Resilient Agriculture: Adapting to a Changing Climate

Poster Symposium

Building an Integrated and Sustainable Vision for Cropping Systems

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1. Modeling the Impacts of Climate Change on Midwestern U.S. Corn Yields

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Climate change is likely to have considerable effects on corn production in the Midwestern United States. The possible extent of change - because the U.S. produces ~40% of the world's corn - is crucial to both national and global interests. Despite projected increases in precipitation and CO_2 concentrations, it is hypothesized that the concurrent rises in temperature will reduce yields, given that corn's optimum growth temperature (84°F / 29°C) will be increasingly exceeded as end-of-century projections exceed 91°F (33°C) between 20-50 times per year, as compared to 5-25 times per year over the last century. Additionally, higher temperatures reduce the number of calendar days required to satisfy the number of growing degree days the plants require to reach maturity, thereby reducing the time spent in growth stages, including the grain filling period, further reducing yields. Using the most current climate change data, corn yields are modeled for 10 sites in the Sustainable Corn Project using the Systems Approach to Land Use Sustainability (SALUS) model to examine changes in heat stress, time to maturity, grain filling, and yields. SALUS calculates daily crop growth in response to changing climate, soil, and management conditions and is ideal for monitoring changes in growth and development in response to environmental changes. Finally, the wide range of locations in the Sustainable Corn Project allows the discernment of corn's region-specific vulnerabilities and growth characteristics that will need to be modified for growers to optimize yield in their region.

2. A Preliminary View of Multidecadal Corn Yields in Iowa at the County Level

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Favorable yields result from the influence of several factors; of which climate and management plays a substantial role. Previous attempts to assess the individual contributions of management and climate have proven limited, however, in reaching agreement about the true effects of one or the other on crop yields. The present research aims to identify whether the increasing corn yields in the last decades can be attributed to improved technology, or have been the result of direct climate action instead. From data collected from the National Agriculture Statistical Service (nass.usda.gov), we analyzed how yields have varied on a 40-year series of corn yields at the county level in Iowa. Also, I evaluated the percentage changes in yield experienced as time has gone by, and technology have progressed, since 1970 until 2010. Preliminary findings suggest that while yields have increased, the trends displayed over time might not be uniform, and may suggest different rates of technology adoption depending on the location. Posterior analyses might involve implementing clustering techniques in order to identify and group counties with similar yield trends over time. Finally, if the ultimate goal is to better discerning the true causes for crop performance variation over time, I suggest the use of additional statistical techniques that remove possible confounding effects in the data, such as hidden influence of yields in previous years on subsequent years, or variation due to geographical influence.

3. Regional Differences in Water Use by Corn Under Different Cropping Systems

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The United States Department of Agriculture (USDA) has identified the US agricultural base as potentially susceptible to changing climate conditions. In contrast to numerous and extensive agronomic studies of conventional crop rotations, there are only sparse data pertaining to multi-year crop rotations more common in organic agriculture. The objective of this field-based research was to quantify water budgets of diverse, multi-year organic and conventional crop rotations and identify which rotations are most resilient under various climate conditions. The data for this regional project come from two experimental sites, one located in southwest Minnesota and the other in east-central Ohio. Plot-scale experiments are being conducted using a combination of meteorological and field measurements to develop comprehensive water budgets for diverse crop rotations. Daily precipitation and minimum and maximum air temperature along with continuous soil temperature and volumetric soil water content data were collected to assess changes in soil water conditions from various crop rotations. Data presentation will focus on the corn component of each rotation. Information gained from this project will assist organic as well as conventional producers in making management decisions that will lead to increased water use efficiency (WUE) and improve long-term soil sustainability and resiliency. A key product from this study will be improved knowledge of diverse crop rotation performance under current and potential future climate scenarios.

4. Drainage Water Management Effect on Peak Drain Flows During Rainfall Events

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Drainage water management, the practice of raising the drainage outlet at times when maximum drainage of a field is not necessary, can be used to conserve drainage water and reduce nitrate loads from agricultural fields. This study investigated reductions in peak drain flow during rainfall events due to drainage water management, which could contribute to reducing downstream flooding. A 40-acre field at the Davis Purdue Agricultural Center (DPAC) in eastern Indiana is divided into four quadrants, of which two have drainage water management installed and two are conventionally drained. Twenty-two drainage events in 2012 and 2013 were identified and analyzed. Drainage water management reduced peak drain flow by 16-29%, with the reduction varying for different precipitation events. In addition, the time between the start of rainfall and the peak drain flow ("time to peak") increased in managed quadrants compared to free-draining quadrants, meaning that the highest drain flow rates would reach the ditch or stream more slowly, further reducing flood peaks. However drainage water management resulted in more days when the water table was above the ground surface, which suggests the potential for increases in surface runoff, not measured in this study. Some of the ponded water remained on the field in surface depressions, eventually infiltrating in place, so did not increase runoff. Geospatial analysis of LiDAR (Light Detection and Ranging) elevation data is being used to quantify depression storage volumes, which will help estimate the overall downstream effects on flooding from the combination of potential increased surface runoff and reduced drain flow peaks.

