USDA Agricultural Research Service
Northern Great Plains Research Laboratory
July 2013

INTEGRATOR

SOIL ECOSYSTEM ENGINEERS - HOLDING THE WORLD TOGETHER

What holds the world together? Would you believe soil microorganisms 20 to 100 times smaller than a human hair?

French Composer Claude Debussy said, "Music is the space between the notes." In the same way, soil needs open space between the physical material to function effectively.

Dr. Kris Nichols

In a recent review article entitled 'Roles of Biology, Chemistry, and Physics in Soil Macroaggregate Formation and Stabilization', Drs. Kris Nichols and Jay Halvorson, NGPRL, and TheCan Caesar, ARS Sidney, MT, postulate that the flow of photosynthetic carbon from plants into soil organisms may influence how soil aggregates are formed and stabilized. Soil aggregation is a feat of microbial engineering where biological, chemical, and physical processes bind soil particles together to create soil structure or the 3D configuration of open and closed spaces that define macroscopic soil functions like water infiltration, water holding capacity, soil structure, and carbon and nutrient cycling. French Composer Claude Debussy said, "Music is the space between the notes." In the same way, soil needs open space between the physical material to function effectively.

Carbon flow from the roots is a way of transferring energy captured from sunlight to the soil food web and providing the carbon molecular building blocks for microbial bodies and biomolecules such as polysaccharide and protein glues and waxes that initiate aggregate formation and provides season-to-season stability through wet-dry and freeze-thaw cycles. To begin aggregate formation, roots and strands of thin fungal hyphae form a net upon which soil debris and particles begin to collect (Figure 1).

Most of these hyphal strands are the thin, long, crooked, light brown to colorless bodies of symbiotic, mycorrhizal fungi. Mycorrhizal (literally fungal-root) fungi grow out from plant roots into the soil and collect nutrients and water which are carried through the hyphae back into the plant root and delivered to the plant in exchange for sugars.

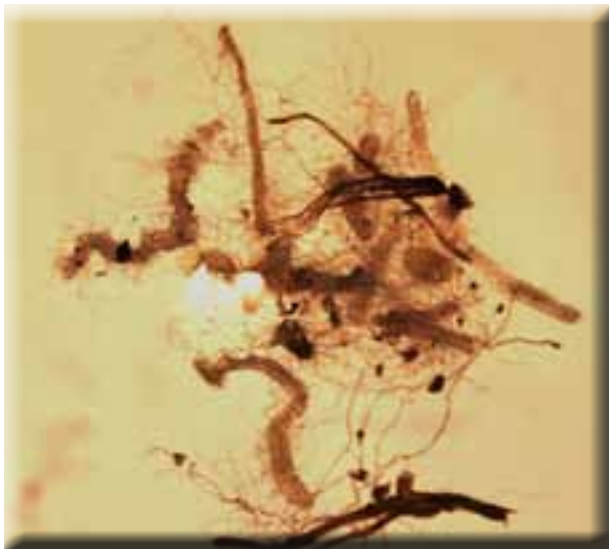

Figure 1. Soil debris, organic matter, root fragments, sand particles, clay minerals, and silt particles are collected on the hyphal net and stuck together by microbial glues such as glomalin and bacterial polysaccharides to begin forming soil aggregates. As biological, chemical, and physical processes bring these materials closer together, these amorphous conglomerations become the soil aggregates pictured in Figs. 2-3.

In this issue:

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WELCOME TO THE SUMMER ISSUE OF THE INTEGRATOR

This issue has several pieces of useful information from recently completed research and updates on people and facilities. As per the adage, change has been a constant at NGPRL. We have weathered another budget cut as a result of the sequester earlier this year. Our budget was cut by 7.8%, which we met by eliminating two vacant permanent positions, reducing the number of part-time student hires, and further reducing our operating and facilities costs. In addition, Dr. Rebecca Phillips resigned from the USDA-ARS in April to take a research position in New Zealand. At this point, we will likely eliminate that vacant position as well to cope with future budget uncertainties.

On the positive side of change, we have several new staff at NGPRL, most of whom were hired on grant or contract funds. We also have two summer student interns working on some exciting research projects at the lab. Details on the new hires and the summer interns are on the following pages.

Construction has begun on the NEON (National Ecological Observatory Network) site at our south unit. This site is part of a national network funded by the National Science Foundation and is an exciting new addition to our research facility. Construction should be completed in September. We will have a tour of the site as part of Friends and Neighbors Day on July 18.

