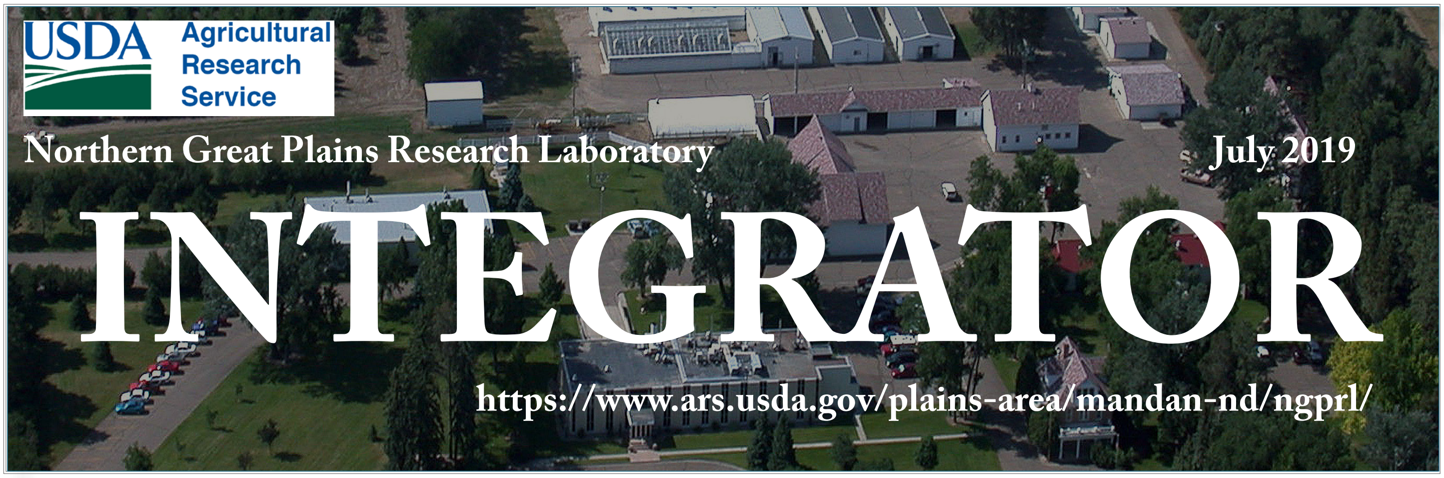

Improving water efficiencies in spring wheat

Drs. Jonathan Halvorson, David Archer, Mark Liebig

In semi-arid rainfed farming regions such as central North Dakota, effective use of water is critical. Historically, cropping systems which were conventionally tilled included fallow to conserve water. However, these systems have been shown to be relatively inefficient and otherwise unsustainable. Efforts to improve water use have focused on adoption of conservation tillage, improved crop rotations, use of cover crops and application of living or residual mulches to cover soil.

While there are many ways to measure water efficiency, two common measurements are water use efficiency (WUE) and precipitation use efficiency (PUE). Both measurements can be useful, but it is important to understand how they differ.

Water use efficiency is measured as the ratio of production (grain yield) to water used during the growing season. In our field plot research, we estimate water use during the growing season as the amount of precipitation received during the growing season plus the change in root zone (0-48 in depth) soil water from planting to harvest. For example, if we had 8 inches of water in the root zone at planting and 3 inches left at harvest, this indicates we used 5 inches of soil water. If we also received 7 inches of rain during the growing season, that total water use was 5 + 7 = 12 inches. If our spring wheat yield was 48 bushels per acre, then WUE would have been 48/12 = 4 bu/ac/in. This measure is mostly determined by the plant and how well it grows with the water it has available, so it is most closely related to crop genetics and plant physiology rather than cropping system. However, effects of cropping system on improving water capture and reducing soil losses during the growing season are included in WUE. So, for example, the effect of crop residue on the surface in reducing evaporation can increase water use efficiency as more of the water in the soil is available for plant growth.

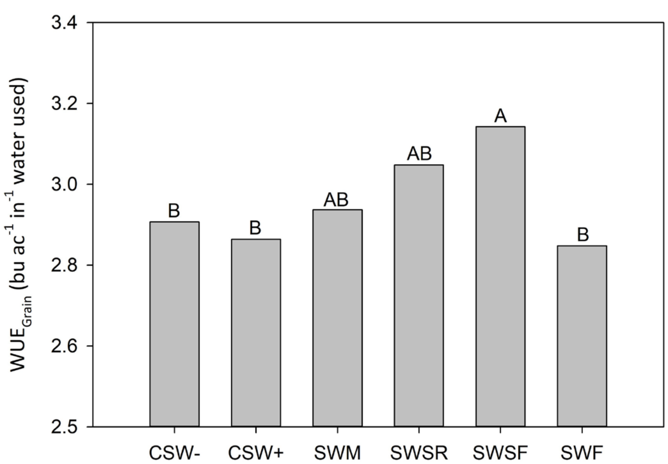

Fig. 1. Water use efficiency (WUE) for spring wheat grain yield under continuous spring wheat with residue removed (CSW-) and residue kept in the field (CSW+), spring wheat-millet hay (SWM), spring wheat-safflower-rye (SWSR), and spring wheat-safflower (SWSF), and spring wheat-fallow (SWF) rotations. Differences between sequences are denoted by letters ($P \leq 0.05$).

