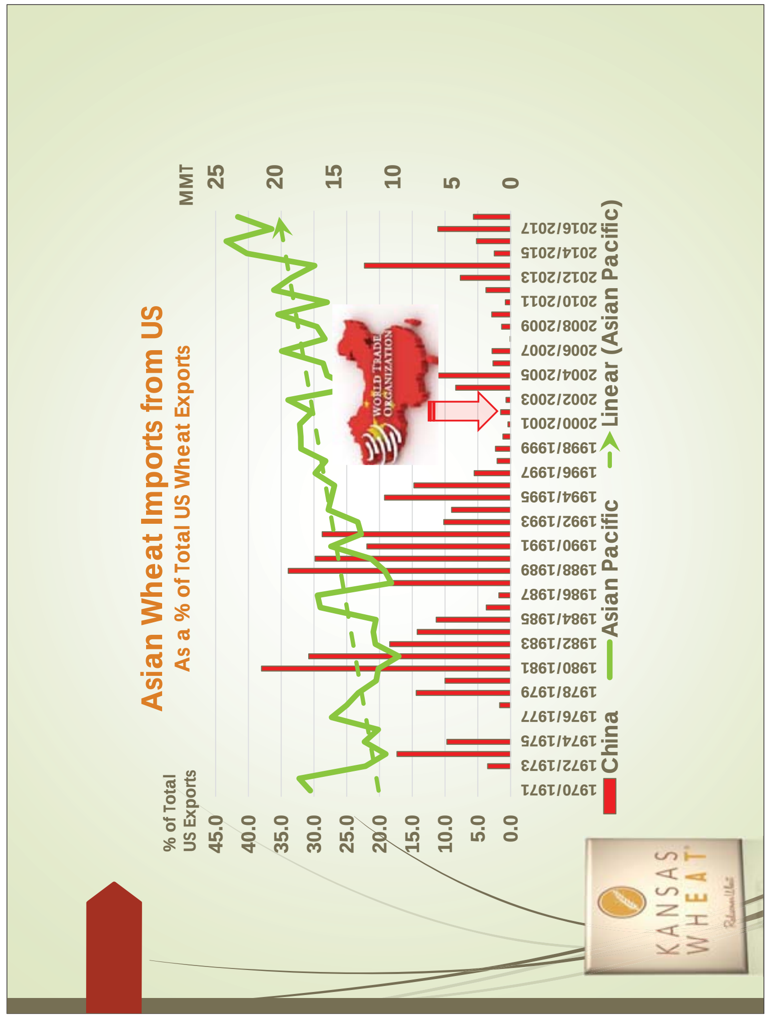

Latin America Wheat Imports
1000 MT
30,000 25,000 20,000 15,000 10,000 5,000 0
Percent of US Total
45.0 40.0 35.0 30.0 25.0 20.0 15.0 10.0 5.0 0.0
Share of US total exports increases from 10% to 40%!
1990/1991 … 2017/2018
Imports - All Latin America
Share of US Exports to Latin America
Linear (Share of US Exports to Latin America)
KANSAS WHEAT

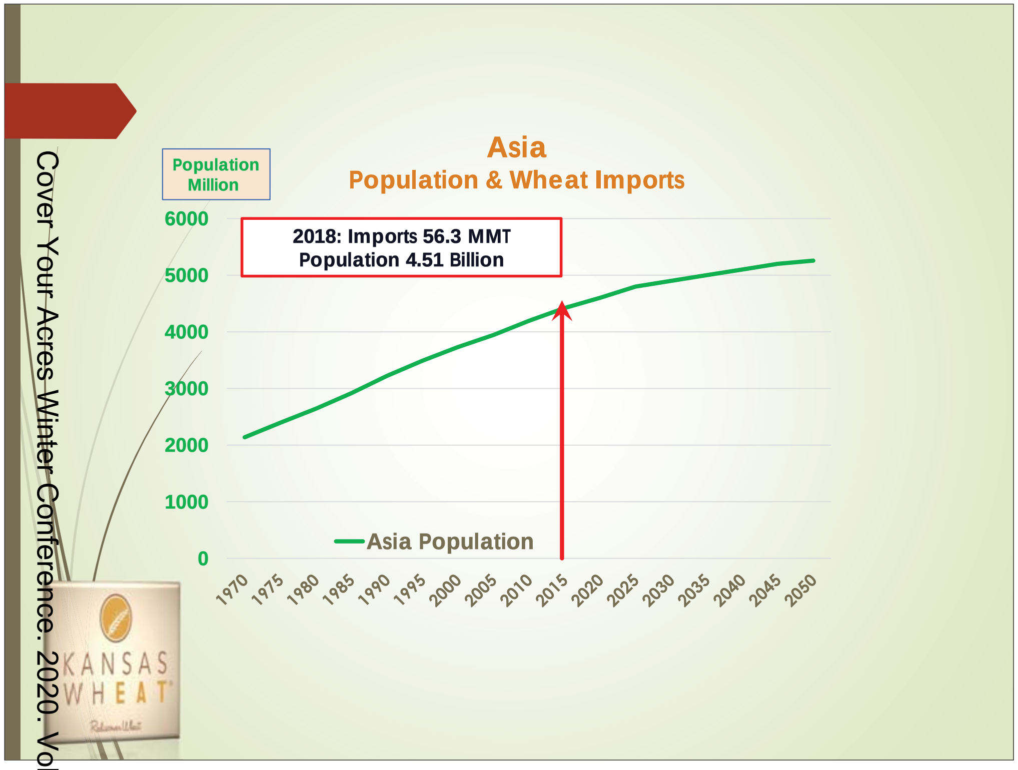

Latin America Wheat
Wheat imports increase from 10 to 25 MMT
1000 MT
30,000 25,000 20,000 15,000 10,000 5,000 0
1990/1991 … 2017/2018
Imports - All Latin America
Linear (Imports - All Latin America)
KANSAS WHEAT

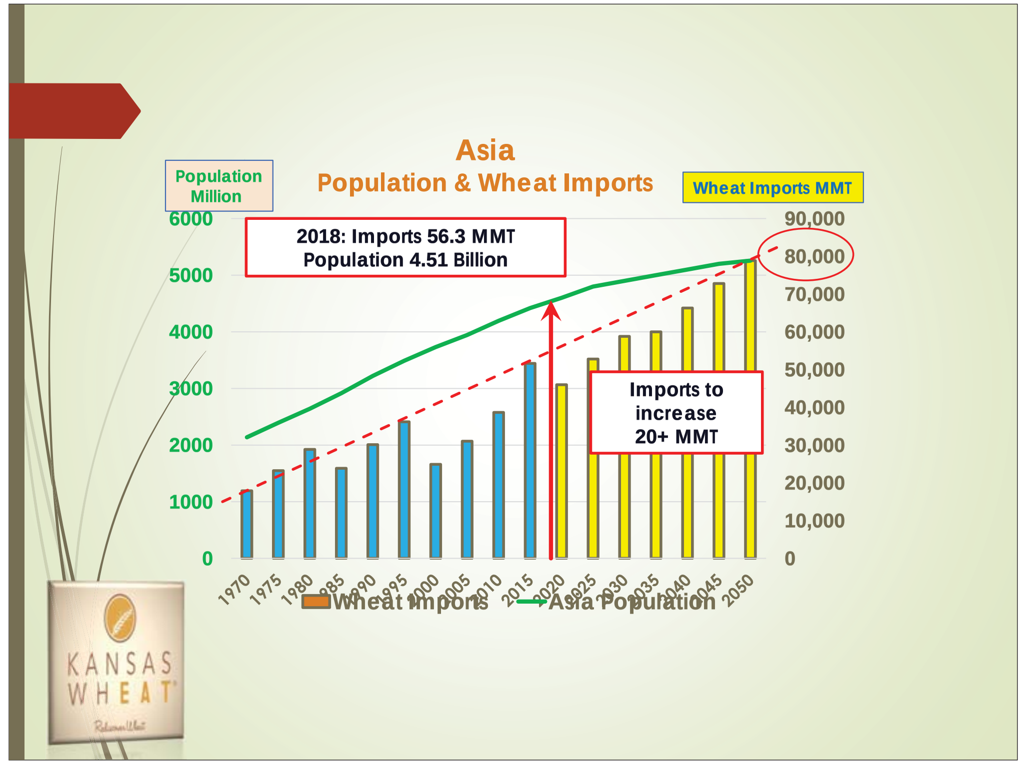

Latin America
Population & Wheat Imports
Population
800,000,000
700,000,000
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
0
1990 1995 2000 2005 2010 2015 2018 2020 2025 2030 2035 2040 2045 2050
2018: Imports 24.9 MMT
Population 652 Mil.
KANSAS WHEAT


Latin America
Population & Wheat Imports
Population
Wheat Imports MMT
800,000,000
700,000,000
600,000,000
500,000,000
400,000,000
300,000,000
200,000,000
100,000,000
0
35
30
25
20
15
10
5
1990 1995 2000 2005 2010 2015 2018 2020 2025 2030 2035 2040 2045 2050
2018: Imports 24.9 MMT
Population 652 Mil.
Imports to
increase
+/- 10 MMT
KANSAS WHEAT


Asian Wheat Imports from US
As a % of Total US Wheat Exports
% of Total
US Exports
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Share of US total exports increases from 20% to 43%!
1970/1971 1972/1973 1974/1975 1976/1977 1978/1979 1980/1981 1982/1983 1984/1985 1986/1987 1988/1989 1990/1991 1992/1993 1994/1995 1996/1997 1998/1999 2000/2001 2002/2003 2004/2005 2006/2007 2008/2009 2010/2011 2012/2013 2014/2015 2016/2017
Sub-Continent
Asian Pacific
KANSAS WHEAT

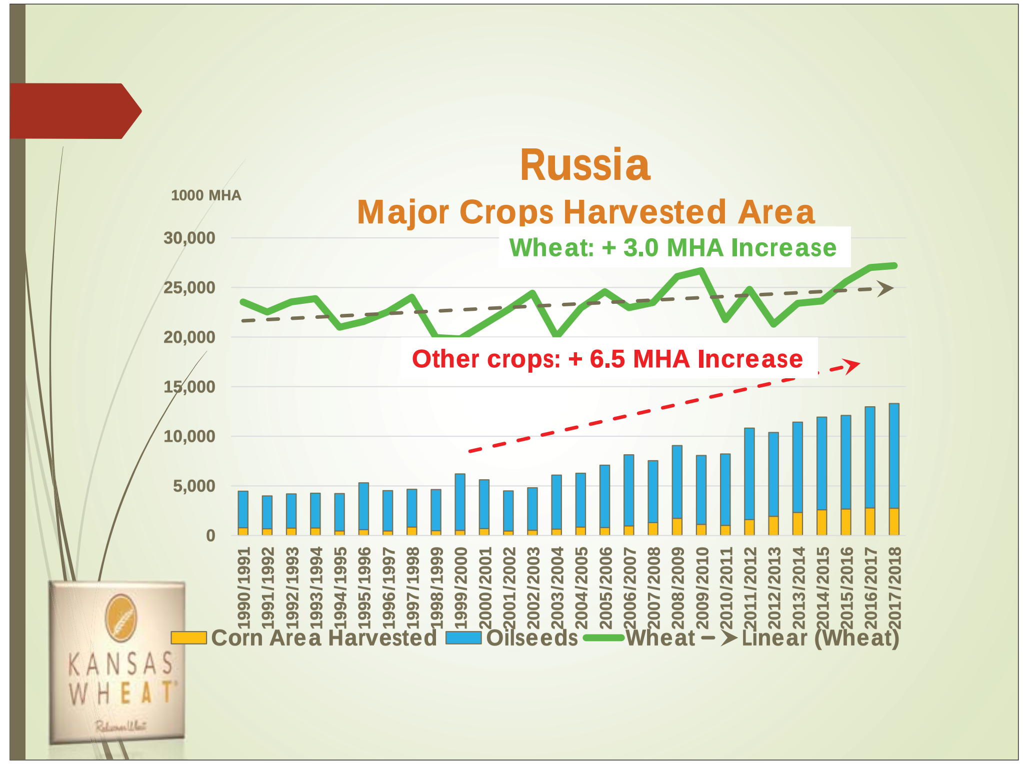

Asian Wheat Imports from US
As a % of Total US Wheat Exports
% of Total
US Exports
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
MMT
25
20
15
10
5
0
1970/1971 1972/1973 1974/1975 1976/1977 1978/1979 1980/1981 1982/1983 1984/1985 1986/1987 1988/1989 1990/1991 1992/1993 1994/1995 1996/1997 1998/1999 2000/2001 2002/2003 2004/2005 2006/2007 2008/2009 2010/2011 2012/2013 2014/2015 2016/2017
WORLD TRADE ORGANIZATION
China
Asian Pacific
Linear (Asian Pacific)
KANSAS WHEAT


Asia
Population & Wheat Imports
Population Million
2018: Imports 56.3 MMT
Population 4.51 Billion
Asia Population
KANSAS WHEAT


Asia
Population & Wheat Imports
Population Million
Wheat Imports MMT
2018: Imports 56.3 MMT
Population 4.51 Billion
Imports to increase 20+ MMT
Wheat Imports
Asia Population
KANSAS WHEAT


Russian Wheat Situation
Shift: Importer to Exporter
1000 MT
30 year transition from
+/- 15 MMT Importer to 40* MMT Exporter
Imports
Exports
Linear (Imports)
KANSAS WHEAT


Russia Export Markets
Middle East & Africa
82% of Russian Exports
KANSAS WHEAT


Russia
Major Crops Harvested Area
1000 MHA
30,000
25,000
20,000
15,000
10,000
5,000
0
Wheat: + 3.0 MHA Increase
Other crops: + 6.5 MHA Increase
1990/1991
1991/1992
1992/1993
1993/1994
1994/1995
1995/1996
1996/1997
1997/1998
1998/1999
1999/2000
2000/2001
2001/2002
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2007/2008
2008/2009
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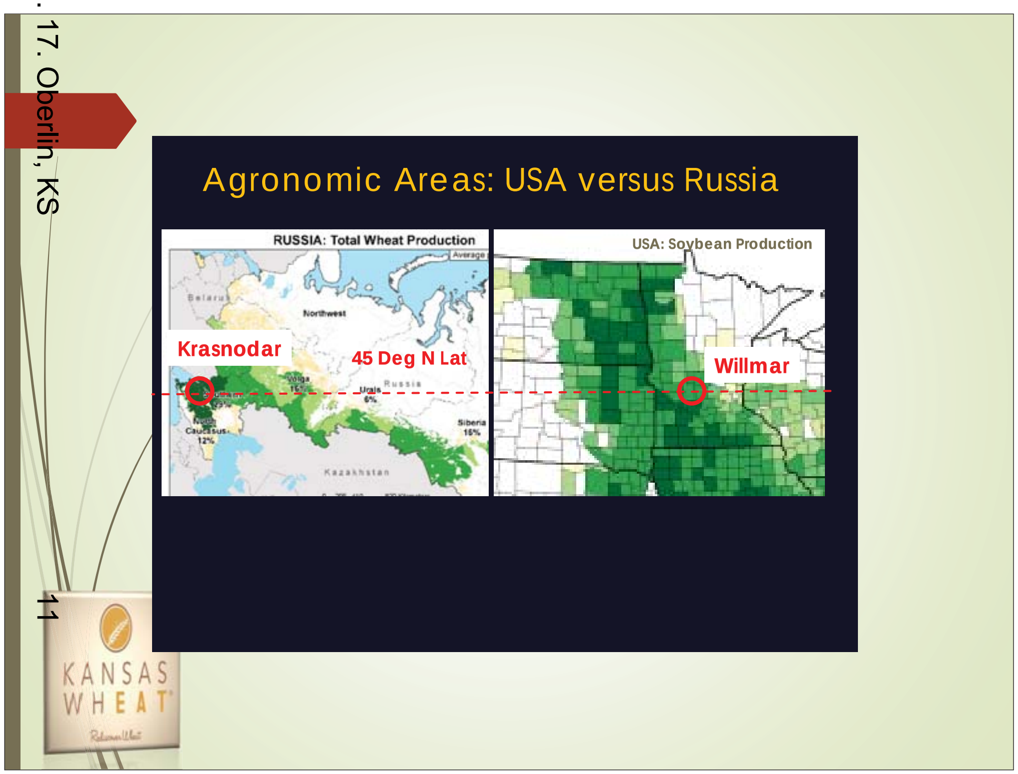
2012/2013
2013/2014
2014/2015
2015/2016
2016/2017
2017/2018
Corn Area Harvested
Oilseeds
Wheat
Linear (Wheat)
KANSAS WHEAT


Russia Export Markets
Middle East and Africa
+1.3 Billion more people by 2050
Consuming 125 MMT more wheat
Importing 60 MMT more wheat
KANSAS WHEAT


Agronomic Areas: USA versus Russia
RUSSIA: Total Wheat Production
USA: Soybean Production
Krasnodar
45 Deg N Lat
Willmar
KANSAS WHEAT

Implications of Cover Crop Termination Timings on Weed Suppression and Yield in Soybeans

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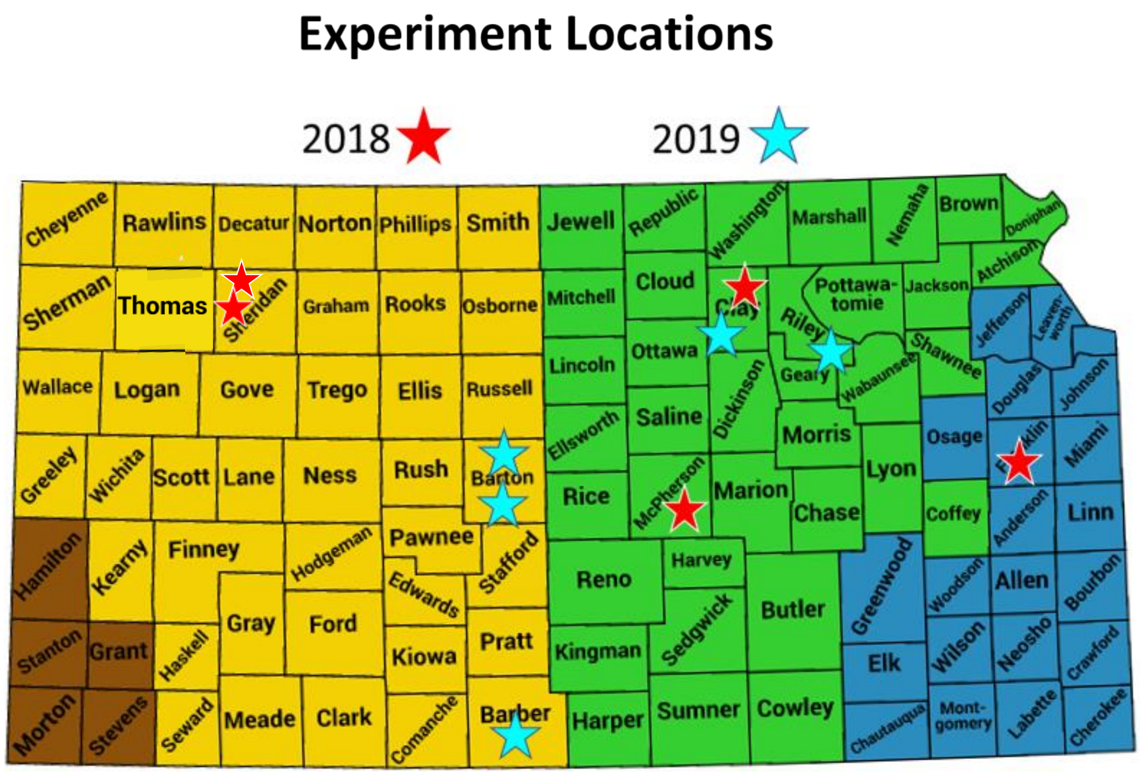
Introduction

The use of cover crops for weed management has become widely adopted in recent years due to herbicide-resistant weeds and the need for integrated weed management strategies. Cover crop management, specifically termination time, is a common concern for many growers. In Kansas, concerns arise when the cover crop acquires too much biomass, using a significant amount of soil moisture important for the following cash crop.

