2018 Field Day

USDA-ARS
Central Great Plains Research Station
111th Annual Field Day

Tour One

Table of Contents

2018 Field Day

June 13, 2018

USDA-ARS Central Great Plains Research Station

Highway 34, Four Miles East of Akron, CO

Registration begins at 8:30am with Coffee and Donuts

8:55 AM	**Dr. Merle Vigil, ARS** Welcome to the Central Great Plains Research Station's 2018 Field Day
9:00 AM	**Wayne Shawcraft** Wheat Year Precipitation/Temperature Analysis 2018 Crops
9:15 AM	**Neeta Soni, CSU** Potential for Harvest Weed Seed Control in Colorado
9:30 AM	**Dr. R. Brent Young, CSU** Wheat Market Outlook
9:45 AM	**Dr. Merle Vigil, ARS** Precision Farming Project Update
10:00 AM	**Break**
10:15 AM	**Dr. Scott Haley, Dr. Jerry Johnson and Sally Jones, CSU** The 2018 Wheat Variety Field Day at Akron
11:15 AM	**Dave Poss, ARS** Will a Winter Annual Forage Crop Fit In Your System? Yields & Quality Results from 2017
11:35 AM	**Dr. Maysoon Mikha, ARS** Long-Term Corn Yield at Different Nitrogen Rates and Types
11:55 AM	**Dr. John Spring, CSU** Pre-emergent Herbicides for Improved Control of Kochia in Chemical Fallow
12:20 PM	**Joel Schneekloth, CSU** Impacts of Residue/Tillage Management
12:40 PM	**Dr. Francisco Calderon, ARS** Soil C and Soil Chemistry Effects of Residue Management in Irrigated Corn
1:00 PM	**Catered Lunch in Building 18**

Our Staff

Admin

Sarah Bernhardt
Carolyn Brandon
Amber Smith

Seasonal

Leanna Clarkson
Kelsey Guy
Kristofer Jones
Taylor Krause
Cameron Lyon
Alexys McGuire
Lindsey Wagner
Morgan Woods

Scientists

Merle Vigil
Francisco Calderon
Maysoon Mikha
David Nielsen

Technicians

Paul Campbell
Cody Hardy
Delbert Koch
Brandon Peterson
Stacey Poland

CSU Staff

Ed Asfeld
Sarah Clarkson
Kiara Guy
Sally Jones
Joel Schneekloth

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WHEAT YEAR PRECIPITATION / TEMPERATURE ANALYSIS
2018 CROP

Dr. R.Wayne Shawcroft
Extension-Irrigation Agronomist
(Retired)

Central Great Plains Research Station
Akron, Colorado

Data through MAY 21, 2018

WINTER WHEAT--CROP MOISTURE YEAR

In the conventional Wheat-Fallow system, the moisture year for the wheat crop can be divided into two periods: a 14-month Fallow Period and a 10-month Growing Period.

The TOTAL WATER AVAILABLE for the wheat crop depends on how much of the precipitation is stored in the soil during the fallow period or the (% STORAGE EFFICIENCY) *and the* GROWING SEASON PRECIPITATION.

The following tables compare the **FALLOW PERIOD** and the **GROWING PERIOD** conditions for the current wheat crop...to be **harvested in 2018.**

Summary of Fallow Period 14-month
(J,A,S,O,N,D,J,F,M,A,M, J,J,A) = 14-months
July 2016 -- Aug 2017

Month	Year	Fallow Precip in	109-year Average Precip	Departure
Jul	2016	3.03	2.622	0.41
Aug	2016	0.84	2.157	-1.32
Sep	2016	0.68	1.277	-0.60
Oct	2016	0.70	0.916	-0.22
Nov	2016	0.39	0.542	-0.15
Dec	2016	0.44	0.424	0.02
Jan	2017	0.43	0.329	0.10
Feb	2017	0.16	0.362	-0.20
Mar	2017	1.45	0.845	0.61
Apr	2017	2.37	1.655	0.72
May	2017	2.96	2.930	0.03
Jun	2017	3.34	2.447	0.89
Jul	2017	1.12	2.610	-1.49
Aug	2017	2.17	2.163	0.01
Total		**20.08**	**21.278**	**-1.20**

total months= 14

Growing Period Precip
10-Month Sep-June

Month	Year	Sep2017-Jun 2018 Precip	109-yr Ave Precip	Departure	Days of Snow Cover	Snow Depth in.
Sep	2017	1.25	1.29	-0.04	0	0.0
Oct	2017	0.89	0.89	0.00	1	1.0
Nov	2017	0.13	0.52	-0.39	0	0.0
Dec	2017	0.11	0.42	-0.31	8	3.5
Jan	2018	0.88	0.34	0.54	4	8.3
Feb	2018	0.69	0.36	0.33	12	14.9
Mar	2018	0.55	0.82	-0.27	4	4.5
Apr	2018	2.33	1.67	0.66	4	9.5
May	2018	4.93	2.96	1.97	0	0.0
Jun	2018		2.44	-2.44	0	0.0
Total		11.76 inches	**11.72**	0.04	33	41.7

total months = 10

21-May-2018 <Last Update

FALLOW PERIOD SUMMARY:

The July '16 - Aug. '17 fallow period precipitation was **20.08 inches**, which ranks as the **63rd wettest** fallow period in the 109-year record for the 1908-09 through 2016-17 records. This is **1.20 inches** below the average of 21.28 inches. The fallow period began with good rainfall in July, but the Aug-Feb period was very dry. Fallow storage during this period was low. Precipitation from March through August was high, and with the exception of July, was above the average for the period. The moisture for seeding the new crop (2018 crop) was generally good, but very warm conditions dried surface soil considerably causing sporadic germination and poor stand establishment in some fields.

GROWING SEASON SUMMARY Sep '17-Jun '18: The *GROWING SEASON* precipitation for the **2018** crop (through May 21, 2018) has been **11.76 in.** which is **0.04 inches ABOVE the average of 11.72** inches. The *GROWING SEASON* precipitation for the current crop ranks as the **52th wettest** on record or the **58th driest.** This **does not include the remaining days in MAY and JUNE**, which could increase this amount. Fall precipitation was very low after early October. Some wheat was very slow germinating and stand establishment was difficult. Light, but very beneficial snows in January and February, did bring more favorable conditions for spring growth. March was below average in precipitation, but April and May rainfall have been very beneficial for the current wheat crop, and barring dry and hot conditions, the prospects look very good.

SNOWFALL - WINTER 2017-18

Fall snowfall was only 4.5 inches with 9 days of snow cover and only 0.38 inches of precipitation. The Jan.14 to April 30 period had 37.2 inches of snow with 24 days of snow cover and 4.02 inches of precipitation. Winter snowfall has been good and provided substantial moisture for the wheat crop as it came out of the dormant period.

The big snow/blizzard of April 13-14 provided a big boost to the overall moisture conditions for the crop. The total snowfall has been near 42 inches, but the rapid melting has provided only 33 days of snow cover.

TEMPERATURES Sep.17-Jun18: The months of Sep through Jan had well above average warm temperatures. Several new high temperature records were set in this period. The months of Feb and April were much colder than average and delayed the wheat from breaking dormancy too early. March was a very warm month, but April turned very cold ranking in the coldest 20% of the April's on record.

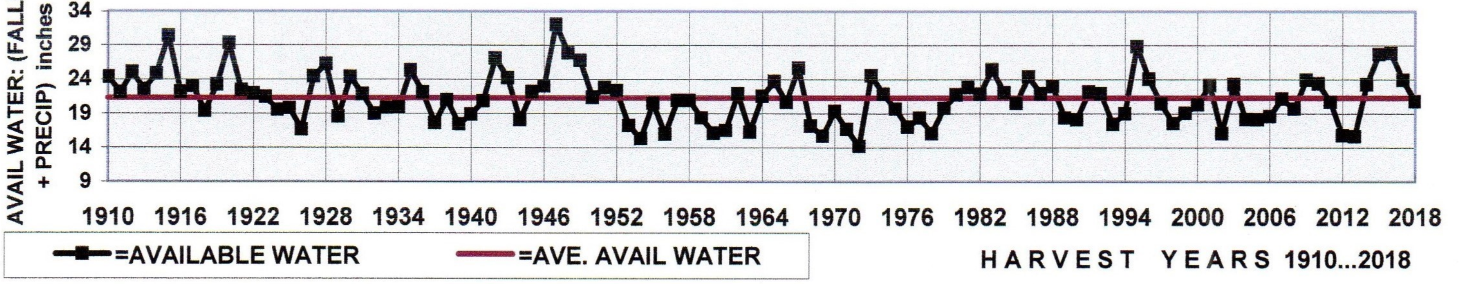
The Sep-May average temperature overall ranks in the upper 20% of the warmest for the 107-year period. In general the winter has been relatively mild with no prolonged cold spells. April was a strange month in that it ranked in the coldest 20% of the 107-year period. There were relatively few extremely cold temperature readings, but the average was very low. The average temperature for the Sep17-May18 period (**through May 21**) was 43.15 deg F. This compares to the 107-year average of 41.63 deg F.

AVAILABLE WATER SUPPLY:

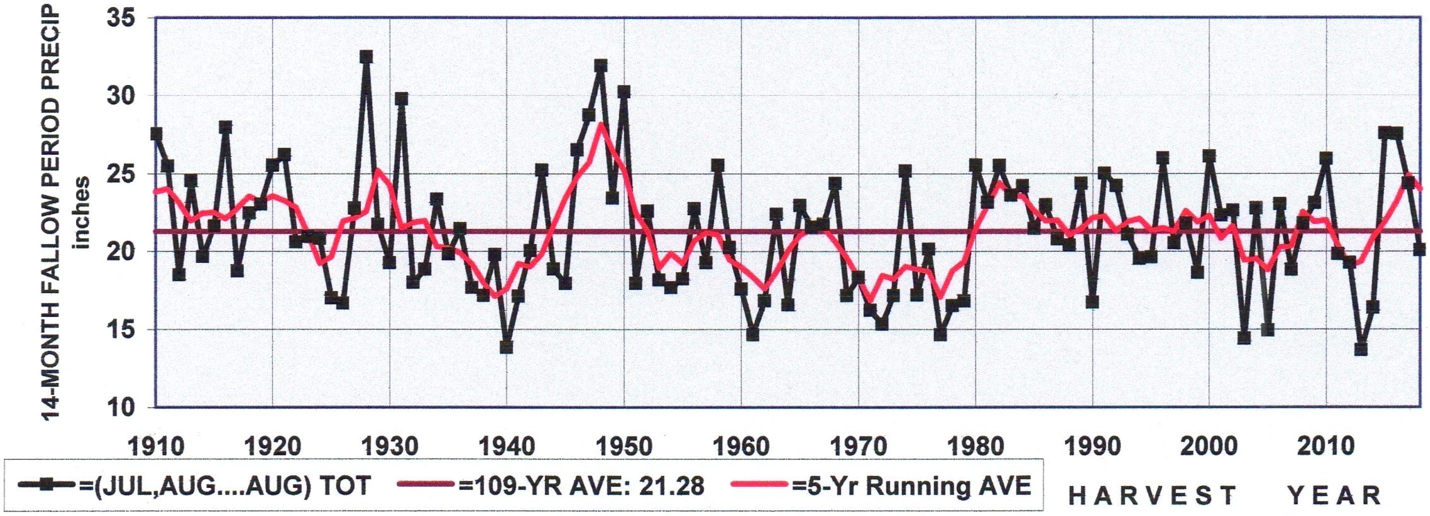
At a fallow storage efficiency of **25%**, the available water supply for the **2018-crop**, ***so far***, would be **16.78 inches**, which is just BELOW the average of **17.01 inches**.
At a fallow storage efficiency of **45%**, the available water supply would be **20.80** inches, which is again, a fraction BELOW the average of **21.27 inches, not including the remainder of May and June**. The current wheat crop condition reflects a moderate fallow period precipitation, as well as the February, March, April, May, June growing period.
At **25% storage** efficiency the seasonal available water would be **70.1%** from growing season precipitation, and at **45% storage** efficiency growing season precipitation would be at **56.5%** of total available. At the 25% storage efficiency, the 2018-crop may be marginal, unless late May and early June precipitation is substantial. At the 45% storage efficiency, the **20.80 inches** of water available might be in the "border-line" to "good" range for good yields.

