2019 Field Day

Central Great Plains Research Station 112th Annual Field Day

USDA

United States Department of Agriculture

Agricultural Research Service

Colorado State University

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Impacts of Residue Management on Water and Soil Properties

2019 Field Day

Agenda

June 19, 2019

USDA-ARS Central Great Plains Research Station

Highway 34, Four Miles East of Akron, CO

Registration begins at 8:30 am with Coffee and Donuts

8:55 AM	**Dr. Merle Vigil, ARS** Welcome to the Central Great Plains Research Station's 2019 Field Day
9:00 AM	**Dr. R. Wayne Shawcroft** Wheat Year Precipitation/Temperature Analysis 2019 Crops
9:15 AM	**Dr. Dannele Peck , ARS** Weather & Climate Resources for Dryland Farming
9:30 AM	**Dr. Merle Vigil, ARS** Precision Farming Project Update
9:45 AM	**Dr. Francisco Calderon, ARS** Field variability in soil properties according to altitude at the Akron field station

10:00 Break

Dr. Scott Haley Sally Jones-Diamond, Rick Novak , CSU & Brad Erker of Colorado Wheat
Walk-through of Wheat Variety Trial

Dave Poss, ARS
Growing Winter Annual Forages in Northeastern Colorado

Dr. Maysoon Mikha, ARS
Microbial Community Structure Influenced by Residue Removal and Nitrogen Sources

Dr. John Spring, CSU
Pre-emergent Herbicides for Improved Control of Kochia in Chemical Fallow

Joel Schneekloth, CSU
Impacts of Residue Management on Water and Soil Properties

Tour 1	Tour 2
10:15 Scott, Sally, Rick & Brad	10:15 Dave Poss
11:15 Dave Poss	10:35 Maysoon Mikha
11:35 Maysoon Mikha	10:55 John Spring
11:55 John Spring	11:20 Joel Schneekloth
12:20 Joel Schneekloth	11:45 Scott, Sally, Rick & Brad

12:45 Lunch in Bldg. 18

Our Staff

Scientists

Merle Vigil Research Leader (acting)
Francisco Calderon
Maysoon Mikha
David Poss

Admin
Sarah Bernhardt
Carolyn Brandon
Joy Quick

Seasonal
Leanna Clarkson
Kelsey Guy
Cameron Lyon
Alexys McGuire
Orian Wagers
Ty Lucero
Levi Kipp
Anthony Dreher
Mallory Thompson

Technicians
Paul Campbell
Cody Hardy
Delbert Koch
Brandon Peterson
Stacey Poland

CSU Staff
Ed Asfeld
Linda Hardesty
Sally Jones-Diamond
Joel Schneekloth
Sarah Clarkson
Kiara Guy

Thank You Sponsors

21st Century John Deere

Bayer CropScience

Buffalo Brand Seed

CHS- M&M Co-op Colorado

Colorado Corn Administrative Committee

Colorado Wheat Administrative Committee

Cope Soil Conservation District

Culligan

Farmer's State Bank of Akron

Global Harvest Foods

Gowan Company, LLC

Ison Oil CO

J&H Auto Carquest

Lewton Ag Services

MONSANTO

Northern Feed & Bean

Sukup Quality Irrigation

Soil & Crop Sciences, CSU

Stockmens Bank of Colorado Springs

Wagers Farms Pioneer Seed

Ward Laboratories

West Plains Company

Y-W Electric Association

WHEAT YEAR PRECIPITATION / TEMPERATURE ANALYSIS
2019 CROP

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

Central Great Plains Research Station
Akron, Colorado

Data through MAY 29, 2019

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 2019.**

Summary of Fallow Period 14-month
(J,A,S,O,N,D,J,F,M,A,M, J,J,A) = 14-months
July 2017 -- Aug 2018

Month	Year	Fallow Precip in	110-year Average Precip	Departure
Jul	2017	1.12	2.622	-1.50
Aug	2017	2.17	2.157	0.01
Sep	2017	1.25	1.277	-0.03
Oct	2017	0.89	0.916	-0.03
Nov	2017	0.13	0.542	-0.41
Dec	2017	0.11	0.424	-0.31
Jan	2018	0.88	0.329	0.55
Feb	2018	0.69	0.362	0.33
Mar	2018	0.55	0.845	-0.29
Apr	2018	2.33	1.655	0.68
May	2018	6.44	2.930	3.51
Jun	2018	2.91	2.447	0.46
Jul	2018	2.06	2.610	-0.55
Aug	2018	0.21	2.163	-1.95
Total		**21.74**	**21.278**	**0.46**
	total months=		14	

Growing Period Precip
10-Month Sep-June

Month	Year	Sep2018-Jun 2019 Precip	110-yr Ave Precip	Departure	Days of Snow Cover	Snow Depth in.
Sep	2018	0.26	1.28	-1.02	0	0.0
Oct	2018	1.21	0.90	0.31	2	3.0
Nov	2018	0.30	0.52	-0.22	7	3.5
Dec	2018	0.05	0.42	-0.37	1	0.5
Jan	2019	0.36	0.34	0.02	7	5.5
Feb	2019	0.45	0.36	0.09	16	9.8
Mar	2019	1.62	0.83	0.79	5	4.5
Apr	2019	0.47	1.66	-1.19	3	4.0
May	2019	3.38	2.95	0.43	2	3.5
Jun	2019		2.44	-2.44	0	0.0
Total		**8.10** inches	**11.70**	**-3.60**	43	34.3
	total months =		10			

29-May-2019 <Last Update

FALLOW PERIOD SUMMARY:

The **July '17 - Aug. '18** fallow period precipitation was **21.74 inches**, which ranks as the **49th wettest** fallow period in the 110-year record for the 1908-09 through 2017-18 records. This is **0.46 inches** above the average of 21.28 inches. The fallow period began with moderate rainfall in the Jul-Oct period. The fall period was dry. The spring period had good rains through April. May through July rain was substantial, but Aug turned very dry. Seeding moisture for the fall crop was marginal.

GROWING SEASON SUMMARY Sep '18-Jun '19:

The ***GROWING SEASON*** precipitation for the **2019** crop **(through May 29, 2019)** has been **8.10 in.** which is **3.60 inches BELOW the average of 11.70** inches. The ***GROWING SEASON*** precipitation for the current crop ranks only as the **96th wettest** on record or the **15th driest.** This **does not include the remaining days in MAY and JUNE**, which could increase this amount. Sept. was very dry, but October was wet. Winter precipitation was low in Nov-Dec, Jan and Feb were about average in precipitation, but March was above average. April was dry, but May has been well above average. Moisture prospects look good through the end of May. The summer pattern seems to be showing frequent rains with cooler temperatures, and should be beneficial for the wheat crop of 2019.

SNOWFALL - WINTER 2018-19

Fall snowfall was 7.0 inches with 10 days of snow cover and only 0.61 inches of precipitation. The Jan.1 to May 22 period had 27.3 inches of snow with 33 days of snow cover and 3.83 inches of precipitation. Winter snowfall was sporadic, and somewhat less than average for the winter months. Late spring snows added substantial rainfall for the crop. The big snow/blizzard of March 14-15 provided a big boost to the overall moisture conditions for the crop. The total snowfall has been near 43 inches, but the rapid melting has provided only 33 days of snow cover. The mid-May snow brought a heavy rain-snow mix, but also some freezing temperatures. Late May rainfall has been substantial.

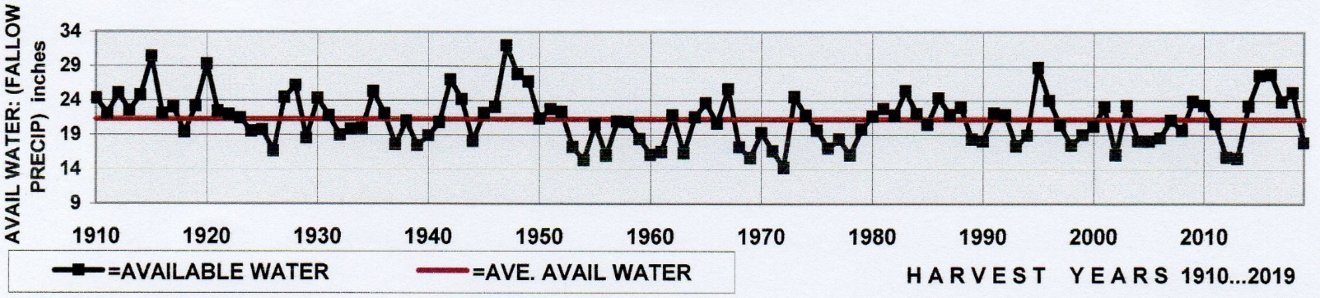
TEMPERATURES Sep.18-Jun19:

The month of Sept. was very warm, but cooler than average temperatures followed in Oct. and Nov. Dec. and Jan. quite warm. Feb and March were cooler than average, followed by a warm and dry April. May is turning out to be exceptionally cool with several new "cold" records set. Freeze of May 22nd will likely be significant. May, so far, is ranking as **5th coldest** May on record. New record low maximum temperatures were recorded on May 21 and 22, and a new record low minimum of 29 occurred on the 22nd. The Sep-May average temperature overall ranks in the coldest 40% of the 108-year record. The **41.16** average mean temperature ranks as only the **70th warmest** of the 108-year record.

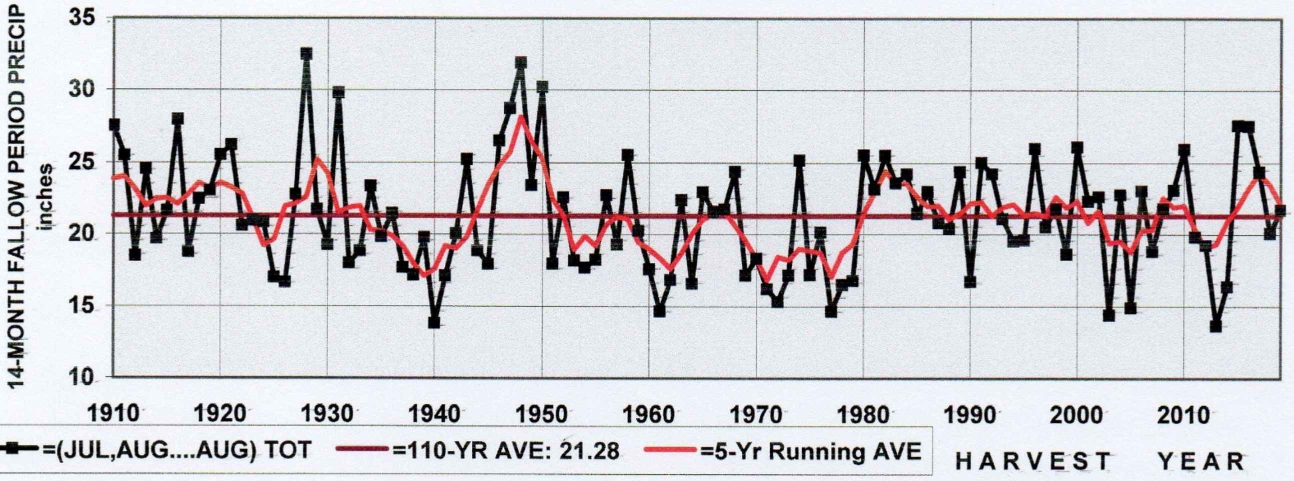
AVAILABLE WATER SUPPLY:

At a fallow storage efficiency of **25%**, the available water supply for the **2019-crop**, ***so far***, would be **13.54 inches**, which is **BELOW** the average of **17.02 inches**.
At a fallow storage efficiency of **45%**, the available water supply would be **17.88** inches, which is again, **BELOW** the average of **21.28 inches, not including the remainder of May and June**. The current wheat crop condition reflects a moderate fallow period precipitation, as well as the somewhat up and down spring precipitation.
At **25% storage** efficiency the seasonal available water would be **59.8%** from growing season precipitation, and at **45% storage** efficiency growing season precipitation would be at **45.3%** of total available. At the **25% storage efficiency**, the 2019-crop may be marginal, unless early June precipitation is substantial. At the 45% storage efficiency, the **17.88 inches** of water available might be in the "border-line" range for good yields, and likely will need additional and substantial rainfall in June for good yields.
Fallow storage efficiency is usually a key to the success of the crop. With a good fallow period and the late spring precipitation, the prospects for **2019** look relatively good. The range of **13.54 inches at 25% efficiency** to **17.88 inches at 45% efficiency** would appear to be "marginal" for good yields. Late May rainfall likely needs to continue into early June for good yields.