continued on page 2

In this issue:

Improving water efficiencies in spring wheat

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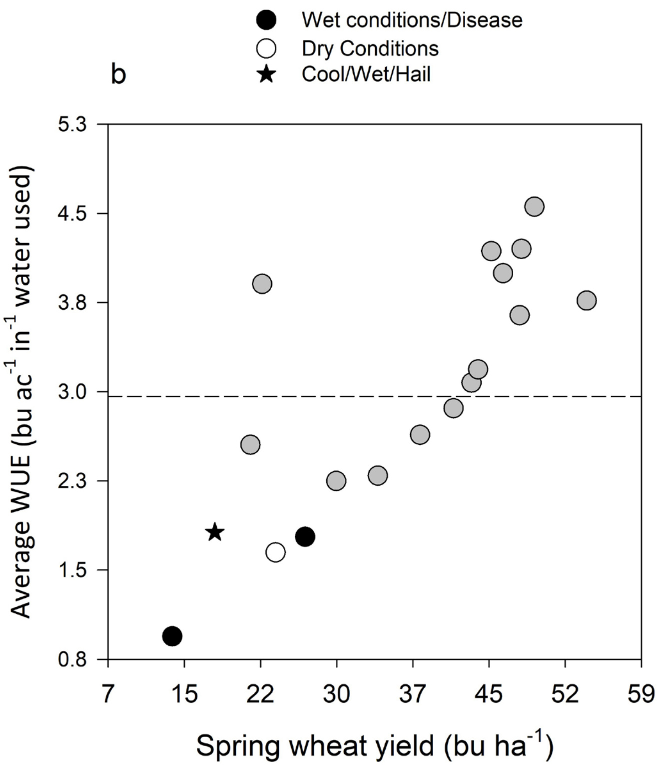

Fig. 2. Water use efficiency (WUE) as a function of grain yield. The dashed line is the average WUE over all years and treatments (3.0 bu/ac/in).

Precipitation use efficiency is another common measure useful for comparing production efficiencies among cropping systems. The PUE is calculated as the ratio of grain yield to the precipitation that occurred since the previous crop harvest. This measure is a broader efficiency measure since it includes the effect of the cropping system in capturing precipitation for the entire period from previous crop harvest (not just the growing season) and making it available for crop growth. So, this includes effects of capture and storage of late fall and winter precipitation. For example, if a millet hay crop is harvested in July and spring wheat is grown the next year and harvested at the end of August, the total precipitation for the 13+ month period from July through August is included. As an illustration, let's assume this is 20 inches. If spring wheat yield is again 48 bushels per acre, then PUE is 48/20 = 2.4 bu/ac/in. In calculating PUE, no measurement of soil moisture is included. It is strictly a measure of how much yield was produced given the precipitation that was received in the time since the previous crop was harvested.

As part of a long-term (1993-2011) study near Mandan, ND, we measured soil water at various depths, and together with precipitation and yield data, determined WUE and PUE for spring wheat grown under minimum- or no-till in different crop sequences of varying cropping intensity. These sequences included continuous spring wheat with residue removed (CSW-) and residue kept in the field (CSW+), a spring wheat-millet hay (SWM) rotation, a spring wheat-safflower-rye (SWSR) rotation, and spring wheat-safflower (SWSF) rotation, and a spring wheat-fallow (SWF) rotation. The CSW-, CSW+, and SWM rotations were considered the highest intensity rotations, since a crop was harvested each year. The SWSR and SWSF rotations were intermediate intensity, with crops harvested 2 years out of 3, and the SWF rotation was the lowest intensity with a grain crop harvested every other year. The rye phase of the SWSR rotation was not harvested but was grown as green fallow cover crop.

Spring wheat WUE was highest for the intermediate intensity, 3-phase sequences that included safflower and either a fallow or rye phase compared to either the CSW or SWF sequences (Figure 1). Intensified management through use of continuous cropping resulted in lower WUE under minimum-till but did not significantly influence WUE under no-till. In a continuous crop sequence under minimum-till it appears that water limitations can constrain spring wheat production while no-till or the inclusion of fallow or a lower water use cover crop phase may reduce this constraint. There is a potential tradeoff between reducing intensity and storing water to improve spring wheat WUE and increasing production in the rest of the rotation by increasing intensity. This tradeoff may be made worse with minimum-till compared to no-till.

Generally, WUE was higher with higher crop yields (Figure 2). While average WUE for all treatments was 3.0 bu/ac/in, WUE generally increased with higher yield, with highest WUE of 4.6 bu/ac/in occurring in the most favorable year (1997). Variation in WUE is a reflection of conditions that can limit crop growth including timeliness of precipitation, temperature, disease and pest pressures, nutrient availability, and

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Improving water efficiencies in spring wheat

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weather hazards such as hail. The upper end of WUE reflects what is possible when other conditions are not limiting.

