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MESSAGE FROM DR. JON HANSON

LABORATORY DIRECTOR

USDA-ARS Northern Great Plains Research Laboratory

The Area IV SCD Cooperative Research Farm was established through the joint efforts of several North Dakota Soil Conservation Districts and the USDA Northern Great Plains Research Laboratory. Throughout its history, the Research Farm has focused on making conservation tillage—specifically no-till farming—a commonplace practice for the northern Great Plains. This unique joint venture continues to allow USDA-ARS scientists to investigate current or potential economically important crops and crop management systems for use in conservation management systems. Through conscientious use of the research farm, our scientists are able to provide scientifically acceptable natural resources investigation within the framework of real world farming practices. Agriculture, as we know it, is destined to undergo remarkable change. Eight current trends that will effect agricultural development include (1) increase of land degradation; (2) competing land uses; (3) focus on single ecosystem service; (4) increase in farm size; (5) movement toward commercialization; (6) genetic engineering; (7) global markets; and (8) changing social structure. The face of agriculture continues to change and the needs for tomorrow include new agricultural management systems that are designed to provide alternatives that are environmentally and economically compatible and sustainable while maintaining a high degree of social acceptability. The agricultural community will face many new and difficult challenges in the years to come, including (1) competitive pressures; (2) sustainable development; (3) resource conservation; and (4) research and development. New agricultural management systems need to be developed that include consideration and inclusion of economics and economic policies, environmental sustainability, social and political concerns, and new and emerging technology. These systems can ultimately assist land managers to develop new and improved sustainable land-use strategies to the benefit of generations to come.

We must be responsive to these trends and push the envelope of agricultural systems. At our laboratory, continue to strive to provide producers with alternatives in their management practices. That includes the use of a diversity of crops with the capacity to compensate for various climatic trends and innovative methods for improving and protecting the soil resource. Thus,

- We must change our strategy for meeting the needs of future farmers.
- We must be prepared to examine innovative ways to integrate crop and crop products in enterprises on the farm.
- We must be creative in developing new research projects that fulfill our mission at the Area IV SCD Research Farm and leverage us for enhanced funding.

This past year, we had the opportunity to rewrite the mission for our laboratory, which now states:

To develop environmentally sound practices and add value to farming systems in the Great Plains in terms of food, feed, and biomass by conducting team-focused, systems-oriented research and technology transfer.

The NGPRL has capacity to provide solutions to these issues through a multifaceted research program emphasizing dynamic-integrated agricultural systems. An integrated system involves multiple synergizing enterprises (cash and bioenergy crops, livestock, and/or forages) that interact in space and time to form a unified whole. Dynamic agriculture is a concept or philosophy emphasizing flexible annual strategies to optimize production systems (crops, crop sequences, livestock, etc.) to meet the economic and resource conservation goals of producers. A dynamic-integrated agricultural system unites the philosophy of flexible annual strategies with an integrated multiple enterprise system. Thus, the ultimate goal of our research is to minimize economic and environmental risks while maintaining profitability and social acceptance.

By combining new lines of research with our current new mission, our ongoing research will provide direction for future Agricultural policy decisions as well as help family farmers successfully thrive on the land and improve the resource for future generations. We will continue to strive to include the sustainability of the family farm in the research we conduct.

