2016 FIELD DAY

tour #1

2016 ANNUAL FIELD DAY

wednesday, june 15, 2016

registration begins at 8:30 am in building 18
with coffee and donuts

INTRODUTORY TALKS

8:55 9:00	Dr. Merle Vigil WELCOME TO THE CENTRAL GREAT PLAINS RESEARCH STATION'S 2016 FIELD DAY
9:00 9:15	Dr. Frank Peairs, CSU WHEAT STEM SAWFLY AND OTHER PESTS OF WHEAT
9:15 9:30	Dr. Peter Baas THE NEXT GENERATION OF BIOSTIMULANTS TO IMPROVE CROP YIELD AND HEALTH
9:30 9:55	Dr. Merle Vigil TWENTY FIVE YEARS OF ALTERNATIVE CROP ROTATION RESEARCH IN 25 MINUTES
9:55 10:55	Dr. Scott Haley and Dr. Jerry Johnson THE 2016 WHEAT VARIETY FIELD DAY AT AKRON

TOUR ONE

11:00 11:15	Snack *in Seed House*
11:25 11:40	Dr. Maysoon Mikha *at the organic plots, south of the ACR* SOIL CARBON AND NITROGEN INFLUENCED BY COMPOST AMENDMENT
11:45 12:00	Dr. Joseph Benjamin *at the organic plots, south of the ACR* COMPOST USE IN DRYLAND ORGANIC WHEAT PRODUCTION: EFFECTS ON SELECTED PHYSICAL AND CHEMICAL PROPERTIES
12:05 12:20	Dr. Joel Schneekloth IMPACT OF RESIDUE AND TILLAGE MANAGEMENT ON SOIL WATER INTAKE–YR. 2
12:25 12:40	Dr. Francisco Calderon *at the LTT Plots, south of the weather station* LONG-TERM TILLAGE EFFECTS ON SOIL CARBON CHEMISTRY AT AKRON, COLORADO
12:45 1:00	Dr. David Nielsen *at the ACR plots* ARE FLEXIBLE CROPPING SYSTEMS WITH FORAGES BETTER ADAPTED TO VARIABLE CLIMATE THAN FIXED GRAIN-BASED ROTATIONS
1:10	Lunch *in Building #18*

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WHEAT YEAR PRECIPITATION / TEMPERATURE ANALYSIS
2016 CROP

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

Central Great Plains Research Station
Akron, Colorado

Data through May 27, 2016

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 2016.**

Summary of Fallow Period 14-month
(J.A.S.O.N.D.J.F.M.A.M. J.J.A) = 14-months
July 2014 -- Aug 2015

Month	Year	Fallow Precip in	107-year Average Precip	Departure
Jul	2014	2.28	2.621	-0.34
Aug	2014	4.94	2.163	2.78
Sep	2014	3.48	1.293	2.19
Oct	2014	0.23	0.918	-0.69
Nov	2014	0.29	0.536	-0.25
Dec	2014	0.68	0.422	0.26
Jan	2015	0.33	0.330	0.00
Feb	2015	0.39	0.354	0.04
Mar	2015	0.36	0.833	-0.47
Apr	2015	1.67	1.638	0.03
May	2015	5.41	2.919	2.49
Jun	2015	2.42	2.438	-0.02
Jul	2015	2.34	2.620	-0.28
Aug	2015	2.74	2.175	0.56
Total		**27.56**	**21.260**	**6.30**
	total months=		14	

Growing Period Precip
10-Month Sep-June

Month	Year	Sep2015-Jun 2016 Precip	107-yr Ave Precip	Departure	Days of Snow Cover	Snow Depth in.
Sep	2015	0.17	1.29	-1.12	0	0.0
Oct	2015	0.94	0.90	0.04	0	0.0
Nov	2015	1.36	0.53	0.83	13	11.0
Dec	2015	0.55	0.43	0.12	19	10.0
Jan	2016	0.11	0.33	-0.22	17	2.0
Feb	2016	1.45	0.35	1.10	13	11.5
Mar	2016	1.45	0.82	0.63	5	10.8
Apr	2016	2.77	1.66	1.11	1	11.0
May	2016	3.98	2.94	1.04	3	3.0
Jun	2016		2.43	-2.43	0	0.0
Total		**12.78** inches	**11.68**	**1.10**	71	59.3
		total months =	10			

27-May-2016 <Last Update

FALLOW PERIOD SUMMARY:

The July '14 - Aug. '15 fallow period precipitation was **27.56 inches**, which ranks as the **8th wettest** fallow period in the 107-year record for the 1908-09 through 2014-15 records. This is **6.30 inches** above the average of 21.26 inches. The fallow period began with good summer rainfall in July, August, and September. The fall and winter months were very dry. Very dry, open weather conditions prevailed until April, when rainfall increased. May brought heavy rain, and rainfall through the summer months of 2015 were near or above average. With the good summer rainfall, the fallow period set up well, and prospects for good fall planting conditions prevailed.

GROWING SEASON SUMMARY Sep '15-Jun '16: The *GROWING SEASON* precipitation for the **2016** crop (through MAY 27, 2016) has been **12.78 in.** which is **1.10 inches ABOVE the average of 11.68** inches. The *GROWING SEASON* precipitation for the current crop ranks as the **33rd wettest** on record or the **75th driest** and this **does not include the remaining days in May or the *full* month of June**, which could increase this amount. Fall rain was very low, but winter precipitation has been substantial. Good snowfall through winter also kept wheat in good condition. May rain has been above average (through the 27th), and rains seem to be steady so shortage is not anticipated. Hail appears to be the greatest danger for the wheat crop, since moisture supply looks promising through the June ripening period.

SNOWFALL - WINTER 2015-16 Winter snowfall has been substantial through the first of May. Fall snowfall was heavy with a total of 21 inches. Snow cover days were also substantial with 13 days in November, 19 days in December, and carry-over snow cover of 17 days in January. A big 11-inch snow in early Feb., provided good moisture and snow cover. Other big snows occurred on March 18-24, April 16-18, and April 30 - May 1. The overall snowfall was substantially above average with 59.3 inches of snowfall and amounting to 8.1 inches of precipitation. Five winter months had snow depths of 10 inches or more. Snow cover days have amounted to 71 days of cover.

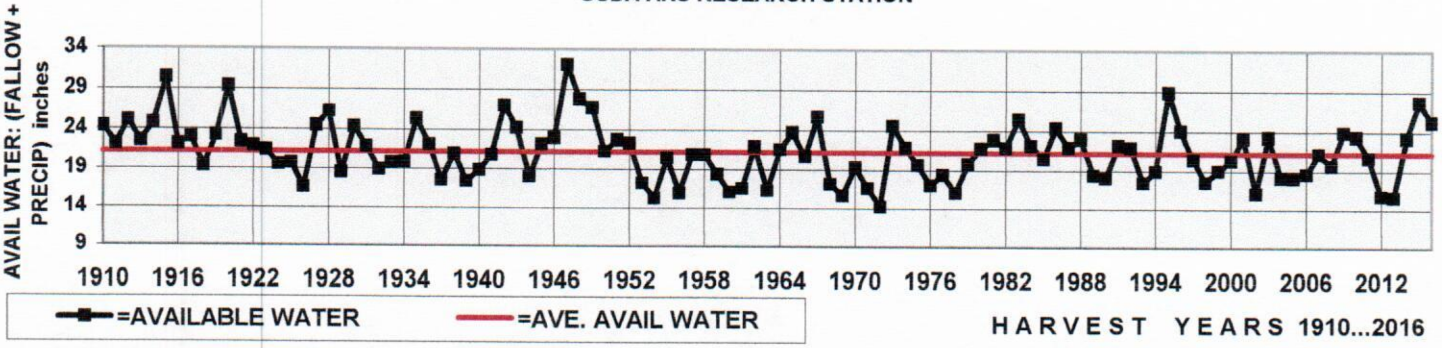
TEMPERATURES Sep.15-Jun16: September and October were very warm months, with a new record high average mean for the month set in Sept. The warm winter continued into spring with Jan. through April being much warmer than average. Only Dec. and April were somewhat cooler, but still had average monthly mean temperatures that were above the long-term averages. Freezes occurred on the last days of April and also on May 2nd. May has been cooler than average. Overall, the growing period has been very warm and mild. The Sept.- May average of **44.76 deg F** ranks as the **4th warmest** in the 105-year record, and continues a trend in recent years of warm winter and spring months.

AVAILABLE WATER SUPPLY:

At a fallow storage efficiency of **25%**, the available water supply for the **2016-crop, *so far***, would be **19.67 inches**, which is well above the average of **16.97 inches**. At a fallow storage efficiency of **45%**, the available water supply would be **25.18** inches, which is well above the average of **21.23 inches, not including the remainder of June**. The current wheat crop condition reflects the high fallow period precipitation, as well as the substantial growing period precipitation. At **25%** storage efficiency the seasonal available water would be **65%** from growing season precipitation, and at **45%** storage efficiency growing season precipitation would be at **50.8%** of total available. Even with a hot or dry June or pre-harvest period, it appears that the current crop will have adequate moisture to see things through to harvest. Even at **25%** storage, the 19.67 inches of water available should provide a very good yield. Weather patterns into June appear to be showing moderate temperatures with above normal precipitation, so the crop should be in excellent shape come harvest.

Fallow storage efficiency is usually a key to the success of the crop. With the near record fallow period and the substantial winter-spring growing period precipitation this has been somewhat masked for the 2016 crop. The range of **19.67 inches at 25% efficiency** to **25.18 inches at 45% efficiency** would appear to be adequate for a good crop.