Fallow storage efficiency is usually a key to the success of the crop. With moderately good fallow period and the late spring precipitation, the prospects for **2018** look relatively good. The range of **16.78 inches at 25% efficiency** to **20.80 inches at 45% efficiency** would appear to be "marginal" to "good" for good yields. Late May through early June precipitation prospects look very good for the crop.

WHEAT AVAILABLE WATER SUPPLY: @ 45% EFF
USDA-ARS RESEARCH STATION



WHEAT:14-MON FALLOW PERIOD TOTAL PRECIP
USDA-ARS RESEARCH STATION AKRON, COLO.



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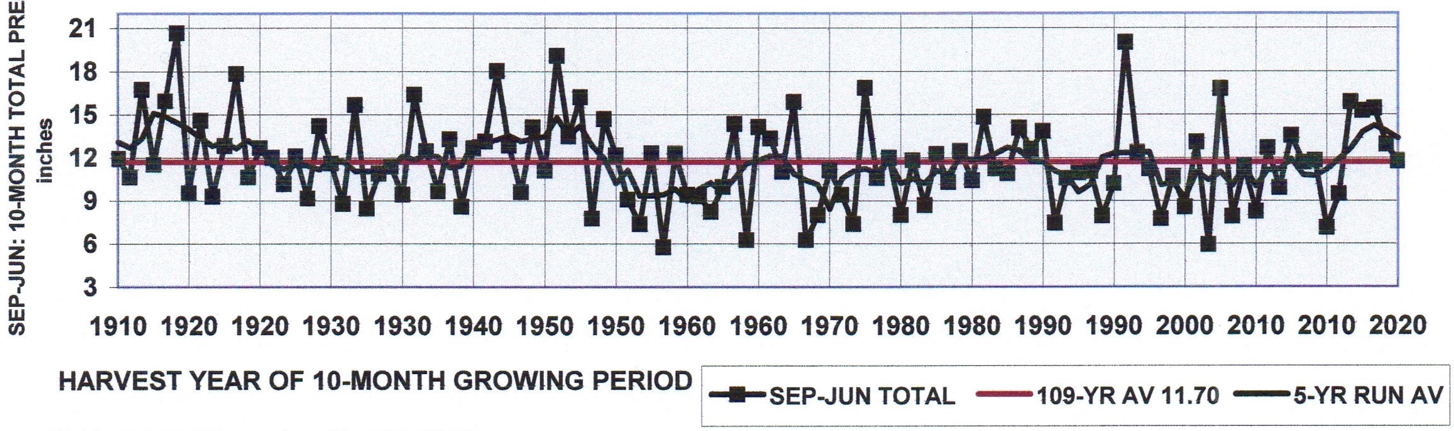
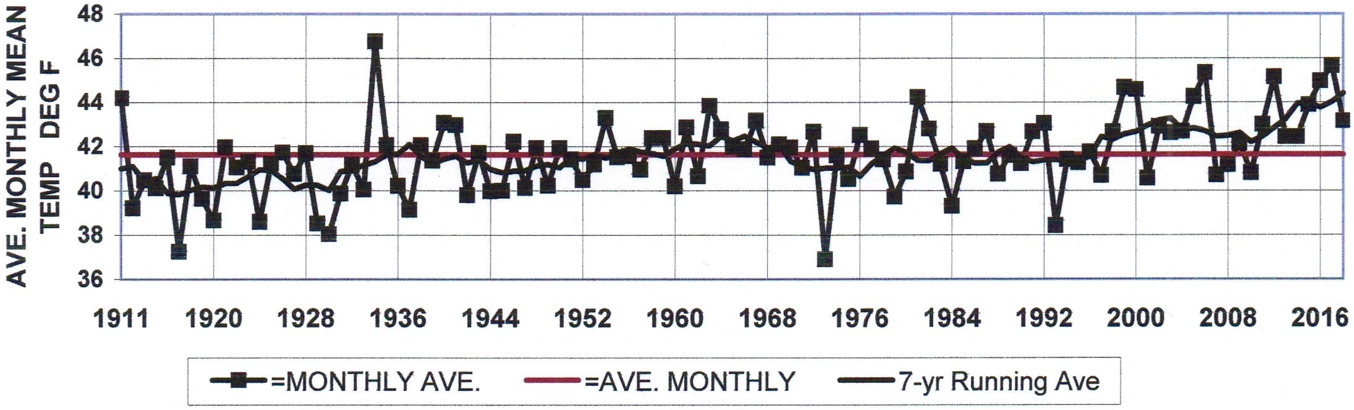
WHEAT: GROWING PERIOD (SEP-JUN) PRECIP
USDA-ARS RESEARCH STATION AKRON, COLO.



2018 updated through : May 21, 2018

saved as: tab "GraphYears" in file "GROWRNK1" printed: 5/21/2018

SEPT-MAY AVE. MEAN TEMP.
USDA-ARS RES. STATION, AKRON, COLORADO



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Marketing Wheat in Challenging Times: Avoid Common Mistakes

R. Brent Young

Professional tennis players make 80% of their shots while amateur tennis players miss 80% of their shots. Given this fact the best way for an amateur tennis player to improve their game would be to eliminate their mistakes.

Many farmers consider themselves to be amateurs when it comes to marketing their grain. If you believe the tennis analogy, then it would stand to reason that the best way for farmers to improve their grain marketing ability would be to eliminate their marketing mistakes.

Edward Usset, Grain Marketing Specialist for the Center for Farm Financial Management, University of Minnesota compares tennis players to farmers as he introduces his presentation titled “Five Common Mistakes in Grain Marketing”. I have taken Ed’s thoughts and made a couple of minor changes to reflect winter wheat marketing in the Great Plains.

Not knowing your cost of production (COP) is first on my list of common mistakes (not included in Ed’s list for mid-west farmers). Locking in a profitable market price should be a driving factor in making any marketing decision. The first step in determining if the market is offering an acceptable price is knowing your COP. The secret to knowing your COP is having good farm financial records that allow you to conduct enterprise analysis. If your current record keeping system does not allow you to calculate your COP there are several reasonably priced, computerized accounting packages available that will help you to complete this important task.

In my revised list the second mistake is reluctance to pre-harvest price crops. In most years the market will provide opportunities to price the crop that will result in a return greater than pricing only at harvest time. Producers can utilize forward contracts, futures and options contracts to accomplish this task.

Mistake number three is the failure to understand and track local basis. Basis is the difference between the local cash price and the nearby futures price. While futures prices can vary year to year and season to season, basis tends to follow similar patterns year to year. In many cases grain pricing opportunities are the result of changes in basis and not upward movement in the futures market.

If you are interested in tracking local wheat basis, I would suggest that you utilize the Kansas State University Interactive Basis Tool https://www.agmanager.info/grain-marketing/interactive-crop-basis-tool . This web based tool tracks most of the winter wheat markets in eastern Colorado and will also provide 3 and 5 year weekly averages.

Failure to have a pricing strategy is mistake number four. How many of us have missed an opportunity to sell our grain at a profit because we thought the market would go up a nickel and then we would wait to sell only to watch the market go down 15 cents. A pricing strategy (a component of a marketing plan) allows us to take some of the emotion out of marketing and make decisions based on our cost of production. Pricing strategies can be either price and/or timing driven.

Some grain market analysis like to quote what they call the 11th commandment of winter wheat marketing, “Thou shall not hold un-priced winter wheat in the bin past April 1st”. This commandment relates to my fifth common mistake in winter wheat marketing, that being holding unpriced grain in storage too long. The most egregious example would be selling last year’s winter wheat crop just in time to place this year’s crop in the bin. Not only have you sold last year’s crop at the typical market year low, you have the expense of storing the old crop for an entire year.

If you’re like many grain producers and feel that when it comes to marketing you are more of an amateur than a professional limiting your grain marketing mistakes could pay big dividends.

Dr. R. Brent Young – Regional Extension Specialist – Agriculture & Business Management, CSU Extension, Phone: 970-522-7207, Email: brent.young@colostate.edu

Field Elevation as a Proxy for Field Productivity: Precision Farming Study and Management Zones

Vigil M.F., F.J. Calderon, D. J. Poss, D.C. Nielsen, P. Campbell, and C. Hardy

PROBLEM: The topographical elevation in a field greatly influence winter wheat grain yields and therefore the economic optimum N rate (EONR) will be different for different locations in a field. The change in yield with topographical elevation in a field is linked to changes in soil type and soil productivity, as one moves from the high points in a field to the lower elevations in a field. The change in yield may also be the result of both run-off and run-on of rainfall water from high points in the field to lower elevations in the field.

APPROACH: Wheat grain yield maps are measured for several wheat fields at the research station (Fig 1). The corresponding elevations in each field are then matched to grain yields at each location (Table 1). We are in effect dividing up this field into 6 separate management zones by yield and elevation. We know from previous research that to achieve 12% grain protein we need grain N to be at 2.105%; which translates to 1.263 lbs. of N per bushel of grain. The total N needed is more than that because fertilizer recovery is only about 50%. If we assume N recovery is 50% the actual N required per bushel yield is about 2.53 lbs. to achieve a grain N concentration of 12% (2.53=1.263/0.50).

Before we calculate the N rate to apply for each location in this field, we need to consider residual inorganic N already present in the soil (nitrate-N plus NH4-N). We also need to consider the amount of N that will be made available during the season from organic matter (OM) decomposition (OM comes from crop residues, and resident soil organic matter, manure etc.). CSU has used the relationship of 30 lbs. of N/acre will be released from organic matter decomposition for every 1% OM in the soil in the top 6 inches of soil. I checked that rule of thumb and found the relationship is between 20 and 50 depending on the moisture and temperature conditions during the decomposition period. The rule is not too far off so we will use it in our calculations. The fertilizer requirement equation then becomes:

Fert required = (Expected yield x (N needed for 12% protein/efficiency factor) – (N from OM)
-(residual N in the top 2 feet of soil profile x efficiency factor for residual N).

Where:

Fert required = fertilizer N required; in lbs. of N per acre.
Expected yield = the yield map yield for an average year, in bushels per acre.
N needed for 12% protein = 2.53 lbs. of N per bushel yield; 2.53 = 1.263lbs of N required per bushel divided by the efficiency factor for fertilizer recovery of 50% (0.50).
N from OM = N mineralized or released from decomposing soil organic matter based on soil analysis of soil in top 6 inches of profile.
Because this N is slow release N, and because we have measured this value using 15N tracer's, we assume the efficiency factor is already accounted for in the value.
We assume 30 lbs. will be accumulated by the crop per 1% OM, and 60 lbs. for 2 % OM.

Residual N = Nitrate N plus NH_4-N found in the top 2 feet of soil profile, where we assume the same efficiency factor as fertilizer of 50%.

For a 42.4 bushel expected yield, with 0.8% organic matter and 40 lbs. of residual N in the top 2 feet of the profile the equations become:

Fert N required = (42.4 x 2.53) – (0.8 x 30) -40 x 0.5
Fert N required = (107.1) -24 -20
Fert N required = 63.05 lbs. of N to apply per acre.

If we use the above relationship for N required per bushel of grain yield expected on average measured at various locations in the field, in combination with the soil OM and residual N found at that location, we can estimate potential N fertilizer to apply to achieve that yield for any region in the field (see last column in Table 1).