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

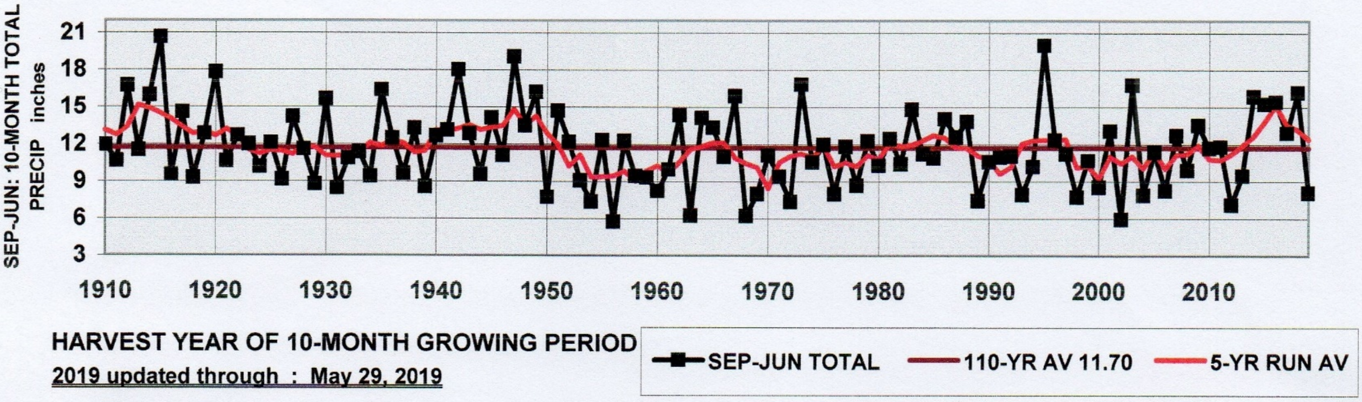


WHEAT:14-MON FALLOW PERIOD TOTAL PRECIP
USDA-ARS RESEARCH STATION AKRON, COLO.



saved as: Graph, in FALWRANK printed: 5/29/2019

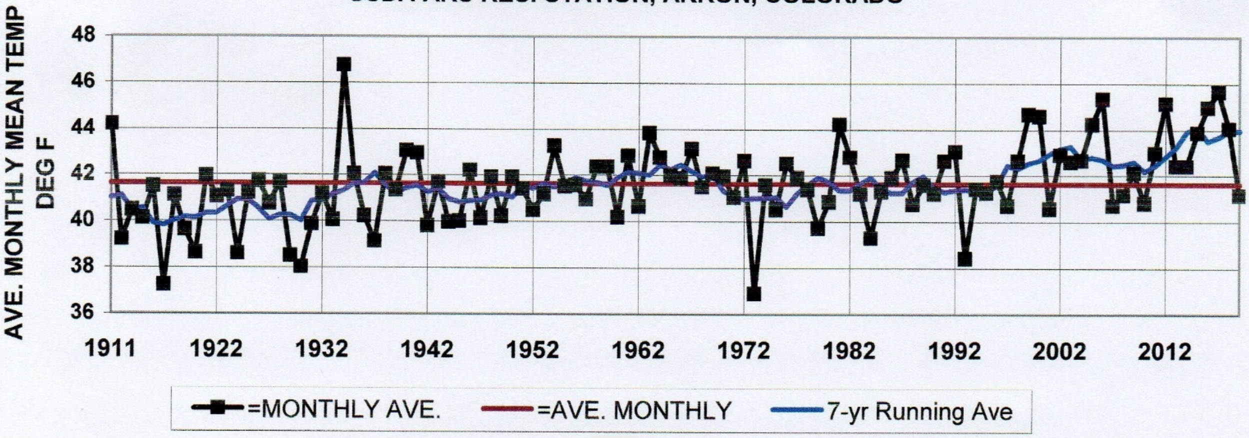
WHEAT: GROWING PERIOD (SEP-JUN) PRECIP
USDA-ARS RESEARCH STATION AKRON, COLO.



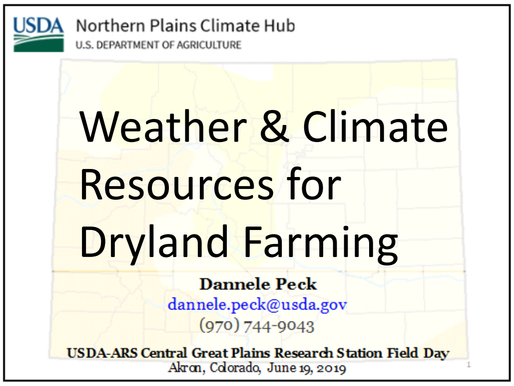
HARVEST YEAR OF 10-MONTH GROWING PERIOD
2019 updated through : May 29, 2019

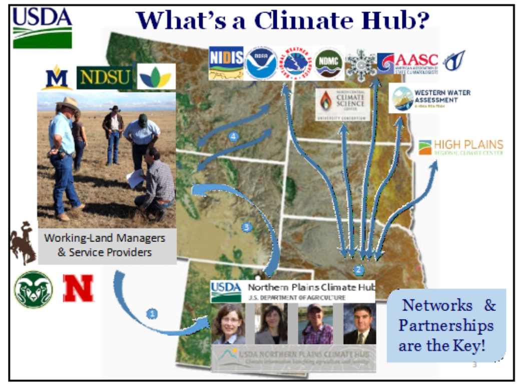
saved as: tab "GraphYears" in file "GROWRNK1" printed: 5/29/2019

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

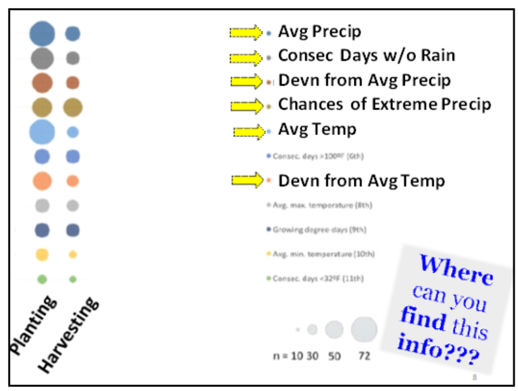


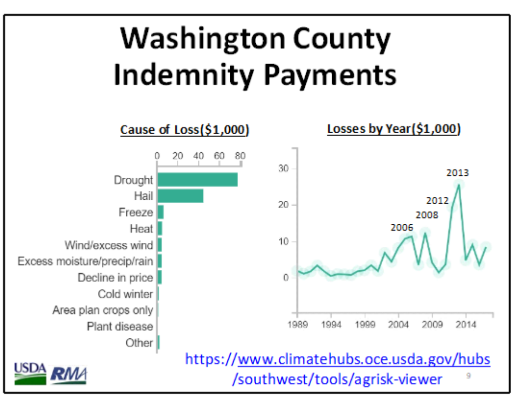
"Graph" in "SEPMAYT" printed: 5/29/2019


USDA
Northern Plains Climate Hub
U.S. DEPARTMENT OF AGRICULTURE
Weather & Climate Resources for Dryland Farming
Dannele Peck
dannele.peck@usda.gov
(970) 744-9043
USDA-ARS Central Great Plains Research Station Field Day
Akron, Colorado, June 19, 2019

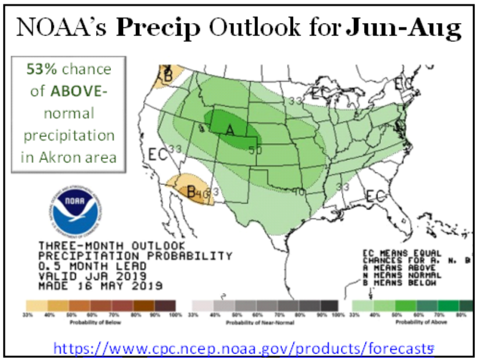

USDA
What's a Climate Hub?
NDSU
NIDIS
NDMC
AASC
WESTERN WATER ASSESSMENT
HIGH PLAINS
Working-Land Managers & Service Providers
N
USDA Northern Plains Climate Hub
Networks & Partnerships are the Key!

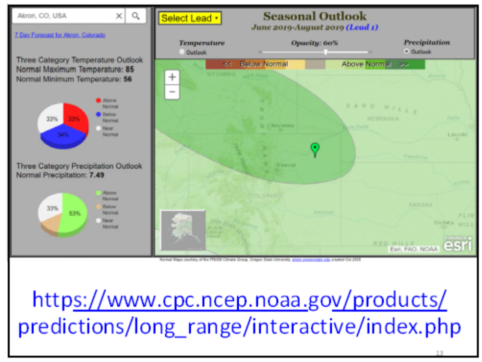

What are Your
Weather Worries
this Summer and Fall?
Klemm & McPherson 2018
Weather Information Needs for Growing Winter Wheat
A survey of Extension Agents

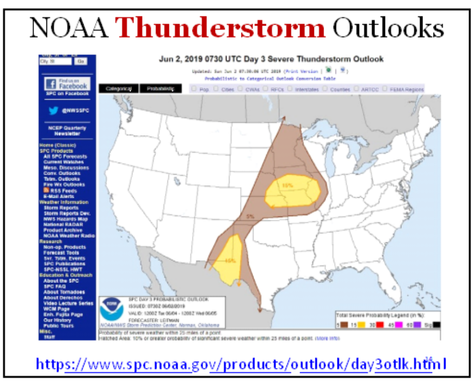

Avg Precip
Consec Days w/o Rain
Devn from Avg Precip
Chances of Extreme Precip
Avg Temp
Consec. days >100°F (6th)
Devn from Avg Temp
Avg. max. temperature (8th)
Growing degree-days (9th)
Avg. min. temperature (10th)
Consec. days <32°F (11th)
n = 10 30 50 72
Planting
Harvesting
Where can you find this info???

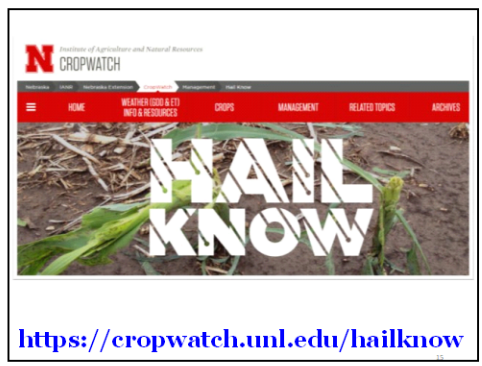

Washington County Indemnity Payments
Cause of Loss($1,000)
Losses by Year($1,000)
0 20 40 60 80
Drought
Hail
Freeze
Heat
Wind/excess wind
Excess moisture/precip/rain
Decline in price
Cold winter
Area plan crops only
Plant disease
Other
30
20
10
0
2013
2012
2008
2006
1989 1994 1999 2004 2009 2014
USDA RMA
https://www.climatehubs.oce.usda.gov/hubs/southwest/tools/agrisk-viewer

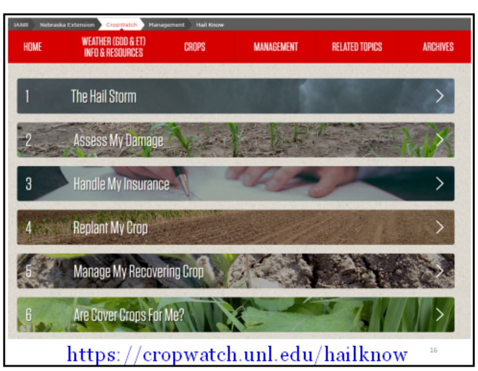

Weather WORRIES during Harvest


NOAA's Precip Outlook for Jun-Aug
53% chance of ABOVE-normal precipitation in Akron area
THREE-MONTH OUTLOOK
PRECIPITATION PROBABILITY
0.5 MONTH LEAD
VALID JJA 2019
MADE 16 MAY 2019
EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW
https://www.cpc.ncep.noaa.gov/products/forecasts


Akron, CO, USA
Select Lead
Seasonal Outlook
June 2019-August 2019 (Lead 1)
Temperature
Opacity: 60%
Precipitation
Below Normal
Above Normal
Three Category Temperature Outlook
Normal Maximum Temperature: 85
Normal Minimum Temperature: 56
Three Category Precipitation Outlook
Normal Precipitation: 7.49
esri
https://www.cpc.ncep.noaa.gov/products/predictions/long_range/interactive/index.php

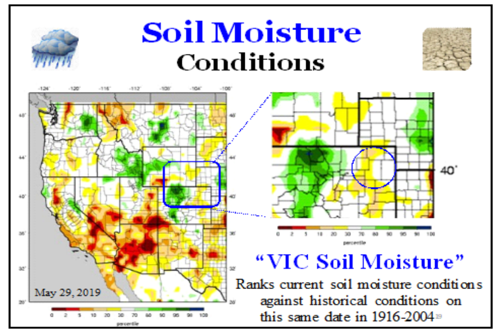

NOAA Thunderstorm Outlooks
Jun 2, 2019 0730 UTC Day 3 Severe Thunderstorm Outlook
https://www.spc.noaa.gov/products/outlook/day3otlk.html

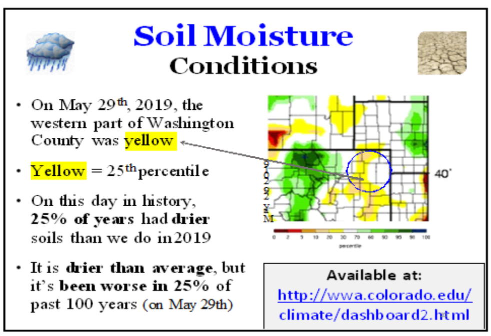

Institute of Agriculture and Natural Resources
CROPWATCH
HOME
WEATHER (GDD & ET) INFO & RESOURCES
CROPS
MANAGEMENT
RELATED TOPICS
ARCHIVES
HAIL KNOW
https://cropwatch.unl.edu/hailknow

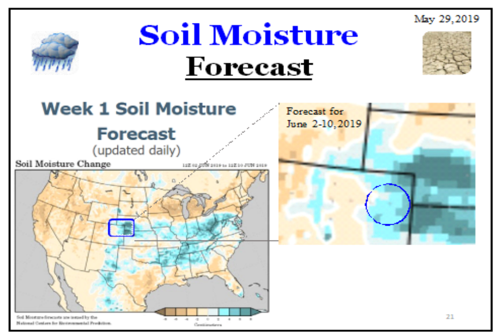

HOME
WEATHER (GDD & ET) INFO & RESOURCES
CROPS
MANAGEMENT
RELATED TOPICS
ARCHIVES
1 The Hail Storm
2 Assess My Damage
3 Handle My Insurance
4 Replant My Crop
5 Manage My Recovering Crop
6 Are Cover Crops For Me?
https://cropwatch.unl.edu/hailknow

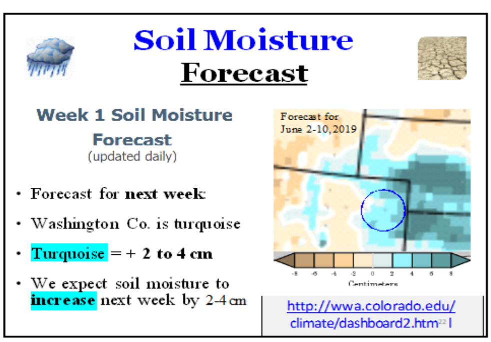

New Hail Study at CSU
Wants YOUR Ideas & Stories!
Sam Childs: new CSU grad student in Atmosph Science
• Trying to improve:
- Hail forecasts for Ag
- Hail early-warning
• But needs YOUR help!
- Share your hailstories & forecasting wishes
- 1-hr visit, one-on-one, at a location conv'nt for you!
Grab a flyer &
Help science help YOU!