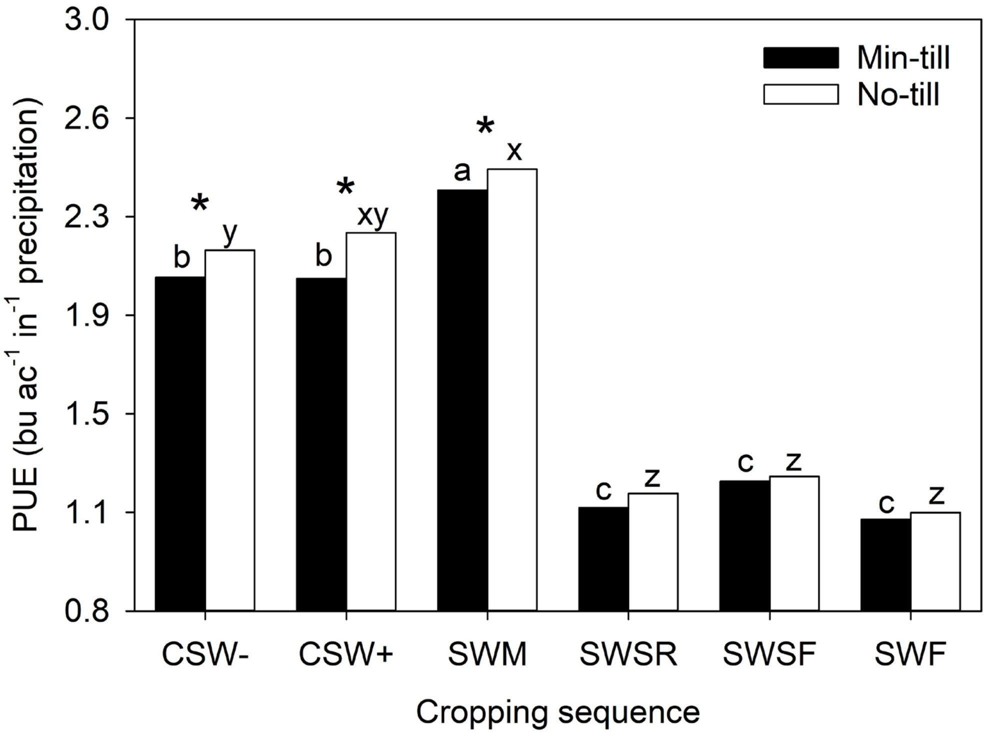

Fig. 3. Precipitation use efficiency (PUE) for spring wheat grain yield under continuous spring wheat with residue removed (CSW-) and residue kept in the field (CSW+), spring wheat-millet hay (SWM), spring wheat-safflower-rye (SWSR), and spring wheat-safflower (SWSF), and spring wheat-fallow (SWF) rotations. A significant difference between tillage treatments within each crop sequence is denoted by an asterisk while differences between sequences within each tillage treatment are denoted by letters ($P \leq 0.05$).

Looking at PUE, continuous cropping resulted in markedly higher PUE than sequences with fallow (Figure 3). Continuous cropping resulted in PUE of 2.0 to 2.4 bu/ac/in compared to 1.0 to 1.2 bu/ac/in for sequences that included fallow. Also, under continuous cropping, PUE was significantly higher with no-till than minimum-till. When fallow is included in the rotation, additional water may be stored reducing potential constraints, but some of the precipitation occurring during the fallow period may not be able to be utilized by the crop. For example, once the soil profile is full additional precipitation may runoff or be lost by percolation below the root zone. Also, during fallow periods precipitation that is stored in the soil may be lost to evaporation before it can be utilized for crop growth. These are some of the inefficiencies of fallow that have been noted by other researchers. Our results show this also pertains to a rye green fallow cover crop and could potentially pertain to any sequence that leaves substantial water in the soil profile.

Optimizing water use through crop sequences to maximize short-term production value while carrying over storage to reduce production risks to subsequent crops is a key challenge. Practices that maximize precipitation capture in the soil and reduce losses of stored soil moisture can be helpful. But, annual or even intra-seasonal patterns of precipitation and temperature make this particularly challenging in the northern Great Plains. Synchronizing the availability of soil water to meet actual crop use is an important consideration when developing crop sequences for sustainable intensification under semiarid dryland cropping. Capitalizing on this opportunity will likely require the adoption of adaptive management practices given the variable weather conditions throughout the region.

Impacts of Intensified Cropping Systems on Soil Water Use by Spring Wheat, 2019, Jonathan J. Halvorson; David W. Archer; Mark Liebig; Kathleen M. Yeater; Donald L. Tanaka, Soil Sci. Soc. Am. J., doi: 10.2136/sssaj2018.09.0349

