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110TH ANNUAL FIELD DAY

JUNE 14TH 2017

USDA-ARS Central Great Plains Research Station

HIGHWAY 34, FOUR MILES EAST OF AKRON, COLORADO

Registration begins at 8:30 am with Coffee and Donuts; Program Begins at 8:40 am

8:40 AM	**Dr. Merle Vigil** Welcome to the Central Great Plains Research Station's 110th Anniversary Field Day
8:45 AM	**Wayne Shawcraft** Wheat Year Precipitation/Temperature Analysis 2017 Crops
9:00 AM	**Dr. Frank Peairs, CSU** Wheat stem sawfly and other pests of Colorado wheat
9:15 AM	**Dr. Sean Gleason** Corn Growth During Drought: the Gory Details of What Drought Does to Corn… and What Can be Done to Avoid It
9:30 AM	**Dr. Louis Comas** Adapting irrigation management to water scarcity
9:45 AM	**Dr. Huihui Zhang** UAV-based remote sensing for crop monitoring
10:00 AM	**Dr. Merle Vigil** Millet Research and the Central great Plains Research Station
10:20 AM	**Darren Bowder and Christopher Stum** Update on High Plains Miller Association
10:40 AM	**Break**

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HIGHWAY 34, FOUR MILES EAST OF AKRON, COLORADO

Registration begins at 8:30 am with Coffee and Donuts; Program Begins at 8:40 am

11:00 AM **Dr. Scott Haley and Dr. Jerry Johnson**
The 2017 Wheat Variety Field Day at Akron

12:05 PM **Dr. Maysoon Mikha**
Soil Carbon Associated with Fifty Years of Tillage and Nitrogen Fertilization

12:25 PM **Joel Schneekloth**
Impacts of residue and tillage: Year 3

12:45 PM **Dr. Francisco Calderon**
Infrared Spectroscopy Potential as a Fast Measurement of Soil Quality in the Field

1:05 PM **Dr. David Nielsen**
A Water Use/Yield Production Function for Grain Sorghum

1:25 PM **Dave Poss**
Winter Annual Forage Variety Trial Yield and Quality Results

1:45 PM **Lunch in Building 18**

2:05 PM **Various Speakers/Presenters - Demonstrating New and Interesting Agricultural Activities**

OUR STAFF

Admin Team

Sarah Bernhardt

Carolyn Brandon

Amber Smith

Scientists

Merle Vigil

Francisco Calderon

Maysoon Mikha

David Nielsen

Summer Students

Levi Basler

Brock Benson

Leanna Clarkson

Lynzee Dorrenbacher

Kristopher Jones

Cameron Lyon

Alexys McGuire

Lexi Thompson

Lindsey Wagner

Jacob Williams

Technicians

Paul Campbell

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Delbert Koch

Brandon Peterson

Stacey Poland

CSU Staff

Ed Asfeld

Joel Schneekloth

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West Plains Company	Wickham Tractor Co.
Y-W Electric Association	21st Century John Deere

WHEAT YEAR PRECIPITATION / TEMPERATURE ANALYSIS
2017 CROP

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

Central Great Plains Research Station
Akron, Colorado

Data through May 22, 2017

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 2017.**

Summary of Fallow Period 14-month
(J.A.S.O.N.D.J.F.M.A.M. J.J.A) = 14-months
July 2015 -- Aug 2016

Month	Year	Fallow Precip in	108-year Average Precip	Departure
Jul	2015	2.34	2.618	-0.28
Aug	2015	2.74	2.169	0.57
Sep	2015	0.17	1.283	-1.11
Oct	2015	0.94	0.918	0.02
Nov	2015	1.36	0.544	0.82
Dec	2015	0.55	0.423	0.13
Jan	2016	0.11	0.328	-0.22
Feb	2016	1.45	0.364	1.09
Mar	2016	1.45	0.839	0.61
Apr	2016	2.77	1.648	1.12
May	2016	4.06	2.930	1.13
Jun	2016	2.57	2.439	0.13
Jul	2016	3.03	2.624	0.41
Aug	2016	0.84	2.163	-1.32
Total		**24.38**	**21.289**	**3.09**
	total months=		14	

Growing Period Precip
10-Month Sep-June

Month	Year	Sep2016-Jun 2017 Precip	108-yr Ave Precip	Departure	Days of Snow Cover	Snow Depth in.
Sep	2016	0.68	1.29	-0.61	0	0.0
Oct	2016	0.70	0.89	-0.19	0	0.0
Nov	2016	0.39	0.53	-0.14	3	3.0
Dec	2016	0.44	0.43	0.01	13	6.2
Jan	2016	0.43	0.33	0.10	9	7.2
Feb	2016	0.16	0.35	-0.19	3	1.7
Mar	2016	1.45	0.82	0.63	1	0.5
Apr	2016	2.37	1.67	0.70	0	0.0
May	2016	**2.53**	2.92	-0.39	1	2.0
Jun	2016		2.43	-2.43	0	0.0
Total		**9.15** inches	**11.67**	**-2.52**	30	20.6
	total months =		10			

22-May-2017 <Last Update

FALLOW PERIOD SUMMARY:

The **July '15 - Aug. '16** fallow period precipitation was **24.38 inches**, which ranks as the **25th wettest** fallow period in the 108-year record for the 1908-09 through 2015-16 records. This is **3.09 inches** above the average of 21.29 inches. The fallow period began with good summer rainfall in July, August, but a dry September. The fall and winter were relatively wet with the exception of January. Late winter and early spring conditions were very wet with ten-inch plus snows in Feb, Mar, and Apr. Summer rains were substantial through July. August turned dry, but the overall fallow period had good precipitation that set up good prospects for the 2017 wheat crop.

GROWING SEASON SUMMARY Sep '16-Jun '17:

The *GROWING SEASON* precipitation for the **2017** crop **(through MAY 22, 2017)** has only been **9.15 in.** which is **2.52 inches BELOW the average of 11.67** inches. The *GROWING SEASON* precipitation for the current crop ranks as the **86th wettest** on record or the **23rd driest** this **does not include the remaining days in May or the *full* month of June**, which could increase this amount. Fall and winter precipitation has been very low through February. Spring rains, I.e. Mar,Apr, and May have been substantial, and even with the considerable deficit the prospects for the the wheat crop is promising.

SNOWFALL - WINTER 2016-17

was only 9.2 inches with 16 days of s Winter snowfall has been very low with only 20.6 inches of snowfall, and only 30 days of snow cover. Snowfall in the Nov. 18 to Dec 26 period of precipitation. A surprise late wet snow on May 20 brought good precipitation, but near freezing temperatures just at wheat heading time. Snow fall was one of the lowest in recent winters.

TEMPERATURES Sep.16-Jun17:

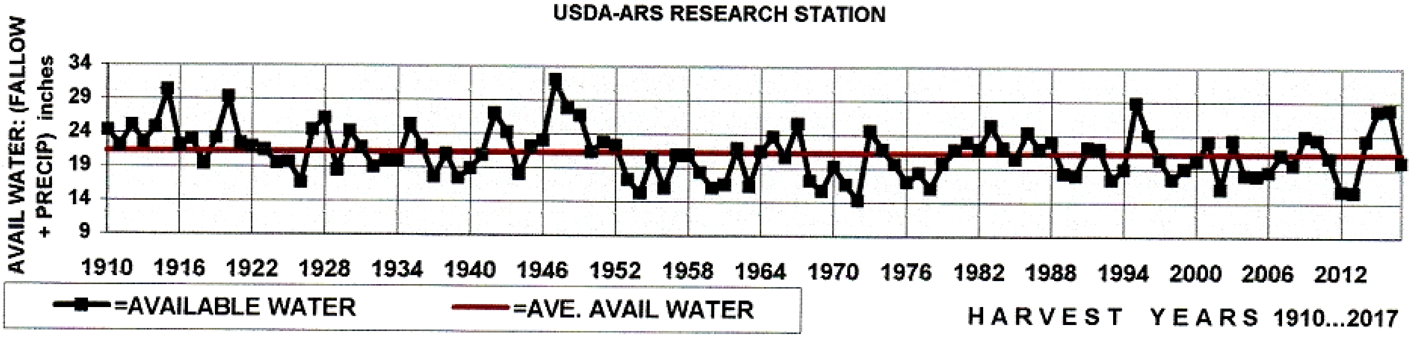
and January was only slightly above average. Very warm temperatures prevailed in Feb. and March, with a new record maximum of 80 and new record minimum of 40 (twice) set in Feb. April was a little cooler, but still ε The fall and early winter months were very warm with extremely above average temperatures from Sep. - Nov. December was somewhat cooler, Overall the Sept. - May temperature record is tracking as the **3rd warmest on the 106 year record**, with an average mean of **45.21 deg F.** This is well above the 106-year average of **41.61 deg F.**

AVAILABLE WATER SUPPLY:

At a fallow storage efficiency of **25%**, the available water supply for the **2017-crop, *so far***, would be **15.25 inches**, which is slightly below the average of **16.98 inches**. At a fallow storage efficiency of **45%**, the available water supply would be **20.12** inches, which is again, slightly below the average of **21.24 inches, not including the remainder of May-June**. The current wheat crop condition reflects a good fallow period precipitation, as well as the March, April, and May growing period. At **25%** storage efficiency the seasonal available water would be **60%** from growing season precipitation, and at **45%** storage efficiency growing season precipitation would be at **45.5%** of total available. Even with a hot or dry June or pre-harvest period, it appears that the current crop should have adequate moisture to see things through to harvest. At **25%** storage, the 15.25 inches of water available might be in the "border-line" range for good yields. Weather patterns at this date appear to be showing moderate temperatures with above normal precipitation, so the crop should be in reasonably good shape come harvest.

