NC-1178: Annual Report of the Intensification of Agroecosystems and Soil Carbon Dynamics Regional Project

This report was generated from individual state reports submitted by this regional project's participants. Included in this report are the minutes from the meeting held in Madison, WI (August 2-3, 2017), and state reports from the nine states that have actively participated and submitted reports for this multi-regional project. These states include Guam, Illinois, Iowa, Kansas, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. A summary table of specific institutions and participants is included below.

Respectfully submitted by Francisco Arriaga, 2017 Chair.

Report Period
June 1, 2016 to May 31, 2017

Outcome/Impacts
A total of 19 peer-reviewed journal publications, 4 book chapters, and 38 presentations at professional conferences and workshops/field days, from data collected from projects associated with this regional project. In addition, six graduate students (M.S. and Ph.D.) are currently working on these projects or completed their degrees during this reporting period. Other graduate students are actively working and training on these projects. We estimate the total audience of oral presentations, including scientific and extension/outreach, that has benefited from data generated from projects associated with NC-1178 this reporting period to be approximately 5,000+ scientists, farmers, agricultural professionals and county/state/federal agency personnel. Although difficult to quantify, we feel these efforts have created changes in farmer behavior by improving soil management practices that enhance organic carbon dynamics in soil and improve long-term crop productivity, as well as changing recommendations made to farmers by practicing professions (e.g. crop consultants and agency personnel).

Accomplishments
The aggregated research efforts of the individual participants has helped improve crop productivity in a sustainable manner, while promoting increased crop productivity. This work has promoted the importance of soil health on crop production and environmental stewardship. Research work includes assessment of reduced tillage practices, implementation of cover crop systems into existing crop rotations, soil carbon cycling, and evaluation of erosion reduction strategies, among others. Multiple locations have been able to collected long-term data to determine the impact of agricultural intensification practices on soil properties and function. Results generally show a decrease in soil health parameters with increasing unchecked management practices, and highlight the importance of preserving organic carbon in soils. The magnitude of these changes varies in the length of time practices are implemented (i.e. short- versus long-term effects). Further, environmental impacts of these practices have also been quantified by several regional project members. Differences in weather patterns year-to-year,

differences in soil types between regions, microclimatic variations, and other variables stress the importance of investigating the role of soil management on soil health and organic carbon cycling in soils. The complexity of these systems highlights the need for more research.

Publications

See individual state reports attached for a complete list of publications and their authors.

External Funding

- USDA funding received in 2014 at SDSU will be used to leverage this work and conduct additional soil hydraulic properties measurements.
- Agronomic Science Foundation; ~$20,000 during this reporting period for work at UW-Madison (6-year annually renewable project).
- Endowment at the Department of Agronomy at Iowa State University from 2008 to present in the amount of $215,000 towards ISU efforts.
- NSF funding to Kansas State University for student training of $10,000.
- U.S. DOE sub-award to Kansas State University ($125,000) for bioenergy research (total award of $9 million).

Active Participants

State / Territory	Institution	Representative
Guam	University of Guam	Mohammad H. Golabi
Illinois	University of Illinois	Ken R. Olson
Iowa	Iowa State University	Mahdi Al-Kaisi
Kansas	Kansas State University	DeAnn Presley
Nebraska	University of Nebraska-Lincoln	Humberto Blanco
North Dakota	North Dakota State University	Larry Cihacek
Ohio	The Ohio State University	Rattan Lal
South Dakota	South Dakota State University	Sandeep Kumar
Wisconsin	University of Wisconsin-Madison	Francisco J. Arriaga

NC-1178 Annual Meeting 2017

August 2, Madison WI

Dept. of Soil Science, 1525 Observatory Drive

University of Wisconsin-Madison

Minutes

Minutes by **Jose Guzman** (substitute for Sandeep Kumar)-South Dakota State University, and **Francisco Arriaga**-University of Wisconsin.

Attendee List: Mahdi Al-Kaisi (Iowa State University), Francisco Arriaga (University of Wisconsin), DeAnn Presley (Kansas State University), Larry Cihacek (North Dakota State University), Humberto Blanco (University of Nebraska), Rattan Lal (Ohio State University), Mohamad Golabi (University of Guam), Jose Guzman (substitute for Sandeep Kumar, South Dakota State University).

Also Attending: Peter Tomlinson (Kansas State University)

Absent List: Kakani, Vijaya Gopal (Oklahoma State University), Steinhardt, Gary (Purdue University), Tiemann, Lisa (Michigan State University), Cox, Michael (Mississippi State University).

2 pm to 2:15pm - Welcoming remarks and Introduction from Alfred Hartemink on the state of Wisconsin's Soil Science Department.

2:15pm to 2:35pm – Discussion points

1. Summit Mid-report by end of December 2017 (determined later on that it has been already completed).
2. Summit Annual Report and minutes 2017
    a. 60 days after 8/2/2017
    b. To be completed by Sandeep Kumar, Jose Guzman, and Francisco Arriaga.
3. Change Title of committee "Impacts of Crop Residue Removal for Biofuels on Soils".
    a. To attract new participants
4. Discussed what other related committees and history of NC-1178 to think of goals for next project cycle. Must keep in mind;
    a. Residue management
    b. Soil Health
    c. Soil Carbon Sequestration

Summary reports and Presentations

2:35pm to 2:45pm - Mohamad Golabi presented on "Evaluating the benefits of Biochar on soil quality while determining its effect on Soil Carbon Sequestration – A pathway to Sustainability".

2:50pm to 3:00pm – Rattan Lal presented on "Residue management effects on corn grain and stover yields and harvest index".

3:00m to 3:25pm – DeAnn Presley presented on “Residue Removal effects on Yields, Soil Carbon, and Residue Levels”.

3:25pm to 4:30pm – Mahdi Al-Kaisi presented on “Long-term (17 years) Tillage and Crop Rotation effects on Yield, and Economic Returns”.

4:30pm to 4:45pm – Jose Guzman presented on “Crop Residue Removal and Cover Crop Impact on Soil Hydrological Properties, Water Storage, and Soybean Yield”.

4:45pm to 4:55pm – Humberto Blanco presented on “Residue grazing and baling of corn residues: Implications on soil ecosystem services”

4:55pm to 5:30pm – Discussion points

1. Determined that Mid-report has already been completed.
2. Renewal **–** Not sure, need to ask Christina and Gary Pierzynski.
3. Larry Cihacek was voted secretary for term 2018. Will host annual NC-1178 meeting in North Dakota State University in 2019. Mahdi Al-Kaisi was voted secretary for term 2019.
4. Discussion to email non-participants and contact new participants if they cannot participant. If no response, Gary Pierzynski can email Dean of University from non-participants. Need to check past reports for participation.
5. Renewal Report
    a. Was voted that Larry Cihacek can write on the Historical section
    b. Was voted that Sandeep Kumar would be in charge of report (since hosting next meeting), but will primarily be written by Mahdi Al-Kaisi and Humberto Blanco.
6. Discussion of changing Title of NC-1178 Committee from website (NIMSS).
    a. New title is “Land use and management practices impacts on soil carbon and related agroecosystems services”.
7. Objectives 1 and 2 on website are broad, and sufficient but could include;
    a. Need to include organic amendments and biochar
    b. Instead of GHG, change to environmental footprints
    c. Add 3rd objective (instead of removing one objective as done in previous years), to include ecosystem service, soil health (remove soil quality), carbon footprint. Synthesize objectives 1 and 2.
8. Show incentives for new participants on web site
    a. List of publications
    b. New review article and list all contributing authors from the committee (and Jose Guzman).

5:30pm - Meeting adjourn

Dinner at Café Hollander

August 3, 2017 - State Reports (continued) and Field Trip

Attendee List: Mahdi Al-Kaisi (Iowa State University), Francisco Arriaga (University of Wisconsin), Larry Cihacek (North Dakota State University), Rattan Lal (Ohio State University).

Group convened at 8:30am. Given the rainy weather and forecast, it was decided to cancel the field trip and remain on the Madison campus. The presentations planned for the field trip were given indoors.

8:45-9:10am Reports given by Larry Cihacek and Francisco Arriaga.

9:15-9:50am Presentation given by Dr. Gregg Sanford (Research Scientist, Dept. of Agronomy, UW-Madison); Wisconsin Integrated Cropping Systems Trial (WICST), and Great Lakes Bioenergy Research, Sustainable Cropping Systems.

9:55-10:10am Presentation given by Laura Adams (M.S. student, Dept. of Soil Science, UW-Madison, advisor-F. Arriaga); Integrating Reduced Tillage and Cover Crops into Dairy Forage Production for Improved Productivity and Soil Health.

10:15-10:45am Presentation given by Melanie Stock (Ph.D. student, Dept. of Soil Science, UW-Madison, advisor-F. Arriaga); Multi-scale Approach for Assessing Winter Runoff Mechanisms After Liquid Dairy Manure Application to Soil.

10:45-11:30am Further discussions and deliberation on regional project.

11:50am Meeting adjourned

NC1178 Project Station Report
By
Mohammad H. Golabi
University of Guam
Mangilao, Guam-USA

****For impacts and accomplishments, try to emphasize collaborative, multistate efforts whenever available.**

1. **Impact Nugget: A concise statement of advancements, accomplishments and impacts. (Limit to 1-2 sentences)**

   These preliminary findings show that soil disturbances including crop residue removal increase the potential for soil carbon loss hence overall reduction of carbon storage on the soil. Increased carbon loss from the soil translates to increased net carbon dioxide emission to the atmosphere due to continues disturbances in agricultural fields. On the other hand, conservation tillage practices such as reduced till as well as the application of carbonized material from the incomplete combustion of organic wastes on the degraded lands will increase soil carbon content, hence soil quality and soil health for agricultural sustainability and environmental integrity in Guam and the other islands of the western pacific.