Methods

The goal of this study was to determine the effect of cover crop termination timing on weed densities and on soybean yield. Experiments were conducted during the growing seasons of 2018 and 2019. In 2018 four experiments were performed on farmer fields and on one university experiment station.



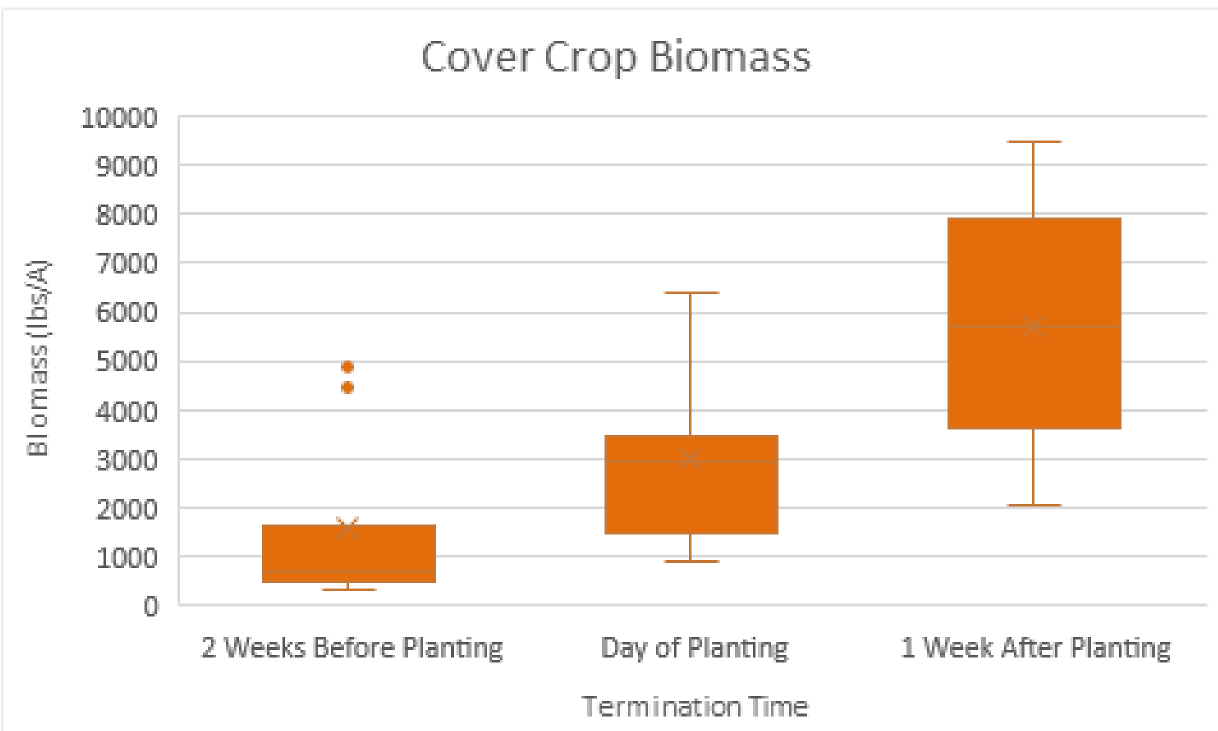
A winter cereal cover crop was drilled in the fall of 2017 and was then terminated with glyphosate using a standard four-nozzle backpack sprayer at three different times relative to the soybean planting date. These timings included, terminating 12-15 days before soybean planting, the day of planting and terminating seven days after planting. In 2019 three experiments were performed on farmer fields, and on one university experiment station, using cereal cover crop drilled in the fall of 2018 with the exception of one field that was drilled in the spring. The treatments in 2019 were the same as the previous year with an additional termination timing at 35 days before planting that represented “no cover”. All experiments were designed as a randomized complete block with four replications. Weed counts were taken 25 days after soybean planting. A post-emergence herbicide was applied to the experiments after the weed count evaluation to ensure that competition from weeds was not a factor in soybean yield. Soybean was hand harvested from a 4 m^2 section of the center two rows of each plot and then processed and weighed.

Results and Discussion

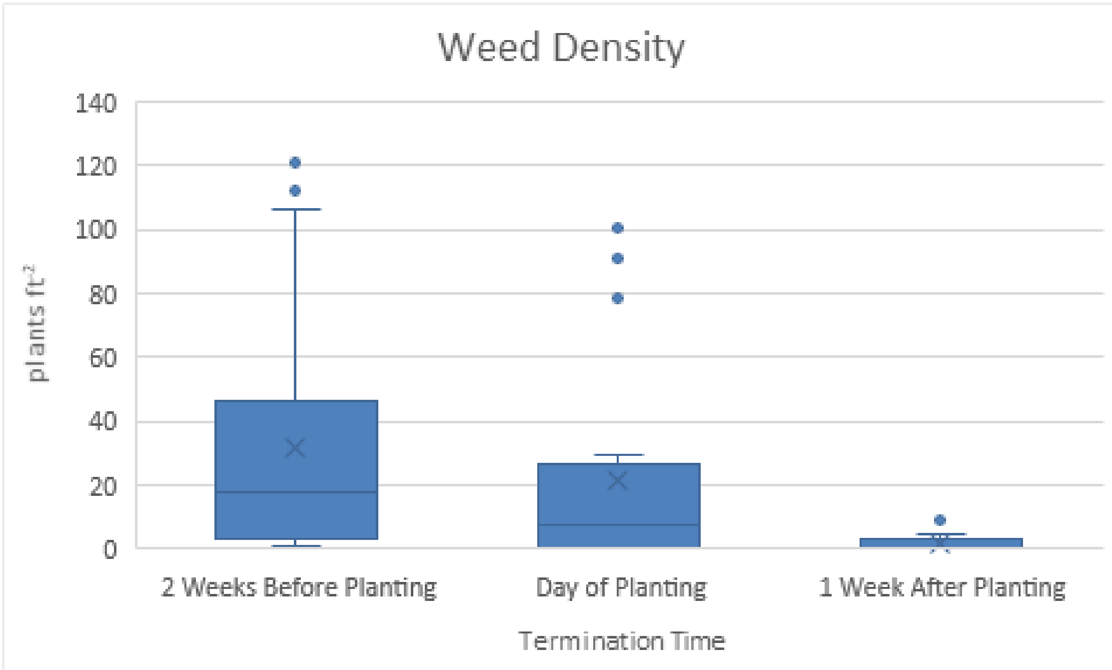
Results showed that there were no differences in soybean yields between cover crop termination timings for any sites across both years. In both 2018 and 2019 there were significant differences in weed density at 25 days after soybean planting in each of the cover crop termination timings. Weed suppression increased with delay in termination timing, with the greatest weed suppression from cover crop termination seven days after planting. This result is likely due to increased biomass accumulation by the cover crop. Therefore, we conclude that later termination timings can reduce the density of weeds without influencing soybean yield.

Weed Differences Between Termination Times

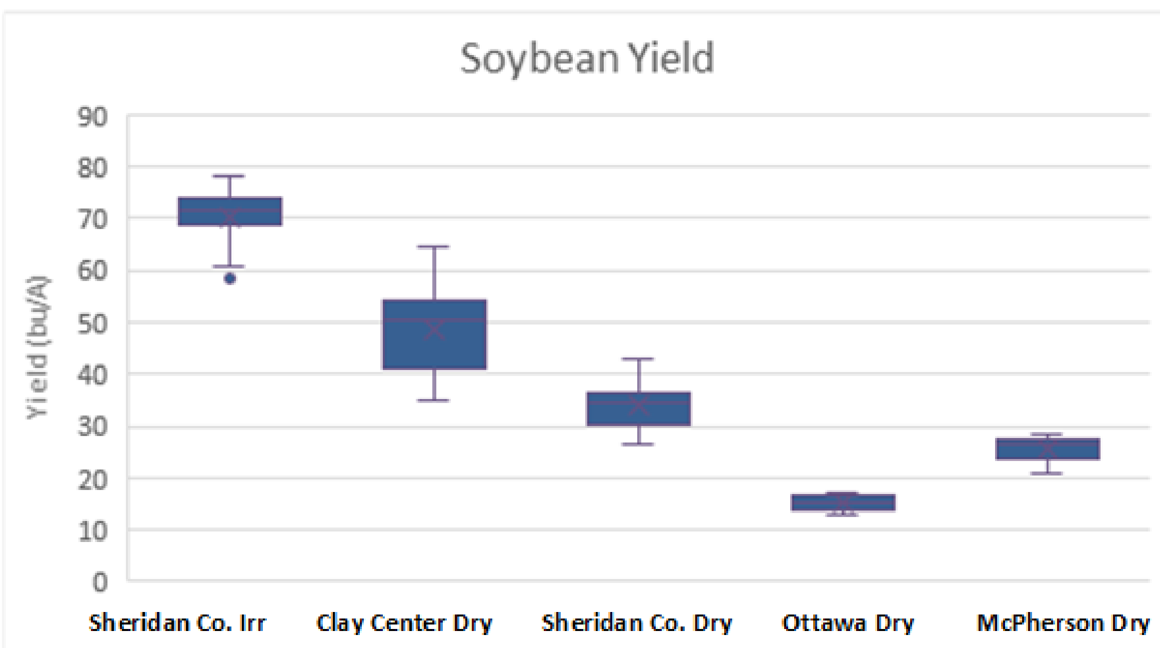
Observations made 20 days after planting in Manhattan, KS



Cover crop dry matter, (biomass) was measured at the time of each termination treatment. The biomass increased with the delayed terminations. The latest termination timing (one-week post-planting) provided 8000 pounds per acre of residue on average (last photo above.)



Weed density was taken 25 days after soybean planting. Weed density was reduced with the delay of each termination treatment. Terminating one week after planting (last photo above) resulted in the fewest weeds.



Yield was taken from four square meters of the two center rows of each plot. Yields did not vary among cover crop treatments at any location. There were differences in mean yield among locations however, due to annual rainfall variations throughout the state.

Impact of Cover Crops on Early Season Weed Control and Nitrogen Availability in Corn

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Introduction

Use of cereal cover crops for weed suppression in corn presents a challenge for managing nitrogen availability because of the difficulty of quantifying the amount of N tied up in the residue left behind. In 2019 a study was conducted near Manhattan, Kansas to determine cover crop suppression levels of Palmer amaranth, success of corn stand establishment, and impact on corn yield of N availability throughout the season following cereal and leguminous cover crops.

Methods

Four cover crop treatments were implemented with two termination timings and two N fertilization levels. The cover crops were fall-drilled triticale, spring-drilled field pea, a mix of triticale and field pea, and a no-cover check. Cover crops were terminated three weeks prior to planting (5/14/19) and at planting (6/5/19). Nitrogen was hand- broadcasted, 46-0-0 urea; and rates were 90 and 150 lbs N per acre.

Results and Discussion

No cover and late-terminated pea treatments had the highest Palmer amaranth densities of all treatments at one week after corn planting. Triticale and mixed pea and triticale cover treatments had the best stand establishment and late terminated pea and no cover treatments had the poorest stand establishment, likely due to greater weed density and reduced soil moisture retention that resulted in corn planting and germination difficulties. Corn yield differed among cover treatments with a 13 and 24% yield reduction in triticale and mixed pea and triticale treatments, respectively, compared to no cover. Yields in pea cover and no cover treatments were not different. The early termination timing had greater yield than late termination timing, except in triticale plots which were all terminated three weeks prior to planting.

Table 1: Corn yield data at Manhattan, KS 2019. Yield differences between cover treatments and by termination timing across all cover treatments. Cereal and Mixed cover treatments were not different from each other but were lower than all other cover treatments. Pea and no cover were not significantly different from each other.

Cover	**Yield (bu/A) +/-**	
Cereal	119	2.26
Mixed	109	4.56
No Cover	143	4.08
Pea	137	6.41
Termination Time		
3 weeks before planting	134	3.31
At planting	121	4.33

Nitrogen fertilization level was not significant in any cover treatment, indicating there may have been nitrogen-limiting conditions, especially in the treatments containing triticale, which showed lower yield than the other cover treatments. Future research will attempt to measure the differences in N availability throughout the season to better explain the impacts of N availability on corn yield.

Figure 1: Weed Density comparisons at corn planting

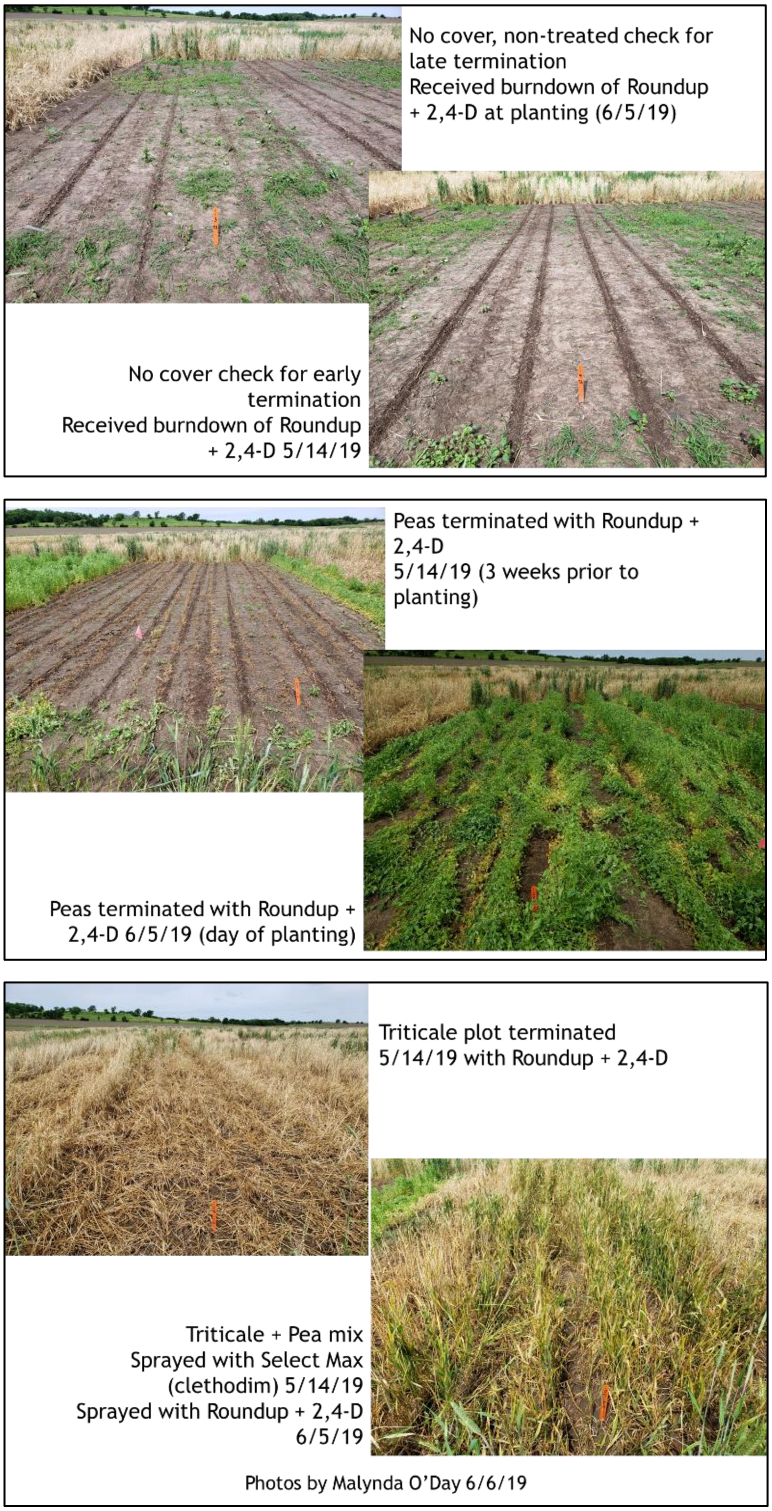

Table 2: Late-season differences in corn plant health

Cover	Chlorophyll Meter Reading	
Pea	53.9	a
No Cover	53.4	a
Mixed	46.5	b
Cereal	44.0	c
Nitrogen		
150 lbs N/acre	50.7	a
90 lbs N/acre	48.2	b

Chlorophyll meter readings were taken at R5 (dent stage) to assess differences in plant health as influenced by leaf chlorophyll concentrations (greenness), which can be used as an indicator of N status in the plant. Pea and No cover treatments were significantly greener than other treatments. Treatments containing pea and triticale had better readings than triticale alone but were not as good as pea and no cover. Nitrogen also had a significant impact on apparent plant health with higher nitrogen rates resulting in healthier plants, as would be expected.