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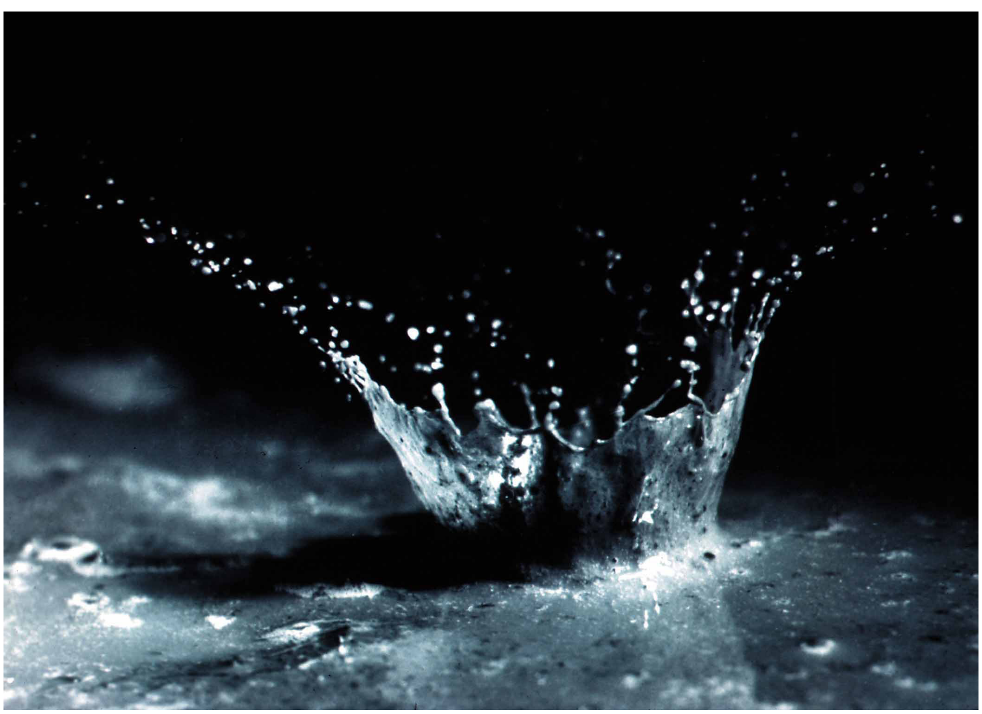
Message from Dave

Dr. David Archer, Research Leader

As I write this, thundershowers are rolling through the area bringing additional moisture. We are about 1.5" above normal for the year. While it is certainly possible to get too much rain, in this part of the country it is usually good to get a bit more. Indeed, much of the research conducted here has focused on ways to capture, store, and retain water so it can be put to productive use. In grazing lands, the previous edition of the Integrator (February 2019) included an article by David Toledo on effects of grazing and prescribed fire on infiltration in Kentucky bluegrass dominated rangelands, and current research is looking at the effect of drought in these systems. For cropland, the research has included minimum and no-till systems and residue management to improve snow capture and infiltration of rainfall, reduce losses to evaporation, and improve soil water holding capacity. It has

also included crop sequence research to best match water availability and needs, and better understand the ability of crops to access water in the soil. What is additional water worth? In the cover article for this issue led by Jay Halvorson, different measures of water efficiency are discussed. By one measure, an additional inch of water produces an average of 3 bushels per acre of wheat. That is $13.50 per acre at today's prices, and provides some incentive to make sure we are able to capture and utilize every inch. Something to think about the next time thundershowers roll through the area. We hope you enjoy this issue.

Dave Archer 701.667.3048 david.archer@usda.gov



NRCS

Tannin in hay reduced methane emissions and nitrogen in urine in mature beef cows and growing beef heifers.

Dr. Rachael Christensen

Reducing greenhouse gas (GHG) emissions and nitrogen (N) waste from beef cows and heifers is an important way to improve the environmental sustainability of beef ranches, especially since GHG, carbon and nitrogen balance, and carbon credits are very much in the public light. Livestock raised on high forage, grass- only diets have been shown to have higher methane emissions than those raised on legume-based diets and/ or concentrate-supplemented diets in several studies.

Most studies evaluating GHG utilized freshly grazed or green-chopped feeds, but not much has been published using harvested and preserved hays. Additionally, it is known that methane emission has been shown to be reduced by feeding tannin-containing, non-grass, fresh feeds, such as birdsfoot trefoil, sanfoin, and small burnet, a forage forb, but whether the action of tannins to reduce methane is effective in harvested hay is unknown. Therefore, investigation of tannin-containing and legume forages harvested as hay that may decrease environmental waste was the focus of a livestock research project.

Our study compared methane emissions and nitrogen (N) input versus output of cows and heifers fed 6 different types of hay. Three of those hays, birdsfoot trefoil (BFT), sanfoin (SAN) and small burnet (SML) were non-grass, tannin-containing forages. Two of the hays were non-tannin legume hays, alfalfa (ALF) and cicer milk vetch (CMV). Neither one of these legumes contain tannins, though CMV is known to reduce bloat. Meadow bromegrass (MB) was the "control" grass that the others were compared to. All 6 hays were fed to 5 non-pregnant, non-lactating mature Angus beef cows and 3 heifers in rotation of 2 experiments. Each period consisted of 14 days of adaptation of the animals to the diet, followed by 5 days of sample collection. All 3 heifers were used to evaluated methane emission during each

