Northern Great Plains Research Laboratory

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NORTHERN GREAT PLAINS
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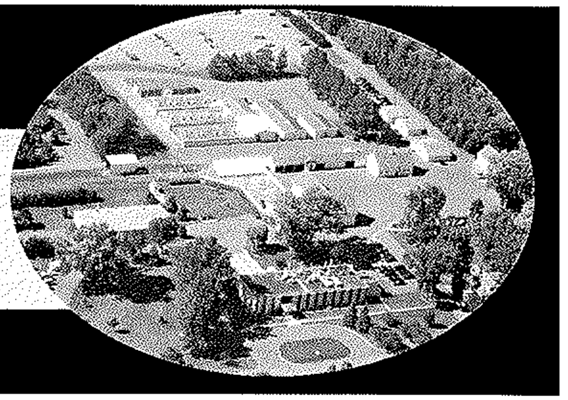
For environmentally and economically sound agro ecosystems for the northern Great Plains.

July 2006



Measuring Water Infiltration and Water Holding Capacity

In semiarid regions, such as the northern Great Plains, water is usually the limiting resource in plant production, but demonstrating the link between soil quality, water infiltration, and water-holding capacity is challenging. Dr. Kris Nichols, Soil Microbiologist at the Northern Great Plains Research Laboratory has showed that a method developed using paper cups with perforated bottoms may accurately demonstrate these concepts (see below for method details). This method is readily adaptable on the farm to a variety of soils, conditions, and types of containers.

Soil samples used in Nichols' study included surface depths (0-5, 0-10, and 0-15 cm) collected from four existing studies in North and South Dakota: 1) a cropping systems study at the Northern Great Plains Research Laboratory (NGPRL) near Mandan, ND (SQM); 2) a rangeland restoration study at NGPRL (RR); 3) a combination cropping and rangeland management study near Platte, SD (CR); and 4) a rangeland management study near Streeter, ND (RM). The SQM study had two tillage treatments [minimum (MT) and no till (NT)] applied to soils with one of the following four crop sequences: i. Continuous spring wheat with crop residue (CSW+); ii. Continuous spring wheat with crop residue removed (CSW-); iii. Spring wheat-fallow (SW-F); or iv. Spring wheat-safflower-rye (SW-S-R). The CR study had six treatments: i. No-till (NT); ii. Conventional till (CT); iii. Conventional till with manure (CT+); iv. Native grass with rotational grazing (native, rot); v. Tame, grass with heavy grazing (tame, heavy); and vi. Tame grass with rotational grazing (tamerot). Finally, the RM study had three grazing management treatments: i. Idle (no grazing); ii. Rotational; and iii. Seasonlong. All samples were air-dried, except for SQM which had both field-moist and air-dried samples. Soil was placed in a 5-ounce paper cup with a perforated bottom. This cup was inserted into the upper rim of a 3- ounce paper cup. Ultra pure water equivalent to 1 inch was added and the infiltration rate was measured. For the air-dried samples, another 1 inch of water was added. Water collected in the bottom cup was measured using a graduated cylinder and analyzed for nitrate (NO_3) concentration using colorimetric test strips and ion chromatography. Soil in the top cup was incubated in the laboratory to measure the rate at which the soil returned to an air dry state. Results showed infiltration rates in the rangeland soils were faster (up to 20 times) than in the cropland soils for both the first and second inch, while the cropland soils had higher (about 10 times) nitrate concentrations. There was no statistical difference in the amount of water collected in the bottom paper cup among all treatments, but overall the SQM sites had more than the rangeland sites. Laboratory incubation studies also showed that by Day 6, there was still about 5% more water in the rangeland soils, and on Day 11 there was almost 2% more water. Nichols'method provides an inexpensive and simple procedure to examine water infiltration and soil water holding capacity in your field. To adapt the procedure for your use, refer to the methodology below.

