MINUTES OF NCR-59
Technical Committee on Soil Organic Matter: Formation, Function and Management
Harvard Forest, Petersham, Massachusetts
August 23-24, 2004

Administrative Advisor:
Dr. Gerald Miller
Associate Dean, College of Ag.
132 Curtiss Hall
Iowa State University
Ames, IA 50011-1050

Chair:
Dr. Serita Frey
Natural Resources
215 James Hall
Univ of New Hampshire
Durham, NH 03824

Chair-Elect:
Dr. Sieglinde Snapp
Crop & Soil Science
Michigan State Univ

Members in Attendance:
Serita Frey, New Hampshire; Chuck Rice, Kansas; Doug Archibold, Pennsylvania; William Horwath, California; Ray Weil, Maryland; Richard Dick, Oregon; Deborah Allan, Minnesota; Michelle Wander, Illinois; Larry Cihacek, North Dakota

Members Absent:
Rhae Drijber, Nebraska; Sieglinde Snapp, Michigan; Ronald Turco, Purdue; Peter Motavalli, Missouri, Laurie Osher, Maine

Advisors: Gerald Miller, Administrative Advisor, present.; Melvalin Morant, CSREES Representative, absent.

Other Agency Representatives and Guests: Mel Knorr, University of New Hampshire

Detailed notes from the annual meeting:

The meeting was held at the Harvard Forest Research Center in Petersham, Massachusetts. Serita Frey, NCR-59 Chair, organized the meeting.

Day 1 – August 23, 2004

Serita Frey called the meeting to order, made introductions, and distributed 2004 state reports and 2003 meeting minutes. Gerald Miller indicated that the 2003 state reports were not included in the handouts, but available on the NCR-59 website

Mervalin Morant, CSREES/USDA, sent a CSREES update which was passed out and discussed. Several items were highlighted:

- New funding opportunity—Enhancing the Prosperity of Small Farms and Rural Agricultural Communities
- CSREES will host a Stakeholder listening session for Soil Science in conjunction with the upcoming ASA-CSSA-SSSA meetings in Seattle, WA. The session is scheduled for October 31 from 1-4 pm.
- FY 2005 research priority areas

The minutes from last year were approved.

The group was reminded that Sieglinde Snapp will become chair on 10/01/04
Leslie Cooperband, current secretary and 2005 chair-elect, has resigned from the committee. Elections were held to fill the chair-elect and secretary positions.

- Ray Weil was elected chair-elect
- Doug Archibold was elected secretary

Gerald Miller reminded the group that the committee's renewal review will occur in 2006.
Suggested linkages with other multi-state committees.

- Larry Cihacek proposed to act as a liaison between NC-1017 (focused on C sequestration in landscapes) and NCR-59. Suggested future joint meeting
  - Meet jointly every third year
  - Begin meeting jointly next year (2005)
  - Larry will work with Sieglinde Snapp to organize joint meeting

Other suggested linkages: NC-1022; Humic Substances Society; Soil Ecological Society; International Soil Science Society meeting in Philadelphia July 10-14, 2005.

A subcommittee was formed to organize joint meetings

- Sieglinde Snapp
- Larry Cihacek
- Will Horwath

The group discussed status of state members

- Request to drop Laurie Osher from Maine since she has not participated in committee activities
- Request to add Teri Balser from Wisconsin to replace Leslie Cooperband
- Request to add A. Stone from Oregon
- Missing members for South Dakota and Iowa

Gerald Miller noted that NCR nomenclature will change

- NCCC will focus on either research, education or extension
- NCERA is integrated

The group voted to change from NCR to NCERA.

Michelle Wander discussed the status of the Soil Quality website

- Hosted by Soil and Water Conservation Society
- Suggested that NCR-59 administer the website

A website subcommittee was formed to determine how NCR-59 members can contribute effectively to website management

- Michelle Wander
- Will Horwath
- Deborah Allan

Will Horwath led a discussion on the Nature/Science paper to focus on C sequestration

- Main theme: Intensive and extended management required
- Link to N use efficiency
- Comment to Schlesinger's broad statements on soil C storage
- Link to ecosystem dependency
- Moisture and nutrient limitations
- Specify systems
- Include inorganic C sequestration
- Influences of a climatic gradient
- Emphasize regional differences

Will Horwath and Chuck Rice will draft an outline by 10/01/04

- Feedback by 11/01/04
- Writing assignments handed out by 11/01/04
- Drafts due by 12/31/04

The group toured the Harvard Forest Museum and several long-term research experiments in the afternoon.

- Soil Warming Study
- Chronic Nitrogen Addition Study
- Eddy Flux Tower Site

Day 2 – August 24, 2004 Business Meeting

Gerald Miller gave the committee update

- Mid-term review letter of approval handed out
- Discussed overview and peer reviews
- Main point – need linkages by renewal review in 2006
- Explained NIMSS handout which provides information on how to navigate the new website

Accomplishments from past year:

- A symposium on *Meaningful Pools in Determining Soil C and N Dynamics* will be held on November 3, 2004 at the Soil Science Society annual meeting in Seattle, Washington. This symposium was organized by Dan Olk, Ed Gregorich and Cindy Cambardella. Michelle Wander and Rhae Drijber are speakers. Chuck Rice will present a poster at the associated poster session. The symposium is co-sponsored by NCR-59, S-3 (Soil Biology and Biochemistry) of the SSSA, the Canadian Society of Soil Science, and the Canadian and U.S. chapters of the International Humic Substances Society. The proceedings will be published.