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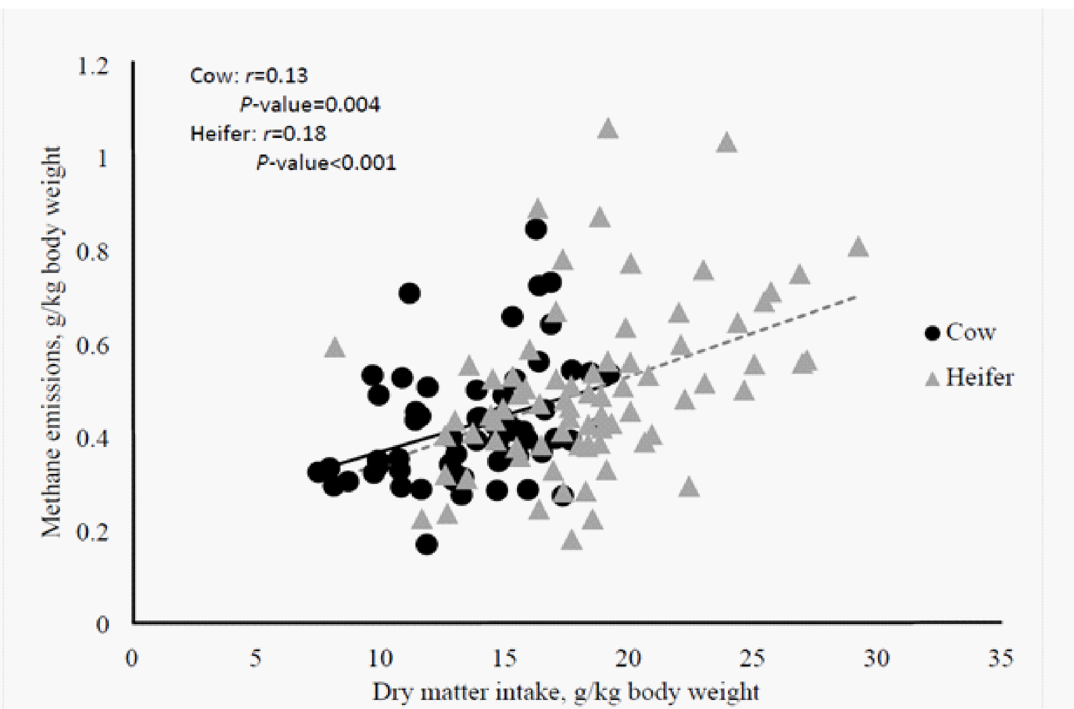

Fig. 1: Relationship between methane emissions (y axis; g Methane/kg body weight) and dry matter intake (x axis; g hay/kg body weight) for mature cows and growing heifers fed 6 types of hay.

Tannin in hay reduced methane emissions and nitrogen in urine in mature beef cows and growing beef heifers.

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Under-halter canister used for sulfur hexafluoride tracer method of methane collection from cows on feeding trials. (Photo source: SRUC Beef Research Center)

experimental run, while 3 of the 5 cows were selected for methane evaluation, and all animals had total collection of urine and feces for N balance purposes.

Each experimental period consisted of 14 days of adaptation to the assigned hay in a group pen followed by 5 days of sample collection in individual pens. Each animal was given ad libitum hay, water, and trace mineral salt block. During sample collection, intake and refusal of hay was recorded, and total collection of urine (via in-dwelling catheters) and feces performed, all weights and volumes recorded and subsamples analyzed for urea N and total N. Fecal subsamples were freeze dried, ground, then analyzed for organic matter, dry matter, ADF, NDF, total N, and condensed or hydrolysable tannin. Data were used to calculate apparent digestibility, N retention, and protein digestibility. Blood was sampled on the last day, serum collected, and analyzed for urea nitrogen.

Enteric methane was measured on individual animals using a sulfur hexaflouride tracer and evacuated canisters worn by the cows while attached to a halter. Canisters collected emitted methane and sulfur hexafluoride for 24 hour periods, then were changed every day for an empty one, and repeated for 5 days. In the lab, canisters were sampled into evacuated and sealed serum bottles, for later methane and sulfur hexafluoride gas chromatography analysis.

Results showed that feed intake (on a dry matter basis) for the mature cows was not different between the treatments. Digestibility of crude protein and neutral detergent fiber was greatest for cows consuming BFT and CMV, indicating better quality feeds and utilization. In heifers, those consuming ALF had highest intake, and digestibility was higher for those consuming CMV and CFT.

There were no differences among treatments for methane emitted per cow per day, but when expressed as grams of methane per kg intake, SML-fed cows emitted less methane than other hays, except for ALF. A positive relationship was found between methane emission per kg of body weight and dry matter intake per kg of body weight, which has been noted in other studies. Heifers consuming meadow bromegrass hay had greatest methane emissions per kg of intake than heifers consuming any of the other hays. This hay also had the highest fiber content, which a positive relationship between fiber consumption and methane has been shown in other studies.

Overall, heifers responded in a similar way to those in studies that fed fresh tannin-containing hays and decreased methane emission when fed tannin-containing legume hay compared to ALF and MB, but cows showed little difference in methane emission due to various hay diets, except for SML, a forb that in this study contained 4.5% hydrolysable tannin. This forb is a perennial forage that is adaptable to many climates, and would work well in hay production in North Dakota as a companion crop to traditional hays.

Effect of tannin-containing hays on enteric methane emissions and nitrogen partitioning in beef cattle, E. Stewart, K. Beauchemin, X. Dai, J. MacAdam, R. Christensen, J. Villalba., Journal of Animal Science June 2019

Rachael Christensen rachael.christensen@usda.gov 701.667.3028

Soil Health Connections

Raising Soil Awareness Through Hands-On Assessments

Join NGPRL staff for an afternoon training session on the use of visual soil assessments to support decision making for sustainable land management

USDA United States Department of Agriculture Agricultural Research Service

AREA 4 SCD Cooperative Research Farm

When: 5 September 2019; 1:00-5:00 p.m.

Where: USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND, and Area IV SCD Cooperative Research Farm.