2. **New Facilities and Equipment. Include production areas, sensors, instruments, and control systems purchased/installed.**

   The study is being conducted at the University of Guam's experiment station located in the district of Inarajan village in Southern region of Guam. The station is equipped with full set of farming machinery that are operated and maintained by the university personnel working at the station. However, the equipment at the station does not include No-till planters and similar machinery for conservation farming system. Therefore, no till planting is conducted manually using hand held planter. In addition to farm machineries, the facilities in Ija station also include resident building and water supply. Due to unpredictable weather patterns in the area, irrigation lines were installed for regular watering as well as for fertigation procedures. Also, in order to measure the carbon dioxide emission from the soil, a set of homemade monitoring devices were developed by using sodium hydroxide solution and placed them on each plot for monitoring the effect of individual treatment on CO_2 emission. In addition, soil samples from the study plots were obtained from three different depths in order to measure their carbon content as affected by different treatment. Soil samples were brought to the 'Soil Labs' at the University of Guam for carbon content evaluation as well as other soil parameter measurements.

3. **Unique Project Related Findings. List anything noteworthy and unique learned this year.**

   Preliminary results from the study thus far has shown (Figure 1) that the higher percent carbon content of the soil under the no-tillage (NT) treatment was due to no disturbances on the soil surface during the study period. On the reduced till (RT) treatment plots, the percent carbon content also remained high next to the NT plots mainly due to the reduced disturbances as compared to conventional tillage (CT) practices. As it is shown (Fig. 1), the percent carbon content in the conventional tilled (CT) plots, where the crop residue was removed were the lowest for all sampling events. On the other hand, when 'biochar' a carbonized material from the incomplete combustion of organic waste (Glaser et al. 2000, 2001, Murukesan, 2013) were applied the carbon content of the soil remained relatively high. It was believed that the 'biochar' application to the conventionally tilled plots (CT/BC), not only would serve as soil amendment for soil quality improvement but also, it increased the carbon content of the soil as compared to CT treatment mainly due to the carbon effect of the 'biochar' that was added to the soil before planting. Although not conclusive, the data from this study has shown that tillage systems in general affect the amount of soil carbon storage/sequestration, hence the carbon dioxide emission into the atmosphere (Fig. 2). In addition, the data from the study thus far has shown (Fig. 2) that CO_2 emission from the no-till (NT) plots were lower due to the 'no disturbance' on the soil surface, as compared to conventionally tilled (CT) soils where the soil surface was disturbed due to tilling action as well as crop residue removal following the harvest.

4. **Accomplishment Summaries. Draft one to three short paragraphs (2 to 5 sentences each) that summarize research or outreach accomplishments that relate to the project objectives. Please use language that the general public can readily comprehend.**

   Soil quality and soil and water conservation strategies are the building blocks of agricultural sustainability in Guam and the other islands of the American Pacific's. In order to improve the soil quality for agricultural sustainability, among the methods and management practices proposed on these demonstrations are; reduced and minimum tillage practices, crop rotation, crop residue management, use of green manure (legume) and the application of 'biochar' as soil amendment for increased soil carbon storage capacity and improved soil quality. Our parallel research works have shown (Golabi, et. al., 2014) that relatively long growing season and adequate rainfall in Guam enables growth of legumes which can be used to supply nitrogen to subsequent crops, hence maintaining crop productivity and agricultural sustainability in the islands of Micronesia.

   Moreover, excessive tillage and frequent soil disturbances especially crop residue removal significantly reduces the chances for increasing soil organic matter resulting in poor soil quality. Excessive tillage also attributes to soil erosion by water, hence deteriorating the environmental quality in Guam and other island of Micronesia where water quality and coral health are affected by sedimentation and runoff from unprotected farms, ranches and general landscape.

Research has shown (Golabi, et. al., 2014) that under reduced and no-tillage systems, water infiltration into the soil is considerably higher. The greater water infiltration, coupled with reduced evaporation afforded by mulch resulted in more water available for crop use hence, making crop more resistant to occasional droughts in Guam and pacific islands.

5. **Impact Statements. Please draft 2 or 3 impact statement summaries related to the project objectives. Statements should be quantitative when possible and be oriented towards the general public. This is perhaps the most difficult yet most important part of the report.**

The results of this on-going research work has shown that the residue removal affects the amount of soil carbon content especially near the soil surface, hence affecting carbon sequestration potential of these degraded soils of southern Guam (Figure 1).

Furthermore, findings from this on-going experiment will contribute to the overall scientific efforts in understanding the role of different agriculture practices in carbon dynamics of the soils, and the ways in which this may reduce atmospheric carbon dioxide. It also provides information pertaining to the local conditions of the island tropical climate as relates to carbon sequestration and/or carbon loss in the form of carbon dioxide emission into the atmosphere following the removal of crop residue as well as disturbances that occur during the tilling process.

Furthermore, and in order to disseminate the findings of this project occasional field days, and other educational events and publication materials (brochures, technical reports, Newspaper articles, etc.) have been organized during the project life for agricultural professionals as well as farmers and ranchers and the general public at the University of Guam research station located in Ija (southern Guam).

6. **Published Written Works. Include scientific publications, trade magazine articles, books, posters, websites developed, and any other relevant printed works produced. Please use the formatting in the examples below.**

<u>BOOK CHAPTER:</u>

Jose Guzman, and **<u>Mohammad H. Golabi</u>**. (2017). Agroecosystem Net Primary Productivity and carbon Footing. *In the:* ‘Soil Health and Intensification of Agroecosystems’, edited by; Mahdi Al-Kaisi (Iowa State University), and Birl Lowery (University of Wisconsin-Madison).

Academic Press (AP), An imprint of Elsevier. London, San Diego, Cambridge, MA, Oxford, England. ***Published***

7. **Scientific and Outreach Oral Presentations. Include workshops, colloquia, conferences, symposia, and industry meetings in which you presented and/or organized. See below for formatting.**

CONFERENCE/MEETING PRESENTATIONS

1. **Golabi, Mohammad H**., and Clancy Iyekar. (2017). Evaluating the role of Soil and Water Conservation on 'Carbon Sequestration' for reducing the carbon dioxide (CO_2) emission into the Atmosphere – a Case study from southern Guam. S*ubmitted to the:* 1st World Conference on Soil and Water Conservation under Global Change (CONSOWA-2017) for: Sustainable Life on Erath through Soil and Water Conservation. Lleida, Spain June 12 - 16, 2017. ***Invited Paper***

2. **Golabi, Mohammad H**., and Clancy Iyekar. (2017). Would the land application of 'Biochar' help 'Sequester' soil carbon hence reduces the CO_2 emission into the Atmosphere? – an environmental case study in southern Guam. *Submitted to:* The 8th Regional Conference on Island Sustainability. April 17-21, 2017 at the Hyatt Regency hotel in the island of Guam.

3. **Golabi, Mohammad H.**, and Clancy Iyekar. Evaluating the benefits of 'Biochar' on soil quality while determining its effect on 'Soil Carbon Sequestration – A pathway to Sustainability. *Abstract Submitted to the:* 72nd International Annual Conference of the Soil and Water Conservation Society. Madison, Wisconsin, July 30th to August 2nd, 2017.

8. **Fund leveraging, specifically, collaborative grants between stations and members**.

COLLABORATIVE EFFORTS

Potential collaborative research project(s) in the pipe:

1. Pursuing collaborative efforts with an Agronomy Researcher and Extension Specialist at the Cooperative Research and Extension, Agricultural Experiment Station, College of Micronesia, in the island of Pohnpei, the Federated States of Micronesia (FSM). COM-FSM CRE Division, Kolonia, P.O. Box 1866, Kolonia, Pohnpei FM 96941.

9. **Other relevant accomplishments and activities.**

1. In addition to the dissemination of the results from this research via publications and conference presentations indicated above this project has also been used as a teaching tool/opportunity throughout each academic year for educational purposes. Graduate and undergraduate

students from the Soil as well as Geography classes had been taken to the project site where the purpose and the objectives of the project were described to the students as part of outside classroom learning opportunities. The effect of each tillage treatments and crop residue removal as well as the application of 'biochar' a carbonized material from the incomplete combustion of organic waste have been demonstrated to students at the project site where they were able to write report and/or provide answers to the related exam questions.

References:

Golabi, M. H., S.A. El-Swaify, and Clancy Iyekar (2014). Experiment of "no-tillage" farming system on the volcanic soils of Tropical Island of Micronesia. *International Soil and Water Conservation Research Journa*l. Vol. 2, No. 2, June 2014.

Golabi, M.H., S.E. Radcliffe, W.L. Hargrove, and E.W. Tollner. 1995. Macropore effects in conventional tillage and no-tillage soils. Jour. Soil and Water Cons. 50(2) 205-210

Glaser, B., Balashov, E., Haumaier, L., Guggenberger, G. and Zech, W. 2000. Black carbon in density fractions of anthropogenic soils of the Brazilian Amazon region. *Org Geochem*., 31: 669-678.

Glaser, B., Haumaier, L., Guggenberger, G. and Zech, W. 2001. The 'Terra Preta' phenomenon: a model for sustainable agriculture in the humid tropics. *Naturwissenschaften*, 37-41.