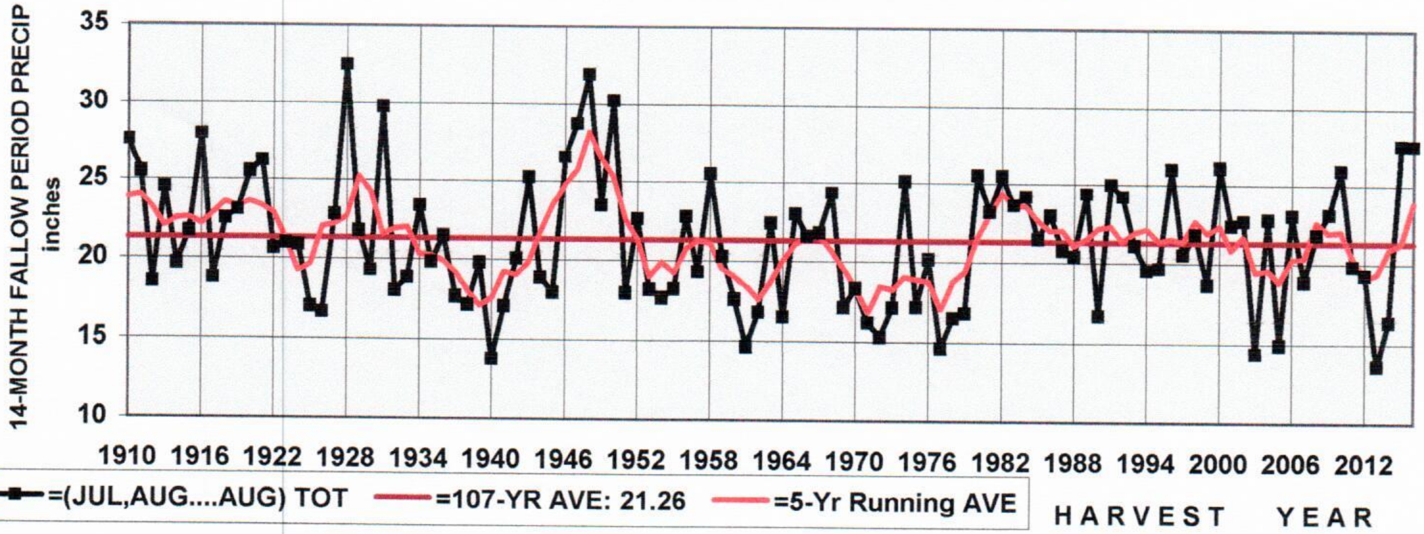
WHEAT AVAILABLE WATER SUPPLY: @ 45% EFF
USDA-ARS RESEARCH STATION



FLDDAY2016, in file "FLDDAY2016" printed: 5/31/2016

Graph, AVAIL45%

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



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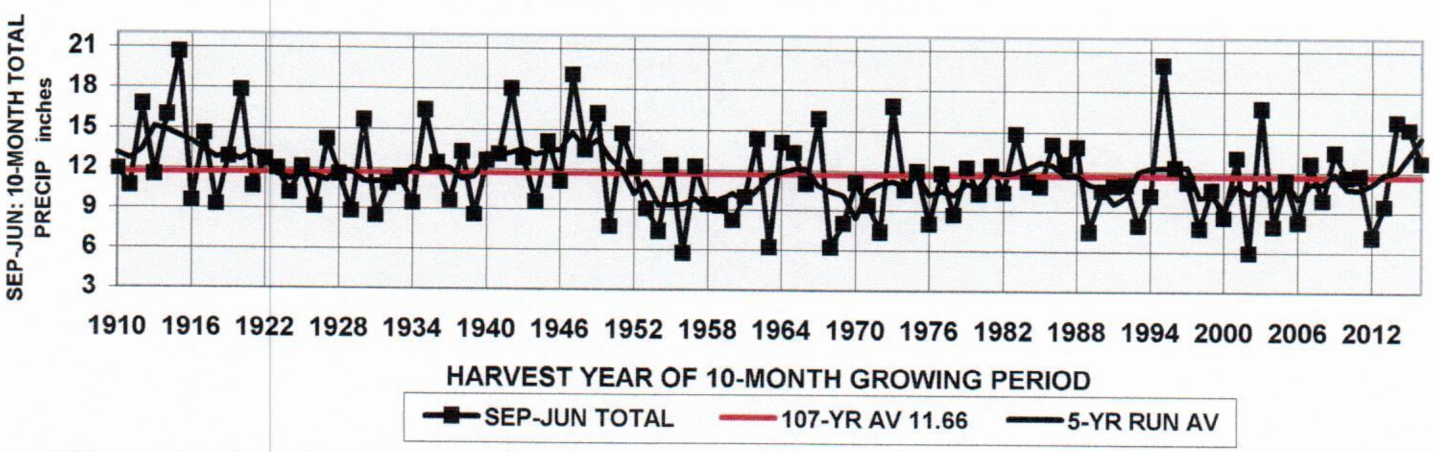
WHEAT: GROWING PERIOD (SEP-JUN) PRECIP
USDA-ARS RESEARCH STATION AKRON, COLO.



2016 updated through : MAY 27, 2016

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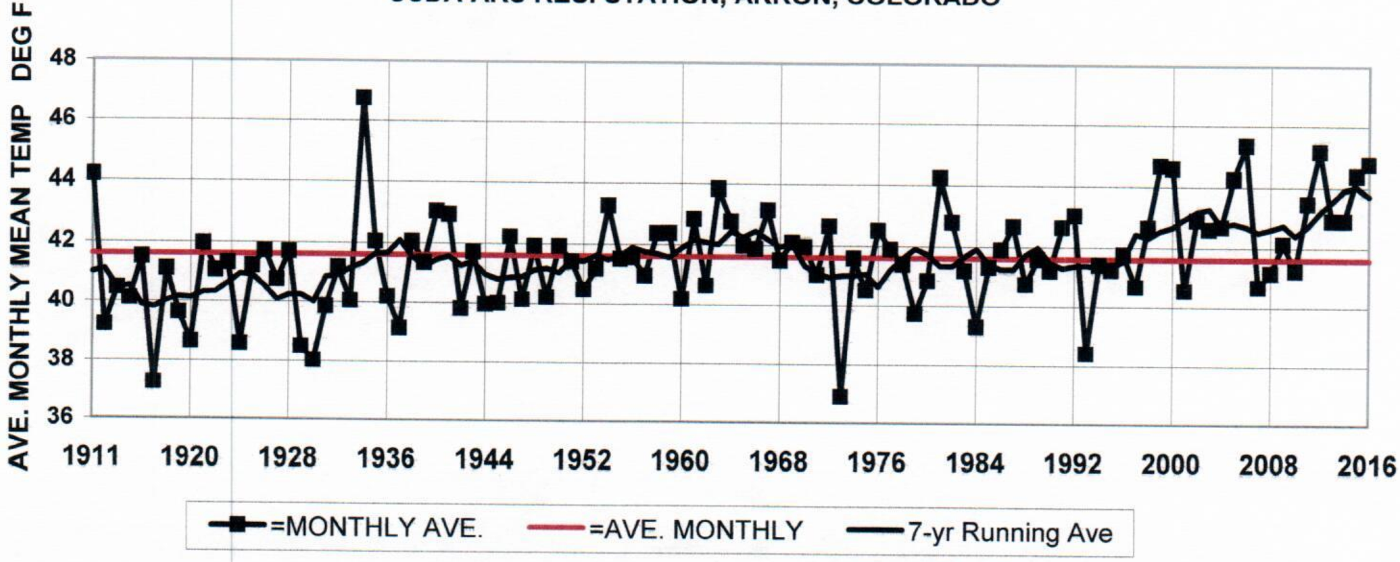
SEPT-MAY   AVE. MEAN TEMP.
USDA-ARS RES. STATION, AKRON, COLORADO



"Graph" in "SEPMAYT"   printed: 5/31/2016

Arthropod Pests of Colorado Winter Wheat

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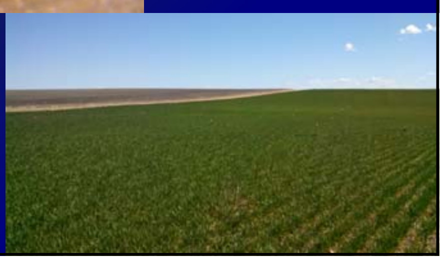
Sipha maydis – Research Needs

- Threat assessment
  - Yield effects
  - Potential distribution
- Initial resistance screening



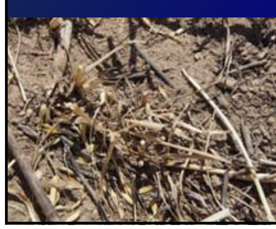
Wheat Stem Sawfly

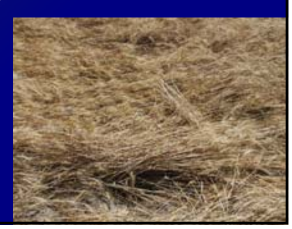
Use spring abundance to inform fall management decisions:

- Solid stem varieties
- Thimet
- Trap crops

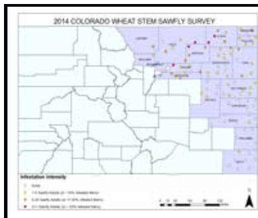
Trap Capture vs Yield Loss

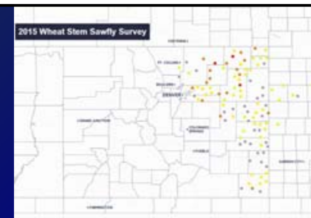
Trap captures relate well to infested stems and yield per stem – boring and cutting average 25% loss in attainable yield

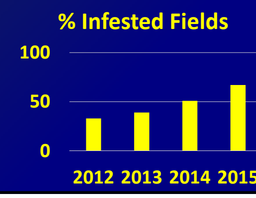




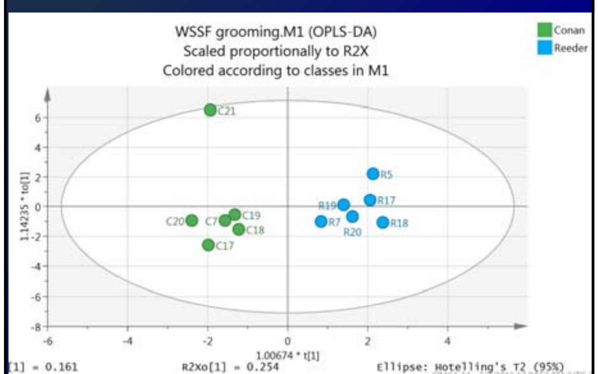
Also need relationships with residue losses, weed problems – regional differences?