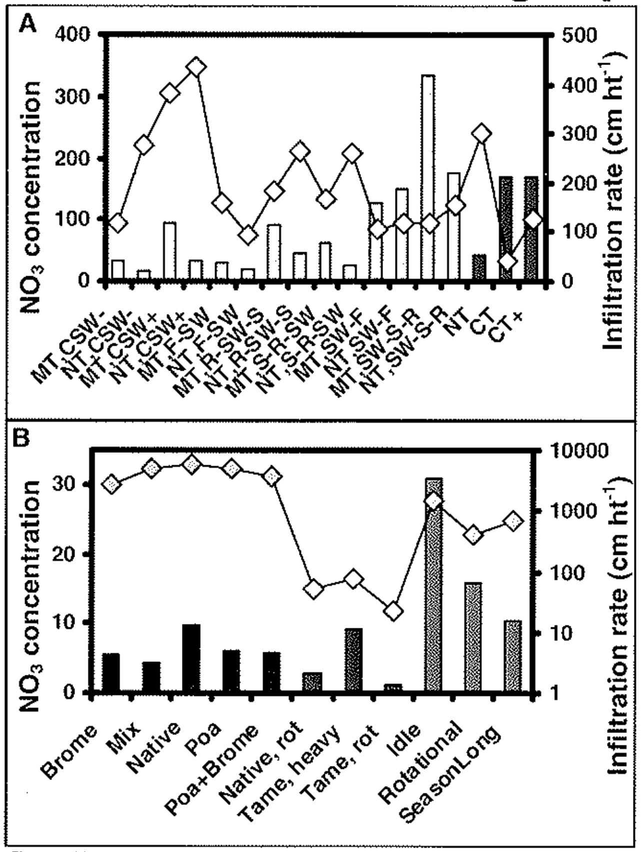


Figure 2. Nitrate concentrations (bars) in the water collected in the bottom cups were about 10 times higher in the cropland (A) than rangeland sites (B) while the infiltration rates (line) for the first 2.54 cm were about 20 times higher in the RR site than the SQM site, nearly 4 times higher at the RM site than the SQM site, and higher in the rangeland treatments than the cropland treatments at the CR site.

Infiltration and Water Holding Capacity Demonstration

1.Prepare 5-oz paper cups (1/sample) as follows:
  a. Using an 18G needle or small finishing nail, poke 50 holes in the bottom of the paper cup.
  b. Draw a line on the outside of the cup where the circumference equals 15.5 cm (about 3 cm from the bottom)
  c. Place the 5-oz paper cup in a 3-oz paper or plastic cup.

Other containers besides the paper cups may be used. You will need one container that you can poke holes into and another container that you can fit the top container into and collect the water. The volume of water and amount of soil may have to be adjusted depending on the size of container as described later.

2. If conducting the experiment in the field, use a trowel to dig a hole 4 inches deep and about 2 inches wide. If conducting the experiment in the laboratory or classroom, use field moist or air-dried soil that has been pre-measured to either the same volume or weight (Fig. 1). If weight is used, a well aggregated soil will typically have a greater volume of soil due to greater porosity and less compaction.

3. Remove soil and transfer enough into a paper cup to reach the line drawn on the cup. Shake the cup gently to evenly distribute the soil and gently break-up any large clods.

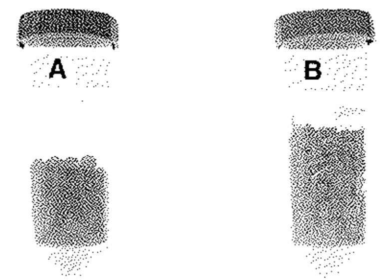


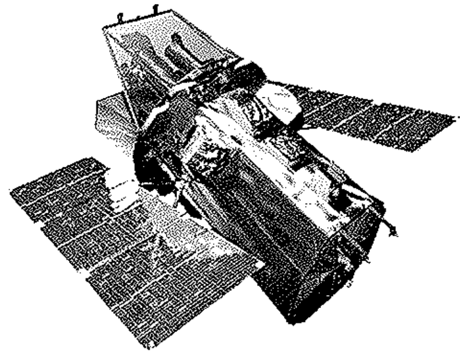
Figure 1. Air dried soil samples of the same weight (25 g) from not well aggregated (A) and well aggregated (B) soils. Volume differences demonstrate the role that aggregation has in increasing porosity.