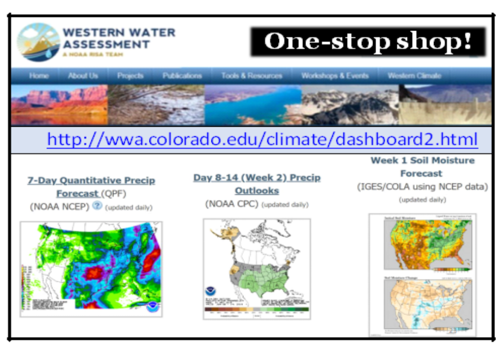

Weather
WORRIES
during
Planting


Soil Moisture
Conditions
May 29, 2019
40°
"VIC Soil Moisture"
Ranks current soil moisture conditions against historical conditions on this same date in 1916-2004

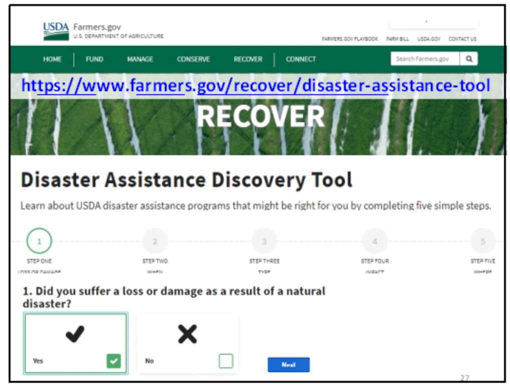

Soil Moisture
Conditions
On May 29th, 2019, the western part of Washington County was yellow
Yellow = 25th percentile
On this day in history, 25% of years had drier soils than we do in 2019
It is drier than average, but it's been worse in 25% of past 100 years (on May 29th)
40°
Available at:
http://wwa.colorado.edu/climate/dashboard2.html

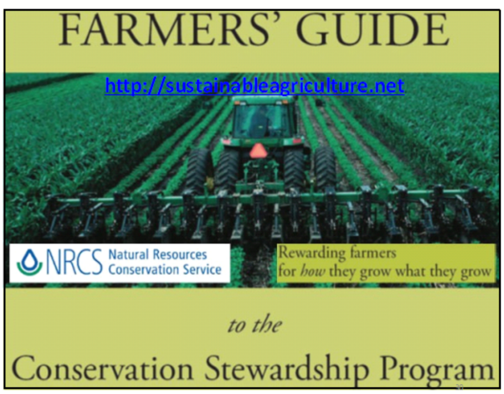

May 29, 2019
Soil Moisture
Forecast
Week 1 Soil Moisture Forecast
(updated daily)
Soil Moisture Change
Forecast for June 2-10, 2019


Soil Moisture
Forecast
Week 1 Soil Moisture Forecast
(updated daily)
Forecast for next week
Washington Co. is turquoise
Turquoise = + 2 to 4 cm
We expect soil moisture to increase next week by 2-4 cm
Forecast for June 2-10, 2019
Centimeters
http://wwa.colorado.edu/climate/dashboard2.html


WESTERN WATER ASSESSMENT
One-stop shop!
http://wwa.colorado.edu/climate/dashboard2.html
7-Day Quantitative Precip Forecast (QPF)
(NOAA NCEP) (updated daily)
Day 8-14 (Week 2) Precip Outlooks
(NOAA CPC) (updated daily)
Week 1 Soil Moisture Forecast
(IGES/COLA using NCEP data)
(updated daily)


Are you working without a net?
USDA Programs


USDA Farmers.gov
HOME FUND MANAGE CONSERVE RECOVER CONNECT
https://www.farmers.gov/recover/disaster-assistance-tool
RECOVER
Disaster Assistance Discovery Tool
Learn about USDA disaster assistance programs that might be right for you by completing five simple steps.
1. Did you suffer a loss or damage as a result of a natural disaster?
Yes
No
Next


FARMERS' GUIDE
http://sustainableagriculture.net
NRCS Natural Resources Conservation Service
Rewarding farmers for how they grow what they grow
to the
Conservation Stewardship Program


RESILIENT: DRYLAND FARMING ON THE SEMI-ARID HIGH PLAINS
13
Heavy Downpours
Unlike the prairie, which is always covered, tilled, bare soil does a poor job of collecting and storing water. In fact, seeing water on the soil surface is a sign that something underneath the soil's not functioning correctly; the value of TILLING, which disturbs the soil surface and contributes to SOIL EROSION, is increasingly coming into question.
thelexicon.org/resilient
http://www.thelexicon.org/resilient/


Closing Thoughts on Being
Proactive & Prepared
• Proper planning prevents painfully poor production
• It wasn't raining when Noah started building the Ark!
• Give me 6 hours to chop down a tree and I will spend the first 4 hours sharpening the axe"
– Abraham Lincoln
USDA Service Center
Akron Service Center
26924 US Hwy 34
(970) 345-2364


Thanks! Questions?
USDA Northern Plains Climate Hub
U.S. DEPARTMENT OF AGRICULTURE
USDA NORTHERN PLAINS CLIMATE HUB
Dannele Peck, Director
USDA Northern Plains Climate Hub
dannele.peck@usda.gov
https://climatehubs.oce.usda.gov
Twitter: @USDAClimateHubs

Field Elevation as a Proxy for Field Productivity: Precision farming Study

Vigil M.F., Francisco Calderon, D. J. Poss, Paul Campbell, and Cody Hardy

PROBLEM: The topographical elevation in a field greatly influence winter wheat and dryland corn 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 and corn grain yield maps are measured for several 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 fields into 3-6 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 becomes.

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).

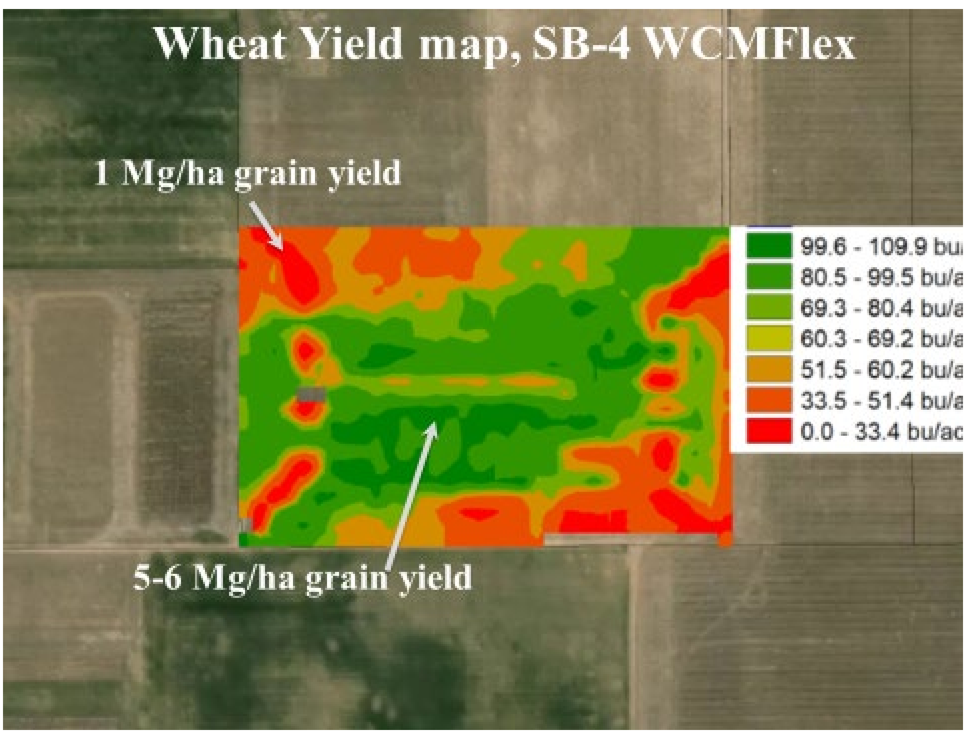


Fig 1 Winter wheat grain yield map of field SB-4 (1.12 Mg/ha is approximately 16.7 bushels per acre). The high yields are associated with low points in the field and the low yields are associated with high points in the same field. The elevation difference was about 4.7 feet between the high points and 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			N required			
	above	Management Zone	to meet yield goal		Nitrate plus	N
above sea level	lowest point	Grain yield	and 12% protein	OM	NH_4-N top 2 ft	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 that should be taken into account to precision manage this wheat field for 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				N required			
Elevation		Management		to meet		Nitrate	
	above	Zone		protein		plus	N
above	lowest	Grain	protein	and yield		NH_4-N	Fertilizer
sea level	point	yield	goal	goal	OM	top 2 ft	to apply
-Ft-	-Ft-	bu/acre	%	lbs/acre	%	lbs/acre	lbs/acre
4530.6	4.7	16.7		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.

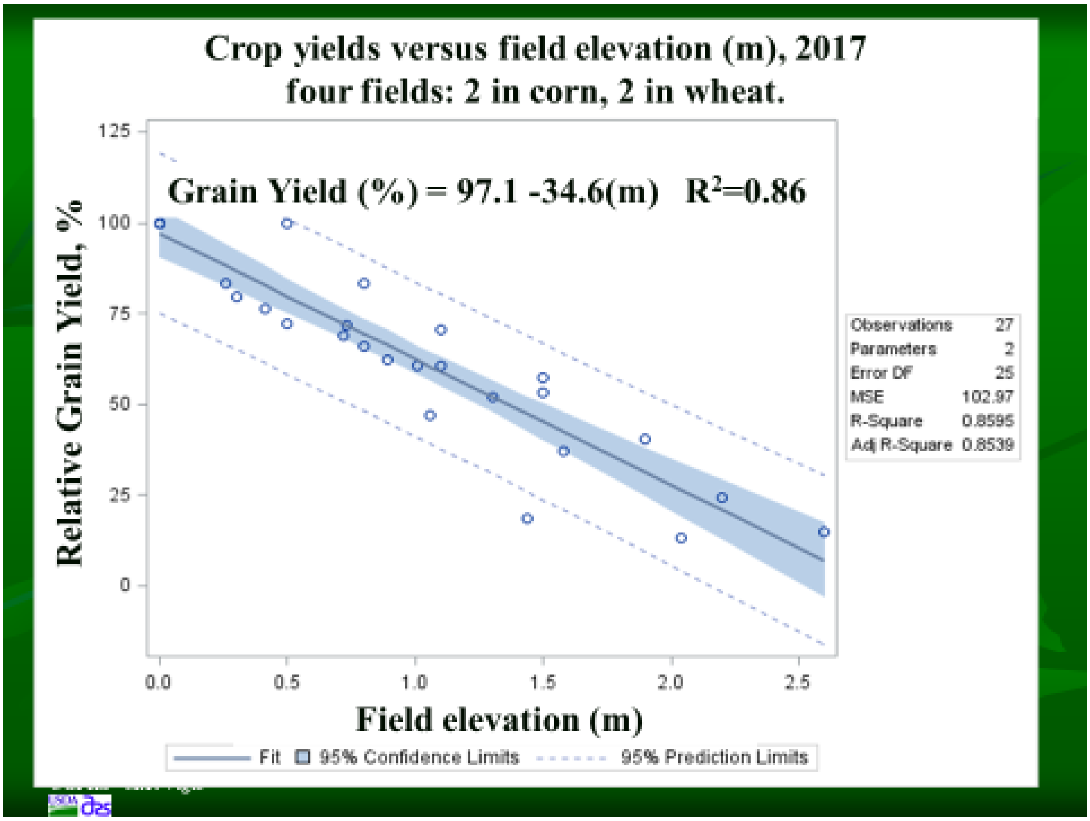


Fig 2. Wheat and corn relative yields versus elevation in 4 fields. Actual yields ranged from 10 to 130 bushels depending on the crop. The data in the graph is normalized to 100%. The relationship indicates that 35% of the expected yield is lost for every m increase in elevation from the lowest point in the field to the highest point for the four fields from which the data was collected. We suspect both run-off and run-on of rainfall and inherent soil depth and natural fertility is causing the yield differences with elevation.

Variable N Application by Soil Type.

Vigil M.F., D. J. Poss, and Francisco Calderon

PROBLEM: Economic optimum nitrogen (N) rates (EONR) are highly dependent on weather, soil nitrate, 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.

N rate	grain yield	biomass Yield	anthesis N-uptake	grain 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.

N rate	grain yield	biomass Yield	anthesis N-uptake	grain 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 is ongoing to sort out the predictive relationships between EONR soil type, available water at planting time, growing season precipitation, and residual inorganic nitrates. We are using this data set as a beginning place for developing N rates on the precision farming project.