Krishnapillai, Murukesan V. (2013). Role of biochar in improving the fertility of degraded volcanic red soils in Yap. Proposal by: Murukesan V. Krishnapillai, Agricultural Experiment Station, Cooperative Research and Extension, College of Micronesia-FSM, Yap Campus, Colonia, Yap, FSM

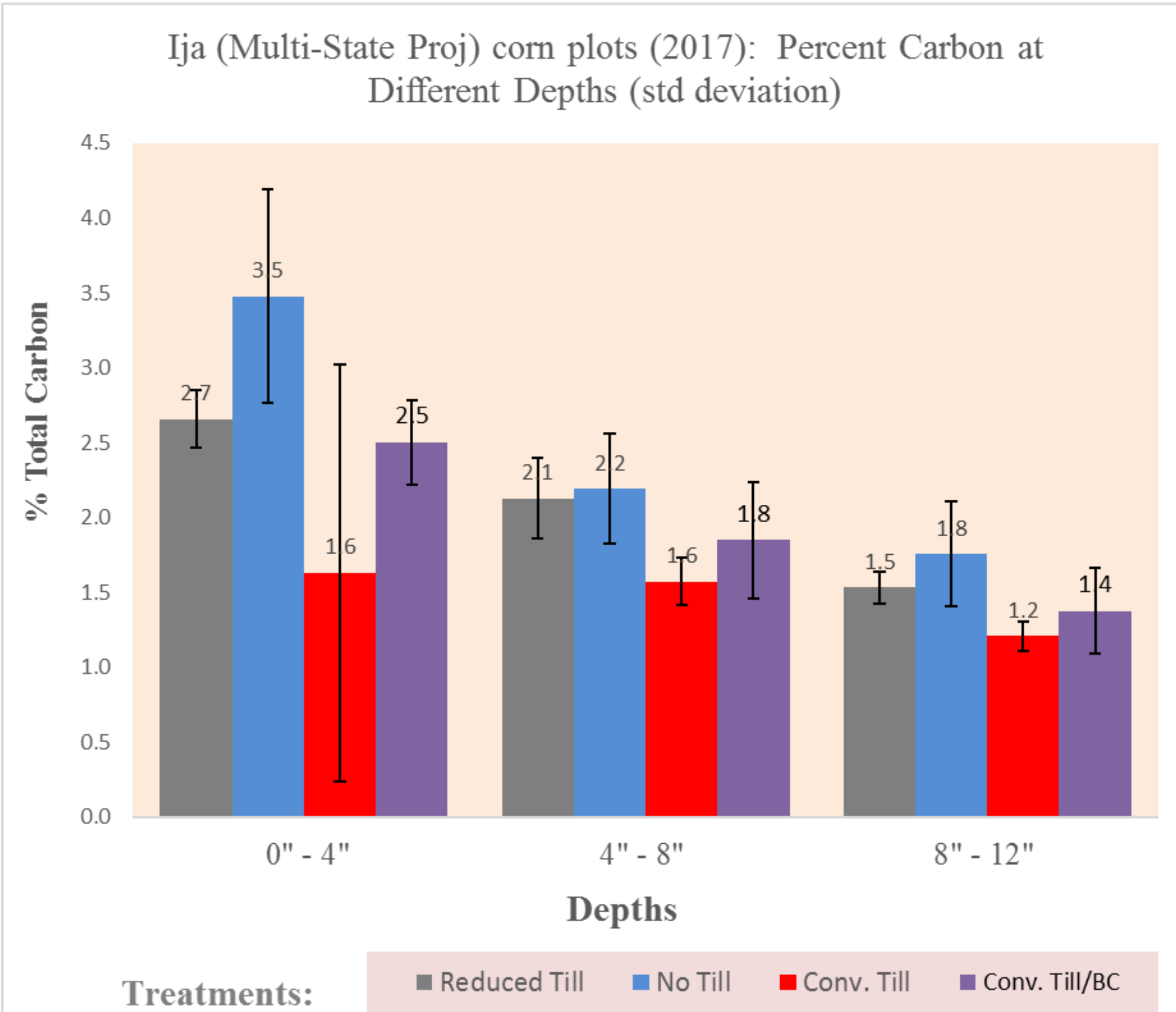


Figure 1.: Showing percent carbon content of the soil at different depth under different treatments: Reduced till (RT), No-Till (NT), Conventional till (CT), and Conventional till with 'Biochar application' (CT/BC).

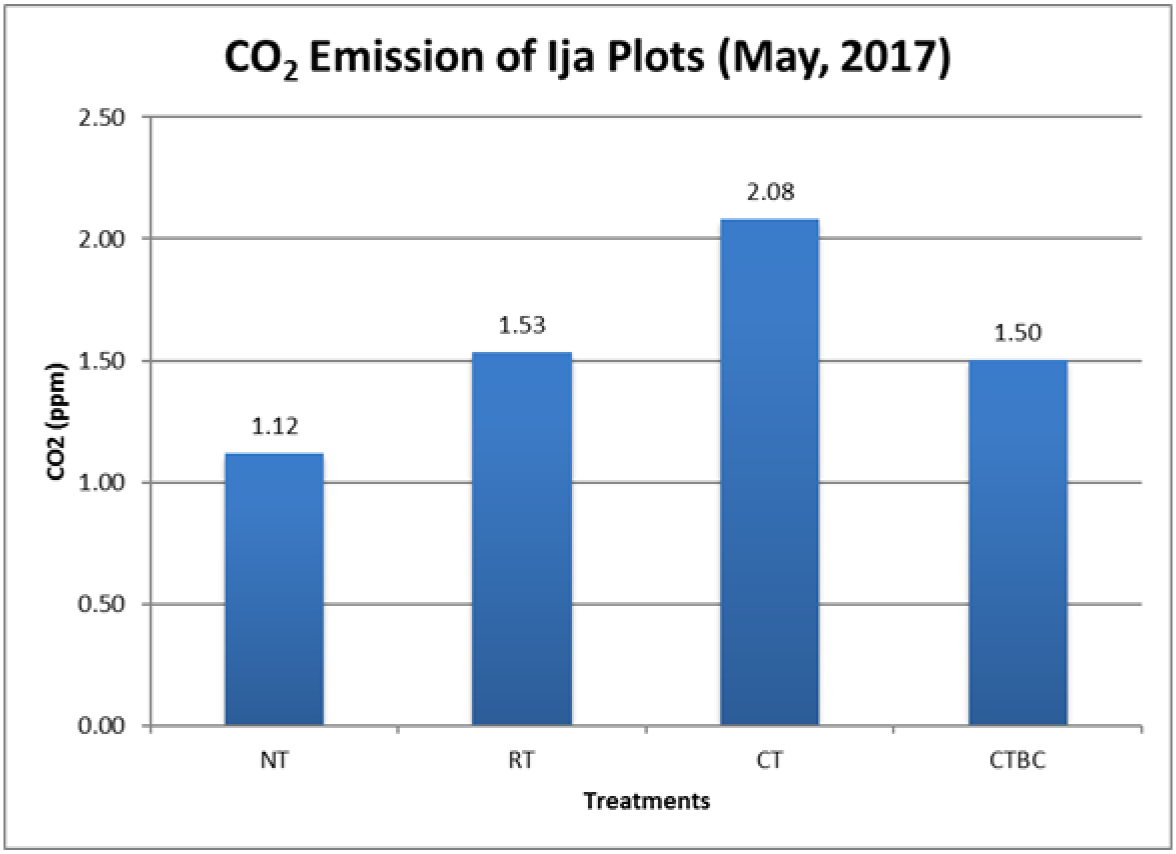


Figure 2.: Showing carbon dioxide (CO_2) emission from the soils under different treatments: No-till (NT), Reduced till (RT), Conventional till (CT), and Conventional till with 'biochar' application' (CT/BC).

SOC sequestration and stock writing committee 2017 Final Report – K.R. Olson

Our writing subcommittee of NC-1178 has previously reported on three other papers published in 2014 (SSSAJ experimental design – O, A, L and BL), 2014 SWCS SOC sampling protocol and experimental design– O, A, L and BL), and in 2015 Catena (Soil sampling depth – O and A).

In the last 12 months the 4th writing team paper (2016 OJSS erosion -SOC dynamics– O, A, L and C), the 5th (2016 JSWC – Erosion – SOC stocks– O, A, L and C) and the last team paper (6th) in (2017 JSWC - Soil ecosystems services and SOC) (O, A, L and Morton) have been publish (see references at the end of this report).

Soil erosion, agricultural land unit management effect on SOC stock and ecosystem services

A landscape soil sampling protocol was developed to establish baseline SOC stock to a 1 m depth for the entire native prairie or forest landscape. The cropland SOC stock was determined for each landscape position and the entire landscape to determine cropland retention of SOC stock. The cropland landscape adjacent to Dinesen Prairie had less SOC stock than the baseline prairie landscape except for the TS which retained more SOC stock in the upper 1 m as a result of erosion from the upper landscape positions and the deposition of SOC rich sediment on the TS. For the entire landscape the cropland retained only half of the baseline prairie SOC stock. If the intention of monitoring SOC stocks is to detect change and attribute the change to a particular land management practice/use then samples must be obtained over the entire landscape unit. In this case mean change and its variability determine level of detectability of such change. Consequently, this will dictate the intensity of soil sampling across the landscape unit to determine SOC stocks at different locations. When implementing, attention must be paid to the processes which maintain and form SOC stocks to ensure soil productivity and reduce the degradation processes, such as erosion, which drive SOC depletion. These processes are influenced by both natural and anthropogenic drivers. Soil erosion should be viewed as SOC redistribution not only across landscape, but also in the larger context of impacts on soil function and ecosystem sustainability and services and disservices. Appropriate soil sampling designs and sampling procedures are needed to determine SOC change and verify SOC net storage or sequestration. Quantifying the SOC loss due to erosion will help avoid over estimation of the management practices on net SOC stock over time.

Soil erosion and agricultural land unit management affect SOC stock of sloping agricultural land units along with the attendant changes in SOC sequestration, storage, retention, and loss. It is imperative to recognize that water and wind erosion processes of transport and deposition of SOC enriched-sediments within a landscape unit contribute to redistribution of SOC stock, in particular within the upland agricultural land unit boundaries, water bodies beyond those land units, or into the atmosphere. Redistribution of SOC because of soil erosion process neither constitutes nor is equivalent to SOC sequestration, which involves the dynamic interactions between soil, plant, and atmospheric CO_2 within the designated unit. The absence of such dynamics leads to the conclusion that soil erosion is a destructive process altering and changing soil C stocks (organic and inorganic) causing the loss of significant amount of relatively stable SOC that has been retained in the soil system for millennia, and adversely affecting net primary productivity and use efficiency of inputs. The selection of agricultural land unit and its position for study and determining SOC stock can affect the results and their interpretations. An eroding land unit will underreport the SOC stock, a depositional agricultural land unit will overestimate the SOC stock, while an agricultural mixed landscape (combined eroding and depositional) land unit can have a different and an uncertain SOC distribution outcome because of losses by decomposition, leaching, and runoff.