5. Controlled Drainage Reduces Nitrogen and Phosphorus Loading in the Lake Erie Watershed

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Currently, more than 750 aquatic systems around the globe suffer from water quality impairments such as hypoxic "dead zones" and harmful algal blooms. These issues are caused by high levels of nitrogen and phosphorus in surface water. In northwest Ohio, agriculture is a primary source of excess nutrient with applied nutrients moving into surface water via subsurface drainage. Recent algal blooms in Lake Erie are an example of these issues and have been linked to high loads of dissolved phosphorus from agricultural non-point sources. One suggested management practice to reduce agricultural nutrient loss is controlled drainage which allows farmers to control field water levels and the volume of water released through subsurface drains. While controlled drainage has been shown to successfully reduce nitrate loading its impact on phosphate loading has rarely been monitored. This study analyzed the export of dissolved phosphorus and nitrogen at six fields with paired controlled and uncontrolled drainage systems in the southwestern Lake Erie watershed. Drainage volume was measured continuously during the sampling period to quantify the volume reduction through the use of controlled drainage. Nutrient concentrations and the volume of water released from subsurface drains were used to estimate nitrate and phosphate loading rates from controlled and uncontrolled drainage systems. By reducing drain flow, controlled drainage reduced loading of dissolved phosphorus and nitrogen. These results show the potential for controlled drainage to reduce losses of phosphorus and nitrogen from row crop production.

6. Effects of Drainage Water Management on Crop Yield, Drainage Volume, and Nitrate Loss in South Eastern Iowa

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Subsurface drainage removes excess water from agricultural land, especially during the rainy spring months when the timeliness of field operations, such as planting, are important. The objective of this study was to determine the impact of shallow drainage, controlled drainage, conventional drainage, and no drainage on crop yields, depth to water table, subsurface drainage volumes, and nitrate loss through subsurface drainage. This research was conducted at the Iowa State University Southeast Research Farm near Crawfordsville, Iowa. There are eight plots so that there were two replicates for each of the four treatments. Each plot had half of the plot in beans and half to corn, and the halves were rotated every year in accordance with a typical corn-soy rotation. While there were no significant yield differences in either corn or soybeans between the management types, in years with high rainfall, there was a significant yield reduction in both corn and soybeans in the undrained plots. The undrained plots also tended to have a water table closest to the soil surface, which can impact field operations. In every year, the conventionally drained plots lost both the highest volume of subsurface water and the most nitrate. This study highlights the importance of drainage water management for maintaining crop yields and reducing nitrate export. With increasing concern on nitrate loss to downstream waters this study highlighted that controlled and shallow drainage have the potential to significantly reduce nitrate export.

7. Effects of Nitrogen Application Timing, Tillage Systems and Winter Cereal Rye Cover Crop on Corn and Soybean Yields and Nirate-Nitrogen Concentrations From a Tile-Drained Field in Iowa

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In field practices including nutrient management, tillage and alternative cropping systems are a promising way to reduce nitrate-nitrogen (NO_3-N) export from tile drained agricultural fields. The specific objective of this study was to determine the effects of nitrogen fertilizer application timing (spring versus fall), different tillage practices (conventional tillage versus no-till) and cover cropping systems (with and without winter rye cover crop) on NO_3-N leaching concentrations along with potential impacts on crop yield. The field experimental study was conducted at the Gilmore City Research Facility, Iowa, from 2011 to 2013. The treatments investigated at the research site consist of 8 plots with a corn-soybean rotation, where 4 plots are in corn and 4 in soybeans each year. Continuous flow measurements and composite water samples were used to quantify NO_3-N concentrations and loss with drainage from the representing treatments. The results indicate that average annual NO_3-N concentrations exceeded or were slightly below 0.0013 ounce per gallon (10 mg/L) in all years from systems where corn and soybeans are grown without cover crops. Averaged over 3 yr, the winter cereal rye cover crop showed potential to reduce nitrate-N concentrations in the subsurface drainage by 46% and 29% after soybean and corn, respectively. Also, the no-till systems have NO_3-N concentrations that are tending to be lower than the conventional tillage systems. Timing had little impact on NO_3-N concentrations. Due to plot-to-plot flow variability, in general there are few significant differences in nitrate-N losses between the treatments and flow-weighted nitrate-N concentrations are likely a better measure of treatment performance. Overall, corn yields were generally better on the chisel plow treatments without rye cover crop. Overall these results highlight that in-field management can impact NO_3-N concentrations leaving subsurface drainage systems.

8. Effects of a Cereal Rye (*Secale Cereale* L.) Cover Crop on Soil Properties and Crop Productivity in Southeast Indiana

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Throughout the Midwestern United States, the use of cover crops in corn-soybean (*Zea mays* L. – *Glycine max* L. Merr.) rotations is becoming a popular way to improve soil properties and increase cash crop productivity. The Sustainable Corn Project recognizes the benefits of cover crops and is measuring their ability to increase soil organic matter, retain nutrients, reduce off-field nitrogen (N) losses, and ensure crop productivity under various climatic stresses. A field site was established in 2011 at the Southeast Purdue Agricultural Center (SEPAC) in Butlerville, Indiana to study the effects of a cereal rye cover crop on a corn-soybean rotation system in no-till. The cover crop is grown after both corn and soybeans and is compared to control plots with no cover crop. Soil and crop measurements are being taken over a five-year period to evaluate potential changes in the system with time. Cereal rye biomass ranged from 570 to 4000 pounds/acre in the spring prior to termination, depending on the year and termination date. Cover crop growth is being measured to determine the potential for build-up of soil organic matter. The cereal rye biomass contained 14 to 100 pounds of N/acre. Some of the N scavenged by the cover crop would otherwise have been subject to leaching losses, whereas the cover crop retains the N for potential later use by the cash crop or for building soil organic matter. Soil aggregate stability values have been consistently higher on plots with cover than plots without. Greater aggregate stability is usually related to less erosion, increased water infiltration, greater water-holding capacity, and less surface crusting. Thus far, cash crop yields have not shown statistically significant differences between treatments. Data will be presented from the first three years of this project.