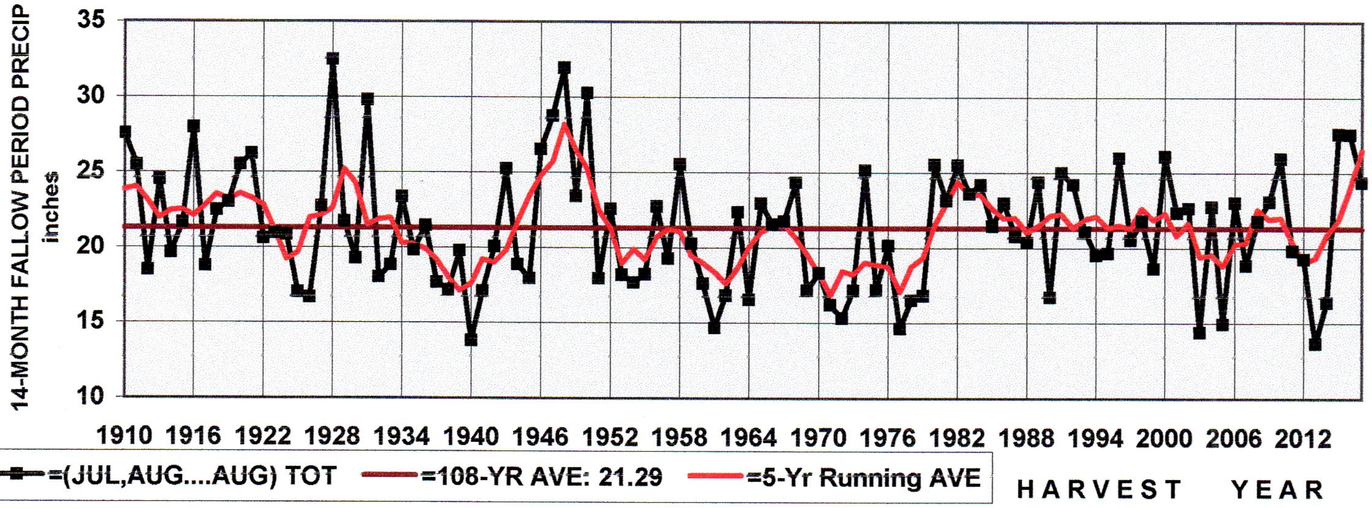
Fallow storage efficiency is usually a key to the success of the crop. With the relatively good fallow period and the late spring precipitation, the prospects for 2017 look good. The range of **15.25 inches at 25% efficiency** to **20.12 inches at 45% efficiency** would appear to be adequate for a good crop, although somewhat below recent years.

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



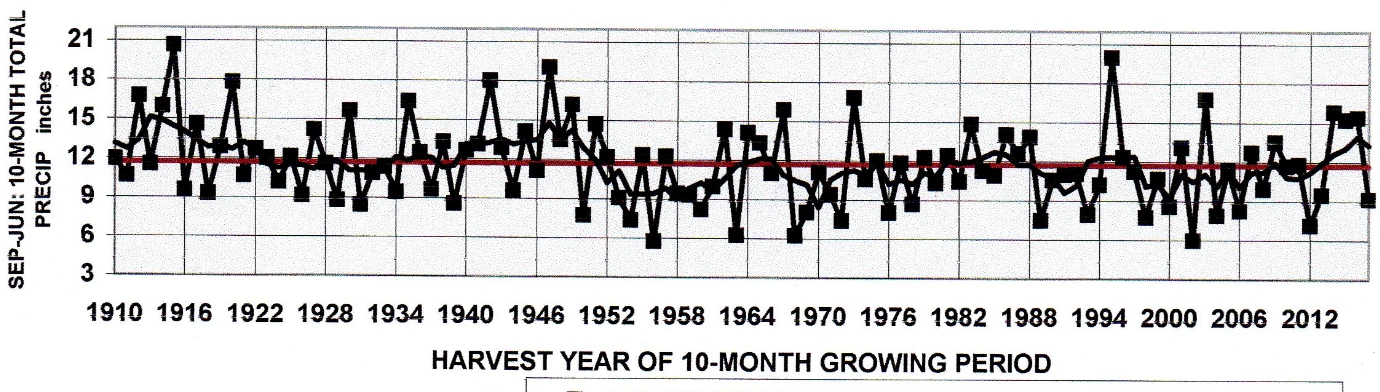
FLDDAY2017, in file "FLDDAY2017" printed: 5/22/2017

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



saved as: Graph, in FALWRANK printed: 5/22/2017

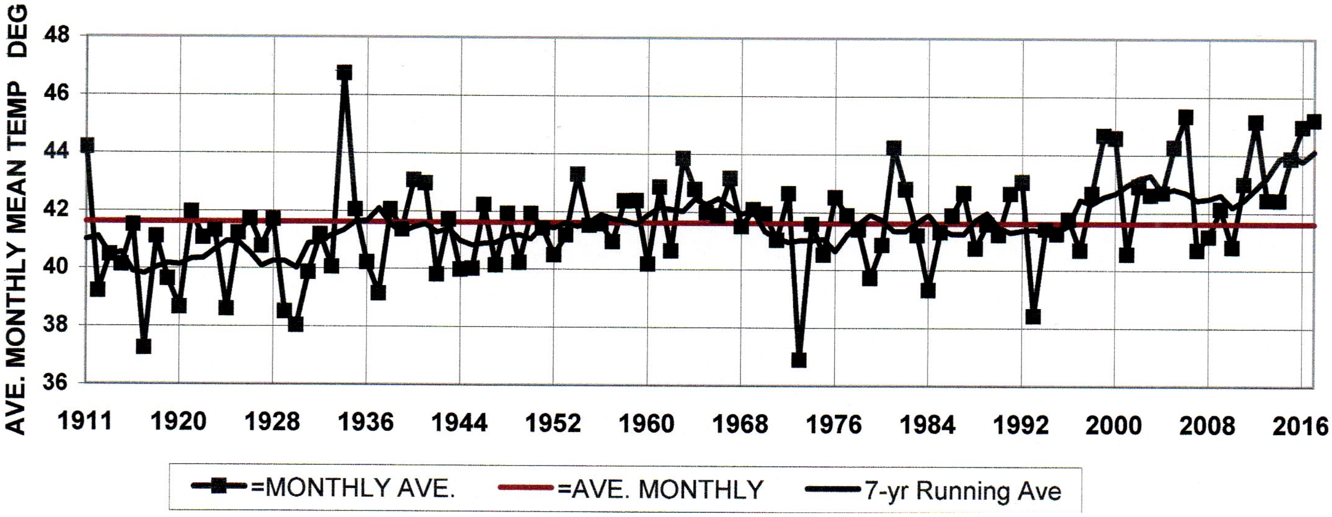
WHEAT: GROWING PERIOD (SEP-JUN) PRECIP
USDA-ARS RESEARCH STATION AKRON, COLO.

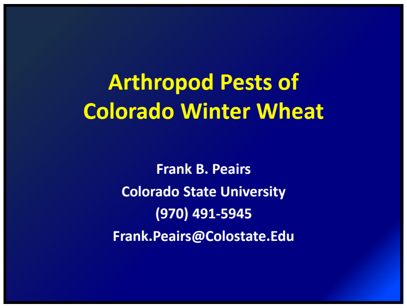


2017 updated through : MAY 22, 2017

saved as: tab "GraphYears" in file "GROWRNK1" printed: 5/22/2017

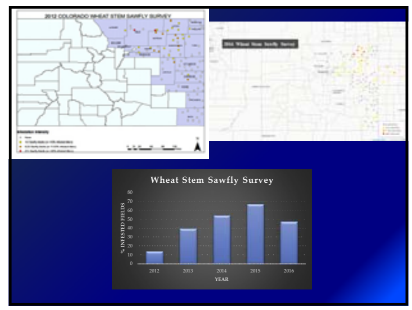
SEPT-MAY AVE. MEAN TEMP.
USDA-ARS RES. STATION, AKRON, COLORADO



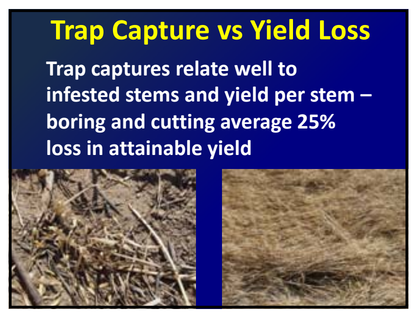

Arthropod Pests of
Colorado Winter Wheat
Frank B. Peairs
Colorado State University
(970) 491-5945
Frank.Peairs@Colostate.Edu


Sipha maydis
Hedgehog grain aphid


Wheat Stem
Sawfly

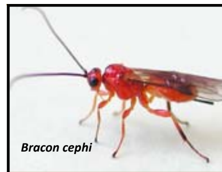

Wheat Stem Sawfly Survey


Use spring abundance to inform fall management decisions:
• Solid stem varieties
• Thimet
• Trap crops


Trap Capture vs Yield Loss
Trap captures relate well to infested stems and yield per stem – boring and cutting average 25% loss in attainable yield

Also need relationships with residue losses, weed problems – regional differences?

Wheat stem sawfly: Plant Resistance



Favored by cool, wet springs that delay crop development

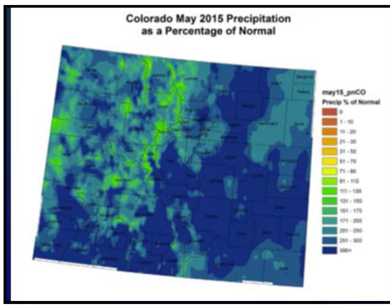
Negatively affected by drought, which, in turn, favors WSS

Biological control

Chemical control: Thimet

Control of wheat stem sawfly larval infestation and stem damage with soil applied Thimet 20G, 1.2 oz/1000 row ft, New Raymer, CO, 2015.

Treatment	Total larvae/100 stems	Cut stems per 100
90 days prior to harvest	63	54
90 days prior to harvest, incorporated	69	67
Early regrowth	73	60
At planting	74	62
Untreated	83	54



Control of wheat stem sawfly larval infestation and stem damage with soil applied Thimet 20G, 1.2 oz/1000 row ft, New Raymer, CO, 2016.

Treatment	Total larvae/100 stems	Cut stems per 100
90 days prior to harvest	5.8 B	2.7 B
90 days prior to harvest, incorporated	16.0 B	7.3 B
Early regrowth	21.0 B	9.5 B
At planting	58.8 A	32.7 A
Untreated	69.5 A	37.0 A

Questions?

CORN GROWTH DURING DROUGHT: THE GORY DETAILS OF WHAT DROUGHT DOES TO CORN… AND WHAT CAN BE DONE TO AVOID IT

Sean M. Gleason[1], Dustin R. Wiggans[1], Garrett Banks[1]

[1]Water Management and Systems Research Unit, Fort Collins, CO

Maximizing corn yield depends critically on the timing and quantity of irrigation water applied. This is because the timely application of water is aimed to avoid stress, and therefore maximize photosynthesis and improve grain development. We report here for the first time that the presently accepted view of drought stress in maize is likely to be incorrect. This discrepancy has arisen from our historically poor understanding of water transport mechanisms in crop plants, as well as the conditions required for the maintenance and repair of these mechanisms. This presentation will describe how drought affects the transport of water through a corn plant, the soil water conditions necessary to maintain an uninterrupted supply of water to the leaves and developing grain, and how irrigation management can be used as a tool to avoid the failure of the water transport pathway and facilitate its repair.

Growth in plants is a hierarchal process that begins with the absorption of water by the root system, the transport of this water through the vascular tissue (xylem), and the final use of this water at the sites of photosynthesis (water uptake → water transport → photosynthesis and growth → yield). Every aspect of plant development and growth depends on the efficient functioning of water transport tissue and the delivery of water to all points throughout the plant. However, the capacity of the hydraulic system to deliver water varies considerably among different corn varieties, as does the ability of the hydraulic system to resist damage during drought stress.