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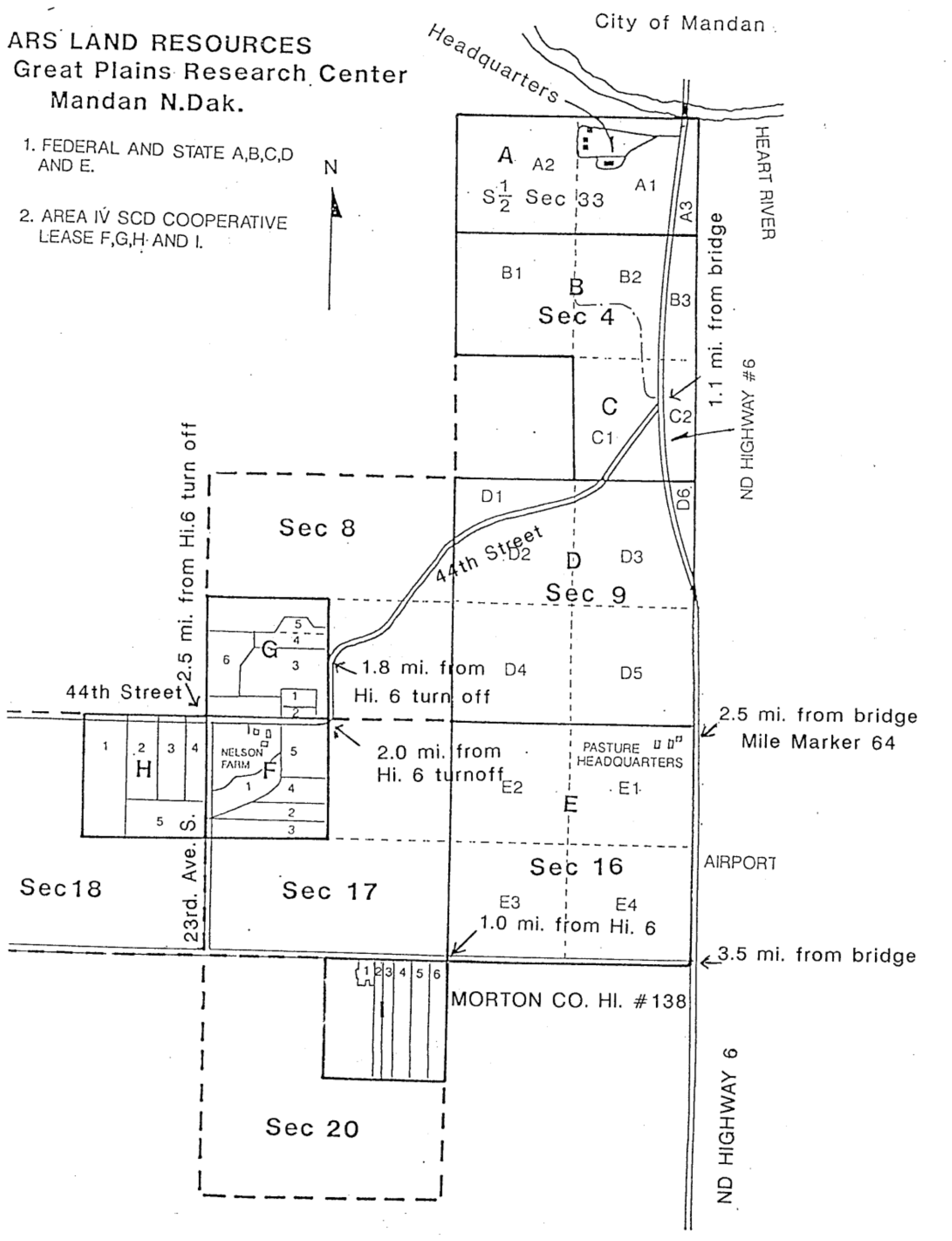
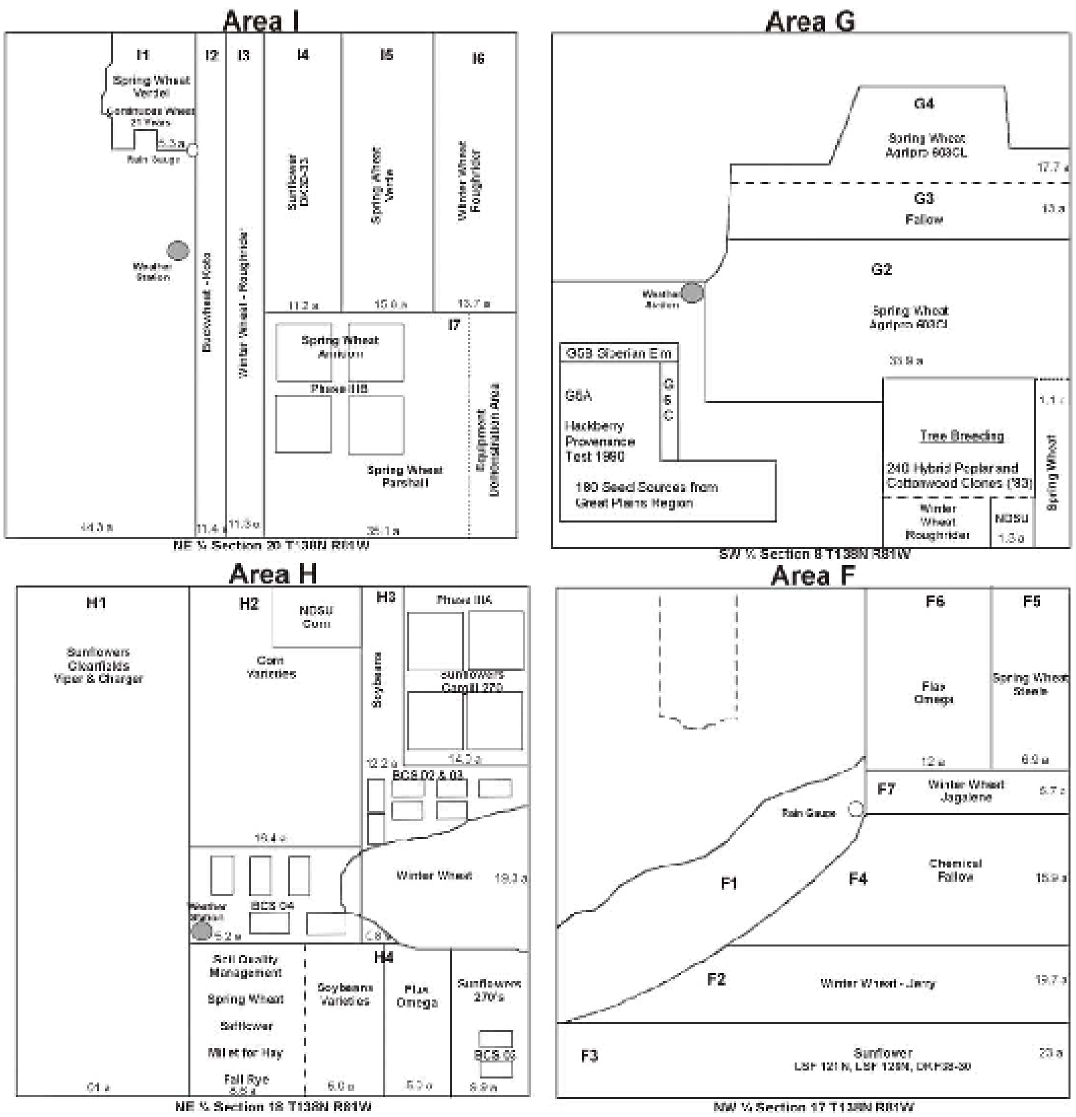
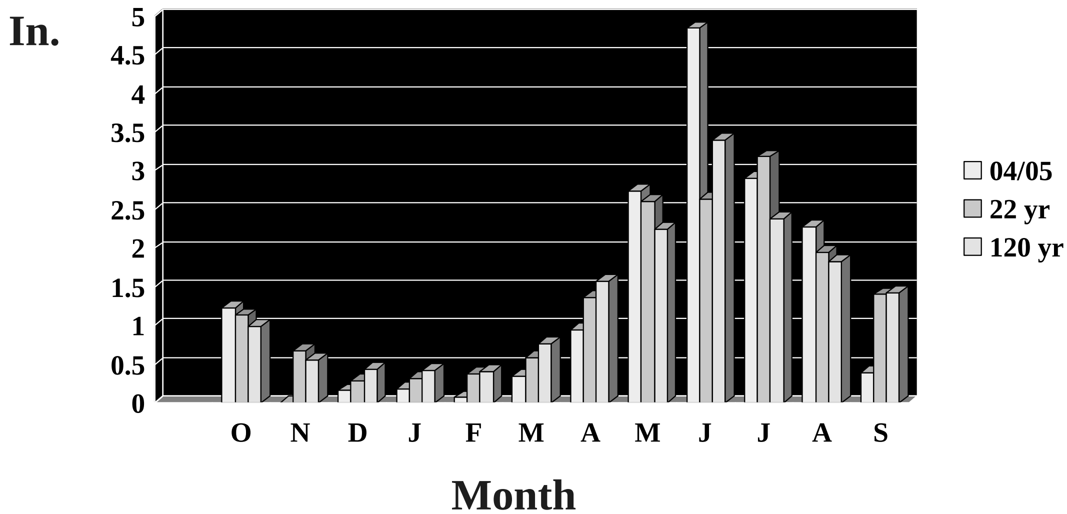
USDA-ARS LAND RESOURCES (FEDERAL & STATE) A, B, C, D, AND E
AREA IV SCD COOPERATIVE RESEARCH FARM
LAND RESOURCES F, G, H, AND I



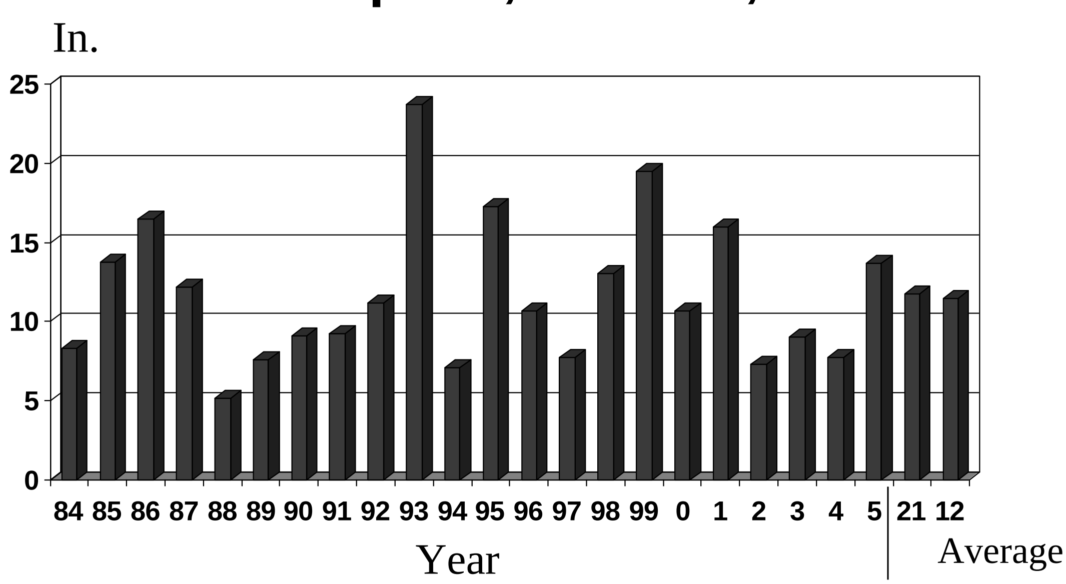
Area IV Cooperative Research Farm
2005 Crop Plan