9. Effect of Tillage, Cover Crop and Corn-Soybean Rotation on Soil Pore Space Indices

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Knowledge of the impact of soil management practices on soil properties is important in farm management. We studied the effect of tillage (no-till vs conventional tillage), cover crop (no-rye vs rye) and crop rotation (continuous corn, continuous soybean, corn-soybean and soybean-corn) treatments on soil pore space indices: the relative gas diffusion coefficient (Ds/Do) and the pore tortuosity factor (T). The study was conducted in 2011 and 2012 on a silt loam soil at Freeman farm of Lincoln University, Jefferson City, Missouri. Soil samples were collected from four depths: 0-3.93 in (0-10 cm), 3.93-7.87 in (10-20 cm), 7.87-15.74 in (20-40 cm) and 15.74-23.62 in (40-60 cm) and their fresh weights recorded. Those samples were later oven dried at 221°F (105°C) for 72 h. After drying, soil air content and other soil properties were calculated. Results showed that either tillage or cover crop or crop rotation alone did not affect the relative gas diffusion coefficient. However, cover crops were significantly affected by the pore tortuosity factor. Plots with cover crops and crop rotation either increased or decreased gas diffusion and soil pore tortuosity. Similarly, plots with cover crop and tillage management also increased or decreased gas diffusion and soil pore tortuosity. Thus we concluded that the relative gas diffusion coefficient and pore tortuosity factor can be used to assess the impact of soil management practices on soil physical properties.

10. Corn Yields Following Rye Cover Crops in Fields with Diverse Terrain

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Cereal rye (*Secale cereal* L.) is a cover crop with great potential for the use in the Midwest but it has been shown to affect subsequent corn (*Zea mays* L.) yield in both positive and negative ways. Allelopathic effects of rye resulting in reduced corn yields have been well documented and farmers are warned to wait at least 10 days before planting a corn crop. Greater stress in important soil properties can lead to intensified allelopathic effects. Terrain strongly influences many important soil properties, e.g. SOM, water infiltration, soil texture, and thus we hypothesized that it can also influence how rye cover affects subsequent corn crop. Yield variability attributed to topography can vary year by year under different management practices. The objective of this study was to quantify the yield differences in corn between plots with and without rye cover crop at three contrasting topographical positions, i.e. summit, slope, and depression. Data from two years of rye and corn yields from four different research locations in three different states were analyzed in this study. Terrain influence on the rye cover crop differed from its influence on the main corn crop. e.g., rye biomass in spring prior to cover crop termination tended to be higher on summits, while the highest corn grain yields were observed in topographical depressions. We found that the differences in corn yield between plots with and without rye cover different among different topographical positions. Specifically, the reduction in corn yield due to rye presence was the highest in the depression. However, in summits and slopes there were no sizable yield losses due to rye presence, and sometimes there were even yield gains. These trends were consistently observed in all studied locations of both studied years.

11. Using Computed Microtomography to Look at Cover Crop Effects at the Soil Aggregate Scale

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Soil quality is of utmost importance to sustainable agriculture. Soil organic matter (SOM) is a key component of soil quality as it affects soil aggregation, cation exchange, soil water holding capacity, and several other soil quality attributes. Increasing SOM is one of the well documented benefits of including cover crops in crop rotations, but how and why is currently unknown preventing optimum cover crop strategy development. Most of the newly added SOM is stored within soil aggregates, but studying intra-aggregate structure has been extremely difficult. The advent of computed microtomography (µCT) allows for the in situ and non-destructive study of soil aggregates at the microinches (micrometer) scale. Gray scale values (GSVs) from images of scanned soil aggregates are related to different structural components of the aggregates, such as mineralogy, pore/void space, density, and SOM presence/amount. SOM is less dense than the mineral phase, thus greater presence of SOM can be expected to produce somewhat lower GSVs in the aggregate µCT images. The objective of this study is to examine the effect of long term (>20 years) presence of cover crops in agricultural rotations on intra-aggregate spatial patterns. Using geostatistical techniques, a graph showing how the aggregate differs over distance called a variogram is produced. Different components of this graph were compared for 5 different subsamples from 11 aggregates from each treatment, namely, corn-soybean-wheat rotation managements with and without cover crops. The analysis indicates that there is more variability in aggregates under cover crop management. Since the aggregates have identical mineralogies and densities, intra-aggregate distribution of SOM is assumed to be one of the leading factors in spatial variation of GSVs. We suggest that greater variability in intra-aggregate distribution of SOM is one of the components contributing to greater SOM protection and accumulation in soils under prolonged management with cover crops.