- Serita Frey and Rhae Drijber collaborated on a project to examine how long-term soil warming has influenced microbial community composition and soil organic matter dynamics
- Continuation of Soil Quality website development
- Ray Weil edited the book: Magdoff, F., and R.R. Weil, (eds.) 2004. Soil organic matter in sustainable agriculture. CRC Press, Boca Raton, FL, 398 p.
- Larry Cihacek developed a protocol for C sequestration monitoring. A experiment station bulletin will be published in the next six months.
- Ron Turco and Chuck Rice organized a CASGMS workshop on measurement, monitoring and verification of soil C. The workshop was geared toward policy-makers and scientists; 120 people attended.

Chuck Rice reported on several upcoming events:

- The third CASGMS workshop on C sequestration in the cornbelt will be held December 15-16, 2004. Call for NCR-59 to co-sponsor
- A USDA symposium on greenhouse gas mitigation in agricultural and forest soils will be held in March 2005 in Baltimore. Call for NCR-59 to co-sponsor.
- There will be a symposium at the next AAAS meeting titled *Can we Feed the World without Poisoning the Earth?*

A suggestion was made to prepare a poster of the history and goals of NCR-59 for display at conferences and society meetings

- Link to website
- A poster subcommittee was formed: Chuck Rice, Deborah Allan, and Richard Dick

The meeting was adjourned at 11 am.

Signed: *Serita Frey*
Serita Frey
Committee Chair

Signed: *Gerald Miller*
Gerald Miller
NCR-59 Administrative Advisor

State Reports of the NCR-59 Committee

Dr. Douglas Archibold
Department of Crop & Soil Sciences
Penn State University
Phone: 814-865-8449

I am new to the NCR-59 project and I hope to be able to report collaborations with the other members at subsequent meetings. My research area is the application of analytical chemistry in crop and soil sciences. During this last year I have become much more

involved in characterization of soil organic matter to support various research projects at Penn State University.

1. Contributions to studies of the role of laccase and minerals in a model humification process:

PIs: Jerzy Dec and Jean-Marc Bollag

I collaborated with the PIs and Mi-Youn Ahn, who received a Ph.D. in Ecology (Penn State University, 2004) for a dissertation entitled "Incorporation of Chlorophenols and Humic Monomer into Soils by Metal Oxides and Fungal Laccase."

Mi-Youn Ahn, Carmen E. Martínez, Douglas D. Archibald, Jean-Marc Bollag, and Jerzy Dec, "Transformation of catechol in the presence of a laccase and metal oxides" (submitted to: Soil Science Society of America Journal, June 2004).
In this study Mi-Youn carried out experiments that demonstrated non-additivity of the catalytic action of laccase and birnessite on catechol.

Mi-Youn Ahn, Douglas D. Archibald, Carmen E. Martínez, Jean-Marc Bollag, and Jerzy Dec, "Characteristics of *Trametes villosa* laccase adsorbed on aluminum hydroxide" (to be submitted to: Soil Biology and Biochemistry).
This study demonstrated that laccase adsorbs strongly to aluminum hydroxide with little change in the enzyme structure or activity.

2. Contributions to a study on the modeling of vibrational spectra of biochemicals adsorbed on minerals:

PI: James D. Kubicki

My role was to set up a method to collect and process infrared spectra of the adsorbed species in the carbonyl spectral region. Jim and his students are applying the method to evaluate various solution-adsorbate-mineral combinations that they also model computationally. The data has not yet been analyzed.

3. Development of infrared spectroscopic approaches for characterization of soil organic carbon for application in soil management studies:

PI: Douglas D. Archibald

Collaborators: Richard C. Stehouwer, Heather D. Karsten, Mary Ann Bruns and Sjoerd Duiker

The initial objectives are to advance the technology, to determine how well the methods work with different kinds of soils, and to identify applications in crop-soil

management studies that take advantage of the unique characteristics of each spectral approach. Preliminary results will be presented at a conference this fall. Graduate student Rupinder K. Randhawa and I will then work with our departmental colleagues to apply infrared techniques in crop-soil management studies.

Douglas D. Archibald, Amy L. Shober and Rupinder K. Randhawa, "Evaluation of two types of infrared methods to characterize soil organic carbon" (poster to be presented at the Federation of Analytical Chemistry and Spectroscopy Societies meeting in Portland, Oregon, October 2004).
Preliminary data evaluation indicates that infrared and near-infrared techniques can have similar performance for determination of carbon content, but that the near-infrared sensitivity is mainly due to optical phenomena, whereas spectroscopic phenomena are more significant in the infrared. We suspect that near-infrared methods will be more strongly influenced by soil mineral type.

4. Contributions to a study of maturity of vermicompost derived from either manure or food waste:

PI: Richard L. Stehouwer

Graduate student P. Drew Mather is conducting studies to characterize the products from mid-size continuous-flow vermicomposting systems. I am helping him with a spectroscopic study of the organic matter transformation process. Drew will be presenting his preliminary results at a meeting this fall.