SOC stocks provide an essential flow of ecosystem services necessary to sustaining the productivity of corn-based cropping systems, the maintenance of the integrity of the wholeness of the agroecosystem, and long-term capacity to provision society. Intensified cropping systems must pay attention to the processes which maintain and form SOC stocks to ensure soil productivity and reduce the degradation processes, such as erosion, which drive natural capital stock depletion. These processes are influenced by both natural and anthropogenic drivers.

Farming practices and soil management have large impacts on the provision of SOC ecosystem service values. Since the landscape unit often only retains part of the SOC- rich sediments that were eroded, transported and deposited, SOC rich sediment are lost either by wind or water action out of the landscape unit to water or released to the atmosphere. Wind and water erosion can lead to significant disservices in the soil ecosystem environment causing a strong loss in biodiversity and primary productivity, leading to greater loss of wildlife habitat and human and animal food insecurity. This loss in biodiversity and NPP can have significant impact on SOC input through active below and above-ground biomass production and increase the vulnerability of ecosystem to tolerate adverse effects of climate change and water availability.

Erosion destroys soil biodiversity and vegetation cover resulting in C loss and reduction in quality of wildlife habitat. It is critical to recognize the adverse effects of soil erosion as a process that destroys soil sustainability and can lead to increased greenhouse gas emissions and loss of crop productivity which can threaten food security. Soil erosion should not only be viewed as SOC redistribution across landscape, but also in the larger context of impacts on soil function and ecosystem sustainability and services and disservices. Conversion of conventional plow-based tillage to no-till or conservation tillage in conjunction with cover cropping can create positive natural capital (increase the SOC storage budget) and increase carbon sequestration for rooting depth over a period of years. No-till farming should be practiced in conjunction with cover cropping and residue retention to restore the depleted natural capital such as SOC stock, soil functions and processes and ecosystem services.

SOC Writing Team Report Publications – for use in IA, ND and OH state reports (if useful feel free to select any sentences that fit the new Report Criteria).

Olson, K.R., M. M. Al-Kaisi, R. Lal and L. Cihacek. 2016. Soil erosion and landscape considerations in determining soil organic carbon stocks: review and analysis. J. Soil Water Conservation 71 (3): 61A-67A.

Olson, K.R., M. M. Al-Kaisi, R. Lal and L. Cihacek. 2016. Soil organic carbon dynamics in eroding and depositional landscapes. Open Journal of Soil Science Vol. 6(8): 121-134.

Olson, K.R., M. M. Al-Kaisi, R. Lal and L.W. Morton. 2017. Quantifying and monitoring soil organic carbon stock and natural capital and ecosystem services. J of Soil and Water Conservation. 72(3): 64A-69A

NC1178 Annual Report, August 2-3, 2017

Long-term tillage and crop rotation effects on soil carbon dynamics and yield

Mahdi Al-Kaisi, Professor
Department of Agronomy, Iowa State University

Impact Nugget:
Iowa State University research demonstrated a reduction in input cost of producing corn and soybean with No-till and Strip-till by $15-25/ha compared to conventional tillage and increase in soil water infiltration by 70% with NT and ST over conventional tillage treatments.

Accomplishments:
Iowa State University conducted long-term tillage and crop rotation study that include five tillage systems include: no-till (NT), strip-till (ST), chisel plow (CP), deep rip (DR), and moldboard plow (MP) and the three crop rotations include two with soybean: Corn-soybean (C-S), Corn-corn-soybean (C-C-S) and a continuous corn (C-C) system. Corn and soybean yields were determined from the center 4 and 6 rows of each plot, respectively. These experiments implemented at seven Iowa State University Research and Demonstration Farms representing different soil types and climate conditions. Analysis of 14 years of data showed greater yield response with C-S rotation compared to C-C by 11-28% across all tillage systems and greater input cost with Conventional tillage systems compared to NT and ST by 7.5% and %.7%, respectively.

Impact Statements:
The analysis of 14 years of data on the effect of long-term tillage and crop rotation on corn and soybean yield and economic returns showed an interesting trend across the state of Iowa. Corn yield and economic return showed significant variability across the state as affected by soil type and climate conditions. Economic return showed a significant advantage for NT over conventional tillage systems where input cost was $15-25/ha less with NT compared to conventional tillage systems. Also the results reveal a significant decline in corn yield with continuous corn compared to corn following soybean rotation. The soybean yield in the same study shows no significant differences in yield regardless of tillage or crop rotation. However, economic return for soybean across all tillage systems and locations was 5% greater with C-C-S compared to C-S rotation.

Scientific and Outreach Oral Presentations:
During the growing season of 2016, several presentations of the preliminary findings of these studies were presented to local farmers and agronomists in the state. These workshops were organized by Extension as part of the annual Extension and education program. Training sessions, PowerPoint presentations, and educational materials were presented during these events. In addition to field days, initial findings of this research were shared with other colleagues and agricultural professionals through newsletter articles, American Society of Agronomy (ASA) annual meetings, refereed journal articles, presentation at the regional committee meeting, and presentation to extension educators

and other agricultural professionals during various events such as the Integrated Crop Management (ICM) conference in Iowa in 2016. The ICM conference is organized annually and approximately 1,000 agricultural professionals attended the conference.

Publications:

The following refereed journal articles, book chapters, and a book are products of this effort.

Ye, D.L., Zhang, Y.S., Al-Kaisi, M.M., Duan, L.S., Zhang, M.C. and Li, Z.H. 2016. Ethephon improved stalk strength associated with summer maize adaptations to environments differing in nitrogen availability in the North China Plain. Journal of Agricultural Science. 154, 960-977.

Olson, K.R., Al-Kaisi, M.M., Lal, R. and Cihacek, L. 2016. Impact of soil erosion on soil organic carbon stocks. Journal of Soil and Water Conservation. 71:61A-67A.

Olson, K.O., Al-Kaisi, M.M., Lal, R. and Cihacek, L. 2016. Soil Organic Carbon Dynamics in Eroding and Depositional Landscapes. Open Journal of Soil Science. 6:121-134.

Al-Kaisi, M., S.V. Archontoulis, and D. Kwaw-Mensah. 2016. Soybean spatiotemporal yield and economic variability as affected by tillage and crop rotation. Agron. J. 108 (3): 1-14.

Al-Kaisi, M. and B. Lowery. 2017. Soil Health and Intensification of Agroecosystems. Academic Press. (Book).

Al-Kaisi, M., R. Lal, K. Olson, and B. Lowery. 2017. Fundamentals of Soil Environment and Functions. In: Al-Kaisi, M. and B. Lowery (Eds), Soil Health and Intensification of Agroecosystems. Academic Press.

Al-Kaisi, M. and R. Lal. 2017. Conservation Agriculture Systems to Mitigate Climate Variability Effects on Soil Health. In: Al-Kaisi, M. and B. Lowery (Eds), Soil Health and Intensification of Agroecosystems. Academic Press.

Olson, K.R., Al-Kaisi, M.M., Lal, R. and Wright Morton, L. 2017. Soil ecosystem services and intensified cropping systems. Journal of Soil and Water Conservation. 72(3):64A-69A

Funding: None

NC1178 2017 Report

DeAnn Presley
Carbon Management and Sequestration Center
Kansas State University
Manhattan, KS 66506

1. **Impact Nugget**:

Over an 8-year average, crop residue removal had no significant effect on corn yield at two locations in Kansas; numerically the yields increased with increasing residue removal levels. At the Colby location, the 0, 25, 50, and 75% removal levels sequestered soil organic C between 2009 and 2015, and the 100% removal level maintained soil organic C at the 2009 levels. At the Ottawa site, the 0% removal treatment sequestered soil organic C while all other removal levels declined in soil organic C content over the 2009 to 2017 period.

2. **New Facilities**: None

3. **Unique Project Related Findings**:

The tradeoff between increasing crop yields and increasing soil organic C sequestration is an illustration of the need for balancing two ecosystem services provided by cropland soils, i.e., provisioning and regulating.

4. **Accomplishment Summary**:

A corn residue removal research project began in 2009 at three sites. One site was discontinued after 2011, but the other two locations are still active research sites. Residue removal studies continue on two sets of plots with 0, 25, 50, 75, and 100% stover removal levels. One plot is in eastern Kansas, and the other is an irrigated site in western Kansas. Crop grain yield is measured annually and soil organic C and bulk density are measured every other year in odd years. Thus far, there have been few instances where crop residue removal has been detrimental to corn yields. In fact, removal has led to increased crop yields at the irrigated Colby site, where an average of 330 mm irrigation is applied during the corn growing season. Corn yields are high; therefore residue production has been high, and removal led to increased crop yields at Colby in this high-yielding environment. At the rainfed

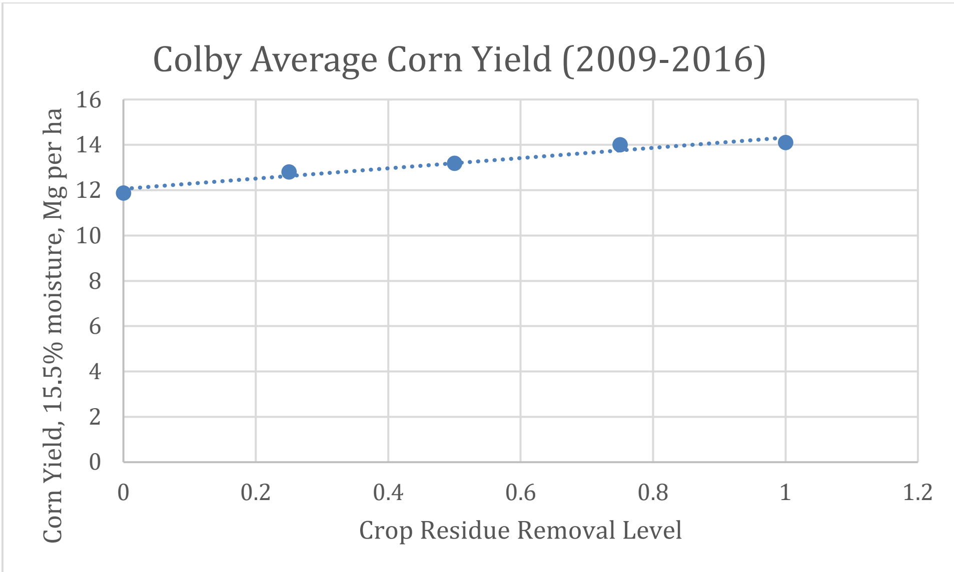
Ottawa site, differences in crop yields were observed in 2009, 2010, and 2015, when crop yields increased with increasing residue removal. Soil organic C has been measured multiple times during the experiment. Relative to the 2009 baseline levels of soil organic C in the upper 10 cm of the soil profile, at the Colby location, the 0, 25, 50, and 75% removal levels sequestered soil organic C, and the 100% removal level maintained soil organic C at the 2009 level. At the Ottawa site, the 0% removal treatment sequestered soil organic C while all other removal levels declined in soil organic C content over the 2009 to 2017 period.