Scientists at NGPRL continue to receive national recognition. Dr. David Archer received the Conservation Research Award from the Soil and Water Conservation Society in July. And, Dr. David Toledo (new post doc at NGPRL) received the Distinguished Graduate Student Award for Excellence in Research from Texas A&M University in May. Congratulations to both Davids!

As always, we appreciate the outstanding support from our customers, stakeholders, and community. We look forward to working with you in the coming year.

NATIONAL ECOLOGICAL OBSERVATORY NETWORK CONSTRUCTION SITE D9: NORTHERN GREAT PLAINS RESEARCH LABORATORY

The long-planned NEON observatory is now under construction at NGPRL. The field research tour at the July 18th Friends & Neighbors Day (departs at 3:00 p.m.) will tour the site.

The National Ecological Observatory Network (NEON) is a continental-scale observatory designed to gather and provide long-term ecological data on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. NEON is a project of the National Science Foundation, with many other U.S. agencies and non-government organizations cooperating.

All NEON data and information products will be freely available via the Web. NEON's open-access approach to its data and information products will enable scientists, educators, planners, decision makers and the public to map, understand and predict the effects of human activities on ecology and effectively address critical ecological questions and issues.

http://www.neoninc.org

INTERNS

Allison Haider is working at NGPRL this summer as a USDA-ARS Northern Plains Area co-funded intern.

Allison is currently attending NDSU where she is majoring in Biology with a minor in Chemistry.

Allison's internship project focuses on evaluating the soil, vegetation and forage quality changes that occur when Kentucky bluegrass invades native grassland. To do this, Allison is learning plant species, using a unique method to measure soil nutrient dynamics, and will be gaining experience in using laboratory techniques to determine forage quality.

Allison's NGPRL mentors are John Hendrickson, Mark Liebig and Scott Kronberg.

Allison Haider inserts ion exchange probes into the soil to estimate nutrient availability.

Lauren Beshears

This summer NGPRL animal scientist, Scott Kronberg, and his team at the lab are being assisted by **Lauren Beshears**, a senior student at Cal Poly - San Luis Obispo who is doing her senior internship at the lab.

The intent of the project she is working on is to determine if the daily forage intake of grazing cattle can be accurately estimated with an entirely new approach that is less expensive and requires less labor.

Data on the daily forage intake of grazing cattle is valuable information for various uses including helping to determine the production efficiency of individual cows for breeding purposes.

Standard approaches for estimating daily forage intake of individual grazing cows or yearlings are very labor intensive and expensive, so few if any cattle producers obtain data on the daily forage intake of their cattle when they are grazing.

STAFF RECOGNITION

Dr. David Archer has been selected to receive the Conservation Research Award from the International Soil and Water Conservation Society. The award is conferred on society members or whose research has led to exceptional improvements in soil conservation, water conservation, and/or related natural resources research. The award may be given for research excellence or results of the research that have led to significant conservation improvements.

A research poster coauthored by Dr. David Archer, "*Double- and Relay-cropping Oilseed and Biomass Crops for Sustainable Energy Production*" was presented the "Best Visual Presentation Award" in the Biomass Feedstock, Residues and By-products in June at the European Biomass Conference and Exhibition held in Copenhagen, Denmark.

Dr. David Toledo received the 2013 Texas A&M University Association of Former Students Distinguished Graduate Student Award for Excellence in Research for his "outstanding academic record and contributions in teaching and research". The work Dr. Toledo performed that led to this award evaluated the social dimensions of using extreme fire as a rangeland restoration tool in Texas and in the Janos Biosphere Reserve in Mexico.

SOIL ECOSYSTEM ENGINEERS - HOLDING THE WORLD TOGETHER

continued from page 1

In addition to using these sugars for their hyphal bodies, mycorrhizal fungi (which can be seen glowing green following a laboratory procedure in Figure 2) make a sticky protein, called glomalin.

Glomalin also creates a waxy coating on the surface of aggregates to help keep them water-stable. Also, some of the sugars given from the plant to the mycorrhizal fungi are traded to bacteria growing in and around fungal hyphae in the soil for nutrients, such as phosphorus, which the bacteria release from minerals in the soil. The carbon feed to the bacteria is used in their bodies and to make the sticky polysaccharides which also help glue aggregates together. Figure 3 shows aggregates formed around roots using fine roots and hyphal nets.