Monthly Precipitation (in.)
Oct-2004/Sep-2005
Area IV plots, Mandan, ND



Growing Season Precipitation (in.)
April, May, June, July, August 1984-2005
Area IV plots, Mandan, ND



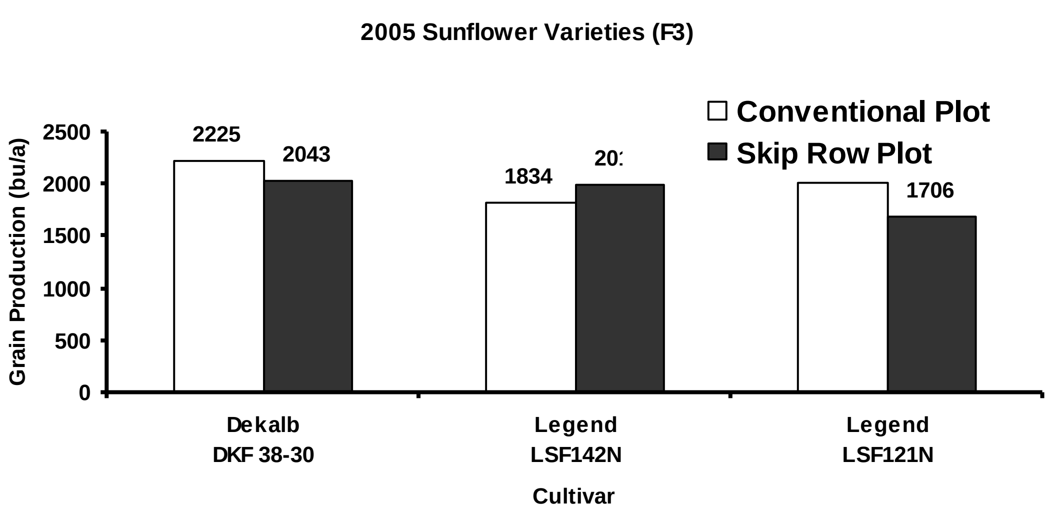
MANAGEMENT PRACTICES, 2005
AREA IV SCD/ARS RESEARCH FARM

AREA-F FIELD OPERATIONS, NW ¼ Section 17 T138N R81W

FIELD F1 This conservation bench terrace area has been excluded from the total acreage leased by AREA IV SCDs since 1987.

FIELD F2, JERRY WINTER WHEAT
Previous crop fallow
9/22/04 Field was sprayed with Glyphomax (32 oz/a), LV4 (16 oz/a) and ammonium sulfate.
9/22/04 Seeded Jerry winter wheat at a rate of 1.3 million seeds/a. East half of field was seeded using the JD 750 drill (7.5-inch row spacing) while the west half was seeded using the Bourgault air seeder (10-inch row spacing). Seed was treated with Raxil MD Extra and 50 lbs/a of 11-52-0 was put down with seed.
3/7/05 Contractor bulk spread Urea at 70 lbs N/a.
4/21/05 Contractor sprayed field with Salvo at 12 oz./a.
7/29/05 Field was swathed.
8/4/05 Winter wheat was harvested and yielded 39.0 bu/a. It was sold for $3.07/bu.

FIELD F3, SUNFLOWERS SKIP-ROW
Previous crop winter wheat
3/7/05 Contractor bulk spread Urea at 70 lbs N/a.
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
5/4-6/05 Sonalan 10G at 11 lb/a applied with undercutter.
6/3/05 One third of the field was seeded to Legend LSF142N with half seeded conventionally at 24,000 seeds/a (6 rows, 30 inches apart) and the other half seeded skip-row. Skip-row was also seeded at 24.000 seeds/a with two rows seeded for every one skipped. The field was seeded with a JD Maxemerge II planter.
6/6/05 The other two-thirds of the field was seeded to Dekalb DKF38-30 and Legend LSF121N sunflowers in the same manner.
6/7/05 Field was sprayed with Roundup Ultra Max at 20 oz/a using Flexicoil 50 foot tractor sprayer.
7/11/05 Contractor sprayed field with Poast at 1 pt/a.
8/10/05 Contractor sprayed Asana at 6 oz/a.
9/27/05 Contractor sprayed field with Gramoxone (1 pt/a) and Liberate (crop dessication).
10/25/05 Sunflowers were combined. See chart below for results. Trend suggests skip row reduces sunflower production. May be the result of poor weed control in the skip. Sunflowers were sold for $9.35 cwt.



FIELD F4, CHEMICAL FALLOW
Previous crop sunflower
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
6/10/05 Sprayed field with Glyphomax at 20 oz/a and LV4 at 16 oz/a.
9/27/05 Sprayed field with Roundup Ultra Max at 16 oz/a and ammonium sulfate.
9/28/05 Seeded east and west sides of field with Roughrider winter wheat using the Bourgault air seeder (10-inch row spacing). Seeded middle of field with Jerry winter wheat using a Haybuster 8,000 seeder (10-inch row spacing).

FIELD F5, STEELE SPRING WHEAT
Previous crop soybean
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
4/26/05 Seeded Steele spring wheat at 1.3 million seeds/a using a John Deere 750 no-till drill (7.5-inch row spacing). Seed was treated with Enhance. 70 lbs N/a (Urea) and 50 lbs/a 11-52-0 were put down at seeding.
6/2/05 Contractor sprayed field with Affinity (0.6 oz/a), Puma (7 oz/a), and Salvo (8 oz/a)
8/15/05 Field was straight combined and yielded 44.0 bu/a.
9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

FIELD F6, OMEGA FLAX
Previous crop corn and fallow
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
4/28/05 Omega flax was seeded at 4 million seeds/a (1 bu/a) with a JD 750 no-till drill. 70 lbs N/a (Urea) and 50 lbs/a 11-52-0 were put down at seeding.
6/20/05 Field was sprayed with Poast (14 oz/a), Prime Oil (32 oz/a), and Curtail-M (21 oz/a).
8/22/05 Swathed flax.
8/26/05 Flax was combined and yielded 26.4 bu/a. Flax was sold for $5.80/bu.
9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).
9/26/05 Field was seeded with Yellowstone, Jerry, and Roughrider winter wheat in 90 ft. strips using Bourgault air seeder (10-inch row spacing) and Haybuster 8000(10-inch row spacing) drills. Plant population was 1.3 million viable seeds/a and 50 lb/a of 11-52-0 was placed with the seed.