Why: There are a growing number of methods for assessing soil health. Unfortunately, their practical value to producers is often unclear due to their complexity and limited relevance to management goals. Select hands-on soil evaluations have been shown to address these drawbacks using simple methods such as visual assessment of surface soil. Educational activities are needed to share these methods, while also highlighting effects of long-term land management on soil health, agricultural production, and economic returns.

Who: Producers, conservationists, and educators interested in improving their knowledge and skills to support soils-focused decision making.

To Attend: Contact Mark Liebig by phone (701-667-3079) or email (mark.liebig@usda.gov) by 30 August 2019. There is no cost to attend. Due to the hands-on nature of the training and the importance of knowledge exchange among attendees, attendance will be capped at 12 participants.

Join us in celebrating Area 4 Farm 35th year!

Join the USDA-ARS Northern Great Plains Research Laboratory for an open house!

USDA United States Department of Agriculture

USDA-ARS Northern Great Plains Research Laboratory

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No-till cropping systems a greenhouse gas sink? NGPRL study suggests otherwise

Drs. Mark Liebig, David Archer, Jonathan Halvorson; Holly Johnson, and Nicanor Saliendra

Climate change is creating significant challenges for farmers and ranchers through warmer and more variable weather, increased pest pressure, and loss of land in flood-prone areas. Accordingly, increasing the resilience of agricultural production systems to climate-induced change is increasingly important, as is the development and adoption of practices that decrease the emission of greenhouse gases (GHGs) to the atmosphere. In brief, what's needed are robust production systems with small GHG footprints.

In response to this need, innovative producers, corporations, and governments throughout the world are accounting for where GHG emissions come from and developing plans to reduce those emissions. Research activities at NGPRL have contributed to this ambitious effort since the mid-1990s by first tracking GHG emissions and carbon sequestration from grazing lands. More recently, aligned research efforts at NGPRL have focused on cropland and integrated crop-livestock systems.

A recently published study conducted on the Area IV Soil Conservation Districts Cooperative Research Farm documented GHG emissions from three no-till cropping systems. The cropping systems evaluated included spring wheat-fallow (SW-F), continuous spring wheat with residue retained (CSW), and spring wheat-safflower-fallow/rye (SW-S-R).

Management records, coupled with published carbon dioxide (CO_2) emission estimates, were used to determine emissions from production inputs and field operations. Measurements of methane (CH_4) and nitrous oxide (N_2O) fluxes were made over a 3-year period, while changes in profile soil organic carbon (SOC) stocks were determined over 18 years. Collectively, emissions from each cropping system were used to estimate global warming potential (GWP) (see sidebar for description of GWP on page 10).

Major findings from the study were as follows (Table 1):

• Emissions associated with production inputs and field operations were generally greatest for the least diverse cropping system (CSW), intermediate for the most diverse cropping system (SW-S-R), and lowest for the cropping system with alternate years of fallow (SW-F). This trend was largely driven by N fertilizer requirements and the frequency of grain harvest within each cropping system.

Table 1. Cropping system effects on global warming potential (GWP) and factors contributing to GWP.

	Spring wheat □ Fallow (SW-F)	**Continuous spring wheat (CSW)**	**Spring wheat □ Safflower □ Rye (SW-S-R)**
Factor	- - - - - - - - - - - **lb $CO_{2equiv.}$ ac^{-1} yr^{-1}** - - - - - - - - - - -		
Seed production	19 b□	37 a	42 a
Fertilizer production	59 c	212 a	153 b
Pesticide production	100	73	88
Field operations□	83 c	128 a	114 b
Soil organic carbon change	62	-183□	-1110
CH_4 flux	-17	-10	-12
N_2O flux	428	1480	713
Net GWP	**734**	**1739**	**-12**

□ *Means in a row with unlike letters differ (P≤0.05).*
□ *Inclusive of emissions associated with seeding, pesticide application, and harvest.*
□ *Negative values imply net CO_2 uptake.*

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No-till cropping systems a greenhouse gas sink? NGPRL study suggests otherwise

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- Soil organic carbon stocks did not change over the course of the study and did not differ among cropping systems. Numerical outcomes suggested CSW and SW-S-R sequestered a small amount of carbon, while SW-F lost soil carbon.

- All cropping systems were minor CH_4 sinks, but CH_4 uptake did not differ among cropping systems.

- Despite large numerical differences, N_2O flux did not differ among cropping systems.

Factors contributing to net GWP across cropping systems decreased in relative impact in the order of N_2O flux, soil organic carbon change, CO_2 emissions

associated with fertilizer production, field operations, pesticide production, and seed production, and CH_4 flux. Nitrous oxide flux made up most of the emissions in SW-F and SW-S-R, accounting for 58 and 85% of net GWP, respectively. Nitrous oxide emission accounted for 64% of the soil C sink capacity in SW-S-R when expressed on a CO_2equiv. basis, while soil organic carbon change negated 12% of observed N_2O emission in CSW. Large variation in soil carbon stocks and GHG fluxes across replications in the experiment compromised the ability to detect significant treatment effects. Accordingly, after summing all contributing factors, net GWP did not differ among cropping systems.

This study highlighted the challenges associated with creating cropping systems that are net GHG sinks in semiarid regions. Transitioning semiarid cropping systems to GHG sinks will require new technology and methods to improve efficiency of N use by crops, thereby decreasing contributions of N_2O flux to net GWP. Concurrent to improved N management is the need for adoption of cultural practices known to increase soil carbon stocks well above accrual rates typical of continuously cropped, no-tillage systems.