5. Implementation of a method for determination of the quantity of humic acids in soil by extraction:

PIs: Douglas D. Archibald and David M. Geiser

Over the summer I was fortunate to have high-school senior Matthew B. Beard assisting with development of this method. We can achieve good precision with a fixed set of experimental parameters. However, further study will be needed to establish the most appropriate experimental parameters.

Dr. Deborah Allan
Soil, Water & Climate
University of Minnesota
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In my research program I have been examining soil quality in different cropping systems. As a result of findings at the long-term cropping systems trial located in Lamberton, MN, we have now begun to investigate coupled 13C and 15N labeled inputs to measure the storage and turnover of C and N in active and resistant organic matter pools at this site. Last fall we applied 15-N labeled manure to microplots in the organic system; this summer

we applied 13-C labeled CO2 several times to corn microplots that will have labeled root and shoot (reciprocally transferred) material in the 4-yr organic (with and without cover crop), 2 and 4-yr low-input, and 2 and 4-yr high-input systems. We also applied 15N urea to microplots in the non-organic systems. We will sample this fall and next spring and for a second season in these microplots, and will repeat the labeling in an additional set of plots next year. We will look at the sequestration of the 13C and 15N in soil and aggregate fractions. Two collaborators, Jennifer King and Jeff Strock, will measure C and N losses from the microplots via NO3 leaching and gaseous emissions of CO2, CH4, and N2O.

Another project we are finishing was a three year assessment of differences in yield, nitrogen supply and soil quality resulting from applications of digested versus raw manure or inorganic fertilizer at the Haubenschild Dairy Farms in Princeton, MN. We were unable to detect differences in yield and few differences for most nutrient or soil parameters with any of the three amendments. This result may have been partially due to the high variability at the site. In laboratory incubations, digested manure released nitrogen more quickly because there was much less immobilization than for the raw manure. However, where differences did occur in the field results, they suggest that raw manure was better than digested manure for building potentially mineralizable nitrogen, total N and total C in the soil. Both types of manure were better at building microbial biomass than the inorganic fertilizer.

Theses being revised for publication:

Clayton, K. 2004. Effects of digested manure on nutrients and soil quality. M.S. thesis, University of Minnesota.

Kuratomi, M. 2003. Assessing soil quality in alternative and conventional cropping systems. M.S. thesis, University of Minnesota.

Dr. Larry J. Cihacek
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No report.

Dr. Richard Dick
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Non-thermal Biomass/Min Tillage Management in Grass Seed Systems: The goal of this research is to determine the degree, type of effect and length of the effect on soils after rotating from a perennial grass seed crop to row crops under conventional or no-till system

on soil quality. After 5 years of grass seed followed by incorporation has shown that it may take up to 3 years after conversion to row crops that microbial and soil physical properties are maximized. This suggests that for this particular system, not only lack of disturbance and rhizosphere effects of perennial grass seed are important, but also the incorporation and decomposition of the residues can make a significant contribution for increasing soil quality.

Cover Crop and Tillage Management and Soil Ecology: This research is investigating no-till vegetable and winter cover crops systems in relation to soil compactions. Soil ecology and microbial community research is in progress on whether manipulating cover crop residues to improve earthworm activity can improve soil quality. Also, farm-scale research is being conducted on 6 vegetable farms where two treatments (conventional vs. integrated-winter cover crops/reduced till planting) are being assessed with the Oregon Soil Health Scorecard and a soil quality kit (USDA/NRCS). We are finding there is a rapid biological response (earthworms and micrbrobial) to strip tillage and cover crops but at the same time there is concomitant increase in soil compaction (at least for first 2 years after conversion) and this has been correlated with reduced yields.

Organic Matter Inputs and Disease Suppression: Research is investigating mechanisms for disease suppression of Verticilium wilt in potatoes using cover crop green manures. Soil ecology studies are in progress but preliminary work shows cover crops can suppress this disease but may be confounded by soil pH. We have evidence for a general suppression mechanism for all cover crops but Austrian winter pea has greater efeects at lower GM rates (6-12 Mg/ha) than Sudan grass or broccoli.

C Sequestration in Forests: At the ecosystem level, forest stand age influences rates of litter accumulation and quality and micro-climatology, which could affect the microbial community structure and C sequestration processes. To investigate this we are using a novel approach that combines stable isotopic tracking with molecular techniques. We are doing paired comparisons of old growth stands with 1977 and 1994 clear cuts. This is being done with *in situ* microcosms containing ^{13}C-labeled needles and root material to study time course ^{13}C incorporation into labile pools including microbial community members ("active" players), and humic fractions. If the subsequent data collection and more detailed analysis follow preliminary observations; we theorize that the younger stands have higher levels of C decomposition and that soluble products of decomposition are more readily leached out of the litter in these younger stands than out of the old growth litter layers.

Dr. Rhae Drijber
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No report.

Dr. Serita Frey
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Microbial contributions to soil organic matter formation and stabilization
PIs: Serita Frey and Johan Six (UC-Davis)
Participants: Tonia White, Rod Simpson, Mel Knorr, Rachel Thiet
Funded by USDA; 12/00-12/05
This project examines the microbial mechanisms that regulate the retention and accumulation of C in agroecosystems. In particular we are investigating the interactions between soil structure and the dynamics of microbial-derived soil organic matter (SOM). Bacterial and fungal cell wall constituents (muramic acid and glucosamine) are being measured to quantify the relative contribution that bacteria and fungi make to the production and stabilization of microbial-derived SOM. ^{13}C-labeled plant residues are being used to trace the movement of substrate C into bacterial and fungal products to examine the rates of bacterial versus fungal product decomposition. Soil physical fractionation procedures are being applied to relate the dynamics of microbial-derived C to the location of this material within the soil aggregate structure.