Figure 1 shows the decline in corn's ability to transport water (stem "conductance") during a typical summer day, under well-watered conditions. Note that even under well-watered conditions the conductance of corn's water-transporting tissue is significantly impaired each and every day. The good news is that as long as adequate water is available in the soil this loss of water transport can be regained overnight (Figure 2).

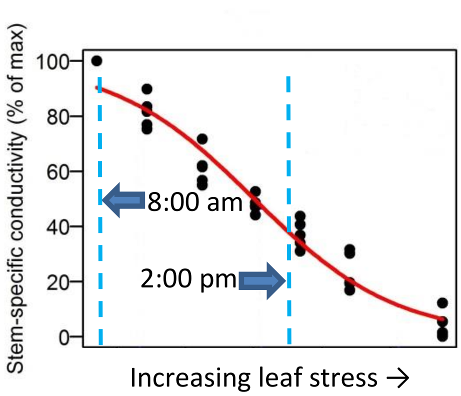


Figure 1. *Decline* in the capacity of corn stems to transport water during a typical summer *day*

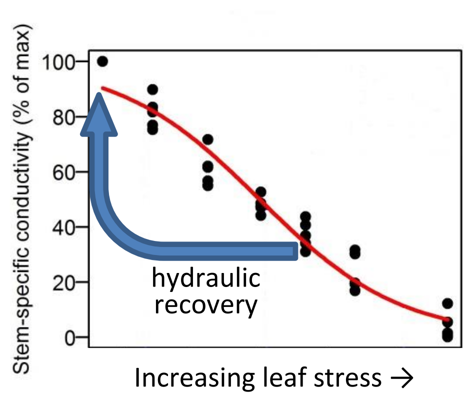


Figure 2. *Recovery* of corn stems (blue arrow) during a typical summer *night*

The functioning of the hydraulic system (and therefore growth and yield) is dependent on three processes: A) the maximum capacity of hydraulic system (how well plants transport water when fully hydrated), B) the ability of the hydraulic system to resist damage (the shape of the curve in Figure 1), and C) the ability of the plant to repair the hydraulic system overnight (shape of the blue arrow in Figure 2). We have measured the hydraulic capacity, as well as the resistance of the hydraulic tissue to dysfunction across several corn genotypes, but have only a limited understanding of the repair process and how it might vary among different corn varieties. However, it is likely that heritable variation in all three of these traits is likely to exist, and therefore also the opportunity to improve the species via breeding programs.

Through water management, processes 2 and 3 can both be effectively addressed. By ensuring soils have adequate water the percent loss of conductance can be significantly reduced and the recovery of conductance overnight can be facilitated. But how much water is needed?

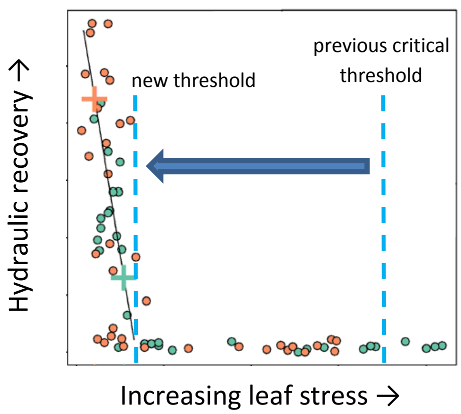


Figure 3. Overnight repair of hydraulic conductance in corn stems (greenhouse plants).

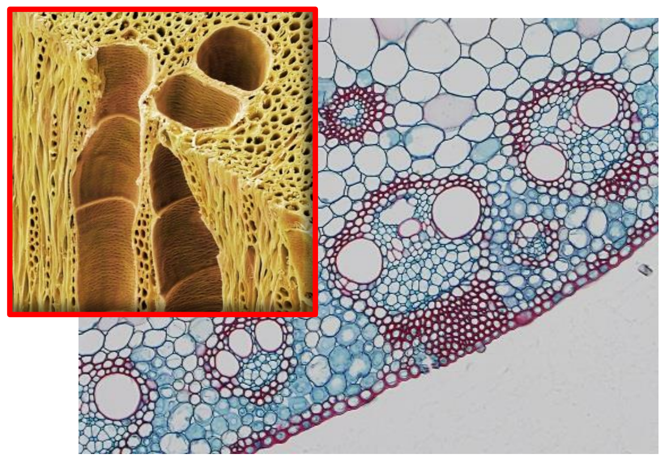


Figure 4. Images of conduits that transport water during the day, which ultimately fail and require repair during the night.

Generally, stress is considered something that happens during the day, when stress exceeds the "previous critical threshold" line in Figure 3. Wilting and leaf curl are some of the visual indicators of daytime drought stress. However, our research indicates that although daytime stress reduces photosynthesis and growth, without adequate water during the night ("new threshold" in Figure 3) corn plants cannot recover from the damage they experience during the day. Rather, a significantly lower level of nighttime stress is required to repair this damage. If sufficient soil water is not provided to achieve this repair, maximal growth and performance should not be expected.

We suggest that the direct measurement of soil water potential, a potentially easy and relatively inexpensive measurement, would allow for the timely application of irrigation. USDA-ARS Water Management and Systems Research Unit is presently developing a soil water sensor to do this. This technology will be made "open-source" and free of charge to anyone wanting to build or develop these sensors.

The Mini Soil Moisture Potential Sensor (MSMPS) consists of a single transistor encased in a 3D printed housing and filled with gypsum. The soil water potential of the gypsum matrix, (which is at equilibrium with the soil) is measured by passing current through the transistor and simultaneously measuring the differential voltage drop across the base and emitter legs. With more water the transistor readily dissipates heat into the gypsum matrix and there is less voltage drop across the base-emitter junction. This phenomenon is related to the quickness of the transistor to dissipate heat. By encasing the sensor head in gypsum the heat dissipation is buffered against thermal properties of different soil types and soil water potential can be calculated. The cost to make the sensors is less than $3.00 and parts can be purchased easily from local electronics vendors. A more intense study of the sensors is to be conducted this summer.

Figure 5. *Unfinished sensor, transistor head can be seen within the 3D printed casing*

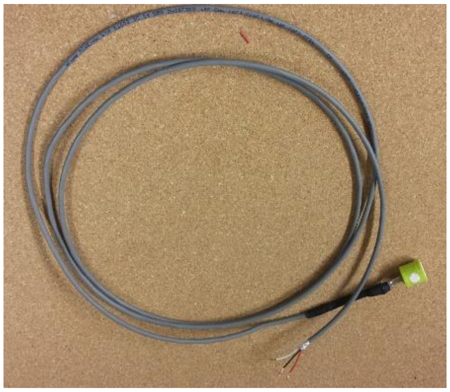


Figure 6. *Finished 3 wire MSMPS sensor*

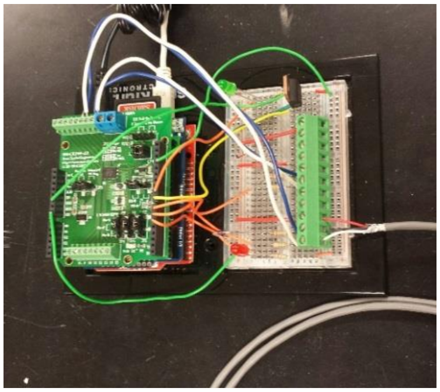


Figure 7. *Arduino based measurement and data logging*

A BRIEF SUMMARY OF MILLET RESEARCH AT THE USDA CENTRAL GREAT PLAINS RESEARCH STATION

M.F Vigil D.C. Nielsen, David Poss and Francisco Calderon

PROBLEM: Proso millet is well adapted to our climate and cropping systems. The issue is the size of the market and how that affects price. Colorado is number one in Millet production in the United States. Currently Colorado millet producers make up about 66% of the total US production. The next two states tied for second are Nebraska and South Dakota each with about 17% of the total production. In our state millet acres can range from a low of 170,000 acres in 2009 to a high of 370,000 acres in 2013. The 10 year average is about 263,000 acres. Therein lies the problem. The market demand for proso is only big enough to support about that many acres in Colorado. If we surpass that number the price drops below breakeven. The small market for millet makes it hard to justify too many acres in the region. Total US acreage is around 512,000. Just for comparison total US Wheat acreage is about 58 million with Colorado wheat at about 2.5 to 3 million acres. Wheat markets are large and mostly stable because wheat is mostly consumed by us humans as bread, cookies, cakes, noodles, crackers, tortilla's etc. In fact in the USA 100 lbs of wheat is consumed per person each year. Twenty percent of all calories consumed worldwide come from wheat. Millet on the other hand, is grown mostly for birdseed in the USA. It doesn't have to be just bird seed. Millet is a highly nutritious grain that surpasses many others for both fiber, protein and human digestibility (table 1). Millet is often compared to rice because when dehulled it resembles rice in texture and in taste.

Table 1. A comparison of cooked and raw dehulled proso millet with cooked and raw rice.

	200 grams raw and uncooked			One cup cooked boiled or steamed	
	Millet	Rice*		Millet	Rice
calories	756	716		285	199
	grams of component in 200 grams			grams of component in one cup cooked	
protein	22 g	13 g		8.4 g	4.2 g
carbohydrates	146 g	158 g		56.8 g	44.7 g
fiber	17 g	6 g		3.12 g	1.2 g
fat	1 g	1 g		2.4 g	0.4 g
calcium	2%	1%			
iron	38% RDA	47% RDA			

*The biggest difference is nearly all rice will have some arsenic accumulation while Millet is essentially arsenic free.

APPROACH: Proso millet has been incorporated into several dryland rotations over the years. Proso millet fits well in our wheat based dryland rotations. All of the millet grown in rotations on the Research Station have been managed no-till with direct seeding into the previous year's standing crop stubble. Millet is drilled at a seeding rate of 15 lbs per acre. Our target date for planting millet is the first week of June. But we have had success planting it as late as the 15th of June. During the millet growing season millet we occasionally will spray for broadleaf weed control with combinations of 2, 4-D and Dicamba (banvel, clarity). Most of our millet is swathed when two thirds of the head has turned from green to brown-yellow. We have had some success with harvesting millet directly without swathing with a stripper header. Wind late in Late August or early September can negatively affect millet yields by shattering the seed shattering on the ground.

RESULTS: Millet average yields in our research average between 30 and 40 bushels per acre depending on the rotation (Table 2). On occasion millet yields have exceeded 85 bushels/acre. The 80 bushel plus yield occurred when rainfall was timely in August and early September. Millet needs less N to make descent yields than wheat or corn. We often can get a top response with just 30-40 lbs of applied N per acre. Our highest yielding millet rotation is Wheat-Millet fallow managed with no-till. Millet after corn most of the time will yield less than millet in WMF or continuously cropped Wheat-millet without fallow.