Figure 1. Economic optimum N rates for 30 different N rate studies with winter wheat. The EONR values are plotted on the vertical axis (Y axis) and the delta yields are plotted on the horizontal or x axis. Delta yield is the difference in yield from the zero N rate and the economic optimum N rate. The values in red are the probabilities of receiving a given amount of growing season moisture plus pre-plant available water stored from the previous year's fallow season moisture plus pre-plant available water stored from the previous year's fallow season.

FIELD VARIABILITY IN SOIL PROPERTIES ACCORDING TO ALTITUDE AT THE AKRON FIELD STATION.

Francisco Calderón, Merle F. Vigil, and Dave Poss

PROBLEM: Many farmers in the high plains have the capacity to obtain a wealth of tractor-based yield data and topographic information. In addition, technologies such as Veris-EC allow for the rapid acquisition of large amounts of soil data across fields. However, there are currently no clear guidelines about how to use this data to inform field management decisions. This is because of the lack of a fact-based consensus about the development of specific recommendations based on the different field data layers. In this project, we are studying a replicated set of field-sized experimental plots that each have considerable unevenness in grain yield. We aim to explore and document the relationship between crop productivity and soil variability under natural climate fluctuations at our research station. Ultimately, we will develop an understanding of how adjusting N fertilizer rates across management zones the field can be used to improve farm gate income. We hypothesize that elevation gradients within each field in part account for differences in soil quality, profile water storage, and water movement, all of which determine grain yield variations across the field. A necessary first step in this effort is to is to document geospatial variability in grain yields and soil parameters and identify soil characteristics that are associated with low and high productivity areas within a field. Once those associations are recognized and measured, then we will be able to modify management practices to exploit some of those differences.

APPROACH: We have divided our fields into two main treatments: aspirational, and business as usual. The aspirational four-year rotation consists of winter wheat-corn-millet-fallow, which will be managed using a precision farming approach with variable N fertilizer rates. The business as usual rotation will be a reduced-till wheat-fallow managed uniformly across each field. All phases of each rotation appear each year to avoid confounding with year-to-year climate variability. In order to characterize the spatial variation in soil quality across the fields we sampled the soils using a grid pattern in each field with 30 m by 30 m equidistant spacing. Soil samples were obtained at 0-15 and 15-30 cm depths. This sampling is currently also being used to provide data for constructing management zone boundaries that will help decide future sampling locations and management decisions. Soil data includes percent clay, percent sand, nitrate, total N, total C, plant available Olsen P, K, S, Zn, Fe, Cu and Mn. Veris-EC data was obtained separately with a tractor mounted sensor which ran transects across each field. Yield was obtained at harvest time and elevation maps were obtained at planting using Ag-Leader and Trimble software fully integrated on our combine harvesters and planters. Each soil sample, Veris, elevation and grain yield data layer were interpolated with GIS software, which allowed for the comparison of the soil and yield data layers.

RESULTS: The kriging of the different data sources permitted us to carry out a redundancy analysis between the different soil properties across the 12 different aspirational fields, which are divided into three different areas within the research station, namely S, SCD, and SB (Figure 1; Table 1). The redundancy analysis in figure 1 shows arrows for the different soil properties, and when these arrows point in the same direction, it indicates a positive correlation between the soil attributes. Conversely, soil variables with arrows pointing in opposite directions are anticorrelated, and the length of the arrows indicates the strength of the relationship. The analysis shows that

Olsen P, which measures plant available P, is higher in the 0-15 cm soil depth than the deeper depth, and that Olsen P is positively related to Fe, Mn, and Cu content, but anticorrelated with pH. The CEC is a common a measure of soil fertility which indicates the capacity of the soil to hold several nutrients like K, NH4, and Ca in a form available to plants. Figure 1 shows that CEC increases with pH, salts, and Ca, clay and Mg. Soil organic matter (OM_LOI) is correlated to K, and anticorrelated to sand. The figure also shows that pH increases with soil depth. In terms of the fields, The S fields, which are all clustered at the south of the research station, tend to have low sand content, and high soil organic matter. The SB fields, at the northeast end of the station, tend to contain high sand content and low organic matter.

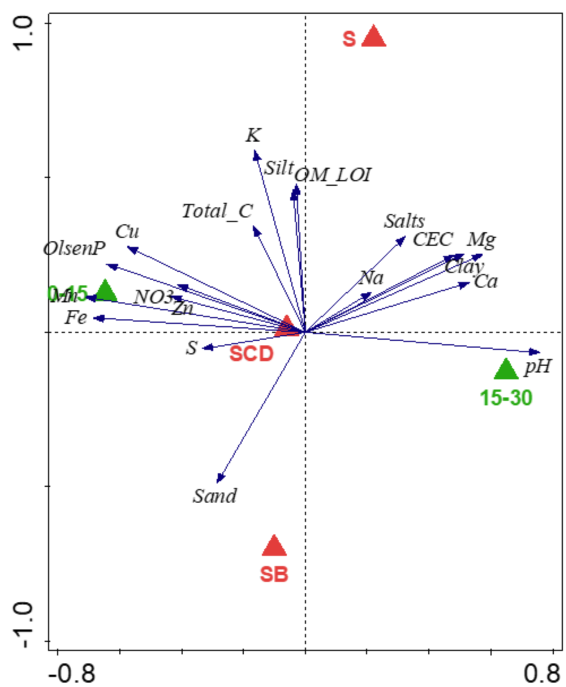


Figure 1. Discriminant analysis biplot of the soil data from the 0-15.2 cm depth.

Up to two years of crop yield data was available from each field, from 2017 to 2018. A few fields only had one crop year because one of the years coincided with a fallow period. Here there were high variability between fields, and crop species, overall 2018 tended to have slightly higher grain yields than 2017 (Table 1). 2017 had a cumulative precipitation of 416.6 mm for the year, which is slightly below the long-term average, while 2018 reached 454.7 mm.

The average grain yields from the kriged data shows that fields in the SB section of the station had the highest wheat yields, whereas fields in the SCD section of the field had the highest millet and corn yields (Table 1). This is surprising, given that the S fields had higher soil organic matter and least sand of all fields. Within each field, the more marked the elevation difference between high and low point, the more likely topography was to affect crop yields. This pattern was evident only on the S and SCD fields, not on the SB fields (which also were the sandiest).

Table 1. Elevation difference between the high and low points in each field and mean and standard deviation of selected variables from the raster files produced by kriging interpolation from the grid sampling.

Field	Elev. diff., meters	Yield kg ha^{-1}	% Soil C, 0-15.2 cm	% Soil C, 15.2-30.4 cm	Clay % 0-15.2 cm	Sand % 0-15.2 cm	Olsen P 0-15.2 cm	Soil pH 1:1, 0-15.2 cm	Veris Ec shallow
		--mean (std)--							
S2	1.2	Wheat (2018): 5157.4 (423.0)	1.23 (0.10)	1.08 (0.34)	27.9 (0.7)	32.8 (2.7)	20.3 (4.7)	6.66 (0.24)	32.0 (3.5)
S4	2.1	Corn (2017): 3306.8 (853.7) Millet (2018): 2862.4 (1052.8)	1.05 (0.10)	0.93 (0.27)	28.1 (1.2)	37.9 (1.4)	25.5 (9.0)	6.62 (0.59)	27.9 (3.3)
S5	2.4	Wheat (2017): 1710.8 (956.3) Corn (2018): 4367.9 (1424.9)	0.86 (0.06)	0.73 (0.05)	25.4 (1.0)	42.0 (2.9)	25.4 (3.5)	6.11 (0.16)	25.5 (2.5)
S6	2.3	Millet (2017): 2342.6 (1851.6)	0.95 (0.12)	0.71 (0.09)	28.1 (1.1)	37.2 (2.0)	33.7 (2.7)	5.87 (0.19)	23.3 (4.1)
SB-1	2.7	Corn (2017): 3599.9 (682.3) Corn (2018): 3354.4 (780.2	0.91 (0.03)	0.79 (0.15)	24.8 (0.9)	42.6 (1.1)	27.6 (2.0)	6.18 (0.29)	20.4 (5.4)
SB-4	1.5	Wheat (2017): 5170.1 (1251.5) Millet (2018): 2957.3 (1645.3)	0.96 (0.12)	0.76 (0.12)	23.9 (1.7)	46.2 (3.3)	32.2 (3.3)	6.10 (0.11)	19.0 (4.8)
SB-5	3.6	Wheat (2018): 3979.7 (712.2)	0.57 (0.04)	0.52 (0.04)	19.8 (1.1)	63.7 (1.9)	10.1 (1.7)	6.46 (0.23)	29.0 (5.5)
SB-7	3.5	Millet (2017): 2083.7 (1296.1)	0.66 (0.09)	0.55 (0.06)	21.1 (0.8)	57.6 (1.8)	14.4 (1.1)	6.29 (0.37)	18.6 (2.4)
SCD-2	2.1	Corn (2017): 3383.3 (797.2) Millet (2018): 2585.7 (1111.0)	0.91 (0.07)	0.75 (0.08)	22.7 (0.7)	45.5 (2.7)	39.9 (4.7)	5.63 (0.14)	25.1 (5.6)
SCD-3	2.3	Wheat (2018): 4390.8 (628.6)	0.87 (0.15)	0.87 (0.38)	25.5 (0.8)	41.3 (3.5)	31.7 (6.2)	6.43 (0.68)	32.5 (6.2)
SCD-5	1.9	Millet (2017): 5552.9 (3635.8)	0.86 (0.04)	0.64 (0.02)	23.5 (1.5)	48.3 (5.4)	26.0 (2.1)	6.38 (0.40)	19.0 (2.7)
SCD-6	1.7	Wheat (2017): 2976.5 (595.3) Corn (2018): 4377.6 (575.6)	1.07 (0.07)	0.73 (0.04)	26.6 (0.6)	40.1 (0.9)	31.6 (1.2)	6.20 (0.03)	27.5 (3.6)

Table 2 shows the correlation between soil attributes and grain yields for the different fields and crop species. The table does show that generally our hypothesis that elevation is negatively correlated to crop yields is true for most fields, crop yields do increase in the low parts of each field. Although there is a high amount of variability, Table 2 also indicates that sections of the field with high Olsen P and low sand content also tend to give higher grain yields. Also, Veris Ec seemed to be a better indicator of grain yields in corn than in millet or wheat. Conversely, clay was sometimes positively correlated with grain yields, and this was more evident in some of the wheat fields. Clay ended to be highly correlated with yields only when elevation was negatively correlated with yields (Tables 1 and 2). Again, surprisingly soil C did not have a consistent geospatial relationship with yields.

Table 2. Correlations (R) between crop yields and selected variables from the raster files produced by interpolation, including elevation, yields, and soil pH and C data from the grid sampling.

Field	Crop	Elev.	Soil C 0-15.2 cm	Soil C 15.2-30.4 cm	Clay 0-15.2 cm	Sand 0-15.2 cm	Olsen P 0-15.2 cm	pH 0-15.2 cm	Shallow Veris Ec
S2	Wheat	0.05	-0.52	-0.01	-0.04	-0.26	-0.07	0.24	-0.16
S4	Corn	-0.60	-0.56	-0.39	-0.43	0.20	0.48	-0.14	-0.02
S4	Millet	-0.71	-0.68	-0.70	-0.31	0.33	0.57	-0.59	-0.11
S5	Wheat	-0.77	-0.22	0.43	0.47	-0.39	-0.21	0.43	0.03
S5	Corn	-0.61	-0.03	0.27	0.38	-0.53	-0.02	0.27	-0.11
S6	Millet	-0.45	-0.11	-0.29	-0.07	-0.44	0.04	-0.15	-0.29
SB-1	Corn	-0.52	0.44	0.20	0.31	-0.11	0.30	-0.13	-0.48
SB-1	Corn	-0.64	0.44	0.35	0.16	0.18	0.03	0.04	-0.61
SB-4	Millet	-0.19	0.40	0.47	0.42	-0.40	0.37	-0.03	-0.15
SB-4	Wheat	-0.56	0.57	0.27	0.57	-0.50	0.58	-0.44	-0.40
SB-5	Wheat	-0.38	0.14	-0.18	-0.17	0.00	0.30	-0.22	-0.10
SB-7	Millet	0.20	0.26	0.36	0.16	-0.28	0.04	-0.27	0.11
SCD-2	Corn	0.05	0.40	0.12	0.11	-0.55	0.63	-0.41	-0.45
SCD-2	Millet	-0.32	-0.04	0.031	0.13	-0.18	0.19	-0.31	-0.35
SCD-3	Wheat	-0.26	-0.27	-0.42	0.38	-0.34	0.37	-0.37	0.15
SCD-5	Millet	-0.04	0.03	-0.12	0.02	-0.13	0.04	0.02	0.00
SCD-6	Wheat	-0.03	-0.07	0.09	0.11	-0.03	0.00	0.00	0.05
SCD-6	Corn	0.22	0.26	-0.35	-0.38	-0.11	0.12	0.012	-0.03

Figure 2 shows the interpolations for field SB-1, which has a particularly strong relationship between corn yields, elevation, soil C, and Veris Ec. The graphics show that for this particular field, soil C has a positive relationship with yields, while Veris Ec and elevation have a clear negative relationship. Coming into the project, we hypothesized that patterns such as this would be more prevalent, but it turns out that field SB-1 is rather the exception.