FIELD F7, JAGALENE WINTER WHEAT
Previous crop barley
9/20/04 Jagalene winter wheat was seeded using the Haybuster 8000 hoe drill (10-inch row spacing) at 1.3 million seeds/a. Seed was treated with Enhance and south half of field was treated with Jumpstart. 50 lbs/a of 11-52-0 was put down with seed.
9/22/04 Field was sprayed with Glyphomax at 32 oz/a and LV4 at 16 oz/a.
3/7/05 Contractor bulk spread Urea at 90 lbs N/a (based on soil test).
4/21/05 Contractor sprayed field with Salvo at 12 oz./a.
7/26/05 Field was cut for hay. Freezing temperatures in late April resulted in no seed in the heads.
9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

AREA-G FIELD OPERATIONS, SW ¼ Section 8 T138N R81W

FIELD G1, ROUGHRIDER WINTER WHEAT
No previous crop
9/20/04 Roughrider winter wheat was seeded at 1.3 million viable seeds/a using a Haybuster 8,000 seeder (10-inch row spacing). 50 lbs/a of 11-52-0 was applied at seeding. Seed was treated with Raxil MD Extra.
3/7/05 Contractor bulk spread Urea at 70 lbs N/a.
4/21/05 Contractor sprayed field with Salvo at 12 oz./a.
8/4/05 Field was harvested and yielded 40 bu/a. It was sold for $3.07/bu.

FIELD G2, AGRIPRO 603CL SPRING WHEAT
Previous crop corn
4/18/05 Field was seeded with Agripro 603CL spring wheat using a Bourgault air seeder (10-inch row spacing) at 1.3 million viable seeds/a. Seed was treated with Raxil MD Extra. Fertilizer, a blend of Urea (70 lb N/a) and 50 lb/a of 11-52-0, was side banded at seeding.
5/29/05 Contractor sprayed field with Beyond (4 oz/a), Headline (10 oz/a), Widematch (1.33 pt/a), and ammonium sulfate (1 qt/100 gal H_2O).
8/8/05 Spring wheat was harvested and yielded 26.1 bu/a.
9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

FIELD G3, FALLOW
Previous crop spring wheat
9/7/04 Contractor sprayed field with Glyphomax at 32 oz/a and LV4 at 16 oz/a.
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
6/10/05 Sprayed field with Glyphomax at 20 oz/a and LV4 at 16 oz/a.
9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

FIELD G4, AGRIPRO 603CL SPRING WHEAT
Previous crop fallow
4/21/05 Field was seeded to Agripro 603CL spring wheat using a John Deere 750 at 1.3 million viable seeds/a. 50 lbs/a of 11-52-0 was applied at seeding. Seed was treated with Raxil MD Extra. Urea at 70 lb N/a was banded at seeding.
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
5/29/05 Contractor sprayed field with Beyond (4 oz/a), Headline (10 oz/a), Widematch (1.33 pt/a), and ammonium sulfate (1 qt/100 gal H_2O).
8/8/05 Field was harvested and yielded 41.4 bu/a.
9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

AREA-H FIELD OPERATIONS, NE ¼ Section 18 T138N R81W

FIELD H1, CLEARFIELD SUNFLOWER VARIETIES
Previous crop winter wheat
3/7/05 Contractor bulk spread Urea at 70 lbs N/a.
4/18/05 Contractor sprayed field with Prowl H_2O at 48 oz/a.
5/19/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
6/6/05 The west half of the field was seeded no-till to Charger and the east half to Viper using a JD Maxemerge II planter at 24,000 seeds/a.
6/6/05 Contractor sprayed field with Beyond (4 oz/a).
7/11/05 Contractor sprayed field with Poast (1 pt/a).
8/10/05 Contractor sprayed Asana at 6 oz/a.
9/27/05 Contractor sprayed field with Gramoxone (1 pt/a) and Liberate.
10/19/05 Sunflowers were harvested. Charger sunflowers yielded 1700 lb/a and Viper yielded 1560 lb/a. Sunflowers sold for $9.35 cwt.

FIELD H2, NDSU CORN STUDY
Previous crop sunflower
3/24/05 Contractor bulk spread Urea at 80 lbs N/a.
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
5/3/05 Seeded 16 corn hybrids into sunflower stubble at 3 plant densities 12,000 seeds/a, 20,000 seeds/a, and 28,000 seeds/a using a JD Maxemerge II planter with 30-inch row spacing
6/7/05 Field was sprayed with Roundup Ultra Max II at 20 oz/a and Sterling at 8 oz/a.
10/18/05 Corn varieties were hand harvested by NDSU.

FIELD H2, CORN VARIETIES SKIP-ROW

Previous crop sunflower

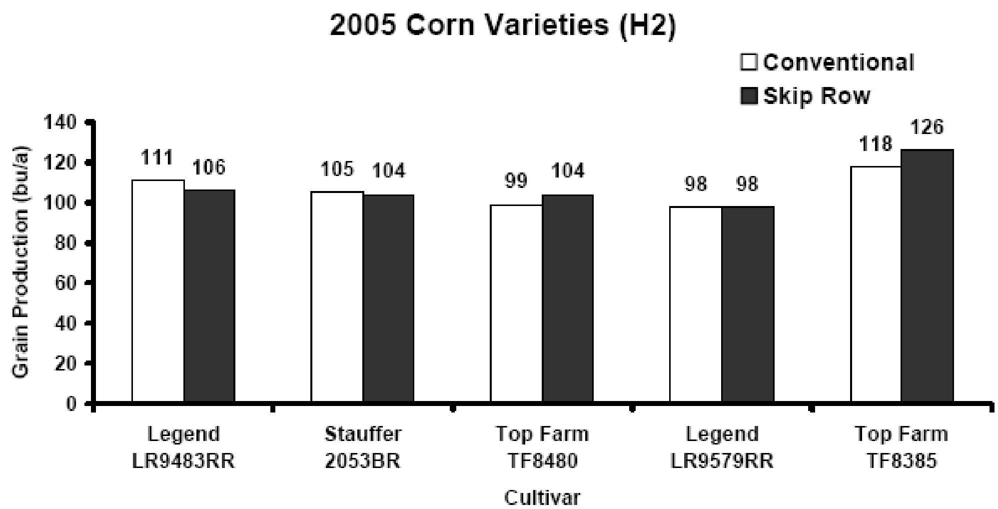
3/7/05 Contractor bulk spread Urea at 80 lbs N/a.

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

5/23/05 Seeded corn varieties (Legend Seeds LR9483RR and LR9579RR, Stauffer Seeds 2053BR, and Top Farm TF8480 and TF8385) into sunflower stubble at 24,000 kernels/a using a JD Maxemerge II planter with 30-inch row spacing. Half of each variety was seeded conventionally (6 rows) and the other half by skip row technique (seed two rows, skip one) at 24,000 kernels/a.