At Friends and Neighbors Day, Nichols will demonstrate how soil aggregates are formed and stabilized by microorganisms and show how if 'soil is treated like dirt', aggregates will explode. She will show how aggregates reduce runoff by providing space for water to flow into the soil and improve availability near growing roots. A rainfall simulator and table-top demonstrations provided by Susan Samson-Liebig with NRCS will show how soil surface management influences soil organisms to engineer aggregates to reduce nutrient and soil loss, increase water infiltration rates, and water holding capacity.

http://vimeo.com/21310772

Dr. Kris Nichols, Soil Microbiologist

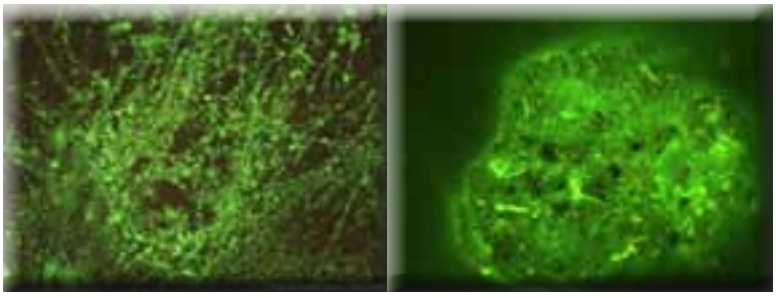


Figure 2. The monoclonal antibody against glomalin is used in immunofluorescence to indicate where glomalin is located on fungal hyphae (left) and soil aggregates (right)by glowing green.

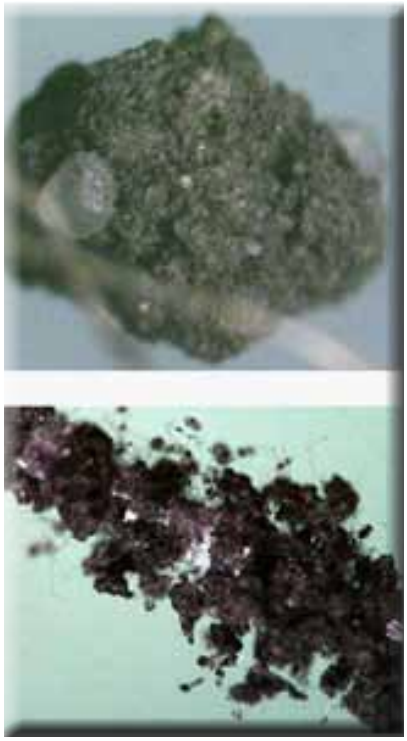
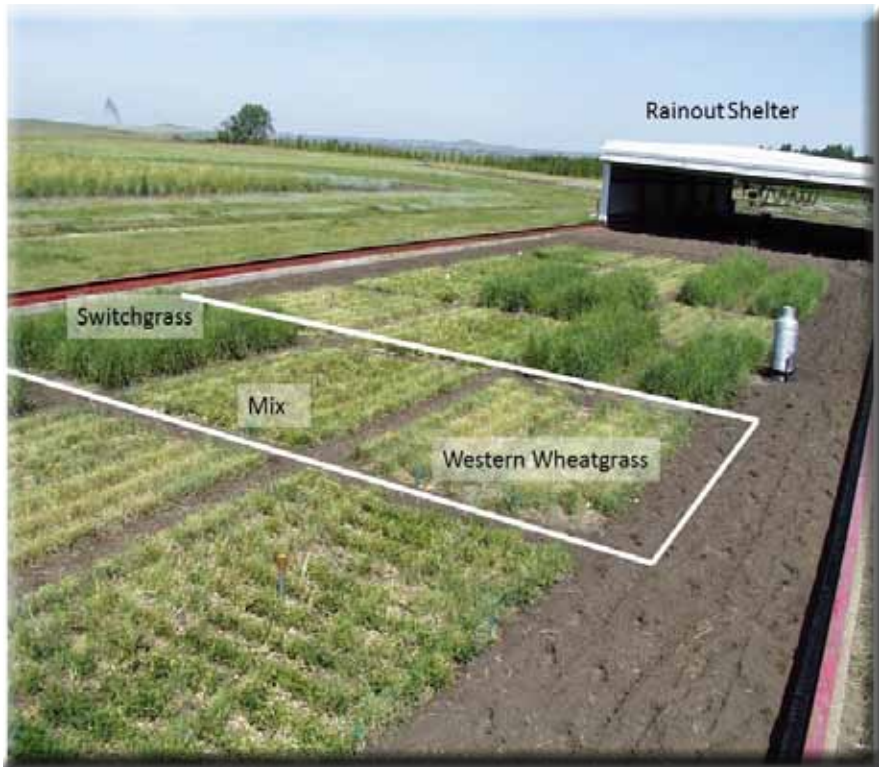