Continued on page 5

Satellite-Based Forage Assessment for Northern Mixed-Grass Rangelands

Plant carbon/nitrogen (C:N) ratio has significant impact on agricultural production, yet remote quantification at field or pasture scales has been hindered by coarse satellite spatial resolution and the influence of variable plant water content on spectral reflectance.

In June, Drs. Rebecca Phillips, Mark Liebig and Ofer Beeri (University of North Dakota, John D. Odegard School of Aerospace Sciences) cooperatively published a new land evaluation opportunity in the article, "Landscape estimation of canopy C:N ratios under variable drought stress in Northern Great Plains rangelands," in the Journal of Geophysical Research-Biogeosciences.



The C:N ratio represents a measurable landscape-scale signal of vegetation quality that, if remotely derived from satellite data, could improve rangeland quality assessment by providing real-time % crude protein values at field or pasture scales.

Laboratory studies have accurately determined optimum reflected light wavelengths for leaf nitrogen detection using hyperspectral sensors on dried plant material, but this signal is masked by water in living tissue. These scientists identified a solution to this issue by identifying spectra influenced by plant C:N ratio and not by plant water content.

Experiments at plant, plot, and pasture scales were used to identify and evaluate reflected light spectra sensitive to % crude protein under variable drought stress conditions for mixed-grass prairie rangelands.

"We grew monocultures of warm season blue grama and cool season bluegrass from seed under laboratory conditions to identify those spectral bands and band combinations that were influenced by plant % crude protein, but not by water content," says Dr. Beeri.

By experimentally testing for the effects of plant C:N and plant water content on plant hyperspectral signatures, they developed a new satellite-based model applicable to mixed-grass prairie rangeland under variable drought stress.

"In this scientific journal, we proposed an innovative, integrated approach with an emphasis on bridging spatial, temporal and spectral scales for satellite-based assessment of landscape forage quality based on plant physiological data from monocultures, mixed-grass prairie field plots, and working rangelands," said Dr. Phillips.

"We approached the water content problem first by identifying those reflected light spectra sensitive to C:N but not sensitive to varying intensities of plant water stress under laboratory conditions," she says. "Then we tested formulae developed at a plant scale with monocultures on mixed-grass prairie field plots and derived an optimum formula for rangeland landscape C:N." Crude protein was evaluated on pastures under experimental grazing treatments using mid-resolution, multispectral sensors multiple times over the growing season.

The scientists employed a hyperspectral sensor under experimental conditions and then convolved the data to fit multispectral sensors. Reflected light most highly correlated with C:N were found in the red, blue, and mid-infrared portions of the spectra. Formulae were developed to utilize these reflected light spectra to determine plant quality measured as C:N ratio.

They proceeded to the plot-scale phase by testing their new formulae on working lands. Plot-scale data from three grazing treatments were then collected: a moderately grazed mixed-grass prairie, a heavily grazed mixed-grass prairie, and an annually fertilized, heavily grazed field of crested wheatgrass. Directly after spectra were recorded, standing biomass and litter was harvested and material was separated into litter, standing-dead, and standing-live material. Crude protein concentrations for each pool were determined and calculated to include all plant material for % crude protein. "We aimed to include senescent material in our model because both live and senescent materials con-tribute carbon and nutrients to rangeland ecosystems," claims Beeri.

Six multispectral productivity indices, two multispectral vegetation stress indices, three multispectral simple ratio indices, and one hyperspectral index were included in the list of 12 indices significantly affected by C:N ratio and species but not affected by water content. The best predictors of canopy C:N ratio were then evaluated intra-seasonally using Landsat 5 and ASTER satellites multispectral satellite data for the pastures at Mandan.