Figure 3: Late season plant health comparisons (R5) Top left: triticale cover, top right: late-terminated pea cover, bottom left: no cover

Challenges are the Norm in Agriculture

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Introduction

Agriculture in America can be characterized by 3 – 5 years of excitement: (1914-1918, 1945 – 1948), (1973-1976), and 2007 – 2012), followed by 25 – 30 years' periods of breakeven at best years. All of these are similar in the sense that there were unexpected demand shocks (world wars, agricultural commodity, and energy demand with currency fluctuations) followed by years of excess production. From this brief thumbnail sketch of US Agriculture Economic history one can easily state that, challenges are the norm in Agriculture. Weather, markets, equipment breakdowns, employees, financial stress, and operator physical and mental stress are challenges for every farm operation, but how operators manage these challenges can be quite different. I would like to take a few minutes of your time to note observations that separate those operators that plan for and manage challenges versus those who react to them. Planning by my definition simply means prepared. I encounter this issue on every farm visit. The discussion frequently focuses on all the problems and excuses for the current situation on one farm and then I move down the road and the second operator has a plan and is moving forward. The operators that plan in a forward thinking manner are generally much more successful and satisfied with their career in agriculture. I have found that to have made a decision, even if the future shows it was not "right", frequently is better than NOT making a decision (which is a decision in itself). After all, "a ship that is not moving does not steer very well". It seems that when there are no "good" choices available, the tendency is to make NO decision rather than fear making the wrong one. I call this management paralysis. Operators with this management disease rarely have a farm operation to hand off to the next generation, they often become the terminal generation on that farm.

Know Your Finances (<u>and be honest with them</u>)

I am not talking just balance sheet in this case. I handed a farmer a print out of his projected cash flow several years ago. He took one look at the balance sheet and said, "good I still have 10 million in net worth", but I pointed out to him that the cash flow projection showed a shortfall of $1 million. He was focused on equity, and I wanted him to focus on profitability. Many operations today have healthy equity positions (mostly due to the persistence in land values) while they have lost their liquidity and have ballooning operating debt. I have observed excess operating debt restructured on land twice in many cases and a few are already past the third time. Most banks I interact with are extremely reluctant to do it again, possibly indicating that bank examiners are starting to express concern as well. The squeeze is on and the unwillingness of bankers to extend additional credit is the source of most of the financial stress I see currently.

Understand Your Accrual Income vs. Cash Flow vs. Taxable Income

Remember that accrual income includes the net cash generated plus change in grain and livestock inventories and prepaid expenses at the end of the year. It is important to be profitable first, then focus on cash flow, then manage the tax liabilities as a final step. Too many farmers make decisions to avoid taxes as long as the bank lends them the money. Most of the "tax problems" we experience are due to liquidating two crops sold in one year; prior year inventories are sold in January or February then sold again at harvest time to pay bills. As cash goes to debt payments instead of farm expense, taxable income is incurred because carryover LOC balances represent expense already deducted in prior years.

Focus on Profitability, The "Exercise" of Working a Cash Flow Projection

Operators that know their costs have an advantage over those that do not. It can be as detailed as a cash flow projection for the year with enterprise budgets showing break evens based on assumed yields or livestock production. Obviously, no one knows what the weather is going to do to crops in a given year, but you need to know whether it takes 80 bushel or 50 bushel per acre wheat to break even at $4. If your breakeven yield for a given enterprise is well beyond the normal yield expectations, then you should consider moving to another crop enterprise or rotation. Alternatives are much easier to consider during the planning phase of a cash flow projection, rather than after the resources have been committed, or a knee jerk change mid-stream during the year. I assist a few operators with cash flow projections in January or February each year. This exercise is to satisfy the request of the banker usually, but these operators and I have learned over the years the value of knowing, if we need $4.00 corn or $5.00 wheat to meet our cash flow objectives. Frequently the market does not provide our breakeven prices at the time of the cash flow projection. As an alternative, we plug in the "new crop" prices listed for the likely delivery elevator. When the cash flow is negative, we start looking at payment requirements, family living draws, and overhead costs. I rarely encourage cutting direct crop expenses. The operator's direct crop expenses budgets are typically within acceptable ranges for their area. Occasionally, I compare their costs with those of the KFMA, NW Enterprise analysis data and discuss the reasons for the difference. I find the strategy of cutting input costs to save money frequently contributes to lower production and results in lower cash flow potential in the end.

The Trap of Too Much Debt: What about Term Debt Payments and Overhead Costs?

I have found that the term-debt payment schedule is the primary culprit for farms in financial stress. Simply put, an operator may have a healthy profitability for their size of farm, but there is not adequate cash flow to support the purchasing habits. May times these operators have purchased too much land too recently for their cash flow to adequately support. Machinery purchases are also a challenge, but those are starting to slide off the schedule. The big purchase years of 2007- 2013 are more than five years in the past. Unfortunately, all too often the last two or three years of machinery payments for a tractor or combine purchased in 2013 or 2014 are actually hiding inside the operating debt or line of credit. Two things bloat line of credit balances these days, term debt payments and family living draws that exceed cash flow. It is always wise to spend some time annually to review overhead cost items. Farm property and liability insurance policies should be evaluated to be sure you have adequate coverage, but if the premiums are increasing over 10% per year and this is the fifth year in a row, you should consider coverage levels and alternative insurance carriers.

The Challenge of Machinery Cost: Balancing Reliability, Cost, and Ego

Equipment costs, including repairs, fuel, machine hire, and management depreciation should be evaluated. The ProfitLink analysis provides an opportunity to compare your costs to farms of your type and size. I use "machinery cost per harvested acre" as a discussion point at farm visits and when evaluating cost issues and building a cash flow. Rarely are these costs easily controlled, but identifying where the issues are can be worth the time. I am always concerned if the operator has high machinery repairs at the same time that management depreciation of equipment is high. I suspect this operator and/or his employees are very hard on equipment. If the operator has a shop and facilities to do basic maintenance, but takes the equipment to town, I would want to know why. The issue could be labor available or skill level. Labor utilization is a key to efficient management on any farm. Labor is not just the "hired hand", but also the operator or family members contributing to the farm labor resource. As the operator ages, the ability to do the more difficult physical jobs starts to slip. Frequently maintenance begins to slip as well. This can contribute to more expensive equipment repairs, more services from dealers, or trading for newer equipment in an attempt to improve dependability or timeliness of accomplishing farming tasks. Interestingly, more equipment purchases to improve timeliness or reliability, when there is an honest timeliness issue, can contribute to improved incomes. Success requires sufficient equipment productivity to get the job done in a timely fashion. Whether your operation runs older equipment that is well maintained, or newer equipment, also well maintained, does not really matter as long as you get the job done timely and at a sustainable cost per harvested acre. One of the issues with machinery cost per harvested acres is the number of harvested acres. Size of farm has a significant influence on machinery cost efficiency. It is important to have machinery costs balanced to the acres of your operations over time. Note the common element mentioned earlier, "well maintained". Management attitude, when discouraged (depressed), frequently leads to neglect of equipment maintenance and personal health maintenance as well. It seems that avoiding the "problem" can compound other "problems" in a variety of ways.

The Back of the Envelope Cash Flow

Those producers that don't go through the full exercise of developing a projected cash flow can work through a ProfitLink analysis (assuming you are a KFMA member) to get a good idea of enterprise profitability and break even prices. When working with a KFMA member that has a completed ProfitLink enterprise analysis, we look at their total cost per acre, make some back of the envelope adjustments acknowledging known cost changes from last year, and then plug in the anticipated crop yields based on crop conditions at that time. Once those values are determined, we can have a market price objective for marketing to cover cash flow needs. The key here is using the total expense value on the enterprise analysis which has all variable and fixed costs including operator labor charges (family living draws), depreciation (equipment payments), and a land charge (proxy for land payments) for owned land. It is a good idea to compare the sum of operator labor charges, management depreciation, and land charges across all enterprises on the farm with actual or projected family living draws, machinery term principle, and land term debt principle. Interest on the term debt payments would be included in indirect expenses. In most cases, the market is not providing resources to cover "total expenses" but it is important for the cash flow plan to find a way to cover total variable cost and operator labor (family living proxy). This leaves the machinery and land payments to the operating note and potential restructure if there are no other options. In other words, this operation might keep going another year.

Income Timing, Don't Depend on Operating Debt for Everything

Once the cash flow needs are established and commodity market price objectives are established, the next challenge is timing of income. In times past, lenders attempted to time the term payments to match when cash flow should be available to make the payment. Interestingly, I find that most machine financing arrangements are simply termed to match the annual or semiannual date of purchase. Rarely does that coincide with cash flow sufficient to cover the payments. Buying a combine ahead of harvest, therefore setting the payment date ahead of harvest, does not match well with cash flow of selling grain after harvest. Land term debt is more likely to be scheduled with cash flow in mind, but frequently the payment is scheduled for December 31 so the interest can be timed as a tax deduction either in the current year or after the first of the year. My experience working with farmers has shown that December 31 is probably the worst cash flow timing for a land payment. The farm operator is likely focused on prepaying expenditures to lower taxes and typically be running a negative cash balance at the end of the year. This can be mitigated by substantial deferred grain or livestock sales contracts receivable on January 2 to cover the "float" of the checks. The problem gets serious when the farm operation no longer has grain inventory priced for January 2 receipt. The past few years have found KFMA, NW members with corn in bags and not deliverable due to full elevators, feedlots, weather, or simply not priced yet because the operator does not want to accept the price. The seasonal price and the related carry in the corn marked has rewarded storage in any form from harvest to March/April most years (not so much in 2018). I have strongly pushed my KFMA members to work the grain marketing with an eye to future cash flow needs and pull the trigger on grain sales whenever the market provides an opportunity. Most farm operators don't like to price too much grain as they don't know the eventual harvest production and that is understandable, but what about 25% - 30% - 50% of multiple year average bushels produced? The case in point is that KFMA, NW members in the western counties have had $4 corn pricing opportunities in May the past few years, which would have covered total enterprise cost given the crops raised those same years (especially irrigated corn), but very few bushels were priced at that time. My progressive managers have adequate commodities priced ahead, at breakeven levels to keep their cash flow timed properly almost every year.

Income Planning for the Current Year

When working Fall farm visits I typically work through a year-end income planning projection. This entails current income and expenses year-to-date from the computer records. Adding the expenses spent last year from the date of the last entry in their current year records through the end of last year. For example, if a member has their computer records current to 8/15/19 on the farm visit, I would then generate a report from 8/15/18 to 12/31/18. This total is a good proxy for estimated expenses to year-end for the current year. Not perfect by any means, but quick and amazingly closer than you think. It does not take long to adjust for known changes in the current year from last year and it helps me to identify big expenses for that farm between the farm visit and the end of the year. The focus of this discussion is to plan for appropriate income to cover anticipated cash flow and tax planning objectives. I have found over the years that my members have rarely thought in August about how much income they will need to cover operating expenses and term debt payments by year-end. I just completed a farm visit in August where the member needs $2.4 million to reach zero net income. Then we started discussing anticipated production. We work through the acres, rent share, and potential yield to get projected production. This specific member had experienced hail on their corn such that we have lost at least 30 bushels per acre from last year. Price is then estimated by using the value of contracts already in place and new crop bids from their local grain marketing outlets. Unfortunately, this member's crops are not going to equal the $2.4 million needed. At the time of the farm visit Market Facilitation Payments (MFP) were not published for their county. We did not calculate that value, but this member will struggle to reach zero. This farm has financial stress written all over it, and I see it in their faces at the farm visit.

Reality of Grain Logistics

Even if we had sufficient projected production to reach the bushels needed to manage cash flows properly, how in the world will we get the inventory into cash? The physical ability to deliver the grain during a drawn out harvest with elevators and feedlots full from another large crop is a real challenge. Many Northwest Kansas operators have built grain storage and/or moved to bagging corn as a method of improving harvest efficiency and storage. Unfortunately, this ties up the grain until "un-bagged" sometime in the spring and summer (there are still bags from last year). The two most common methods are to deliver on OND (October, November, December) delivery contracts with elevators to get the payment, or to store grain on farm or in bags to take a CCC loan. This is NOT the favorite practice of most operators, but the only way to advance cash (cash flow timing), treat as income (income tax planning), and retain the commodity for market and/or basis improvements later in the marketing year.

Tax Planning in a Cash Flow Crunch Year

Start thinking of deferring expenses into next year if possible. I can set major repair expenses on depreciation to stretch out the expenses, which raises taxable income to zero, but does not help with cash flow stress. An infusion of income/cash from the sale of unneeded assets is a possibility, but I always get the line, "it really isn't worth much, so why sell it?" My guess is that it will be worth less next year and even less the next, so why ride the value on down to zero? There are a few of my members liquidating real estate to reduce some of their term debt payment schedule tyranny and try to fix their cash flow crisis.

A non-farm income strategy that does not help cash flow but takes advantage of a negative tax situation is to roll Traditional IRA accounts into Roth IRA Accounts, if they qualify, while at a loss or in a lower tax bracket. You may pay some state income taxes, but at least you would use up your federal standard deduction and farm losses this way and eliminate future taxes on those dollars rolling into a Roth IRA.

Tax Planning in a Cash Flow Excess Year

On farms that are doing very well making income, they might have the other problem. They carried so much inventory over from 2018 that their income is already higher than desired and future sales this year should be deferred into 2020. I have a few of these as well, but few is the key word.

Be Willing to Pay Some Taxes

I think a big part of the reason operators hold back on sales is because they want a higher price for their commodities ***and*** they do not want to pay taxes. If they live and operate on operating debt they will not pay any taxes, but once they start selling grain to pay that loan back they "might" pay some taxes. I argue that preparing for an appropriate tax liability is part of a success plan. Preparing for an appropriate tax liability is also understanding the true amount of deferred tax liabilities most producers are carrying. For example, consider the carryover inventory sales plus prepaid expenses then pay federal, self-employment, and state income tax on that amount. Or take the total amount of debt an individual has and generate income to pay that off; pretty soon we need $1.30 to pay off $1.00 of debt. Those that perpetually try to avoid paying taxes sufficient to cover term debt payments and family living draws, are likely to experience continual financial stress. Let us examine the results of the KFMA NW 2018 analysis by quartile of Net Farm Income in Table 1 on the next page.

Table 1

	Average	Low 25%	High 25%
Net Farm Income	$113,286	$ (60,343)	$357,006
Non-Farm Business	$ 18,373	$ 18,373	$ 18,373
Wages	$ 23,389	$ 23,389	$ 23,389
Rent/Royalties	$ 13,958	$ 13,958	$ 13,958
Dividends/Interest	$ 1,238	$ 1,238	$ 1,238
Social Security	$ 8,244	$ 8,244	$ 8,244
Adjusted Gross Income	$178,488	$ 4,859	$422,208
Plus Management Depreciation	$ 63,170	$ 49,147	$119,659
Total Cash Available	$241,658	$ 54,006	$541,867
Family Living	$ 79,651	$ 79,651	$ 79,651
Accrued Income Tax	$ 37,289	$ -	$108,784
Total Non-Deductible Expense	$116,940	$ 79,651	$188,435
Current Debt / 5 years	$ 68,937	$ 77,862	$105,593
Non-Current Debt / 20 years	$ 27,903	$ 37,297	$ 34,897
Total Loan Payments	$ 96,839	$ 115,159	$140,490
After Tax Earned Equity	$ 27,879	$(140,804)	$212,942

This is not a perfect comparison since I am using accrual net farm income and treating it as if it were schedule F cash farm income. I did assume $25,000 of the taxable income was from machinery or breeding livestock sales. Note how the average KFMA farm needs a tax adjusted gross income of $178,488 to experience a net worth increase of $27,879 after paying for family living, income tax, and debt service. Since the earned equity change is less than depreciation, it is safe to say the average producer is still “living on depreciation” or “living on borrowed money.” Net farm income of $113,000 sounds like a lot but cash disappears quickly. The Low 25% quartile is losing borrowed money; there might not be a tax liability situation but there definitely is financial stress. The High 25% pays the largest tax bill and the most debt payments but there is sufficient income to cover both and have positive net worth change. Every farm operation is in a different situation but all should strive for positive net worth changes year after year.

Which farm income category would you like to be? I would take the high 25% tax bill and earned equity change any day. Those KFMA members that have learned this years ago are not in current financial stress and they are ready, willing, and able to buy the real estate from the low 25% income farms when it comes up for sale. Think about it…..

The Handy Bt Trait Table

for U.S. Corn Production

The latest version of the table is always posted at https://www.texasinsects.org/bt-corn-trait-table.html

For questions & corrections: Chris DiFonzo, Michigan State Univ., difonzo@msu.edu
Contributor: Pat Porter, Texas A&M University (web site host)

Updated May 2019

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. This latest version incorporates two new findings of resistance, and categorizes western & northern corn rootworm separately.

Breaking News #1: Entomologists at the University of Guelph in Canada confirmed European corn borer (ECB) resistance to Cry1F Bt (the Herculex I trait) in corn. In 2018, ECB populations were collected from multiple locations in the Maritime Provinces of eastern Canada where unexpected damage was reported. Lab bioassays showed a high level of resistance to Cry1F; the registrant of the trait independently confirmed the results. *This is the first case of field-evolved resistance by ECB to Bt corn.*

Use of single-trait hybrids likely contributed to the problem. In eastern Canada, hybrids with only one Bt trait (Cry1F) were still being sold & planted, well after an expected phase out in favor of multi-Bt pyramids to allow for reduced 5% refuge. Although the Maritime provinces are far from the major corn production area in the central U.S., the bioassay results demonstrate that ECB resistance to Bt corn can happen, and that phasing out single-trait hybrids is critical. In short-growing season areas of the U.S. and Canada, seed options tend to be limited, so single-trait hybrids may still be available. Using them risks the development of additional resistant insect populations.

Breaking News #2: Entomologists at North Dakota State University confirmed northern corn rootworm resistance to Cry3Bb1 and Cry34Ab1/Cry35Ab1. Although resistance to multiple traits is well-documented in the Midwest for western corn rootworm, this is the *first confirmation of field-evolved resistance by the northern corn rootworm*.