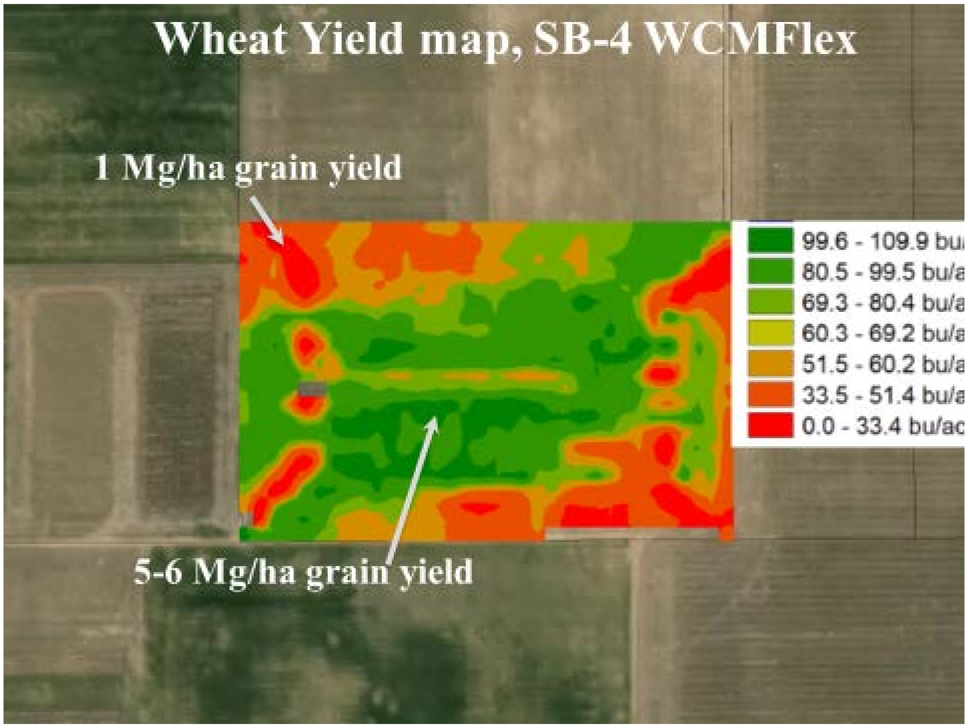

Fig 1 Winter wheat grain yield map of field SB-4 (1.12 Mg/ha is approximately 16.7 bushels per acre). The high yields are associated with low points in the field and the low yields are associated with high points in the same field. The elevation difference was about 4.7 feet between the high points and the low points.

Table 1. Wheat grain yields, N required and N fertilizer to apply as related to field elevation in field SB-4 using measured yields and a protein goal of 12%.

Management Zone Elevation above sea level	above lowest point	Management Zone Grain yield	N required to meet yield goal and 12% protein	OM	Nitrate plus NH_4-N top 2 ft.	N Fertilizer to apply
-Ft-	-Ft-	bu/acre	lbs./acre	%	lbs./acre	lbs./acre
4530.6	4.7	16.7	21.0	0.6	30	9.1
4529.4	3.5	42.5	53.5	0.8	40	63.1
4528.8	2.9	55.9	70.6	1	40	91.2
4528.3	2.4	64.7	81.5	1.1	55	102.9
4526.7	0.9	90.0	113.6	1.2	60	163.8
4525.9	0.0	104.7	132.2	1.5	70	184.4

The N rate values calculated in the last column of the table were calculated using the 12% protein as the protein goal for the yield measured in that portion of the field. We assumed 50% recovery efficiency for the applied fertilizer N, and we subtracted off the N expected from OM and the residual N already in the soil. In this calculation we have measured yield and elevation and we are estimating the OM levels based on visual soil color and previous analysis of the soils in these fields. The residual N values are based on soil analysis of similar soils on the farm. These data of OM and residual inorganic N (nitrate plus NH_4-N) we are measuring on a 30 by 30 m grid for each field in the study. That analysis has not been completed as of this write-up. Therefore, the final calculations may change a little (but probably not substantially) from what is reported here. In any case, these are the data needed to make an educated guess at N fertilizer required for each region or management zone in the field.

An analysis of the data in Table one, suggests the poorer production, in the areas of the field at higher elevations, will require less fertilizer N than in the low-lying areas of the same field. In those elevated areas, we have measured lower yields. A walk and visual inspection of the high points in this field showed less stubble, and a lighter colored soil and texture suggesting lower OM. A walk to the lower elevations in the same field revealed better stubble and a darker soil suggesting higher soil OM. We suspect a shallower soil with lower organic matter and less water holding capacity on the high points and a better soil quality at the lower elevations. Those assumptions have yet to be proved through grid sampling of this field and intensive laboratory analysis of those soil samples.

An analysis of the data in Table one, also suggest that N required to achieve grain with adequate protein and yield in the good parts of this field will be 100 to 184 lbs. of N. Whereas, the low yielding portions in this field little N is required to achieve 12 % protein. We have not completely done the soil analysis and so some of the numbers might change after that analysis is complete. Also, there is the idea of blending high proteins from one part of the field with lower proteins on another part of the field to achieve the best income for the farmer. For example, perhaps 11.5% protein should be the goal for the high yielding portions of the field and 13 or 14% protein should be the goal for the low yielding regions of the field. If we use those protein goals, we calculate different N rates for each management zone (Table 2). In Table 2, we recommend slightly more N for the poorer yielding soils to achieve 14% and 13% protein than in Table 1. Also, for a lower protein goal of 11.5%, for the high yielding portions of the field, N rates decrease slightly (compare Table 1 and Table 2). All of these ideas need to be tested. Final N recommendations are pending further soil and field analysis of each region in the field. However, the data does suggest a large difference in N requirement for different locations in the field are needed. Precision N management of these fields should increase crop yield, crop quality, and net returns to land labor and capital investment.

Table 2. Wheat grain yields, N required and N fertilizer to apply as related to field elevation in field SB-4 adjusted for different protein goals from 11.5 to 14.

Management Zone Elevation above sea level -Ft-	above lowest point -Ft-	Management Zone Grain yield bu/acre	protein goal %	N required to meet protein and yield goal lbs./acre	OM %	Nitrate plus NH_4-N top 2 ft. lbs./acre	N Fertilizer to apply lbs./acre
4530.6	4.7	16.7	14	24.5	0.6	30	16.1
4529.4	3.5	42.5	13	58.0	0.8	40	72.0
4528.8	2.9	55.9	12	70.6	1	40	91.2
4528.3	2.4	64.7	12	81.7	1.1	55	102.9
4526.7	0.9	90.0	11.5	108.9	1.2	60	154.3
4525.9	0.0	104.7	11.5	126.7	1.5	70	173.4

We did a simple linear regression between elevation in field SB-4 and yield and found that for every meter (3.28 feet) we go up in elevation that were losing about half of the yield potential found in the lowest portions in the field (fig 2.)

Finally, in the next write up we have included some of our actual N rate response data for both a good soil and a poor soil. (see following writeup on variable N rates). That small data set confirms our ideas that management zones may have real value in adjusting N rates for poor soils differently than for high yield soils.

FUTURE PLANS: We are grid sampling all of the fields in this experiment on a 30 m (98.4 feet) by 30 m grid. The experiment takes up about 140 acres and so the number of samples is extensive. At each gird point we will measure total N and C, inorganic N, available P, pH, EC, texture, Soil organic matter (SOM), avail Zn, Fe and Cu. The sampling and analysis will be done incrementally down to a depth of 4 feet (120 cm) starting at the 0-6 inch depth, 6-12 inch depth and then at 1-foot increments thereafter. Yield maps, elevation maps, and soil depth maps will be collected for each field and the grid data will be matched to try to best manage field areas in each field for optimal N management. This will require the establishment of variable N rates across soil types to obtain N response relationships with soil location.

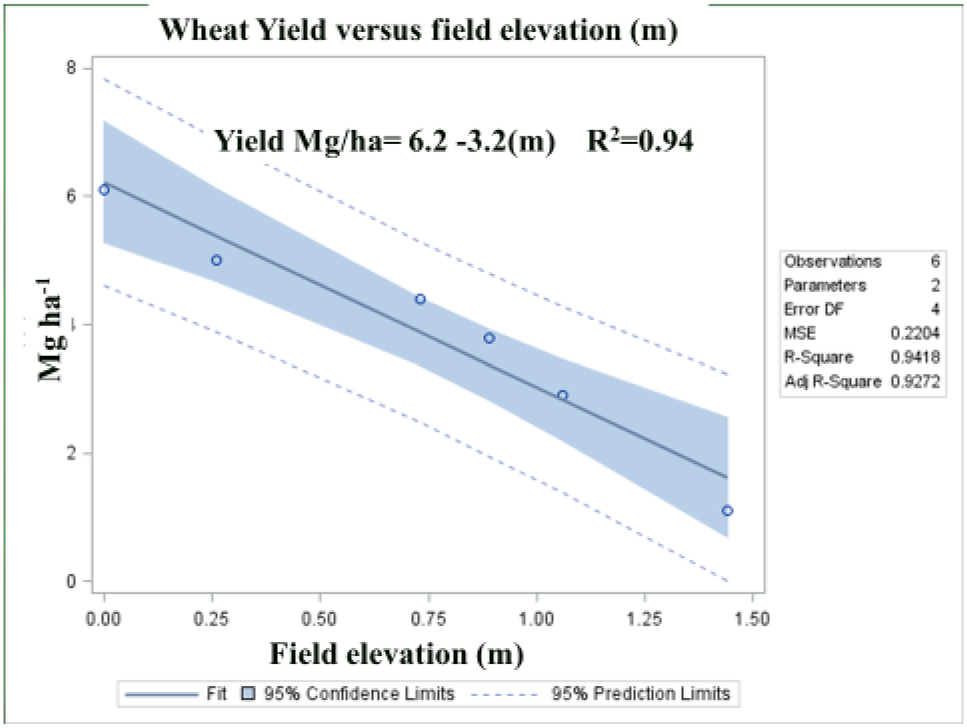

Fig 2. Wheat yields versus elevation in field SB-4. Six Mg/ha is about 89 bushels/acre, and 1 Mg/ha is about 14.9 bushels per acre. And so, the yield relationship in bushels per acre is: Yield (bushels/acre) = 92.2 bushels -47.6bushels*(elevation in meters).

Variable N Application by Soil Type

Vigil M.F., D. J. Poss, D.C. Nielsen, and F.J. Calderon

PROBLEM: Economic optimum nitrogen (N) rates (EONR) are highly dependent on weather, residual soil N, native soil organic matter, management, soil type and production potential of that soil type. In this study, we evaluated 12 years of a 20-year study of winter wheat yield response to N applied and residual inorganic soil N (nitrate-N and ammonium-N) (NO_3-N and NH_4-N), by soil type.

APPROACH: Winter wheat N response was measured in a wheat-corn-millet fallow rotation over a four-year period. The four-year rotation was established on a low productivity shallow soil (Norka-Colby complex) in one replication, a good soil (Rago silt loam) and two replications on a Platner silt loam which is intermediate in soil quality and in production potential. To determine total N requirement, we collected biomass yields and biomass N at anthesis each year and compared the total N uptake at anthesis with total N in the grain.

The soil at each of the 12 site-years was sampled to 4 feet for pre-plant inorganic N (nitrate-N and ammonium-N). Fertilizer N was top-dressed in broadcast applications at incremental N rates of 0, 30, 60, and 90 lbs. of N/acre as dry urea (46-0-0); or as ammonium nitrate, (34-0-0). All experiments were replicated 4 times. We fertilized the wheat with a phosphorous (P) rate of 15-20 lbs. of P as P_2O_5 placed with the seed. Most years we used di-ammonium phosphate DAP (11-52-0) or ammonium polyphosphate (10-34-0). Grain yields were collected and quadratic N response equations were fit to the yield data as a function of N rate and pre-plant available NO_3-N from the top 2 feet of the soil profile.

RESULTS: The grain yield N response on the poor soil is flat (Table 1) for the 12 years used in the analysis. The 12 years used in this analysis all had average yields greater than 23 bushels per acre. This soil never showed a positive measurable grain yield response to applied N. The yields with no N applied, were essentially the same as in those plots that received N rates of 30, 60 and 90 lbs. of N per acre. Biomass yield and grain proteins did significantly increase on this soil with applied N. We were surprised that total N uptake at anthesis was about the same on average as the amount found in the grain at harvest. This suggest that translocation of N to the grain is very efficient and that anthesis N is a good proxy for the total that will be recovered in the grain at harvest.

Table 1. Grain yield, biomass yield, N uptake at anthesis, N uptake in the grain at harvest and grain protein from 12 years of an N response study established on a Norka-Colby complex. Drought years with less than 23 bushel/acres were not included in the analysis.

			anthesis	grain	
N rate	grain yield	biomass Yield	N-uptake	N-Uptake	Protein
lbs./acre	bushels/acre	---------------lbs. /acre--------------			%
0	40	3430	37	43	10.4
30	41	4340	44	52	12.4
60	39	4480	68	54	13.4
90	42	4850	57	64	14.5
average	**40**	**4280**	**52**	**53**	**13**
P > F	0.82	**0.0259**	**0.0158**	**0.001**	**<.0001**

For this poor yielding soil, it probably still pays to apply about 30 lbs. of N to keep proteins above 11.5%. Flour needs to be greater than 11.5% protein to make a loaf rise adequately. Even though yields were the same with no N applied, the proteins drop to an unacceptable level of 10.4% with 0 N application (Table 1).