Figure 3. A macroaggregate is formed primarily by a 'sticky-string bag' process where roots and fungal hyphae act as a framework to envelope soil particles. This picture shows a macroaggregate formed around a big bluestem root in a 3-month pot culture study where the plants were grown in a 1:1 sand:soil mix (top). Aggregates are formed quickly (54 days) around millet roots collected from a cover crop mixture which was planted on July 7, 2007 following harvest of forage pea on a farm near Bismarck, ND. Hyaline strands of AM fungal hyphae extending out from the millet root have many soil particles adhering to the hyphae even where aggregates are not completely formed (bottom).

WATER USE EFFICIENCY FOR SWITCHGRASS, WESTERN WHEATGRASS AND A WESTERN WHEATGRASS ALFALFA MIXTURE

Water and agricultural use of water is becoming a greater concern, especially in western parts of the Great Plains and there are concerns about how biofuel production may affect water quality and quantity. Because of these reasons, it is important to evaluate the water use efficiency and soil water deficit of potential biofuel crops as well as other forages. We used a rainout shelter at the Northern Great Plains Research Laboratory at Mandan, ND to evaluate water use efficiency and soil water deficits for switchgrass, western wheatgrass, and a western wheatgrass – alfalfa mixture under an early-season (May-June), a late - season drought (July-August) and a control group (normal growing season moisture).



In both drought treatments, approximately 50% of the long-term average May – August precipitation (10.15 inches) was applied as irrigation water. In the early-season drought, only 20% of the 4.5 inches of the irrigation water applied from May through August was applied in May-June while the remainder (80%) was applied in July-August. In the late-season drought a similar approach was used. However, in the late-season drought, 80% of the 4.9 inches irrigation water applied between May through August was applied in May-June, while the remaining 20% was applied in July-August.

Biomass production was measured at the end of the growing season in October. In 2006, switchgrass produced 6.3 tons per acre under the control treatment, 3.8 tons per acre under the early-season drought and 4.8 tons per acre under the late-season drought. Under the early-season drought, switchgrass produced almost three times the biomass as western wheatgrass and under the late-season drought, switchgrass produced four times biomass as western wheatgrass and twice as much as the western wheatgrass-alfalfa mixture.

Water use efficiency was strongly influenced by the amount of forage produced. Switchgrass always produced more biomass than the western wheatgrass monoculture and so the water use efficiency for switchgrass was greater than for the western wheatgrass monoculture. The water use efficiency for switchgrass ranged from 0.31 to 0.41 pounds of biomass per inch of water used which was nearly 4 to 5 times greater than the water use efficiency for western wheatgrass (0.06 to 0.11 pound of biomass per inch water). Water use efficiency for the mixture (western wheatgrass and alfalfa) was much more variable. For example, under the early season drought (May-June), water use efficiency for the mixture was similar to switchgrass. However, for a later drought and the control, water use efficiency for the mixture was similar to western wheatgrass. The year after the drought, water use efficiency for the mixture was similar to switchgrass again.

Soil water deficit was also evaluated in the study. Soil water deficit was calculated as the difference between the month with the greatest soil water and the month with the least soil water. Although switchgrass had the greatest water use efficiency it also resulted in the greatest soil water deficit while the water deficit for the mixture was usually the lowest except for the control. The water deficit for the western wheatgrass-alfalfa mixture was 31% and 38% lower than the water deficit for the switchgrass for the early and late drought stress respectively.

The results from this project suggest that switchgrass is an appropriate perennial biofuel to use in the drier areas of the northern Great Plains because of its greater water use efficiency. However, its greater soil water deficit suggests that switchgrass may deplete the soil water more under a multi-year drought than western wheatgrass or a grass alfalfa mixture. This may be especially crucial if switchgrass was used as a perennial phase in a crop rotation. Researchers and producers need to be aware of the benefits and drawbacks for using switchgrass in dry or drought prone areas.

http://link.springer.com/article/10.1007%2Fs12155-012-9290-3

Drs. John Hendrickson, Marty Schmer, and Matt Sanderson

TREATMENT OF FLAXSEED FED TO INCREASE OMEGA-3 FATTY ACID CONCENTRATIONS IN RED MEAT

There is considerable evidence that the health of many people could be improved by greater intake of omega-3 fatty acids. Red meat can be a source of these healthy fats. Two studies at the Northern Great Plains Research Laboratory were preformed to determine if flaxseed treated with a formaldehyde-free process could increase a-linolenic (ALA) form of omega-3 acid fatty acid concentrations in lamb and steer muscle.