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

Trade name for trait	Event	Protein(s) expressed	Primary Insect Targets + *Herbicide tolerance*
Agrisure CB/LL	Bt11	Cry1Ab + *PAT*	corn borer + *glufosinate*
Agrisure Duracade	5307	eCry3.1Ab	rootworm
Agrisure GT	GA21	*EPSPS*	*glyphosate*
Agrisure RW	MIR604	mCry3A	rootworm
Agrisure Viptera	MIR162	Vip3Aa20	broad caterpillar control, except for corn borer
Enlist	DAS40278	*aad-1*	*2,4-D herbicide detoxification*
Herculex I (HXI) or CB	TC1507	Cry1Fa2 + *PAT*	corn borer + *glufosinate*
Herculex CRW	DAS-59122-7	Cry34Ab1/Cry35Ab1 + *PAT*	rootworm + *glufosinate*
(None – part of Qrome)	DP-4114	Cry1F + Cry34Ab1/Cry35Ab1 + *PAT*	corn borer + rootworm + *glufosinate*
Roundup Ready 2	NK603	*EPSPS*	*glyphosate*
Yieldgard Corn Borer	MON810	Cry1Ab	corn borer
Yieldgard Rootworm	MON863	Cry3Bb1	rootworm
Yieldgard VT Pro	MON89034	Cry1A.105 + Cry2Ab2	corn borer & several caterpillar species
Yieldgard VT Rootworm	MON88017	Cry3Bb1 + *EPSPS*	rootworm + *glyphosate*

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
ECB European corn borer
FAW fall armyworm
CR corn rootworm (NCR = Northern & WCR = Western)
SB stalk borer
SCB sugarcane borer
SWCB southwestern corn borer
TAW true armyworm
WBC western bean cutworm

The Handy Bt Trait Table for U.S. Corn Production, updated May 2019

Trait packages in alphabetical order (acronym)	Bt protein(s) in the trait package	Marketed for control of:										Resistance confirmed to the combination of Bts in package (check local situation)	Herbicide trait		Non-Bt Refuge % (cornbelt)
		BCW	CEW	ECB	FAW	SB	SCB	SWCB	TAW	WBC	CR		GT RR2	LL	
AcreMax (AM)	Cry1Ab Cry1F	x		x	x	x	x	x				FAW WBC	x	x	5% in bag
AcreMax CRW (AMRW)	Cry34/35Ab1										x	NCR/WCR	x	x	10% in bag
AcreMax1 (AM1)	Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	ECB FAW SWCB WBC NCR/WCR	x	x	10% in bag 20% ECB
AcreMax Leptra (AML)	Cry1Ab Cry1F Vip3A	x	x	x	x	x	x	x	x	x			x	x	5% in bag
AcreMax TRIsect (AMT)	Cry1Ab Cry1F mCry3A	x		x	x	x	x	x			x	FAW WBC WCR	x	x	10% in bag
AcreMax Xtra (AMX)	Cry1Ab Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC NCR/WCR	x	x	10% in bag
AcreMax Xtreme (AMXT)	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x	x	5% in bag
Agrisure 3010 and 3010A	Cry1Ab			x			x	x					x	x	20%
Agrisure 3000GT and 3011A	Cry1Ab mCry3A			x			x	x			x	WCR	x	x	20%
Agrisure Viptera 3110	Cry1Ab Vip3A	x	x	x	x	x	x	x	x	x			x	x	20%
Agrisure Viptera 3111	Cry1Ab Vip3A mCry3A	x	x	x	x	x	x	x	x	x	x	WCR	x	x	20%
Agrisure 3120 E-Z Refuge	Cry1Ab Cry1F	x		x	x	x	x	x				FAW WBC	x	See bag tag for code EZ0 NO EZ1 YES	5% in bag
Agrisure 3122 EZ Refuge	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x		5% in bag
Agrisure Viptera 3220 E-Z Refuge	Cry1Ab Cry1F Vip3A	x	x	x	x	x	x	x	x	x			x		5% in bag
Agrisure Viptera 3330 E-Z Refuge	Cry1Ab Vip3A Cry1A.105 + Cry2Ab2	x	x	x	x	x	x	x	x	x			x		5% in bag
Agrisure Duracade 5122 E-Z Refuge	Cry1Ab Cry1F mCry3A eCry3.1Ab	x		x	x	x	x	x			x	FAW WBC WCR	x		5% in bag
Agrisure Duracade 5222 E-Z Refuge	Cry1Ab Cry1F Vip3A mCry3A eCry3.1Ab	x	x	x	x	x	x	x	x	x	x	WCR	x		5% in bag
Herculex I (HXI)	Cry1F	x		x	x	x	x	x				ECB FAW SWCB WBC	x	x	20%
Herculex RW (HXRW)	Cry34/35Ab1										x	NCR/WCR	x	x	20%
Herculex XTRA (HXX)	Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	ECB FAW SWCB WBC NCR/WCR	x	x	20%
Intrasect (YHR)	Cry1Ab Cry1F	x		x	x	x	x	x				FAW WBC	x	x	5%
Intrasect TRIsect (CYHR)	Cry1Ab Cry1F mCry3A	x		x	x	x	x	x				FAW WBC WCR	x	x	20%
Intrasect Xtra (YXR)	Cry1Ab Cry1F Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC NCR/WCR	x	x	20%
Intrasect Xtreme (CYXR)	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x	x	5%
Leptra (VYHR)	Cry1Ab Cry1F Vip3A	x	x	x	x	x	x	x	x	x			x	x	5%
Powercore [a] Powercore Refuge Advanced [b]	Cry1A.105 Cry2Ab2 Cry1F	x	x	x	x	x	x	x				CEW WBC	x	x	[a] 5% [b] 5% in bag
QROME (Q)	Cry1Ab Cry1F mCry3A Cry34/35Ab1	x		x	x	x	x	x			x	FAW WBC WCR	x	x	5% in bag
SmartStax [a] Smartstax Refuge Advanced [b] SmartStax RIB Complete [b]	Cry1A.105 Cry2Ab2 Cry1F Cry3Bb1 Cry34/35Ab1	x	x	x	x	x	x	x			x	CEW WBC WCR	x	x	[a] 5% [b] 5% in bag
Trecepta [a] Trecepta RIB Complete [b]	Cry1A.105 Cry2Ab2 Vip3A	x	x	x	x	x	x	x	x	x			x		[a] 5% [b] 5% in bag
TRIsect (CHR)	Cry1F mCry3A	x		x	x	x	x	x			x	ECB FAW SWCB WBC WCR	x	x	20%
VT Double PRO [a] VT Double PRO RIB Complete[b]	Cry1A.105 Cry2Ab2		x	x	x	x	x	x				CEW	x		[a] 5% [b] 5% in bag
VT Triple PRO [c] VT Triple PRO RIB Complete [d]	Cry1A.105 Cry2Ab2 Cry3Bb1		x	x	x	x	x	x			x	CEW NCR/WCR	x		[c] 20% [d] 10% in bag
Yieldgard Corn Borer (YGCB)	Cry1Ab			x			x	x					x		20%
Yieldgard Rootworm (YGRW)	Cry3Bb1										x	NCR/WCR	x		20%
Yieldgard VT Triple	Cry1Ab Cry3Bb1			x			x	x			x	NCR/WCR	x		20%

Impact of Planter Downforce on Row Unit Acceleration and Seed Placement Consistency

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INTRODUCTION

Planting operation is one of the most important stages in crop production. Seeds must be placed in desired depth and equally spaced from each other providing them ideal conditions for germination and proper root development. Planting quality as defined by consistent seed placement can be achieved with the use of precision planters. Aside from accurate seed metering and delivery system, another technological component of the planter that influence planting quality is downforce. Varying field and operating conditions require different levels of downforce to achieved the desired planting quality. Planter downforce is the amount of load acting on the row unit and mainly taken up by the disc openers and gauge wheels during planting operations. This load consists of the weight of the row unit and additional load applied using either spring, airbags or hydraulic systems. Selecting the ideal level of downforce is critical as too much downforce can compact the soil (Hanna et al., 2010) while too little downforce could result in shallow planting depth (Karayel, et al, 2011). Both situations could potentially affect emergence and root development and eventually reduces yield. Therefore, proper selection of gauge wheel load can highly influence planter performance in providing the desired seed placement consistency during planting. Likewise, speed of planting could potentially affect emergence and crop development. Previous studies have reported the effect of ground speed on crop stand establishment (Liu et al., 2004; Ozmerzi et al., 2002; Staggenborg et al., 2004) and yield (Nielsen, 2013). However, limited data reports the row unit acceleration across a wide range of machine operating conditions and its effect on seed placement consistency. Therefore, the objectives of this research were (a) to understand row unit acceleration across varying levels of downforce settings and ground speed and (b) to assess its impact on seed placement consistency.

METHODOLOGY

Planter setup and instrumentation

Planting operations were accomplished using a Horsch Maestro (Horsch Maschinen GmbH, Schwandorf, Germany) row crop planter operated by a John Deere 8250R tractor. The planter consists of 12 row units spaced at 762 mm apart. Individual row unit was equipped with a load cell (6784, Horsch Maschinen GmbH, Schwandorf, Germany) used to measure real-time the gauge wheel load (GWL). Row units were grouped into control sections where each section can be programmed to implement a different level of downforce. Control section 1 included the row units 1, 2 and 3, control section 2 consisted of row units 4, 5, 8 and 9, control section 3 contained row units 6 and 7 and section 4 comprised of row units 10, 11 and 12. Control sections 1 and 4 is referred herein as wing section (WG), control section 2 as track section (TR) and control section 3 as non-track section (NT).

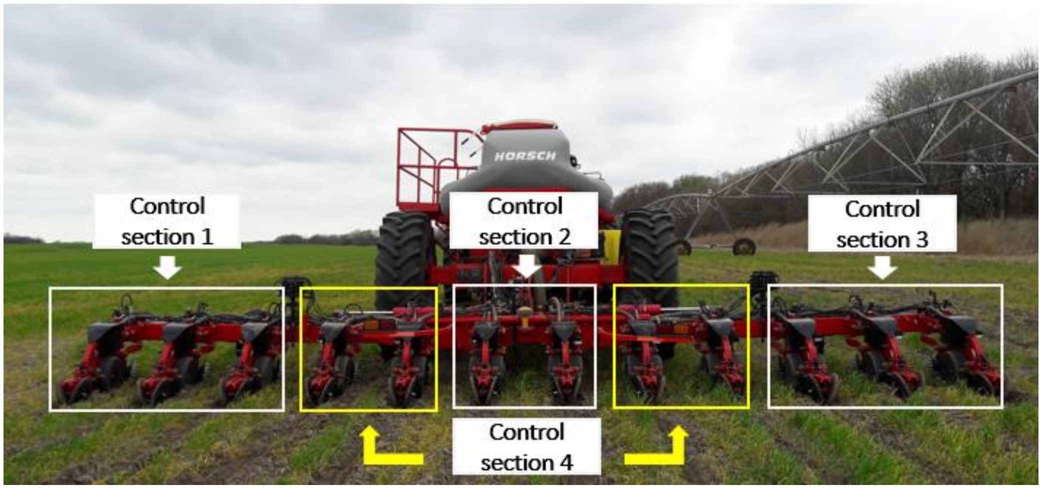

Figure 1. The row units grouped in control sections to implement an active downforce setting

Each section was installed with a hydraulic pressure sensor to measure the real-time hydraulic oil pressure applied during planting operation. Oil pressure readings will indicate the hydraulic system applying constant pressure on row units thus maintaining a constant downforce during planting. Control sections 1, 2 and 4 were fitted with transducers having a measuring range between 0 to 25 mPa with an output signal of 4 to 20 mA (HDA 844L-A-0250-161, Hydac, Glendale Heights, IL, USA) while control section 2 was equipped with a transducer with measurement ranges from 0 to 52 mPa with an output signal of 0.5 to 4.5 Vdc (Model KM41, Ashcroft Inc., Stratford, CT, USA).

A seed sensor (Hy Rate Plus, Dickey-John Corp., Auburn, IL, U.S.A.) was placed along the seed tube on each row unit to provide feedback on seed singulation, doubles and misses shown in field computer. Accelerometers (Model 3741E1210G, PCB piezotronics, Depew, NY, USA) were mounted on row unit one for each control section to record row unit vibration during planting. A potentiometer (Model 424A11A090B, Elabou sensor Technology Inc., Waukegan, IL, USA) was mounted on the planter toolbar to measure the planting position. Location and ground speed were recorded using a sub-inch accuracy GPS unit (GR5, Topcon Positioning Systems, Inc., Livermore, CA, USA). Signals from the load cells, pressure sensors, accelerometers, potentiometer and GPS were collected at 10 Hz sampling frequency using a custom-made LabVIEW program.

Study area and field layout

The study was performed in a production cornfield located near Clay Center (39.304310, -97.000470). The field is a 72.8 acre no-till with cover crop. Test plots were arranged in a split-plot design structure where downforce was randomly assigned to the whole plot and ground speed were randomly assigned to each subplot. Two load levels of active downforce were selected which will implement low and high downforce based from producer's preference. Target gauge wheel load (GWL) was set at 140 lb to implement an active low downforce setting, referred herein as "D1" and GWL was set at 220 lb to implement an active high downforce setting, referred herein as "D2". Four levels of ground speed were selected, 4.5 mph, 6.0 mph, 7.5 mph and 10.0 mph, referred herein as S1, S2, S3 and S4, respectively.

Data collection

A seeding rate of 34,000 seeds per acre was applied which corresponds to a target spacing of 7 inches (18 cm) while seeding depth was set at 2 inches. Seeding depth and plant spacing was collected for every plant along a randomly selected row across each pass for every subplot. The length of each row or test strip was 17.5 feet equivalent to 1/1000th acre for a row width of 30 inches. Plant spacing was measured after emergence was considered complete. A 7.6-meter (25-feet) standard measuring tape was laid out along 17.5 feet test strip and recorded the accumulated plant spacing measurements. Plant spacing uniformity were quantified using indices defined by the ISO 7256/1-1984(E) using 18 cm (7 inches) as the theoretical plant spacing. These are multiples index, miss index, quality of feed index and precision. Seeding depth was collected by manually excavating emerged plants and look for the seed then measuring the distance between the ground surface and the seed. Gauge wheel load and acceleration on every test strips were also collected from the machine data recorded during planting.

Statistical analysis

Analysis of variance (ANOVA) was conducted by using the PROC GLIMMIX in SAS University Edition (2017 version, SAS Institute Inc, Cary, NC, USA) to determine significance of main treatments. Statistical comparisons among means were done using Fishers protected (Least significant difference) LSD test at 95% confidence interval with an alpha value of 0.05.

RESULTS AND DISCUSSION

Gauge wheel load and row unit acceleration

Figure 2 shows row unit acceleration and gauge wheel load as influenced by downforce setting and ground speed. Results indicate the system was able to implement the desired levels of GWL for each setting as shown by nearly uniform GWL at slower ground speeds. GWL begins to decrease as speed increased to 7.5 mph at D1 and at 6 mph at D2. This reduction on GWL can be influenced by the increasing row unit acceleration with increasing ground speed. Staggenborg et al. (2004) reported that faster planting speed are likely to increase row unit bounce Too much row unit bounce could influence seed placement uniformity as seed tends to bounce around the seed tube before dropping into the trench. Likewise, reduction of GWL at faster ground speed could suggest seeding depth could be compromised. Such results suggest selection of higher downforce settings to implement the desired level of GWL when ground speed is increased to 6 mph or above on no-till field under study to achieve the desired seed placement consistency.

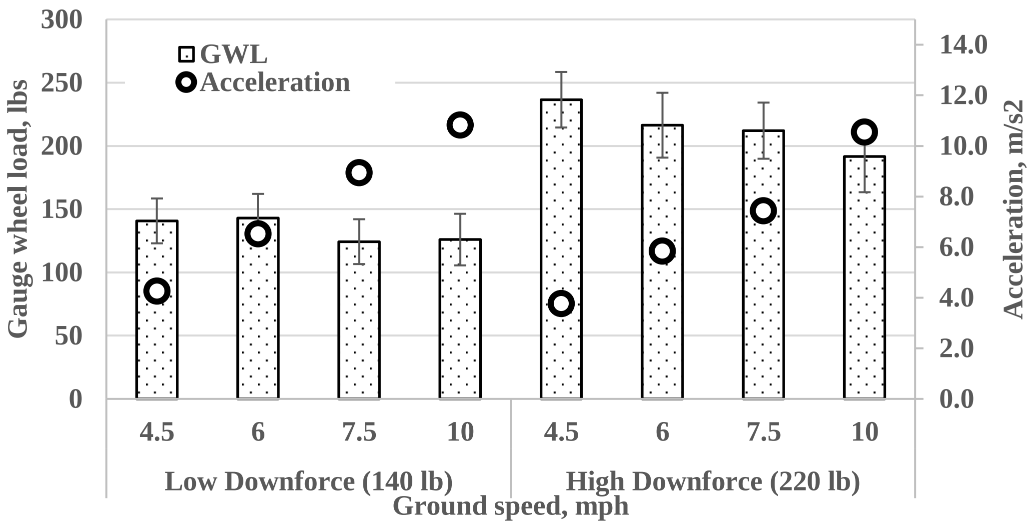

Figure 2. Gauge wheel load and acceleration on each downforce setting at increasing ground speed

Plant spacing and seeding depth

Figures 3 and 4 shows that mean plant spacing and plant spacing uniformity indices were not influenced by level of downforce setting applied. Although plant spacing variability (PSV) on D2 was a little outside the acceptable precision of 6.7 cm for mechanical planting (Liu et al., 2004) suggesting the decrease in GWL at 6 mph ground speed could have influenced plant spacing subsequently resulting to higher incidence of missed and double planted seeds.

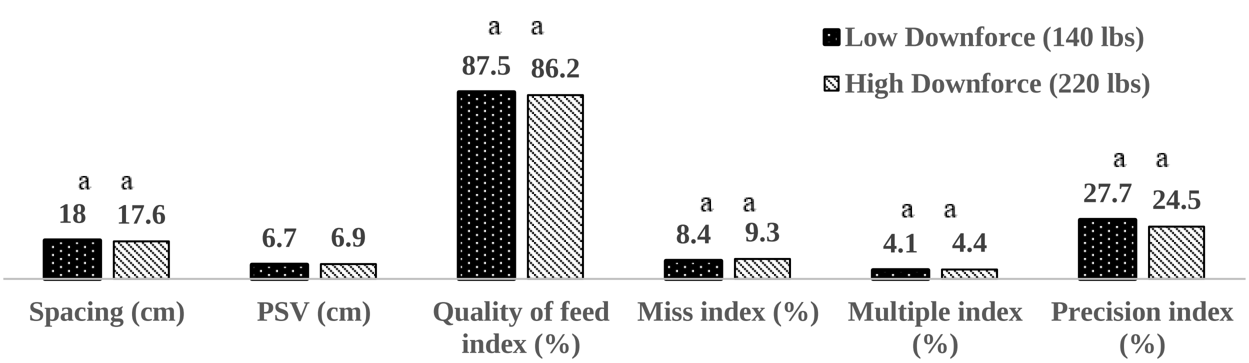

Figure 3. Mean plant spacing and plant spacing uniformity indices as influenced by downforce setting. Similar letters indicate no significant difference.