Grain yield response to applied N on the good soil for the same years showed a significant increase in grain yield, biomass yield and protein (Table 2).

Table 2. Grain yield, biomass yield, N uptake at anthesis, N uptake in the grain at harvest and grain protein from 12 years of an N response study established on a Rago silt loam. Drought years with less than 23 bushel/acres were not included in the analysis.

			anthesis	grain	
N rate	grain yield	biomass Yield	N-uptake	N-Uptake	Protein
lbs./acre	bushels/acre	---------------lbs. /acre--------------			%
0	48	4390	39	50	9.9
30	57	5910	60	61	10.2
60	60	6480	69	71	11.4
90	59	6170	70	69	11.7
average	**56**	**5740**	**60**	**63**	**11**
P > F	**0.0259**	**0.0021**	**0.0005**	**0.0001**	**.0019**

For the Rago soil, the average yields during the same years were about 16 bushels better than with the poor soil (compare grain yields in Table 1 with those in Table 2). With the Rago soil we measured a classic grain yield and biomass yield response to applied N that increased with each increase in N rate up to 60 lbs. of applied N per acre. The 90 lb. N rate on average was required to keep proteins above the 11.5% level even though yields did not increase from the 60 lb. N rate to the 90 lb. N rate. Overall this soil produced average protein levels that were less than those of the poor soil but made up for it with greater yield. The highest biomass yield coincided with the highest grain yield at the 60 lb. N rate. For this Rago soil 60 lbs. of N was not enough to maintain adequate protein levels. On the other hand, the 60 lbs. of N was enough to maximize wheat grain yields and was slightly more than the calculated economic optimum N rate (EONR) for $3.30 wheat and $0.60 N of 56 lbs. of N per acre.

FUTURE PLANS: The effort to sort out the predictive relationships between EONR with soil type, available water at planting time, growing season precipitation, and residual inorganic nitrates is ongoing. We are using this data set as a beginning place for developing N rates on the precision farming project.

Winter Annual Forage Variety Trial

D. J. Poss and M.F. Vigil

PROBLEM: While there is a vast amount of information available about varieties or hybrids of major field crops, there is very limited information about winter annual forage varieties. From personal conversations with producers we have found that when a decision is made to plant triticale or other winter annual forages, most producers call a seed dealer and purchase the variety they carry. Also, most seed dealers carry only one variety and often that variety is 'VNS' (Variety Not Stated). Our objective is to provide an unbiased replicated study of available triticale and winter annual forages for the benefit of producers in the Central Great Plains region.

APPROACH: For the second consecutive year several varieties of winter annual forages were planted in a randomized complete block design. For the 2016-17 crop year six hybrid ryes were also included in the trial along with 11 triticale varieties and one forage wheat variety. The Triticale varieties were mostly procured from the University of Nebraska's breeding program. Some of the varieties were released over fifteen years ago, while others in the trial are experimental and have not been released yet. KWS seeds provided the six hybrid rye varieties for the trial.

The plots were planted on 4 October 2016 at a seeding rate of 60 lbs/ac. A cone drill was used with double disc openers at 7.5-inch row spacing. Urea fertilizer was broadcast applied prior to planting at 72 lbs N/acre. Individual cultivar plots were 30 feet long and 15 feet wide, and were replicated four times in a randomized complete block design. Three 5-foot-wide passes were planted side by side to accommodate two forage sampling dates and one grain sampling date hence a fifteen-foot-wide plot. While planting, the planter did have a few seed tubes become plugged, so some plots have blank rows. Care was taken during harvest to not take samples from a row that was adjacent to a blank row.

Forage samples were taken on 31 May and 15 June using a Carter forage harvester with a flail head leaving approximately six inches of stubble. Five rows were harvested for a sampling width of 37.5 inches. The samples were weighed using a scale on the machine. A fresh subsample was collected from each harvested plot. The sample was weighed fresh and then placed in a forced air-drying oven and dried at 60 degrees C until moisture lost ceased. The dry weight of the sample was then measured to obtain to calculate n harvest moisture. The forage samples were mailed to Ward Labs in Kearny, NE for forage quality and protein analysis.

Grain samples were collected on 17 July using a Wintersteiger plot combine with a header width of 60 inches. These samples were collected and returned to the lab where they were weighed and analyzed for moisture and test weight.

RESULTS:

2016-17 Trial

Precipitation prior to planting and during the growing season was above average, which gave us very good yields (Table 1). The driest period was immediately prior to planting during the months of August and September 2016. Surface soil water was very dry, so planting was delayed until early October. However, due to the abundant precipitation prior to that period, stored soil water was good. Also, the spring precipitation following planting was very good which resulted in excellent forage and grain yields.

Table 1. Precipitation for the pre-plant and growing season periods.

	2015-2017 inches	**Mean** inches
Pre-Plant (Sept.'15-Sept.'16)	21.82 in.	17.75
Growing Season (Oct. '16-May '17)	9.02 in.	7.99
TOTAL (Sept. '15-May '17)	30.84in.	25.74

The rye hybrids certainly had higher forage yields than the triticale varieties on the first sampling date of 31 May averaging 8,100 lbs/ac and 7,200 lbs/ac for the rye and top six triticale varieties, respectively (Table 2). However, fifteen days later when the second sample was taken, the top six triticale varieties caught up with the rye varieties. This was due to the rye having an earlier maturity date so when the first sample was taken it was close to its peak growth curve compared to most of the triticale varieties, especially the higher yield triticale varieties.

As expected, protein levels decreased during this time period. The relative feed quality (RFQ) index however had mixed results. With only one minor exception the RFQ increased from the first sampling date to the second sampling date for rye and decreased for triticale. That one exception is for the higher yielding triticale, NT07403, the RFQ increased, but only by one point.

We did not do a detailed growth stage analysis at each sampling time by plot. In hindsight, growth stage data would have made it easier to interpret the yield and quality data and compare across varieties.

The timing of the sampling should have been earlier. For the first sampling date of 31 May the rye and a few of the triticale varieties were completely headed. The plan was to collect the second samples one week later, however due to rain and conflicts; it was much later (15 days). All of the varieties in the trial were headed and more mature than a producer would want. Ideally, we would sample each variety or hybrid by growth stage, however due the time requirement and the maneuvering the equipment in the plots this was not possible. An attempt will be made in the future to take the first sample when the earliest maturing varieties are at the late boot to early heading growth stage and take the second sample when the later maturing varieties are at this growth stage.

Grain yields were exceptional with rye hybrid yields ranging from 99.5 bu/ac to 113.2 bu/ac. Triticale yields were much lower, but still very good, with the highest yielding triticale variety being NT07403, which had a yield of 88.8 bu/ac. The thrashing of the rye with the combine was simple and the grain cleaned easily, similar to wheat, however the triticale varieties were difficult to thrash leaving more chafe and head pieces in the grain sample. This is likely one reason the test weight data for the triticale was lower than that of rye. The test weight for the six rye hybrids averaged 54.7 lbs/bu compared to 50.1 lbs/bu for the five heaviest triticale varieties.

In much of the Central Great Plains area rye has a negative reputation. This reputation is warranted due to persistent volunteer rye which originated from when it was planted decades ago. Other crops such as wheat and even triticale have not had these persistent volunteer issues. The question is, will these hybrid rye varieties act more like the rye, which has been planted in the past, or more like other winter annual cereals with regard to the persistent volunteering? To answer this question we must ask, why has the rye planted in the past behaved differently than other winter annual cereals in this regard? While we have ideas as to why this difference exists, further research is needed to answer this question.

2017-18 Trial

The trial was conducted again this year. A couple entries were omitted, including the forage wheat. An additional rye hybrid and an older triticale variety were added.

Last year, we applied 75 lbs N/acre and nitrogen deficiency symptoms were present, so for this year's crop we applied 90 lbs N/acre. Considering the amount of moisture we have received thus far this year, increasing the nitrogen rate was a good decision.

For precipitation, as of 21 May 2018, we are 90% above the long-term mean at 9.37 inches for the calendar year. For the water year (October 1 to present), which closely corresponds to when the trial was planted we are 54% above the mean at 10.50 inches of precipitation. Precipitation during the months of November and December was well below the mean; however, since then we have been above the mean except for March.

At the time of this writing (5/21/2018), no yields had been taken yet. The rye hybrids are heading so yield samples will be taken soon.

Forage Quality & Harvest Timing

When selecting a variety, one variable to consider is the forage quality of each variety. However, this selection criterion should be given less weight that other criteria such as yield potential, diseases, etc. There are subtle differences in quality between varieties, however the timing of the harvest will affect the quality much more that differences between varieties.

Producers always want to maximize yield and maximize forage quality; however, this is almost never possible. As a crop matures its forage quality decreases. The end use of the forage determines what the optimum yield verses quality should be. When the end use is forage for a dairy operation, yield would be sacrificed for better quality, which would demand a higher price per ton. For a cow/calf operation however, quality, while important, is not as critical as for a dairy operation. In this case, it would be acceptable to allow the crop to become more mature, sacrificing some quality for higher yields. The question becomes, how mature should I let the crop become before harvesting? The soft dough stage is about the most mature a producer would want their crop to be.

At this stage, however it may be advisable to grind the hay to make it more palatable for the livestock.

Another consideration is the presence of awns (beards). Some producers have had bad experiences with awns causing lump jaw in livestock, and understandably avoid any hay that has any awns present. However, when harvested at an earlier growth stage it is less likely to cause these issues. This is because the awns are less stiff. If awns in the forage is a concern, then grinding the hay is a possible solution to be able to utilize the forage. We have tested awnless varieties in the past and they have always had the lowest yields. Recently, there have been awnless triticale varieties released that seem to have higher yields. We hope to include some of these varieties in the trial next year.

Table 2. Winter Annual Forage Variety Trial at Central Great Plains Research Station at Akron, CO in 2016-17 Crop Year.

		May 31 Forage			June 15 Forage			Grain	
Variety	**Species**	**Yield** lb/ac	**Protein*** %	**RFQ****	**Yield** lb/ac	**Protein*** %	**RFQ****	**Yield** bu/ac	**TW** lb/bu
KWS Daniello	Rye	8,571 a***	12.8 f	123 d	12,316 ab	8.6 e	130 ab	108.2 ab	54.9 a
KWS Progas	Rye	8,446 a	13.5 ef	125 cd	12,903 a	9.9 bcde	136 a	103.9 ab	54.0 a
KWS Bono	Rye	8,294 ab	12.5 f	121 d	11,795 abc	8.7 e	131 ab	113.2 a	55.7 a
KWS Gatano	Rye	8,178 ab	12.7 f	125 cd	11,333 abc	8.8 e	136 ab	104.0 ab	54.7 a
NT05421	Triticale	7,711 abc	14.1 cdef	130 abcd	12,379 ab	10.1 bcde	128 ab	77.6 cd	49.8 c
KWS Dolaro	Rye	7,644 abc	13.6 def	128 bcd	11,789 abc	9.0 e	134 ab	111.1 a	54.4 a
NT07403	Triticale	7,567 abc	14.1 cdef	129 abcd	11,490 abc	9.8 bcde	130 ab	88.8 bc	51.8 c
Syngenta 718	Triticale	7,488 abc	14.1 cdef	129 bcd	12,718 a	9.4 cde	110 c	63.0 de	47.0 de
Brasetto	Rye	7,476 abc	13.5 ef	118 d	11,210 abc	9.2 de	128 ab	99.5 ab	54.5 a
NT01451	Triticale	6,989 abc	15.8 bc	138 abc	10,769 bc	10.4 bcde	129 ab	82.9 cd	48.9 cd
NE441T	Triticale	6,830 abc	15.0 cde	131 abcd	11,337 abc	11.0 bc	115 c	45.4 f	45.6 e
NT11428	Triticale	6,757 abc	15.2 cde	144 a	11,555 abc	10.2 bcde	130 ab	72.6 cd	49.3 c
NE422T	Triticale	6,676 abc	16.8 b	141 ab	11,262 abc	10.4 bcde	117 c	51.3 ef	48.9 cd
NT094231	Triticale	6,467 bc	17.0 b	141 ab	10,349 c	10.1 bcde	132 ab	71.9 cd	50.1 c
NT06422	Triticale	6,430 bc	15.0 cdef	137 abc	10,556 bc	10.8 bcd	133 ab	77.4 cd	48.1 cd
NE426GT	Triticale	6,027 c	15.4 bcd	143 a	10,126 c	11.1 bc	133 ab	76.2 cd	49.5 c
NT11406	Triticale	5,914 c	16.9 b	141 ab	10,447 bc	11.6 b	132 ab	64.4 de	48.9 cd
Willow Creek	Wheat	4,529 d	20.7 a	130 abcd	8,747 d	13.3 a	121 bc	19.6 g	54.0 b
MEAN		7,111	14.9	132	11,282	10.1	128	79.5	51.1

*Dry weight basis.