Linking soil aggregation, organic chemistry, and microbial community composition, diversity and activity to understand the turnover and sequestration of soil organic matter in agroecosystems
PI: Serita Frey, Johan Six (UC-Davis), Tim Filley (Purdue)
Participants: Rachel Thiet, Mel Knorr
Funded by CASMGS; 9/1/03-8/31/05
This project falls under Subtask I within the Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS). The goal of CASMGS, which is a collaborative effort involving 10 universities, is to quantify the mechanisms and fundamental processes that regulate the capacity of soils to sequester C and mitigate greenhouse gas emissions.

Linking external nitrogen availability, litter chemistry, and decomposer organisms to explain the inconsistent effect of nitrogen additions on litter decomposition.
PI: Serita Frey
Participants: Mel Knorr, Rod Simpson, Eric Saas
Funded by NSF; 7/01-7/05
This project examines how decomposer microorganisms respond to nitrogen additions and how this response is modified by litter chemistry and soil nitrogen availability. The objectives are to (1) examine the interactive effect of soil nitrogen availability and litter chemistry on decomposition, nitrogen immobilization, and the litter microbial community, (2) construct a complete budget of litter N inputs for three ecosystems (forest, grassland, agroecosystem) to determine the processes by which litter-associated microorganisms immobilize N, and (3) identify the microbial mechanisms underlying the differential effect of nitrogen addition on nitrogen immobilization and decay dynamics.

Nitrogen addition effects on the forest soil microbial community.
PI: Serita Frey
Participants: Mel Knorr, Eric Saas, Heather Smith, Joseph Blanchard, Sarah Eisenlord
Funded by McIntire-Stennis; 10/02-10/05
This project is examining the effects of N enrichment on the structure and function of the microbial community associated with forest soils exposed to chronic N additions.

Relationships between macrophyte diversity, sediment bacterial diversity, and trace gas fluxes in freshwater wetlands.
PIs: Virginie Bouchard (Ohio State University) and Serita Frey
Participants: Sharon Reed, Janice Gilbert, Mel Knorr
In this project, we are examining whether plant (macrophyte) diversity in wetlands impacts sediment microbial diversity and, in turn, whether shifts in microbial diversity significantly impact the fluxes of CO_2, CH_4, N_2O. We are currently conducting a mesocosm experiment in which we have manipulated macrophyte functional diversity (1 to 5 functional groups per mesocosm) and are measuring plant productivity, trace gas fluxes, sediment C pools (total C and N, particulate organic matter C, dissolved inorganic and organic C, and microbial biomass C), and sediment microbial diversity.

Averett, J.M., R.A. Klips, S.D. Frey, and P.S. Curtis. 2004. The effects of soil carbon amendment on nitrogen availability and plant growth in an experimental tallgrass prairie restoration. *Restoration Ecology* (in press).

Frey, S.D., M. Knorr, J. Parrent, and R.T. Simpson. 2004. Chronic nitrogen enrichment affects the structure and function of the soil microbial community in a forest ecosystem. *Forest Ecology and Management* 196, 159-171.

Simpson, R.T., S.D. Frey, J. Six, and R.K. Thiet. 2004. Preferential stabilization of microbial-derived carbon in microaggregates contained within macroaggregates of no-tillage soils. *Soil Science Society of America Journal* 68, 1249-1255.

Paul, E.A., H.P. Collins, KI. Paustian, E.T. Elliott, S.D. Frey, N. Juma, H. Janzen, C.A. Campbell, R.P. Zentner, G.P. Lafond, and A.P. Moulin. 2004. Management effects on the dynamics and storage capacity of soil organic matter in the Canadian prairies. *Canadian Journal of Soil Science* 84, 49-61.

Frey, S.D., J. Six and E.T. Elliott. 2003. Reciprocal transfer of carbon and nitrogen by decomposer fungi at the soil-litter interface. *Soil Biology & Biochemistry* 35, 1001-1004.

Dr. Jonathan Halvorson
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Appalachian Farming Systems Research Center
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- Silvopastoral management in Appalachia usually includes tree thinning (soil disturbance) liming, and fertilization but little is known about how these management practices might effect soil carbon and nutrient pools and processes. We used a 6-month incubation study to measure the effects of liming and fertilization practices and

disturbance on rates of carbon mineralization and pools of soluble carbon and nitrogen. Preliminary data suggest that rates of soil respiration are higher after additions of lime and phosphorus fertilizer even in preincubated soils but applications of nitrogen fertilizer did not incrementally increase respiration rates from the soil. Our data suggest care must be taken to avoid increased carbon losses from soil when developing silvopastoral grazing systems (JH). Short title: "**Silvopastoral management practices may increase potential rates of soil respiration"**

- Total protein, determined by the Bradford assay is thought to represent glomalin, an important soil glycoprotein related to aggregation and soil carbon storage. We measured Bradford reactive protein (BRP) in soil from pastures, hayfields, cultivated fields or "natural" areas in southwestern West Virginia. We found highest concentrations of BRP near the soil surface, decreasing significantly with depth, and in soil from "natural" areas compared to pastures, hayfields, or cultivated fields. Understanding the distribution and quantity of BRP in Appalachian pastures will allow us to determine its importance as a pool of soil organic matter and assess its suitability as an indicator of soil quality (JH). Short title **"Quantity and patterns of distribution of Bradford Reactive Protein in Appalachian soils"**

Dr. William Horwath
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University of California--Davis
Phone: 530-754-6029

My research and teaching activities focus on understanding the fundamental processes controlling the formation and maintenance of humic substances. I am conducting applied research on 'Reducing Non-point dissolved organic carbon (DOC) and N Exports from agricultural landscapes.