Ground speed affected plant spacing uniformity. Mean plant spacing was significantly higher at 10 mph with PSV increasing as ground speed increases. Previous studies have reported similar findings (Nafziger, 2009, Staggenborg et al., 2004 and Nielsen, 1995). Too much row unit bounce could have caused seeds to bounce along the seed tube and furrow resulting to consistent decrease in plant spacing uniformity as ground speed increased from 4.5 mph to 10 mph. Such results suggest that downforce setting D1 may be enough to achieve the plant spacing uniformity comparable to downforce setting D2 on no-till field under study. However, achieving the desired plant spacing uniformity may require higher downforce setting when ground speed is 6 mph or higher.

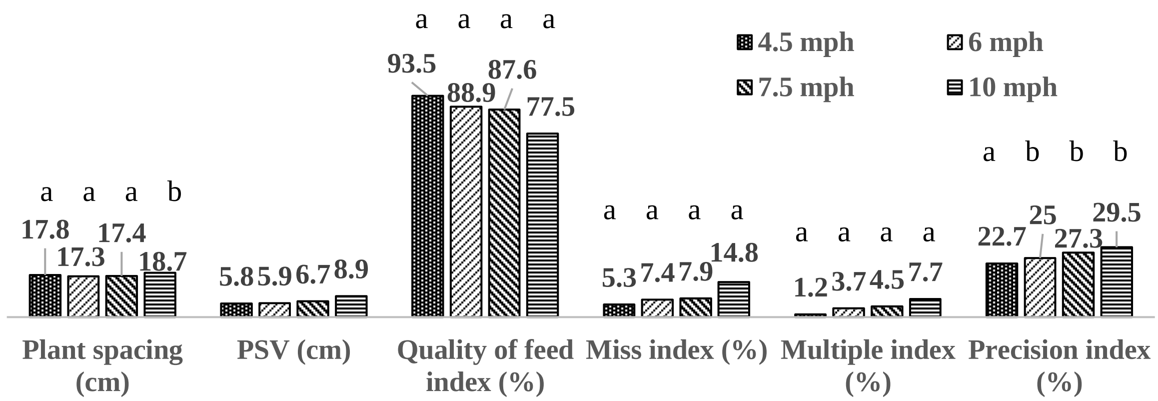

Figure 4. Mean plant spacing and plant spacing uniformity indices as influenced by ground speed. Similar letters indicate no significant difference.

Target seeding depth was achieved by both downforce setting at 4.5 mph but continuously getting shallower as ground speed increased from 6 mph to 10 mph (Figure 5). On average, downforce setting D2 resulted to higher seeding depth but results suggest selected downforce settings may not be able to provide enough load for the disc openers in creating the furrow at the desired depth in a no-till field under study. Moreover, crop residue and cover crops could reduce seeding depth (Buchholz et al., 1993) as compressed material may create space between gauge wheels and ground surface resulting to shallower seeding depths (Morrison and Gerik, 1985).

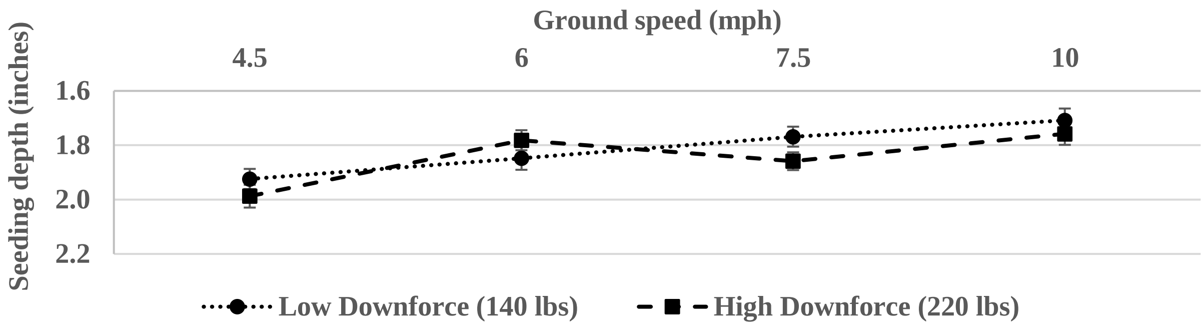

Figure 5. The influence of downforce setting and ground speed on seeding depth

Results suggest seeding depth tends to become shallower at faster ground speed indicating a decrease in rolling resistance prevented the opening disc from penetrating the soil at the desired depth. Thus, selection of a higher level of downforce could prevent the possible loss of ground contact due to increased row unit bounce that may resulted in shallower seeding depth and non-uniformity in plant spacing.

CONCLUSIONS

Results of the study revealed the following conclusions:

First, the downforce system was able to implement desired gauge wheel load (GWL) at slower ground speeds. Increasing ground speed from 4 mph to 10 mph revealed increasing row unit acceleration which are likely to increase vibration on the seed metering unit potentially affecting its ability to singulate seeds effectively. Second, downforce settings D1 and D2 did not influence plant spacing. Plant spacing uniformity decreases at 10 mph suggesting that seed placement is compromised at high speed due to increased row unit bounce causing the seeds to bounce along the seed tube and in the furrow during planting. Finally, seeding depth was affected by downforce setting and ground speed. Both downforce settings achieved the desired seeding depth at 4 mph but consistently getting shallow as ground speed increases Such result indicate that the field under study requires higher downforce selection especially at faster ground speed allowing opening discs to have enough load in penetrating the soil and compressing crop residue and cover crops to achieve the desired seeding depth and seed placement consistency.

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The War on Weeds

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There are many weed species that can be difficult to control in our fields, but often Palmer amaranth is listed first and most challenging. There are a number of characteristics that make Palmer amaranth a formidable opponent in crop production. Its origins are in the desert southwest and northern Mexico, resulting in drought tolerance. It is a dioecious plant, meaning there are both male and female plants. This forces crossbreeding and high genetic diversity within the population. It is also a prolific seed producer, with over 500,00 seeds per plant. The emergence pattern of Palmer amaranth seems to be continual throughout the growing season, with seedlings being found before a killing freeze. Finally, it is highly competitive with crops and can reduce crop yields. In a K-State study, Palmer at a density of 3 plants per 10.7 sq ft reduced corn yields by 13-30%.

Herbicide resistance with Palmer amaranth has been well documented in Kansas. Atrazine and ALS-resistance is widely found and farmers now plan herbicide programs with HPPD-inhibitors and glyphosate resistance in mind. In the last year, two Kansas Palmer amaranth populations were discussed with resistance to multiple herbicide sites of action, including resistance to post emergence applications of growth regulator herbicides (Figure 1).

Manhattan population (Dallas Peterson)	**Barton Co population (Vipan Kumar)**
Auxin-type – (4)[1] 8- to 10-fold resistance to 2,4-D 81% survival to dicamba (0.5 ae/a) HPPD-inhibitors – 3 oz mesotrione (27) 88% survivors PPO-inhibitors– 10oz lactofen (Cobra) (14) 69% survivors *Highly suspected resistance to:* ALS-inhibitors (2) Photosystem II inhibitors – atrazine (5) EPSPS synthase inhibitors – glyphosate (9)	2,4-D 3.2-fold (4) Glyphosate 11.8-fold (9) Glean 5.0-fold (2) Atrazine 14.4-fold (5) Mesotrione 13.4-fold (27) *Reduced sensitivity:* Flexstar (fomesafen) 2.3-fold (14 – PPO Inhibitors) All herbicides were applied at typical field use rates

[1] Numbers in parenthesis denote the herbicide site of action

Figure 1. Kansas Palmer amaranth populations with resistance to multiple sites of action (2019).

Because of this, there has been increased emphasis put on integrated weed management. This includes utilizing elements of chemical control, biological control, cultural control, and mechanical control. The goal is to gain a competitive advantage on the weeds, by using multiple tactics. However, with any type of weed control, there are benefits and challenges (Table 1).

Table 1. Benefits and challenges with components of integrated weed management plans.

	Examples	Positives	Negatives
Chemical Control		Know pretty quick if works Have equipment Familiar with it	Herbicide resistance Increased costs with multiple sites of action
Biological Control	bacteria fungi insects	Fair amount of research going on	Can be at the whim of Mother Nature (resulting in variable control)
Cultural Control	row spacing crop rotation cover crops planting dates	Some methods may be relatively easy to implement Could help with other pests	Can be at the whim of Mother Nature May not be economical Can be time consuming
Mechanical Control	tillage hoeing burning harvest weed seed	Can be thought of as relatively inexpensive Create seed bed Fertilizer applications	Can be thought of as relatively inexpensive Potential to lose soil moisture Lose/dislodge residue

Recent research at K-State has shown the interactions of multiple weed control tactics can be challenging to unravel. Hay et al. studied the single components and interaction of the components of an aggressive herbicide program, in-crop cultivation, use of cover crops, and narrow row spacings in both double-crop sorghum and soybeans in eastern Kansas. Here are some of the key points from the sorghum portion of the research:

- The herbicide program component provided the most effective pigweed control in contrast to the cultural and mechanical components considered. The success of the aggressive program was likely due to the use of overlapping residuals, multiple effective sites of action in each application, and the timeliness of all applications.
  - Pre- followed by post-emergence herbicide applications provided better pigweed control than preemergence applications alone.
  - Layering herbicides with residual activity (long chain fatty acid herbicides, like s-metolachlor) in both pre- and post-emergence applications were most effective for control.
- Row-crop cultivation was the most effective component outside of the herbicide program and provided 79% reduction in pigweed density by 3 WAP (weeks after planting) when implemented at 2.5 WAP.
- Pigweed control with the cover crop component had mixed results. While half of the site-years resulted in approximately 50% reductions in Palmer amaranth density and biomass in both early and late season observations, the other site-years resulted in no change or greater densities of Palmer amaranth and waterhemp. Further investigation is needed.
- Pigweed control by 3 WAP was not influenced by narrow row width and would not reduce the selection pressure on pigweed from POST herbicide applications.

Reduced pigweed biomass by 8 WAP illustrated the potential benefit of narrow rows because less seed production is likely from pigweed escapes.

- Integrating the use of narrow row width or row-crop cultivation together with an herbicide program will achieve consistent control of pigweed and reduce the risk of evolving herbicide resistance.

Prevention is a key component and overarching piece of the weed management puzzle. This has been proven as farmers learned to manage glyph0sate resistant kochia. Preventing kochia emergence is a key point because of the lack of effective postemergence herbicide options. However, preventing Palmer amaranth emergence is a little more challenging than preventing kochia emergence. The majority of kochia emergence is in a relatively short period in early spring. However, Palmer emergence can continue season long, after beginning in early- to mid-May. Many times, there is a flush of Palmer emergence after a rainfall event. Because of this, there is pressure on preemergence herbicides later in the growing season.

The concept of overlapping residuals stems from the need of preventing weed emergence during a majority of the growing season. The use of overlapping residual herbicides includes applying a preemergence herbicide with residual activity and following it up with another herbicide with residual activity postemergence (in the growing crop). Therefore, providing an herbicide barrier to prevent weed emergence through a great deal of the growing season (Figure 2).

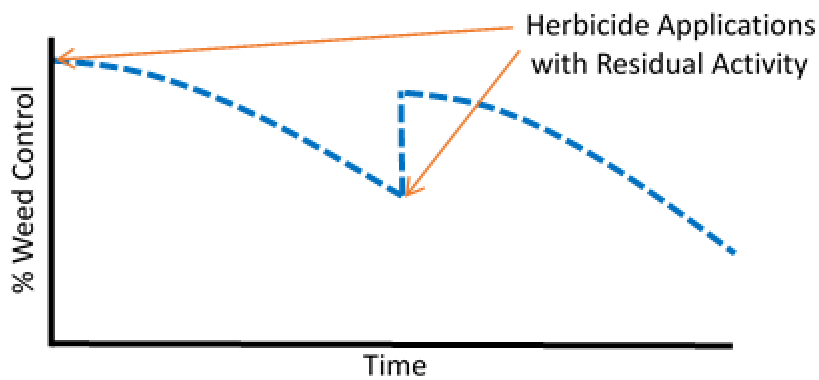

Figure 2. Weed Control over time with overlapping residual herbicides.

The challenge with planning for overlapping residuals is the question of the length of residual activity of the first herbicide. Herbicide soil persistence or residual life is the length of time a herbicide remains active in a soil. The soil persistence of a herbicide is often stated as 'half-life', which is the amount of time it takes to decompose 50% of the applied chemical to an inactive form. However, the 'half-life' is determined in a laboratory, so may vary under field conditions. There are several factors contributing to the length of residual herbicide activity in the field. Herbicide persistence in the soil can be affected by: microbial degradation, chemical composition of the herbicide, soil adsorption, volatilization, photodecomposition, plant uptake and metabolism, leaching, and surface runoff.

In addition, the susceptibility of a weed species will play a role in residual weed control. For example, a less susceptible weed species will need more herbicide concentration in the soil to prevent emergence. Whereas, a more susceptible weed species will be controlled with a lower concentration in the soil (Figure 3).

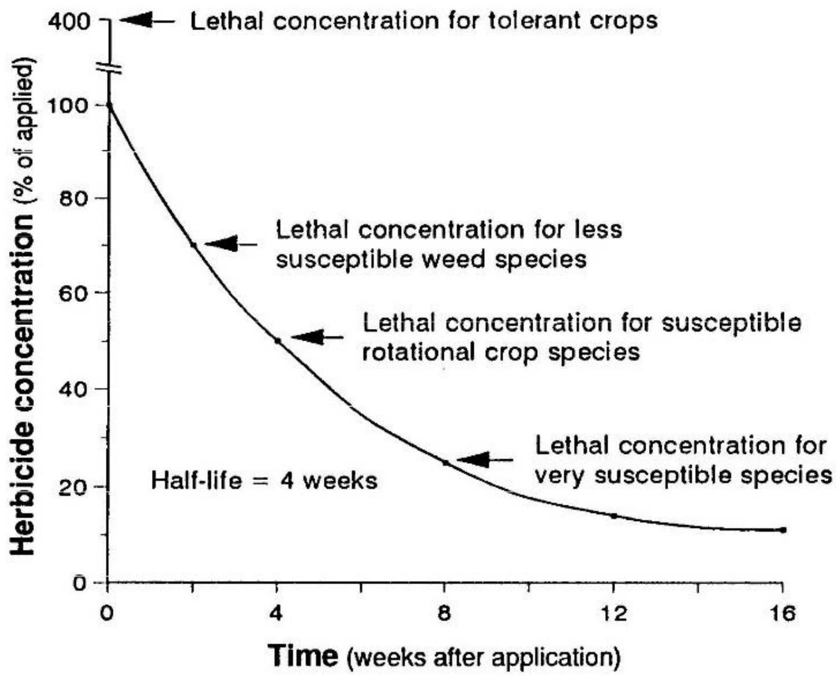

Figure 3. An example of how half-life and herbicide residues affect weed control and rotational crop injury. From K-State Residual Herbicides, Degradation, and Recropping Intervals (C-707)

For corn, there are several herbicides that can be applied after corn emergence, provide residual herbicide activity and are rated excellent on *susceptible* pigweeds. Many of the herbicides include the active ingredients (but are not limited to): s-metolachlor (15), atrazine (5), mesotrione (27), pyroxasulfone (15), dicamba (4), tembotrione (27), rimsulfuron (2), and topyralate (27). Many residual products that farmers are currently applying as an early postemergence application contain a combination of these products. Many are relying heavily on s-metolachlor, atrazine and mesotrione. As discussed earlier, each herbicide has different residual activity and is affected by weather and microbial activity. The half-life of herbicides range from 12 days to 2- to 4-months for mesotrione and s-metolachlor, respectively. It is important to note, weed and corn size restrictions for some of these products are relatively small. For example, Harness Max (acetochlor+mesotrione) may be applied to corn up to 11 inches tall and before weeds exceed 3 inches tall. However, others allow for larger corn. For example, Acuron Flexi (s-metolachlor+mesotrione+bycyclopyrone) allows application up to 30 inches tall, up to the 8 leaf growth stage and will control susceptible Palmer less than 3 inches tall. Some of these products do not have activity on emerged weeds (s-metolachlor), so an effective post herbicide should be included in the tank mix. In addition, rainfall/irrigation is important to the efficacy of many of these herbicides. Many restrictions and guidelines are listed in the K-State Chemical Weed Control Guide. Be sure to check the individual herbicide labels for rates, size restrictions, crop rotation restrictions and moisture activation requirements.

One place in a wheat-corn-fallow rotation that weed control really seems to struggle is the late summer after wheat harvest. Many spring herbicides provide a long residual, are relatively inexpensive and relied on heavily by farmers. They include triasulfuron (Amber; triasulfuron+dicamba = Rave) and metsulfuron (Ally; chlorosulfuron+metsulfuron = Finesse). These are both ALS-inhibiting herbicides (group 2). These herbicides provide good to excellent control on many winter annuals, but may not provide a great deal of help on Palmer amaranth. Recent research in western Kansas showed spring applications of ALS-inhibitors (some tank mixed with growth regulators) provided less than 70% control of Palmer amaranth after harvest. This is because ALS-inhibiting herbicide resistance, as both preemergence and postemergence applications, is very prevalent in Palmer amaranth populations. Therefore, herbicide programs relying on other herbicide sites of action will provide better control of Palmer. These may include metribuzin (Sencore), dicamba, and pyroxosulfone (Zidua). However, these herbicides may not provide as good of control on the winter annuals, like tansy mustard. In addition, after harvest, paraquat is a popular burn down treatment. However, it provides no residual weed control.

It is important to note that residue, an effective preemergence herbicide program followed by an effective postemergence treatment, and a good crop stand can provide good weed control. This plan gives the crop the competitive advantage by keeping weed seed in the dark (many species need light to germinate), preventing emergence with effective preemergence herbicides and competition for the later emerging weeds.