The regression formulae derived for each index were then tested on field plots located inside grazing treatments. Most formulae, when applied to hyperspectral records collected from grassland communities, did not agree well with field measurements. Of the 24 formulae derived from the greenhouse phase of our study, one index (ND53) proved the best predictor of forage quality at the field-plot scale.

Model validation was performed with field observations for all pasture treatments five times during the growing season in conjunction with satellite flyover. Plots were clipped to ground level within each pasture and standing-live, standing-dead, and litter material separated, weighed and analyzed for carbon and nitrogen within four days of satellite overpasses. Spectral radiance was also recorded using a hand-held, hyperspectral spectroradiometer.

The Landsat 5 estimates were within 14% of actual plot-scale measurements, while ASTER estimates were within 10% of actual. Hectare-scale, spatial variability measured among grazing treatments and bi-monthly, temporal variability measured among collection times were similar to remote estimates despite variable plant water content.

"Our results suggest forage crude protein content can be estimated for large landscapes with reasonable accuracy using modern satellite sensors for northern mixed-grass rangelands," Phillips says. "Spatial and temporal variability among grazing treatments and collections times were similar to remote estimates despite variable plant moisture, indicating that rangeland % crude protein may be quantified using, economical, current satellite sensors."

Grazing is known to invoke changes in rangeland community structure and vegetative quantity and quality, depending upon factors such as grazing intensity and timing of defoliation. The net effect of grazing on rangeland health will vary with phenology and weather, so remote-based tools that resolve pasture-scale variability and that are appropriate for the ecoregion are needed by modern managers.

For northern Great Plains ranchers, quantification of rangeland % crude protein with synoptic, spectral data represents a practical application of technology for use in support of grazing management decisions.

Germination of Switchgrass under Various Temperature and pH Regimes

Switchgrass is a native prairie grass that is being increasingly considered as a biomass energy crop. Opportunities may soon be available for farmers in the northern Great Plains to produce this versatile grass for energy production and/or livestock forage. It is productive on many diverse sites including marginal land and can be managed using conventional harvest equipment.

To determine optimal conditions for germination, Jon Hanson and Holly Johnson investigated the effect of temperature and pH on several popular switchgrass cultivars.

Seeds of eight cultivars were germinated at five temperatures (41, 59, 77, 95 and 104°F) and nine pH levels (4, 4.63, 5, 6, 7, 7.4, 8, 9 and 10).

Germination occurred in soils with pH values ranging from 6-8 if the temperature were within 77-95°F.

TABLE 1. Comparison of data for eight switchgrass cultivars averaged across five germination chamber temperatures ranging from 41-104°F (41, 59, 77, 95 and 104°F) and nine pH levels (pH 4, 4.63, 5, 6, 7, 7.4, 8, 9 and 10) assayed by 1) percentage germination, 2) germination index, and 3) percent age germination at pH 7 (provided as a point of reference). The cultivars with a germination index greater than 20 performed best in these trials.

Variety	% Germination	Germination Index	% Germination at pH 7
Cave-in-Rock	24.4	16.5	40.0
Dacotah	**30.8**	**22.0**	**47.6**
ND 3743	**29.9**	**21.0**	**44.4**
OK NU2	13.8	9.5	21.8
Shawnee	4.4	2.9	6.2
Summer	2.4	1.3	1.6
Sunburst	**30.9**	**21.6**	**48.4**
Trailblazer	6.0	3.7	6.0

Seeds of eight switchgrass cultivars were studied: Dacotah, ND 3743, Summer, Sunburst, OK NUT, Cave-in-Rock, Trailblazer and Shawnee.

The pH level was the component with the largest variance. It contributed to 23-32% of the total germination variance and the percentage germination.

Temperature and switchgrass cultivar were approximately equal in overall variance.