What is Global Warming Potential?

Major greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Each of the gases differ in their capacity to trap heat in the atmosphere. The capacity of a greenhouse gas to trap heat in the atmosphere is referred to as global warming potential (GWP). GWP values are expressed relative to CO_2 for a 100-year time horizon. CO_2 is assigned a value of 1, CH_4 a value of 25, and N_2O a value of 296. So, to think of it in a different way, one molecule of N_2O is equivalent to 296 molecules of CO_2 with respect to its capacity to trap heat in the atmosphere. This makes N_2O a very strong greenhouse gas.

Inclusion of perennial crops for forage and/or biofeedstock production in semiarid cropping systems can result in large increases in soil carbon due to abundant and deep-rooted biomass. However, management practices are needed to ensure GHG mitigation benefits from soil carbon increases are retained throughout the perennial-annual rotation cycle.

The study was conducted as part of a USDA-ARS cross-location research effort called GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network), which seeks to provide information on GWP of current agricultural practices, and to develop new management practices to reduce net GHG emissions from agricultural practices.

More information about this study can be found in the article appended below (available free online).

Adapted from Liebig, M.A., D.W. Archer, J.J. Halvorson, H.A. Johnson, N.Z. Saliendra, J.R. Gross, and D.L. Tanaka. 2019. Net global warming potential of spring wheat cropping systems in a semiarid region. Land 8(2), 32; doi:10.3390/land8020032.

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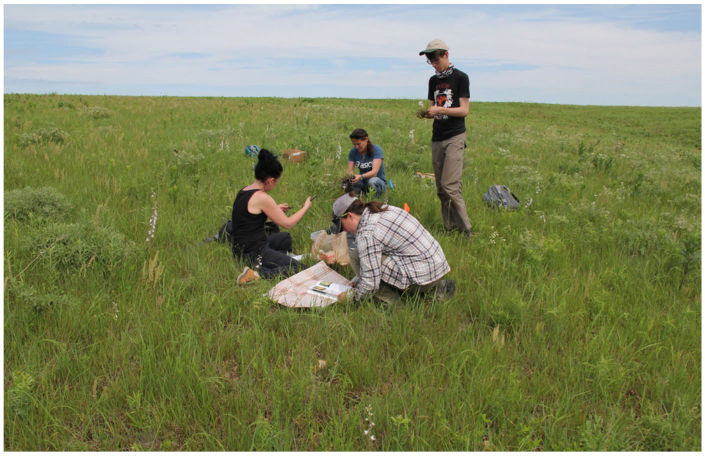
Czech research group studying plant clonality visits Mandan ARS

Dr. John Hendrickson

A team of researchers from the Institute of Botany of the Czech Academy of Sciences visited the Northern Great Plains Agricultural Research Laboratory in Mandan, ND, as part of their month-long sampling tour of the Great Plains.



Ott, Martinkova, Klimes, and Rehakova sample in the field at Konza Prairie in Manhattan, KS.

Professor Jitka Klimešová, Drs. Jana Martínková, Ondřej Mudrák, and Klára Řeháková and Mr. Vojtěch Klimeš are studying the belowground organs of perennial plants and their associated microbial communities across the east-west precipitation gradient in the Great Plains.

Klimesova draws belowground clonal organs of perennial plants in the lab.

For most grassland plants, the below ground buds, rather than seeds are the major source of new stems (>99%). These belowground buds are located on belowground organs such as tubers, roots, and rhizomes.

Klimes unearths Cucurbita foetidissima at the Central Plains Experimental Range in Colorado.

Through a collaboration with Dr. Jacqueline Ott (USFS Rocky Mountain Research Station- Rapid City, SD) and funding from the Czech government, the Czech research team has been able to sample and process over 1000 individuals of ~160 species in their first 3 weeks while sampling in Kansas, Colorado and North Dakota.

Klimesova holds a plant sample from Fort Hays, KS showing the extensive belowground rhizomes.

For each species, clonality, distance of lateral spread (e.g. how far apart a clonal plant can place new individuals away from the parent plant), persistence of the connection

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Czech research group studying plant clonality visits Mandan ARS

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Blumenthal helps the team harvest an Atriplex species at the Central Plains Experimental Range in Colorado.

Photo credit: Ondrej Mudrak except for the Ott pix which is Jacqueline Ott.

between daughter and parent organs, vascular development, and age were assessed.

Based on initial measurements, prairie rose can have rhizomes as long as 3ft 10in connecting two individual plants.

The belowground organs of the collected plants have been drawn by Professor Klimešová. Professor Klimešová has produced the only belowground plant trait database in the world (CLO-PLA) for central Europe and aims to develop a larger database for the world.