Table 2. Corn Millet and wheat yields in typical rotations over the last 26 years in ACR plots.

Rotations				Annualized	Increase over WF-CT
	bushels/acre			lbs/acre	%
	Corn	Millet	Wheat		
WCMF-NT	39	31	42	1570	66
WCF-NT	42		43	1630	72
WMF-NT		38	41	1450	54
WCM-NT	28	30	20	1420	50
WM-NT		34	21	1480	57
WF-NT			43	1290	36
WF-CT			32	950	--

FUTURE PLANS: This research will continue mostly with analysis of existing data sets on N response and rotation response. David and I just recently submitted an updated millet water use production function for publication. The response function will be shared with the public after publication. We also will continue to explore other uses for millet (see next few pages for more on millet as a human food).

Dehulled Proso Millet an underappreciated Cereal Grain

Dr. Merle F. Vigil and the Staff at the USDA-ARS Central Great Plains Research Station

Akron, Colorado

Have you ever eaten proso millet for dinner? You should try it. When we think of proso millet we think bird seed or hog feed. However, if one removes the hull on proso millet you have a cereal grain that can be cooked up like rice. Cooked like rice, dehulled-proso is a healthy, tasty, and nutritious staple.

Dehulled proso cooks up like rice, taste like rice and has a similar consistency. At the USDA-ARS Research Station we had a dehulled proso-millet cook off (see attached recipes). In that exercise, my staff and I learned that anything you make with rice you can make with dehulled proso-millet. Rice pudding with raisons can just as easily be proso-pudding with raisons. How about chicken and rice soup? It can just as easily be chicken and proso soup. However, proso has more protein and more fiber than rice (it is more nutritious than rice). Because proso is not grown in flooded soils the arsenic accumulation problems that can occur in rice production is not an issue. The arsenic issue with rice has to do with flooded soils. When a soil is flooded, the redox potential of that soil is reduced and that reduction in redox potential increases arsenic solubility and mobility. The net result is that in some flooded soils arsenic uptake by the rice plants is enhanced and unfortunately some of that arsenic accumulates in the rice grain. That does not happen with proso because as you all know proso is never grown under flooded conditions. If you need to be gluten free, proso-millet is a gluten free grain.

The above shot is of the millet yummies we made at the research Station last year. I have to admit some recipes were better than others. However all were very good. Dehulled Millet cooks up like rice.

USDA Central Great Plains Research Station Dehulled Millet Recipes

Chicken Veggie Soup with proso as a substitute for rice

Ingredients

- Two cups of diced celery
- One large diced onion
- One cup diced carrots
- One cup of fresh diced or a can of diced tomatoes
- 3 cups of water,
- 2-4 chicken bouillon cubes (to taste)
- Pepper to taste
- One boneless chicken breast and thigh
    - Fry the chicken and then dice to ¼ inch size cubes
- ¼ cup of dehulled proso millet

Steps

1. Wash proso in warm water throw away rinse water
2. Start the proso boiling in 3 cups of water set heat to gently boil
3. Fry the chicken, let cool.
4. Dice all the veggies while chicken is cooling
5. Put in the bullion and add the diced veggies to the gently boiling soup
6. Cube the cooled chicken meat and add to the soup
7. Take off heat when proso is soft and carrots are soft but not mushy (about 40 minutes on a low simmer)
8. Serve warm a nice soup for a cold day

Merle F. Vigil

Crockpot Grains

Makes 8 servings

Ingredients

- ¼ C millet, uncooked
- ¼ C barley, uncooked
- 1/3 C brown rice, uncooked
- 1 C chopped onions
- 1 C chopped green pepper
- ½ C finely chopped carrots
- 1 1-lb can kidney beans
- 1 8-oz can tomato sauce
- 1 1-lb can tomatoes, chopped, drained (Reserve liquid)
- 1 ½ canned or frozen corn, drained
- 1 tsp dried oregano

- 1 tsp dried basil
- ½ tsp garlic powder
- Salt and pepper to taste

Steps

1. Combine all ingredients in a crock pot
2. Add water to reserved tomato liquid to equal 2 ½ cups
3. Stir into grain mixture
4. Cover and cook on low setting 8 hours.

Linda Hardesty

Fried Millet

Ingredients

- ¾ Cups of Millet (Cooked & Drained)
- ½ # of Fried Bacon
- 6 Eggs fried in Bacon Fat (Stirred)
- 5 Green Scallion onions chopped
- ½ Green Pepper chopped

Steps

1. Sauté onion & pepper in Bacon Fat (Drain)
2. Mix all of the above add Salt & Pepper and enjoy!

Carolyn Brandon

Mexican Proso (barley can be used instead)

Ingredients

- Boil 3 cups of water and 1 cup of proso
- Boil until it "pops"
- Drain, set aside and dice
- One cup of green peppers
- One cup of onions
- One cup of tomatoes (or 1 can)
- One tablespoon of jalapeño

Steps

1. Add one cup of shredded cheese
2. Butter to your likely
3. Mix into proso
4. Bake in oven for 30 minutes
5. Top with more cheese

Stacey Poland

Millet Muffins

Ingredients

- 2 ¼ cup whole wheat flour
- 1 cup buttermilk
- 1/3 whole dehauled millet
- 1 egg, lightly beaten
- 1 teaspoon baking powder
- ¼ cup pomagrate applesauce
- 1 teaspoon baking soda
- ½ cup honey
- 1 teaspoon salt

Steps

1. Preheat oven to 400 degrees. Greases 16 muffin cups
2. In large bowl, mix dry ingredients. In separate bowl, mix wet ingredients. Stir wet ingredients into the dy mixture until just evenly moist. Transfer batter to the prepared muffin cups
3. Bake 15 minutes in the preheated oven

Karen Couch

Skillet Millet

Ingredients

- ¼ c butter
- 1 lg. onion chopped
- ¾ c basic cooked millet, cooled

Steps

1. Serve this with almost anything. Melt butter, in large skillet, sauté onion until tender and lightly brown.
2. Add millet and mix well. Lower heat and simmer for 15 minutes, stirring with fork. Don't cover

Linda Hardesty

Wonderful Millet

Ingredients

- 1 cup millet
- 5 cups chopped tomatoes and juice from Progresso Italian tomatoes with basil
- 1 onion
- 1 clove garlic (optional)
- ¼ c sesame seeds

- ¼ c sunflower seeds
- ½ tsp. basil
- ½ tsp oregano

Steps

1. In a shallow, covered casserole dish, mix together all ingredients.
2. Bake @ 325-350 degrees for 1 ½ hours.

Linda Hardesty

Basic Millet

Makes 6 Servings

- 1 Cup millet
- 3 Cups water
- Pinch of sea salt

1. Toast millet in dry pan over medium to low heat until grains begin to pop and give off a nutty aroma.
2. Add water and salt. Cover and bring to a boil. Reduce heat to low and simmer for 25 min or until water is absorbed.

Look on a bag of rice. Proso has better nutrition than rice in a number of categories including protein and fiber. And it is grown right here in Colorado.

Soil Carbon Associated with Fifty Years of Tillage and Nitrogen Fertilization

Maysoon M. Mikha[1] and Augustine K. Obour [2]
[1] USDA-ARS, Central Great Plains Research Station, Akron, CO
[2] Kansas State University, Agricultural Research Center, Hays, KS

In the Great Plains Region, dryland farmers are increasingly adopting conservation tillage practices in their farming system. In 2012, it was estimated that approximately 35% of total planted acreage in the United States were under no-tillage (NT) practices. The NT has many benefits such as enhanced soil organic matter (SOM) content, improved soil physical properties, and reduced soil erosion and runoff, specifically in dryland cropping systems. However, NT may increase bulk density near the soil surface and increase acidification in the upper soil surface due to fertilizer addition. However, conventional tillage (CT) or moldboard plowing (MP) could reduce soil acidification, decrease bulk density at the depth of tillage due to soil mixing, and decrease SOM by incorporating crop reside, as well as enhance residue decomposition. The combination of different tillage practices and fertilizer rates were found to influence soil nutrient dynamics at the surface layers for NT as well as within the depth of tillage with tillage treatments, thus increasing crop yield. Long-term studies are valuable to improve our knowledge of nutrient dynamics influenced by different management practices that could be difficult to gather from short-term studies. This statement is true specifically in the semi-arid atmosphere of the Great Plains region that exhibit low precipitation and low plant biomass production. Therefore, SOM accumulation in semi-arid regions may take longer time when compared to environments with greater precipitation.

Objectives

- Evaluate the influence of different N rates and tillage treatments (NT, CT, and MP) on soil organic C and wheat production after 50 years of management.

Materials and Methods

The long-term tillage and N rates study was initiated in 1965 at the Agricultural Research Center near Hays, Kansas State University (KSU). Long-term average annual precipitation covering 142 years at the experimental site is 22.8 inches, of which more than 75% (17.2 inches) is received from April through September **(Table 1)**. Mean annual temperature is 53.6 ^{O}F. The last killing frost in spring occurs around April 27, and the first killing frost in the fall occurs the second week in October. The average frost-free growing season is 168-d.

Throughout the 50-year study period, the study site is maintained in wheat-grain sorghum-fallow (W-S-F) rotation scheme. Each phase of the W-S-F crop rotation was present in each year of the study. The wheat crop was planted in late September or the first week in October and was harvested the following June or July. Then, the plots was planted to grain sorghum the following year in June and harvested in November. The land remains fallow until the following September or October when it is planted to winter wheat again. This W-S-F cropping system allows production of two crops in 3-yrs with a 10 to 11-month fallow period between grain sorghum and winter wheat crops.

Ammonium nitrate was the N fertilized source from 1975 to 2002. After 2002 to present time urea was used as a N fertilizer source. The N fertilizer rates were applied at 0, 20, 40 and

60 lb/ac from 1975 to 2014 growing seasons; thereafter, the N fertilizer changed to 0, 40, 80 and 120 lb/ac. The N fertilizer was broadcasted in the fall prior to wheat planting and incorporated in the CT and MP treatments while fertilizer addition remained on the soil surface under NT treatment. Over the 50-yr study period, no other type of fertilizer was added because soil test levels for available P were medium to high and exchangeable potassium (K) are inherently high in this soil.