Wheat stem sawfly: Plant Resistance



Favored by cool, wet springs that delay crop development

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

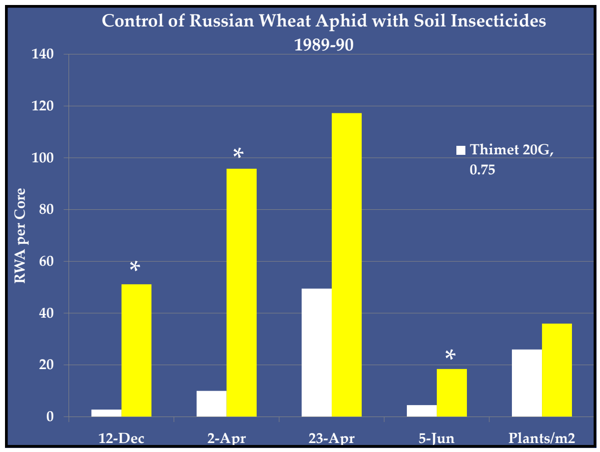
Cultural controls

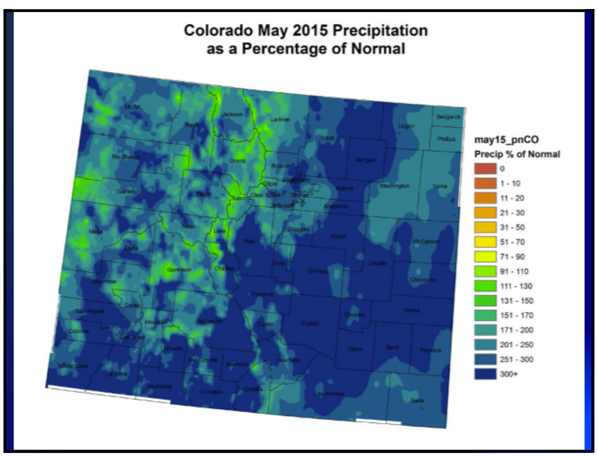
Cultural control observations from Canada

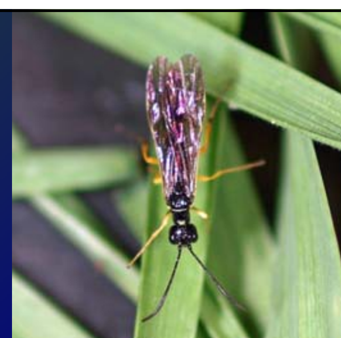
- Less cutting at lower seeding rates (solid stem varieties)
- Lower N, less cutting
- More parasitoids under no-till
- More parasitoids with increased cutting height

Chemical control: Thimet

Treatment	% Infested Stems	% Lodged Stems
Thimet 20G	8.5	2.9
Warrior II, applied twice	96.0	35.2
Untreated	97.5	29.8







Questions?

Long Term Alternative Crop Rotation Experiment: A brief Summary
USDA-ARS Akron, Colorado

M. F. Vigil D. C Nielsen, Francisco Calderon, Maysoon Mikha, Joe Benjamin, Rudy Bowman, Randy Anderson, Brien Henry, Ardell Halvorson, Rob Aiken and Steve Hinkle.

Introduction

In 1990, the long term alternative crop rotation experiment (ACR) was established at the USDA-ARS Central Great Plains Research Station at Akron Colorado. The goal of the ACR experiment was to identify crop rotations other than winter wheat (*Triticum aestivum* L.) -fallow (WF) that are viable rotations for the dryland farmers in the Central Great Plains Region. Utilizing no-till technology and more intensive cropping, over the last 25 years we have demonstrated and evaluated several alternative rotations to WF. Depending on the year and prices some have been superior to standard conventional till wheat fallow and some have been inferior to WF. Our objective here, is to summarize some of the knowledge gained from this 26 year experiment.

Materials and Methods

The field experiment is set up with several fixed crop rotations in a randomized complete block design with three replications. Each phase of each rotation appears each year in a separate plot. For example, for the Wheat-Corn-Millet-Fallow rotation we have three plots in wheat, three in corn after wheat, three in millet after corn, and three in fallow after last year's millet (12 plots total). The rotations that have been studied are listed in (Table 1).

Table1. Rotations studied in the ACR experiment. Rotations in red were discontinued because they showed less success than the others studied. Those in Green have been added recently to evaluate forages in the ACR. Also included in the design are 3 grass plots and 3 sweetclover plots.

Two year rotations	Three year rotations	Four year rotations
Wheat Fallow no-till (WF-nt)	Wheat-Corn-fallow (WCF) both skip-row and standard planting	Wheat-Corn-Millet-Fallow (WCMF)
Wheat Fallow reduce till (WF-rt)	Wheat-Millet-fallow (WMF)	Wheat-Corn-Safflower-Fallow (WCSfF)
Wheat Fallow conventional till (WF-ct)	Wheat-Sorghum-fallow (WSgF) both skip-row and standard planting	Wheat-Millet-Safflower-Fallow (WMSfF)
Wheat millet (WM)	Wheat-Sunflower/Safflower-Fallow (WSfF)	Wheat-Corn-Millet-Forage Pea (WCMFrP)
Wheat Grain Crop (WGc)	Wheat-Corn-Millet (WCM)	Wheat-Corn-Millet-Pea (WCMP)
	Wheat-Corn-Pea (WCP)	Wheat-Safflower-Millet-Pea (WSfMP)
	Forage Millet-Forage Triticale-Corn*	Wheat-Wheat-Corn-Millet
	Forage Millet-Forage Triticale-Forage Sorghum	Wheat-Wheat-ForageMillet-ForagePea (WWFrMFrP)
	Wheat-Forage Sorghum-Flex	
	Wheat-Flex1-Flex2	

Some rotations include summer fallow and some are continuously cropped without summer fallow. All rotations are being compared for effects on soil quality, yield, and economic returns. Here we focus on the economic returns to land labor and capital of 7 alternative rotation sequences (established in 1991) is compared up through 2013. Also, we report some of the effects of rotation intensity on changes in soil organic matter, soil aggregate stability. We also document our thoughts on how far we can push the system to eliminate fallow. Grain yields were measured in each rotation over a 17-year period starting 4 years after rotation establishment (1994-2013). Whereas most of the rotations have been managed using no-till we have included a conventional sweep-tillage Wheat Fallow treatment for comparison. Preliminary analysis indicated the most favorable sequences were no-till wheat-millet (*Panicum miliacium* L.)-fallow (WMF) wheat-corn (*Zea mays* L.)-millet-fallow (WCMF) and wheat-millet (WM). The poorest performance was measured with WF conventional till and WCM no-till. With respect to soil quality enhancement the best rotations were the continuously cropped WCM followed by WCMF and WCF and the poorest was with the WF conventional till rotation.

Results and Discussion

Much information has been gleaned from this experiment. We have found that with greater rotation intensity, moving away from WF to 2 crops in three years and three crop in 4 years and with continuous cropping, that soil quality has improved with greater rotation intensity and with rotation length. The improvements are documented as increases in aggregate stability, increases in glomalin content (the microbial exudate that acts as a glue to holds soil particles together), increases in particulate soil organic matter (POM), increases in soil organic matter (SOM), greater total N and a decrease in soil pH. All of these changes are documented to occur only in the surface soil. Specifically the top 4 to 6 inches of soil. Most of these effects took over 7 years to be statistically significant.

The rotations significantly affected winter wheat yields, but the crop yields of the summer crops tested (corn, millet sorghum) were generally not statistically affected by rotation sequence unless continuously cropped. Wheat yields were decreased by the absence of fallow. They also decreased if in rotation with crops that were effective in depleting stored soil water reserves like sunflowers or safflowers. We measured significant decrease in wheat yields even after summer fallow when in rotation with sunflower or safflower.

Greater rotation intensity increased net returns to land labor and capital in a long term economic analysis. This was especially true when forages were included as a rotation crop in recent years. The best rotations were WCMF WMF WM and WCF. Rotations that showed poor returns were WCM and WF- CT. Less fallow was good yet several of our best rotations had fallow as part of the rotation.

ACR corn yields are significantly lower (11 to 18 bushels lower) than all of the other dryland corn yields measured in other experiments on the station. Suggesting that in general the experiment may not be the best tool to evaluate rotations with corn in them. That aside the experiment has been a tremendous resource for agronomic experimentation of the science in developing our ideas about sustainable dryland cropping systems.