6/7/05 Field was sprayed with Roundup Ultra Max II at 20 oz/a and Sterling at 8 oz/a.

10/17/05 Corn was combined. See chart below for results.



- Averaged over all corn varieties, conventional row yields were 106 bu/a while skip row was 108 bu/a. Good weed control and good residue management are critical for skip row to be effective.

FIELD H2 SOUTH, SCLEROTINIA BIOLOGICAL CONTROL STUDIES

Previous crop barley

See ‘Sclerotinia (White Mold) Research, 2005’, page 32

FIELD H3, SOYBEAN VARIETIES

Previous crop spring wheat

5/19/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

6/6/05 Seeded soybean varieties LS0522RR on the West side and Gold Country 2305RR on the East side at 200,000 seeds/a using a JD 750 drill with 7.5” row spacing. 50 Lbs of 11-52-0 was applied at seeding. Soybean varieties were inoculated with Soy-sterile.

10/17/05 Soybeans were harvested and yielded 30 bu/a. Soybeans sold for $4.59/bu.

FIELD H3, CROP SEQUENCE PROJECT, PHASE III A
MYCOGEN 270 SUNFLOWERS

Previous crop see ‘Diverse Cropping Systems Sequence Project’ page 14

3/7/05 Contractor bulk spread Urea at 70 lbs N/a.

4/18/05 Contractor sprayed field with Prowl H_2O at 48 oz/a.

5/19/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

5/27/05 Field was seeded to SF270 sunflower at a rate of 25,000 viable seeds/a with a JD Maxemerge II planter (30-inch row spacing).

6/2/05 Field was sprayed with Glyphomax at 20 oz/a.

8/10/05 Contractor sprayed Asana at 6 oz/a.

10/27/05 Harvested sunflowers with plot combine.

FIELD H3 SOUTH, SCLEROTINIA BIOLOGICAL CONTROL STUDIES
See 'Sclerotinia (White Mold) Research, 2005', page 32

FIELD H3 SOUTH, WINTER WHEAT (Intermittent water pond area)
Previous crop "ducks"
9/21/04 Roughrider winter wheat was seeded at 1.3 million seeds/a using the Bourgault air seeder (10-inch row spacing). 50 lbs/a of 11-52-0 was applied at seeding. Seed was treated with Raxil MD Extra.
3/7/05 Contractor bulk spread Urea at 70 lbs N/a.
4/21/05 Contractor sprayed field with Salvo at 12 oz./a.
8/2/05 Winter wheat was harvested. No yields were taken. Wheat was sold for $3.07/bu.

FIELD H4, SOIL QUALITY MANAGEMENT
See 'Management Strategies for Soil Quality' on page 26

FIELD H4, SOYBEAN PROTEIN ENHANCEMENT
Previous crop spring wheat
9/10/04 Soil analysis showed Nitrates at 64 lbs/ac (0-24"), and Phosphorus at 21 ppm.
4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
5/19/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.
5/27/05 Seeded RR soybean varieties (TF6052, TF6002, LS0093 and LS0522) at 200,000 viable seeds/a using a JD 750 drill with 7.5" row spacing. Fifty lb/a of 11-52-0 was applied at seeding. All varieties were inoculated with Soy-sterile.
9/29/05 Soybeans were combined. See results below.

	Variety				
	Legend		Top Farm		
	0093 RR early maturing	0522 RR moderate maturing	6002 RR early maturing	6052 RR moderate maturing	
Treatment	---lbs/a---				Treatment averages
Control	2076	2002	1869	2080	2006
N applied at R1-R2	2016	1964	1752	2038	1942
N applied at R3-R4	1832	1998	1839	1985	1913
N applied at R5-R6	2145	1951	1812	2088	1999
Variety averages	2017	1979	1818	2048	

- Top Farm 6002 (early maturing variety) had the lowest yield of the four varieties.
- Applying 30 lb N/a as URAN using Nitro-bars at the different plant development stages did not increase seed yield. Samples need to be analyzed for protein.

FIELD H4, OMEGA FLAX

Previous crop spring wheat and winter wheat

9/7/04 Contractor sprayed field with Glyphomax at 32 oz/a and LV4 at 16 oz/a.

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

4/28/05 Omega flax was seeded at 4 million viable seeds/a with a JD 750 no-till drill. 70 lbs N/a (Urea) and 50 lbs/a 11-52-0 were put down at seeding.

6/20/05 Field was sprayed with Poast (14 oz/a), Prime Oil (32 oz/a), and Curtail-M (21oz/a).

8/22/05 Swathed flax

8/26/05 Flax was combined and yielded 26.4 bu/a.

9/2/05 Sprayed flax stubble with Glyphomax at (20 oz/a) 24-D amine (1 pt/a) and ammonium sulfate.

9/26/05 Planted Yellowstone winter wheat with Haybuster Hoe-drill at 1.3 million viable seed/a. Fertilizer (11-52-0) was applied at seeding.

FIELD H4, MYCOGEN 270 SUNFLOWERS

Previous crop winter wheat

3/7/05 Contractor bulk spread Urea at 70 lbs N/a.

4/18/05 Contractor sprayed field with Prowl H_2O at 48 oz/a.

5/19/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

6/7/05 Seeded Mycogen 270 sunflowers with a JD Maxemerge II planter at 25,000 seeds/a. (30-inch row spacing).

8/10/05 Contractor sprayed Asana at 6 oz/a.

10/27/05 Harvested sunflowers with plot combine.

FIELD H4 EAST, SCLEROTINIA BIOLOGICAL CONTROL STUDIES

See 'Sclerotinia (White Mold) Research, 2005', page 32

<u>AREA-I FIELD OPERATIONS,</u> NE ¼ Section 20 T138N R81W

FIELD I1, VERDE SPRING WHEAT

Previous crop spring wheat

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

4/25/05 Verde spring wheat was seeded at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing). 50 lbs/a of 11-52-0 and 70 lb N/a as Urea was banded at seeding. Seed was treated with Raxil MD Extra.

6/2/05 Contractor sprayed field with Affinity (0.6 oz/a) and Salvo (8 oz/a).

8/16/05 Spring wheat harvested and produced a yield of 29.6 bu/a. Crop sold for $3.80/bu.

FIELD I2, KOTO BUCKWHEAT

Previous crop sunflower

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

5/16/05 Field was sprayed with Glyphomax (24 oz/a) and 2,4-D (16 oz/a).

6/6/05 Field was seeded to Koto buckwheat using a JD 750 no-till drill at 1 million viable seeds/a. 50 lbs/a of 11-52-0 and 70 lbs N/a (Urea) were applied at seeding.

7/6/05 Field was sprayed with Poast at 16 oz/a.

9/2/05 Buckwheat was swathed.

9/19/05 Buckwheat was harvested and yielded 1330 lb/a. Buckwheat sold for $10.00 cwt.