In the first study, twenty-four lambs averaging 97 pounds initial body weight, were randomly divided into four groups for a 90 day trial. One treatment group was fed 1/3 pound per day of nontreated ground flaxseed; two other treatment groups (with different additives) were fed the flaxseed ration, but treated to protect a-linolenic acid from microbial hydrogenation. A control group was fed corn and soybean meal with similar crude protein levels.

Intake of treated flaxseed raised plasma triacylglycerol concentrations of a-linolenic acid more than intake of nontreated flaxseed did, but there was no difference in alpha-linolenic acid increase between the two treated flaxseed groups. Intake of treated flaxseed increased muscle phospholipid a-linolenic acid and eicosapentaenoic acid concentrations more than nontreated flaxseed did. There were no differences in muscle phospholipid omega-3 concentrations between either treated groups.

A second study was conducted with steers. Ten yearling steers were randomly divided into two groups. One group was fed ground flaxseed (0.05% of body weight per day) and a second group was fed treated flaxseed at the same rate. The 175 day trial was divided into two periods: high roughage, low concentrate period followed by high concentrate, low roughage period. There was no difference in increase of alpha-linolenic acid in blood plasma of treated and untreated flaxseed fed groups by the end of the first period. However, the non-treated flaxseed-fed group had 16% greater concentration of alpha-linolenic acid in blood plasma during the second period. Muscle phospholipid omega-3 fatty acid was not greater for slaughtered steers from the treated flaxseed-fed group.

Intake of treated flaxseed raised omega-3 concentrations in blood and muscle of sheep, and in blood of cattle but did not increase omega-3 fatty acid concentrations in muscle of steers.

Dr. Scott Kronberg, Animal Scientist

Treatment of flaxseed to reduce biohydrogenation of alpha-linolenic acid by ruminal microbes in sheep and cattle, and increase n-3 fatty acid concentrations in red meat, Journal of Animal Science. 2012 Dec;90(12):4618-24. Doi: 10.2527/Jas.2011-4774. Epub 2012 Jun 13. Kronberg SL, Scholljegerdes EJ, Murphy EJ, Ward RE, Maddock TD, Schauer CS.

http://www.journalofanimalscience.org/content/90/12/4618.abstract

CONDENSED TANNIN IN DRINKING WATER REDUCES GREENHOUSE GAS PRECURSOR UREA IN SHEEP AND CATTLE URINE

Ingestion of small amounts of naturally-occurring condensed tannin by ruminants can provide several benefits including potential reduction of ammonia and nitrous oxide emissions over the long-term by reducing their urine urea excretion. However, providing grazing ruminants with sufficient amounts of condensed tannin-containing pasture forages such as birdsfoot trefoil and sainfoin is difficult for reasons related to the challenges of growing these tannin-containing plants. Providing condensed tannin in the water of the grazing animals may be an alternative. Two trials were conducted to determine if urine urea levels in sheep can be decreased after drinking water containing condensed tannin.

In the first trial, serum urea was measured as a surrogate for urine urea when four wethers drank tap water or tap water with very low (0.25% of daily dry matter intake), low (0.05% of daily dry matter intake), medium (1.0% of daily dry matter intake) or high (2.0% of daily dry matter intake) amounts of quebracho tannin. Blood serum urea concentration was measured after the animals drank the treatments for seven days. Mean serum urea concentration in the sheep was reduced when they consumed water with quebracho tannin, but only when they drank the mixture with the highest amount of quebracho tannin. Mean body blood serum urea concentration was also reduced in cattle that drank water which included tannins.

In a second sheep trial, four wethers were fed alfalfa pellets (3.5% nitrogen) and given tap water or tap water with low (0.5% of daily dry matter intake), medium (1.0% of daily dry matter intake) or high (1.5% of daily dry matter intake) amounts of quebracho tannin and their urine urea excretion measured. There was a linear effect of quebracho tannin intake on daily urine urea excretion as a percentage of nitrogen intake.

Ingestion of water containing the low, medium and high levels of quebracho tannin resulted in reductions in daily urea excretion as a percentage of nitrogen intake of 3.5%, 6.6%, and 12.6% less, respectively, for the low, medium and high quebracho tannin intake. Small amounts of quebracho tannin in the drinking water of grazing sheep and cattle can reduce their urine urea excretion.