**RFQ = Relative Feed Quality

***Means followed by the same letter within a column are not significantly different at the 0.10 alpha level based on SNK mean separation test.

Long-Term Corn Yield at Different Nitrogen Rates and Types

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Nitrogen (N) types and rates are important elements in managing crop production in any agricultural system. Nitrogen requirements for crop production can be derived from several sources: (i) soil organic matter (SOM) mineralization; (ii) plant residue or organic amendments decomposition, such as manure; and (iii) synthetic fertilizer (F) addition. Nitrogen availability from organic amendments or crop residue can be highly influenced by environmental conditions (moisture and temperature), soil type, organic residue quality, and soil health (soil microbial composition). A big portion of crop N requirements can be supported by organic amendments or SOM decomposition while reducing the usage of synthetic fertilizer that could be lost to ground and/or surface water. Long-term studies associated with organic amendments and synthetic fertilizer are important to improve our understanding of the impact of N managements on land sustainability. Although short-term studies are valuable in assessing the N management practices. The fact remains that the impact of the environmental conditions on crop production regardless of N managements could be difficult to accurately evaluate in short-term studies.

Objectives

Evaluate the corn (*Zea mays* L.) production as influenced by:

1) Two N types, cattle beef manure (M) and synthetic fertilizer (F)
2) Two rates, high N rate at 168 kg N ha^{-1} (150 lb ac^{-1}) and low N rate at 84 kg N ha^{-1} (75 lb ac^{-1}).
3) Two tillage practices, no tillage (NT) and conventional tillage (CT).

Materials and Methods

The long-term continuous corn, manure, and tillage study was established in 1990 at the Kansas State University North Agronomy Farm in Manhattan, KS. The average and the monthly precipitations throughout the 24 years of the corn growing season (March through September) is presented in **Table 1**. The 24 years average annual precipitation at the experimental site was 25.79 inches.

Management practices included no-tillage (NT) and chisel-disk (CT; fall chisel plow and spring offset disk). Nitrogen sources included control (no N applied), solid beef manure (M) at two rates, and commercial fertilizer (F) consisting of ammonium nitrate (NH_4NO_3) that was converted to urea-N source after 1999. The N rates consisted of high N rate at 68 kg N ha^{-1} (150 lb ac^{-1}) and low N rate at 84 kg N ha^{-1} (75 lb ac^{-1}) for both N sources (manure and commercial fertilizer). For NT treatment, the M and F were broadcast and left on the soil surface. For CT treatment the M and F were incorporated at 0-10 cm (0-6 inches) depth by disking. For each treatment combination, plot size was 7.5 m (24.6 ft) wide x 6 m (20 ft) long.

Annually, M was analyzed for inorganic and organic N content and the M addition was calculated considering 100% of inorganic (ammonium, NH_4^+; and nitrate, NO_3^-) manure associated N and 30% of the organic manure associated N will be available during the first year of application. Using the above assumption, the mass of annual manure added to designated plots was calculated to provide 168 kg N ha^{-1} (150 lb ac^{-1}) for the high N treatment and 84 kg N ha^{-1} (75 lb ac^{-1}) for the low N treatment. The tillage, N-types, and N-rates were organized in randomized complete block design with four replications. The tillage (NT and CT) were considered the main plot treatment, and N source (M, F, and 0-N control) was considered the subplot treatment. The N rates were analyzed as a split plot within each N-type plot.

Annually, corn (hybrid Pioneer 33G28) has been planted at a seeding rate of 50,494 seed ha^{-1} in the spring. Weed controls were performed approximately one month following the corn emergence using 321 g L^{-1} of atrazine and 400 g L^{-1} of metolachlor (Bicep 6L, Ciba-Geigy) at the rate of 4.76 L ha^{-1}. Corn ears from the middle 2 rows of each plot at 10 m (32.8 feet) length of each plot were hand harvested. The corn grain was adjusted to 15.5% moisture for yield calculation.

Note: No statistical analysis was performed for the yield data from 1990 to 1994 because the individual plot data is missing and the only available data is the mean value associated with individual treatments.

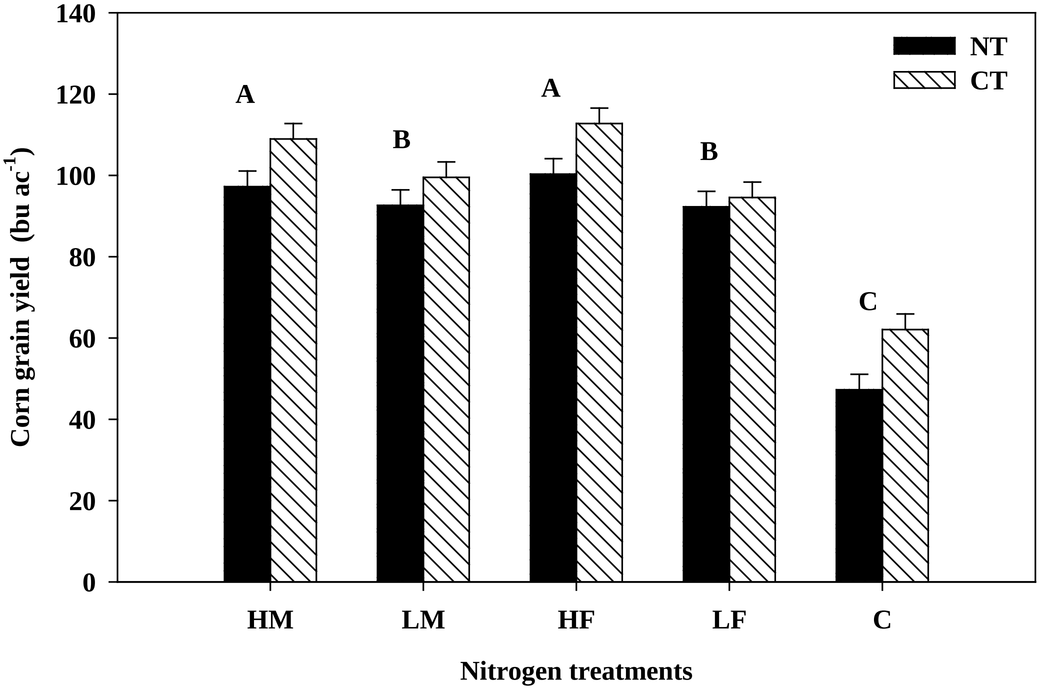

Figure 1. Corn Yield from 1995 to 2014 averages across time (tillage x N-treatments interaction) as influenced by N source (M and F) and N rates (high, H at 150 lb N ac-1 and low, L at 75 lb N ac-1). The error bars represent the slandered deviation among the mean. The individual plot yield data from 1990 to 1994 are missing and are not included with the statistical analysis.

Table 1. Precipitation from 1990 to 2014 throughout the corn growing season and the 24 years averages at Manhattan, Kansas

	Year											
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**Average 1990-2014**
	Inch											
March	3.46	1.34	3.11	2.95	0.24	3.82	1.61	0.07	2.44	1.26	0.28	**1.94**
April	0.79	4.20	0.91	1.97	3.66	2.80	1.61	3.13	1.73	9.02	0.00	**2.90**
Mays	3.98	5.24	2.01	9.84	3.07	11.46	9.09	1.79	1.69	3.66	1.85	**4.29**
June	4.37	0.94	1.89	8.66	5.12	2.99	2.72	2.10	7.17	7.52	19.00	**5.68**
July	7.32	1.54	12.95	12.76	1.57	0.79	0.24	2.13	5.87	2.95	8.05	**4.01**
August	6.06	2.01	2.52	6.26	3.03	1.22	3.77	5.63	0.83	8.11	0.71	**4.34**
September	0.71	1.38	3.11	3.50	0.08	4.21	3.55	2.76	5.94	4.02	1.19	**2.63**
Growing Season	**26.69**	**16.64**	**26.50**	**45.94**	**16.77**	**27.28**	**22.60**	**17.60**	**25.67**	**36.54**	**31.07**	**25.79**

	Year										
	2001	**2002**	**2003**	**2004**	**2005**	**2008**	**2009**	**2010**	**2011**	**2012**	**2014**
	Inch										
March	3.32	0.83	1.01	2.20	0.70	2.32	3.17	1.76	1.33	2.75	0.45
April	1.88	4.63	4.54	2.58	0.73	2.07	6.20	2.31	2.49	1.96	4.15
Mays	2.99	5.41	2.23	2.35	1.53	4.75	0.48	3.63	5.16	1.07	1.93
June	1.19	1.94	6.24	6.85	12.16	11.95	8.13	6.62	4.77	3.30	8.83
July	4.02	2.48	1.83	6.37	1.86	5.09	5.70	4.19	2.08	0.58	0.67
August	10.79	3.18	5.51	5.09	6.53	4.59	4.67	3.20	2.33	4.21	3.99
September	1.99	2.26	2.47	1.40	4.50	5.81	1.81	3.00	1.46	1.64	1.15
Growing Season	**26.18**	**20.74**	**23.83**	**26.84**	**28.01**	**36.59**	**30.16**	**24.71**	**19.62**	**15.50**	**21.17**

Results and Discussion

Throughout the study period, CT significantly ($p < 0.05$) increased corn yield compared with NT, but N treatment by tillage interaction across the study period was not significant **(Fig 1)**. This indicated that tillage has no influence on corn yield production when we averaged across the study period from 1995 to 2014. The study period from 1990 to 1995 was not included within the statistical analyses because the individual plot data is missing and the available data is only the mean associated with each treatment combination. Average across time, the N rate (H and L) had a great effect on the corn yield despite the source (M or F) of N **(Fig 1)**. Our data indicated that the high rate of M and F yielded a greater amount of corn by approximately 10% when compared with the low rate and by 83% compared with the control treatment (no N added). Whereas, the low N rate yielded more corn by approximately 73% when compared with the control treatment.

The average across N treatments (N types and N sources) indicated that the corn grain yield was significantly influenced by time and by tillage x time interaction **(Fig. 2)**. The temporal variability in corn yield associated with time shows the effect of precipitation type on the productivity. The significant reduction in yield associated with 2005 and 2010 was due to severe hail damage. The effect of tillage was significant in some years but not in the other years. This long-term yield data indicates that many factors in conjunction with tillage can influence grain yield in any individual year such as amount, intensity, type of precipitation, and the ambient temperature. However, the inclusion of NT has been proven to improve soil health compared with CT.

The average across tillage indicates that corn grain yield was significantly influenced by N treatments x time interaction **(Fig. 3)**. The control treatment exhibits the lowest yield compared to any N addition treatments. From 1995 to 1999, the F treatment showed a tendency to have a higher yield than the M treatment in both N rates addition. However, from 2000 to 2014, the M treatment showed the tendency to increase the yield over the F treatments and in some years the increase was significant **(Fig. 3)**. The tendency to increase yield with the M rather than the F treatments after many years of manure addition could be related to the improvement of some aspect of soil quality and soil health that translated to enhancing the grain yield.