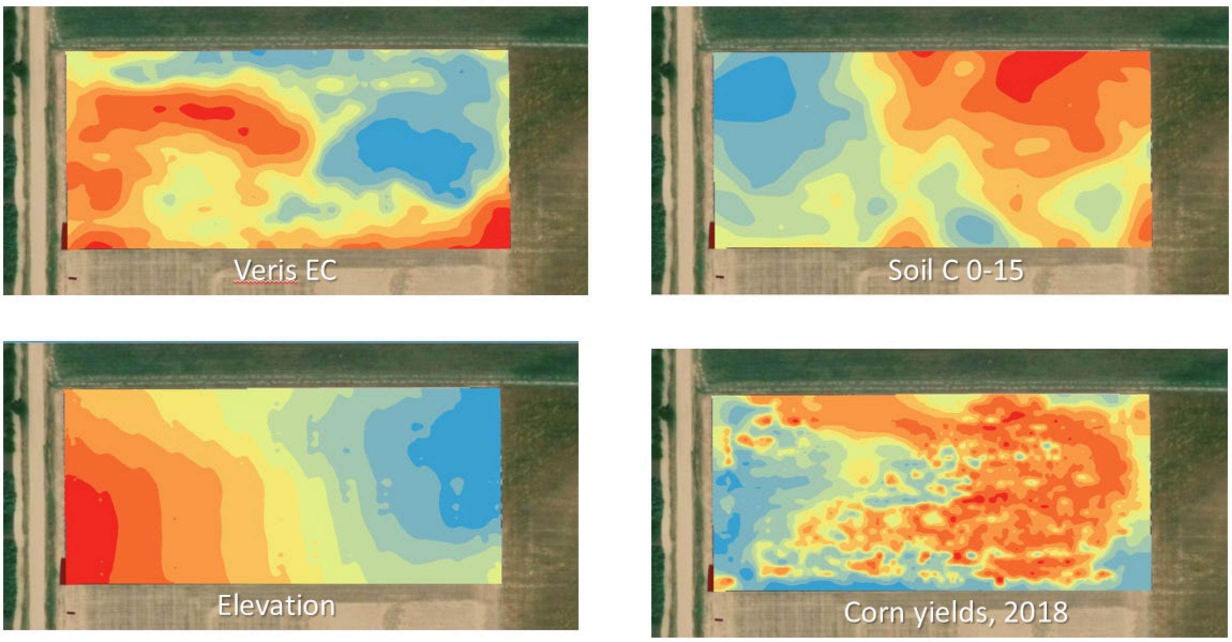


Figure 2. Kriging interpolations of corn yields, elevation, Veris Ec, and soil C. Reds indicate high values, and blues indicate low values.
Although the data ranges are not shown, the interpolations show the geospatial relationship between the different layers.

In conclusion, with the first two years of data, it is becoming evident that topography is more important than soil factors in determining the spatial variation in crop yields. We believe that these rather small variations in elevation are associated with hydrologic phenomena that are in the end the most directly pertinent to crop performance in our semiarid climate.

FUTURE PLANS: This effort will continue, and we expect to obtain more samples and more geospatial data in future years to develop an understanding of field variability in soil quality and the potential benefits of precision zone management in dryland systems

Winter Annual Forage Variety Trial

D. J. Poss, 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) seed. For the benefit of producers in the Great Plains area that grow triticale and other annual forages, an unbiased replicated study of available varieties is needed.

APPROACH: For the third consecutive year several varieties of winter annual forages were planted in a randomized complete block design. Starting in the 2016-17 crop-year, rye hybrids were included in the trial. We procured most of the triticale varieties from the University of Nebraska's breeding program. KWS seeds provided the hybrid rye varieties for the trial.

The plots were planted on 18 October 2017 at a seeding rate of 50 lbs/ac. We planted the plots using a cone drill with double disk openers spaced 7.5 inches apart. Urea fertilizer was broadcast applied prior to planting at 90 lbs N/ac. This rate was 18 lbs/acre higher than last year since nitrogen deficiency symptoms were apparent in the 2016-17 crop. Plots measured 30 feet long by 15 feet wide, replicated four times. Three passes were planted side by side to accommodate for two forage sampling dates and one grain sampling date.

We took forage samples on 24 May and 06 June 2018 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. We weighed the samples using a scale on the machine. A subsample was taken from which harvest moisture was calculated after drying the samples at 60 degrees C until no more moisture was being lost. The forage samples were mailed to Ward Labs in Kearny, NE for a forage analysis.

We collected grain samples on 19 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, cleaned, and analyzed for moisture and test weight.

RESULTS: Precipitation prior to planting and during the growing season was slightly above average. Planting was delayed a few weeks due to rain. On 22 September, we received 0.89 inches of precipitation and the following two weeks it stayed cooler and more precipitation was received preventing us from planting until the middle of October. This later planting date did not appear to affect stand or yield. Precipitation during the critical months of April and May was 189% of average (Table 1). The precipitation received during these months resulted in exceptional yields.

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

	2016-2018 inches	Mean inches	% of Mean
Pre-Plant (Sept.'16-Sept.'17)	16.98	16.50	103%
Growing Season Early (Oct. '17-March '18)	3.25	3.41	95%
Growing Season Late (April '18-May '18)	8.76	4.63	189%
TOTAL (Sept. '15-May '17)	28.99	24.54	118%

The rye hybrids certainly had higher forage yields than the triticale varieties on the first sampling date of 24 May averaging 5,627 lbs/ac and 4,34 lbs/ac for the rye and top six triticale varieties, respectively (Table 2). However, thirteen days later when the second sample was taken, the top six triticale varieties nearly caught up with the rye varieties at 9,783 lbs/ac and 9,341 lb/ac.. 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 yielding triticale varieties. Both triticale and the hybrid ryes have vigorous growth if weather conditions are favorable. This year demonstrated this well since biomass yield doubled in thirteen days between the two harvest dates. The mean yield on 24 May was 4,446 lbs/ac and on 06 June the mean yield was 9,091 lbs/ac.

As expected, protein levels decreased significantly during the period between the two harvest dates from 16.5% on 24 May to 10.4% on 06 June averaged across all varieties. The relative feed quality (RFQ) index also decreased during this period. So, while yields increased substantially between the two sampling dates, the quality of the forage decreased, as we would expect. When is the best time to harvest? This is a question that can be different for every producer depending on how it fits into a ration, method of harvest (hay or silage), concern about the presence of awns, plus other possible factors.

Grain yields were exceptional with rye hybrid yields ranging from 100.4 bu/ac to 111.8 bu/ac. Triticale yields were much lower, but still very good, with the highest yielding triticale variety being NT09404 which had a yield of 83.8 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 seven rye hybrids averaged 55.7 lbs/bu compared to 54.1 lbs/bu for the seven heaviest triticale varieties.

In much of the Central Great Plains area rye has a very 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 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 have to 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.

Yields from the previous two years were good as well (Tables 3 & 4). Since initiating this study, we have had very favorable spring precipitation. The data from the 2015-16 and 2016-17 are included here for your convenience. It is best to make variety decision based on more than one year. The details from the previous years has been published in the Central Great Plains Research Station annual report for the respective year.

FUTURE PLANS: This trial will be planted again in fall 2019.

Table 2. Forage & Grain Yields from the Winter Annual Forage Variety Trial at Central Great Plains Research Station at Akron, CO in 2017-18 Crop Year.

		May 24 Forage					June 6 Forage					Grain			
Variety	**Species**	**Zadok's**	**Yield** lb/ac		**Protein*** %	**RFQ****	**Zadok's**	**Yield** lb/ac		**Protein*** %	**RFQ****	**Yield** bu/ac		**TW** lb/bu	
Bono	Rye	58	6,002	a***	14.4	120	75	9,855	a**	9.1	101	107.5	a	55.9	abc
Progas	Rye	58	5,834	ab	14.6	118	75	9,797	a	10.7	110	103.8	a	53.8	bcdefg
Dolaro	Rye	56	5,725	abc	14.7	122	75	10,460	a	9.3	107	111.8	a	55.7	abcd
Daniello	Rye	59	5,708	abc	13.2	113	75	9,630	ab	10.3	107	106.5	a	55.7	abcd
Propower	Rye	56	5,684	abc	14.4	112	75	10,597	a	9.1	99	100.4	a	55.7	abcd
Gatano	Rye	59	5,427	abc	14.8	117	75	9,092	ab	9.8	106	107.1	a	56.2	ab
Presto	Triticale	56	5,123	abcd	16.5	126	75	9,246	ab	9.7	105	79.4	cde	53.7	bcdefg
Brasetto	Rye	57	5,008	abcd	15.3	120	75	9,050	ab	8.9	94	108.8	a	56.8	a
Syngenta 718	Triticale	42	4,431	abcde	16.6	128	72	9,708	a	10.3	98	53.9	g	51.6	gh
NT07403	Triticale	58	4,298	abcde	15.7	127	75	9,561	ab	9.5	106	66.7	cdefg	51.1	h
NT05421	Triticale	43	4,209	abcde	16.9	127	75	9,282	ab	11.3	103	73.7	bcdef	52.9	efgh
NT13416	Triticale	43	4,086	bcde	17.4	130	72	9,022	ab	10.4	101	68.1	cdefg	54.2	bcdefg
NT09404	Triticale	45	3,904	cde	17.4	134	75	8,742	abc	11.8	114	83.8	bc	52.1	gh
NE441T	Triticale	41	3,872	cde	18.7	131	70	8,871	abc	11.9	111	64.1	defg	54.7	abcdef
NT12403	Triticale	51	3,866	cde	16.8	130	75	8,815	abc	10.6	102	81.9	bcd	53.1	defgh
NT13443	Triticale	43	3,538	de	17.2	120	70	9,159	ab	9.8	97	62.7	efg	52.3	fgh
NT11406	Triticale	48	3,520	de	19.1	136	75	7,566	bc	11.2	109	73.3	bcdef	53.9	bcdefg
NT11428	Triticale	43	3,498	de	17.9	135	70	8,418	abc	9.5	104	65.7	cdefg	53.3	cdefgh
NT12414	Triticale	49	3,465	de	18.3	130	75	8,407	abc	11.1	106	70.9	bcdefg	52.7	fgh
Pika	Triticale	40	3,245	de	17.8	126	57	8,558	abc	11.4	104	58.5	fg	55.4	abcde
NT09423	Triticale	43	2,929	e	19.2	128	75	7,070	c	12.8	113	87.7	b	54.8	abcdef
MEAN			4,446		16.5	125		9,091		10.4	105	82.7		54.1	

*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.

Table 3. 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.

Table 4. Forage Yields from the Winter Annual Forage Variety Trial at Central Great Plains Research Station at Akron, CO in 2015-16 Crop Year.

		June 10 Forage					June 16 Forage				
Variety	Species	Zadok's	Yield		Protein*	RFQ**	Zadok's	Yield		Protein*	RFQ**
			lb/ac		%			lb/ac		%	
NT11406	Triticale	61	9,094	ab***	13.4	133	69	11,730	a	11.8	132
NT11428	Triticale	61	8,879	ab	12.3	132					
NT05421	Triticale	61	8,706	ab	11.9	126					
NT01451	Triticale	61	8,698	ab	13.7	142					
Syngenta 718	Triticale	61	8,405	abc	11.8	121	69	9,134	ab	10.0	113
NT07403	Triticale	61	8,208	abc	11.7	128					
NT094231	Triticale	61	8,075	abc	13.3	138					
NT06422	Triticale	61	8,071	abc	11.7	125					
NE422T	Triticale	55	7,408	bc	11.5	131	61	10,376	ab	11.2	112
Pika	Triticale	57	7,047	bc	12.5	134	61	10,337	ab	9.7	103
NE426GT	Triticale	61	6,993	bc	14.0	142					
NE441T	Triticale	59	6,587	bc	12.0	130	65	10,308	ab	9.6	108
Presto	Triticale	61	6,392	bc	13.2	139	69	7,904	abc	11.0	133
Willow Creek	Wheat	45	4,783	c	17.7	148	47	8,848	ab	14.5	137
MEAN			7,667					9,805			

*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.

Microbial Community Structure Influenced by Residue Removal and Nitrogen Sources

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INTRODUCTION:

Management decisions such as residue removal level, nitrogen sources, and tillage practices are critical to manage water availability for crop production and sustain soil health. Maintaining crop residue on the soil surface could reduce wind erosion, increase soil organic matter (SOM), and provide nutrients for subsequent crops through residue decomposition by soil microbial communities. This practice could be complemented with the use of an organic amendment such as manure, which has been found to increase SOM, provide the macro-and micro-nutrients in addition to N that are necessary for crop production, and reduce or eliminate the usage of the inorganic fertilizer that is mostly added as the N source.

Microorganisms are key in 80-90% of decomposition processes. Evaluating changes in soil microbial community size and composition using Fatty Acid Methyl Ester (FAME) profiling due to management is a sensitive parameter of soil health that could help in management decisions. Soil fungi play an important role in C sequestration, and they are physically and chemically (e.g., products of decomposition that can be referred as cementing agents) bind soil particles to form aggregates that are more resistant to soil erosion. Figure 1 shows how arbuscular mycorrhizal fungi-plant root interactions change root dynamics (increases surface area), which can increase plant water and nutrient uptake and also plant drought resistance. Bacteria are also important in many processes. For example, actinobacteria can decompose complex substrates such as lignin. Soil microorganisms are important indicators of soil health and land sustainability because of their key role in soil processes that lead to increases in SOM and nutrients essential to crop growth.

Figure 1. The symbiotic relationship in soil between plant root and mycorrhizal fungi where the plant and the mycorrhizae exchange carbon in form of sugar and other nutrients.

OBJECTIVES:

Evaluate soil microbial community size and structure in continuous no-tillage irrigated corn as influenced by:

1) Two N types, cattle beef manure (M) and synthetic fertilizer (F).
2) Three residue removal levels: 0%, 50% and 80%.