Publication summary

So far the study has generated enough science for the publication of 107 manuscripts: 53 as refereed journal articles and 25 as proceedings, and 27 as: extension bulletins, fact sheets, book chapters, extension newsletters and decision tool spreadsheets. Twenty five percent of the publications have dealt with agronomy or practical management of no-till dryland rotations. Thirty percent of the manuscripts deal with various aspects of soil quality improvement. About 19 percent have involved the testing or development of simulation models (mostly through collaboration with Liwang, Laj Ahuja and S.A. Saseendran). Fifteen percent of the manuscripts deal with soil chemistry or plant nutrition and 13 percent involve investigations on microbial ecology. Finally, 3 manuscripts involved investigations on pesticide degradation. There has been a total of 104 co-authors on the manuscripts published from scientists that are not permanent staff of the Central Great Plains Research Station. Several graduate students and post docs have made contributions. The major contributors are: David Nielsen, Merle Vigil, Rudy Bowman, Randy Anderson, Maysoon Mikha, Joe Benjamin, Francisco, Calderon, Brien Henry, Ardell Halvorson, Rob Aiken and Steve Hinkle. If you are interested, most of these manuscripts (if not all) can be obtained on our ARS website: www.akron.ars.usda.gov

Soil Carbon and Nitrogen Influenced by Compost Amendment

Maysoon M. Mikha[1] and Jessica G. Davis[2]

[1]USDA-ARS, Central Great Plains Research Station, Akron, CO
[2] Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO

Nationwide, the demanded for organic production, certified organic land, and organic livestock have been continuously increasing from the beginning of 21st century. Organic milk production is one of the fastest growing portions of organic production along with certified organic pasture for dairy-fed products. The transition period from a conventional to an organic system is about 36 months in order to certify the milk as organic. Organic forage production is also needed for certified organic livestock production. Forage production that is consistent on various grass mixture is economically desirable because different grass species is expected to increase pasture survival against diseases, withstand extreme weather conditions, and improve pasture weed competition. In Colorado, cool-season perennial grasses grow well in the cool moist spring and could regrow in the fall with adequate moisture. Manure or compost usage is the common practice to meet fertilizer N needed to sustain the perennial grasses production in the organic systems. The slow nitrogen (N) release from organic amendments most likely supported the perennial grasses growth and production. Therefore, predicting soil organic matter (SOM) dynamics through carbon (C) and nitrogen (N) mineralization is important to improve our knowledge in managing the organic system during the transition period and thereafter.

Objectives

Evaluate the influence of different compost applications and rates on:

1) Soil organic C and total N.
2) Mineralization of C and N from compost amendment.

Materials and Methods

The research site was initiated in the fall of 2007 on an alfalfa field in north-central Colorado at the Agricultural Research Development and Education Center (ARDEC), Colorado State University near Fort Collins. In the summer of 2007, the previously growing alfalfa crop was killed by incorporating with tillage then and the field was blanketed with compost dairy manure (CDM) applied at 10 T/ac. In the fall of 2007, the plots were seeded with two perennial grass mixtures comprised of Wheatgrass-Tall Fescue- Brome (WG-TF-B) and Orchardgrass-Meadow Brome-Smooth Brome (OG-MB-SB). In addition, Tall Fescue grass as a single grass was also planted. The grasses were seeded in September of 2007 with a no-till drill (Model 3P605NT, Great Plains Mfg., Inc., Salina, KS) fitted with a cone seeder attachment (Kincaid Equipment Manufacturing, Haven, KS) and set at a 17-cm row spacing. In April of 2008, all plots received the second CDM application at 10 T/ac. In October of 2008 the grasses plots were split into three sup-plots and received three rates of CDM, (i) 0 T/ac; (ii) 5 T/ac; and (iii) 10 T/ac. The compost C and N content along with compost moisture content and C:N ratio are reported in **(Table 1)**. The study site was irrigated once or twice per week, as needed, with linear move. The plots were harvested five to six times per year to simulate grazing. The plots were approximately 10 ft wide by 40 ft long. Plots were sampled in the fall of 2008 and 2009 and the soils were homogenized and stored for various analysis. Soil C and N mineralization were evaluated with 28 days of aerobic laboratory incubation at constant temperature (25^{o}C; 77^{o}F) and soil moisture content at field capacity.

Table 1. Compost moisture, carbon, and nitrogen content, as received, throughout the study period to establish perennial grass system.

Parameters	Summer 2007	Spring 2008	Fall 2008
Moisture %	25.2	28.6	20.4
Total Carbon %	7.40	9.10	3.60
Total Nitrogen %	0.62	1.10	0.29
C:N ratio	11.9	8.3	12.4

Results and Discussion

Soil organic C (SOC) and soil total N (STN) were not influenced by type of grass. In 2008, the compost was added at the same rate to the entire study site, therefore, it is expected that SOC and STN may not be influenced by the grass treatments. In 2009, the compost was added at three different rates, but the high rate of 10 T/ac did not show higher SOC and STN compared with the zero compost rate **(Table 2)**. On average, SOC was approximately 10% and STN was approximately 15% greater in 2008 compared with 2009 at 10 T/ac compost additions. The differences in SOC and STN between sampling periods were probably related to low compost quality added before 2009 sampling compared with 2008 sampling **(Table 1)**. The C and N content associated with the spring 2008 compost, before fall of 2008 sampling, was higher by approximately 153% for compost C and by 312% for N than compost C and N content added in the fall of 2008 before fall of 2009 sampling. In addition, the mineralizable C and N, during the growing season of 2009, could be leached below 4 inches measuring depth before fall sampling in 2009 because of the irrigation system.

Nitrogen mineralization (N_{min}) is defined as the amount of N that can be mineralized during a specific incubation period under specified incubation parameters. In this study, the easily degradable N sources during the short-term incubation that lasted for 28 days are refed as N_{min}. There were no differences in N_{min} among the grass treatments in the 2008 sampling period **(Figure 1)** due to the fact that compost was added at the same rate for the entire study site. Average across the grass treatments the amount of N_{min} was approximately 3.6% of the total N addition. In 2009 sampling period, N_{min} did not correspond to the rate of compost addition **(Figure 2)**. The N_{min} associated with 10 T/ac was lower by an average of 42% than the 5 T/ac compost and by an average of 8% than the 0 T/ac compost across the grass treatments. The low N_{min} associated with 10 T/ac compost compared with other compost rates could be either due to N_{min} leaching through irrigation or to N immobilization by soil microbes. Average across the grass treatments, the amount of N_{min} was approximately 1.4% for 0 T/ac, 1.9 for 5 T/ac, and 1.4% for 10 T/ac of the total compost N added.

Table 2. Soil organic carbon (SOC) and soil total N (STN) as influenced by grass mixture, and compost rate at 0-4 inches depth for 2008 and 2009 sampling period on perennial grass system.				
Grass	N-source	N-rate	SOC	STN
		----- T ac^{-1} -----	------------------------ % ----------------------	
-- 2008 --				
HWG-TF-HB†	Compost¶	10	1.4	0.17
TF††	Compost	10	1.5	0.18
OG-MB-SB‡	Compost	10	1.4	0.17
-- 2009 --				
HWG-TF-HB	Compost	0	1.4	0.17
TF	Compost	0	1.4	0.16
OG-MB-SB	Compost	0	1.4	0.17
HWG-TF-HB	Compost	5	1.3	0.15
TF	Compost	5	1.3	0.16
OG-MB-SB	Compost	5	1.3	0.15
HWG-TF-HB	Compost	10	1.2	0.14
TF	Compost	10	1.3	0.16
OG-MB-SB	Compost	10	1.3	0.15

† Represents Hybrid Wheatgrass-Tall Fescue-Hybrid Brome.
†† Represents Tall Fescue.
‡ Represents Orchard grass-Meadow Brome-Smooth Brome.
¶ Represents compost dry manure added at different rates.

Over all, the 2008 N_{min} was 163% higher than the 2009 N_{min} at the same rate of compost application (10 T/ac). The differences in N_{min} between 2008 and 2009 were related to low compost quality added in the fall of 2008 and before 2009 sampling **(Table 1)**.

The differences in % C mineralization could be related to field variability during the first year of the grass establishment for the 2008 sampling period **(Figure 3A)**. Average across grass treatments, The C mineralization was approximately 9% of the total C addition. In 2009 sampling period, C mineralization was not influenced by compost rates **(Figure 3B)**. In general, across the grass treatments and compost N rates, C mineralization was on average of 4.4% of the total C added. Carbon mineralization was approximately 107% higher in 2008 compared with 2009 at the same amount of compost addition (10 T/ac). Similar to N_{min}, the percentage of C mineralization was due to low compost quality added before the 2009 sampling compared with the 2008 sampling period.

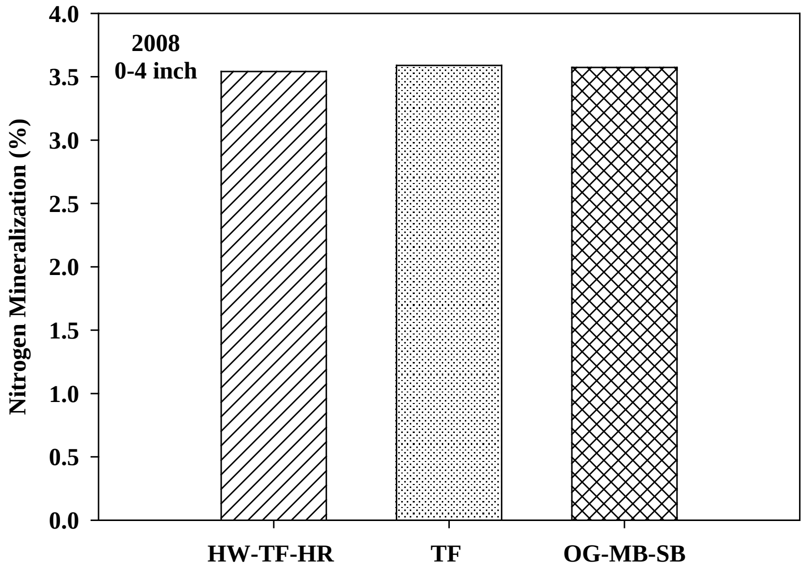


Figure 1. 2008 Soil nitrogen mineralization as influenced by multiple compost addition during the transition from traditional to organic system to establish perennial grass system. The HW-TF-HR, represents Hybrid Wheatgrass-Tall Fescue-Hybrid Brome; TF, represents Tall Fescue; and OG-MB-SB, represents Orchard grass-Meadow Brome-Smooth Brome.