Dr. Scott Kronberg, Animal Scientist

Condensed tannin in drinking water reduces greenhouse gas precursor urea in sheep and cattle urine. 2011. Rangeland Ecol. Manage. 64:543-547., Kronberg, S.L. and M.A. Liebig.

http://www.bioone.org/doi/pdf/10.2111/REM-D-10-00165.1

PRESENTATIONS AT THE USDA FRIENDS & NEIGHBORS DAY

Taking the Heartbeat of Soil
Benefits of Healthy Rangelands
Unlock the Secrets in Your Soil
What's Wrong with My Tree?
Soil Health-Microbe Engineers
Crop Alternative-Grass Farm Economics
Seeds of Resilience
Remote Sensing to Map Grassland Productivity
Kentucky Blue Grass: From Lawn to Rangelands
Modeling Crop Growth
Ecological Sites and Grassland Management
Developing Plants and Technology for Conservation
NGPRL - Research for You and the Nation

Feel free to pass on this issue of Northern Great Plains Integrator to others interested in agricultural research in the northern Great Plains. Northern Great Plains Integrator is published and distributed by the USDA-ARS, Northern Great Plains Research Laboratory, PO Box 459, 1701 10th Avenue S.W., Mandan, ND 58554.
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USDA Friends & Neighbors Day

Northern Great Plains Research Lab

South of the Heart River on Highway 6 in Mandan

1701 10th Avenue SW

Important DATE!

July 18, 2013

2-8 PM CT

www.ars.usda.gov/npa/ngprl or 701.667.3001

Enjoy the park-like campus filled with Children's Activities, Presentations, Exhibits, Demonstrations, Tours, Evening Barbecue & Entertainment

Learn about:

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- Soils and Microbiology
- Cropping Systems
- Rangeland Health
- Invasive Plants
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GREAT RIVER ENERGY