The optimum temperature for germination of switchgrass was 77°F and the optimal pH value was 6.0.

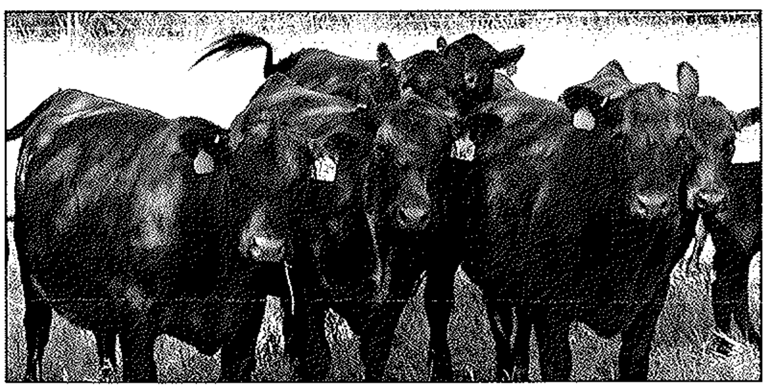
As temperature increased from 77 to 104°F germination dropped by 44%.

The interaction between pH and temperature was significant. In the pH range 6-8, germination stayed relatively high at 77 and 95°F. At 59 and 104° F, germination dropped off sharply when the pH increased above 6.0. By pH 9.0, germination was below 15% and dropped to 0% by pH 10.

This research showed that switchgrass should be grown in soils with pH above 5.0 and below 8.0. Considerations outside this pH range will inhibit stand development.

All processes controlling stand development, from planting and germination to actual emergence and seedling establishment, must be examined so that alternative management scenarios can be developed to reduce producer risk

A Small Cow Herd for the Northern Great Plains Research Laboratory



The Northern Great Plains Research Laboratory is in the process of forming a small herd of 60 to 80 cows for research related to low-input cow-calf production. This will allow scientists to evaluate a variety of innovative ideas related to reducing annual cow costs and provide a source of good calves for evaluating various low-input growing and finishing strategies. The herd is being formed by retaining heifers out of 40 Angus cows owned by Howrey Angus that is based near Hettinger, ND. Monte and Tesha Howrey produce Angus cows with an emphasis on high fertility, longevity, calm disposition, moderate frame size, good fleshing ability, good maternal instincts, and good udders, legs and hooves. Howrey's cows will be at the research laboratory for 5 years while the staff builds the cow herd.

Retirements

Dr. Steve Merrill, Soil Scientist at the Northern Great Plains Research Laboratory, retired April 1st, concluding over 39 years of USDA-ARS soils research, nearly thirty of them at Mandan. Merrill continues as a collaborator at the Mandan USDA-ARS laboratory, bringing current research projects to completion and assisting other scientists with their work. Merrill plans to study new forms of soil and land science, and write about how soil and other earth sciences impact society.

Dr. John Berdahl, Research Geneticist at the Northern Great Plains Research Laboratory for 30 years, retired on June 2nd. His research led to the development of the two most widely grown intermediate wheat grass cultivars in the USA (Manska and Reliant) and the Russian wildrye cultivar, Mankota. In cooperation with USDA NRCS, Berdahl cooperated in the release of five warm-season and one cool-season grass cultivars. Berdahl authored or coauthored over 70 publications in refereed scientific journals. He has been recognized as a Fellow of the Crop Science Society of America and American Society of Agronomy, and received the Outstanding Achievement Award by the Society of Range Management. Berdahl continues as a scientific collaborator at the Mandan USDA-ARS campus.

Friends & Neighbors Day 2006

The USDA-ARS and Area 4 SCD Cooperative Research Farm invite farmers, ranchers, and residents of the area to visit the campus and tour research at the Northern Great Plains Research Laboratory on Thursday, July 20th. Campus activities begin at 2 PM and registration for research tours at 3:30 PM.