Table 1. Yearly precipitation and 145 years average at Hays, Kansas

	-- Year --			
Months	**2013**	**2014**	**2015**	**Average 1868-2012**
	-- Inch --			
January	0.70	**0.16**	**0.46**	0.44
February	1.19	**0.92**	**0.71**	0.72
March	0.78	**0.17**	**0.09**	1.24
April	1.06	**0.91**	**0.96**	2.07
May	2.16	**0.82**	**6.44**	3.18
June	2.73	**9.45**	**0.76**	3.33
July	7.08	2.36	4.11	3.22
August	0.59	1.64	0.46	2.91
September	2.98	5.94	0.42	2.15
October	**0.99**	**2.15**	1.75	1.41
November	**1.16**	**0.05**	1.83	0.83
December	**0.05**	**0.73**	1.77	0.65
Yearly Total	**21.53**	**25.30**	**19.76**	**22.79**
Growing Season		**14.63**	**12.35**	

The CT treatment was tilled with residue-saving implements such as V-blade and sweeps to about 6 inches deep. The MP treatment was done by disking and plowing with residue-incorporating (disk and mulch treader) to about 6 inches deep during the fallow period. Approximately 3 to 4 tillage operations were performed in the fallow phase of CT and MP plots for weed control. Herbicides were used for weed control in the NT plots and as needed across tillage practices during the growing season and fallow periods. Two to four applications of glyphosate [isopropylamine salt of *N*-(phosphonomethyl) glycine] and 2, 4-dichlorophenoxyacetic acid were applied to kill emerged weeds prior to winter wheat planting. Winter wheat was planted at the seeding rate of 58 lb/ac. Grain yields were evaluated by harvesting an area of 6 ft × 100 ft from each plot using a plot combine. The three tillage treatments were arranged in randomized complete blocks with four replications as the main plots and N rates were considered the sub-plot factor. The tillage plot sizes were 67 ft × 100 ft and the N application rate treatments 11 ft × 100 ft.

Results and Discussion

In 2014, winter wheat grain yield was not influenced by N rates or tillage treatments **(Fig. 1)**. The winter wheat grain yield in 2015 was only influenced by N rates, but not by tillage treatments **(Fig. 2)**. The low precipitation throughout the 2014 wheat growing season (October 2013 to May 2014) contributed to lower yield when compared with the 2015 yield. The 6.44 inches of precipitation in May of 2015 highly contributed to the wheat yield increase regardless of N rates and tillage practices. Across tillage treatments, the wheat yield in 2015 associated with 0 and 40 lb/ac N fertilization were greater than the wheat yield in 2014 by an average of 37.5% (12 bu/ac). The low precipitation was the major factor contributing to the low wheat crop regardless of the N rates or tillage practices especially in 2014. Changing the N rates in 2015 could have some benefits on increasing wheat grain yield, but the precipitation amount and timing still remained the major factor influencing yield in this semi-arid region.

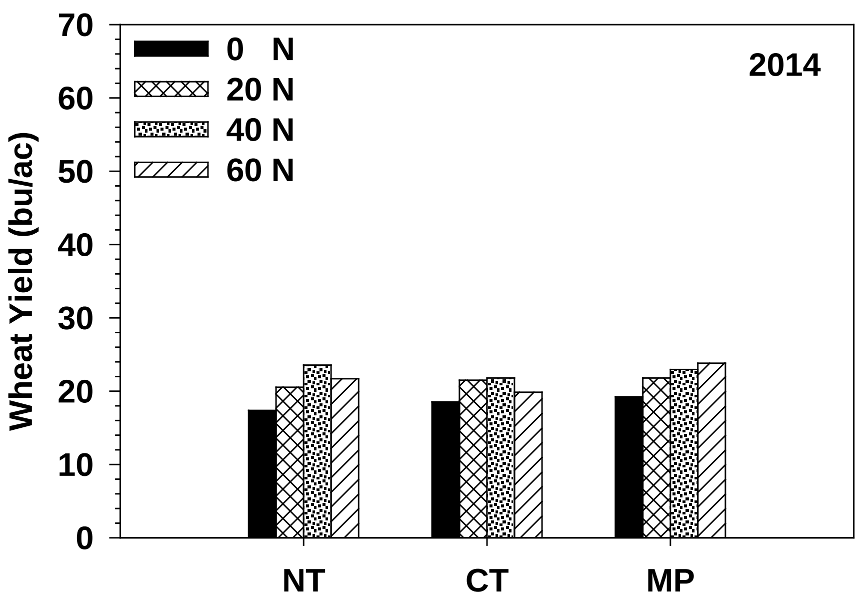


Figure 1. 2014 winter wheat grain yields (bu/ac) at different N rates and tillage treatments

Relative to control (0-N) treatment **(Fig. 3 and Fig. 4)** and across tillage treatments, wheat yield in 2014 associated with 40 lb/ac N fertilization **(Fig. 3)** were lower than the wheat yield in 2015 **(Fig. 4)** by approximately 46% (2 bu/ac). The high precipitation **(Table 1)** in Jun of 2014 did not benefit wheat yield and it negatively influenced the yield when compared with the high

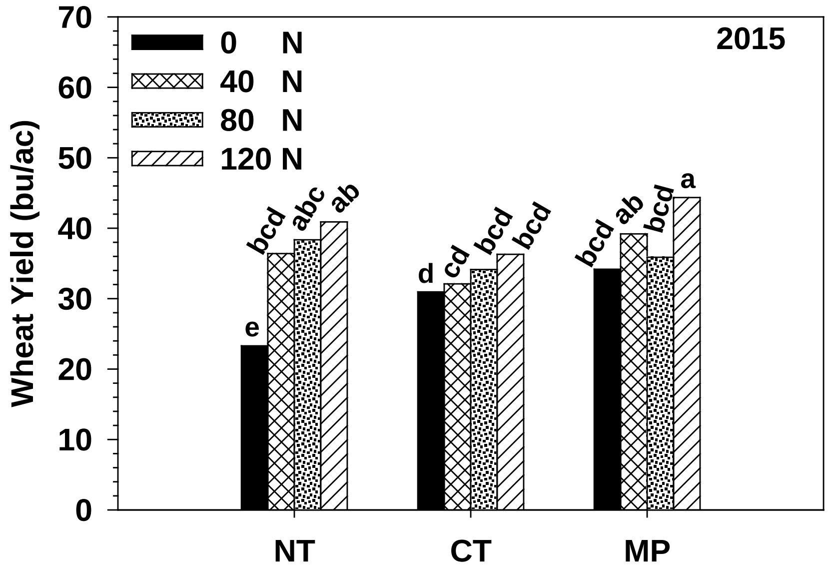


Figure 2. 2015 winter wheat grain yields (bu/ac) at different N rates and tillage treatments

May precipitation in 2015 that positively benefits the yield. Average across N rates, relative yield was influenced tillage treatments where it was significantly higher with NT than CT and MP treatments **(Fig. 4).** The response of wheat yield to tillage practices could be directly related to precipitation in May of 2015 where the crop benefits from the moisture and the NT conserved more moisture when compared with CT and MP practices.

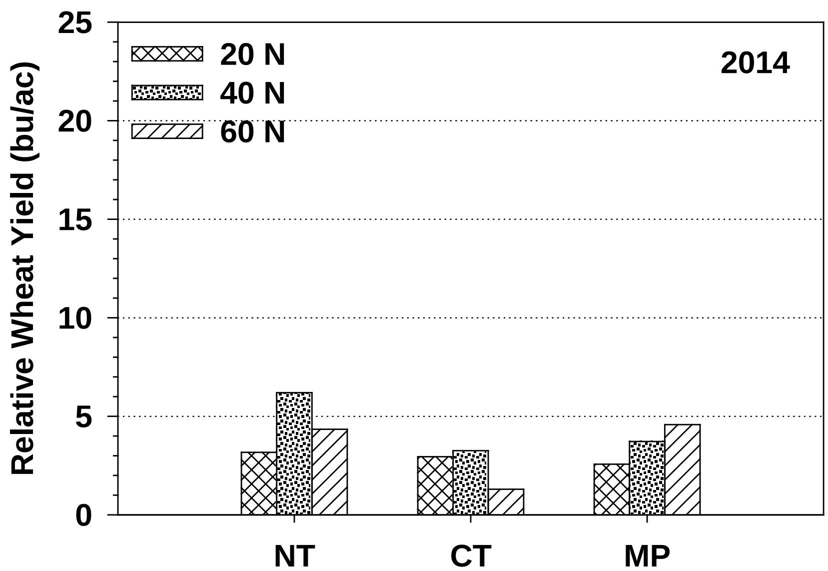


Figure 3. 2014 Relative wheat yield to control (0-N) treatment.

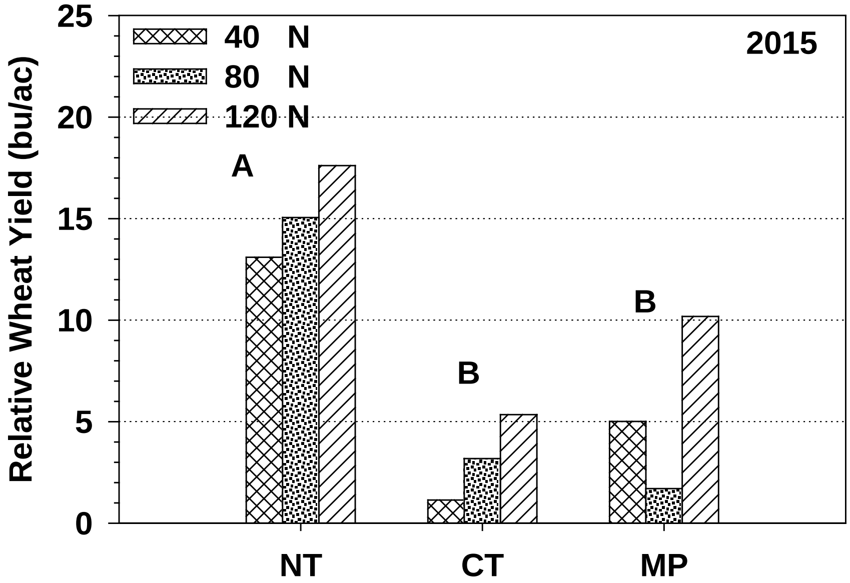


Figure 4. 2015 Relative wheat yield to control (0-N) treatment.

The 2015 soil organic C (SOC) was not influenced by N fertilization or tillage treatments, but it was influenced by depth **(Fig. 5)**. Average across N rates and tillage practices, SOC was significantly higher at the surface 0-12 inches depth when compared with the below surface of 12-24 inches depth. The lack of SOC response to different N rates and tillage practices could be related to low yield associated with low precipitation during the growing season since 2012. In this study site, increasing in SOC is directly related to the crop productivity that could be related to high wheat biomass production, thus influencing SOC level.