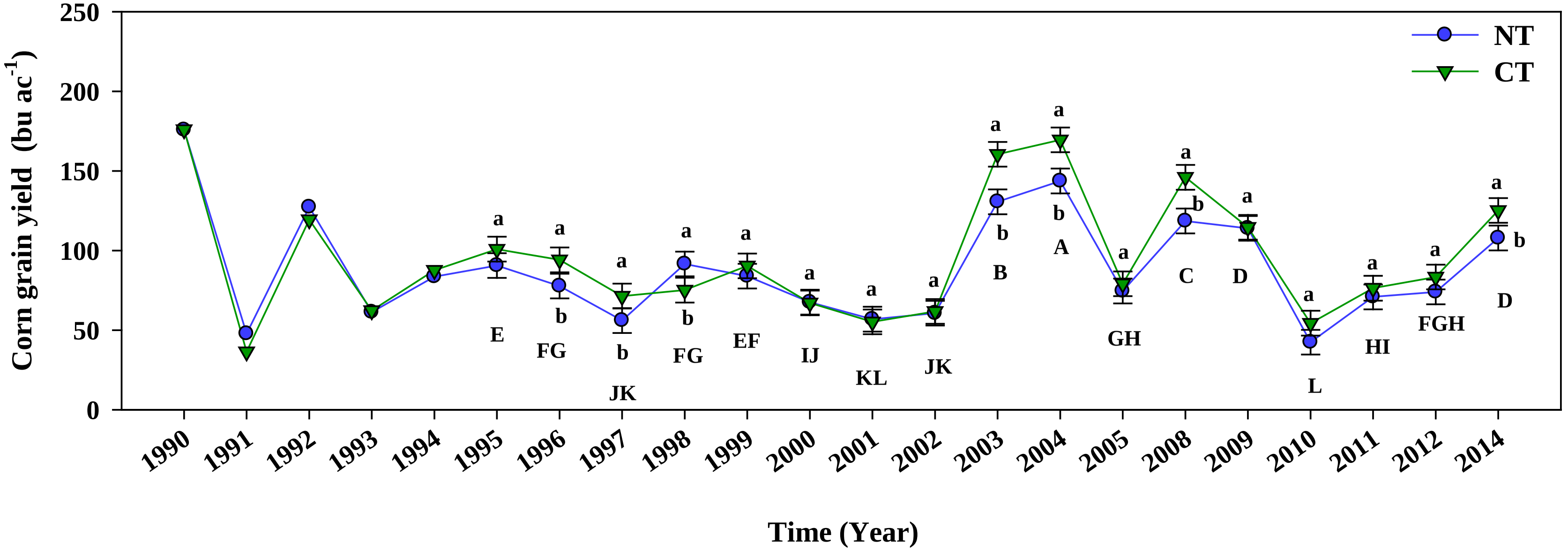

Figure 2: Corn yield averaged across N treatments (tillage x time interaction) as influenced by N sources (M and F) and N rates (high at 150 lb N ac^{-1} and low at 75 lb N ac^{-1}). The lowercase letters represent significant ($P < 0.05$) differences between tillage within each year. The uppercase letters represent significant ($P < 0.05$) difference with time average across tillage and N treatments. The error bars represents the standard deviation among the means. The individual plot yield data from 1990 to 1994 are missing and are not included with the statistical analysis.

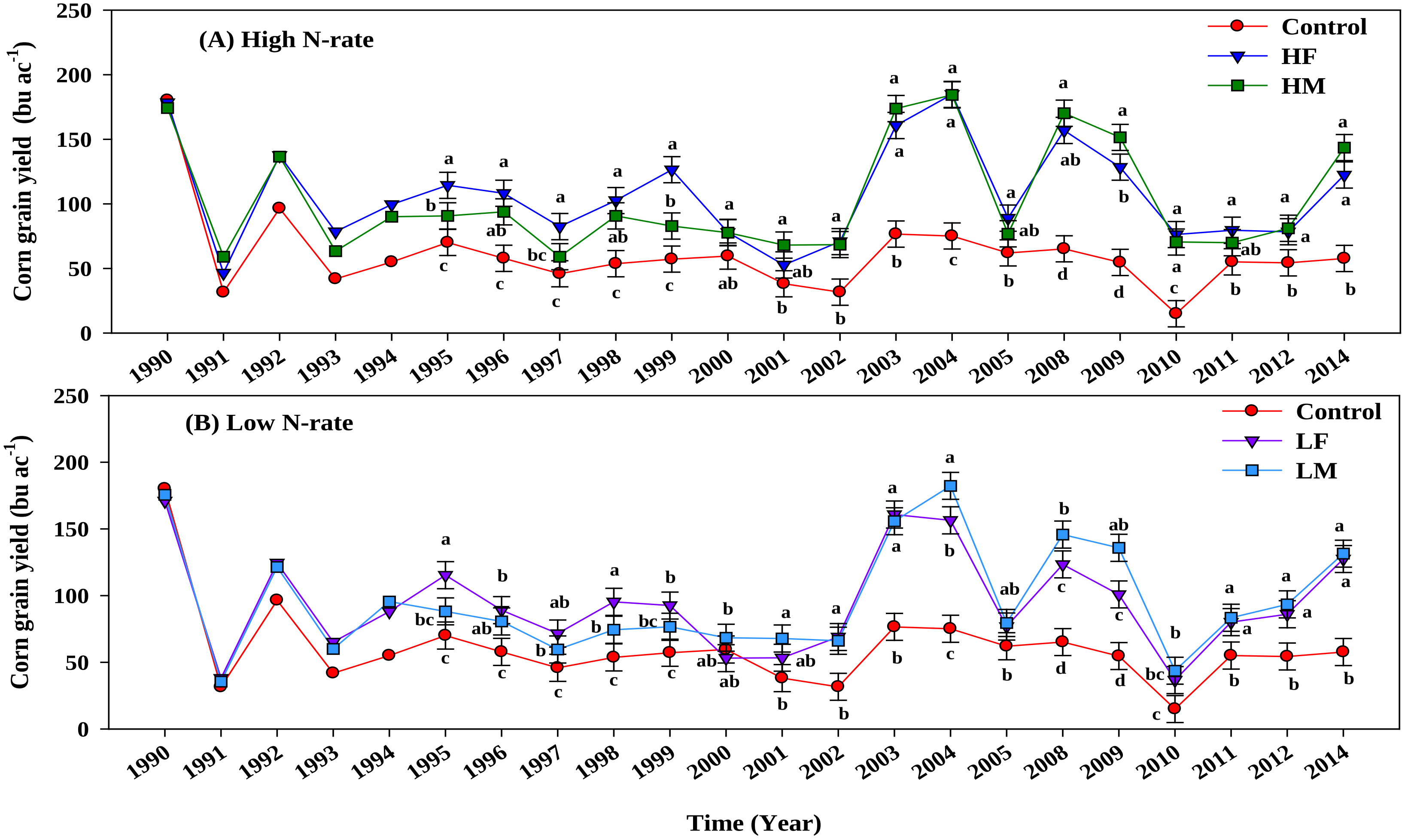

Figure 3: Corn yield average across tillage (N treatments x time interaction) as influenced by N source (M and F) and N rates (high, H at 150 lb N ac^{-1}; and low, L at 75 lb N ac^{-1}). The lowercase letters represent significant ($P < 0.05$) differences between N treatments within each year crossing through both figures A and B. Control treatment (zero N rate) was added in each figure for statistical comparison. The error bars represent the standard deviation among the means. The individual plot yield data from 1990 to 1994 are missing and are not included with the statistical analysis.

Conclusions

- This long-term yield data indicates that many factors in conjunction with tillage can influence grain yield for individual years such as amount, intensity, type of precipitation, and the ambient temperature.
- Throughout the 24 years of tillage managements, corn grain yield was significantly influenced by tillage treatments, but not in 7 years out of the entire study period.
- The temporal variability in corn yield associated with time shows the effect of precipitation type on the productivity.
- The average across time indicates that the high N rate had a great effect on the corn yield despite the N source (M or F).
- The tendency to increase yield with the M rather than the F treatments after many years of M addition could be related to the improvement of some aspect of soil quality and soil health that translated to enhanced grain yield.
- In this study site, the influence of different management practices on the soil physical and biological properties are being evaluated and will be presented in the future.

Pre-emergent Herbicides for Improved Control of Kochia in Chemical Fallow

John Spring, CSU Extension

PROBLEM: Glyphosate-resistant kochia continues to spread across northeast Colorado and western Nebraska, and is especially problematic in chemical fallow. In western Kansas, the use of pre-emergence herbicides has been a successful strategy to help manage resistant kochia populations. As climate and growing conditions differ somewhat between regions, field trials are needed to evaluate the performance of pre-emergence herbicide options for kochia control in northeast Colorado and western Nebraska chemical fallow.

APPROACH: Field trials were established at the USDA-ARS Central Great Plains Research Station near Akron CO and at the UNL High Plains Ag Lab near Sidney NE to screen several pre-emergence herbicides for control of kochia in chemical fallow over the 2018 growing season. Herbicides were applied March 8, 2018 in Akron, and March 12, 2018 in Sidney. Adequate precipitation to activate herbicides fell at both sites on March 18th. No emerged weeds were present at the time of application, and initial kochia emergence was not observed in plots until late April.

Treatment	Product	Active Ingredient	Rate (oz/ac)	Mode-of-Action	Plots				
1	check - no PRE	*na*	*na*	*na*	101	211	302	408	505
2	Prowl H20	*pendimethalin*	64	3	102	204	306	412	513
3	*Milestone	*aminopyralid*	1	4	103	213	312	404	508
4	Clarity	*dicamba*	16	4	104	207	305	402	503
5	Glory	*metribuzin*	11	5	105	201	313	409	510
6	Atrazine 4L	*atrazine*	32	5	106	205	309	414	504
7	*Command	*clomazone*	21	13	107	209	310	401	514
8	Spartan Charge	*sulfentrazone*	6.5	14	108	214	307	410	502
9	Valor SX	*flumioxazin*	2	14	109	206	301	405	512
10	Sharpen	*salflufenacil*	4	14	110	203	311	406	501
11	Zidua	*pyroxasulfone*	4	15	111	210	303	413	509
12	Outlook	*dimethenamid*	18	15	112	208	314	411	506
13	Scoparia	*isoxaflutole*	2.5	27	113	202	304	403	507
14	*Callisto	*mesotrione*	3	27	114	212	308	407	511

* Products marked with * were applied under an experimental use exemption and are not currently labelled for use in chemical fallow.

RESULTS: At 9 weeks after application (May 11th in Akron, May 15th in Sidney), several herbicides provided complete control of kochia at both sites. In Akron, kochia plants were in the early stages of emergence at this time and too small to count accurately. Accordingly, Akron plots were rated for kochia emergence on a yes/no basis. In Sidney, the actual number of kochia plants was counted in each plot.

Kochia emergence at 9 weeks after application.

Treatment	**Product**	**Akron:** % plots with kochia emergence	**Sidney:** average kochia plants/plot
1	check - no PRE	100	30
2	**Prowl H20**	**20**	**2**
3	Milestone	60	31
4	**Clarity** (dicamba)	**20**	**4**
5	**Glory** (metribuzin)	**0**	**0**
6	**Atrazine 4L**	**0**	**0**
7	**Command**	**20**	**3**
8	**Spartan Charge**	**0**	**0**
9	**Valor SX**	**0**	**0**
10	Sharpen	40	44
11	**Zidua**	60	**1**
12	Outlook	80	11
13	**Scoparia**	**20**	**2**
14	Callisto	60	23

At both sites, metribuzin, atrazine, Spartan Charge (sulfentrazone) and Valor (flumioxazin) completely controlled kochia emergence at 9 weeks after application. Russian-thistle was present at Sidney, and was also controlled by these products. Prowl H$_2$0, dicamba (Clarity), Zidua, and Scoparia suppressed kochia emergence at both sites, but did allow some level of germination.

A NOTE ON HERBICIDE RESISTANCE AND PRODUCT STEWARDSHIP: While herbicides were tested individually in this trial for development purposes, they should never be used alone in production fields. *Using any of these herbicides alone poses unacceptably high risk for quickly selecting resistant populations of kochia or other weeds.* Tank mixing multiple modes-of-action is one of the most effective methods to delay development of herbicide resistance. For this approach to work, both tank mix chemicals must perform well on the target weed(s) and have about the same length of soil residual activity. Determining this necessitates testing herbicides individually in small plot trials during development of tank mix recommendations. In full-scale field use, however, residual herbicides should always be combined in multiple mode-of-action tank mixes to lower the risk of selecting herbicide resistant weed populations.

FUTURE RESEARCH: Further trials will be conducted in 2019 to follow up with the more effective treatments identified this year. Tank mixes, and several application timings (fall and spring) will likely be tested beginning in 2019. Also, additional trial locations are wanted for next year. If you are interested in potentially hosting a trial on your ground, or have suggestions for future work, please contact John Spring (john.spring@colostate.edu; or 970/474-3479).

ACKNOWLEDGEMENTS: Grant support for this project from the Colorado Wheat Research Foundation is gratefully acknowledged. Thanks also to Cody Creech for collaboration and hosting the Sidney site, and to Merle Vigil for hosting the Akron site.