I have a number of grants (totaling approximately $6,000,000) from the California Water Resources Control Board. Agricultural activities are thought to decrease water quality by elevating levels of dissolved organic carbon (DOC) and nitrogen in irrigation return water in the form of crop residues and decomposed soil organic matter. This DOC poses potentially serious health concerns when Delta waters are used as drinking water, since disinfection through ozone or chlorination is required for virtually all domestic waters derived from surface waters, during which DOC and bromide form disinfectant bi-products. This research is specifically examining cropping system management and soil factors controlling the decomposition of soil organic matter (SOM) and the production of DOC.

I am conducting basic research on microbial inputs to humic substance formation. I attained an NSF grant "Collaborative Research: Microbial Communities as Biochemical Inputs to Forest Soil Humification processes" ($1,100,000) to study the effects of ecosystem and soil type on microbial inputs to humic susbstances. The turnover of the soil microbial biomass represents a significant source of labile C and potential precursors for

stable SOM products. The measurable microbiological controls on humification will be especially useful in predicting the short-term (1-10 yr) sequestration and turnover of C and N that determines net ecosystem productivity and refine our long-term predictive ability of SOM dynamics central to global climate issues.

These applied and basic research projects address specifically address Objectives 2 and 3 of the current mission of understanding the genesis, composition and reaction of soil organic matter in relationship to soil function and management.

Dr. Peter Motavalli
Natural Resources
University of Missouri
Phone: 573-884-3212

My research has been addressing the effects of management practices on soil microbially-mediated C and N processes. The relevant research projects I currently am working on include:

- Examining the effects of transgenic Bt corn residues on soil C and N mineralization, soil microbial diversity and activity, and on subsequent growth of soybeans in rotation. This project was expanded in 2003 with collaboration with Dr. Michelle Wander, a member of NCR-59, to include evaluation of the persistence of Bt toxin from corn rootworm Bt corn in corn-soybean rotations. We are currently developing a research project to examine the effects of growth of transgenic pharmaceutical tobacco and incorporation of processed plant waste from the transgenic tobacco on soil biological functions and processes.
- Determining spatial variation in soil C and N fractions and soil CO_2 and N_2O gas efflux in paired watersheds with contrasting alley cropping practices, including warm-season grass buffer strips and tree plus grass buffer strips.
- Evaluating the effects of flooding regimes on decomposition of plant residues in floodplain soils and production of soluble and soluble and insoluble phenolics that can be phytotoxic or reduce plant-available N. This project is in collaboration with Dr. Dan Olk, a member of NCR-59, who is with USDA-ARS.
- Determining the relationship between N fertilizer source (urea and polymer-coated urea), and soil water content on N_2O gas efflux in corn production on claypan soils with different artificial drainage and irrigation systems.

Five papers from the NCR-59-sponsored symposium at the 2002 American Society of Agronomy Meetings entitled “The Environmental Impact of Transgenic Crops on Soil Biological Processes and Functions” were published in the May-June, 2004 issue of the Journal of Environmental Quality. An introduction was published with the collection of papers that acknowledges the sponsorship of NCR-59. I also presented a two-day workshop entitled “Setting Priorities for Research on Carbon Sequestration in Thailand”(June 12- 13, 2003) for scientists in Thailand with sponsorship from Kasetsart University in Bangkok, Thailand and NCR-59.

Recent Publications:

Motavalli, P.P., C.S.M. Washburn, J.A. Lory, and N.R. Kitchen. In review. Apparent soil electrical conductivity used to determine soil phosphorus variability in poultry litter-amended pastures. J. Environ. Qual.

Fang, M., R.J. Kremer, P.P. Motavalli, and G. Davis. In review. Comparison of microbial communities in rhizospheres of non-transgenic and transgenic corn using Biolog metabolic fingerprinting and denaturing gradient gel electrophoresis. Applied and Environmental Microbiology.

Mungai, N.W. and P.P. Motavalli. In review. Litter quality effects on carbon and nitrogen dynamics in temperate alley cropping systems. Applied Soil Ecology

Mungai, N.W., P.P. Motavalli and R.J. Kremer. In review. Soil organic C and N fractions in long-term alley cropping systems. Agroforestry Systems

Mungai, N.W., P.P. Motavalli, R.J. Kremer, and K.A. Nelson. In review. Spatial variation of soil enzyme activities and microbial functional diversity in temperate alley cropping systems. Applied Soil Ecology

Motavalli, P.P., R.J. Kremer, M. Fang and N.E. Means. 2004. Impact of genetically-modified crops and their management on soil microbially-mediated plant nutrient transformations. J. Environ. Qual. 33:816-824.