12. Cover Crop and Ridge Tillage Effect on Greenhouse Gas Emission at Diverse Agricultural Landscapes

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Most of agricultural practices in conventional cropping systems contribute to greenhouse gas (GHG) emission that causes global warming and climate changes. As a result introducing cover crop and ridge tillage system to conventional cropping systems are some of the strategies to adapting and mitigating climate changes. Because cover crops enhance soil carbon sequestration and soil health, reduce amount and cost of nitrogen fertilizer and herbicides used, prevent soil erosion, conserve soil moisture, and protect water quality and improve overall crop productivity. Similarly, ridge tillage is one of the tillage systems currently practiced in corn and soybean based systems of Midwest USA for early planting in poorly drained soils, reduce erosion when used on contour, conserve soil moisture, concentrate plant nutrients for growing plant and reduce cost of production and weed infestation as compared to conventional tillage system. However, the actual benefits of cover crops and ridge tillage can depend on soil type, topographic position, type of agronomic managements and climatic conditions. Topographic positions, particularly, can affect most of environmental and economic benefits of cover crop and ridge tillage system. Thus the objective of this study was to evaluate the effects of cover crop and ridge tillage on greenhouse gas emission at diverse terrains of agricultural landscapes. Field experiments have been established at two research fields of Michigan State University: Kellogg Biological Station (KBS) and Mason in 2011. The treatments of the study consisted of two tillage systems (chisel and ridge) as main plots; and rye cover crop (cover and no cover) as sub plot at depression, slope and summit

topographic positions. Topographic positions significantly affected the performance of rye cover crop and GHG emissions. The performance of cover crop was poor at depression although the highest carbon dioxide (CO_2-C) and nitrous oxide (N_2O-N) emission were measured at this position. The presence of rye cover crop also significantly increased CO_2-C emission but did not affect N_2O-N emission. The CO_2-C and N_2O-N emission were higher in ridge tillage than that of chisel tillage at most of topographic positions, and soil temperature also significantly contributed to CO_2-C emission at submit and depression. The results of the present study highlight the importance topographic positions, soil temperature and inherent soil characteristics on performance of rye cover crops and GHG emission in corn-soybean rotation system.

13. Early Cover Crop Planting Effects on Crop Yields and Environmental Benefits

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We seek to evaluate long-term cover crop impacts on corn-soybean rotations in the Midwest using a cropping systems model. During calibration we tested model performance for the corn, soybean and wheat (to represent a winter rye cover crop) crop modules as well as soil temperature and soil water components. Initial calibration and validation results found acceptable agreement comparing field data to model predications. Interview data from the Sustainable Corn project indicates that farmers in Iowa specifically name cover crop fall establishment as a major management challenge. Therefore, we set up a simulation with the calibrated model to investigate how an earlier planting date impacted cash crop yield, cover crop biomass accumulation and subsequent environmental benefits. Only minor to positive cash crop yield changes were predicted for the five sites across the state of Iowa that we established. An earlier planting date of September 1st (versus late September) doubled winter rye biomass and led to significant improvements in nitrate retention and erosion prevention. Although more work is needed this is a promising approach to evaluate the Sustainable Corn research sites across the Midwest.

14. Life Cycle Assessment of Corn-Based Cropping System With and Without Cover Crop

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Life cycle assessment (LCA) is a widely used approach that can evaluate the performance of a product or service in term of mass and energy inputs, and the environmental impacts involved in each stage throughout the life cycle. The objective of this study is to assess the environmental trade-offs of including a winter rye cover crop in the corn-soybean rotation from a life cycle perspective, and to compare the trade-offs both within a single site and across the study sites in different geographical locations. No-till corn-soybean rotation with and without cover crops at four experimental sites were included, in the treatment with cover crop; rye was planted right after both corn and soybean and terminated two weeks before the planting of the main crop without removing any residue. The analysis was performed by a cropping-system based "cradle to gate" LCA tool with the field edge as its system boundary. Impact categories considered were: crop yield energy balance, trace gas fluxes, nutrient loss, and soil erosion.

Based on my analysis, it was found that growing winter rye cover crops can offer multiple benefits without affecting the crop yield. The cover crop practice is promising in reducing soil loss, nutrient loss and trace gas fluxes, the effectiveness of cover crops varies with from site to site depends on the climate, soil conditions and crop productivity. In contrast to the environmental benefits, approximately 0.9 ~ 2.0 mmBTU (946 ~ 2136 MJ/acre) of additional energy was consumed by the management of cover crop practice, which reveals the importance of cost-sharing or subsidies from government to counterbalance the adopting cost and motivate the application of winter cover crop

15. Corn Belt Farmers' Perception of Soil Health and Cover Crop Adoptions (Benefits and Barriers)

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Climate change is likely to increase the variability of weather, including more frequent floods, droughts and severe weather events with greater erosion across the Corn Belt. Although practices designed to improve soil health and reduce erosion have been researched and developed, most are not being implemented on a large enough scale across the Midwest. Upon conducting a literature review, the research team found that little data has been collected on farmers' perceptions of soil health outside of Romig's "Farmer-Based Assessment of Soil Quality: A Soil Health Scorecard" (1996). Even less research had been conducted on farmers' motivations for adopting cover crops. This study focuses on soil health assessment and cover crop adoption as two key emergent themes from in-depth interviews with farmers conducted across the Corn Belt. First we explore how farmers assess soil health on their farms and what motivates them to manage for improved soil health. Preliminary results suggest that farmers assess their soil through observing/testing soil texture, nutrients in the soil, infiltration capacity, soil organic matter, crop performance, and soil structure. Additionally, cover crops are likely to have soil health benefits and play an important role in farmer adaptation to increased weather variability. We explore what farmer interview participants think about

the benefits of cover crops and barriers to their adoption. Some preliminary results suggest that the major barriers to farmer adoption of cover crops include the timing of management (specifically fall planting), the costs of planting and terminating, fall stand establishment, spring burn down and general uncertainty about the technology. On the other hand, farmers saw many potential benefits of cover crops, listing erosion control, improved soil health, efficient nutrient management, and many other gains associated with using cover crops.