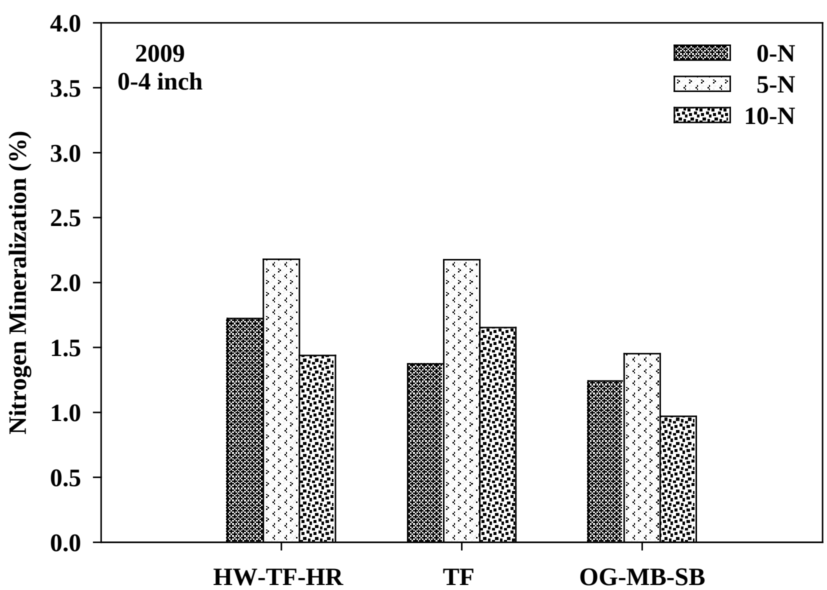
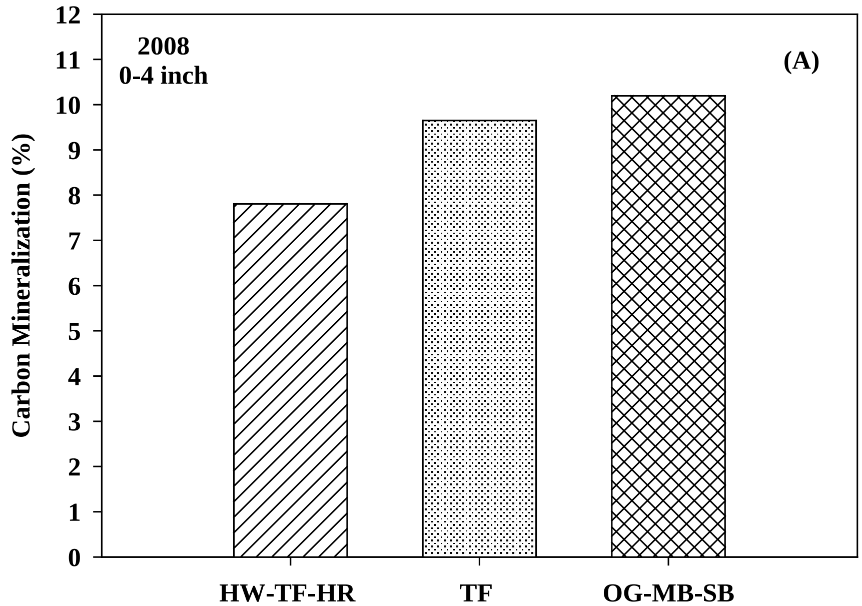


Figure 2. 2009 soil nitrogen mineralization as influenced by multiple rates of compost additions and during the transition from traditional to organic system to establish perennial grass system. The HW-TF-HR, represents Hybrid Wheatgrass-Tall Fescue-Hybrid Brome; TF, represents Tall Fescue; and OG-MB-SB, represents Orchard grass-Meadow Brome-Smooth Brome.



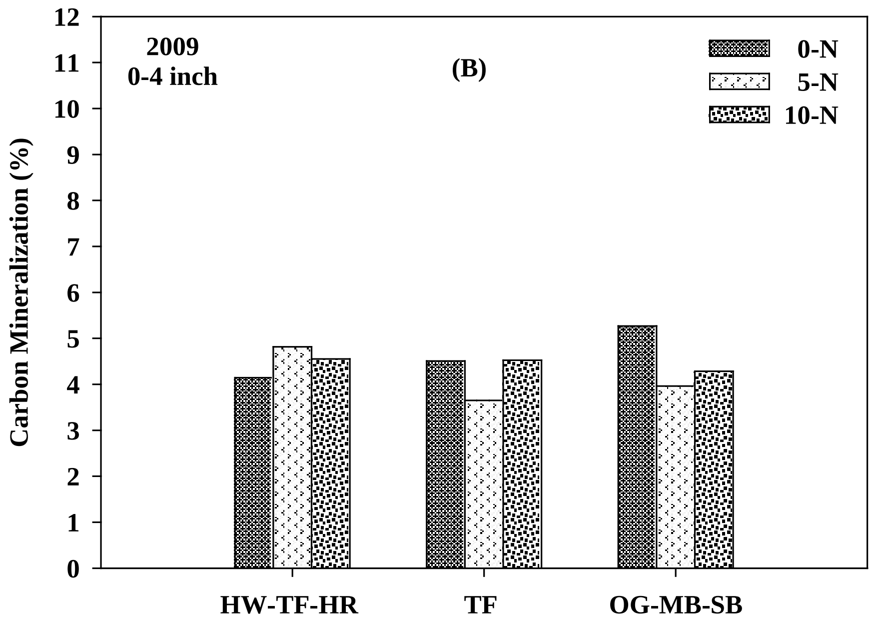


Figure 3. Soil carbon mineralization in (A) 2008 and (B) 2009 as influenced by multiple compost additions and at different rates during the transition from traditional to organic system to establish perennial grass system. The HW-TF-HR, represents Hybrid Wheatgrass-Tall Fescue-Hybrid Brome; TF, represents Tall Fescue; and OG-MB-SB, represents Orchard grass-Meadow Brome-Smooth Brome.

Conclusions

1) Throughout the two years of the study period, the quality of compost added influenced soil parameters studied such as SOC, STN, N_{min}, and C mineralization.
2) All the parameters studied were grater in the first year than the second year and they were related to compost quality.
3) This research shows that the addition of organic amendment, such as compost, need to be added base on compost-N content rather than on the total amount of compost.
4) In this transitioning system (traditional to organic), more than two years is required to detect the benefit of the organic amendment in increasing soil N and N_{min} with adequate amounts of compost addition.

Future Researches

- Continue with the long-term Remediation/Restoration study using manure for several more years to evaluate the improvement in soil quality and plant productivity.

- Continue with manure amendment study to prevent deterioration of soil quality parameters with different rates of residue removal.

Compost Use in Dryland Organic Wheat Production: Effects on Selected Physical and Chemical Properties

Joseph Benjamin and Francisco Calderon

Organic agriculture often uses animal waste as a natural source of plant nutrients for crop production. Many times the manure is first composted before application to minimize objectionable odors and decrease the viability of weeds and pathogens. The process of composting stabilizes many nutrients, such as nitrogen (N), supplying them to the plant slowly as the compost further decomposes.

Besides supplying plant nutrients, the addition of compost or manure adds significant amounts of carbon (C) to the soil. Increasing soil C has several benefits, such as increasing aggregate stability, increasing soil water holding capacity, and decreasing soil strength.

One way to evaluate compost effects on soil physical properties is to use the Least Limiting Water Range (LLWR). The LLWR combines limitations of soil water holding capacity, soil strength, and soil aeration into a range of water contents that would not be considered limiting from crop growth. In general, a greater LLWR indicates a better soil physical condition and fewer limitations to crop growth during the growing season. Management effects on the LLWR can be estimated from soil texture and management changes in C and bulk density (BD).

A study to examine the effects of beef manure compost on organic winter wheat production was started at the Central Great Plains Research Station near Akron, CO in 2010. Prior to the study, the plot area was in permanent grass vegetation. In 2008, the plot area was moldboard plowed to a depth of 25 cm. A winter wheat – fallow rotation was established. Treatments included a 0X rate of compost (no compost) a 1X rate of compost (20,400 lb/ac, estimated to supply the N needs for a winter wheat crop) and a 5X rate of compost (97,000 lb/ac, approximately five times the rate as the 1X). Compost was first applied in 2010 and also was applied in 2012 and 2014.

Soil samples were collected in June of 2015. A probe with an internal sleeve was inserted into the soil to a depth of 24 inches. The sample was sectioned into 3 inch increments. The BD for each sample was determined and a subsample extracted to determine organic C, soil pH, total phosphorus (P), and soluble salts.

The total C applied for the 1X rate was 12840 lb/ac and for the 5X rate was 60950 lb/ac. After six years, about 34% to 36% of the organic C applied as compost remained in the soil (**Table 1**). This compares with 80% to 85% of the total P applied by the compost remaining in the soil (**Table 2**). Loss of soil C is attributed to oxidation of the compost in the soil rather than erosion.