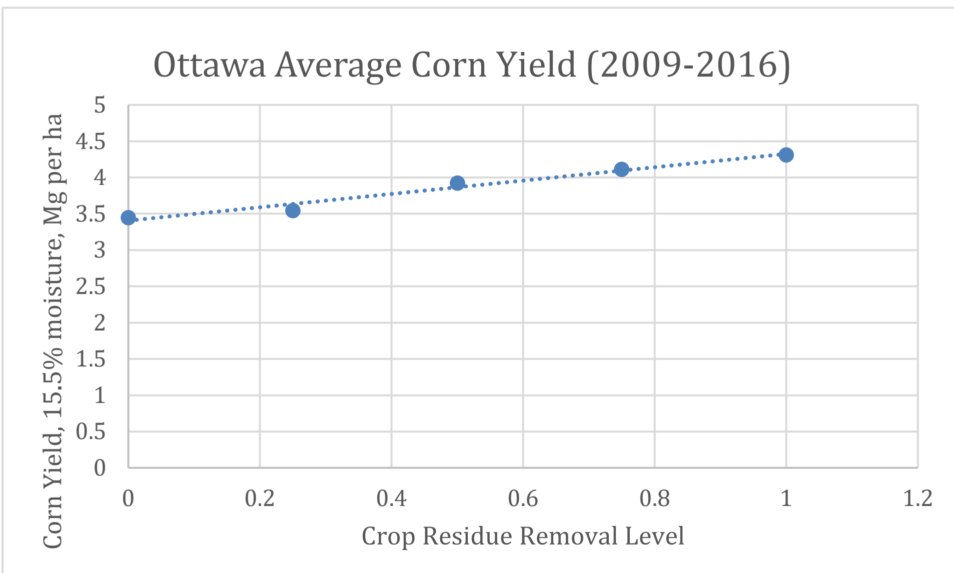
Table 1. Corn yields 15.5% moisture, Mg ha^{-1}, 2009-2016. Letters denote statistical differences among treatments within each site year ($p<0.05$).

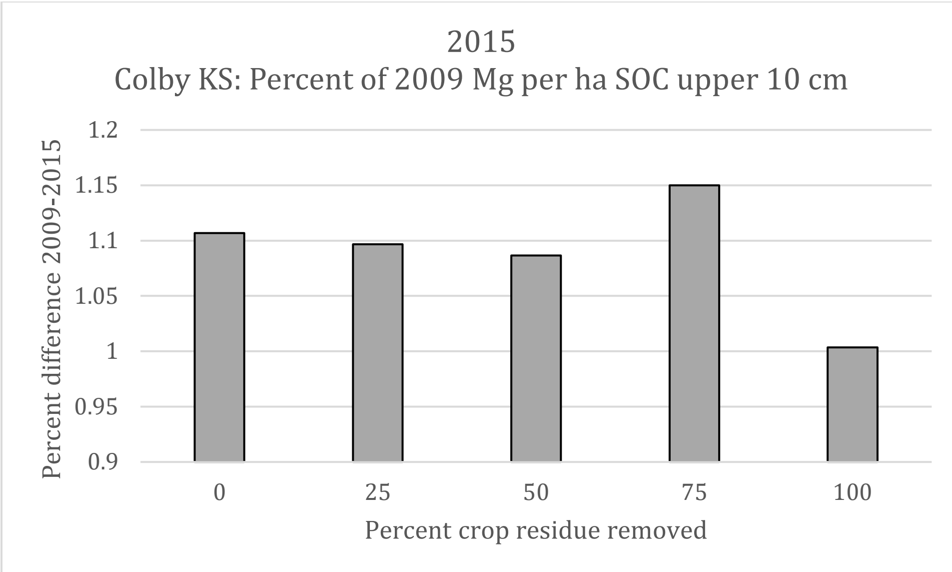
Time	Removal Level	**Colby**		**Ottawa**	
2009	0%	13.11	b	7.49	bc
	25%	16.48	ab	6.32	c
	50%	17.86	a	7.96	ab
	75%	18.14	a	8.08	ab
	100%	17.32	a	9.43	a
2010	0%	13.48	ab	4.41	c
	25%	12.59	b	4.40	c
	50%	14.41	ab	4.59	bc
	75%	15.89	a	5.56	a
	100%	15.72	a	5.33	ab
2011	0%	6.73	a	0.88	a
	25%	8.81	a	1.05	a
	50%	9.42	a	1.23	a
	75%	8.91	a	1.58	a
	100%	9.99	a	1.40	a
2012	0%	9.61	b	1.27	a
	25%	10.06	ab	1.59	a
	50%	11.01	ab	1.52	a
	75%	12.45	a	1.22	a
	100%	12.31	ab	1.72	a
2013	0%	12.33	b	9.22	a
	25%	13.98	ab	9.02	a
	50%	12.68	b	9.35	a
	75%	14.88	a	9.89	a
	100%	14.67	a	9.45	a
2014	0%	11.32	b	7.96	a

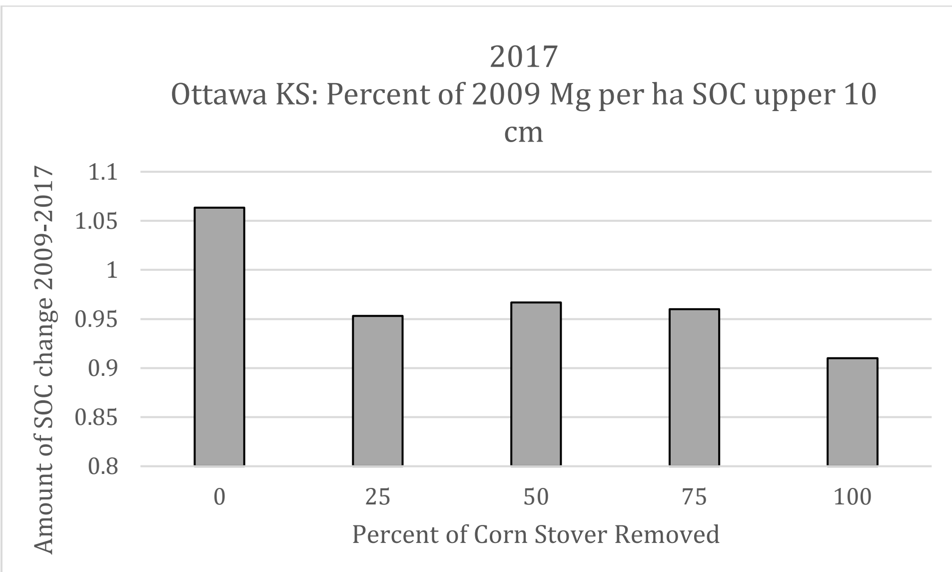
	25%	12.86	ab	7.84	a
	50%	11.79	b	8.85	a
	75%	14.14	a	8.46	a
	100%	14.01	a	9.86	a
2015	0%	14.7	a	6.77	b
	25%	13.1	a	8.14	a
	50%	13.3	a	8.71	a
	75%	13.0	a	8.53	a
	100%	13.3	a	8.32	a
2016	0%	11.8	a	8.6	a
	25%	12.7	a	9.0	a
	50%	13.1	a	8.2	a
	75%	12.7	a	8.6	a
	100%	13.6	a	8.0	a

Figure 1. Corn yields at 15.5% moisture, averaged by treatment 2009-2016.


Colby Average Corn Yield (2009-2016)
Corn Yield, 15.5% moisture, Mg per ha
16
14
12
10
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
Crop Residue Removal Level


Ottawa Average Corn Yield (2009-2016)
Corn Yield, 15.5% moisture, Mg per ha
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
1.2
Crop Residue Removal Level





5. Impact Statements:

- On average, crop residue removal has had no statistically significant effects on continuous no-till corn yields in this eight years, two site location study.
- Residue removal affected the soil organic C differently at the two sites. At Colby, the 0, 25, 50, and 75% removal levels sequestered soil organic C between 2009 and 2015. At Ottawa, only the 0% removal level sequestered soil organic C, while all other removal treatments lost soil organic C between 2009 and 2017.

6. Published Written Works

He, Y., **D. Presley**, and J. Tatarko. 2017. Liquid N And S Fertilizer Solutions Effects On The Mass, Chemical, And Shear Strength Properties Of Winter Wheat (Triticum Aestivum) Residue. Trans. Am. Soc. Ag. Eng. 60: 671-682.

Wills, Skye A., Candiss O Williams, Michael C Duniway, Jessica Veenstra, Cathy Seybold, and **DeAnn Presley**. 2017. Chapter 18, Human Land-Use and Soil Change. Pages 351-371. In: Soils of the USA. Eds. L.T. West, M.J. Singer, and A.E. Hartemink. Springer.