MATERIALS AND METHODS:

This study was initiated in Spring 2011 on irrigated land at the Southwest Research-Extension Center near Tribune, KS to address the effects of crop residue removal and beef manure additions on soil quality and plant productivity. The experiment is a randomized strip design with no-tillage management and two nitrogen sources (manure, M and commercial fertilizer, F). The same N rate of manure nitrogen and commercial fertilizer nitrogen (urea) was added every spring for corn crop production. Three residue removal levels were implemented: No residue removal (0%), Medium residue removal (40-55%), and Maximum residue removal (75-95%). 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^-) M associated N and 30% of the organic M associated N will be available during the first year of application. Using the above assumption, the mass of annual M added to designated plots was calculated from 2011 to 2017 where it ranged between 11.18 to 28.9 ton/ac to provide and average of 180 lb N/ac. The fertilizer plots received Urea at the rate of 180 lb N/ac and 50 lb/a of P_2O_5. Corn (hybrid "Pioneer 1151XR") is normally seeded on early May at 32,000 seed/ac using a JD 1700 planter with 30 inches row spacing.

Soil samples were taken in Spring 2017 at 0-2, 2-4, and 4-6 inches to evaluate microbial community size and composition after 6 years of management practices using the ester-linked FAME procedure. The community size was evaluated according to the sum of all FAMEs. Selected FAMEs were used as microbial markers according to previous research including Gram-positive (Gram+) bacteria (i15:0, a15:0, i17:0, a17:0), Gram-negative (Gram−) bacteria (cy17:0, cy19:0), and actinobacteria (10Me16:0, 10Me17:0, 10Me18:0). Fungal markers included saprophytic fungi (18:1ω9c, 18:2ω6c) and arbuscular mycorrhizal fungi (AMF) (16:1ω5c).

RESULTS AND DISCUSSION:

Evaluation of organic amendment and residue removal rates across depth:

After 6 years of N addition with manure or fertilizer, and different levels of residue removal (0%, 50%, and 80%), total FAMEs were greater under M (compared with F) and 0% (no) residue removal compared with other removal levels **(Figure 2)**. Thus, the combination of 0% removal and M treatments encouraged a greater microbial community compared with other treatment combination.

A similar pattern was observed when evaluating FAME markers for bacteria **(Figure 3)** or fungi **(Figure 4).** Results indicated that the addition of M (manure) is important in maintaining the soil microbial community when residue will be removed.

Averaged across depths and N source, total FAMEs, bacteria, and fungus were greater with no residue removal (0%) compared with any level of removal. No differences in microbial communities were observed between 50% and 80% residue removal **(Figure 2, 3, and 4)**.

No differences in arbuscular mycorrhizal fungi (AMF) were observed between M and F, but differences were observed among the residue removal levels **(Figure 5)**. The 0% removal enhanced AMF compared with other removal levels. The association between plant and mycorrhizal fungi is important because this association increases plant nutrient and water uptake due to increased plant root volume.

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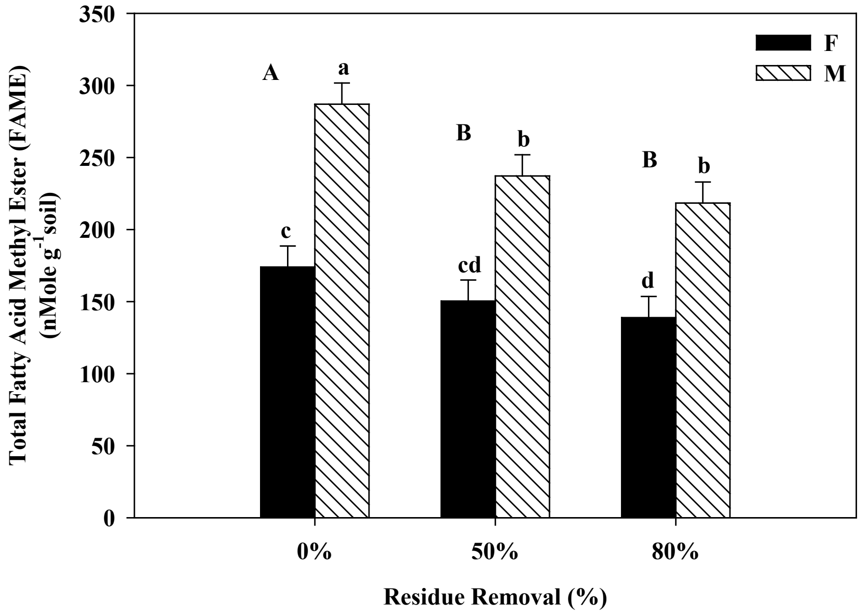

Figure 2. Total FAMEs as influenced by nitrogen source (manure, M and fertilizer F) and residue removal level (0%, 50%, and 80%). The different lowercase letters represent significant differences ($P < 0.05$) between the M and F treatments. The different uppercase letters represent significant differences ($P < 0.05$) among the residue removal levels.

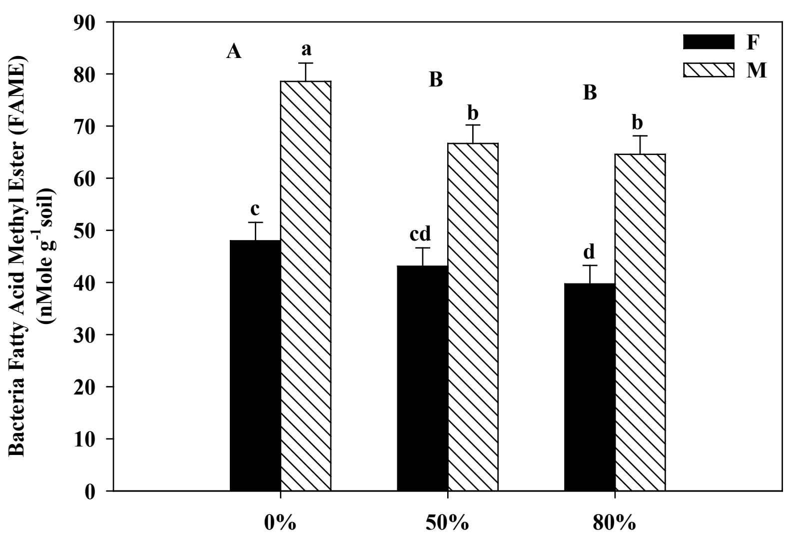

Figure 3. Bacterial markers in soil as influenced by nitrogen source (manure, M and fertilizer F) and residue removal level (0%, 50%, and 80%). The different lowercase letters represent significant differences ($P < 0.05$) between the M and F treatments. The different uppercase letters represent significant differences ($P < 0.05$) among the residue removal levels

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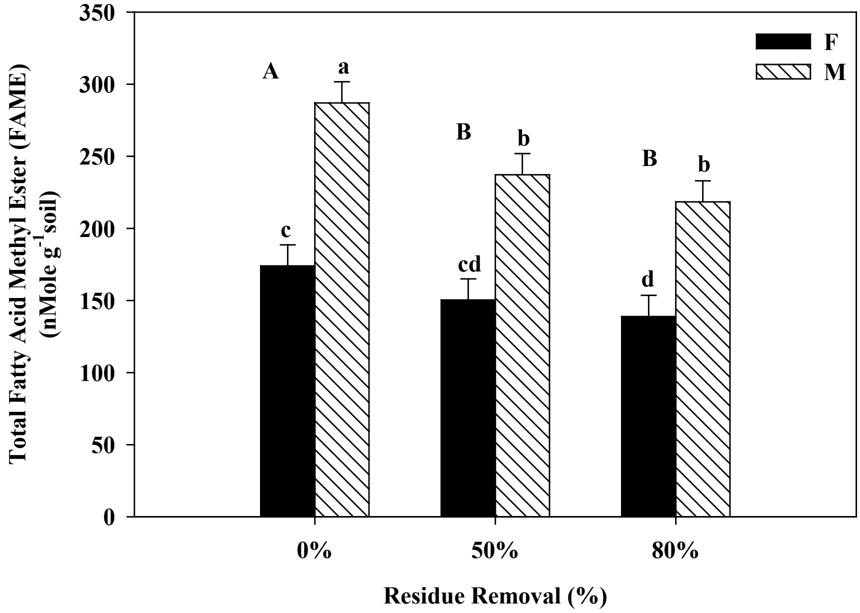

Figure 2. Total FAMEs as influenced by nitrogen source (manure, M and fertilizer F) and residue removal level (0%, 50%, and 80%). The different lowercase letters represent significant differences (P < 0.05) between the M and F treatments. The different uppercase letters represent significant differences (P < 0.05) among the residue removal levels.

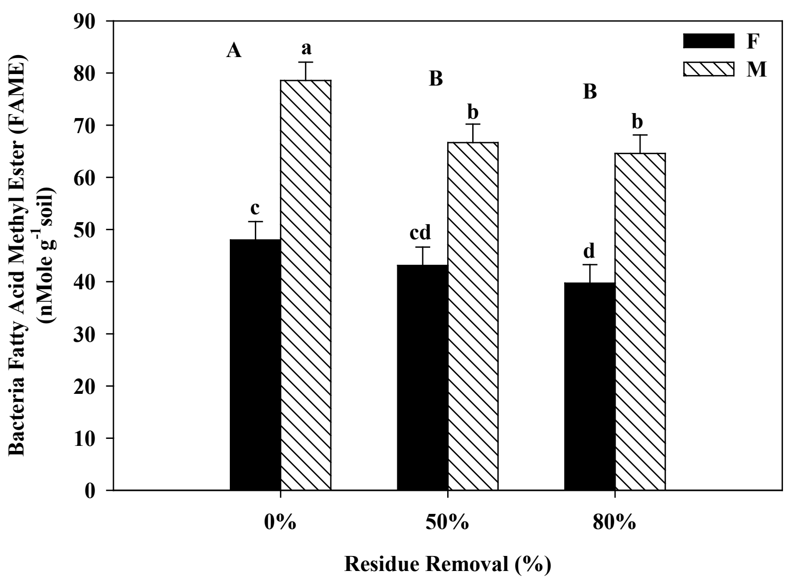

Figure 3. Bacterial markers in soil as influenced by nitrogen source (manure, M and fertilizer F) and residue removal level (0%, 50%, and 80%). The different lowercase letters represent significant differences (P < 0.05) between the M and F treatments. The different uppercase letters represent significant differences (P < 0.05) among the residue removal levels

Distinction of organic amendment and residue removal effects with depth:

Averaged across residue removal levels showed higher total FAMEs at the surface 0-2 inches compared with other depths studied **(Figure 6)**. At any depth studied, M treatment exhibited higher microbial community size compared with F treatment. The data reveals that the addition of an organic amendment such as manure enhanced the microbial community of soil even though both fertilizer sources were applied to provide the same amount of N.

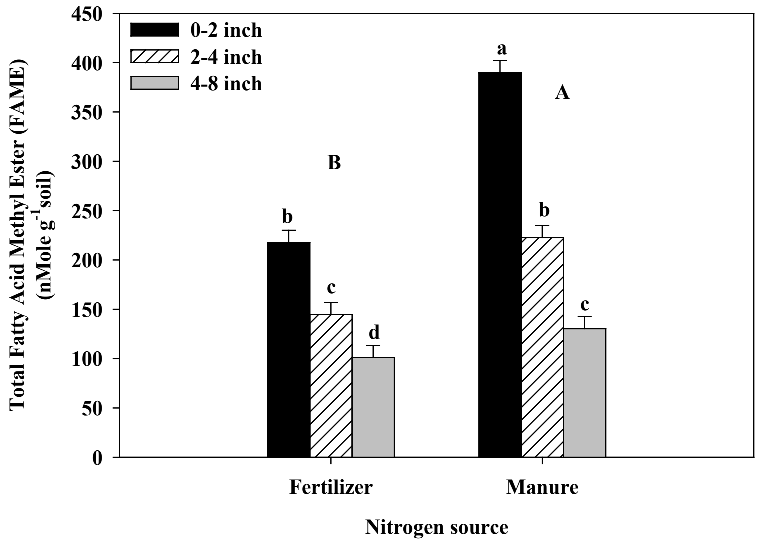

Figure 6. Total soil FAME averages across residue removal as influenced by nitrogen source (manure, M and fertilizer F) and sampling depth. The different lowercase letters represent significant differences ($P < 0.05$) between the M and F treatments. The different uppercase letters represent significant differences ($P < 0.05$) among the residue removal levels.

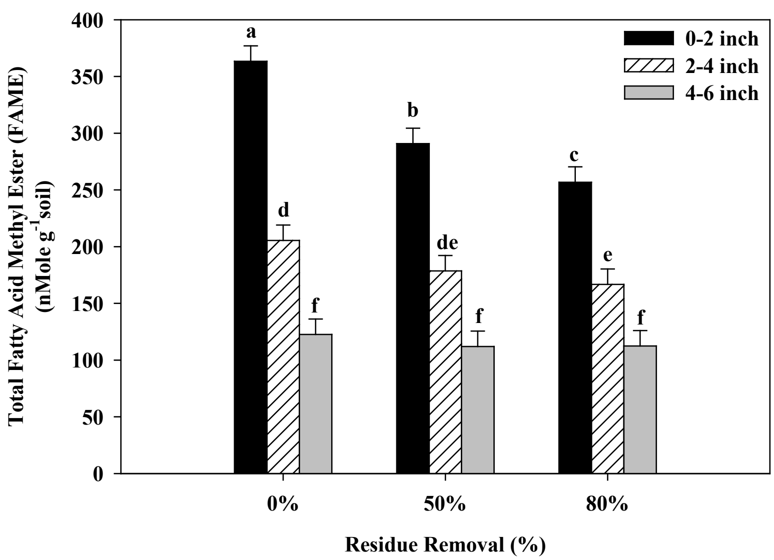

Figure 7. Total soil FAME average across N sources as influenced by nitrogen source (manure, M and fertilizer F) and sampling depth. The different lowercase letters represent significant differences ($P < 0.05$) between the M and F treatments. The different uppercase letters represent significant differences ($P < 0.05$) among the residue removal levels.

differences ($P < 0.05$) between the M and F treatments. The different uppercase letters represent significant differences ($P < 0.05$) among the residue removal levels.