16. Grazing Cover Crops: Lesson Learned

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Grazing cover crops is a good means to put weight gains on cattle, sheep and goats when winter pasture is limited. There are many rewards with grazing cover crops, but also many pitfalls. Maintaining animal body condition score through the winter is one of the rewards, as is resting permanent pastures and allowing them to rejuvenate without grazing pressure. Among the negatives of cover crop grazing are increased weed presence when compared to non-grazed cover crops; getting into fields as timely as non-grazed fields; and soil compaction around congregation points. Tillage may be necessary to address soil compaction issues.

17. Effects of Surface Topography on Nitrogen Transport

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The movement of nitrogen in the soil is known to be influenced by the topography of a field. In other words, nitrate flow (or flux) varies with the landscape. Within the same field, there are differences in flows between areas that can be defined as summit, slope, or depression. These differences are due to variations in soil properties (such as the percentage of sand and clay) and in elevation. These variations in nitrate flows are relevant in the context of nutrient management, minimizing fertilizer runoff, and water conservation. The objectives of our study were (1) to study how the field dynamics of nitrate are influenced by topography during the growing season. For example, how does nitrate move through the soil on a slope? How does it move in a depression area? And (2) to gain insight into how topography influences these flows using computer simulations of water flow and nitrate transport. To meet the first objective, we took soil samples from the three topographical positions (summit, slope, and depression) once a month during the growing season and analyzed them for nitrate content. We also measured soil texture (the percentages of sand, silt, and clay) at these same locations. We then used the computer model to simulate water flow and nitrate flow in the soil. The results showed consistently higher concentrations of nitrate in depression areas compared to slopes and summits. The soil texture analysis showed that the top 12" (30 cm) soil layer in slopes and summits was mainly a sandy loam (more coarse particles). The soil texture in depressions was different, it was mainly silt loam (more finer particles). This difference has several effects. In depressions, the soil had a larger water holding capacity and there was less downward water flow compared to summit and slope areas. There was also more ammonium adsorption and a higher nitrate concentration in the top 12" (30 cm) soil layer in depression plots compared to summit and slope. Based on these results, we conclude that management practices for sustainable crop production need to focus on reduction of nitrogen losses through infiltration in summit and slope areas

18. Impact of Soil Erosion and Climate on Crop Yield

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Topsoil depth plays a considerable role in soil productivity, and its loss can be considered an irreversible impact of soil erosion. Crop roots and available nutrients are concentrated in this layer, and it is critical for nutrient retention and water holding capacity. Climatic factors such as precipitation and temperature further complicate the relationship between soil erosion and crop productivity. Our objective is to determine the impacts of soil erosion and rainfall variation on crop yield in corn systems. Analysis targeted relationships between crop yield versus soil organic carbon content and crop yield versus topsoil depth (A horizon). The variation of yield and growing season rainfall across years were also evaluated to provide an indication of soil resiliency associated with topsoil depth and soil organic carbon levels. Yield data presented are from 2007 through 2012.

19. Towards Consistent Soil Quality Index (SQI)

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Soil quality indicators (SQI) can play a critical role in decision making process regarding sustainable use and management of agro-ecosystems; provision of food and energy; increasing farm income; improving and enhancing human well-being. Soil quality can be assessed qualitatively (e.g., visually where darker soils are considered to be of high quality) or quantitatively by using mathematical models and statistical analyses of measured soil properties data. Characterizing soil quality is challenging because of the spatial and temporal variability in soil properties, especially at the boundaries between different soil types, or at different depth increments; making it difficult to satisfy the scientific requirements of replicability; let alone proposing any remedial strategies of restoring degraded soils. Furthermore, the different measurement and modeling techniques have different assumptions and potentials, which may create errors, leading to problems for interpretation, or scaling up the data for downstream application and policy purposes. Against this background, this study examines the strengths, weaknesses, and future prospects of soil quality assessment approaches, and their potential to be operationalized in soil mapping or modeling programs. Thus the study: (1) compares qualitative and quantitative soil quality assessment methods; (2) describes current and future methods for predicting and validating soil quality, using simplified SQIs.

20. Soil Quality Index of Crosbysilt Loan in Central Ohio

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Soil quality refers to the capacity of soil to provide goods and service for a specific use. Because management practices lead to changes in soil function, there is a need for comprehensive tools and methods to assess soil quality. Soil quality index (SQI) is a tool for assessing the impact of land use and management practices on soil properties. Thus, a field experiment was conducted at The Ohio State University's Waterman Farm in Columbus, OH to evaluate the effects of tillage and surface tile drainage on SQI of Crosby Silt Loam in central Ohio. Treatments included: (i) no-till (NT) with surface tile drainage (ii) NT without drainage (iii) chisel tillage (CT) with tile drainage, and (iv) CT without drainage. Intact soil cores and bulk soil from all the treatments at 0-4, 4-8 8-16, and 16-24 inch depths were collected during April 2011. Results show that NT and surface drainage management have improved the SQI, where it is positively correlated with corn yields (R^2 = 0.75; n=12 at 0-4 inch depth). Thus long-term usage of NT and tile drainage improves crop productivity and SQI.