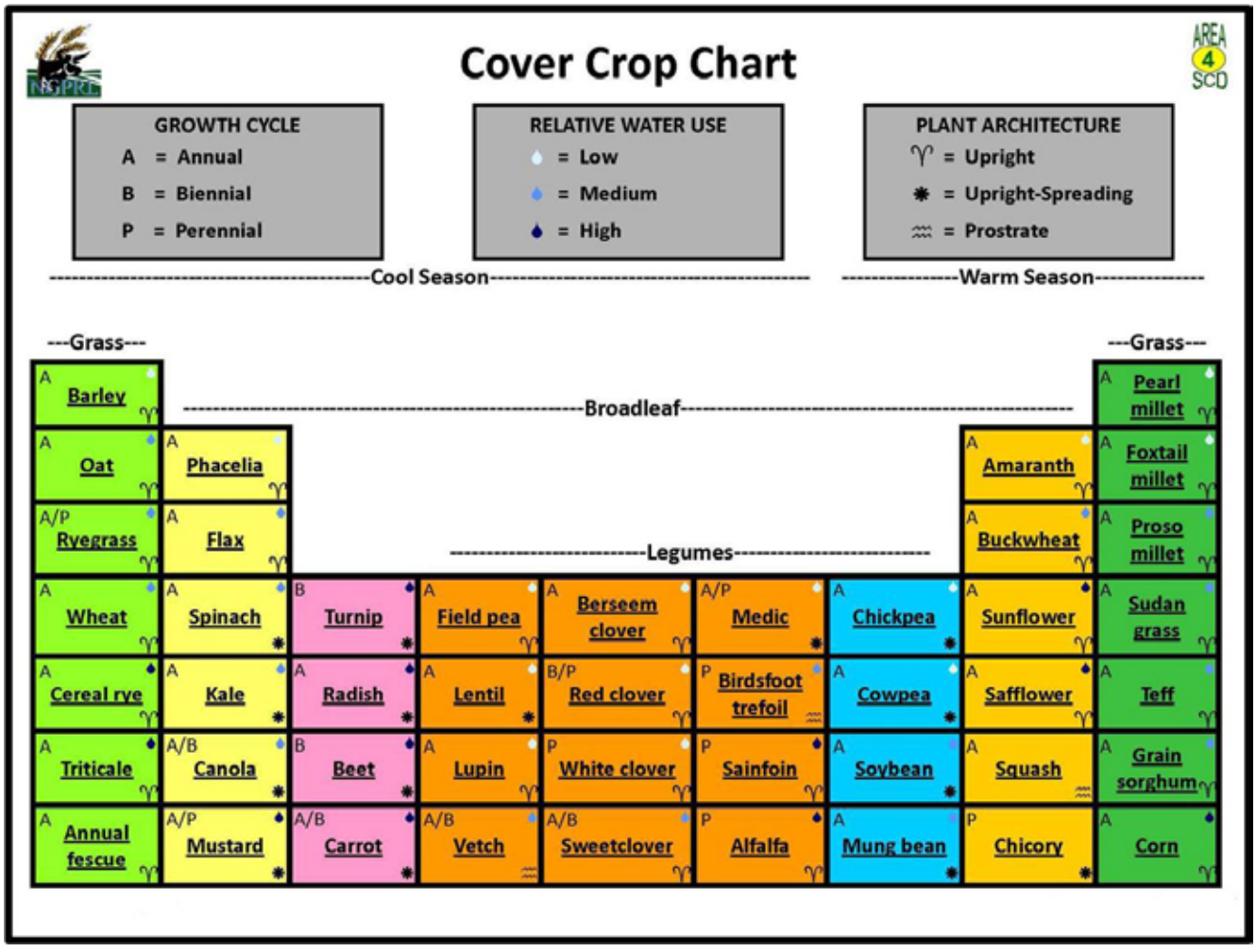
NGPRL COVER CROP CHART PUBLISHED IN JOURNAL OF EXTENSION

Interest in cover crops has increased the need for information regarding their suitability for addressing different production and natural resource goals. To help address this need, staff at the USDA-ARS Northern Great Plains Research Laboratory (NGPRL) developed a decision aid called the Cover Crop Chart (CCC). Visually analogous to the periodic table, the CCC includes information on 46 crop species within a free downloadable Portable Document Format (PDF) file (available at www.ars.usda.gov/npa/ngprl).

A paper reviewing the CCC was recently published in the June issue of Journal of Extension. The paper reviewed development, features, and suggested use of the chart, thereby providing readers a useful primer about the CCC. More generally, the paper should serve as an important communication link to raise awareness of user-friendly decision aids created at NGPRL.

Developing the CCC was a team project, with valuable guidance and suggestions from NGPRL staff, producers and technicians in the Area IV Soil Conservation Districts, and NRCS employees throughout North Dakota.

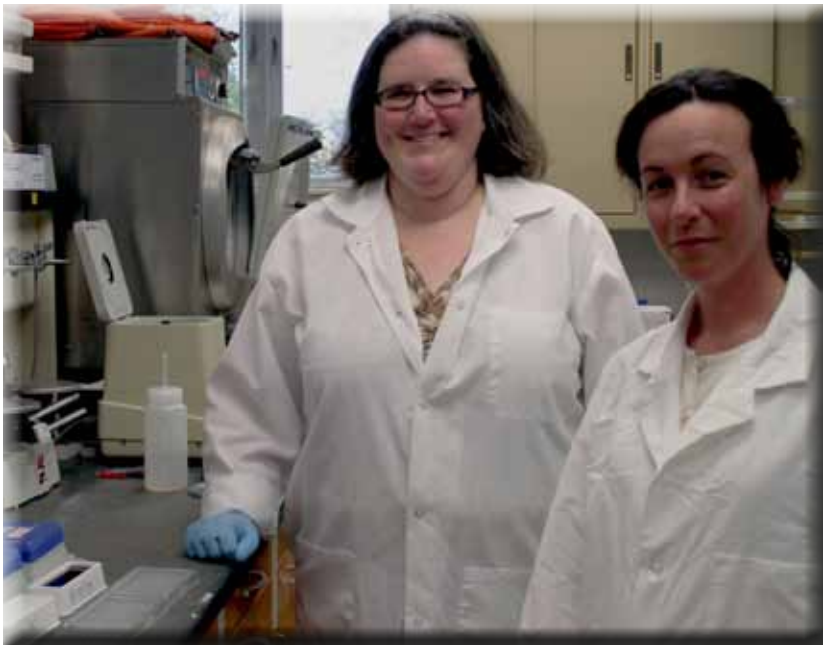
Dr. Mark Liebig, Research Soil Scientist



Liebig, M.A., H.A. Johnson, D.W. Archer, J.R. Hendrickson, K.A. Nichols, M.R. Schmer, and D.L. Tanaka. 2013. Cover Crop Chart: An intuitive educational resource for extension professionals. Journal of Extension [Online], 51(3) Article 3TOT7. Available at http://www.joe.org/joe/2013june/tt7.php

DR. KAREN BARRY'S LOW-INPUT FARMING JOURNEY

On July 1-5, Dr. Kris Nichols hosted Dr. Karen Barry, a visiting scientist from Tasmania.