Impacts of Residue Removal on Irrigated Corn Production

J.P. Schneekloth, F.J. Calderon, and D.C. Nielsen

PROBLEM: Continual removal of corn residue can have significant impacts on soil properties as well as the potential productivity without the additional input of nutrients to offset those removed in the residue. A study began in 2014 at Akron, CO looking at the impact of residue removal and tillage upon the soil characteristics important to crop production as well as crop production and the economics. Two tillage treatments, No-Till (NT) and Tilled (T) were incorporated with residue removal (NR) and no residue removal (R).

APPROACH: Tillage and residue management treatments were initiated in 2014 on irrigated continuous corn plots at Akron, CO. Residue was harvested in the spring or fall prior to the planting season depending upon conditions after harvest. Tillage was done after residue removal and prior to planting.

Measurements of infiltration rates were taken in the fall (August or September) each year after the majority of the irrigation season was over. A Cornell Infiltrometer was utilized to make several measurements of time to first runoff, total infiltration and steady state infiltration.

RESULTS: Average infiltration (Figure 1) for three of the treatments were similar over the 4 year period. However, NT/NR infiltation was substantially less than all other treatments. Although from 2014 to 2016, infiltation was only marginally less than NT/R, T/R and T/NR, in 2017 NT/NR infiltation was substantially reduced compared to previous years. Infiltration for NT/R was relatively steady from 2014 to 2016 but a increase of approximately 0.7 in $^{hr-1}$ was measured. Infiltration for T/NR has been similar to that of T/R in 2016 and 2017 but was lower in 2014 and 2015. It is unclear as to why measured infiltration is remaining high compared to NT/NR when residue is removed. Tillage may have an impact of alleviating the removal of residue short term.

Steady state infiltration (Figure 2) has had a similar trend to total infiltration. In 2017, a substantial increase in steady state infiltration was observed for NT/R and a drop in steady state infiltration for NT/NR. Similar to total infiltration, steady state infiltration for T/NR is remaining relatively high and similar to that of NT/R and T/R.

With the decrease in total and steady state infiltration of the NT/NR, this would indicate that the soil surface is important in this process and that the lack of tillage or residue is impacting infiltration rates faster than when tillage occurs with the T/NR.

One of the benefits of residue and reduced tillage has been the resulting increase in infiltration by previous research. Increasing tillage destroys macro and micro pore structure which reduced infiltration of water. Maintaining or increasing infiltration is important for irrigation sprinkler package design to reduce runoff potential without increasing system pressure to increase the wetted diameter and reduce the maximum application rate.

In semi-arid regions and areas with declining water levels, maximizing precipitation and moisture preservation is important. In 2017 and 2018, (Figure 3) precipitation storage efficiency was greater when residue remained standing in the field prior to the spring tillage and harvest of residue in the fall. The difference in stored soil moisture was 1.5” in 2017 and 1.2” in 2018. This increase in moisture is important in conserving irrigation water.

Another issue in management of soils is organic matter and pH. Organic matter has been reported to increase with no tillage as compared to tillage. In 4 years of tillage management, organic matter has not increased with the use of NT (Figure 4). However, tillage has reduced organic matter levels by 0.05% and 0.125% in T/R and T/NR. Impacts to organic matter may be slow for NT as degradation of residue is slowed. Currently, you can see the previous 3 years of residue in various stages of degradation in NT/R. The lack of tillage in the NT/NR may be slowing the degradation of organic matter in the soil.

Other factors in water conservation is evaporation reduction by residue. From 2015 to 2017, total vegetative ET was reduced only NT/R as compared to all other treatments. Even when residue cover was greater than 50% with the T/R, vegetative ET was similar to when residue was removed. Full cover of the soil is critical in reducing evaporation losses prior to canopy development.

The overall impact is measured in grain yield. The grain yields in 2016 and 2017 for NT/R and T/R were similar overall but with a reduction of 10% in irrigation for the NT/R compared to T/R. Yields were greater when residue remained in the field as compared to when it was removed on average. The average decrease in yield was approximately 9 bu ac^{-1} when residue was removed but was as high as 20 bu ac^{-1} in 2017 for NT/NR compared to T/R.

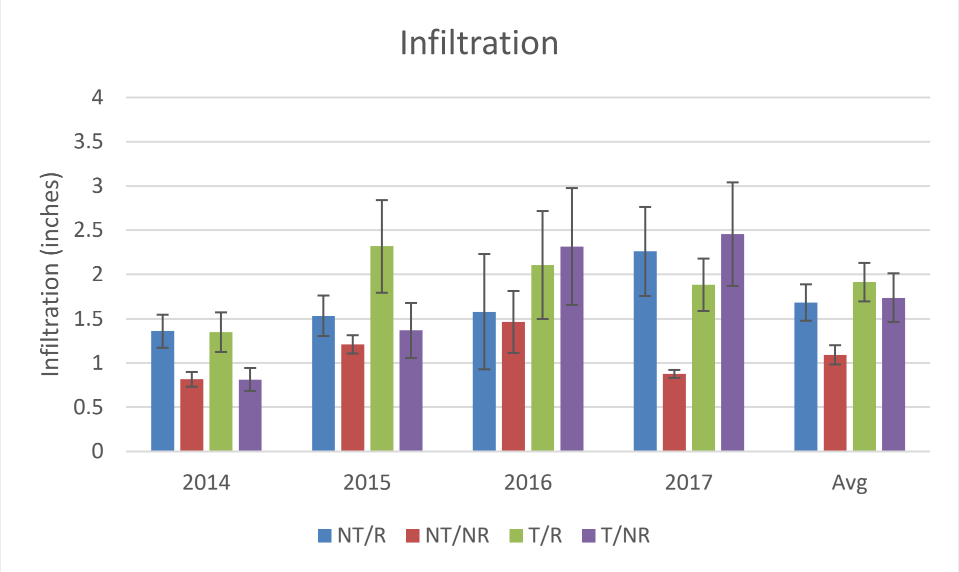

Figure 1. Total infiltration in 30 minutes by tillage/residue management strategy.

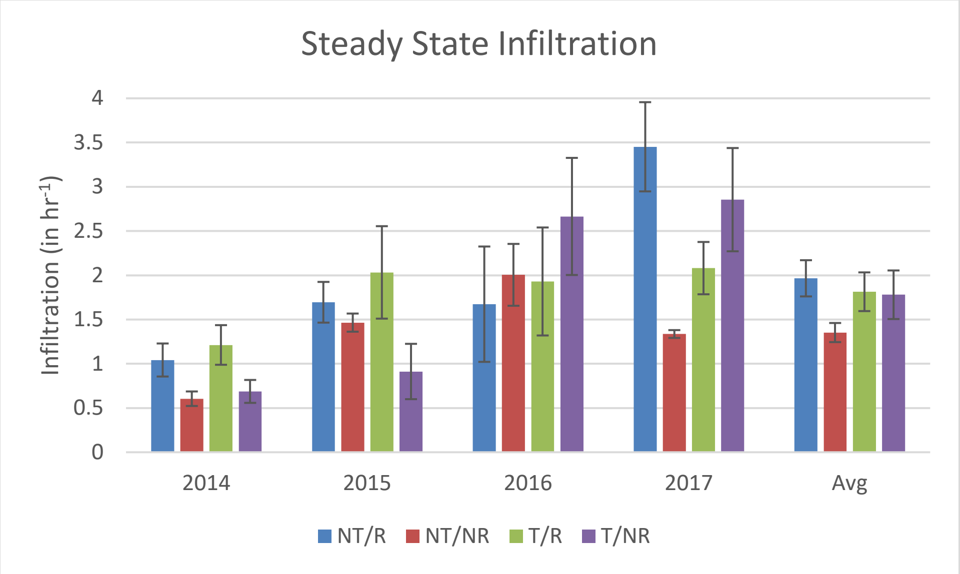

Figure 2. Steady state infiltration by tillage/residue management strategy.

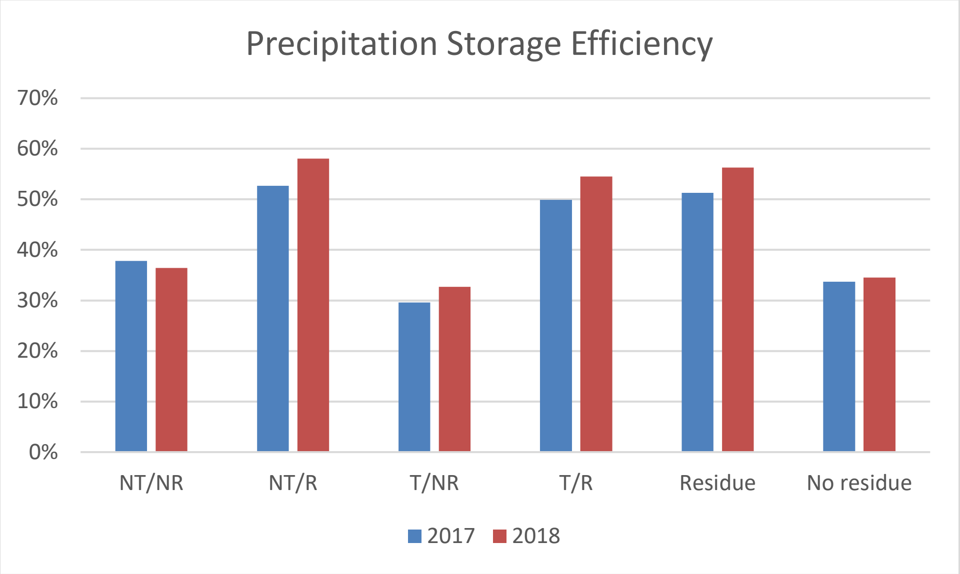

Figure 3. Precipitation storage efficiency by tillage/residue management strategy.

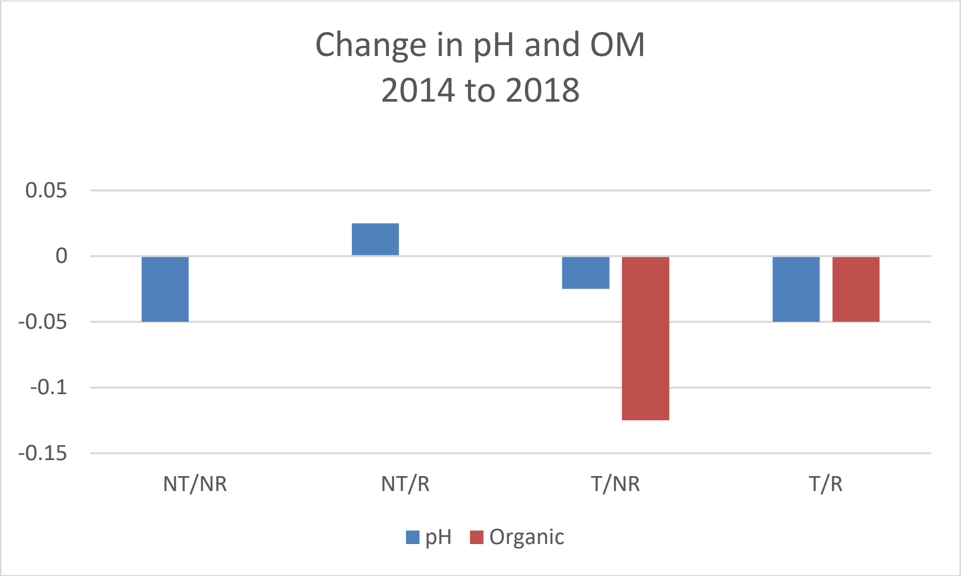

Figure 4. Change in organic matter and pH by tillage/residue management strategy.

FUTURE PLANS: The plan is to continue this study as a long-term residue and tillage management study. This study will continue in its current format for at least 2 more years with full irrigation management as the primary water management. We are trying to collect at least 2 years of yield data not tainted by either hail or a significant nutrient deficiency. After that time, water management practices will change to a limited/deficit irrigation management to look at the impact of water deficiency on residue and tillage management.