21. Comparison of Soil Quality From Three On-Site Farms in Ohio

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The purpose of conducting on-farm field research is to develop with fact-based answers to farming's challenging questions and this type of research targets "real world" data. Current study is a comparative assessment of quality of one muck or organic (Mc), and two mineral (CrB, and Ko) soils. While Mc and CrB were compared for long and short-term tillage operations, Ko soil had cover crop (peas and turnips) and no cover crop or control management. Compared to mineral soil (CrB), muck soil (Mc) had 6.4 and 5 times higher soil-organic-C (SOC) and N concentrations, respectively. Long-term tillage (CT) had no impact on Mc due to its porous nature, weak structure and high organic matter content. Short-term CT significantly affected soil strength and water capacity of CrB. Residue incorporation in the plow layer under CT increased aggregation by up to 19% and SOC by up to 15% in CrB compared with that under no-till. Cover-cropping significantly decreased pH from 6.7-5.7 and increased SOC concentrations from 2.3-2.5% compared to those of soils under no cover crop. Increase in SOC was related to the amount of biomass input. Soybean grain yield was slightly higher under cover crop (2.1 tons/acre) than under control (1.9 tons/acre). These data suggest that (i) selected organic or muck soil had significantly improved soil parameters than those of the compared mineral soil, (ii) long-term tillage did not affect the properties of the native muck soil but increased its rate of decomposition, (iii) surface layer of the long-term no till mineral soil was significantly affected by introduction of only one year of tillage (CT), and (iv) some improvements in soil characteristics are likely even over a short-period only under an appropriate cover crop, however, longer-term data are needed to see whether these trends are transient or not.

22. Soil Physical Properties as Affected by Three Years of Tillage, Cover Crop and Crop Rotation

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Soil productivity and sustainability can be affected by various agricultural management practices like tillage, cover crop and crop rotation. The objective of this research is to understand how soil physical properties are affected by three years of tillage, cover crop and crop rotation management practices. The study was carried out on a silt loam soil, a 10 acre (4.05 ha) farm divided into 48 plots, in Jefferson City, Missouri during the 2011 to 2013 growing season. The main crops grown on the field are corn (*Zea mays* L.) and soybean (*Glycine max* L.). The type of tillage used was moldboard plow and the cover crop of choice was cereal rye. Crop rotation sequences include; Continuous corn, continuous soybean, corn/soybean rotation and soybean/corn rotation. Soil samples were taken, in each year, at four different depths in each plot; 0-3.9 in (0-10 cm), 3.9-7.9 in (10-20 cm), 7.9-15.9 in (20-40 cm) and 15.9-23.6 in (40-60 cm). The samples were taken to the laboratory where the wet weight was taken. Soil samples were then dried for 72 hrs at 221°F (105°C) and then weighed (dry weight). From our studies, we found that tillage, cover crop and crop rotation affected the physical attributes of the soil measured. Tilling the soil destroys soil structure and makes it prone to erosion of the soil and nutrients. We also found that the roots of cover crops open pore spaces in the soil and this increases water infiltration into the soil and improves air movement in the plant root zone, thereby increasing crop yield. The spaces between the soil particles were found to be greater in plots that were planted to cover crops and later tilled, especially in the surface layer (top 4 inches). In general, soil physical properties responded to the various management practices. However, the benefits of these treatments take time (3 or more years) to be manifested.

23. Effects of Fluopyran on Soybean Cyst Nematode and Soybean Sudden Death Syndrome

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Soybean sudden death syndrome (SDS) and soybean cyst nematode (SCN) are two of the most important diseases of soybean. Currently, resistance is the main management strategy for both diseases, and there are few other options available for each disease. Seed treatments are now an option for farmers for use of pesticides in early plant development. A recently registered chemical, fluopyram, has been reported as have activity against both SCN and SDS. This study tested fluopyram in different combinations with currently available seed treatment products for management of each of these pathogens separately and together. Results for the SCN alone experiment were somewhat unclear; however, plants treated with a seed treatment combination of fluopyram with clothianidin, Bacillus firmus, metalaxyl and trifloxystrobin had less SCN females per gram of root when compared to the same combination without fluopyram. Three runs of an experiment with SDS alone and SCN and SDS in combination were conducted. In one of these three runs, fluopyram in combination with trifloxystrobin and metalaxyl had the lowest amount of SDS foliar symptoms, but there were no significant differences among the seed treatments in any of the three runs of experiments with SDS alone and both SCN and SDS. In the SDS and SCN experiments, there were significantly fewer SCN females per gram of root in the presence with fluopyram for the contrast involving clothianidin, Bacillus firmus, metalaxyl and trifloxystrobin. These results indicate that fluopyram may be negatively affecting SCN, but we detected no such negative effects of fluopyram on SDS foliar disease symptoms in our experiments.

24. Microbial Diversity in Long-Term Plots Using Pyrosequencing

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The vast number and types of microorganisms in soil are responsible for how soil performs its many important functions such as plant residue decomposition, maintenance of soil structure, nitrogen fixation, breakdown of toxic compounds, improvement of water quality, and emissions of greenhouse gases. The soil bacterial community can also serve as an indicator of soil health. All living organisms contain the genetic material, deoxyribonucleic acid (DNA) and DNA in bacteria can be used to study the bacterial community in a particular soil. If we know the members of the bacterial community, we can also begin to understand what they may be doing in the soil. This is important because, even now, we can only study in the laboratory using traditional methods, about 5% of the bacterial community members in soil. The objective of our study was to determine the diversity of the types of bacteria in soils managed under continuous corn without rotation and under long-term no-till and plow-till practices. The no-till soils have been maintained (that is never tilled) for 52 consecutive years, longer than anywhere else in the world. DNA was first extracted from soil and purified. Then the specific species of bacteria in the soil samples were identified after amplification and sequencing of the DNA. Currently, the DNA data are being analyzed to help us understand what types of bacteria prefer a tilled soil versus a no-till soil. The results of this study will have implications regarding crop productivity, soil quality and cycling of nutrients through the soil. The results obtained will also contribute to addressing the broader goal of determining how crop production practices affect the diversity of bacterial species in soil and how this may help farmers better maintain high crop yields while helping to reduce the potential impact of agriculture on climate change.