Kremer, R.J. and P.P. Motavalli. 2004. Introduction to papers from symposium on the environmental impact of transgenic crops on soil biological processes and functions. J. Environ. Qual. 33:805.

Motavalli, P.P., S.H. Anderson, P. Pengthamkeerati, and C.J. Gantzer. 2003. Use of soil cone penetrometers to detect the effects of compaction and organic amendments in claypan soils. Soil Tillage Res. 74:103-114

Motavalli, P.P., S.H. Anderson, and P. Pengthamkeerati. 2003. Surface compaction and poultry litter effects on corn growth, nitrogen availability, and physical properties of a claypan soil. Field Crops Research 84:303-318.

Dr. Laurie Osher
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University of Maine
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No report.

Dr. Charles Rice
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Role of mycorrhizae in aggregation and C sequestration

In order to understand one of the mechanisms underlying conservation of soil carbon we examined the role of arbuscular mycorrhizal (AM) on aggregation, a key component in soil C protection. The objectives of our research was to examine the long-term effects (17 yrs) of N enrichment coupled with important tallgrass prairie management practices (annual burning and mowing) on mycorrhizal symbiosis, soil aggregation, and C and N storage. To further investigate the role of AM fungi in soil aggregate stability, we also examined long-term effects (6 yrs)of fungicide applications (AM fungal suppression) in these prairie soils Nitrogen enrichment increased the activity of mycorrhizal fungi and these increases were strongly correlated to increases in water-stable soil macroaggregate formation, as well as the amount of C and N translocated into the soil and into soil aggregates. Suppression of the symbiosis (via fungicide applications), resulted in a large and significant decrease in hyphal networks, and a subsequent reduction of the C sink into the soil. Loss of hyphal networks resulted in a loss of water-stable macroaggregates and a loss of the physical protection provided by the aggregates, followed by a loss of C and N from the soil. This study provides strong evidence that soil structure and stability, as well as enhancement of soil sequestration of C and organic N, are partly defined by AM hyphae.

Plant influences on soil microbial C cycling

Genetic manipulation of plant residue quality to downregulate lignin biosynthesis may allow an assessment of the potential of biotechnology in terms of C sequestration. An experiment was conducted to test the residue decomposition of four different grain sorghum (*Sorghum bicolor* < sp.) varieties in either N amended or unamended soil. Both the wild type (WT) and its brown midrib mutant (BMR) were used from each variety for the 194 d laboratory soil incubation. Cross Polarization/Magic Angle Spinning ^{13}C Nuclear Magnetic Resonance confirmed changes in the plant chemical structure were present in the 145 to 160 ppm aromatic range between each WT and BMR. Chemical analysis indicated that the BMR residue had less acid detergent lignin than the WT residue across all varieties. Mineralization kinetics (k) were represented by three phases: rapid, transition, and slow. Addition of N increased rapid time from 6 to 6.8 d and increased rapid k from 0.058 to 0.062/d, respectively, and decreased the transition phase between rapid and slow mineralization from 54 to 14 d. Over all cultivars, the addition of N suppressed residue mineralization from 71 to 58%, possibly indicating a greater C storage potential in soils with higher N levels. Additionally, the WT group mineralization was slower than the BMR mutants, with values of 63 and 66%, respectively, indicating that downregulating lignin biosynthesis increases mineralization potential of residue.

Tillage and Manure Effects on Soil and Aggregate-Associated Carbon and Nitrogen

In agricultural systems, maintenance of soil organic matter (SOM) has long been recognized as a strategy to reduce soil degradation. No-tillage and manure amendments are management practices that can increase SOM content and improve soil aggregation. We investigated the effects of 10-yr of different tillage systems and N sources on soil aggregate size distribution and aggregate-associated C and N. The study was a split-plot design replicated four times. The main plot treatment was tillage (no-tillage, NT; conventional tillage, CT) and the subplot treatment was N source (manure, M; NH_4NO_3 fertilizer, F). The experiment was established in 1990 on a moderately well-drained Kennebec silt loam (Fine-silty, mixed, superactive mesic Cumulic Hapludoll) with continuous corn *(Zea mays*

L.). In 1999, soil samples were collected (0-5 cm depth) from the field treatments and separated into four aggregate size classes (>2000, 250-2000, 53-250, and 20-53 µm) by wet sieving. Labile C and N content of all aggregate size fractions were measured using 28-d laboratory incubations of intact and crushed aggregates. No-tillage and manure treatments significantly increased total C and N and the formation of macroaggregates. Conventional tillage in comparison with NT significantly reduced macroaggregates with a significant redistribution of aggregates into microaggregates. Aggregate protected labile C and N were significantly greater for macroaggregates, (> 2000 and 250-2000 µm) than microaggregates (53-250 and 20-53 µm) and greater for M than F indicating physical protection of labile C within macroaggregates. No-tillage and M a lone each significantly increased soil aggregation and aggregate-associated C and N; however, NT and M further together improved soil aggregation and aggregate-protected C and N.