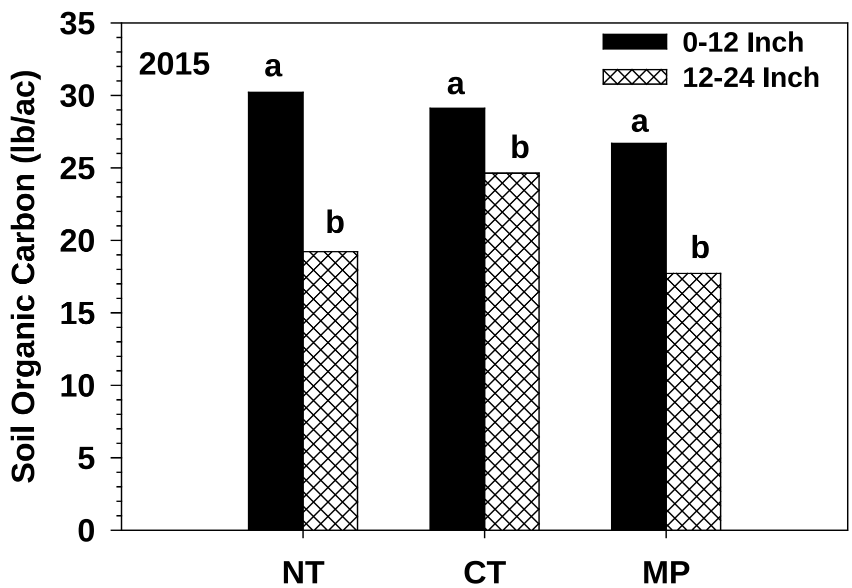


Figure 5. Soil Organic C (SOC) in 2015 soil sampling at 0-12 and 12-24 inches depth.

Conclusions

- After 50 years, wheat grain yield was not influenced by different tillage practices or N rates.
- The amount and timing of the precipitation have a direct impact on wheat yield response to different N rates and tillage practices.
- Relative to control treatment, NT had a tendency (but not significant) for yield increase in 2015, which could be related to long-term NT benefits on conserving soil water when compared with CT and MP practices.
- Soil organic C was influenced by soil depth, but not by tillage treatments or N rates.
- The influence of low precipitation on wheat yield that could suggest low plant biomass production may directly influence SOC accumulation. This is because no other form of organic matter was added except plant roots and crop residue left after harvest.
- At this time it, is difficult to distinguish whether the SOC is directly influenced by 50 years of management practices or by low productivity for the last several years.
- Management influenced on the soil physical and biological properties need to be evaluated in the future.

Impacts of Residue Removal on Irrigated Corn Production
Joel P. Schneekloth, David Nielsen and Francisco Calderon

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: Impacts of residue management had the greatest impact on water infiltration. Maintaining residue in the field increased overall infiltration, steady state infiltration and the time to observe the first runoff. Treatments with residue remaining in the field showed an increase of 0.5 inches infiltrated in 30 minutes over when residue was harvested regardless of tillage management. Maintaining residue in the field also had an increase in steady state infiltration of 0.4 to 0.5 inches $hour^{-1}$ in 2014. In 2015, tillage had a significantly lower steady state infiltration than NT by 0.5 to 0.8 inches $hour^{-1}$.

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 the fall of 2014 and 2015, a Cornell Infiltrometer was used to measure infiltration patterns of the treatments.

Differences were observed in the pattern of measured infiltration by residue management in 2014. Where residue was not removed, infiltration was greater than that of when residue was removed no matter what tillage system was utilized. The major changes in infiltration rates were within the first 300 seconds when water was applied. Positive impacts when residue remained in the field were observed for the 3 major factors of infiltration. The time for measurement of first runoff (Table 1) was doubled when residue remained in the field and was left on the surface or incorporated. When residue was removed, average time to observe runoff was approximately 110 seconds but when residue was not removed the average time to observe runoff was 235 seconds.

The total water infiltrated in 30 minutes was approximately 0.50 inches greater when residue was not harvested (1.36 inches vs 0.81 inches). Intensive precipitation events can better utilized when larger amounts of residue remain on the surface of the soil allowing for reduced irrigation needs. Irrigation system management and design can be minimized by increased infiltration rates which can either reduce energy inputs required for increased pressure for larger wetted diameters to compensate for reduced infiltration rates and runoff potential. With greater infiltration as a result of not harvesting residue, irrigation depths can be increased without the potential of runoff which is important on land with greater slopes.

Differences from 2014 to 2015 occurred in infiltration (Table 2). Time to first runoff was similar to 2014 for all treatments. Total infiltration did increase in 2015 compared to 2014 for all treatments with the greatest increases in treatments where residue was removed. However, total infiltration was still greater for treatments where residue remained in the field. The most dramatic change was in steady state infiltration. In 2014, residue management was the key factor in steady state infiltration. However, in 2015, tillage management was the significant factor with NT having greater steady state infiltration than T treatments. Steady state infiltration was approximately 0.6 to 0.9 inches hour^{-1} greater for NT compared to T.

In 2016, although visual differences occurred, there was no statistical difference between tillage or residue management for total infiltration or steady state infiltration. Variability in reading was much greater in 2016 compared to the 2 previous years. Explanations for this could include the impact of precipitation. Precipitation events after tillage occurred were generally not intense. The highest single hourly precipitation event was less than 0.25" per hr. Also, precipitation was more than adequate that no irrigation was needed prior to full canopy development. Measurement of bulk density at maturity and the time when infiltration was measured showed that all the tilled plots had significantly lower bulk densities compared to the no-till plots.

Table 1. Infiltration parameters for residue and tillage management (2014).

Tillage	Residue Mgt.	Time to first runoff Seconds	Steady State Infiltration in hr^{-1}	Total Infiltration Inches
No-till	Residue	253	1.04	1.36
	No Residue	111	0.61	0.81
Tilled	Residue	217	1.21	1.35
	No Residue	112	0.69	0.81

Table 2. Infiltration parameters for residue and tillage management (2015).

Tillage	Residue Mgt.	Time to first runoff	Steady State Infiltration	Total Infiltration
		Seconds	in hr^{-1}	Inches
No-till	Residue	241	1.69	1.52
	No Residue	114	1.46	1.20
Tilled	Residue	212	0.91	1.91
	No Residue	151	0.91	1.37

Table 3. Infiltration parameters for residue and tillage management (2016).

Tillage	Residue Mgt.	Time to first runoff	Steady State Infiltration	Total Infiltration
		Seconds	in hr^{-1}	Inches
No-till	Residue	105	3.95	2.79
	No Residue	42	2.97	1.47
Tilled	Residue	152	1.92	2.11
	No Residue	85	2.30	2.32

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.

INFRARED SPECTROSCOPY POTENTIAL AS A FAST MEASUREMENT OF SOIL QUALITY IN THE FIELD

Francisco Calderón and Merle Vigil

PROBLEM: Colorado soils vary widely in there ability to support vigorous crop growth. This variability can occur at small areas of the field when erosion results in shallow soil and exposed carbonate-rich sub soils. The growing human population will require that crop yields are maximized throughout the field, even in areas that are currently affected by erosion or low organic material. Among the major row crops grown in the Central Great Plains, Proso millet is particularly sensitive to alkaline soil pH, which is an issue in eroded soils where the top horizon is thin and roots grow into carbonate rich soil layers. Future USDA research in the Central Great Plains will focus on measuring this variability and evaluating new was to achieve uniformly high crop yields and thus maximize productivity and profitability.

Diffuse reflectance infrared spectroscopy (FTIR) can be especially useful to study soil quality issues because it can give a fast estimate of the soil organic matter content as well as it's mineral makeup. Mid infrared spectra are made up of hundreds of absorbance bands, with several peaks for soil parameters such as carbonates, clays, silicates, as well as a variety peaks for different forms of organic matter. Recently, portable infrared spectrometers have become available, opening the possibility for field based measurements which totally bypass laboratory work.

APPROACH: The objectives of this study were: 1) To document field variability in Proso millet health and yield parameters, and 2) To determine if field-based FTIR readings can be used to identify low soil quality in the field and thus explain and remedy areas of poor yields in a Proso millet. We started an experiment in the summer of 2016, in which we studied three 60x70 ft sampling grids within proso millet fields. Three grids were set up in different fields within the CGPRS. Besides a detailed soil total carbon and nitrogen sampling, the grids were sampled for field-based FTIR spectroscopy of the soil surface, canopy cover, NDRE, and NDVI. Proso head counts were used as a yield parameter and were carried out in August 10^{th} 2016.

Figure 1. Photographof Proso millet in plot 49SCD. CGPRS, summer of 2016

RESULTS: The field designated as 49-SCD had observable differences in spatial variability, with areas of poor plant health and chlorosis (Figure 1). The spatial variability was also evident in the normalized difference vegetation index (NDVI) and normalized vegetation red edge (NDRE) measurements.

The NDVI and NDRE are used to estimate how much live green vegetation is present in the field being measured. Red Edge band instead of the Red band. As plants mature, NDVI can plateau and may be less useful for measuring vegetation health. NDRE uses a different spectral region than NDVI and can be a better measure when evaluating plant health near maturity.

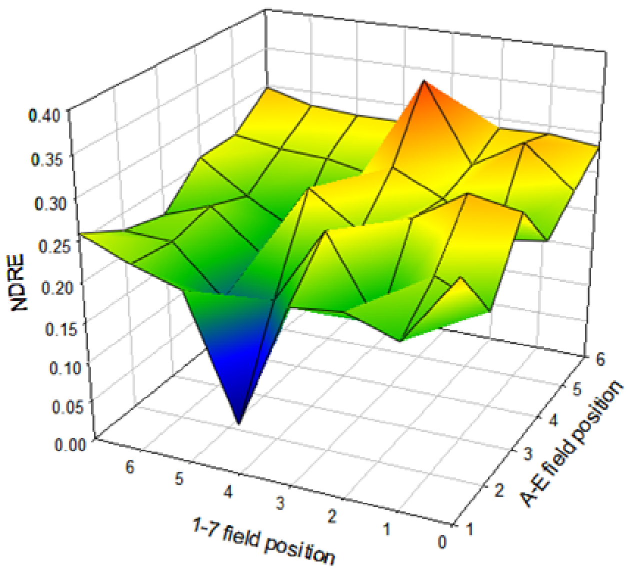


Figure 2. Average NDRE readings from plot 49SCD, summer 2016.

The field-collected FTIR readings while being highly variable, show some absorbance peaks that contain information related to soil quality (Figure 3). The small peak at 2515 cm^{-1} may be relevant to crop performance because it is due to carbonates, which are related to alkaline soil pH. We hypothesize that carbonate signal should be higher in eroded, low productivity soils.

Other relevant ftir bands include the three peaks between 1750 and 1850 cm^{-1}, which are due to silicate (sand) material. Clays are represented by the peak at 3615 cm^{-1}. These bands could be sensitive to soil texture differences in the field. The spectral region that ranges from 1700 to 1260 cm^{-1} is designated as the “organic fingerprint” FTIR region. Within it, there is information about the organic material in the sample. Different organic chemistries that include recalcitrant, labile, and N-containing lignin, proteins, and carbohydrates have unique absorbance bands in this range of the mid infrared. For example, absorbance at 1636 coukld be due in part to amides, and N bearing organic chemica;. Absorbance at 1348 can be assigned to carboxylates, a carbon and oxygen containing chemical form.