25. Effect of Gypsum and Crop Residue on Greenhouse Gas Fluxes From Two Contrasting Soils in Ohio

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Agricultural practices impact emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide from soil. The effect of agricultural practices, such as the application of gypsum and the return of crop residues to soil on these emissions, are not fully understood. An experiment was conducted in a glasshouse to measure greenhouse gas emissions from two contrasting soil types (that is from a Wooster silt loam and a Hoytville clay loam) treated with gypsum (cumulative of 12 tons per acre, applied in four equal doses of 3 tons per acre each) and crop residues (6 tons per acre, applied in a single dose). Emissions of the greenhouse gases were measured every other week for 20 weeks. The total amount of emissions of carbon dioxide, methane, and nitrous oxide were statistically less from Wooster soil as compared to Hoytville soil. A reduction in emissions of carbon dioxide and methane from soils was also measured when gypsum plus residues were added to soil together as compared to their alone application. The way that residue treatment applied alone affected carbon dioxide and nitrous oxide emissions was different for the two soil types. We conclude that application of gypsum and plant residues affect the emissions of greenhouse gases differently in soils. The reduction in methane emissions by gypsum plus residues may be due to improved soil aeration. Also, because gypsum plus residues reduced carbon dioxide emissions, this suggests this combination of soil treatments may provide efficient formation of soil humus and thus improved the soil quality.

26. Relationship Between Soil Properties and CO_2 and N_2O Emissions in Corn-Soybean Rotation

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The physical properties of soil can affect greenhouse gases emissions. We studied the relationship soil temperature (T), soil moisture (H_2O) and Carbon Dioxide (CO_2) and Nitrous Oxide (N_2O) emissions in a corn-soybean rotation. The study was conducted in a Waldron silt clay loam at Freeman farm at Lincoln University of Missouri. Data on CO_2 and N_2O emissions was collected from June to September 2013 at 16 locations in a 4 acre field using

a Photoacoustic Gas Analyzer. Soil temperature and moisture were measured with a KD-2 probe and a TDR 300, respectively. Results showed that, on month to month basis, as T increases, CO_2 emission decreases, while CO_2 emission increases with the increase of the H_2O. H_2O decreases as the T increases. Similarly, when all the data was combined, CO_2 emission decreases as the T increases. N_2O emission also decreases as the soil T increase. Finally, soil moisture decreases as the soil temperature increases. The results on the relationship between T and CO_2 suggest an opposite direction to the trend reported by previous authors. Therefore, more studies are needed to understand what factors are responsible for the shift to that relationship.

27. Nitrogen Fertilizer Rate to Corn Can Affect N_2O Emissions From the Following Soybean Crop in a Midwest US Corn-Soybean Rotation

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Agricultural management strategies are needed to reduce nitrous oxide (N_2O) greenhouse gas emissions from croplands. However, most research has focused on corn due to large N fertilizer inputs that promote N_2O emission. Corn is commonly rotated with other crops that receive little or no N fertilizer, yet little information exists on the potential for N fertilizer applications to corn to affect N_2O emissions during subsequent crops. To determine how N fertilizer application to corn affects N_2O emissions during the subsequent crop in rotation, we conducted a three year study (2011, 2012, and 2013) of N_2O emissions from a corn-soybean rotation at Boone, Iowa with three N fertilizer rates applied to corn at 0 lb N/acre, a recommended rate of 120 lb N/acre (135 kg N/ha), and an excessive rate of 200 lb N/acre (225 kg N/ha). Soybean received no N fertilizer. We further investigated the potential for a winter cereal rye cover crop to affect N_2O emissions from both crops. In both crops, cover crop effects on N_2O emissions and NO_3 concentrations were not consistent across years or N fertilizer treatments. Across all years and irrespective of cover crops, an increase in N fertilizer rate from the recommended to excessive rate resulted in a 16% increase in mean N_2O emission rate from corn. In two of three years, mean N_2O emission rates from the soybean crop were not affected by the N rate applied to the corn. However, in 2013 following the drought year 2012, mean N_2O emission rates from the recommended and excessive rates were 35% and 70% greater than the zero N rate. These results suggest that: 1) cover crops do not consistently affect N_2O emissions, and 2) under certain weather conditions excessive N fertilization in corn can affect N_2O emissions from subsequent unfertilized soybean. Therefore, using recommended rate of N fertilizer could decrease the N_2O emissions in a crop rotation under certain weather conditions.