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SPRINKLER IRRIGATED CORN EFFICIENCY AND PROFITABILITY COMPETITION

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INTRODUCTION:

The Testing Ag Performance Solutions (TAPS) program hosts farm management competitions that promotes profitability and efficiency through peer-to-peer interaction. The program, which started at the West Central Research, Extension, and Education Center in North Platte, Nebraska, is now being hosted in several locations including North Platte, NE, Eva, OK, and Sidney, NE. This innovative & unique program was developed to enhance the engagement of crop producers at a high level around resource use efficiency and profitability by providing a common platform for peer-to-peer learning with participation by scientists and industry personnel. The TAPS competitions are hosted in central locations where growers compete against each other as well as against University extension educators within the same field for most profitable and highest use efficiency for water and nitrogen (N) fertilizer. Each team is provided 3 randomized plots within the field and all management decisions (descriptions below) are implemented by the TAPS team.

The TAPS program concluded its third year in December of 2019 with three successful competitions at North Platte, NE, which included 24 teams in the sprinkler corn competition, 16 teams in the inaugural subsurface drip irrigated (SDI) corn competition, and 10 teams in the irrigated sorghum contest. Over 150 participants hailing from four states made up the 50 teams to compete in this year’s competitions. Although primarily targeting crop producers, the TAPS competition offers a unique chance for those not otherwise involved in day-to-day crop management to gain a better understanding of the complex decisions producers must make when growing a crop. Teams from the Nebraska Department of Natural Resources as well as employees of Natural Resources Districts and undergraduate students from two colleges competed alongside producers in 2019. In addition to the North Platte competitions, the program also expanded in 2019 to include a sprinkler irrigated corn competition near Eva, OK, and a winter wheat competition near Sidney, NE. However, this report will focus on the sprinkler irrigated corn competition from North Platte, NE, but we encourage readers to visit the TAPS website to learn more about the other competitions.

MANAGEMENT DECISIONS

The contestants were responsible for six types of management decisions, including irrigation scheduling; nitrogen fertilizer amounts and application (via pre-plant, side-dress and fertigation); corn hybrid selection; seeding rate; crop insurance selection; and marketing choices of their grain yields. Each team's decisions were made utilizing an online portal (www.taps.unl.edu) and were implemented in the field on three randomized plots for each team (Figure 1). All farm plots were managed by University personnel. The yields and costs from each farm were amplified to represent 3,000 harvested acres (i.e., average grain yield per acre of the contestant plots was multiplied by 3,000). This amplification provided the opportunity to market an amount of grain that was more representative of a modern-sized farm. Each team had access to a number of new and emerging technologies provided by industry partners, such as sensors, models, and imagery, to aid their decision-making process in real-time. A short description of each management decision is provided below.

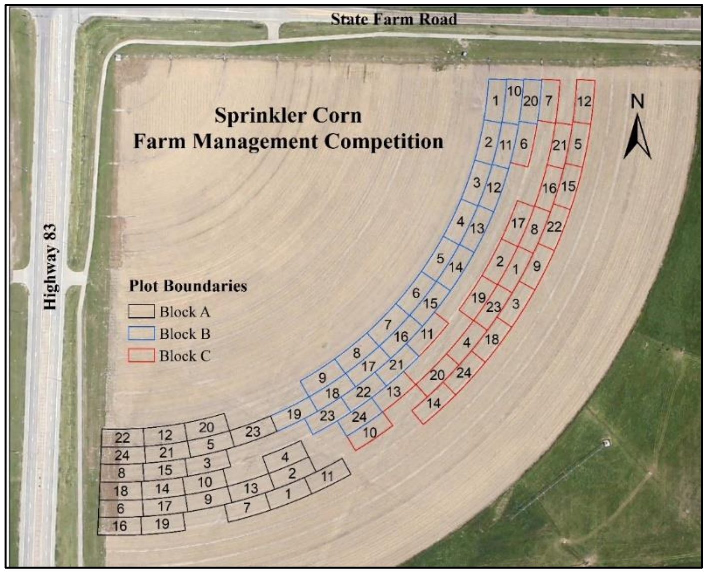

Figure 1. Plot layout for the 2019 Corn Farm Management Competition held at the West Central Research and Extension Center in North Platte, NE. Each team had a randomized plot located in blocks A, B, and C. The background Airscout imagery was collected by Flying M Aviation.

Irrigation Management – Irrigations were applied using a Zimmatic by Lindsay Variable Rate Center Pivot and the system was operated every Monday and Thursday throughout the growing season. The participants had until 10 AM on the irrigation days to submit their irrigation decision via their password protected online portal. If participants failed to indicate their intent to irrigate by 10 AM, no irrigation was applied on that irrigation day. Irrigation depth per application could be between 0 and 1.0 inch in intervals of 0.05 inches. The variable cost to pump an acre-inch of water was $7.80.

Nitrogen Management – Participants had to decide on the amount of pre-plant and/or in-season (via side-dress and/or fertigation) nitrogen (N) fertilizer in the form of UAN 32%. All plots received a baseline 5 gallons per acre of starter fertilizer (10-34-0) at time of planting. Pre-plant and side-dress N was applied using a double-coulter liquid applicator that dribbled UAN 32% at an approximate depth of 1 inch and at a distance of 5 inches from the center of the crop row on both sides. However, in 2019 side-dress N was applied at the crop surface neighboring each crop row using 360 Y-DROP (360 Yield Center, Morton, IL). Fertigations were applied through the center pivot using a variable rate injection pump (Agri-Inject, Yuma, CO) that maintained the system concentration as the irrigation system flow rate changed. Maximum application amount allowed was 180 lbs acre^{-1} for pre-plant, 180 lbs acre^{-1} for side-dress, and 30 lbs acre^{-1} for each fertigation event (i.e., total possible fertigation amount was 120 lbs acre^{-1}). Pre-plant, side-dress (V4-V6), and four fertigation events (V9, V12, VT/R1, and R2) were made available to the participants. A custom application cost of $7.00 per acre was charged for the pre-plant and side-dress applications and $1.00 per fertigation application.

Hybrid Selection and Seeding Rate – Participants were responsible for selecting a hybrid as well as seeding rate. District sales managers (DSMs) of multiple seed companies (Arrow, Big Cob, Channel, Dekalb, Dyna-Gro, Fontanelle, Hoegemeyer, Pioneer, Seitec, Stine) provided a recommended hybrid and seeding rate list for the competition field. Participants had the option of selecting a DSM recommended hybrid or they could supply their own seed. The competition field was picked when the majority of hybrid reached 17% moisture content, which was the upper moisture content allowed at the elevator at time of corn harvest. At time of harvest, all hybrids were charged a drying cost of $0.04 per point per bushel above 15.5% moisture content.

Grain Marketing – Participants were given the following options to market grain: spot (cash) sales, forward contract, basis contract with delivery at harvest, simple hedge to arrive, and futures contract. Marketing was allowed between mid-march and mid-November each year. Participants were not allowed to speculate.

Crop Insurance – Participants were allowed to select a coverage package from the following options: Revenue Protection (either enterprise or optional units), Revenue Protection with Harvest Price Exclusion (either enterprise or optional units), and Yield Protection (either enterprise or optional units) at the levels of 65, 70, 75, 80, or 85%. These rates were for the Universities farm located at North Platte, NE. Hail and wind coverage options were also available. Indemnity payments were based on estimated field loss from selected farms surrounding the competition field.

Other Management Decisions – All other management decisions, such as pesticide use, tillage, residue management, etc., were fixed by the University and were the same for all plots (i.e., farms). The actual physical management such as the operation of machinery, irrigation system, application of chemicals, and harvesting was conducted by University staff. Participants were allowed to observe, install their own equipment and/or collect additional data from their plots throughout the growing season at their own expense. However, no additional inputs, such as fertilizers, additives, etc. were allowed to be applied to the individual plots.

Technology – From the beginning, a main goal of the TAPS program was to provide an opportunity for competitors to use innovative technology and services in a no-risk environment to see if they can bring value to their operation. Participants had access to a variety of technology to make better informed production and marketing decisions. The technology provided to the contestants ranged from in-field and edge-of-field instrumentation, to imagery products, to sophisticated crop management models, and beyond. In addition, contestants had access to a number of ag services and recommendations provided by commercial soil labs (e.g., Ward Laboratories, Inc.), district sales managers from numerous seed companies, among others.

DESCRIPTION OF AWARDS

Participants competed for three awards, 1) Most Profitable Farm, 2) Highest Input Use Efficiency, and 3) Greatest Grain Yield. Cash awards of $2,000, $1,000, and $500 (minus penalty) were granted to the winners, respectively. The highest input use efficiency was calculated as the Water-Nitrogen Intensification Performance Index (WNIPI, Lo et al., 2019):

$$WNIPI = \frac{\left(\frac{Y_{Farm} - Y_{Control}}{Y_{Control}}\right)}{\left(\frac{ET_{Control} + I_{Farm}}{ET_{Control}}\right) \times \left(\frac{ANU_{Control} + N_{Farm}}{ANU_{Control}}\right)} \qquad \text{Eq. (1)}$$

where, "control" is a "farm" managed by UNL that receives no irrigation or N fertilizer (except for 10-34-0 at planting), "ET" is seasonal evapotranspiration, "I" is seasonal irrigation, "N" is total seasonal applied nitrogen, and "ANU" is aboveground nitrogen uptake. The farm with the highest value was determined the winner.

RESULTS AND DISCUSSION

Weather Conditions

The TAPS site received above normal rainfall in 2017, 2018, and 2019 (figure 2). The seasonal rainfall from May 1 to Sept. 30 was 18.2, 14.9, and 21.2 inches (Nebraska State Climate Office (https://nsco.unl.edu/)), which exceeded the long-term (1986-2015) average rainfall of 12.5 inches (High Plains Regional Climate Center's Automated Weather Data Network (HPRCC-AWDN; www.hprcc.unl.edu/awdn). The 2017 growing season was relatively dry; however, three dates (July 29, August 13, and September 24) had rainfall that exceeded 2 inches per day with a cumulative total of 8.5 inches. Whereas, the 2018 and 2019 growing seasons had more frequent rainfall than 2017 and exceeded the long-term average most of the growing season.

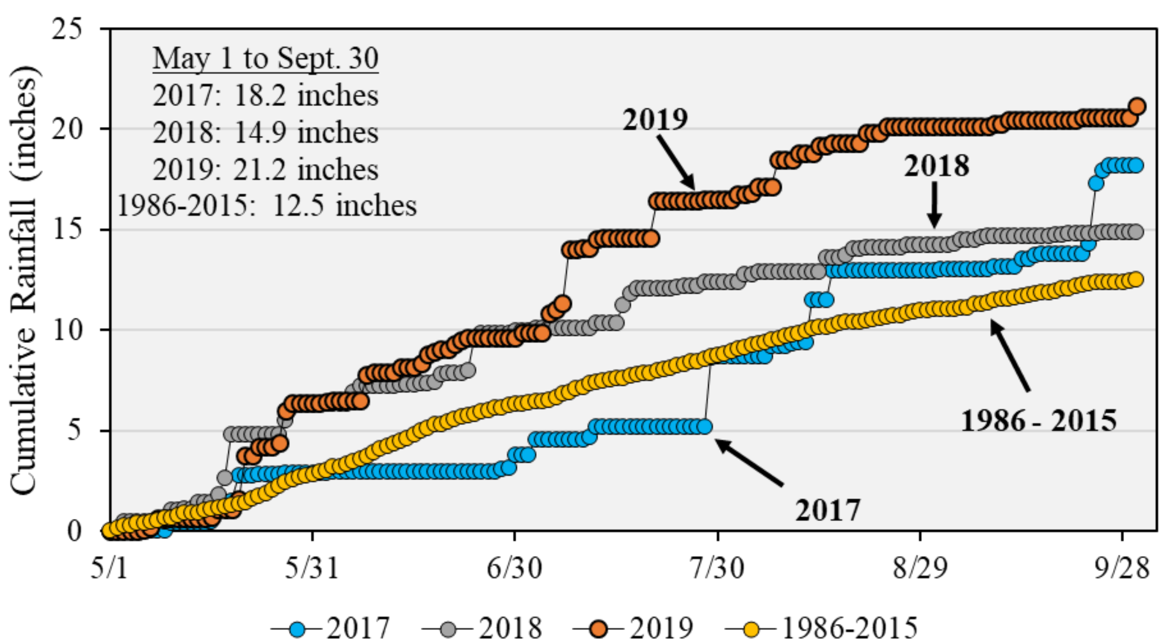

Figure 2. Cumulative rainfall (inches) from May 1 to Sept. 30 for 2017, 2018, 2019, and long-term (1986-2015) at the field site in North Platte, NE.

Management Decisions

Corn was planted on May 9, May 1, and May 13 in 2017, 2018, and 2019, respectively, using a six row precision planter. There were 9, 12, and 15 different hybrids selected across the contestants in 2017, 2018, and 2019, respectively. The cost among these hybrids ranged from \$182 to \$334 per unit (i.e., bag). Statistics describing the differences in decisions made among growers for seeding rate, irrigation, and N fertilizer in 2017, 2018, and 2019 are presented in Table 1. The requested seeding rate per acre ranged from 28,000 to 34,500 in 2017, 26,000 to 34,000 in 2018, and 29,000 to 35,000 in 2019 (Table 1). Although there were differences in seasonal rainfall (Figure 2) and climatic conditions across years, the average and median applied irrigation was similar between 2017 and 2018. Furthermore, the maximum amount of irrigation applied by a contestant was similar across all years with 10.75, 11.70, and 9.90 inches applied in 2017, 2018, and 2019, respectively. In all three years, the spread in total applied N fertilizer ranged more than 95 lbs acre^{-1} with 2019 having the largest application depth of 270 lbs acre^{-1}. However, the median total N fertilizer applied was similar across years ranging between 180 and 190 lbs acre^{-1}, which was close to the recommended seasonal N fertilizer requirement provided to the growers by a commercial soils lab (Ward Laboratories, Kearney, NE). Interestingly, all teams in all years opted to split apply their N fertilizer with all teams applying at least 30 lbs acre^{-1} as fertigation. Though, there were considerable differences in pre-plant versus side-dress applications among the teams. We encourage the reader to visit the TAPS.unl.edu website to download the TAPS reports to obtain a more detailed and complete description of the production and economic decisions made by the participating teams.

Table 1. Descriptive statistics (minimum, median, mean, and maximum) of the various production decisions made by the contestants in 2017, 2018, and 2019.

	Seed Rate	Irrigation	Nitrogen Fertilizer (lbs/acre)			
Statistic	**(Seeds/acre)**	**(inches)**	**Pre**	**Side-dress**	**Fertigation**	**Total**
2017						
Minimum	28,000	2.50	0	0	30	145
Median	33,250	6.93	80	48	80	180
Mean	32,429	6.78	73	43	76	192
Maximum	34,500	10.75	140	125	120	240
2018						
Minimum	26,000	1.05	0	0	30	130
Median	33,000	6.55	60	40	90	190
Mean	32,184	6.88	57	42	88	186
Maximum	34,000	11.70	100	100	120	225
2019						
Minimum	29,000	0.30	0	0	30	140
Median	33,000	3.30	50	40	90	180
Mean	32,717	3.68	59	45	83	187
Maximum	35,000	9.90	180	150	120	270

Grain Yield and Efficiency

There were noticeable differences in grain yield response across the producer teams with yield ranging from 210 to 261 bu acre^{-1} in 2017, 222 to 289 bu acre^{-1} in 2018, and 193 to 241 bu acre^{-1} in 2019. In general, grain yield had a positive response to irrigation when pooling all years with a coefficient of determination (R^2) of 0.36; however, this response was weakened when looking at the individual years. Conversely, seasonal N fertilizer had zero response (R^2 of 0.01) on grain yield when pooling the growing seasons, but had a minor positive response in 2018 with a R^2 of 0.34. Interestingly, when observing neighboring studies at the research center a positive response to irrigation was observed for each year; whereas, each year had a different response to N fertilizer. For example, an adjacent study under the same irrigation system found that seasonal N requirement for corn was 70 lbs acre^{-1} in 2017 (B.T. Krienke et al., unpublished data, 2017); whereas, the TAPS competition data showed an N requirement of approximately 200 lbs acre^{-1} in 2018. The authors suspect the poor relationships observed between grain yield and irrigation and N fertilizer of the TAPS data are due to the influence of other attributes (hybrid selection, seeding rate, growing conditions) and their collective interactions. This emphasizes the true challenge growers' face in optimizing management practices of various inputs (seed, water, fertility, etc.). Consequently, further work is needed to better account for the individual and interacting contributions of each input, so that growers can make economically and environmentally conscientious decisions. Nevertheless, following current best management practices as well as the use of responsive technologies (soil water sensors, canopy reflectance sensors, etc.) to guide inputs as compared to solely relying on fixed or seasonal decisions can help avoid over- or under-application of inputs.

Profit vs Efficiency

Input use efficiency was quantified using the Water × Nitrogen Intensification Performance Index (Eqn. 1). The WNIPI is influenced by a grower's irrigation and N fertilizer amounts as well as their yield. Consequently, both inputs (Irrigation and N fertilizer) have to be managed well without sacrificing production to receive a high value. In other words, if one or both inputs are applied in excess the denominator will increase resulting in a lower index value; whereas, if yield is suppressed due to under application of an input the numerator will decrease resulting in a lower index value. Thus, as one would imagine, WNIPI tends to correlate with net income as shown in Figure 3. The hypothetical net income presented in Figure 3 assumes that all teams sold at market close, which was \$3.03, \$3.26, and \$3.65 per bushel in 2017, 2018, and 2019, respectively, thus removing the influence of marketing strategy from the data. The relationship between WNIPI and net income had a pooled (i.e., 2017, 2018, and 2019) R^2 of 0.62; however, 2017 and 2018 were nearly an extension of each other and if combined had a R^2 of 0.91. The 2019 growing season had higher WNIPI relative to Net Income as compared with 2017 and 2018. This, in part, was attributed to an extremely low control treatment which resulted in an average yield of 90 bu acre^{-1}. Although yields were down in 2019 as compared with 2017 and 2018, the lower productivity of the control treatment will have a direct impact on the magnitude of WNIPI. In addition, differences in operating costs and performance of hybrids relative to inputs can also impact this relationship. Nevertheless, the TAPS data highlights that efficient input management as measured by WNIPI can position growers to be more profitable, and thus growers should consider management strategies and practices that will enhance input use.