Soil C and Soil Chemistry Effects of Residue Management in Irrigated Corn

Francisco Calderón and Joel Schneekloth

PROBLEM: Tillage and residue removal are often carried out in corn-based crop rotations worldwide. However, tillage and residue removal can cause net decreases in soil organic matter, and that way have a negative impact on soil moisture, water holding capacity, soil fertility, soil physical properties and soil biological activity, bringing into question whether these management practices can be sustained on the long-term. No-till can have tangible benefits for crops, because surface residues protect soils from raindrop impact and thus avoid surface sealing, soil losses due to erosion, and water losses due to runoff. Residue retention in no-till can improve soil structure by fostering more earthworm and microfaunal activity, which in turn can enhance several important soil functions including aeration, water infiltration, erosion prevention, root growth and C stabilization. Microbial growth during residue decomposition can help build soil aggregates via the growth of microbial biomass and the associated increase in sticky microbial products, but also due to the increase in fungal hyphae, which are microscopic fibers that can directly tie soil particles together. Never the less, tillage can have important short term beneficial effects by controlling weeds, creating a good seed bed, improving bulk density, and facilitating the turnover of residue nutrients so that they are available to subsequent crops.

Previous work showed that after three years the combined effects of residue conservation and no-tillage benefitted macrofaunal communities, with a five-fold rise in earthworm biomass. the increased earthworm activity accompanied a rise in aggregate stability under no-till with residue and improved water infiltration. At the three-year mark, soil organic matter did not show significant differences between tillage or residue treatments. This prompted us to do another sampling in 2018 to follow how soil chemical, physical, and microbiological properties are responding to the experiment.

APPROACH: The experiment was established in April 2014 at the Central Great Plains Research Station to measure the impacts of no-till and residue removal (Figure 1) The experiment is a replicated randomized design with the following treatments: no-till + residue retention (NT/R); no-till + residue removal (NT/NR); conventional tillage + residue retention (CT/R); and conventional tillage + residue removal (CT/NR). In the spring of 2018, we sampled the soils for physical properties (penetrometer resistance and bulk density), microbial community structure

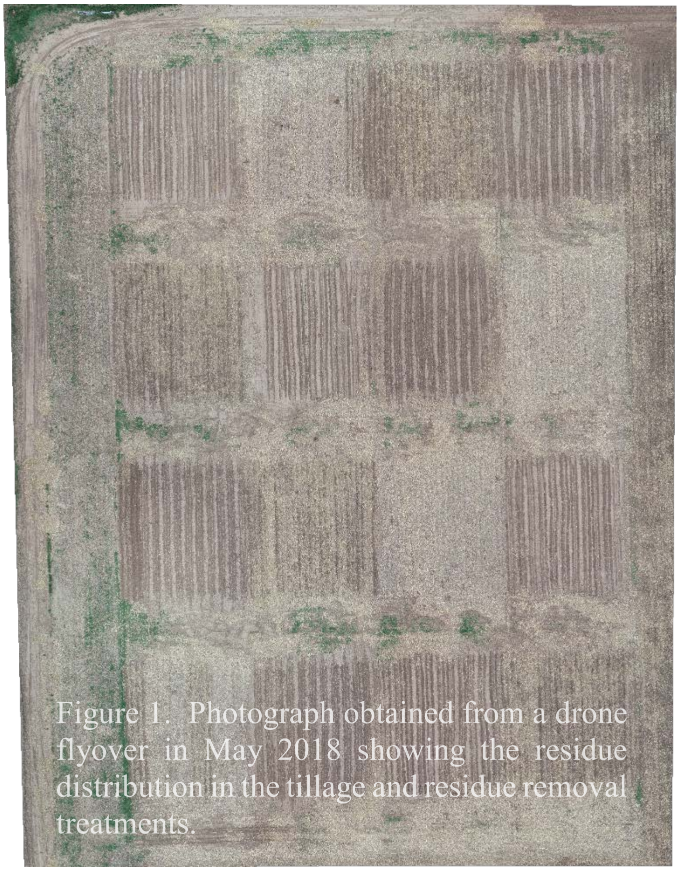

Figure 1. Photograph obtained from a drone flyover in May 2018 showing the residue distribution in the tillage and residue removal treatments.

(phospholipid fatty acids, PLFA), and soil organic matter quality (fourier transform mid infrared spectroscopy).

RESULTS: Our data after 4 years indicates that the soil physical properties are beginning to respond to the experimental treatments. The most common metrics used to determine soil strength in tillage studies are penetrometer resistance and bulk density. Soil compaction and depth of soil disturbance are typically quantified using penetrometer resistance. Because of this, determining the effect of tillage on penetrometer resistance can ultimately help explain the differences in crop yields.

The NT/NR treatment reached penetrometer resistance levels that surpassed 1500 kPa, thought to be the boundary after which root growth becomes limited. This was observed at depths of 10 cm and below. These results underscore the fact that for no-till management to benefit soil quality and crop growth, it is important that it is accompanied by residue retention. Removal of the residues does not allow for increases in earthworm and microfaunal activity that are associated with improved soil porosity and organic matter turnover. In addition, the absence of tillage results in a consolidated soil that could reduce root growth. The bulk density measurements confirm the results of the penetrometer reading, showing the higher bulk density in the NT/NR. The tilled soils had significantly lower bulk density than the NT. The bulk density also had a significant residue effect due to the higher densities in the residue removal treatments.

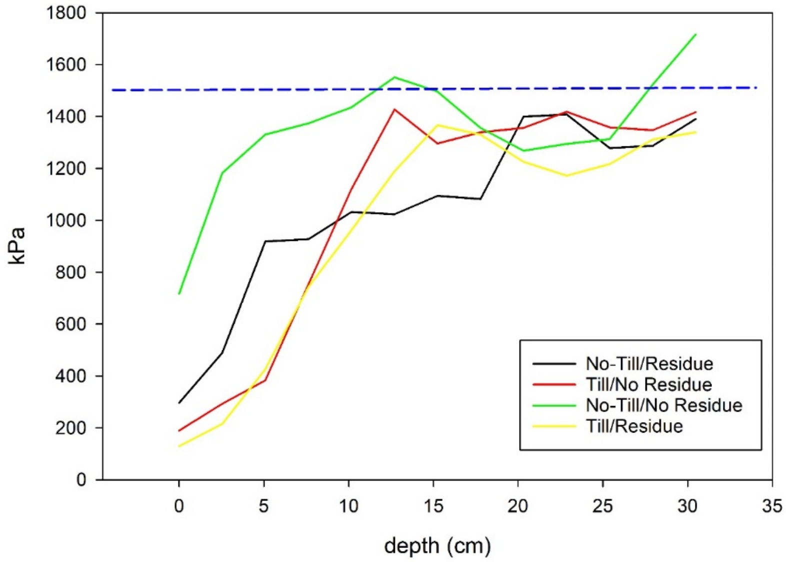

Figure 2. Penetrometer resistance for the tillage and residue treatment combinations obtained in May 2018. The dotted blue line marks resistance at 1500 kPa, considered to be detrimental to root growth

Table 1. Bulk density ($g\ cm^{-3}$) in the residue removal and tillage treatment combinations. All the main effects were statistically significant: Tillage (p=0.03), residue (p=0.04), and depth (p=0.04). The tillage by residue interaction was not significant.

Depth	No Till/No Residue	No Till/Residue	Till/No Residue	Till/Residue
0-5	1.55	1.31	1.42	1.19
5-15	1.47	1.41	1.43	1.41

Phospholipid fatty acids (PLFA) are complex and diverse molecules that are present in living microbial cells. Different groups of fungi and bacteria vary in the type and amount of PLFAs, so

PLFA analysis can be used to determine treatment effects on microbial community structure. Given that PLFAs come in many forms, multivariate analysis is needed to illustrate treatment effects. Figure 3 shows the results of a Discriminant analysis of the PLFA data. It shows that after 4 years the tillage and residue effects are having a clear impact on the soil microbiology.

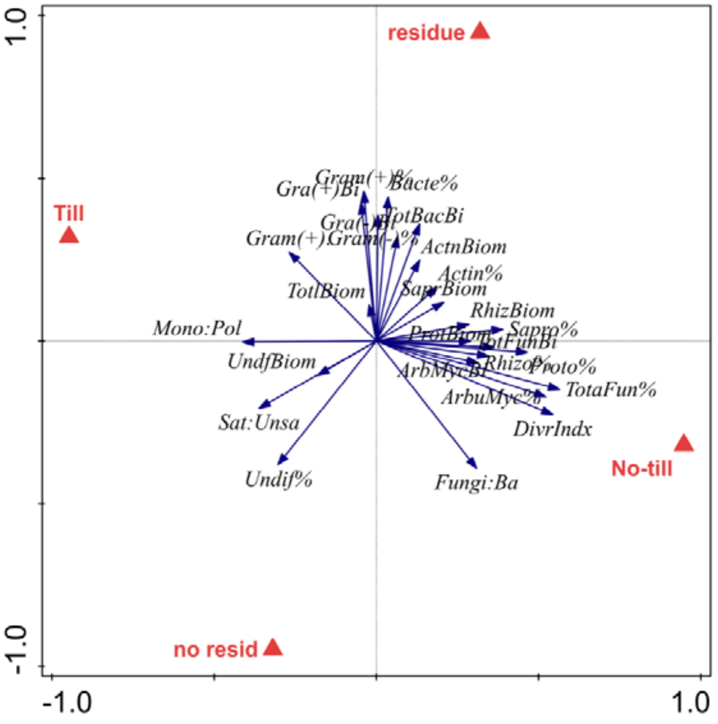

Figure 3. Discriminant analysis of the PLFA microbial community structure data.

The soils that kept the residue in place are overall richer in bacterial PLFA, including Actinomycetes, Gram positive and Gram negative bacteria. In contrast, plots under no-till had higher overall microbial diversity, and higher amounts of fungal PLFA, including saprophytic fungi and arbuscular mycorrhizae. Microbial stress markers are higher in the residue removal treatment. These results indicate that fungi, which are important for residue decomposition and the development of soil structure are favored by no till, possibly because their hyphae are disrupted by tillage. Arbuscular mycorrhizae, which form beneficial symbiotic relationships with roots and help plants obtain P and water, are also favored by no-till. Keeping the residue helps foster bacteria, which are important because they are prolific producers of enzymes that drive nutrient cycling, and also contain high amounts of N in their bodies, that can then be turned over to crops once they complete their life cycle.

Infrared spectra are relatively easy to obtain from soils and they contain a wealth of information about the chemical composition of the soil organic matter. The large amount of information in the mid infrared spectra necessitates the use of multivariate analysis to make sense of the data. Figure 4 shows a multivariate analysis of the mid infrared absorbance data, which indicates that regardless of tillage, the presence or absence of corn residue has a marked effect on the soil organic matter chemistry. This difference is due to

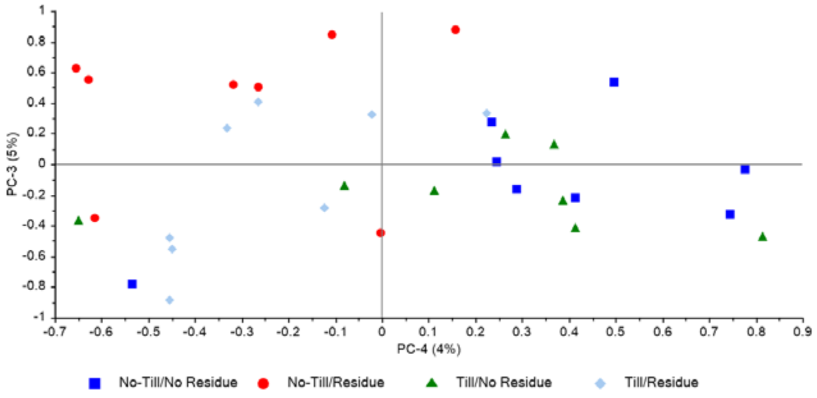

Figure 4. Pricipal components analysis of the mid infrared absorbance data from the soils of the residue and tillage treatments.

higher absorbance for aliphatic CH bonds (at 1454 cm^{-1}) showing that residue material is being incorporated into soil carbon. The soils with residue removal have more marked clay and sand absorbance, consistent with a decline on soil organic matter.

Our findings suggest that no-till and corn residue management practices markedly affect soil structure, organic matter chemistry, and soil microbiology. Because of this, the profits from the sale of corn residues need to be weighed against the benefits to sol quality and soil function brought about by keeping them in place.

FUTURE PLANS: This collaborative effort between CSU and ARS will continue, and we expect to obtain more samples in future years to develop an understanding of the timeline of the residue removal and tillage effects on irrigated corn.