FIELD I3, ROUGHRIDER WINTER WHEAT

Previous crop spring wheat

9/20/04 Roughrider winter wheat was seeded at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing). 50 lbs/a of 11-52-0 was applied at seeding. Seed was treated with Raxil MD Extra.

3/7/05 Contractor bulk spread Urea at 70 lbs N/a.

4/21/05 Contractor sprayed field with Salvo at 12 oz./a.

8/8/05 Winter wheat was harvested and yielded 25.2 bu/a. The wheat sold for $3.07/bu

FIELD I4, DK30-33 SUNFLOWER

Previous crop winter wheat

3/7/05 Contractor bulk spread Urea at 70 lbs N/a.

5/4-6/05 Sonalan 10G at 11 lb/a was applied with an undercutter.

6/2/05 Field was sprayed with Glyphomax at 20 oz/a.

6/6/05 Seeded field with DK30-33 sunflowers using a JD Maxemerge II no-till planter at 24,000 seeds/a.

6/10/05 Field was sprayed with Glyphomax at 20 oz/a.

7/11/05 Contractor sprayed field with Poast at 1 pt/a.

8/10/05 Contractor sprayed Asana at 6 oz/a.

9/27/05 Contractor sprayed field with Gramoxone (1 pt/a) and Liberate.

10/24/05 Sunflowers were harvested and yielded 2320 lb/a.

FIELD I5, VERDE SPRING WHEAT

Previous crop sunflower

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

4/22/05 Verde spring wheat was seeded at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing). Seed was treated with Raxil MD Extra. Urea at 70 lb N/a and 50 lb/a of 11-52-0 were blended and side banded at seeding.

6/2/05 Contractor sprayed field with Affinity (0.6 oz/a), Puma (7 oz/a), and Salvo (8 oz/a).

8/16/05 Spring wheat was harvested and yielded 34.3 bu/a. Spring wheat sold for $3.80/bu.

9/23/05 Roughrider winter wheat was seeded at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing).

FIELD I6, ROUGHRIDER WINTER WHEAT

Previous crop spring wheat

9/20/04 Roughrider winter wheat was seeded at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing). 50 lbs/a of 11-52-0 was applied at seeding. Seed was treated with Raxil MD Extra.

3/7/05 Contractor bulk spread Urea at 70 lbs N/a.

4/21/05 Contractor sprayed field with Salvo at 12 oz./a.

8/5/05 Field was harvested. Yield was 33.6 bu/a and sold for $3.07/bu.

FIELD I7, PARSHALL SPRING WHEAT

Previous crop spring wheat

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

4/26/05 Seeded Parshall spring wheat into spring wheat stubble at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing). 70 lbs N/a (Urea) and 50 lbs/a of 11-52-0 were applied at seeding. Seed was treated with Raxil MD Extra.

6/2/05 Contractor sprayed field with Affinity (0.6 oz/a), Puma (7 oz/a), and Salvo (8 oz/a).

8/16/05 Spring wheat was harvested and yielded 36.0 bu/a. Spring wheat sold for $3.80/bu.

9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

FIELD I7, FALLOW (EQUIPMENT DEMONSTRATION AREA)

Previous crop spring wheat

4/21/05 Contractor sprayed field with Roundup Ultra Max at 16 oz/a.

6/17/05 Field was sprayed with Roundup Ultra Max (16 oz/a), LV4 (16 oz/a), and ammonium sulfate (5.0 gal/ 100 gal).

7/6/05 NDSU Extension/NRCS no-till in-service training. “Equipment for no-till seeding” demonstration.

9/5/05 Contractor sprayed field with Roundup (22 oz/a) and Clarity (4 oz/a).

FIELD I7 CROP SEQUENCE PROJECT, PHASE III B

See ‘Diverse Cropping Systems Sequence Project’, page 14

DIVERSE CROPPING SYSTEMS
CROP SEQUENCE PROJECT
(For 2004)

Drs. Donald Tanaka, Joe Krupinsky, Steve Merrill, Mark Liebig, and Jon Hanson

INTRODUCTION
A multi-disciplinary team of scientists is conducting a multi-phased project with early- and late-season grass and broad leaf crops to develop diverse cropping systems. The team is evaluating the components of crop production, crop residue, plant disease, weeds, root growth, crop-water use, soil quality, and economics to develop guidelines for long-term diversified crop production systems and to provide producers with management flexibility for developing their own cropping systems.

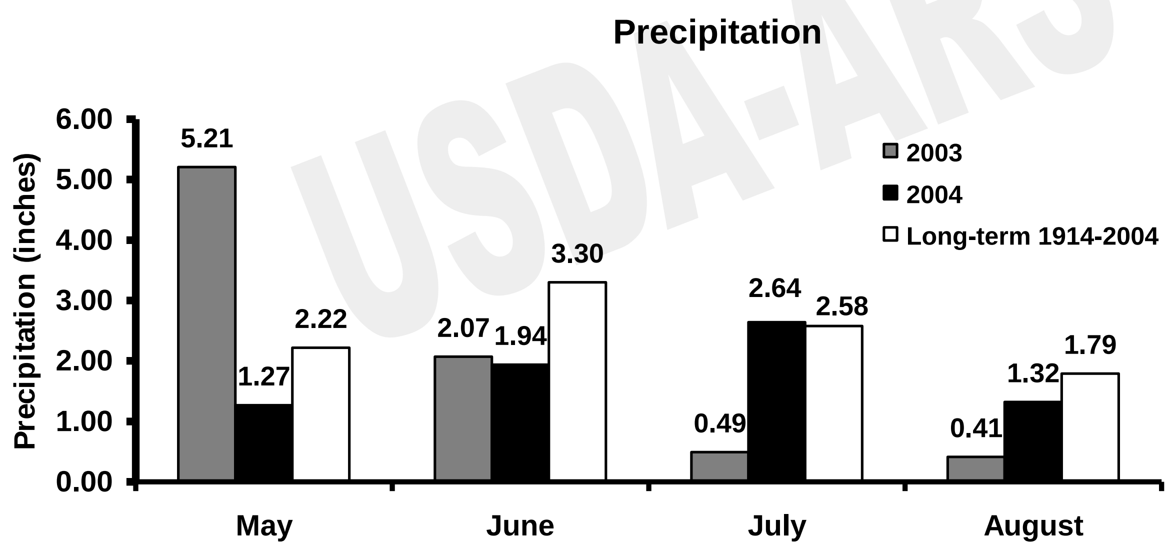


Figure 1. Growing season precipitation (May – August) for 2003, 2004, and long-term average growing season precipitation at Mandan, ND.

Table 1. Crop information for Phase IIIB crops planted in 2004 at Mandan, ND.