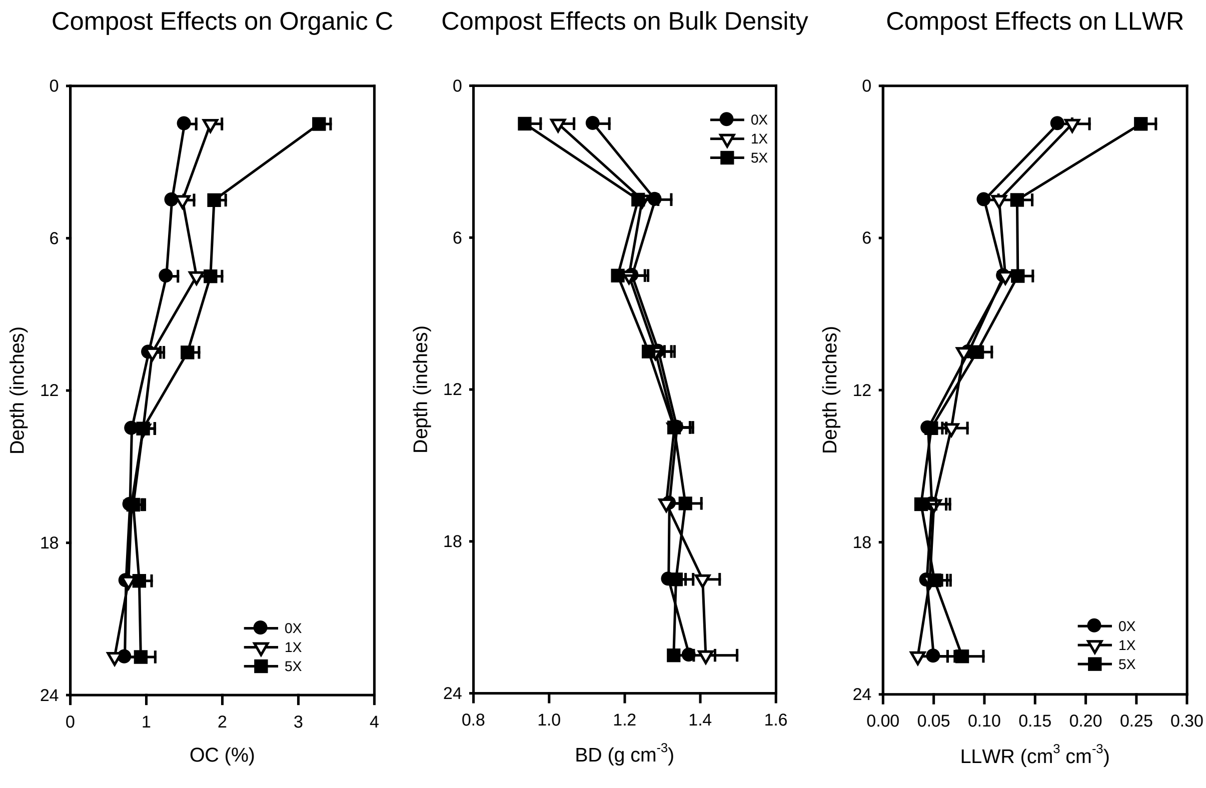
Table 1. Compost treatment effects on C application in compost, C recovery in surface 12 inches of soil, and %C from compost retained between 2010 and 2015.

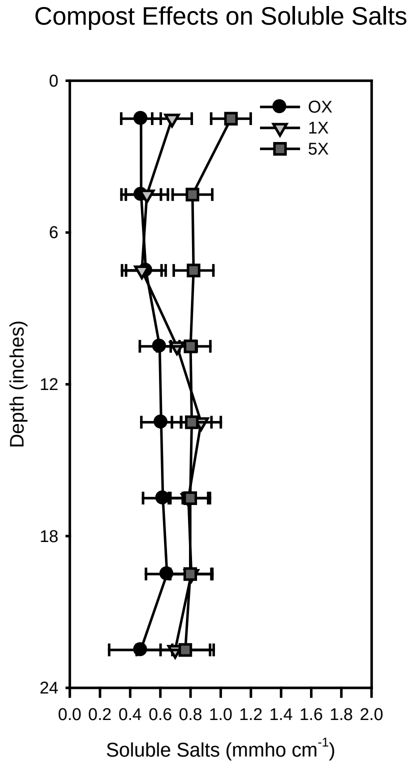
Treatment	C applied	C in soil	ΔC from control	C from compost retained
	lb/ac	lb/ac	lb/ac	%
0X	0	42536	-	-
1X	12840	47116	4580	36
5X	60950	63216	20680	34

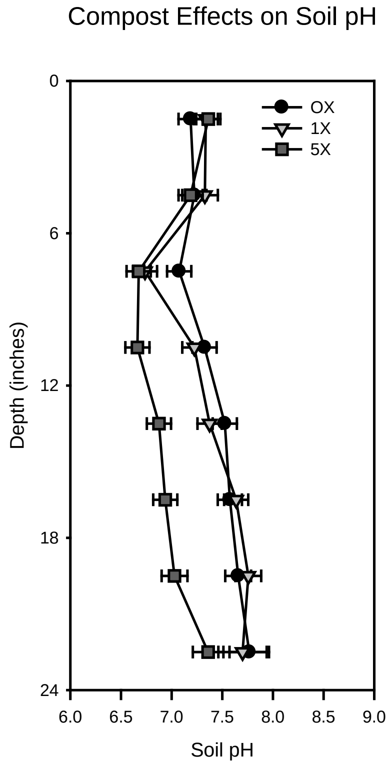
Table 2. Compost treatment effects on P application in compost, P recovery in surface 12 inches of soil, and %P from compost retained between 2010 and 2015.

Treatment	P applied	P in soil	ΔP from control	P from compost retained
	lb/ac	lb/ac	lb/ac	%
0X	0	1666	-	-
1X	357	1955	289	81
5X	1695	3105	1439	85

The C distribution in the soil profile was dependent on compost application. Greater OC was recovered in the surface 12 inches of soil with the 5X compost treatment than for the 0X and 1X treatments, with the greatest difference in the 0-3 inch and 3-6 inch layers. Greater C in the 5X compost rate also corresponded to lower BD in the 0-3 inch layer of the 5X compost treatment. The 1X compost treatment had greater OC and lower BD than the 0X compost treatment in the 0-3 inch layer, but not at lower depths. The LLWR, calculated from BD and OC, was greatest for the 5X compost treatment in the 0-3 inch and 3-6 inch depths, but was similar to the other treatments below 6 inches. The LLWR was similar between the 0X and 1X compost treatments for all depths.







The addition of soluble salts from compost is a concern for soil quality. Soluble salts >2 mmho/cm are considered detrimental to crop production Soluble salts were 0.8 to 1.0 mmho/cm through the soil profile in the 5X compost treatment compared with 0.4 to 0.6 mmho/cm in the 0X treatment. The 1X treatment had 0.4 to 0.6 mmho/cm soluble salts in the surface 12 inches, but about 0.8 mmho/cm below 12 inches.

Soil pH was similar among treatments in the surface six inches of soil (pH about 7.3), but, deeper in the soil profile, the pH was 6.8 to 7.3 in the 5X treatment, compared with 7.0 to 7.8 in the other treatments. Many nutrients can be immobilized in high pH soil, so nutrient availability may be better in the high compost rate.

Table 3. Winter wheat yield in 2014 and 2015.

Year	Treatment	Yield
		Bu/ac
2014	0X	20.0
	1X	15.3
	5X	26.3
SD (P>F)		3.5 (0.14)
2015	0X	29.4
	1X	26.9
	5X	32.5
SD (P>F)		5.6 (0.79)

There was no significant yield response to compost treatment in either 2014 or 2015 (**Table 3**). Winter wheat grain yields were lower in 2014 than 2015 due to residual effects of drought on soil water storage in 2012-2013. Rainfall was above average starting in the fall of 2014, which improved soil water storage for the 2014-2015 crop year. Under both water environments, the 5X compost rate tended to have greater wheat yield than the 0X and 1X compost application rates.

Overall, there was little difference in soil chemical and physical properties between the 0X and 1X compost treatments. Potential improvements of soil C were limited by the high decomposition of compost after application. The 5X compost application rate resulted in a significant increase in soil C, lower bulk density, and increased LLWR while also showing a significant decrease in soil pH lower in the soil profile. Improvements in soil properties did not result in greater crop yield due to overall water limitations on crop production in a semi-arid climate.

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.

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 Infitration 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 Seconds	Steady State Infiltration in hr^{-1}	Total Infitration 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

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.

LONG-TERM TILLAGE EFFECTS ON SOIL CARBON CHEMISTRY AT AKRON, COLORADO

Francisco Calderón, Merle Vigil, Michelle Haddix, and Eldor A. Paul

PROBLEM: The total quantity of soil organic carbon (SOC), and it's resistance to decomposition is determined by the plant community, microbiology, climate, protection by clays, and land management. However, little is known about what determines the speed of decomposition of SOC and crop residues in the short-term. Soil attributes like microbial biomass, texture and chemistry of the SOC can interact to affect degradation. Mid infrared diffuse reflectance spectroscopy (MidIR) is a valuable technique for the study of the C quantity and quality of soils and was used in this study to shed light on the chemical changes in SOC during decomposition of soil C when soils are incubated in the laboratory. The analysis of soil C stable C isotopes is useful because it shows how much of the older prairie organic matter is left in the soil after years of agriculture.