Drs. Kris Nichols and Karen Barry

Dr. Barry is a Research Fellow and Lecturer at the Tasmanian Institute of Agriculture, at the University of Tasmania. She is also a non-executive director of the Ag Institute Australia. Her research is mostly on mycorrhizal fungi in temperate climates.

Dr. Barry envisions a low input future for agricultural production. Low input agriculture occurs by design (e.g., organic farming) or by default (i.e., when inputs are not available or too expensive to use). Synthetic fertilizers are not a renewable resource. Reduced use is advocated in most agricultural sectors and increased cost is already prohibitory for some. Water too is becoming more scarce and prices are increasing. She believes that if we can understand more about the function of mycorrhizal fungi, can we reduce use of synthetic fertilizers, use water more efficiently and better adapt to a future of low-input agriculture.

What are mycorrhizal fungi? The short answer from Dr. Barry is "good fungi that live in the soil and help plants grow, by unlocking nutrients in the soil and extending uptake of water. Over 90% of land plants have mycorrhizal roots: fine roots colonized by mycorrhizal fungi."

Some farming practices, such as tillage, fallow, and high use of chemical fertilizers and pesticides, reduce the survival of these fungi in the soil and the chance of mycorrhizal roots forming.

Dr. Barry received a Winston Churchill Traveling Fellowship to travel throughout the US and Canada. Her journey to learn more about North American cutting-edge research in the field includes stops at the University of Florida, the USDA-ARS Eastern Research Center, the Rodale Institute in Pennsylvania, Northern Great Plains Research Laboratory, and the University of Saskatchewan in Swift Current.

http://malbarry.com/lowimpactfarmingjourney2013/

Dr. Kris Nichols, Soil Microbiologist

NEW FACES

Dr. Anand Kumar Pothula, (Anand for short) joined the Department of Agricultural and Biosystems Engineering at NDSU in April as a Research Associate in the North Dakota Industrial Commission and Green Vision Group funded "Energy Beet Research II" project working with Dr. Igathinathane Cannayen at NGPRL. His research focuses on extracting juice and pulp from the beets in an energy efficient manner utilizing a simplified mechanical processing.

Anand previously served as Assistant Professor at North Eastern Regional Institute of Science and Technology in India where he taught food engineering subjects for six years.

Andrew Carrlson joined the permanent staff in March working for Dr. John Hendrickson as a Biological Science Technician. Prior to coming to Mandan, he worked for the University of Missouri as a Lab Manager. Andrew assisted several graduate students with their data collection and implemented an experiment examining heat transfer from light energy in nesting birds. Andrew received his Bachelors in Natural Resources from the University of Minnesota-Crookston in 2008.

David Clausen is a Financial Technician with the USDA-ARS Grand Forks Human Nutrition Research Center. David utilizes office space at Mandan while his wife studies at the UND Medical School campus in Bismarck. David is a native of Wilton, ND.

Craig Ford joined the staff at the Northern Great Plains Research Laboratory in March. Craig is a Biological Science Technician. Most recently he came to us from the Greenhouse Production Research Group in Toledo, OH where he assisted research on the effects of silicon uptake and media replacement in floricultural crops. Prior to his time in Ohio he worked with the IR-4 program at the Yakima Agricultural Research Laboratory in Wapato, Washington and conducted pesticide residue trials on minor use row crops.

Dr. David Toledo, a headquarters-funded post-doctoral research associate, joined the staff at the Northern Great Plains Research Laboratory in March. Toledo is a post-doctorial research associate responsible for improving ecological indicators of rangeland and pastureland health. His work will result in an integrated grazingland health assessment tool for use in management and conservation planning. David's previous research includes working at the USDA-ARS Jornada Experimental Range in Las Cruces, NM working on the development and application of indicators for monitoring soil and vegetation attributes and assessment of rangeland health.

Justin Schomerus is a recent graduate of Peru State College in Southeast Nebraska. He earned his BS in Biochemistry and Natural Science. Justin works with Drs. Mark Liebig and Nic Saliendra continuing gas exchange study of native grassland and alfalfa crops. Justin grew up on a family farm in Southeast Nebraska where he played an active part in raising primarily corn, soybeans and beef cattle along with oats, red clover and alfalfa.