2003 Crop (Variety)	Seeding Date	Harvest Date	Target Population (Seeds/acre)	Actual Fertilizer Rates N (lbs/a)	P (lbs/a)	S (lbs/a)	Row Space (in.)
Buckwheat (Koto)	6-08-04	9-07-04	1.0 Million	70	10	0	7 ½
Canola (357RR)	4-15-04	8-19-04	800,000	70	10	10	7 ½
Chickpea (B-90)	4-28-04	8-24-04	200,000	0	10	0	7 ½
Corn (TF2183)	5-14-04	11-16-04	25,000	70	10	0	30
Dry Pea (DS Admiral)	4-14-04	7-29-04	350,000	0	10	0	7 ½
Grain Sorghum (DK28E)	6-10-04	11-17-04	200,000	70	10	0	7 ½
Lentil (Richlea)	4-28-04	8-12-04	686,000	0	10	0	7 ½
Proso Millet (Earlybird)	6-09-04	9-21-04	1.5 Million	70	10	0	7 ½
Sunflower (63M91)	6-10-04	11-09-04	25,000	70	10	0	30
Spring Wheat (Amidon)	4-14-04	7-29-04	1.3 Million	70	10	0	7 ½

Table 2. Spray operations for Phase IIIB crops in 2004 at Mandan, ND.

Crop	Date	Chemical/a	Date	Chemical/a	Date	Chemical/a	Date	Chemical/a	Date	Chemical/a	Date	Chemical/a
Buckwheat (Koto)	6/4/05	Roundup Ultra Max (26oz)	6/14/04	Roundup Ultra Max (13oz)								
Canola (357RR)	4/22/04	Roundup Ultra Max (16oz) + LV4 (12oz) + Harmony GT (0.33oz)	6/14/04	Roundup Ultra Max (13oz)	9/9/04	Roundup Ultra Max (16oz) + 2,4-D Amine 4 (16oz)	9/30/04	Roundup Ultra Max (20oz) + LV4 (16oz)				
Chickpea (B-90)	5/4/04	Roundup Ultra Max (1.5pt) + Bison (1pt)	6/22/04	Poast (1pt)	7/13/04	Quadris (6.2oz)	7/27/04	Quadris (6.2oz)	8/25/04	Gramoxone Extra (1.5pt)	9/9/04	Roundup Ultra Max (16oz) + 2,4-D Amine 4 (16oz)
Corn (TF2183)	5/4/04	Roundup Ultra Max (1.5pt) + Bison (1pt)	6/16/04	Option (1.5oz) + Sterling (4oz)								
Dry Pea (DS Admiral)	4/22/04	Roundup Ultra Max (16oz) + LV4 (12oz) + Harmony GT (0.33oz)	5/27/04	Basagran (1.5pt) + Poast (1.0pt)	9/9/04	Roundup Ultra Max (16oz) + 2,4-D Amine 4 (16oz)						
Grain Sorghum (DK28E)	6/4/05	Roundup Ultra Max (26oz)	6/14/04	Roundup Ultra Max (13oz)	7/14/04	Sterling (3oz) + 2,4-D Amine 4 (12oz)						
Lentil (Richlea)	5/4/04	Roundup Ultra Max (1.5pt) + Bison (1pt)	6/22/04	Poast (1pt)	7/13/04	Quadris (6.2oz)	7/27/04	Quadris (6.2oz)	8/13/04	Gramoxone Extra (1.5pt)	9/9/04	Roundup Ultra Max (16oz) + 2,4-D Amine 4 (16oz)
Proso Millet (Earlybird)	6/4/05	Roundup Ultra Max (26oz)	6/14/04	Roundup Ultra Max (13oz)	7/14/04	Sterling (3oz) + 2,4-D Amine 4 (12oz)						
Sunflower (63M91)	5/4/04	Roundup Ultra Max (1.5pt) + Bison (1pt)	6/4/05	Roundup Ultra Max (26oz)	6/14/04	Roundup Ultra Max (13oz)	7/14/04	Poast (1.5pt) + Assert (0.8pt)				
Wheat (Amidon)	4/22/04	Roundup Ultra Max (16oz) + LV4 (12oz) + Harmony GT (0.33oz)	5/27/04	Bison (1.5pt)	9/9/04	Roundup Ultra Max (16oz) + 2,4-D Amine 4 (16oz)						

Ammonium Sulfate @ 2.5 gal/60 gal H_2O was applied with all Roundup Herbicide

2004 Phase IIIB Relative Seed Yield

2003 Crop \ 2004 Crop	Buckwheat	Canola	Chickpea	Corn	Dry Pea	Grain Sorghum	Lentil	Proso Millet	Sunflower	Wheat
Buckwheat	1.00	0.89	3.18	**0.65**	1.13	-	1.19	0.99	**0.08**	0.77
Canola	1.12	1.00	3.35	0.96	1.00	-	1.56	1.11	0.97	0.79
Chickpea	0.89	0.97	**1.00**	1.46	**0.83**	-	**0.83**	1.11	1.50	0.86
Corn	0.98	0.94	2.64	1.00	1.07	-	1.19	**0.91**	1.17	**0.63**
Dry Pea	<u>**1.33**</u>	1.29	<u>**3.50**</u>	1.61	1.00	-	1.73	<u>**1.34**</u>	<u>**1.61**</u>	<u>**1.03**</u>
Grain Sorghum	**0.77**	**0.40**	2.19	1.10	0.91	-	1.08	0.94	1.00	0.71
Lentil	1.00	<u>**1.34**</u>	1.50	1.49	1.02	-	1.00	1.17	0.95	0.95
Proso Millet	0.88	0.85	2.97	1.53	<u>**1.74**</u>	-	1.49	1.00	1.54	0.84
Sunflower	0.98	0.66	2.14	1.04	1.28	-	1.38	0.95	1.00	0.81
Wheat	1.20	0.83	3.32	<u>**1.64**</u>	1.58	-	<u>**2.23**</u>	1.12	1.41	1.00
LSD 0.05	0.29	0.64	2.35	0.54	0.50	-	0.60	0.20	0.71	0.25

Figure 2. Relative yield of ten crops grown on ten crop residues in 2004 at Mandan, ND.
(*Largest relative seed yield – bold underlined; smallest relative seed yield – bold*)

2004 Phase IIIB Precipitation-Use Efficiency (lbs/a/inch)

2003 Crop	2004 Crop									
	Buckwheat	Canola	Chickpea	Corn	Dry Pea	Grain Sorghum	Lentil	Proso Millet	Sunflower	Wheat
Buckwheat	110.48	38.23	75.11	**99.32**	105.41	-	55.00	187.31	**3.44**	160.54
Canola	104.35	32.40	77.55	130.53	74.84	-	51.85	180.58	36.81	136.37
Chickpea	**84.10**	26.57	**53.26**	194.98	**73.44**	-	**31.09**	179.43	57.80	151.39
Corn	108.36	**39.33**	66.50	156.53	110.04	-	47.76	**171.67**	51.44	**131.01**
Dry Pea	**124.16**	38.63	**90.62**	207.24	87.06	-	60.30	**215.63**	61.07	**175.38**
Grain Sorghum	84.82	**18.34**	55.69	179.79	97.22	-	46.89	178.86	45.92	142.72
Lentil	94.70	32.40	69.68	198.88	94.28	-	45.98	189.83	37.36	162.06
Proso Millet	94.56	25.04	82.28	**229.31**	**157.16**	-	69.07	186.34	**64.34**	164.74
Sunflower	106.04	30.34	82.03	154.98	134.12	-	66.05	176.93	33.55	160.15
Wheat	112.66	23.90	80.20	213.62	129.04	-	**83.48**	180.07	53.24	171.50
LSD 0.05	29.71	14.74	30.16	68.03	48.98	-	23.36	32.65	28.34	44.22

Figure 3. Crop sequence influences on precipitation-use efficiency of ten crops in 2004 at Mandan, ND.
(Largest precipitation-use efficiency – bold underlined; smallest precipitation-use efficiency – bold)

SUMMARY

(Figures 1,2, and 3)

1. During the 2004 growing season, growing season precipitation (May through August) was 74% of the long-term average 9.72 inches.