Featured on the research tour will be Dr. Mark Liebig, focusing on the scientific basis for carbon sequestration payments, Nathan Clark of the Chicago Climate Exchange explaining the U.S. Carbon Trading System, and Dale Enerson of the North Dakota Farmers Union discussing the financial opportunities in the new North Dakota Carbon Credit Program.

A major focus of Mandan USDA research has been in reducing production expense and maximizing moisture utilization. This topic will be woven throughout the scientific presentations on the tour. The USDA staff will review local research on incorporating annual crops into perennial systems, plant diseases and crop sequences, integrating crop and livestock production systems, restoring rangeland productivity, opportunities for growing large yearling cattle on annual forages or alfalfa, and utilizing energy supplementation for beef cattle to extend grazing on summer pastures.

Biofuel production, atmospheric greenhouse gas mitigation, agro tourism, wildlife preservation, and resource conservation exhibits from USDA, NDSU, and other research organizations will be featured on the 15 acre Mandan campus. There will also be children's activities.

Over 60 supporters of agricultural and environmental science have come together to sponsor this annual event. Following the tours, there is a free barbecue and entertainment by Ryan Jundt.

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Infiltration and Water Holding Capacity Demonstration

(continued from page 1)

4. Add 50 ml water. (This is equal to 1 inch)
5. Start timing infiltration (Fig. 2). Stop and record when complete (i.e. when the surface of the soil is just glistening). Filling tall and narrow containers to high, or in highly organic soils may required a second inch of water to have a measurable volume in the bottom cup. Large amount of roots or plant material in rangeland soils may result in low infiltration rates. However, the amount of water held by these soils will be higher than in cropland soils.

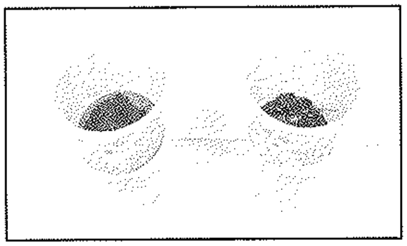

Figure 2. Water pools on the surface and does not infiltrate in the not well aggregated sample (A) but does infiltrate rapidly in the well aggregated sample (B).

Optional tests:

a. Measure volume of water collected using a graduated cylinder in field or lab (Fig. 3). If you do not have a graduated cylinder, compare heights of the water in the paper cups or transfer to clear containers for comparison.
b. Test water for soil nitrates using nitrate test strips.
c. Measure cations and anions in water using an ion chromatograph if available.
d. Estimate water holding capacity by: i. weighing wet soil in the cup after completing the infiltration experiment; ii. incubating the sample at room temperature and weighing the soil in the cup daily until the weight no longer changes; and iii. calculating the percent water in the sample for each day and graph percent water by time to examine the water holding capacity of each sample.

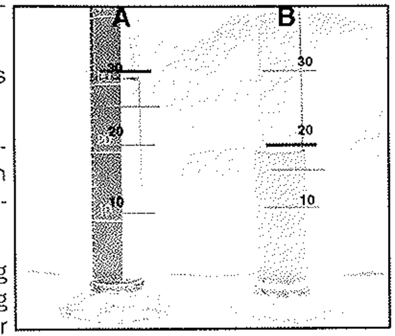

Figure 3. In the not well aggregated soil (A) 31 mls of water was collected in the bottom cup whereas the well aggregated soil (B) had 19 mls of water (dark line indicates the water level).

Farmers group offers credit for conservation

By DAVE KOLPACK
Associated Press Writer

FARGO - North Dakota farmers now have the chance to get paid for conservation practices that keep carbon dioxide in the ground.

Mark Liebig, a soil scientist at the Northern Great Plains Research Laboratory, explains the benefits of carbon storing land use benefits. In back is Agriculture Commissioner Roger Johnson.

The North Dakota Farmers Union has unveiled a program that would pool carbon credits for sale at a private agency that trades greenhouse gases and pollutants, much like other exchanges trade commodities.

Supporters of the plan say it's a way to reward farmers who want to help cut down on global warming.