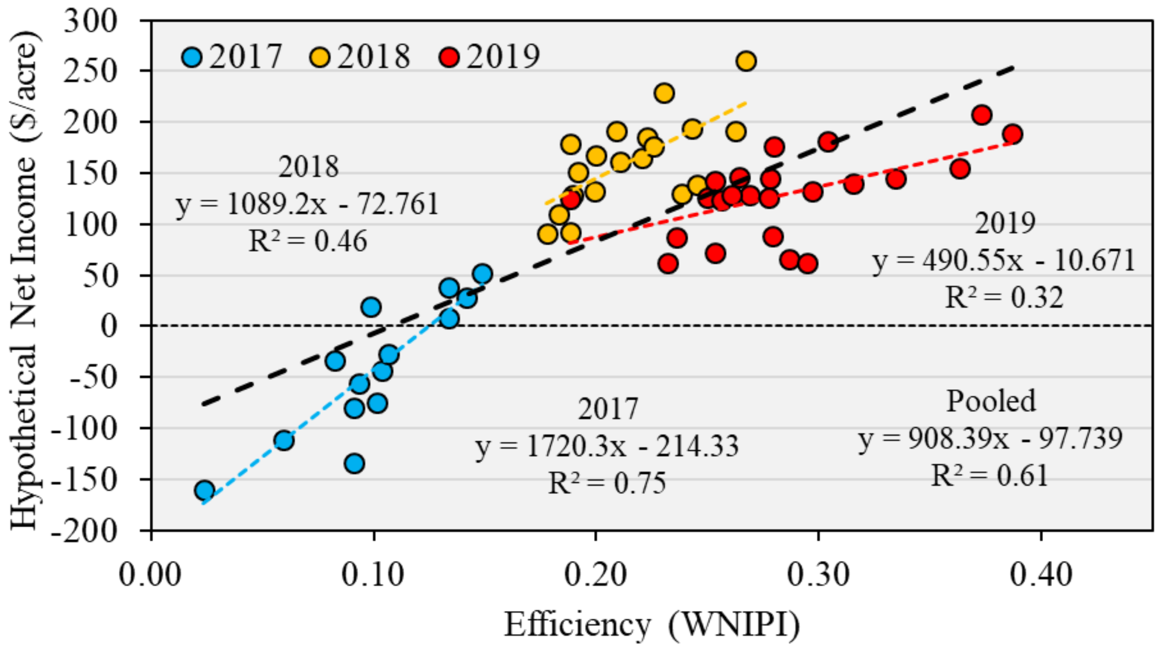

Figure 3. Relationship between the Water × Nitrogen Intensification Performance Index (WNIPI) and hypothetical net income ($/acre) for the 2017, 2018, and 2019 TAPS sprinkler irrigated corn competition. Hypothetical net income was calculated as if all teams sold at the end of the competition (i.e., removing the influence of marketing strategy on profit).

CONCLUSIONS

The TAPS Farm Management Competitions provide insight into various management strategies that can lead to profitable and efficient grain production. In addition, the competitions highlight the challenges associated with accounting for and managing various inputs. This proceedings article serves as a brief summary of the management decisions made and the resulting outcomes of the sprinkler irrigation corn competition hosted in North Platte, NE, from 2017 to 2019. The authors encourage the reader to visit the TAPS website at taps.unl.edu to learn more about the program and to find further insights into the data collected.

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From Sustainable to Regenerative: Exploring an Emerging Trend in the Food Industry

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Introduction

When General Mills announced its commitment to advance regenerative agriculture on 1 million acres by 2030 back in early 2019, it prompted a lot of questions. Why would a major food company champion this emerging paradigm in agriculture? How does General Mills plan to meet this commitment? And what is regenerative agriculture anyway? For General Mills, the Million Acre commitment was the result of a several years of exploration and learning about soil health. Broader trends in the food and agriculture industries suggest General Mills' commitment to regenerative agriculture may be a sign of increasing involvement in agricultural sustainability from the rest of the food system.

From Sustainable to Regenerative

General Mills (GMI) is a global food company with 40,000 employees worldwide, annual net sales of $16.9 billion, and more than 100 brands in over 100 countries, including Pillsbury, Betty Crocker, Nature Valley, Yoplait, Cheerios, Blue Buffalo, Old El Paso, and Häagen-Dazs. The company began researching soil health back in 2015, inspired by the leaders of mission-driven brands within GMI, the need to meet public sustainability commitments, and the recognition that healthy soil might help improve the resilience of its agricultural supply chain. One of the products of this research was the Soil Health Roadmap, developed in conjunction with The Nature Conservancy, which found that improved soil health on 50% of US agricultural land could provide $1.2 billion in annual net economic gains for farmers, and $7.4 billion in water and climate benefits (Doane et al., 2016). These findings created a strong business case for investing in soil health to achieve positive environmental and economic outcomes.

These early learnings also showed the scale of environmental and economic challenges facing the agricultural sector. Agriculture has become much more efficient in recent decades, resulting in greater yields per acre of land, per hour of labor, and per pound of fertilizer. These improvements became the hallmark of sustainability initiatives, and today, “sustainability” is synonymous with efficiency across the food and agricultural industries. However, despite these efficiency gains, environmental and economic conditions are worsening. Productive soil is being lost at unsustainable rates, as 25 million acres of cropland are lost each year due to soil erosion (Pimentel, 2006). Roughly 1 million species are at risk of extinction and North America has lost more than 1 in every 4 birds in the last 50 years, in part due to habitat conversion to agricultural land that supports relatively low levels of biodiversity (IPBES, 2018; Rosenberg et al., 2019). The greenhouse gas (GHG) footprint of agriculture continues to climb year-over-year, while 80% reductions in agricultural emissions are needed by 2050 to avoid the most severe climate scenarios (Foley et al., 2011; Hunter et al., 2017).

Additionally, yield increases in recent decades have not translated to a secure farm economy, as greater yields have been supported by increased use of costly agricultural inputs. For example, the observed doubling in global agricultural production from the 1960s to the 1990s coincided with almost a seven-fold increase in nitrogen (N) inputs and a three-fold increase in pesticide use, with cascading effects for the environment and human health (Tilman, 1999; Tilman et al., 2000; Galloway et al., 2003; Gilliom et al., 2006). The cost of inputs like fertilizer, seeds, and herbicide has risen steadily since the 1960s while commodity prices have stagnated, placing a “double squeeze” on farmer profits (Van der Ploeg, 2006). Currently over half of US farm households lose money on their farm operations each year, and most farmers today cannot stay in business without off-farm income and government subsidies (Carolan, 2016; Hoppe, 2017). In addition to these long-term pressures on the agricultural economy, more frequent and intense weather events are resulting in crop yield and quality reductions that not only threaten farmer economic viability but shock the entire food system that relies on the production from those regions (USGCRP, 2017; Schipanski et al., 2018). The current paradigm of sustainability, while leading to a highly efficient system of agricultural production, has enabled these trends to persist. In order to address these major challenges, it is insufficient to sustain the current degraded state; agricultural ecosystems must be restored.

Regenerative agriculture (RA) is a paradigm in agriculture that has rapidly gained momentum in recent years. RA views the farm or ranch as an ecosystem, and frames common issues like pests, weeds, diseases, salinity, nutrient deficiencies, and poor water infiltration not as disparate problems, but collectively as symptoms of an unhealthy ecosystem. Rather than manage each symptom individually, regenerative farmers and ranchers seek to solve the core issue by fostering the healthiest possible ecosystem and repairing broken ecological cycles (e.g., water cycle, nutrient cycle, pest cycle, carbon/energy cycle). This can be achieved by following the 6 principles of RA: understand context, reduce soil disturbance, maximize plant diversity, keep the soil covered, keep a living root in the ground year-round, and integrate livestock. By restoring ecosystem function, regenerative agriculture has the potential to improve soil health, support biodiversity, and improve profitability by supporting productivity with reductions in input use (LaCanne and Lundgren, 2018; Rosenzweig et al., 2018).

Learning about the promise of RA from pioneering farmers and ranchers in the movement, and seeing farmers' success with RA in the company's own supply chains, GMI began to see RA as the key to reversing concerning trends in soil loss, climate change, biodiversity extinctions, and mounting pressures in the agricultural economy. Recognizing the existing momentum for greater attention to soil health and systems-thinking in agriculture, GMI saw the opportunity to fuel that momentum by announcing the Million Acre commitment and taking a stand as a food industry leader in the RA movement.

Advancing Regenerative Agriculture

General Mills defines regenerative agriculture as a way of farming or ranching that protects and intentionally enhances natural resources and farming communities. Given there is no standard definition of what is or is not "regenerative," the company developed a strategy to focus on outcomes-based measurements in order to could quantify positive impacts. GMI is focused on seeing improvements in three key areas: Soil health, biodiversity, and farmer economic resilience.

There is no blueprint for how a food company can best engage its agricultural supply chain in systems-level change. GMI launched several pilot programs in 2019 to test strategies for advancing RA in its primary agricultural sourcing regions. The initial pilots include GMI's oat sourcing region in the Northern Great Plains, hard red winter wheat sourcing region in Kansas, and dairy sourcing region in Michigan. All three pilots are designed to provide education on regenerative ag for farmers and agronomists in the region, support farmers who want to transition to a regenerative agricultural system, and advance the science around how these transitions impact soil health, biodiversity, and farmer profitability.

In all three pilot regions, there are many unanswered questions about how to successfully implement a regenerative system. In some parts of the Northern Plains for example, practices like cover crops and even reduced tillage are still only being tinkered with by highly innovative farmers, largely on their own without any support. GMI partnered with Understanding Ag, a nonprofit started by regenerative farmer and rancher Gabe Brown, to provide 1-on-1 technical support to the farmers. Gabe and his team of field consultants are meeting individually with each farmer to develop and implement regenerative management plans over the next 3 years. By convening a network of several dozen farmers throughout the region, all entering a regenerative system with a different approach, and connected through a Facebook group, meetings, and field days held throughout the year, the farmers will rapidly accelerate learnings around what works and what doesn't in their region.

Measuring Regeneration

Measuring the impact of these regenerative systems is a critical component of GMI's RA goals, given its outcome-based definition of RA. In addition to partnering with universities to advance the science of RA, GMI is working to quantify the impact of the RA practices in the pilot program on soil health, insect and bird biodiversity, and farmer profitability. Each farmer in the pilot programs has dedicated one field on which GMI and its research partners will be tracking these properties for the next three years, and hopefully for many years to come, to understand how transitions to regenerative systems influence ecosystem function and profitability in the short- and long-term.

Measuring Soil Health

To measure soil health, Understanding Ag is conducting in-field tests like water infiltration and collecting soil samples for a suite of soil health tests, including aggregate stability, active carbon, the Haney Test and phospholipid fatty acid analysis, which is an assessment of microbial abundance and diversity in the soil. Additionally, GMI has partnered with Applied Ecological Services to collect meter-deep soil cores for analysis of soil organic carbon stocks within each soil horizon.

Measuring Biodiversity

A key question that needs further exploration by the scientific community is what kind of biodiversity might respond to a regenerative management system. Insects? If so, what kind? Birds? Mammals? How do these organisms interact, and what ecosystem services do they provide? The challenge is that systems-level research is hard to do. Scientists are good at understanding what happens when one factor at a time is changed, for example looking at the effect of a cover crop versus no cover crop, or tillage versus no-tillage. But what happens when a farmer changes everything at once? It is hard to parse out all the potential changes to the farm ecosystem when systems-level change occurs. To study the impacts of systems-level changes, GMI has partnered with Ecdysis and Applied Ecological Services to study how the insect and bird communities are changing as a result of the regenerative practices, and how these changes are influenced by the habitat in and around the field. By conducting a bio-inventory of invertebrates and assays to measure ecosystem services in the crop fields each year, Ecdysis will study what components of the insect community are responsive to changes in cropping systems and input use, and how that might influence ecosystem services relevant to farmers like predation of crop pests and residue decomposition. Additionally, GMI is investing in technologies to rapidly accelerate the speed and scale at which these insect inventories are done. Applied Ecological Services is also conducting breeding bird surveys to assess how birds may respond to these changes in insect populations, as insects are a key food source, and how the changes in vegetation and disturbance that accompany a regenerative system may alter bird populations. Just this year, they found 200 different species of birds living in and around the pilot farm fields and nearby natural areas in the Northern Plains.

Measuring Farmer Economics

The basic premise of regenerative agriculture is that as farmers begin to restore the natural ecosystem processes of their farm, they decrease reliance on external inputs and therefore reduce costs. For example, Rosenzweig et al. (2018) found that no-till dryland farmers in the High Plains who eliminated summer fallow through a diversified crop rotation were able to produce 60% more total grain with the same amount of nitrogen fertilizer relative to no-till wheat-fallow farmers by building soil organic matter and fostering a microbial community that increased nutrient availability (Rosenzweig et al., 2018). To test how production and input use changes during transitions to regenerative agricultural systems, each farmer in GMI's RA pilots is recording each of their practices, costs, and economic returns from crops and livestock. This will provide important information on what to expect from an economic standpoint for any farmer in the region thinking about transitioning to a regenerative system.

The New Normal?

Today, virtually no consumers today know what the term "regenerative" means, and it is unclear if any brands would be able to drive sales growth by talking about RA. GMI is working to educate consumers about RA and understand how to communicate it to those not familiar with agriculture. In lieu of immediate sales growth, GMI believes that some of the investment in RA will begin to pay for itself through improved resilience in agricultural production, which reduces costs. However, the ultimate goal of the Million Acre commitment is to use the 1 million acres to catalyze changes in the industry which will make regenerative the new normal.

General Mills has been at the front of these emerging trends in sustainability before. In 2015, it was one of the first companies to make a science-based target for GHG reduction. A third-party firm accounted for the GHG emissions across GMI's entire value chain from farm-to-fork-to-landfill, and found that the company would have to reduce its emissions 28% by 2025 in order to meet the 2°C threshold set by the Intergovernmental Panel on Climate Change. They also found that agriculture made up 50% of GMI's total emissions, the largest source by far. Since 2015, many other major companies have made similar commitments, such as Cargill, Walmart, PepsiCo, McDonald's, Coca-Cola, Tyson, and Nestle. Given agriculture makes up a large source of emissions for food and beverage companies, these climate commitments are spurring investments in strategies for promoting adoption of RA practices, as sequestering carbon and reducing fertilizer use are some of the primary ways to reduce GHGs in agriculture. One such strategy backed by many of these companies is the Ecosystem Services Market Consortium, which seeks to incentivize farmers and ranchers to improve soil health by establishing a national market for ecosystem services like carbon sequestration and water quality improvement.

The direction of broader trends in the food industry suggest there will likely be even greater focus on sustainability moving forward. One such trend is the shifting preferences and demands of stakeholders like investors, customers, consumers, and employees. A growing number of investors demand action on sustainability, influential customers like Walmart are demanding GHG reductions from their suppliers, consumers are increasingly prioritizing sustainability in their purchasing decisions and holding companies accountable for environmental harm (HGI, 2019), and employees increasingly want to work for companies that have a legitimate focus on sustainability (Gallup, 2019).

As one of the largest global food companies, General Mills is attempting to leveraging its scale to make a positive impact on the food system. The company is actively forming partnerships with universities, farmers, ingredient suppliers, local conservation leaders, nonprofits, governments, and others in the food and agricultural industries. By collaborating across sectors to support the research, outreach, and financial support that is needed to continue the momentum in regenerative agriculture, the company hopes that its One Million Acre commitment will catalyze a paradigm shift in agricultural production that will impact the entire industry.

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Soil Testing - Interpretations Matter

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While many are familiar with using soil tests for basic soil fertility measures such as pH, N, P, and K, how do you read the rest of your test and what does it mean? Concepts such as Ca:Mg ratios, soil cation exchange capacity, and newly developed soil health tests should be evaluated for their role on soil fertility management and crop productivity.

Is it important to have the proper ratio of Ca and Mg in the soil?

Many producers ask this question when they have their soil tested for nutrient levels. This question also arises at the moment of lime purchase, which can be an important source of Ca and Mg. Calcium and magnesium are plant-essential nutrients. All soils contain Ca and Mg in the form of cations (positively charged ions, Ca^{++} and Mg^{++}) that attach to the soil clay and organic matter; these are also the forms taken up by crops. The relative proportion of these elements, as well as the total amount in the soil, depends mainly on the soil parent material. In Kansas soils, the levels of Ca and Mg are typically high and crop deficiencies are rare.

Soils typically have higher Ca levels than Mg. Table 1 gives the amount and ratios of Ca and Mg for some soils in Kansas. Both nutrients are present in large quantities. Unusual cases of Ca or Mg deficiencies may be found in areas of very sandy soils.

Table 1. Typical calcium, magnesium, and Ca:Mg ratio for several Kansas soils.

Soil	Ca	Mg	Ca:Mg ratio
	- - cmol kg^{-1} - - -		
Canadian-Waldeck	42	11	3.7
Carwile	22	4	5.2
Chase	198	30	6.7
Crete	111	29	3.8
Harley	202	15	13.2
Harney-Uly	200	12	16.1
Keith	127	38	3.3
Las	176	37	4.8
McCook	35	8	4.5
Onawa	163	28	5.8
Ortello	19	6	3.3
Parsons	80	23	3.5
Tully	158	38	4.2
Ulysses	223	36	6.2

Why would the ratio of Ca to Mg be important? The concept of an optimum Ca:Mg ratio started in the 1940s under the "basic cation saturation ratio" theory. The theory is that an "ideal soil" will have a balanced ratio of Ca, Mg, and K. According to this theory, fertilization should be based on the soil's needs rather than crop's needs. This concept of an ideal Ca:Mg ratio has been debated by agronomist over the years. The suggested ideal ratio according to the theory is between 3.5 and 6.0, but this has never proven to be of significance.

One example of research conducted on this topic over the years is shown in Table 2. In that experiment, McLean and coworkers demonstrated the lack of relationship between Ca:Mg ratio and crop yield for several crops. The range of Ca:Mg ratios observed for the highest yields were not different from those observed for the lowest yields. The conclusion from that study was that to achieve maximum crop yield, attention should center on providing sufficient levels of these nutrients rather than attempting to find an adequate ratio.

Table 2. Ratio of Ca:Mg for five crop-years comparing the highest and lower yields obtained

	Corn	Corn	Soybean	Wheat	Alfalfa	Alfalfa
Yield level	- - - - - - - - - -	- - - - - - - - - -	- - - - Ca:Mg ratio - - - -	- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
Highest five	5.7 - 26.8	5.7 - 14.2	5.7 - 14.9	5.7 - 14.0	5.7 - 26.8	6.8 - 26.8
Lowest five	5.8 - 21.5	5.0 - 16.1	2.3 - 16.1	6.8 - 21.5	8.2 - 21.5	5.7 - 21.5

Adapted from: McLean, E.O., R.C. Hartwig, D.J. Eckert, and G.B. Triplett. 1983. Basic cation saturation ratios as a basis for fertilizing and liming agronomic crops. II. Field studies. Agronomy Journal 75: 635-639.