Averaged across N sources **(Figure 7)**, total FAMEs were greater at 0-2 inches compared with other depths studied at any removal level. No differences in total FAME was observed among the removal levels at the deeper depth (4-6 inches) which could be related to the no-till practice that minimize residue and soil mixing. The data generated from this study reveals that the M addition is an important management practice that needs to be considered when the residue will be removed because of M showed a positive influence on soil microbial population size and ultimately soil health.

Conclusions

- Manure addition enhances the microbial community of a soil compared with the use of an inorganic fertilizer at any residue removal level.
- Residue removal (even 50%) can decrease the microbial community of a soil compared with maintaining the residue on the soil surface.
- If having to remove crop residue, it needs to be managed properly with irrigation and organic amendments to prevent decreases in the soil microbial community and SOM.
- The influence of different management practices on other soil properties are being evaluated and will be presented in the future to best describe different aspects of soil health.

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

John Spring, CSU Extension

Problem: Herbicide resistance kochia continues to present problems across northeast Colorado and adjacent growing regions. While glyphosate-resistance remains the major concern, dicamba-resistance is also increasing in prevalence. Incorporating pre-emergence herbicides into chemical fallow programs can be a successful tactic to control resistant kochia, and to reduce the risk of selecting for further herbicide resistance. In 2018, field trials were conducted to compare potential pre-emergent herbicide options for use in northeast Colorado and Nebraska panhandle conditions. Several products provided good control of resistant kochia populations. These products are being evaluated under a range of realistic use patterns over the 2019 growing season.

Approach: Field trials were established on the USDA-ARS Central High Plains Research Station; on the UNL High Plains Ag Lab near Sidney, NE; and on a private farm near Ovid, CO. Herbicides were applied in multiple-mode-of-action tank mixes, at both a late fall and an early spring application timing. Fall applications were made in late November, after soil temperatures had fallen below 50 F. Spring applications were made in mid-March, prior to any kochia germination. Adequate moisture to activate herbicides was received within 10 days of all applications. Herbicide treatments are shown below.

Table 1. Herbicides, rates, and products applied.

Trt	Timing	Active Ingredient	Product	Rate (oz/ac)	Rate (lb ai/ac)	MOA
1	*na*	*check, no PRE*	*na*	*na*	*na*	*na*
2	*fall*	sulfentrazone + metribuzin	Spartan 4F + Dimetric	4.5 + 5	0.14 + 0.25	14 + 5
3	*fall*	sulfentrazone + atrazine	Spartan 4F + AAtrex 4L	4.5 + 16	0.14 + 0.5	14 + 5
4	*fall*	flumioxazin + metribuzin	Valor SX + Dimetric	2 + 5	0.06 + 0.25	14 + 5
5	*fall*	flumioxazin + atrazine	Valor SX + AAtrex 4L	2 + 16	0.06 + 0.5	14 + 5
6	*fall*	isoxaflutole + metribuzin	Scoparia + Dimetric	2 + 5	0.06 + 0.25	27 + 5
7	*fall*	isoxaflutole + atrazine	Scoparia + AAtrex 4L	2 + 16	0.06 + 0.5	27 + 5
8	*spring*	sulfentrazone + metribuzin	Spartan 4F + Dimetric	4.5 + 5	0.14 + 0.25	14 + 5
9	*spring*	sulfentrazone + atrazine	Spartan 4F + AAtrex 4L	4.5 + 16	0.14+ 0.5	14 + 5
10	*spring*	flumioxazin + metribuzin	Valor SX + Dimetric	2 + 5	0.06 + 0.25	14 + 5
11	*spring*	flumioxazin + atrazine	Valor SX + AAtrex 4L	2 + 16	0.06 + 0.5	14 + 5
12	*spring*	isoxaflutole + metribuzin	Scoparia + Dimetric	2 + 5	0.06 + 0.25	27 + 5
13	*spring*	isoxaflutole + atrazine	Scoparia + AAtrex 4L	2 + 16	0.06 + 0.5	27 + 5

Acknowledgements: Grant funding for this project from the Colorado Wheat Research Foundation is gratefully acknowledged. Thanks also to Dr. Cody Creech for collaboration and hosting the Sidney site; to Dr. Merle Vigil for hosting the Akron site; and to Jim Carlson for hosting the Ovid site.

Contact: If you have further questions or comments about this project, please don't hesitate to contact me. I would be happy to discuss it with you in more detail.

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Impacts of Residue Removal on Irrigated Corn Production

Joel P. Schneekloth Francisco Calderon, and Steven Fonte

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 generally in the fall depending upon conditions after harvest. Tillage was done in the spring 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.

Soil Moisture was taken weekly during the growing season to make irrigation scheduling decisions as well as determining crop water use during the growing season. The final growing season soil moisture measurement was taken near crop maturity. The initial spring soil moisture measurement was taken prior to tillage and planting to determine soil moisture gains over the winter and beginning soil moisture.

Results: Infiltration measurements (Figure 1) were taken in early September after irrigation was ended. This ensured a dry soil surface during the time needed to take measurements. During this time period, infiltration rates have varied from year to year. Infiltration rates in 2015 were the greatest of the 5 years. This may be due to precipitation events that were typically low intensity as compared to the other years where there were intense precipitation events that may have impacted the soil surface.

Infiltration potential of the NT/R was the only management practice that had greater than 2" in each of the 5 years. The 5-year average infiltration for NT/R was 2.98" followed by 2.8" for T/R. The average infiltration for T/NR was 2.45" and 1.84" for NT/NR. Statistically, only NT/R was greater than NT/NR. All other treatments combinations were statistically equal. Although there are what appears to be significant differences between R and NR, the variability across the field was great enough to minimize the statistics.

It is uncertain as to why NT infiltration rates are lower than compared to T when residue was removed. However, it may be due to the mixing of soil with T whereas the soil surface with NT was not physically mixed during the 5 years and degradation of the surface layer may have the greatest impact on limiting infiltration potential.

This analysis was done on relatively level soils. Where fields have greater slopes, the potential for runoff would be lower with NT/R because of the residue acting like dams that would slow movement of water within the field.

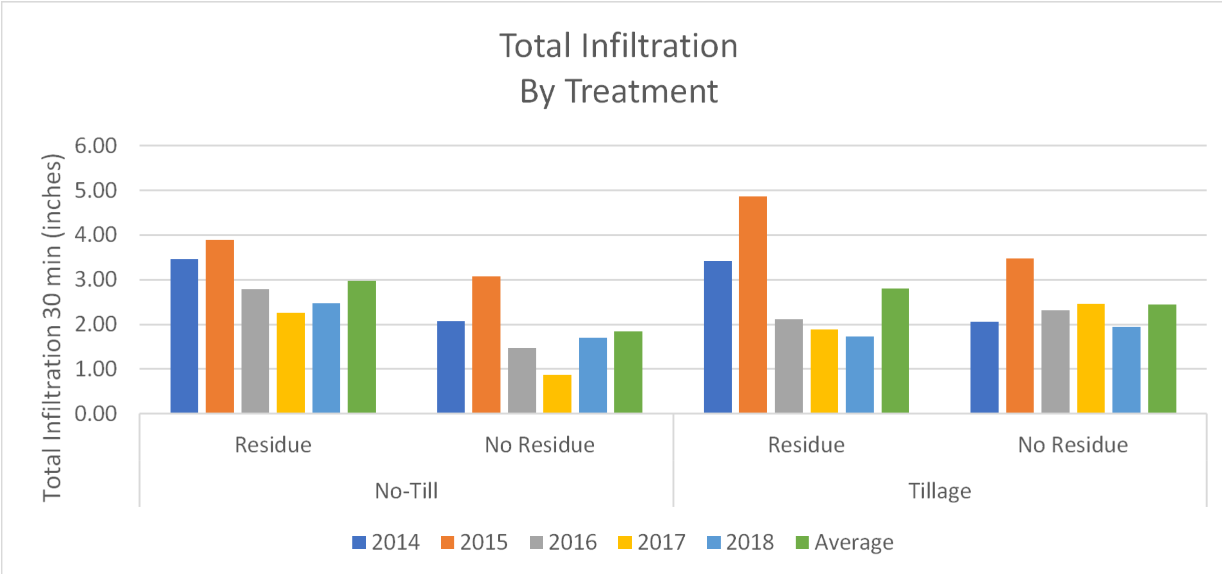


Figure 1. Total water infiltration over a 30 minute measurement for each treatment.

Beginning soil moisture (Figure 2) as well as changes within the growing season and winter are important components of residue management. Beginning soil moisture was greater with NT/R followed by T/R and greater than both T/NR and NT/NR. Much of this seasonal difference can be attributed to the increase in winter precipitation storage efficiency when residue is left in the field compared to when residue was harvested in the fall. Capture of winter precipitation when residue remained in the field was 1.5" per year greater than when harvested. This continual difference each year caused the decline in beginning store soil moisture. The change in beginning soil moisture between NT/R and T/R was less than 1" which can partially be attributed to increased evaporation after tillage occurred for the T/R compared to the NT/R.

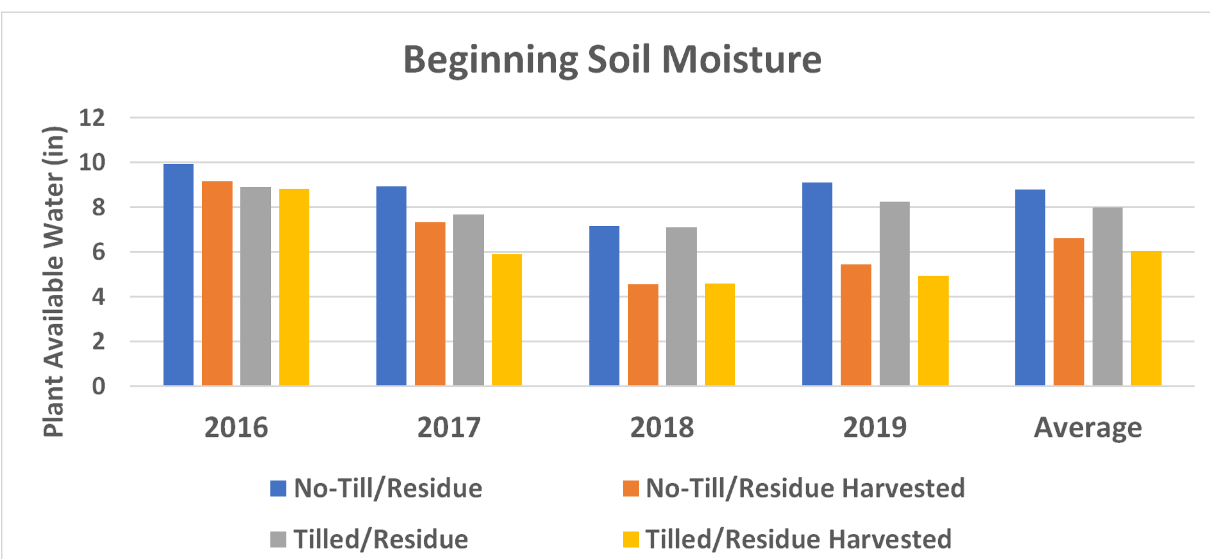


Figure 2. Beginning soil moisture from 2016 to 2019.

With limited water supplies as well as declining aquifer levels, capture and utilization of precipitation is important in irrigated as well as rainfed production.

Over the 5 years, NT/R showed significantly reduced ET during the vegetative growth stages of 0.75” to 1” per year compared to the other management practices. Irrigation needs for NT/R were reduced by approximately 1” per year compared to all other treatments. This reduction over the 3 years would be 3 ac-in and on a typical irrigated circle would be 10.5 ac-ft of water applied per year. The decrease in beginning soil moisture from 2016 to 2019 was about 4” over those 3 years or average 1.3” per year decrease. That water would have had to be replaced by irrigation or another 13.5 ac-ft of irrigation needs. On average, annual irrigation needs were reduced by approximately 24 ac-ft of water when NT/R was utilized compared to residue harvested and either tillage practice utilized.

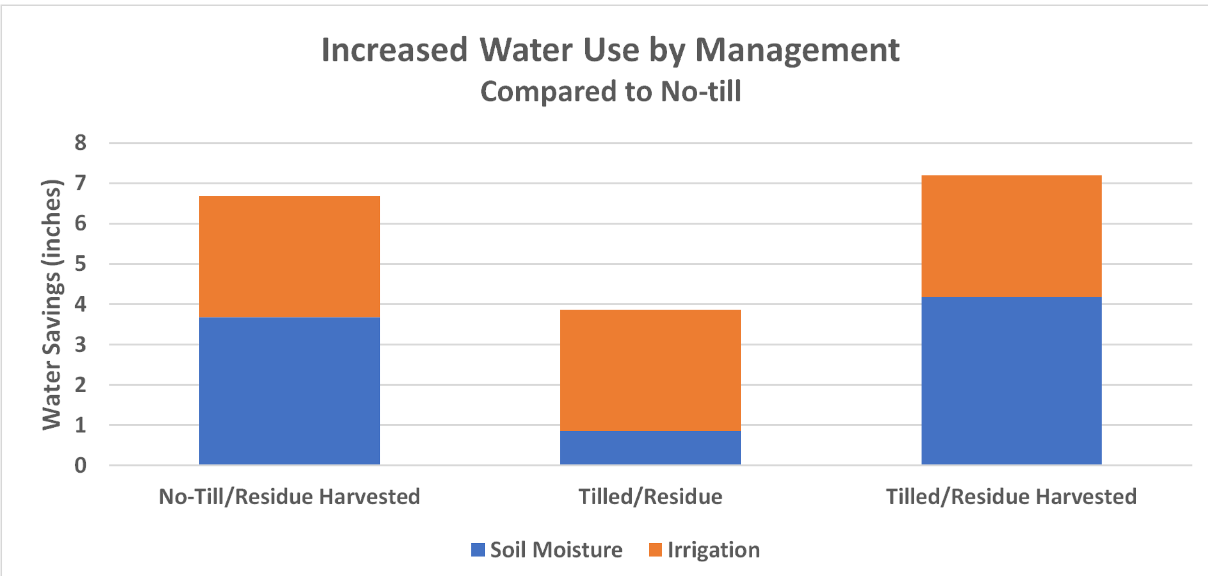


Figure 3. Increased water usage by management strategy compared to No-till/Residue Remained for both irrigation and stored soil moisture.