APPROACH: The long-term tillage experiment was started 49 years ago in 1967 at the CGPRS under various tillage practices in WF rotations. At the start of the project, tillage practices included a stubble mulch tilled treatment with up to six V-blade under-cutter operations down to 4 inches deep during fallow. The moldboard plow treatment was started in 1989. In this treatment, the soils have been plowed down to 8 inches, followed by disking. Sweeping was also done for weed control on the plow treatment. The plots were established on soil that had been cultivated since 1907, and the land was native short grass prairie before that.
The soils were analyzed for C stable isotopes and for infrared spectroscopy in order to measure the C proportion of leftover native soil C in the plowed and stubble mulch -tilled soils, and also the type of C chemistry under the different tillage managements. Samples from adjacent long-term grass were included to provide a point in comparison to the cultivated soils. Soils from each management type were analyzed fresh and incubated (707 days). Before, during, and after the incubation, the soils were scanned for infrared spectroscopy, CO_2 loss and stable isotopes. Our aim was to test how decomposition affect the MidIR spectra of soils, and measure changes in the soil C chemistry when the SOC is allowed to decompose.

RESULTS: Table 1 shows the effect of plowing or stubble mulch tillage on the total soil C, soil N, C stable isotopes, and the native grass C remaining in the cultivated soils. Plowing had a 56% reduction in soil total C relative to the native grass, while the stubble mulch caused a 24% reduction, showing that plowing can be especially detrimental to SOC loss because it causes excessive erosion and oxidation.

Table 1. Site summary of soil characteristics prior to incubation. SM is stubble mulch.

Site	Treatment	Total C	Total N	δ^{13}C of Roots	δ^{13}C of Soil	Pro-portion native soil C	% of Native C lost with cultivation	Size of Active fraction in % soil C
Akron	Plow, W-F	0.66	0.093	-24.87	-17.46	0.89	58.05	3.87
	SM, W-F	0.92	0.114	-24.87	-19.07	0.70	53.91	6.03
	Native grass	1.22	0.140	-16.57	-16.72			12.82

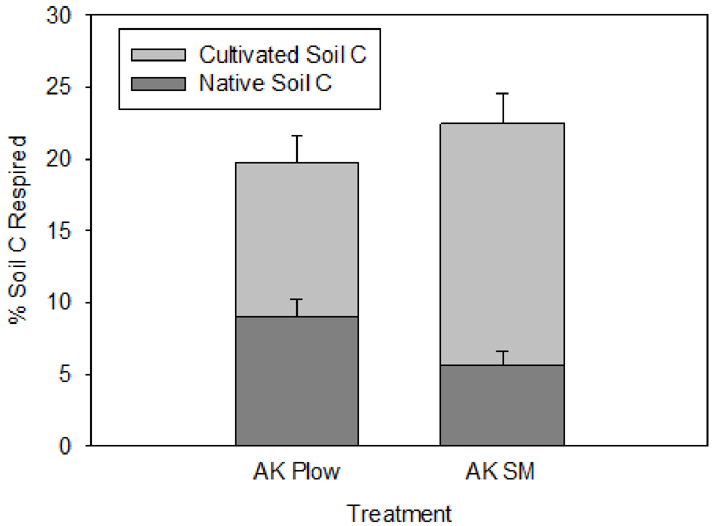


Figure 1. Summary of percent soil C respired after 707 days of incubation for the cultivated soils by the end of the incubation partitioned into the native and cultivated SOM. SM is stubble mulch.

Total soil N followed a similar pattern to total C, with the plow causing more impact than the sweep till. These reductions are obviously due to the tillage itself, but also due to the fact that perennials in the native grass contribute approximately 50% of their photosynthesis products to the soil, while summer annual crops allocate much less, about 16%. This is why prairie soils are so rich in SOC. Stable C isotopic analysis has been commonly used to measure the contributions of C3 and C4 plants to SOC. Given that plant residues are the main source for soil organic matter, then soil stable carbon isotope composition ($\delta^{13}C$) is determined by crop type. This is because C3 (wheat) and C4 plants (corn and other summer crops) discriminate differently between ^{12}C and ^{13}C isotopes, resulting in $\delta^{13}C$ values of −27‰ and −13‰ in C3 and C4 plants respectively. The analysis of our soils shows that the $\delta^{13}C$ ratio is shifting in the soils from the native grass to the cultivated soils, reflecting the $\delta^{13}C$ of the predominant roots in the system (Table 1). The amount of native grass C left in the soils can be calculated with the proportion of native soil C and the total soil C content. The plowed soil has lost 58% of the native grass C, while the stubble much soil has lost 54%.

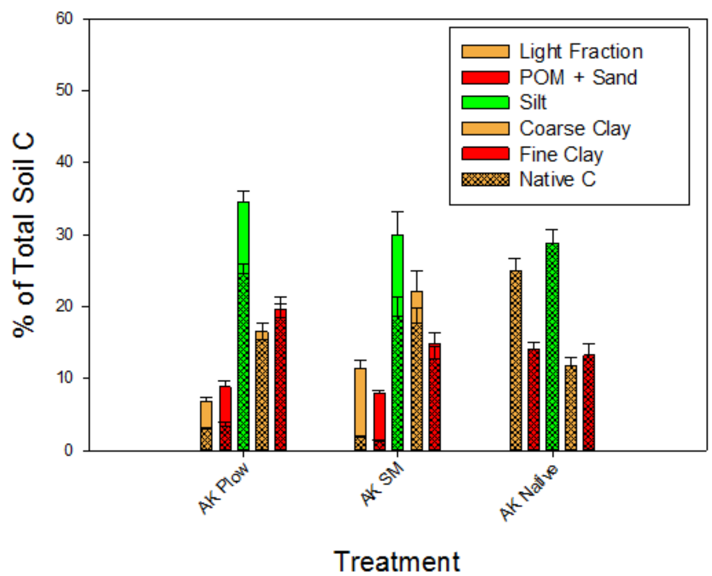


Figure 2. Percent of total soil C in each soil fraction prior to incubation with the shaded area being the amount of soil C from the original native vegetation.

The more decomposable organic substances in soil are called the active C fraction, and the active C was calculated from the timing of C loss during the incubation. The active fraction is larger in the native soil relative to the cultivated soils. This means that the soil C in the native soil has more decomposable organic matter, and in contrast, the plowed soils have “tougher” to degrade soil C overall.

The soils were incubated in the laboratory for 707 days to help us understand how much of the cultivated soil C and the native soil C is lost when conditions are favorable for SOC decomposition. Figure 1 shows that the stubble mulched soil is prone to losing more C than the plowed soil, and that more of the lost C is made up of C recently produced by the crop plants. This is consistent with the larger amount of active fraction in the stubble mulched soils than in the plowed soil. In contrast, a higher proportion of the C lost by the plowed soil is made up of the remnant C leftover from the time when the land was under native grass. We can say that in the plowed soils, not much of the crop residues are becoming SOM, leaving less SOC to supply mineralizable C and possibly.

The soils were also analyzed by a procedure called particle size fractionation, which consists basically on separating the soil according to flotation and sieving using a series of mesh sizes (Figure 2). The light fraction tends to float in a aqueous solution, and consists mostly of partly decomposed plant residues, which have been relatively recently added. The clay and fine clay fractions consist of older C that is more highly decomposed than other size fractions. In the cultivated Akron soils, the percent of leftover native grass C in the SOC goes like this: light fraction> particulate organic matter (POM) >silt>clay> fine clay.

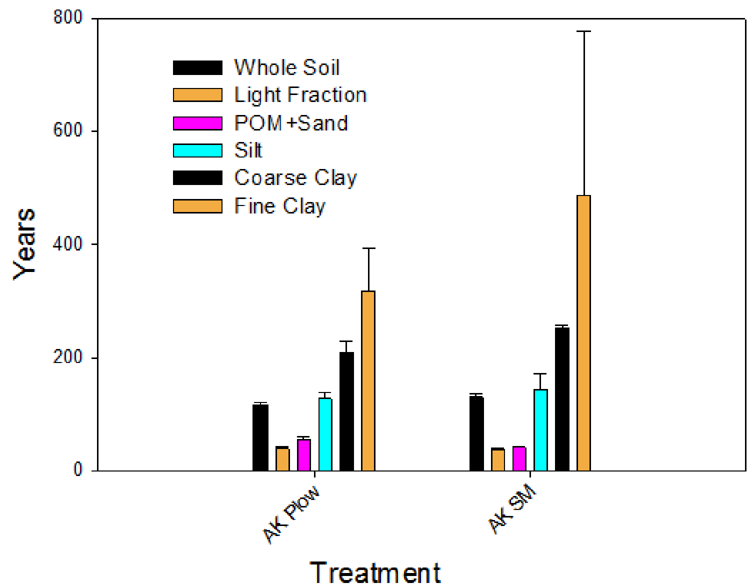


Figure 3. Turnover in years of the native soil C in each fraction prior to incubation for the cultivated treatments using the ^{13}C values.

The ^{13}C content of the samples makes it possible to calculate the age of the C in the different particle size fractions (Figure 3). The fine clay has the C with the longest residence time, meaning that the C has "stayed put" longer in the fine clay fraction compared to the other particle sizes. Conversely the light fraction and POM have C that is lost relatively quickly, in decades rather than hundreds of years.