John Hendrickson john.hendrickson@usda.gov, 701-667-3015

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, Mandan, ND 58554. Use of material in this publication may only be allowed with the consent of the author. The United States Department of Agriculture prohibits discrimination in all its programs and activities on the basis of race, color, national origin, gender, religion, age, disability, political beliefs, sexual orientation, and marital and family status. Mention of trade or manufacturer names is provided for information only and does not constitute endorsement by USDA-ARS. To be added to our mailing list, request a copy through our website or contact editor: Cal Thorson, Technical Information Specialist, USDA-ARS Northern Great Plains Research Laboratory, PO Box 459, Mandan, ND 58554.
Office:701 667-3018 FAX:701 667-3077 Email: cal.thorson@usda.gov

Presentations of NGPRL science

Since the last issue:

On July 8 -11, 2019, ARS Research Animal Scientist Rachael Christensen, of the Northern Great Plains Research Laboratory in Mandan, ND, attended the American Society of Animal Science / Canadian Society of Animal Science Annual Meeting to present an invited presentation, "*Plant secondary compounds and milk production and milk products*" and three abstracts and posters, in Austin, TX

On April 25, 2019, ARS staff at the Northern Great Plains Research Lab hosted parents, students and teachers from local North Dakota schools for an evening environment and conservation fair as part of the Bismarck Earth Day celebration led by North Dakota Parks and Recreation. The event included presentations by the NGPRL staff on the seed cycle, seed germination, with hands on demonstrations and activities.

On December 4, 2018, ARS Research Ecologist Jose G. Franco, of the Northern Great Plains Research Laboratory in Mandan, ND, gave an invited coffee shop talk (online webinar) to the Manitoba Organic Alliance, which serves producers throughout Manitoba, Saskatchewan, Alberta, North Dakota, and Minnesota, entitled, "*No-till organic transition with and without grazing*".

On February 26-27, ARS staff of the Northern Great Plains Research Laboratory in Mandan, ND co-hosted the sixth annual '*Farming & Ranching for the Bottom Line*' conference for family farmers and ranchers at Bismarck State College in Bismarck, ND with the Area 4 SCD Cooperative Research Farm, ND NRCS, ND State University, ND Grazing Coalition, and the Burleigh and Morton County Soil Conservation Districts. The event which attracted over 500 attendees, included presentations by ARS Research Leader David Archer, "*Cover Crops on my Land?*", and Research Soil Scientist Mark Liebig, "*Area 4 Farm Overview*" and was moderated by Technical Information Specialist Cal Thorson. Other guest speakers included Dr. Temple Grandin, Mark Schatzker, and Greg Judy. Bismarck State College Ag Club Students assisted in moderating the event and presented posters of their research.

New science published

Seasonality of prescribed fire weather windows and predicted fire behavior in the northern Great Plains, USA, Kathryn A. Yurkonis, Josie Dillon, Devan A. McGranahan, David Toledo and Brett J. Goodwin, Fire Ecology201915:7, https://doi.org/10.1186/s42408-019-0027-y

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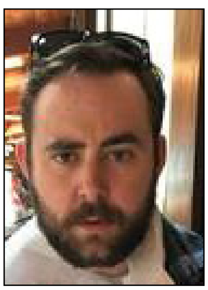
New faces

Jon Mortenson, Biological Science Technician: Jon is a new Lab Technician working with Dr. Jay Halvorson. Originally from Northern Arizona. He received his Bachelors degree in Agronomy from BYU-Idaho and Masters Degree in Plant Science from Utah State University. He worked for ARS before as part of his Masters program at Utah State University. He enjoys traveling, short hikes, reading, learning, dogs, cats and movies.

Dr. Andrea Clemensen, Postdoctoral Research Biologist: Andrea has an interest in plant secondary metabolites (PSMs) and their relevance in agroecosystems at the soil-plant interface. She received her Ph.D. in Ecology from Utah State University in 2018 evaluating how different management strategies influence concentrations of PSMs, and how these metabolites influence soil nutrient cycling. Andrea's research at the NGPRL is part of the Sustainable Agricultural Systems for the Northern Great Plains Research Project. This project builds on continued research at the NGPRL assessing how management impacts ecosystem services in ever-changing environments. The project works in collaboration with other ARS locations, and also includes the National Ecological Observatory Network (NEON) and the Long Term Agroecosystem Research (LTAR) network, with overlying objectives to improve agricultural ecosystems while enriching crop nutrition. Andrea enjoys traveling outside of airports, and spending time in the outdoors with her family.



Robert Pennington, Biological Science Technician: Robert is originally from New Mexico, but has lived all over the US including Texas, Virginia, Ohio, Oregon, and Oklahoma. He was in the US Army from 2010-14 where he spent all of his time in Texas, and then immediately attended University of Oregon, where he earned two B.S. degrees: one in Environmental Science/Ecology, and the other in Art/Printmaking. He did one season as a hydrology survey tech with the Forest Service before moving here to work for ARS. He also runs a small business illustrating and screenprinting concert posters. He has a small dog named Morty, and he is a very good boy.

Nichole Hanson, NDSU Animal Science Technician: Nicole grew up on the Souris River Ranch where she helped her family with their 230 head cow calf operation. Their cattle are Angus/Saler/Hereford cross. She graduated from NDSU in Animal Science May of 2019.

Chantel Kobilansky, Biological Science Technician: Chantel grew up on a ranch southwest of Glen Ullin, ND. She attended college at North Dakota State University majoring in Business Administration. Shortly after starting school decided to change her major to range science to better reflect her interests in agriculture. While at NDSU she worked as an undergraduate research student. She also did a summer internship at the NDSU Extension Research Center in Dickinson, ND. In her free time, she and her husband still help on the ranch. She enjoys doing outdoor activities such as riding horse and kayaking. She also likes traveling and reading a good book.