Related Publications

1) Doyle, G.L., C.W. Rice, and D.E. Peterson. 2004. Biologically defined soil organic matter pools as affected by rotation and tillage. J. Enviorn. Manag. 33:528-538.
2) Rice, C.W., and J.S. Angle. 2004. A role for genetically modified organisms in soil carbon sequestration. p. 61-78. In N.J. Rosenberg, F.B. Metting, and R.C. Izaurralde (eds.) Applications of biotechnology to mitigation of greenhouse warming. Proc. St. Michael Workshop, St. Michaels, MD, 13-15 April 2003. Battelle Press, Columbus, OH. 213 pp.
3) Williams, M.A., C.W. Rice, A. Omay, and C.E. Owensby. 2004. Soil carbon pools in a tallgrass prairie soil under elevated CO_2. Soil Sci. Soc. Am. J. 68:148-153.
4) Mikha, M.M., C.W. Rice. 2004. Effect of tillage and manure on soil and aggregate-associated carbon and nitrogen. Soil Sci. Soc. Am. J. 68:809-816.
5) Paustian, K., B. Babcock, J. Hatfield, R. Lal, B. McCarl, S. McLaughlin, W.M. Post, A Mosier, C. Rice, G.P. Robertson, N. Rosenberg, C. Rosenzweig, W.H. Schlesinger, D. Ziberman. 2004. Agriculture's response to the climate change challenge. CAST Report, Ames, IA.
6) Mikha, M.M, C.W. Rice, and G.A. Milliken. 200x. Carbon and nitrogen mineralization as affected by wetting and drying cycles. Soil Boil. Biochem. (Accepted) AES 04-211-J

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This year we completed work on a multi-site study of tillage impacts on soil C dynamics and sequestration and a three year study of the affects of elevated CO_2 and O_3 on soybean root biomass. Gayoung Yoo's dissertation research investigated the influence of soil physical properties and soil structure on SOC mineralization and SOC fraction dynamics. Pore size distribution, aggregate dynamics and ped size can help explain why the influence of tillage practices on SOC dynamics and the distribution among SOM fractions varies among sites. In a sicl in DeKalb IL, slower aggregate turnover and higher clay contents were associated with relatively low proportions of occluded particulate organic matter (OPOM). Larger dry aggregate size (DMWD) in soils under no-tillage management at this site has lead to accrual of humic materials in surface depths. In Monmouth IL, where soil has lower clay contents and lower activity clays, aggregate DMWD is larger and aggregate turnover rates are faster. Here use of NT practices increases the proportion of OPOM relative to that in tilled soils but humic materials have not accumulated. Veronica Rodriguez completed a M.S. study in SoyFACE in the 2001 and 2002 growing seasons to determine the influence of elevated concentrations of CO_2 (550 ppm) or O_3 (1.2 x ambient) on soybean root biomass; mass partitioning between roots and shoots, and among root components. Exposure to elevated CO_2 increased the mean root biomass ≈33% in the 0-25 cm depth. The elevated O_3 treatment did not significantly affected root biomass, but decrements were suggested toward the end of the growing season. Root biomass estimation and root to shoot ratios from this experiment are consistent with other studies on soybeans. In 2003, we were able to study the affects of the combined CO_2 &O_3 treatments. Hail caused a 60% defoliation of the soybean crop 49 days after planting. Based on comparison of the results from this year with 2001 and 2002, defoliation reduced the seasonal root mass ≈20% in the ambient plots. The additional stress of defoliation appeared to reduce the stimulatory effect of the elevated CO_2 treatment by ≈5% in the 0-25 cm depth compared to previous years. Reduced photosynthate availability and decreased carbon gains increased the deleterious effects of the elevated O_3 treatment on root biomass. Unlike the results from 2002, the elevated O_3 treatment caused a significant reduction in root mass at the end of the growing season. The deleterious effects of the elevated O_3 treatment on root biomass counteracted by the positive effects of the elevated CO_2 treatment, even at the end of the growing season.

We have several active projects ongoing. Two projects address organic management. Emily Marriott is almost done with work that investigates two assays: particulate organic matter (POM) and amino sugar N plus hydrolyzable NH4 quantified by the Illinois N test

(IL-N). The objective of this project is to develop soil test strategies and informational resources for soil fertility management. Post-transition soils were obtained from numerous long-term studies that included organic and conventional production systems. Organic systems that rely on animal inputs including manure or compost were considered separately from those that relied exclusively on mineral amendments, and plant based inputs including legume N. Use of organic practices increased organic carbon and total N contents and the concentrations of POM-C, POM-N and IL-N. Organic systems that relied on animal-based production systems did not do a better job of building total or labile SOM than organic systems that were purely plant based. Organic management increased the proportion of organic matter in POM but not in the IL-N fraction and the quantity of N in POM and the IL-N fraction were similar. POM appears to be a more sensitive indicator of organic management than the AS-N based assay. Carmen Ugarte has just begun a Ph.D. investigating changes in soil quality that result from three organic transition strategies that differ in their level of management intensity.

Other studies of interest to NCR-59 address Bt-toxin persistence and C sequestration under biomass crops. Nirmala Gunapala and I are working to detect and quantify the Bt toxin introduced to soils from Bt corn varieties that release Cry3Bb1, which is toxic to Corn rootworm, and Cry1Ab, which is toxic to European corn borer, and relate these measures to toxicity through bioassays using target larvae. Part of this effort is being done in collaboration with Peter Motavalli. Soil, corn root and above ground tissue samples were collected from experimental plots at Urbana, Monmouth, and Dekalb IL producing CRW-corn (Cry3Bb) during the 2003 season. Samples were also collected for ECB-corn (Cry1Ab) and its controls grown at the Urbana site. Results to date suggest that neither toxin is detectable using available Elias kits at any time during the growing season even when roots and tissues present in the soil do have detectable levels of the toxin. Our inability to extracts toxins from soils may result from their rapid decay, persistence in soils (adsorbed to clays and humic substances) in non-extractable form, or to their loss from soils via leaching. The study of biomass crops has just begun this year. Replicated trials of miscanthus and switchgrass were seeded at six locations in Illinois. Baseline sampling for soil C sequestration was completed and efforts to develop trace-gas sampling and modeling strategies were begun.