28. Greenhouse Gases Emission From Wisconsin Soils in Long-Term Corn Based Rotations

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The Midwestern region of the United States is based on intensive corn production and has been recognized for having a high potential in mitigating anthropogenic greenhouse gas emissions (GHGs) of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). Unlike nitrogen fertilizer and tillage management practices, crop rotation effects are often overlooked by farmers in relation to gas emissions. Our objective was to compare GHGs emission during 2012-2013 growing seasons of six phases of crop rotation treatments involving continuous corn, corn-soybean and corn-soybean-wheat at the Arlington, Lancaster and Marshfield research stations. Gas fluxes were measured using in situ closed-cover flux chambers permanently installed in the rows and between the rows. Sufficient time has passed to allow these crop rotation experiments to equilibrate differences between rotation treatments. The whole 2012 growing season was one of the driest seasons ever recorded in Wisconsin. Whereas 2013, especially in the beginning, was one of the wettest seasons. Averaged across locations, 2013 had similar CO_2 and significantly higher N_2O emissions in all treatments compared to 2012. Nitrous oxide emissions appeared at the beginning of the season, but were mediated by soil moisture. However, they differed temporarily between years and locations. For example, up to mid-season at Arlington in 2013, under wet and cold conditions N_2O emissions were 255% higher compare to 2012. In 2012, averaged across all locations and treatments, soils were a minor CH_4 sink; however, in 2013 at Marshfield significant CH_4 emissions were recorded due to prolonged soil saturation conditions. Our results provide an important understanding on how different weather conditions affect temporal and spatial variability of GHGs emission from agricultural soils during crop production.

29. Climate is Always Changing: Climatologists as Trusted Information Sources

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As weather data is collected, past climate information and future climate models are continuously adjusted. Because agricultural productivity is dependent upon weather, climate science is an important tool to support various agricultural management decisions, such as crop variety or planting density. Climatologists are tasked with providing timely, accurate, and relevant services for climate science users. Information provided by climatologists is important to farmers as they work to minimize risks associated with extreme weather and climate variability. In most states, there is a publicly funded state climatologist who collects and disseminates climate science information. Farmers may utilize resources provided by climatologists to assist in developing long-term management portfolios. While the specific role of a state climatologist varies by state, it often connects to agriculture in the Corn-Belt region. Farmers may benefit from information provided by a climatologist, such as historical or

future climate data that is spatially proximate to their field, or data that is relevant to a certain crop or rotation. Climatologists in the North Central Region provide information in different ways. For instance, a climatologist may simply provide data in the form of a graph or report. Climatologists may also communicate with potential stakeholders to determine what types of information would be most useful and relevant to them. Further, some climatologists may engage with climate science users, such as farmers, to offer input regarding potential impacts of climate information. Climatologists may be a very useful resource to support agricultural management decisions that ensure productivity and resilience.

30. Climate Education Solutions for the US Corn Belt

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The USDA Sustainable Corn Project "Climate change, mitigation, and adaptation in corn based cropping systems" involves more than 100 researchers focused on measuring greenhouse gases and carbon sequestration across the corn belt as well as building solutions that are resilient in times of drought, reducing soil and nutrient losses under saturated soil conditions, reducing farm field nitrogen losses, retaining carbon in the soil, and ensuring crop and soil productivity. The education component of the grant involves the farming community through increasing the climate change and agriculture knowledge of Grade 6-12 science and agriculture teachers. Farmers would also find the information useful since much of the results are from on-farm research to solve problems in a systems analysis approach. Finally, the education objective of the grant provides an avenue for accurate information and engagement with others in the agricultural community by our connection with the National Council for Science and the Environment (NCSE) where our easy to understand Speed Science videos and information sheets are being posted and linked to related information. These created by the Sustainable Corn Project faculty and graduate student researchers. It is hoped that farmers and trusted sources of information for the farming community will seek up to date information from the NCSE internet site in addition to sustainablecorn.org web site for scientific information that will be useful for farmers and the farming community.

31. CAMEL (Climate Adaptation and Mitigation E-Learning) - A Source of Information About Climate Change and Agriculture at www.CAMELclimatechange.org

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CAMEL (Climate Adaptation and Mitigation E-Learning) is an online platform at www.CAMELclimatechange.org to educate and raise awareness within the agriculture sector about the impacts of climate change and options for mitigation and adaptation strategies within the corn-based cropping system. CAMEL currently has more than 3000 peer reviewed encyclopedia-style articles and teaching resources, with more than 300 pertaining to climate change and agriculture. CAMEL includes Speed Science documents and videos developed for farmers under the Sustainable Corn Project. CAMEL's extensive, interdisciplinary taxonomy reflects the complexity of climate change. Topics related to causes, consequences, solutions and actions are included. Its web-based infrastructure includes tools to allow a growing community of farmers, educators and students to network, share and evaluate approaches and materials. CAMEL was created by the National Council for Science and the Environment (NCSE) and its Council of Environmental Deans and Directors (CEDD) and is funded by the National Science Foundation (NSF) and the USDA. CAMEL is an important tool under the Sustainable Corn Project education objective.

32. Climate Change and Agriculture: Preparing the Next Generation

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A week-long workshop focusing on climate change and agriculture was held on the campus of Iowa State University June 9th-13th, 2014. A total of 17 high school science and agriculture teachers from the Midwest participated in the workshop. Four objectives were identified for participants. These were: recognize the future climate change projections and how this will impact agriculture and food production in the Midwest, science and agriscience fair research projects, explore the science behind biomass and bio-fuel harvest and production, and differentiate between various conservation practices and their impacts on agricultural production through field observations. Learning activities included: creation of the science/agriscience fair research project, designing a case study, designing a Webquest, climate change labs using a Waterford Fermenter, participating in a scientific writing workshop, designing a scientific poster, reviewing the CAMEL website, Conservation Station field trip, climate change overview presentation, review of EPA Webquests, cellulosic ethanol and corn stover harvest presentation, agronomic and sustainable agriculture research field trip, and climate projections presentation.