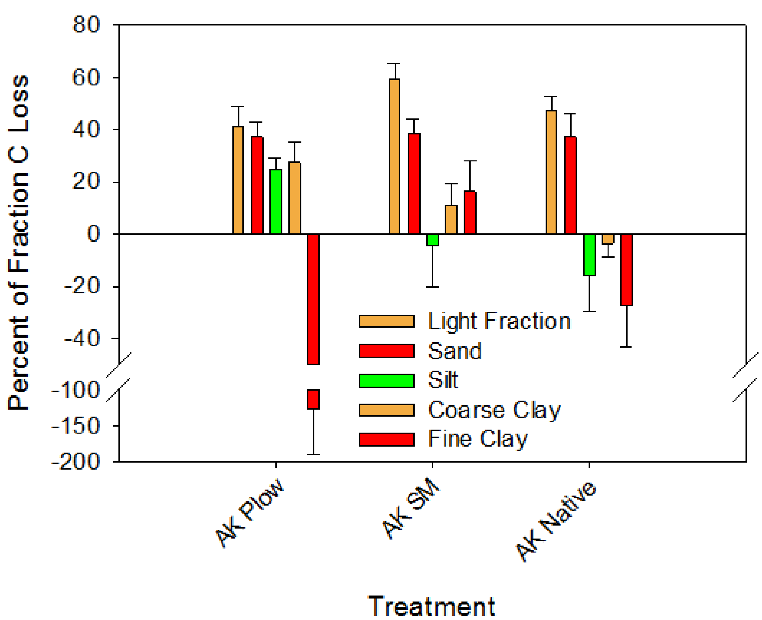


Figure 4. Percent of fraction C loss after 707 days of incubation for the different soils.

The soils were fractionated before and after a 707 day incubation in the laboratory. The results show that the light fraction and POM (sand-sized) fractions lost more than 40 % of their C in all three tillage treatments (Figure 4). In contrast, the fine clay fraction actually increased in C content, suggesting that during decomposition (as in fallow periods), the light fraction and POM are converted to finer clay-sized particles of organic matter.

Mid infrared spectroscopy can be used as a quick way of observing chemical differences in SOC. In this case, we use MidIR to determine how incubation changes the organic material in soil during incubation (Figure 5). The principal components analysis reduces the thousands of data points in the infrared spectra into two components that make it easy to visualize the differences between the day zero soil spectra and the spectra from soils incubated for 707 days. The loadings graph tells us what absorbance bands in the mid infrared are responsible for the differences between the incubated and the fresh soils. The absorbance changes at 1550 and 1660 cm^{-1}, indicate that nitrogen-containing organic matter (such as proteins and microbial C) is getting lost during incubation. The absorbance at 2850-2930 cm^{-1} represents the loss of –CH bonds during incubation. These –CH bonds are present in a variety of crop residue components and soil organic matter, and represents the loss of easy to decompose materials.

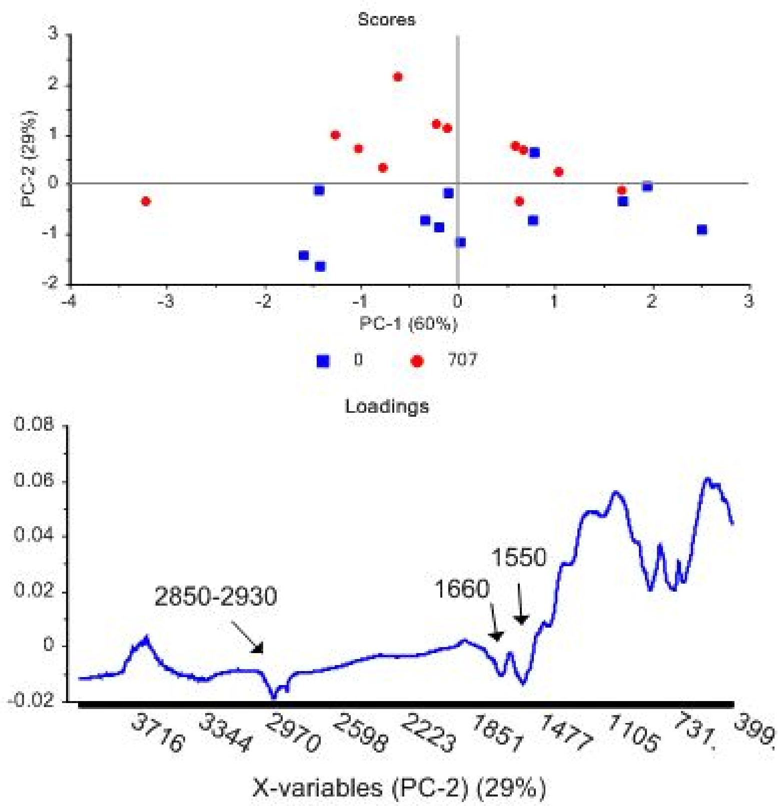


Figure 5. Principal Components Analysis of the mid infrared (MidIR) spectra of Akron soils. Pre-incubated (707d) samples are in black, and fresh soils are in grey.

FUTURE PLANS: The Long Term Tillage Experiment is a valuable legacy that has allowed scientists from USDA and elsewhere to test the effect of different agronomic treatments on soil quality during different time frames. As newer cutting edge techniques become available, we hope to continue examining these interesting soils in the future.

Are Flexible Cropping Systems with Forages Better Adapted to Variable Climate than Fixed Grain-based Rotations?

David C. Nielsen, Merle F. Vigil, Neil C. Hansen

Climate in the semi-arid Central Great Plains is expected to become warmer and drier in coming decades, with potentially greater variability in precipitation and temperature. Cropping systems that include forages and that allow flexibility for determining both if a crop should be planted and which crop to plant (based on available soil water at planting) may provide the opportunity to maintain economic viability in a changing climate environment. The objective of this study was to compare cropping system productivity and profitability of flexible rotations that incorporate forages against grain-based cropping systems that are fixed rotational sequences. Yield and net returns for five set rotations and three flexible rotations were compared at Akron, CO over five years. The crop choice decisions for the flexible rotations were based upon predicted yield as determined from measurements of soil water content at several decision points (fall, spring, summer) and average growing season precipitation. Winter wheat yields were reduced by 57% when the fallow period prior to wheat production was replaced with crop production. Average net income was greatest for the continuously cropped all-forage fixed 3-yr rotation followed by the flexible 3-yr rotations that included wheat and forage phases. The lowest net returns were seen for the fixed grain-based rotations and the flexible wheat-grain crop rotation. Incorporating forage production as a phase in dryland wheat rotational systems can add profitability and sustainability to the production system in the face of climate variability.

Rotations Evaluated

Fixed Rotations	Flexible Rotations
W-F (NT)	W-GC
W-C-F	W-FS-Flex
W-M-F	W-Flex1-Flex2
W-S-F	
FM-FT-FS	

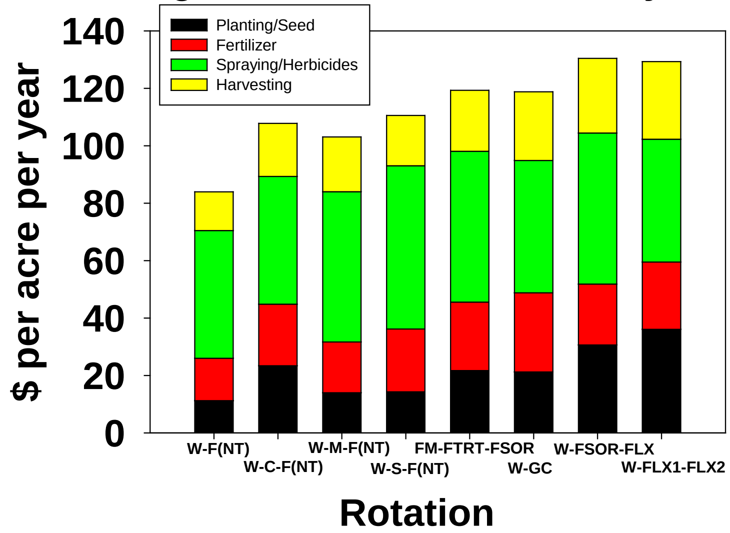
Flexible Crops

	W-GC	W-FS-Flex	W-Flex1-Flex2	
Year	GC	Flex	Flex1	Flex2
2011	Millet	Forg Mil	Forg Pea	Pea
2012	Millet	Forg Pea	Corn Sil	Forg Mil
2013	Millet	Corn Sil	Forg Mil	Corn Sil
2014	Sorg	Forg Pea	Sorg	Forg Pea
2015	Millet	Pea	Forg Pea	Forg Pea

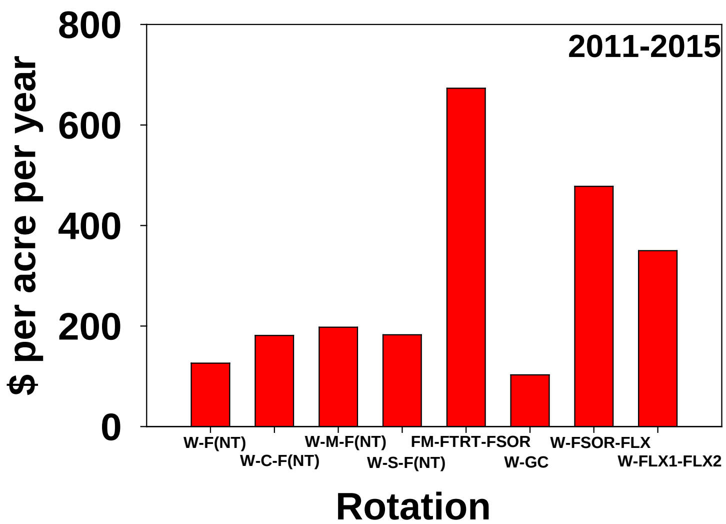
Average Yields

	bu/a	------------T/a----------		
Rotation		FM	FT	FS
W after fallow	39			
W after crop	20			
W-C-F	31			
W-S-F	37			
W-M-F	27			
FM-FT-FS		2.28	3.05	1.81
W-FS-Flex				2.29

Average Production Costs for System



Average Gross Revenue for System



Average Net Value for Cropping Systems