7. Scientific and Outreach Oral Presentations:

1. July 12-15, 2016. Soil salinity and sodicity. KARA Summer Field School. Manhattan, KS. 100 attendees.
2. August 16, 2016. Cover crops and soil health. Cheney Reservoir meeting near Hutchinson, KS. 80 attended.
3. September 7-8, 2016. Kids Field Day. 644 kids, 54 adults.
4. September 20, 2016. Cover Crops. Columbus Field Day, Columbus, KS. 80 attendees.
5. October 5, 2016. Soil Health Boot Camp. Liberal, KS. 11 attended.
6. October 7, 2016. Navigating Tenure, KAWSE panel. 15 attended.
7. November 16, 2016. Cover crops for soil health and forage. Milford Lakes Watershed Restoration and Protection Strategies. Concordia, KS. 12 attended.
8. November 17, 2016. Cover crops for soil health and forage. Southwest Kansas cover crop field tour. Jetmore, KS. 90 attended.
9. December 13, 2016. Cover crops for soil health and forage. Kansas Forage and Grassland Council annual conference. Wichita, KS. 60 attended.
10. December 15, 2016. Cover crop research update. Kansas Alliance of Wetlands and Streams, Wolf Creek Nuclear Operating Center, New Strawn, KS. 12 attended.
11. December 21, 2016. Effects of crop residue removal on soil properties. Southwest Area Agronomy Update. Garden City, KS. 30 attended.
12. January 5, 2017. Cover crops for soil health and forage. KARA Winter Conference. Junction City, KS. 120 attended.
13. Presley, D. (2017, January). Cover Crops. Presented at the Cover Crops Informational Meeting, Lincoln, KS. 20 attended.
14. Presley, D. (2017, January). Cover Crop Impact on Subsequent Crop Yields. Presented at the Coffee Shop Agronomy, Leonardville, KS. 20 attended.
15. Presley, D. (2017, February). Soil Management with Cover Crops. Presented at the Western Kansas Forage Conference, Larned, KS. 50 attended.
16. Presley, D. (2017, March). Cover Crops and Soil Properties. Presented at the Ag Producers Update For 2017, Lyons, KS. 45 attended.

8. Fund leveraging:

a. National Science Foundation Grant: "REU Site: Summer Academy in Sustainable Bioenergy; NSF Award No.: SMA-1359082, awarded to Kansas State University. $10,000.
b. Grant: United States Department of Energy: Enabling Sustainable Landscape Design for Continual Improvement of Operating Bioenergy Supply Systems. Total award $9 million, sub-award to Kansas State University $125,000.

9. Other Activities:

Graduate Students:

1. Abdulaziz Alghamdi, Ph.D. awarded December 2016.
2. Cathryn Davis, M.S. awarded December 2016.

NC1178 2016 Report

Residue grazing and baling of corn residues: Implications on soil ecosystem services

Humberto Blanco, Associate Professor

Department of Agronomy and Horticulture, University of Nebraska-Lincoln

1. **Impact Nugget**:
   Corn residue grazing and baling increased soil compaction at some sites, however the compaction levels were not high enough to effect crop yields. Baling increased wind erodible risk at two out of the five sites while grazing had no effect. Residue baling and grazing had no effect on soil nutrients. Carbon dioxide emissions were lower with baling compared to grazing and control in spring.

2. **New Facilities**:

3. **Unique Project Related Findings**:
   Corn residue grazing may not drastically change soil properties and the impact, if any, is not large enough to cause any degradation of soil quality and soil ecosystem services. Residue baling may increase risks of wind erosion.

4. **Accomplishment Summary**:
   In 2016, field measurements and soil sampling was done on five farm-scale crop residue grazing and baling experiments established in fall 2013. Soil properties related to compaction, wind and water erosion, soil water and temperature regime were measured. In addition, data was collected for soil compaction, soil temperature, soil water content and gas fluxes (CO_2) on bi-monthly basis in spring and at monthly interval in summer and fall at one of the experimental site.

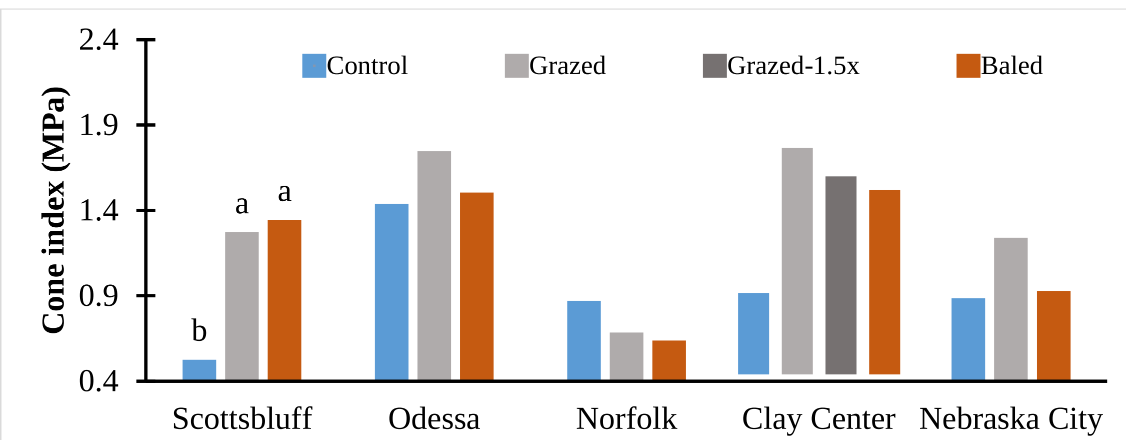


Fig.1 Impact of residue grazing and baling on cone index at five sites located in NE.

Soil compaction parameters such as cone index and bulk density showed that grazing and baling had some effect on soil compaction. Cattle grazing significantly increased compaction at Scottsbluff while the compaction level at other sites was not statistically significant (Fig. 1). Compared to control, cone index was about two times higher with grazing (1.3 MPa) and baling (1.27 MPa) of corn residues at the Scottsbluff site. Similarly, bulk density was significantly higher (~1.1 times) for grazing treatment compared to control at Nebraska City, Clay Center, and Scottsbluff site, while bulk density of baling treatment was significantly different at only Scottsbluff site. The threshold level of penetration resistance value to negatively affect yield is >2 MPa, while that level for bulk density is 1.6 g/cm^3. In this study, cattle grazing and baling caused some compaction, the values were however, below the threshold levels and are not expected to have detrimental effects on crop yields.

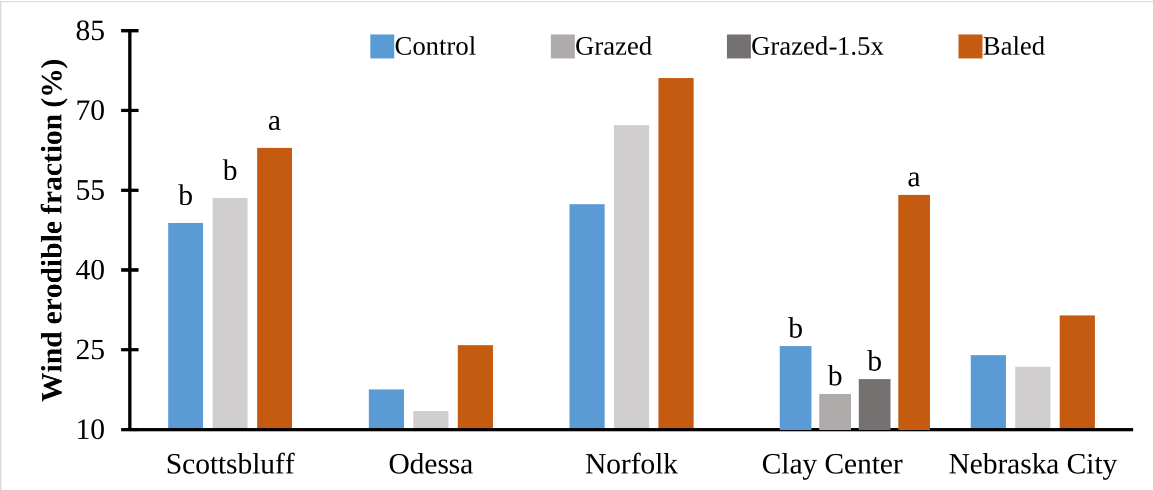


Fig.2 Impact of residue grazing and baling on wind erodible fraction at five sites in NE.

The wind erodible fraction of soil (< 0.84 mm aggregates) was determined at all sites to evaluate the wind erosion risk by cattle grazing and baling of residue. Baling decreased the stability of aggregates and had more susceptibility of wind erosion compared to control at Scottsbluff and Clay Center site (Fig. 2). Compared to control, the wind erodible fraction of baled treatment was 2.3 times higher at Scottsbluff and 1.2 times higher at Clay Center. Grazing did not affect wind erodible fraction.

Soil temperature in spring differed among baling, grazing, and control treatments at three out of five sites. Control treatment had the lowest temperature (~3 ^{o}C less than baled) as compared to baling and grazing treatment. Results indicate that presence of residue acted as mulch to prevent direct exposure of soil surface to sun radiations. Percent crop residue cover was negatively correlated with soil temperature data. Temperature of the soil in spring time increased as residue cover decreased.

Corn residue grazing and baling showed no significant effect on soil nutrients. Results suggest that, in the short-term, cattle grazing may not rapidly change soil fertility status and soil organic C pools.

Results of temporal measurements of carbon dioxide emissions at Clay Center showed that grazing and baling had similar cumulative CO_2 emissions. Averaged across the seasons, baling showed significantly lower emissions than control and grazed plots during the spring. The lower CO_2 fluxes (control ≥ grazed > baled) in baled plots could be due to less substratum available for microbial activity to release CO_2.

5. **Impact Statements**:
    - Residue grazing have small or no effects on soil compaction, wind erosion risk, nutrients and carbon dioxide gas emissions.
    - Residue baling may increase risks of wind erosion and decrease carbon dioxide emissions.
    - Residue grazing can be an important strategy to obtain additional ecosystem services from cropping systems, however the practice of baling might not be a sustainable residue management strategy.