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This is the second year that Maryland has been represented in NCR-59 and the first year that I am attending the annual NCR-59 meeting. My group's work on organic matter management through tillage, rotations, organic amendments and cover crops is the main NCR-59 research being conducted in Maryland. We are currently working on four projects.

First, we are studying nutrient cycling in intensively grazed dairy farm watersheds. This project is winding down with the analysis of a third year of groundwater and stream water data. We are finding that 40 to 60% of the total dissolved phosphorous leaching to groundwater (about 0.1 to 0.01 mg/L) is in organic forms. About 20% of the dissolved N is organic.
Second, we are continuing to refine the use of our active carbon method (by dilute alkaline KMnO4) in terms of interpretation and calibration. Although we initially expected that the ratio of active to total organic C in soils would be the best predictor of soil quality functions, our data suggest that the absolute concentration of active C is more important than this ratio. We have found that for soils high in SOM (> 2.5% C) we have had to modify our method by using a smaller soil sample size (2.5 g instead of 5 g) to avoid having the supply of reagent become limiting. Tentatively, using the 5 g sample size, we suggest that soils with less than 350 mg/kg active C are limited by lack of OM and will likely respond profitably to improved organic matter management, while those with more than 600 mg/kg active C are in good condition and will not likely respond to further enhancements of SOM. We are studying the soil quality functional responses (crop prodcutivi9ty, N mineralization, aggregate stability, infiltration rate, respiration rate) to added SOM in the form of a rye cover crop under no-till management at 4 sites. Each site has plots with initially high or low active C from a long history of previous cropping or perennial grass. The hypothesis is that the active C test will predict fields that will profit most from improved SOM managment.

Third, we are studying the relationship between SOM – related soil properties and the botanical composition of native prairie in Kansas (at the Land Institute). In this work, principal component and multiple regression analysis has suggest that active C is the most significant property distinguishing among the four study sites and between sites with varying levels of legumes in the vegetation community.
Fourth, we are beginning a project to investigate multiple effects of Brassica family (radish, rape) cover crops on soil quality, including the effects of decay products on nematode, weed and disease suppression.
Finally, Brian Needleman, Marty Rabenhorst and I have formally joined the Midwest Regional Carbon Sequestration Project coordinated by Battelle Memorial Institute, Applied Energy Systems. The Midwest Partnership will identify greenhouse gas sources in its region and determine the technical feasibility and cost of capturing and sequestering these emissions in deep geologic formations, agricultural forests, and degraded land systems. Existing regulations and policies will be examined to determine if they hinder the cost-effectiveness of CO2 sequestration options, and ways to overcome these barriers will be outlined. Initially we are collating databases and studying C sequestration in wetlands and urban lands in Maryland. Fred Magdoff of Vermont and I edited a new book that was published in June by CRC press.

Publications on Soil Organic Matter:

Magdoff, F., and R.R. Weil, (eds.) 2004. Soil organic matter in sustainable agriculture. CRC Press, Boca Raton, FL, 398 p.

Magdoff, F., and R.R. Weil. 2004. Strategies for managing organic matter, pp 44-65 *In* F. Magdoff and R. R. Weil, eds. *Soil Organic Matter in Sustainable Agriculture*. CRC Press, Boca Raton, FL.

Weil, R.R., and F. Magdoff. 2004. Significance of Soil Organic Matter to Soil Quality and Health., pp. 1-44 *In* F. Magdoff and R. R. Weil, eds. *Soil Organic Matter in Sustainable Agriculture*. CRC Press, Boca Raton, FL.

Williams, S.M., and R.R. Weil. 2004. Crop cover root channels may alleviate soil compaction effects on soybean crop. Soil Sci. Soc. Am. J. 68:1403-1409.

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Presentations/workshops:

Gilker, R.E., and R.R. Weil. 2003. Nutrients in ground and surface water on intensive grazing and confined feeding dairy farms. Presentation at the Annual Meetings of the Soil Science Society of America. Denver, CO November 2-6, 2003. Agronomy abstracts.

Gordon, C.S., and R.R. Weil. 2003. Soil Quality and Plant Communities in a Native Kansas Prairie. Presentation at the Annual Meetings of the Soil Science Society of America. Denver, CO November 2-6, 2003. Agronomy abstracts

Lucas, S., and R. Weil. 2003. Evaluation of active carbon test for predicting soil functional response to improved soil organic matter management. Presentation at the Annual Meetings of the Soil Science Society of America. Denver, CO November 2-6, 2003. Agronomy abstracts.

Momen, B., and R.R. Weil. 2004. Microcalorimetric quantification of microbial activity in soils with contrasting management histories. Presentation at the 89th annual meeting. Ecological Society of America, Portland, OR, August 2004.