In conclusion, the Ca:Mg ratio concept should not be used for a nutrient application or liming program. The center of attention should be the level of Ca and Mg in the soil rather than trying to manage the ratio. The relative concentration of Ca and Mg in commercial ag lime can be highly variable, and application should be based on the effective calcium carbonate (ECC) to achieve a target soil pH.

Cation exchange capacity (CEC)

Soils have a net negatively charge, this important property is called Cation Exchange Capacity. Positively charged ions, cations, are retained, preventing their leaching from the soil (important cations for crops such as Ca^{2+}, Mg^{2+}, and K^{+}). The source of CEC in soil are clay and soil organic matter. The units are millequivalents of charge per 100 grams of soil and the range of CEC in Kansas soils is roughly 3-50.

One of the main fertility parameters expressed by CEC is the buffering capacity (the ability of soil to resist changes, such as pH). Taking the example of soil pH, with a high buffering capacity change their pH level slowly, and require a great deal of lime to increase pH. Normally, soils high in clay or organic matter (those that have high CEC) have high buffering capacities. An exception to this is high-sand-content soils, where buffering tends to be low. Sandy soils have low buffer capacity, meaning that a relatively large decrease in soil pH occurs as a result of plant root activity and nitrogen fertilization. Heavier soils have high buffer capacity and the decrease in pH is relatively small with the same level of activity. This buffer capacity concept also applies to increasing soil pH with lime. Sandy soils require less lime to increase pH than clayey soils even though initial pH may be the same. All soil test laboratories measure buffer capacity and factor this into the lime recommendation.

Evaluation of soil health test to determine fertilizer needs

Commercially available soil health tests have been developed to measure chemical, physical and biological indicators. The evaluation of these different indicators provide an opportunity to identify potential constraints and implement the right management practice to improve soil health. One key aspect of soil health is related to soil fertility and nutrient availability and is evaluated primarily by the chemical indicators.

Over the years Kansas State University has conducted extensive correlation and calibration research across Kansas to develop fertilizer guidelines, using standard soil testing procedures and extractants, and this research continues. However, this research has not been done in Kansas with the procedures and extractants utilized by the newly-developed soil health tests. Developing the concepts and formulating the scientific basis for soil testing has been one of the most important contributions by soil scientists. Many questions remain, however. Changes in management practices such as long-term no-till system can have important consequences for soil testing. Renewed interest in soil health and sustainable crop production requires a reevaluation of soil testing procedures and correlation/calibrations.

The Soil Science Society of America define soil test correlation as "The process of determining the relationship between plant nutrient uptake or yield and the amount of nutrient extracted by a particular soil test method". And soil test calibration as "The process of determining the fertilizer requirement at different soil test values". These two essential components are well established for currently used test and recommendations in Kansas. When soil is sent to a laboratory for analysis, specific procedures and extractants are used to determine the estimated availability of nutrients. Different extracts and procedures typically result in different estimates of nutrient availability. The process of correlation helps determine the relationship between plant nutrient uptake or yield and the amount of nutrient extracted from the soil. A soil test is considered "correlated" when lower yield and plant growth can be predicted at lower soil test values, and higher yield and plant growth can be predicted at higher soil test values.

Preliminary results of one of common soil health test (CO_2 burst) in corn (Fig. 1) show a significant increase in soil CO_2 (measured in the lab) for long term no-till fields compared to conventional tillage. This difference in value suggest that this soil test can be a good indicator of management, particularly for systems with long term no-till (+25 years) with the use of cover crops and rotation.

Soil sampling procedures for soil health test has been suggested as similar for fertility (0-6 in sampling depth). However, results show that sampling depth can affect values (such as CO_2) (Fig 2), suggesting that sampling procedures for soil health in the field might need adjustments, and more shallow sampling likely required particularly for test related to biological parameters.

Results from multiple locations across Kansas showed that soil CO2 respiration values are related to corn nitrogen removal, indicating that higher values of soil CO2 respiration are related to higher N supply from the soil (Fig 3). Other soil test such as the Haney H3A show a good correlation to traditional methods like the Mehlich-3 for phosphorus, however for some soils with high pH and the presence of calcium carbonate, this relation can be weak (Fig. 4).

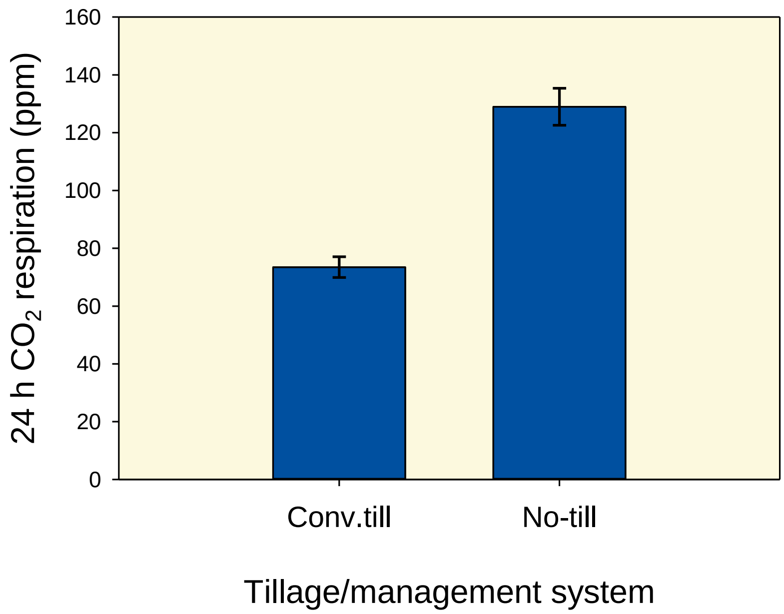

Figure 1. Soil CO2 response as affected by management system (long term no-till versus conventional tillage.

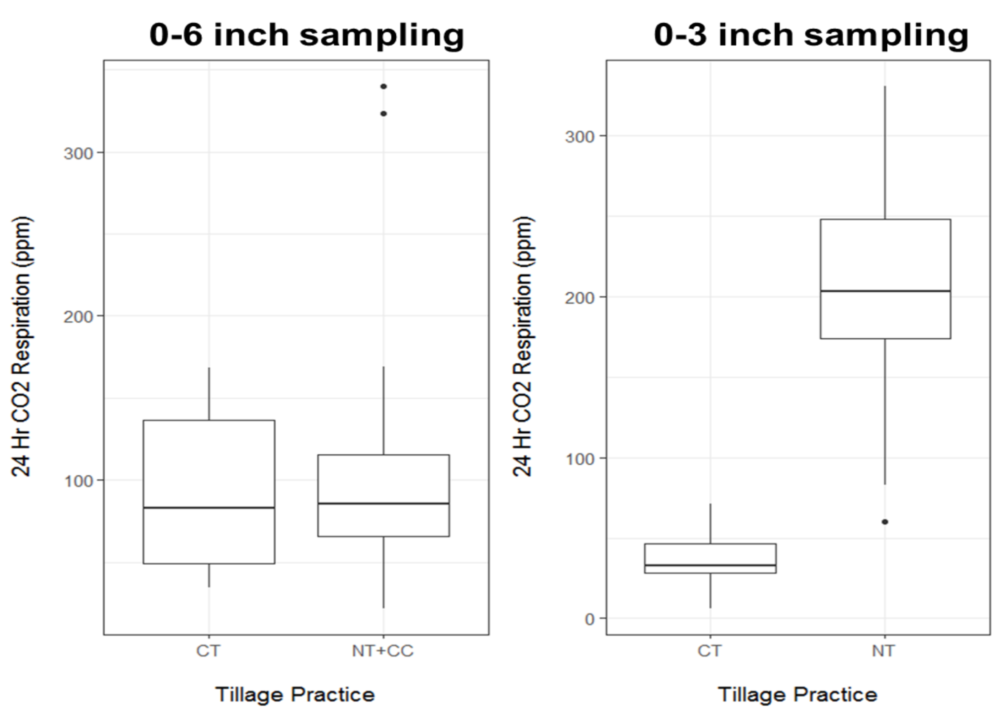

Figure 2. The effect of the soil sampling depth on the values of CO2.

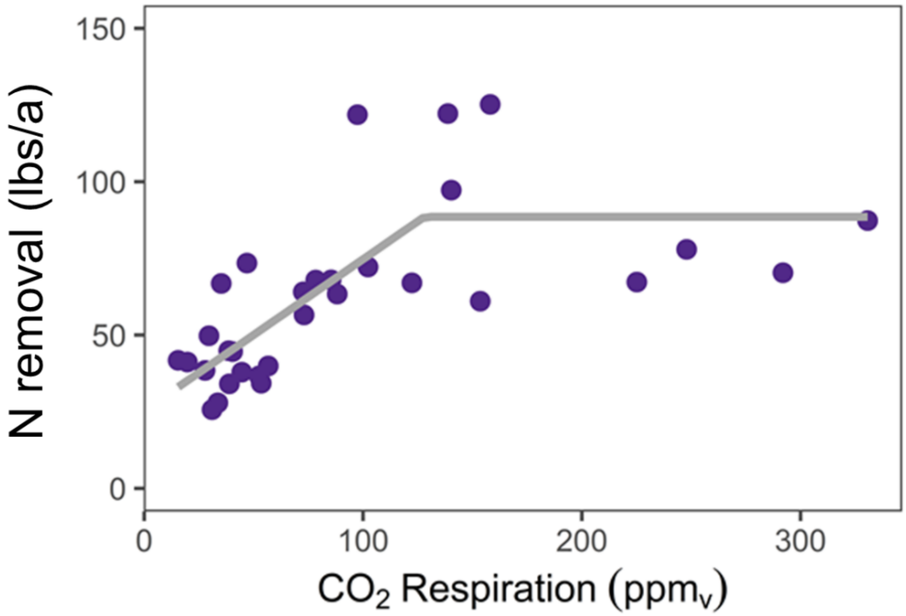

Figure 3. Corn nitrogen removal as affected by soil CO2 respiration values across 18 locations in Kansas.

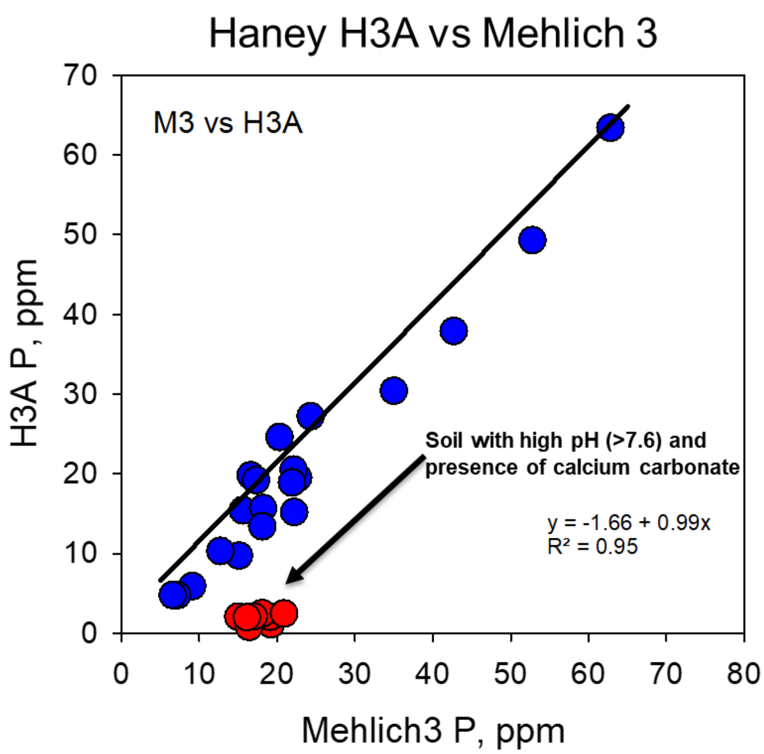

Figure 4. Relationship between soil test phosphorus for Mehlich-3 and Haney (H3A). Samples


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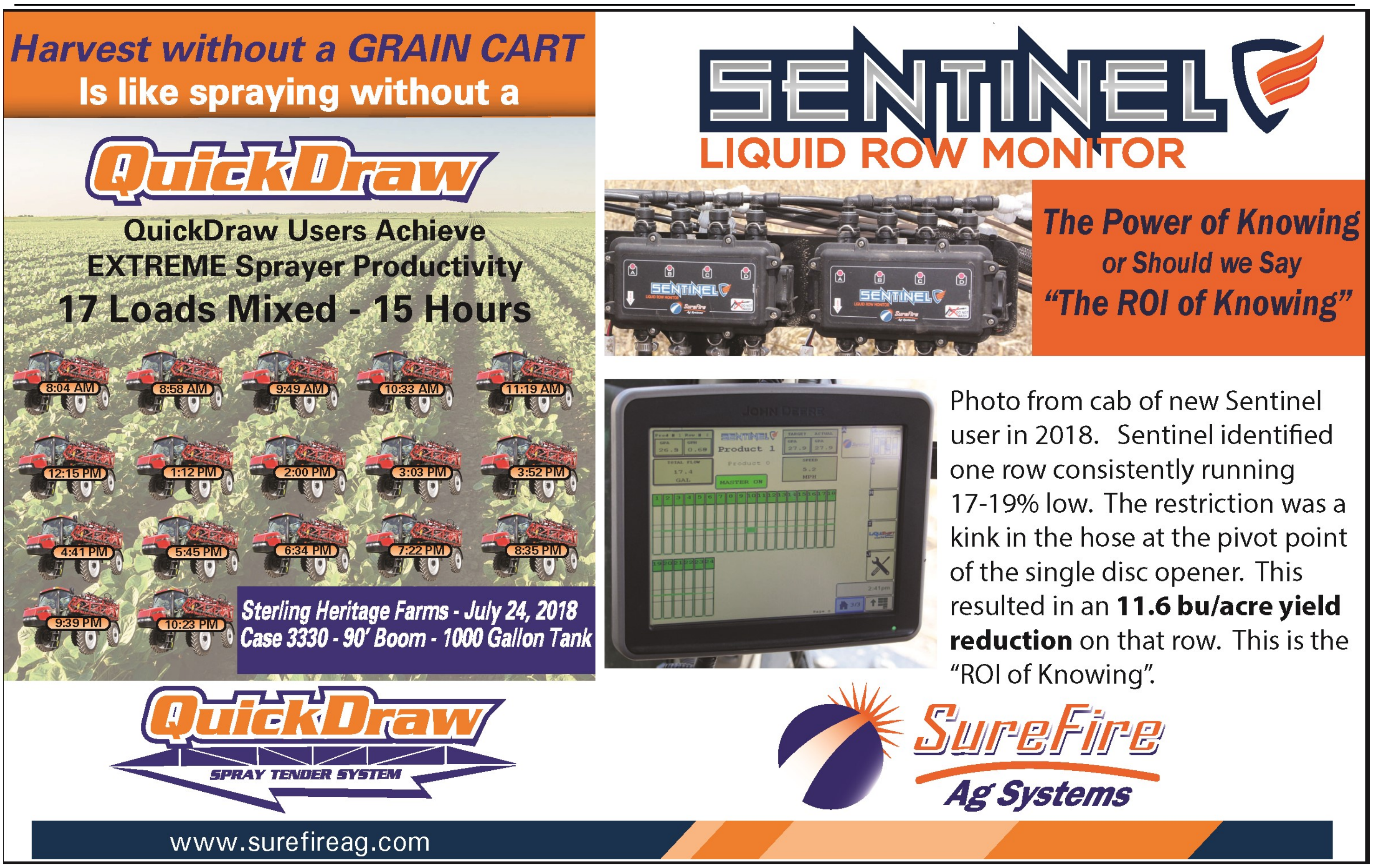
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The plan for the day...

	Room 1	Room 2	Room 3	Room 4
7:45 8:15	*Registration*			
8:15 8:20	*Welcome*			
8:30 9:20	Current Financial Status of NW KS Farms[1] *(J. Steele / M. Wood)*	Insect Management in Dryland Corn [1,2] *(S. Zukoff)*	Food Companies and Soil, What's the Connection?[1] *(S. Rosenzweig)*	*Radical Ideas to Put Profit back into High Plains Ag (Green Cover Seeds) (I)*
9:30 10:20	Cover Crops as a Weed Management Tool[1] *(L. Chism & M. O'Day)*	Alternative Crops[1] *(L. Haag)*	Producers Competing for Irrigated Corn Efficiency[1] *(D. Rudnik)*	*Agronomic Insights from Bayer Crop Science (I)*
10:20 10:50	*View Exhibits*			
10:50 11:40	The War on Weeds [1,2] *(J. Falk-Jones)*	Soil Testing-Interpretations Matter[1] *(D. Ruiz-Diaz)*	Planter Technology Advancements[1] *(A. Sharda)*	*Performance Adjuvants (EGE Products) (I)*
11:50 12:40	Beyond Grain: The Value of Wheat in the Production Chain[1] *(A. Harries)*	Cover Crops as a Weed Management Tool[1] *(L. Chism & M. O'Day)*	*Lunch*	
12:50 1:40	Food Companies and Soil, What's the Connection?[1] *(S. Rosenzweig)*	The War on Weeds [1,2] *(J. Falk-Jones)*		
1:50 2:40	Soil Testing - Interpretations Matter[1] *(D. Ruiz-Diaz)*	Producers Competing for Irrigated Corn Efficiency[1] *(D. Rudnik)*	Beyond Grain: The Value of Wheat in the Production Chain[1] *(A. Harries)*	*Sunflower Industry Update (National Sunflower Assoc.) (I)*
2:40 3:10	*View Exhibits*			
3:10 4:00	Panel Discussion: Industry Tech Showcase Cloud Based Tools	Planter Technology Advancements *(A. Sharda)*	Insect Management in Dryland Corn[1,2] *(S. Zukoff)*	*Saving You Money in 2020 (Sims Fert & Chem) (I)*
4:10 5:00	Alternative Crops[1] *(L. Haag)*	Current Financial Status of NW KS Farms[1] *(J. Steele / M. Wood)*	*Short Statue Corn and Enlist Soybean Technology (Stine Seed) (I)*	

(I) indicate industry sessions.

[1] Indicate Certified Crop Advisor CEUs applied for.

[2] Indicate Commercial Applicator CEUs applied for.

This conference is organized by a committee of producers and K-State 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

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