6. **Published Written Works**

Rakkar, M.K., H. Blanco-Canqui, M.E. Drewnoski, J.C. MacDonald, T. Klopfenstein, and R.A. Drijber. 2017. Impacts of cattle grazing of corn residues on soil properties after 16 years. Soil Sci. Soc. Am. J. 81:414-424.

Blanco-Canqui, H., B.J. Wienhold, V.L. Jin, M.R. Schmer, and L.C. Kibet. 2017. Long-term tillage impact on soil hydraulic properties. Soil & Tillage Research 170:38-42.

Blanco-Canqui, H. and C.A. Francis. 2016. Building resilient soils through agroecosystem redesign under fluctuating climatic regimes. J. Soil Water Conserv. 71:127A-133A.

Blanco-Canqui, H. 2016. Growing dedicated energy crops on marginal lands and ecosystem services. Soil Sci. Soc. Am. J. 80: 845-858.

7. **Scientific and Outreach Oral Presentations:**

- ASA-CSSA-SSSA Conference, Phoenix, AZ. 6-9 Nov,2016
  Poster presentation: Regional Assessment of Cattle Grazing and Baling of Corn Residues in Nebraska: Implications on Soil Ecosystem Services. Soil and Water Conservation division.
- Field days entitled ' Understanding the impacts of grazing and baling corn residue on subsequent crop yield across soil types with different erosion potential' were organized at five different locations:
    1. Ainsworth: September 27, 2016
    2. Norfolk: September 27, 2016
    3. Clay Center: September 28, 2016
    4. Odessa: September 28, 2016
    5. Nebraska City: October 20, 2016.

8. **Fund leveraging:**

9. **Other Activities:**

NC-1178 Annual State Report

Year: 2017
Institution: North Dakota State University
Committee Representative: Larry Cihacek

1. Impact Nugget:

- End of season soil profile N was 15.5 kg/ha greater following hard red spring wheat (HRSW) in an integrated crop-grazing rotation than under continuous production. This is equivalent to a 5-6 bu. /a greater wheat yield potential in the rotational system. Legumes and cover crops in the rotational system enhance N mineralization in the soil.
- Phosphorus (P) availability from grain distillers byproducts showed that condensed distillers solubles (CDS) had a high immediate P availability which declined during the early part of laboratory incubation but increased again after 14 days. Prolific growth of *Mucorales* spp. within 3 days may be causing P immobilization.

2. New Facilities and Equipment:

   None

3. Unique Project Related Findings:

a. Evaluation of N mineralization and cycling in a long-term integrated crop-grazing system in western North Dakota over a 5-year period showed consistently higher growing season plant available N levels in the soil profiles of wheat grown in the rotational HRSW plots than in continuously cropped HRSW plots. Over the 5–year period, N fertilizer recommendations to achieve desired yield goals based on soil tests have declined in both the rotational and continuous HRSW. However, the recommended N rates declined more rapidly in the rotational plots than in the continuously cropped HRSW plots. No additional fertilizer N was recommended for the continuous HRSW plots for the last two growing seasons and for the rotational HRSW plots for the last 3 seasons.
b. Evaluation of ethanol distiller's by-products as sources of plant available nutrients has shown that these by-products contain useful amounts of nutrients. Fifty-six day laboratory incubations of CDS showed that plant available P (Olsen extractable P) declined for the first 14 days of the incubation but increased through the remainder of the 56 day period. However, at 56 days, the average plant available P was still 29% lower than the initial amount of P at the beginning of the study. A vigorous growth of fungal material was observed on the samples receiving the CDS treatments. These were identified as *Mucorales* spp. or common bread mold. The reduced levels of plant available P at the end of the study period suggest that incubations may need to be

conducted for longer periods of time and that missing P is likely immobilized in the soil microbial biomass.

4. Accomplishment Summaries:

Currently work is still continuing on the integrated crop-grazing rotation system study and will continue for at least two more years. N mineralization studies on distiller's by-products have been completed and the data is currently being summarized.

5. Impact Statements:

- Integrating crops and grazing can reduce fertilizer N applications for various cash crops in the system, reducing production costs and improving soil health and production sustainability.
- Distiller's by-products contain useful levels of plant nutrients but the availability of the nutrients should receive the same considerations as applying plant nutrients with animal manures because of the need for mineralization of the nutrients form the solids.

6. Published Written Works:

Augustin, C, and **L. Cihacek**. 2016. Relationships between soil carbon and soil texture in the northern Great Plains. Soil Sci. 181:386-392.

Olson, K. R., M. Al-Kaisi, R. Lal, and **L. Cihacek**. 2016. Soil organic carbon dynamics in eroding and depositional landscapes. Open J. Soil Sci. 6:121-134.

Aher, G., **L. J. Cihacek** and K. Cooper. 2017. An evaluation of C and N of fresh and aged crop residue from mixed long-term no-till cropping systems. J. Plant Nutr. 40:177-186.

7. Scientific and Outreach Oral Presentations.

Cihacek, L. J. 2016. Building soil organic matter for increased nutrient cycling and crop production. August 25, 2016. Building for the Future: Beef and Forage Field Day, Dickinson Research Extension Center Ranch Headquarters, Manning, ND. (*Oral, invited*).

Landblom, D. G., S. Senturklu, **L. Cihacek** and E. Brevik. 2016. Effect of a 5-year multi-crop rotation on mineral N and hard red spring wheat yield, protein, test weight and economics in western North Dakota, USA. Abst. No. EGU2016-17807. Abst. of the European Geosciences Union (EGU) Meetings, April 17-22, 2016, Vienna, Austria.

Landblom, D., S. Senturklu, **L. Cihacek**, and E. Brevik. 2017. Integrated systems mitigate land degradation and improve agricultural system stability. Abst. No. EGU2017-11591.. Abst of the European Geosciences Union (EGU) Meetings, April 23-28, 2017, Vienna, Austria.

Cihacek, L. J. 2016. Building soil organic matter for increased nutrient cycling and crop production. August 25, 2016. Building for the Future: Beef and Forage Field Day, Dickinson Research Extension Center Ranch Headquarters, Manning, ND. (*Oral*, *invited*).

8. Funding Leveraging:

   None

9. Other Relevant Accomplishments and Activities:

   None

NC1178 2016 Report

Rattan Lal
Carbon Management and Sequestration Center
The Ohio State University
Columbus, OH 43210

1. **Impact Nugget**:

Complete residue removal adversely affected corn again yields at South Charleston and Hoytville sites. In comparison with the average yield of all other residue retention treatments, reduction in grain yield was 2.3 Mg/ha (~26.4%) at South Charleston and 0.7 Mg/ha (8.3%) at Hoytville. In addition, residue removal may also affect soil properties including soil organic carbon concentration, crusting, soil biota, and soil temperature.

2. **New Facilities**: None

3. **Unique Project Related Findings**:

The lowest crop yield (20% reduction) with complete residue removal at both sites is an important finding.

4. **Accomplishment Summary**:

The data on grain and stover yields and the harvest index [HI = grain yield / (grain + stover yield) × 100] are presented in Table 1 for South Charleston and Table 2 for Hoytville. Considering average across all treatments, grain yields were the same at 8.3 Mg/ha; stover yield was more at South Charleston (11.8 Mg/ha vs. 8.7 Mg/ha) but the HI was more at Hoytville (48.8% vs. 40.9%). The lowest corn grain yield for the 100% residue removal treatment was 6.4 Mg/ha for silt loam soil at South Charleston compared with 7.7 Mg/ha for a clayey lakebed soil at Hoytville. Because the stover yield was more at South Charleston (11.8 Mg/ha vs. 8.7 Mg/ha), the HI was more at Hoytville (48.8% vs. 40.9%). For both sites, the grain yield and the HI were the least for the 100% residue removal treatment. The difference between the lowest and the maximum grain yield (range) was higher (3.9 Mg/ha) for South Charleston than for Hoytville (2.0 Mg/ha). At South Charleston, the silt loam soil with low available waster capacity, the least HI of 30.8% for 100% residue removal indicates that photosynthates were not transferred to the grains because of drought or nutrient stress. The HI was also the lowest for the 100% residue removal treatment at the Hoytville site, but the large difference (45.1% vs. 30.8%) may be because of favorable AWC of the clayey lakebed soil at Hoytville.

Table 1. Residue management effects on corn grain and stover yields and the harvest index at South Charleston, OH in 2016.

Residues (% Retained)	**Yield (Mg/ha)**				**Harvest Index (%)**	
	Grain		**Stover**			
0	6.4		13.8		30.8	
25	7.5	Av. = 8.7	10.6	Av. = 11.4	40.7	Av. = 42.9
50	10.3		11.5		47.2	
75	8.5		12.0		41.0	
100	8.5		10.2		45.4	
200	8.7		12.7		40.4	
Average	8.3		11.8		40.9	

Table 2. Residue management effects on corn grain and stover yields and the harvest index at Hoytville, OH in 2016.

Residues (% Retained)	**Yield (Mg/ha)**				**Harvest Index (%)**	
	Grain		**Stover**			
0	7.7		9.4		45.1	
25	7.8	Av. = 8.4	7.8	Av. = 8.6	49.6	Av. = 49.5
50	8.0		8.6		48.3	
75	8.5		9.0		48.6	
100	8.2		8.5		49.2	
200	9.7		9.0		51.8	
Average	8.3		8.7		48.8	

The stover yield followed a pattern somewhat similar to that of the grain yield. The highest stover yield in both sites was observed in the treatment with 100% removal of crop residues. Yet, one of the lowest yield was also obtained in treatment with 25% of the residue retention. However, the second highest yield at both sites was obtained for the treatment receiving 200% of the crop residue (Tables 1 and 2).

Trends in the grain and stover yields in relation to the amount of residues retained/removed may be better understood in relation to soil properties. Therefore, periodic (every 2 to 3 year) measurements of soil properties in relation to residue retention is an important consideration.