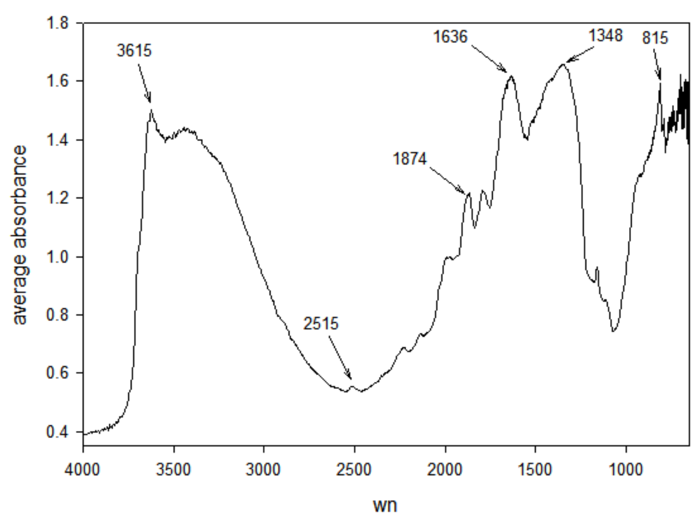


Figure 3. Average mid infrared spectrum of the 3 sampling times from plot 49 scd in 2016.

Infrared spectra are contain a large amount of informtion, so we used principal components analysis to help visualize the differnces between the sampling times (Figure 4). While the field readings were all carried out when the soil surfaces were relatively dry, we expected some differences in the moisture conditions. This is important, because water absorbs highly in the mid infrared, which may cause sampling time variations that may lead to biased comparisons with the crop growth measurements. Fortunately, the multivatiate analysis shows that the three sampling times had relatively similar spectral variation. The analysis did show that there are large differences in spectral properties between fields, which is expected due to differences in soil type and texture (not shown). A correlation analysis between NDRE and the filed collected FTIR data indicates that spectral data relates to crop performance, albeit weakly (Figure 5). The FTIR data had spectral bands that were correlated as well as anti-correlated with NDRE. There was positive correlation at two roganic regions: 1) 1420-1290 cm^{-1}, where C-O groups absorb, and 2) at 1534 cm^{-1}, where aromatic C=C absorbs. The strongest anticorrelation occurred at 2515 cm^{-1}, where carbonates absorb. This confirms our hypothesis that FTIR is sensitive to the presence of shallow soils of low productivity. The technique thus show potential to detect eroded or shallow soils with pH issues. The relatively low correlation coefficients care not surprising given that other aspects of soil quality are likely tohave a strong imapcto on millet performance, such asdifferences in surface sealing, residue cover, water infiltration, and moisture retention.

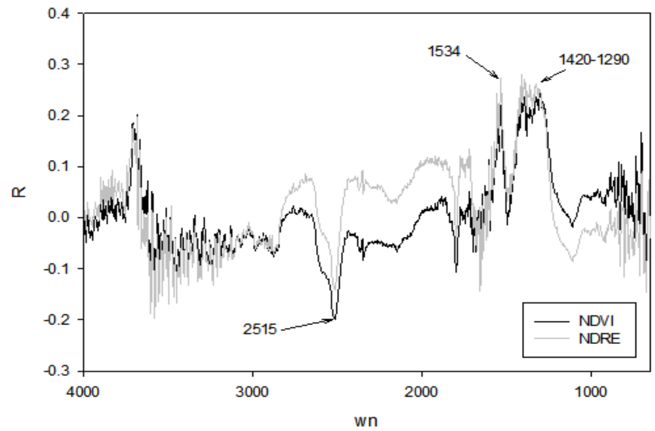


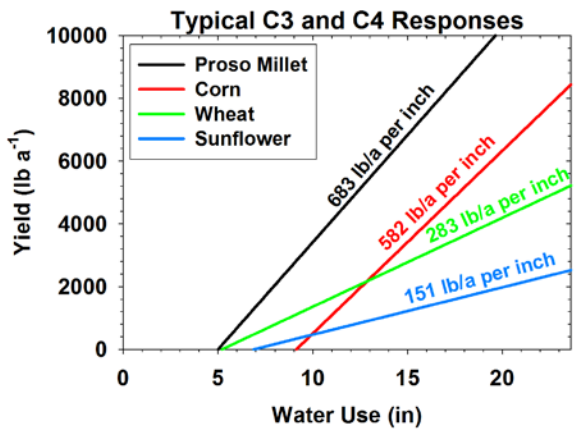
Figure 5. Correlation coefficient between the handeld FTIR spectral bands and the NDVI and NDRE data.

FUTURE PLANS: Soil CHN data is still being analyzed, so one of the forthcoming parts of the study will determine whether FTIR bands are useful in predicting NDVI and total soil C with the filed collected data. this might then become a useful tool in future effors to documentand remedy field veriability in crop yields.

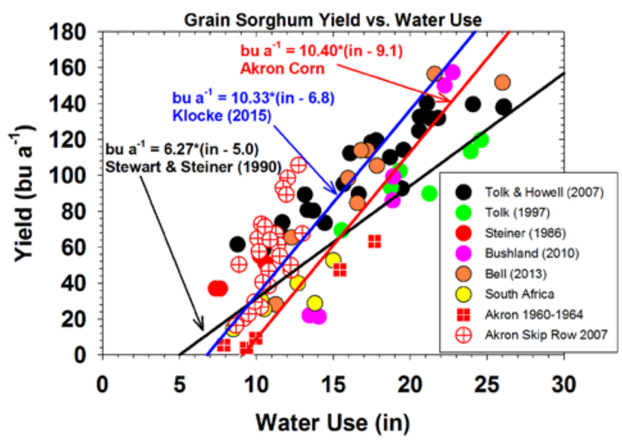
A Water Use/Yield Production Function for Grain Sorghum

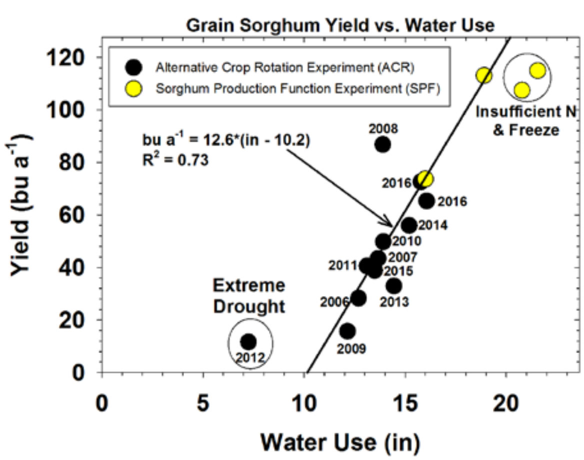
David C. Nielsen, Merle F. Vigil

Grain yield in water-limited environments typically responds linearly to increasing water use when other factors are not limiting. The slope of the linear relationship is primarily influenced by the photosynthetic pathway. C4 plants like corn and millet are more efficient users of water to produce grain than C3 plants such as wheat and sunflower. Additionally, oil is more "photosynthetically expensive" to produce than starch. Hence, sunflower has a very low water use/yield production function slope while proso millet and corn have very large slopes. Atmospheric demand for water can also affect the slope, with hot, dry environments producing production functions with lower slope than cooler, wetter environments.



Grain sorghum is a drought tolerant C4 species capable of making use of limited available water supplies and is suitable for dryland crop rotations in the central Great Plains. In order for farmers to assess the production risk encountered when utilizing sorghum in rotations, a water use-yield production function would be useful. Previously published production functions vary widely in reported slope of the relationship between water use and grain yield, with many of those slopes being much less than expected for a C4 species. A great deal of water use and yield data have been published from studies conducted in Bushland, TX and many of the production functions generated from that data have slopes much less than would be expected for a C4 species grown at Akron, CO. However, there are a couple of short-term studies from Bushland reporting much greater slopes for the grain sorghum production function [see Bushland (2010) and Bell (2013) in the above figure. One year of grain sorghum data (2007) collected at Akron showed a much steeper slope, similar to what would be expected for a C4 species. These data are in contrast to some historical data from Akron from 1960 to 1964 which defined a grain sorghum production function slope more similar to a C3 response.

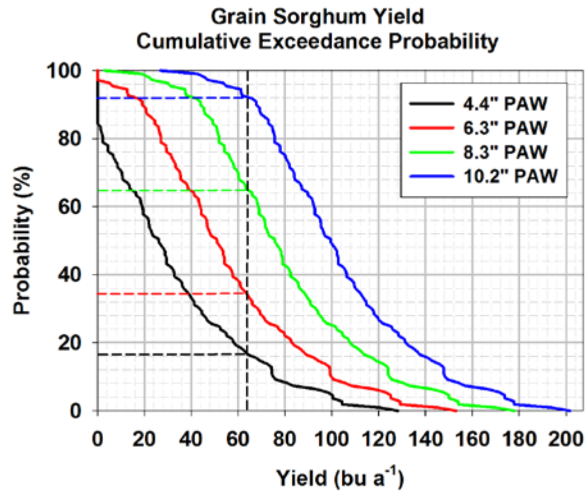




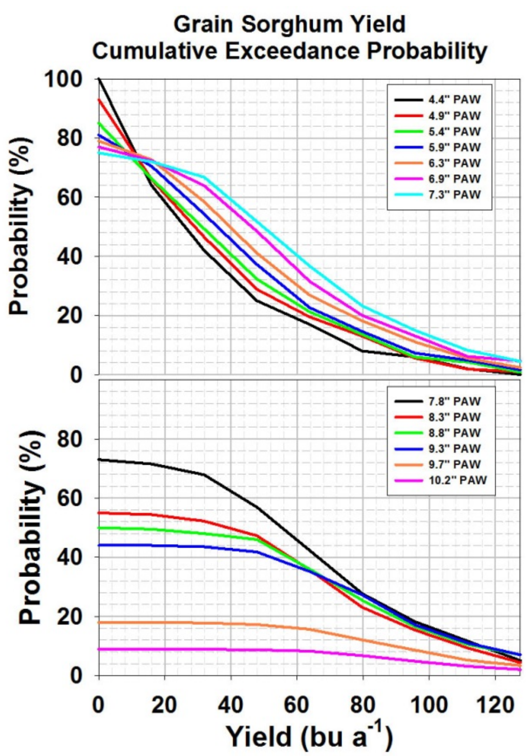
Sorghum water use and yield data were collected from 2006 to 2016 at Akron, CO as part of the long-term Alternative Crop Rotation Experiment and from 2016 in the Sorghum Production Function Experiment which used graded amounts of irrigation. A production function was determined by linear regression to be

$$\textbf{yield [bu/a]} = \textbf{12.6} \times \textbf{(water use [in]} - \textbf{10.2)}$$

This function can be interpreted to mean that 10.2 inches of water use must occur before grain sorghum yield can begin to occur. After that point, grain yield increases 12.6 bu/a for every inch of water use that occurs. The slope of this function is what we would expect for a C4 species at Akron, CO.