"We think this is one of the most exciting projects to come about in a long time," said Keith Trego, director of the North Dakota Natural Resources Trust. "We hope that income will grow over time as interest in this issue continues to grow around the world."

The Chicago Climate Exchange is selling carbon credits at about $1.50 per acre for no-till land and $2.50 per acre for land seeded to grass after Jan. 1, 1999. The actual payment will depend on market prices.

No-till farming uses a machine that can place seed, fertilizer and sometimes chemicals into the ground without tilling the soil first. Along with storing carbon in the soil, it saves fuel and reduces soil erosion, Carlson said.

It's been around long enough that people have seen their neighbors successfully no-till and they know it can work," he said.

"In the eastern part of the state, where the soil is heavier, there isn't as much no-till, but it certainly has been used a lot in the western part. "Some form of conservation tillage is being used on about 8 million of the 21 million acres of cropland in the state, said J.R. Flores, spokesman for the North Dakota Natural Resources Conservation Service in Bismarck. Those producers are immediately eligible for carbon credits.

"I'm guessing that for producers who are currently doing no-till and are experienced at it, this is going to be kind of a no-brainer for them," Carlson said.

Calculations for Adjusting Water and Soil Volumes by Container

The volume (V) of water added needs to be adjusted based on the diameter (D) of the containers used in order to add a cylinder of water that is 2.54 cm high on top of the soil. The diameter may be estimated by measuring the circumference (C) of the container at the height (H) of the soil (Fig. 4, Eq. 1). The diameter value is then used to calculate the volume of water (Eq. 2).

Note: The height of the soil may vary depending on the diameter of container. The volume of water does not take into account the height of the soil and filling narrow containers more than 4 or 5 cm may require another 2.54 cm to collect a measurable volume of water.

$$C = \pi * D \quad (1)$$

$$V = \pi * (D/2)^2 * h \quad (2)$$

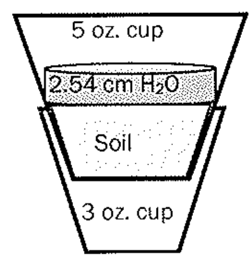

Figure 4. A 5 oz. cup with a perforated bottom is placed in a 3 oz. cup. The soil is placed in the 5 oz. cup to a height of 3 to 5 cm depending on the diameter (D) of the cup and a volume of water equivalent to a height of 2.54 cm is added.

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New Faces

Dr. Jin-xiang Liu, Professor at the Institute of Grassland Science, Zhanjiang Normal University, Zhanjiang City, China, arrived at the Northern Great Plains Research Laboratory in June for a year-long research study sponsored by the USDA and the Chinese Ministry of Science and Technology. He is a member of the Council of Chinese Grasslands and the Chinese Society of Ecology, and an editorial member of both Grassland & Turf and Guangdong Prataculturae.

Tim Faller is director of the NDSU Northern Plains AgroEcoSystem Research Center located on the campus of the USDA-ARS Northern Great Plains Research Laboratory. Faller is currently Assistant Director of Special Projects for the NDSU Agricultural Experiment Stations. He has been on the NDSU staff for over 40 years with 38 years as Research Director at the Hettinger Research Extension Center. As an Animal Scientist, Faller has judged livestock in over 27 states. He also currently serves as chairman of the Southwest North Dakota Rural Economic Area Partnership (REAP) Zone whose objectives are to stem out-migration and facilitate new primary sector job creation. Faller began his work at Mandan in February 2006.

Scott Bylin joined the staff of the Northern Great Plains Research Laboratory as a Physical Science Technician in February 2006. Bylin's training and experience includes Global Positioning Systems, Geographic Information Systems, satellite remote sensing data processing, and plant/soil/atmosphere field data collection in agricultural ecosystems. Scott graduated with a B.S. in Geography from the University of North Dakota in 2003 where he acquired experience in data processing, laboratory and field methods and analytical instrumentation.

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