5. **Impact Statements**:

- Residue management has a strong impact on grain and stover yields.
- The magnitude of yield-dependence on the rate of residue retention differs among seasons depending on the rainfall during the reproductive stage.
- Yield response to residue-removal is moderated by alterations in soil properties due to residue management.
- Residue mulching is an important component of climate-smart agricultural system

6. **Published Written Works**

Chambers, A. R. Lal, K. Paustian. 2016. Soil carbon sequestration potential of US croplands and grasslands: Implementing the 4 per Thousand Initiative. Journal of Soil and Water Conservation 71(3):68A-76A.

Nakajima, T., R.K. Shrestha and R. Lal. 2016. On-farm assessments of soil quality in Ohio and Michigan. Soil Science Society of America Journal 80(4): 1020-26. doi:10.2136/sssaj2016.01.0003

Nakajima, T., R.K. Shrestha, P.A. Jacinthe, R. Lal, S. Bilen, W. Dick. 2016. Soil organic carbon pools in ploughed and no-till Alfisols of central Ohio. Soil Use and Management, doi: 10.1111/sum.12305

Olson, K.R., M. Al-Kaisi, R. Lal, L. Cihacek. 2016. Soil organic carbon dynamics in eroding and depositional landscapes. Open Journal of Soil Science 6:121-134.

Olson, K.R., M. Al-Kaisi, R. Lal, L. Cihacek. 2016. Impact of soil erosion on soil organic carbon stocks. Journal of Soil and Water Conservation 7(3):61A-67A

Stout, B., R. Lal and C. Monger. 2016. Carbon capture and sequestration: The roles of agriculture and soils. International Journal of Agricultural and Biological Engineering 9, no 1: 1-8.

7. **Scientific and Outreach Oral Presentations:**

Lal, R. 2016. Soil C for Climate Change, Food Security and SDGs of the U.N. FACCE-JPI Meeting, Brussels, Belgium 30-31 May 2016.

Lal, R. 2016. Soil Health and Sustainability. GIFS Conference, Saskatoon, Canada, 14-16 June

Lal, R. 2016. Soil Science: Beyond Food and Fuel. IUSS InterCongress Meeting, Rio de Janeiro, Brazil, 20-25 November 2016

8. **Fund leveraging:** None

9. **Other Activities:**

Graduate Students:

1. Reed Johnson
2. Chris Eidson

2017 NC-1178 Annual State Report

Sandeep Kumar (Assistant Professor), Jose Guzman (Assistant Professor), and Kopila Subedi (MS Student) Department of Agronomy, Horticulture and Plant Science, South Dakota State University, Brookings, SD

1. **Impact Nugget**. Effects of residue and cover crop on soil hydrological properties, soil water storage, water use efficiency (WUE) and soybean yield in South Dakota was studied. This study showed that practices such as low residue removal and cover crops have positive impacts on soil hydrological properties. Low residue removal (LRR) with cover crops (CC) increased soil volumetric moisture content (VMC) and soil water storage (SWS) compared with high residue removal (HRR) with no cover crops (NCC) treatments. This study suggested that adopting cover crops practices can increase WUE by 13% and soybean yield by 14%.

2. **New Facilities and Equipment.** Soil auger and core samplers to analyze soil moisture determination and bulk density were purchased. Plastic rings were prepared and installed for testing the soil water infiltration.

3. **Unique Project Related Findings**. Prior to this year, the major focus of this project was to monitor changes in SOC and other chemical and biological properties in response to residue and cover crops under no-till system. This year the major focus was to monitor the changes on soil hydrological properties, soil water storage, WUE and soybean yield.

4. **Accomplishment Summaries.** In this project, data were collected for soil water infiltration and soil water retention in 2014 and 2015. Soil water infiltration was increased with LRR treatments by 66% and 22% in 2014 and 2015 respectively compared with HRR treatment. Similarly, cover crops (CC) increased soil water infiltration by 82 and 22% in 2014 and 2015 respectively compared with no cover crops (NCC) treatments. Significant impact of cover crops was also observed on soil water retention. For the soil volumetric moisture content (VMC) and soil water storage (SWS) determination data were collected from May through October. Data showed that LRR and CC treatments increased SWS and VMC compared with HRR and NCC treatments. In addition, CC treatment significantly increased soybean yield by 14% and water use efficiency (WUE) by 13% compared to NCC treatment. However, there was no impact of LRR treatment on soybean yield and WUE compared with HRR treatment.

5. **Impact Statements**. This research indicates that returning high rate of residue has huge impacts on soil hydrological properties. Addition of cover crops where high level of residue retention is not possible, can mitigate the negative impacts of residue removal by increasing WUE and grain yield of soybean crop.

6. **Published Written Works**.

MS Thesis by Kopila Subedi.

- Subedi-Chalise, K. "Impacts of Crop Residue and Cover Crops on Soil Hydrological Properties, Soil Water Storage and Water Use Efficiency of Soybean Crop" (2017). *Theses and Dissertations*. 1172. http://openprairie.sdstate.edu/etd/1172

7. **Scientific and Outreach Oral Presentations**.

Poster presentations

- Subedi- Chalise, K., Wegner, B., Ozlu, E., Sandhu, S., Osborne, S., and Kumar, S. (2015). Evaluating impacts of crop residue and cover crops on soil organic carbon and water infiltration. Poster presentation at ASA/SSA/CSSA annual meeting, November 15-18, Minneapolis, MN.

- Subedi- Chalise, K., Wegner, B., Osborne, S., and Kumar, S. (2016). Effects of crop residue and cover crops on soil bulk density and water infiltration. Research day at South Dakota State University, April 28, 2016.

8. Fund leveraging, specifically, collaborative grants between stations and members.

9. Other relevant accomplishments and activities

NC-1178 Project Station Report - 2017
University of Wisconsin-Madison
Francisco J. Arriaga

1. **Impact Nugget:**
The University of Wisconsin-Madison measured a 30% to 50% reduction in water runoff, sediment, and phosphorus losses when using a cover crop in dairy forage systems.

The University of Wisconsin-Madison recorded farmer cover crop use behavior, determining that some farmers are willing to make an economic investment in improving soil health and water quality, but others need economic incentives to adopt soil conservation practices.

2. **New Facilities and Equipment:**
An existing rainfall simulator was calibrated and tested, and minor repairs made. Laboratory and field consumable supplies were purchased

3. **Unique Project Related Findings:**
Quantified impact of tillage and cover crop on soil erosion and water quality in a dairy forage system (i.e. corn silage). Allowing the cover crop to grow for a longer period of time in the spring as a forage crop provides a potential feed sources for dairy, which should help management flexibility and risks in marginal production years.

4. **Accomplishment Summaries:**
A survey was created and distributed to various agricultural professionals in Wisconsin to determine if cover crops are a commonly used practice in the state, and to find the incentives or barriers for cover crop use. A total of 86% of respondents have used or currently use cover crops in their operation. The top benefit from using cover crops identified by 74% of participants was reducing erosion, followed by soil health improvements (58%). Those farmers that identified as not using cover crops selected the time/labor required (52%) and no measurable economic return (39%) as the main two deterrents for not using cover crops. Many participants, both cover crop users and non-users, expressed their desire to better understand how cover crops fit into their specific operation and how their use would affect the timing of other management practices.

Another portion of this work aimed to determine the ability of a cover crop to reduce runoff, sediment, and phosphorus losses. Two cover crop treatments (no cover crop as a control, and cereal rye as a cover crop) and two tillage methods (conventional tillage and no-tillage) were compared. Rainfall simulations were performed at three different times throughout the cropping cycle (April, June, and October). Regardless of tillage, treatments with cover crops reduced total runoff volume by 24%, sediment loss by 52%, and total phosphorus loads by 42% when averaged across rainfall simulation timings. Bioavailable P, which is closely linked to algae blooms in lakes and rivers, was reduced by 34% with the cover crop. Tillage had little impact on any parameters analyzed. In most of the Midwest, the majority of runoff and sediment losses occur when soils are thawing between March and May. During the April rainfall simulations, rye as a cover crop reduced runoff by 45.9%, sediment loss by 70.7%, Total P by 68.5% and Bioavailable P by 65.9%, suggesting that cover crops can play a significant role during such a vulnerable time of year.

5. **Impact Statements:**

The University of Wisconsin-Madison has measured a reduction of almost 50% in erosion when a cover crop is used in corn silage forage farming.

The University of Wisconsin-Madison found that a cover crop was effective in reducing phosphorus losses to the environment from farm fields by over 30%, thus reducing the potential for water contamination.

6. **Published Written Works:**
M.S. Thesis
Adams, L.C. 2017. Quantifying cover crops and reduced tillage impacts on corn silage production and water quality. M.S. thesis, University of Wisconsin-Madison.

7. **Scientific and Outreach Oral Presentations**:
Adams, L.C., and F.J. Arriaga. 2016. Benefits of cover crops in reduced tillage systems. Conservation Tillage Conference, Fargo, ND.

Adams, L.C., F.J. Arriaga, and M. Bertram. 2016. Integrating cover crops and no-tillage in a dairy forage rotation to improve yields and reduce runoff. Soil Science Society of America International Annual Meeting, Phoenix, AZ.

Arriaga, F.J., L.C. Adams, and M. Bertram. 2017. Tillage and cover crop impacts on runoff and soil health of dairy forage production systems. Soil and Water Conservation Society 72nd Annual International Conference, Madison, WI.

Arriaga, F.J., L.C. Adams, M. Stock, P. Vadas, L. Ward-Good, M. Bertram, and K.G. Karthikeyan. 2017. Can cover crops and tillage help reduce erosion and phosphorus losses? North American Manure Expo, Arlington, WI.

8. **Fund leveraging, specifically, collaborative grants between stations and members:**
Additional financial support for this work has been received for this work from the Agronomic Science Foundation, and the Monsanto Company.

9. **Other relevant accomplishments and activities:**
A graduate student worked on this research project as part of her M.S. degree requirements and successfully graduated.