Using this production function with the historical precipitation record, we would expect a grain yield of at least 64 bu/a to occur 16% of the time if plant available soil water at planting was 4.4 inches and 92% of the time if 10.2 inches was available. The lines shown in the figure to the right are strictly applicable only to Akron, CO. Similar figures could be constructed from long-term precipitation records at other locations. The lines are valid for calculating yield probability if the amount of plant available water at planting is known.



If that quantity is not known, then the probabilities shown in the figure above must be multiplied by the probability of having a given amount of soil water at planting. That will be a difficult value for most farmers to obtain since it depends on having a long-term record of soil water content at planting at a given location in a given crop rotation. Such a record does exist at Akron for grain sorghum grown in a wheat-sorghum-fallow rotation and was used to produce the graphs to the left.

Using these two graphs we see that the probability of producing at least a 64 bu/a grain sorghum yield ranges between 8% with 10.2 inches of available water at planting (very low because the probability of having 10.2 inches of soil water at planting is so low) to 42% with 7.8 inches of available water at planting.

Since it is so unlikely that farmers would have the data to construct a probability exceedance graph for available soil water at planting at their location, it is much more likely that farmers would get a measurement of available soil water at planting by soil sampling (or estimate it from precipitation records) and use it with the figure above to assess their crop production risk.

Winter Annual Forage Variety Trial

M.F. Vigil, D.J. Poss

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: Calls were made to seed dealers in the area who sold triticale seed. Only three triticale varieties and one forage wheat variety was found from contacted dealers ranging from Greeley, CO to Burlington, CO. A call was also made to University of Nebraska's breeding program, which provided ten varieties from their program. Some of these varieties have been in production for over fifteen years, while others have not been released yet.

A trial was established in fall 2015 containing fourteen varieties and four replicates in a randomized complete block design. The seeding rate was 60 lbs seed per acre. Urea fertilizer was applied prior to planting also at 60 lbs per ac. The study was planted with a cone drill with plots measuring six feet wide by 30 feet long.

Due to planter issues resulting in blank rows, the plots were hand harvested from one row (7 ½" spacing), one meter long from rows that did not have a blank row adjacent to them. The triticale was clipped leaving six inches of stubble, dried in an oven, then weighed. The primary harvest was on 10 June when most of the plants were at early anthesis. Since a few varieties were significantly later maturity at this date a second harvest was conducted on 16 June of the later maturing varieties along with a few earlier maturing varieties.

Forage samples were sent in for analysis to determine the quality of the hay between varieties and with respect to date on selected varieties

RESULTS: Planting conditions were very poor in fall 2015 with very low levels of surface soil water. The planting of the trial was delayed until after a precipitation event in later October to ensure more uniform emergence. Emergence in the fall was good, but due to the late planting date growth prior to dormancy was minimal. Fortunately, precipitation amounts were 55% above average for the period from November 2015 through June 2016. The timing of the precipitation was nearly ideal with the months March through May being 53% above average. Due to the amount and timing of precipitation forage yields were outstanding in 2016.

The first harvest was conducted on 10 June of all varieties and the maturity of the varieties varied greatly on this date from early boot to early anthesis (Table 1). Yields also varied greatly from 4,783 lb/ac to 9,094 lb/ac. The yields were related to maturity with all eight varieties, which were at anthesis having yields within 1,000 lbs of each other.

Due to some of the varieties being later maturing a second sample was taken six days later of the later maturing and some selected earlier maturing varieties (Table 2). Weather conditions must have been near ideal for triticale growth during this time period since the increase in yield for a six-day period was phenomenal. There was one precipitation event on 13 June of 0.96 inches. Temperatures were good averaging 87.8 deg. F for the high and 56.2 deg. F for the low during this time period. For all seven varieties sampled on both dates there was an increase of

Table 1. Winter Annual Forage Variety Trial at Central Great Plains Research Station at Akron, CO on 10 June 2016.

Variety	Growth Stage	Yield		Protein		RFQ**	
		lb/ac		%			
NT11406	Early anthesis	9,094	ab*	13.4	bcd	133.0	bcde
NT11428	Early anthesis	8,879	ab	12.3	cde	132.3	dce
NT05421	Early anthesis	8,706	ab	11.9	de	126.3	ef
NT01451	Early anthesis	8,698	ab	13.7	bc	141.8	ab
Syngenta 718	Early anthesis	8,405	abc	11.8	de	120.5	f
NT07403	Early anthesis	8,208	abc	11.7	de	127.8	def
NT094231	Early anthesis	8,075	abc	13.3	bcd	137.5	bcd
NT06422	Early anthesis	8,071	abc	11.7	de	124.5	ef
NE422T	1/2 Inflorescence emerged	7,408	bc	11.5	de	131.0	dce
Pika	3/4 Inflorescence emerged	7,047	bc	12.5	cde	133.5	bcde
NE426GT	Early anthesis	6,993	bc	14.0	bc	142.0	ab
NE441T	Inflorescence emerged	6,587	bc	12.0	de	129.8	dce
Presto	Early anthesis	6,392	bc	13.2	bcd	138.5	bc
Willow Creek Wheat	Early boot	4,783	c	17.7	a	148.3	a
MEAN		7,667	bu/ac	12.9	%	133.3	

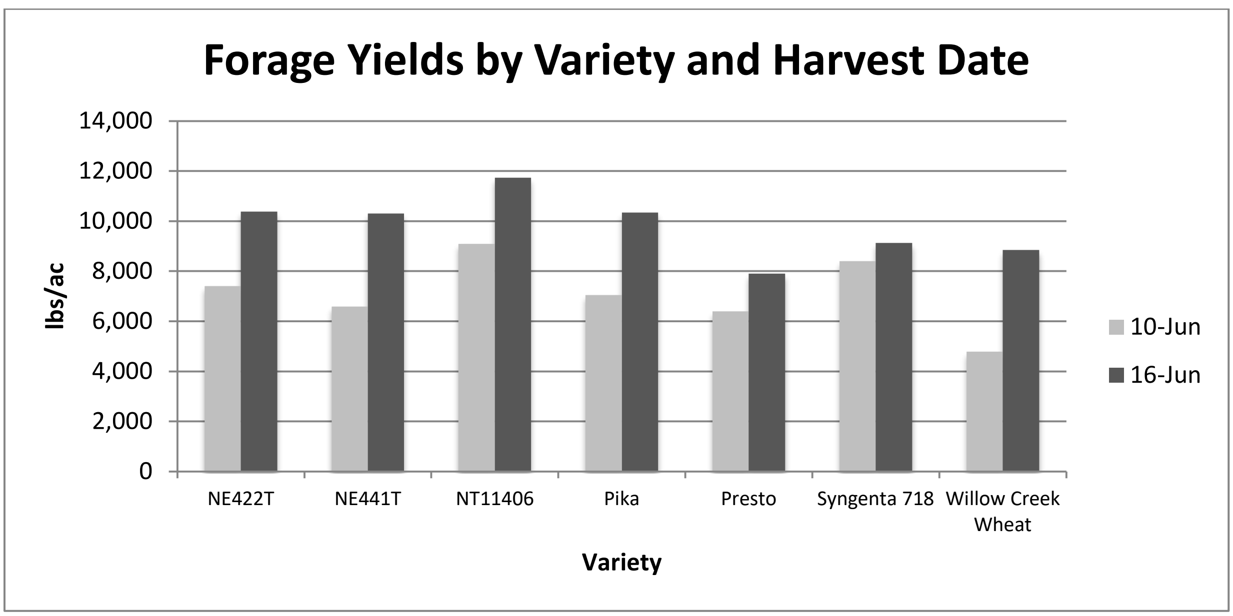
*Means followed by the same letter are not statistically different at the 0.10 alpha level using SNK mean separation.

**RFQ = Relative Feed Quality

2,700 lbs/ac from 7,100 lbs to 9,800 lb per acre. If one separates out the varieties that had not reached anthesis by the first sampling date of 10 June there was an even larger increase in yield. The average increase in yield for those four varieties was 3,500 lbs/ac over this six-day period.

All samples were analyzed for forage quality and for this paper we will report protein and Relative Forage Quality. Protein levels were good which averaged 12.9% for the 10 June harvest date. The Willow Creek wheat protein levels were significantly higher than any of the triticale protein, however its maturity also lagged way behind. At the second sampling date the Willow Creek wheat's protein level had fallen off as it matured, but was still 14.5%, which is quite remarkable since its yield on that date was nearly 9,000 lbs/ac. This forage wheat variety had finer leaves and a much finer stem than any of the triticale varieties.

Table 2. Winter Annual Forage Variety Trial at the Central Great Plains Research Station at Akron, CO in 2016.					
Variety	Sample Date	Growth Stage	Yield	Protein	RFQ*
			lb/ac	%	
NE422T	10-Jun	1/2 Inflorescence emerged	7,408	11.5	131.0
NE422T	16-Jun	Early anthesis	10,376	11.2	111.7
NE441T	10-Jun	Inflorescence emerged	6,587	12.0	129.8
NE441T	16-Jun	mid anthesis	10,308	9.6	107.8
NT11406	10-Jun	Early anthesis	9,094	13.4	133.0
NT11406	16-Jun	Anthesis complete	11,730	11.8	132.0
Pika	10-Jun	3/4 Inflorescence emerged	7,047	12.5	133.5
Pika	16-Jun	Early anthesis	10,337	9.7	102.8
Presto	10-Jun	Early anthesis	6,392	13.2	138.5
Presto	16-Jun	Anthesis complete	7,904	11.0	133.0
Syngenta 718	10-Jun	Early anthesis	8,405	11.8	120.5
Syngenta 718	16-Jun	Anthesis complete	9,134	10.0	113.0
Willow Creek Wheat	10-Jun	Early boot	4,783	17.7	148.3
Willow Creek Wheat	16-Jun	Flag leaf sheath opening	8,848	14.5	136.8
*RFQ = Relative Feed Quality					



FUTURE PLANS: This trial with six additional entries consisting of winter forage rye was planted in fall 2016. The plots were fifteen feet wide instead of six feet to allow for three harvests for all varieties including two forage harvest dates and one grain harvest. We hope to have analysis on all varieties from both harvest dates to get a good estimate on forage quality with respect to crop development stage.