One of the proposed benefits of reducing tillage is increasing organic matter within the soil. Many times, it is heard that organic matter increases with NT are significant within the top 6” of soil. Residue removal would have a significant potential impact on organic matter since the source for producing organic matter, residue, has been removed.

Organic matter (Figure 4) increased in the 0-2” increment for both T and NT when residue remained in the field over the 5 years of management. This increase in organic matter averaged 0.015% for NT/R and 0.03% for T/R. Both NT and T where residue was removed decreased in organic matter by 0.04% per year for NT/NR and 0.05% per year for T/R. Overall, only T/R increased in organic matter within the 0-6” layer of soil. All other treatments had a significant reduction in organic matter from the initial content in 2014. The NT/R management practice is in a delayed response to organic matter changes below 2” since 3 to 4 years of residue remain on the surface in varying states of decomposition. We expect to see significant increases from this point in time as the residue decomposes and is more close to a steady state of decomposition.

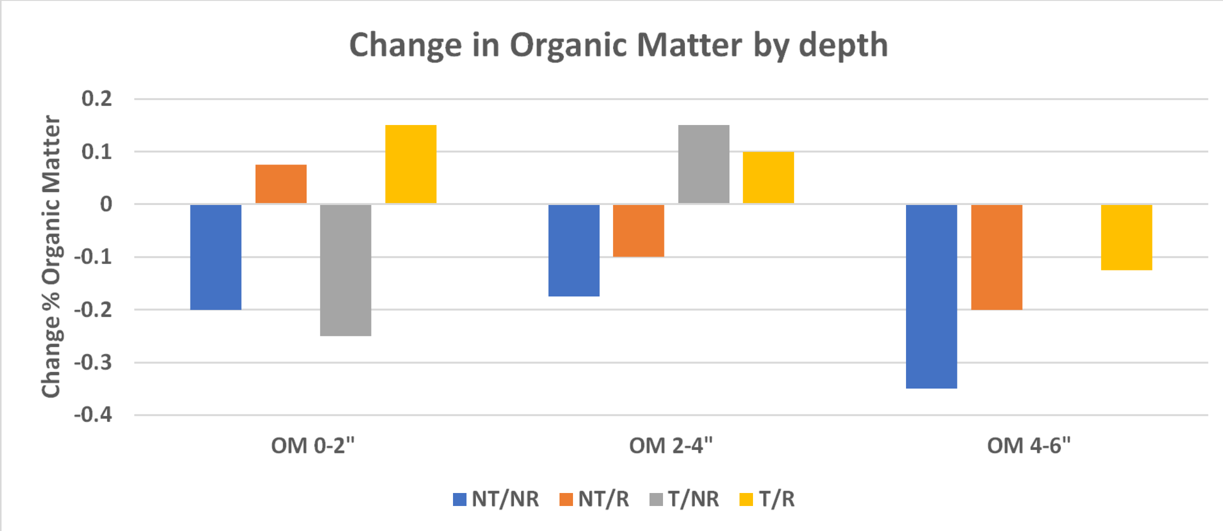


Figure 4. Change in Organic Matter in 2-inch increments to 6 inches by management practice.

Changes in water utilization and soil organic matter are important, however, the overall impact to grain yields and economics are the overriding factor to profitability. Grain yields (Figure 5) in 2016 ranged from 175 to 185 bu ac^{-1}. The grain yields from T/R and T/NR were approximately 10 bu ac^{-1} less than NT/R. In 2017 grain yields for the T/R were 201 bu ac^{-1} compared to 191 bu ac^{-1} for NT/R. Both T and NT when residue was removed were 10 to 15 bu ac^{-1} less than NT/R. In 2018, grain yields for T/NR and NT/NR were 35 bu ac^{-1} less than NT/R and 30 bu ac^{-1} less than T/R. The impact of the accumulative decline in store soil moisture significantly impacted grain yields when residue was removed.

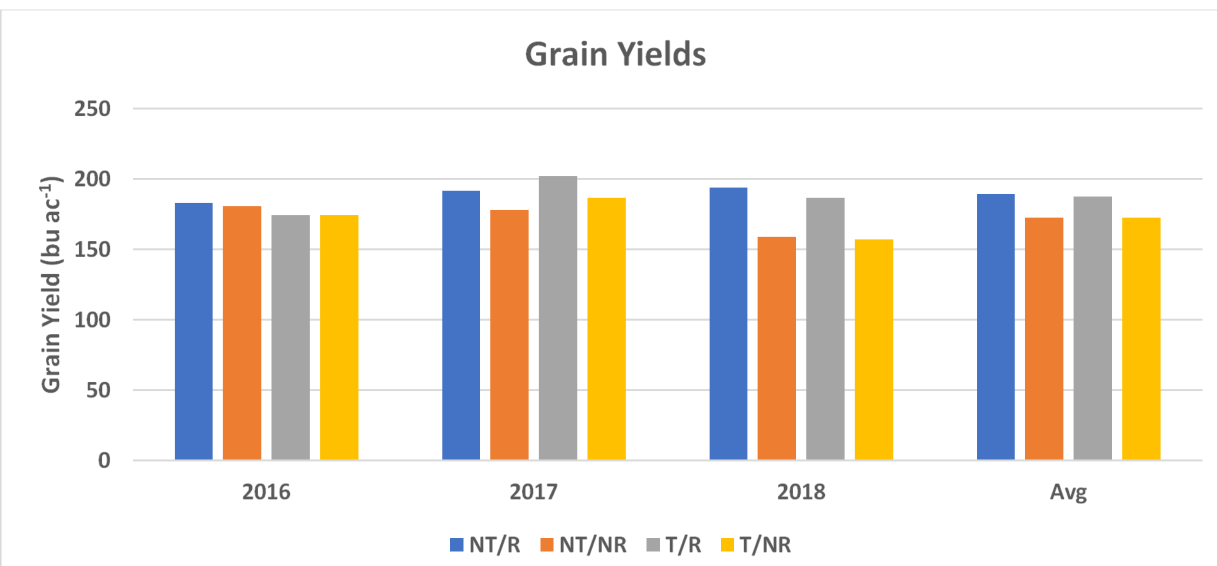


Figure 5. Grain yields under limited irrigation for 2016 to 2018.

Future Work: Beginning in 2019, these treatments were subdivided to include compost and cover crops within the system. We will be able to determine the impact of cover crops and compost within each of the 4 management practices compared to normal management practices.

My PhD Research Question

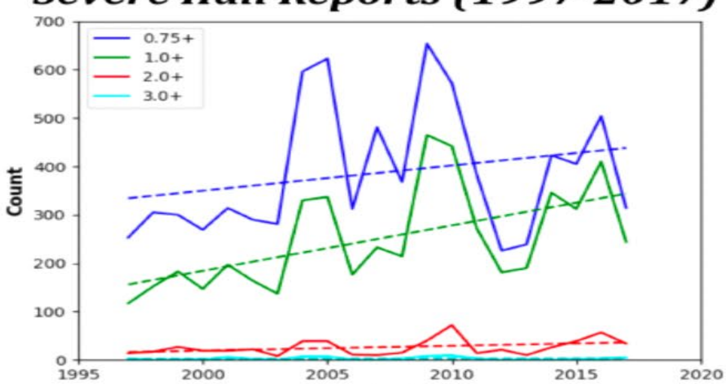
How is human risk from tornadoes and severe hail expected to change across eastern Colorado in the future (by 2100) ?

TWO CONTRIBUTING FACTORS

(a) Meteorology / Climate

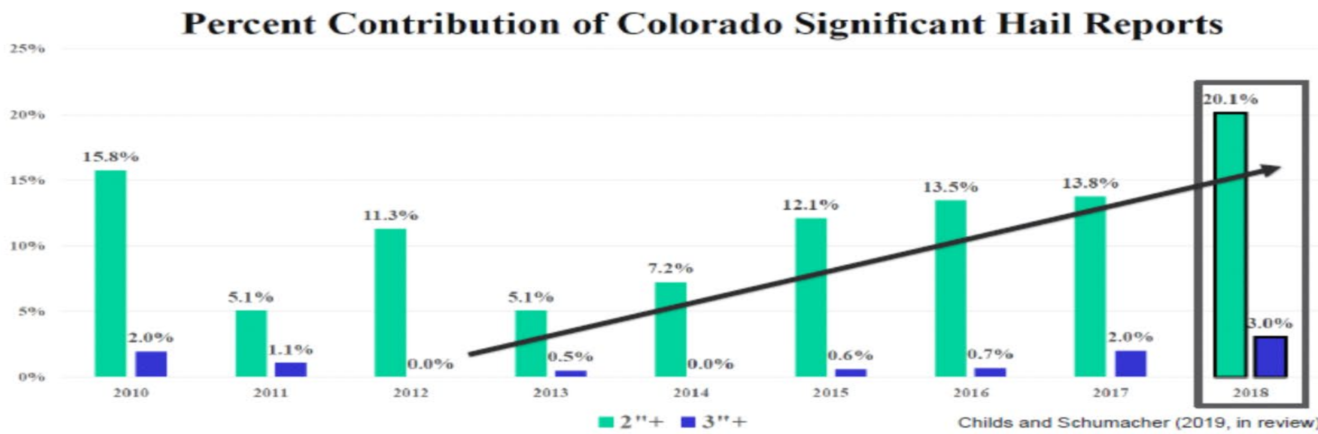
(b) Population Dynamics

Severe Hail Reports (1997-2017)

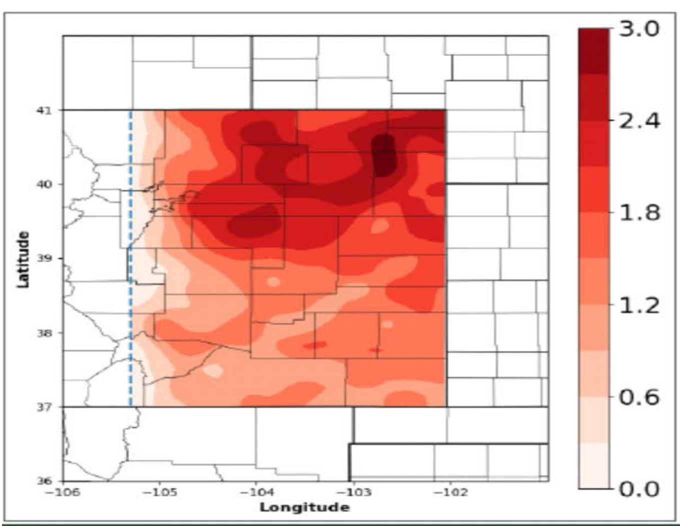


Childs (2018)

****Number of 1"+ hail stones reported in eastern Colorado increasing over the past 20 years due to both population and meteorology****

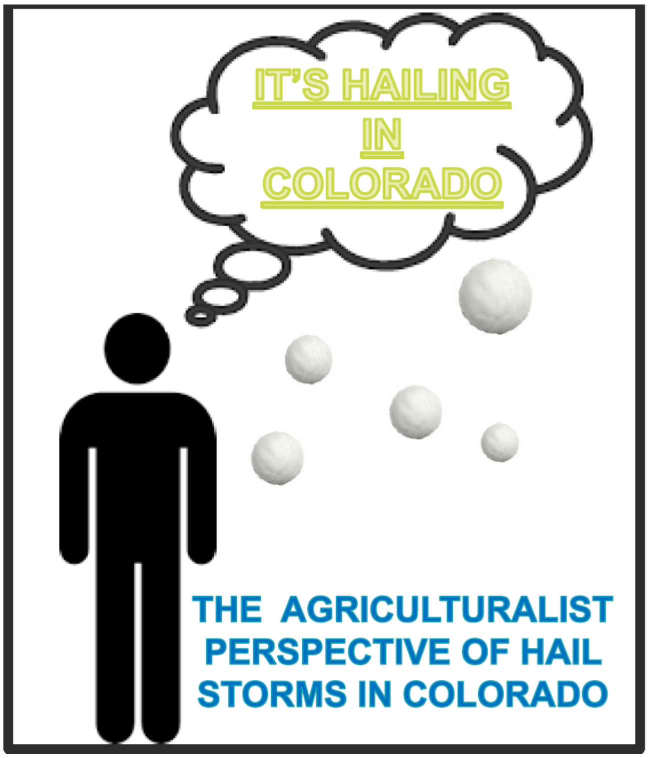


****Percentages of hail reported as 2"+ and 3"+ are increasing over time****



Projecting Severe Hail Storms out to the year 2100

****2-3 more days of severe hail on average per year by the end of the century across much of northeastern Colorado (~15-18 more hail reports)****



I Want to Hear Your Thoughts!!

~40 minute in-person interview
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This summer – can even do today!

If interested, find me today to sign up, e-mail me, or fill out the online form:
CSU_Hail_Interview_Study

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