2. Crop sequence influenced spring wheat the least.

3. Volunteer buckwheat was a problem on row crops such as corn and sunflower.

4. Grain sorghum did not produce any seed in 2004. This could have been due to the cool temperatures during flowering in August.

5. Corn and proso millet had the best precipitation-use efficiency with an average of over 175 lb/a of seed produced for each inch of precipitation.

CROP SEQUENCE EFFECTS AND PRODUCTIVITY AT ALTERNATIVE SOIL SITE

Drs. Steve Merrill, Don Tanaka, Joe Krupinsky, and Mark Liebig

A site with sandy loam soil located near NGPRL headquarters, termed the Alternative Soil Site (ASL), was taken out of perennial grass and developed for cropping systems research. In 2003, a 4 x 4 crop sequence experiment (CSE) was started using the same type of no-till management and the same crop types and cultivars as have been used for the 10 x 10 crop Phase II and Phase III CSE's that were conducted on the Area IV SCD's Cooperative Research Farm. The soil at the ASL site was of sandy loam texture with much lower organic carbon content and lower water holding capacity than the silt loam, glacial till soil at the Research Farm. Although the ASL site soil appears to be of inherently lower soil quality than soil at the Research Farm site, other features of the soil and land, such the relative ease and depth of root penetration, and the presence of protective tree-based shelterbelts apparently raise the soil productivity/quality of the ASL site on a soil profile and landscape basis to a higher level.

Three replication blocks at the ASL site were in residue crops/matrix crops sequences in the 2003 and 2004 seasons, and three other intermingled blocks were in residue/matrix crops in the 2004 and 2005 seasons. Of the four crops, spring wheat and dry pea were common to both Phase II and Phase III CSE's. Corn was grown in the Phase III CSE and soybean was grown in Phase II CSE.

Crop yield results of the two ASL site matrices are summarized in Tables A and B here. The 2003 and 2004 cropping seasons were of below average precipitation and the 2005 season was nearer the average. A number of the crop sequence effects that were observed two years in a row in the ASL experiment here have also been observed in the two Research Farm CSE's: (a) overall negative crop sequence effects of corn, generally attributed to the greater water-depleting potential of this crop; (b) overall positive crop sequence effects of soybean, in harmony with positive leguminous crop sequence effects observed with 5 leguminous species in the two large CSE's; (c) positive soybean-on-soybean crop sequence effects which are believed to represent a soil microbial/symbiont conditioning of the soil. Dry pea exhibited negative overall crop sequential effects in 2004 and positive in 2005, which is not entirely consistent with the Phase II and Phase III CSE's results in which dry peas showed predominately positive crop sequential effect results. In the ASL, the negative effects of dry pea in 2004 are probably due to some combination of factors: (a) significant grazing of the 2003 pea crop by deer and other browsers; (b) significantly increased water use by pea due to after-harvest regrowth of pea that had shelled-out in an hailstorm earlier in the season ; and (c) after-harvest weed growth in pea. The negative overall crop sequence effects of spring wheat in 2005 are possibly due to greater later-season weed growth in that year.

Overall, weed interactions appeared to play a greater role in crop sequential effects at the ASL site than in the Research Farm CSE's. Herbicidal control of weeds may have been more thorough at the Research Farm CSE's, and weed infestations were possibly under less ecological constraint at the sandy loam soil site than at the silt loam Research Farm site. We do not have comparative weed science data on this, but the soil water depletion results discussed in the next article offer some evidence that cropping results at ASL site were more weed-affected than Research Farm site results.

Table A. 2004 matrix crops seed yield in lb/ac and percentage differences from crop average.

	2004 Crops					Net Crop Seq. Effect
2003 Crops	Corn	Dry Pea	Soybean	Spring Wheat		(Sum)
Corn	4693 -0.7%	1254 +4.7%	1390* -13.9%	2197 -0.6%		-10.1%
Dry Pea	4604 -2.6%	1153 -3.8%	1390* -13.5%	2043 -7.5%		-27.4%
Soybean	4759 +0.7%	1164 -2.8%	2046 +27.3%	2504 +13.3%		+38.5%
Spring Wheat	4848 +2.6%	1221 +1.9%	1605 -0.2%	2093 -5.3%		-1.0%
Averages	4726	1198	1608	2209		

Table B. 2005 matrix crops seed yield in lb/ac and percentage differences from crop average.

	2005 Crops					Net Crop Seq. Effect
2004 Crops	Corn	Dry Pea	Soybean	Spring Wheat		(Sum)
Corn	3823 -6.6%	1567 +4.2%	1572 -12.1%	1468 -6.6%		-21.1%
Dry Pea	4494 +9.8%	1395 -7.2%	1822 +1.8%	1752 +11.5%		+15.9%
Soybean	3852 -5.9%	1628 +8.2%	2153 +20.3%	1706 +8.5%		+31.1%
Spring Wheat	4198 +2.6%	1430 -4.9%	1609 -10.0%	1361 -13.4%		-25.7%
Averages	4092	1504	1789	1572		

SOIL WATER DEPLETION AT ALTERNATIVE SOIL SITE

Drs. Steve Merrill, Don Tanaka, and Joe Krupinsky

Soil water depletion (SWD) differences at the sandy loam ASL site are shown for the four alternative crops for sequences with spring wheat in the first year of the sequence. Differences among crops in seasonal SWD is a guide to differences in soil water amounts available in the spring to support the next crop. The same methodology was used as in the Research Farm CSE's, which was periodic measurement of soil water content with non-destructive neutron moisture meters. The standard accounting period for SWD was mid-May to mid-September.

The 2004 cropping season was deficient in precipitation, and soil water storage was relatively low in the spring. Thus, SWD's were lower to negative (gaining soil water) in 2004, as shown in Fig. A. In the Phase II and Phase III CSE's, dry pea consistently had the lowest SWD values of any crop. At the ASL site, dry pea had greater SWD than spring wheat in both 2004 and 2005. The greater SWD by dry pea compared to spring wheat is believed due to greater post-harvest weed growth in pea, whose vegetative structure begins to collapse before its relatively early harvest. Pea harvest leaves almost no standing residue, and thin, non-durable flat residue, whereas spring wheat standing residue could act to some extent as a deterrent to especially post-harvest broadleaf weed growth.

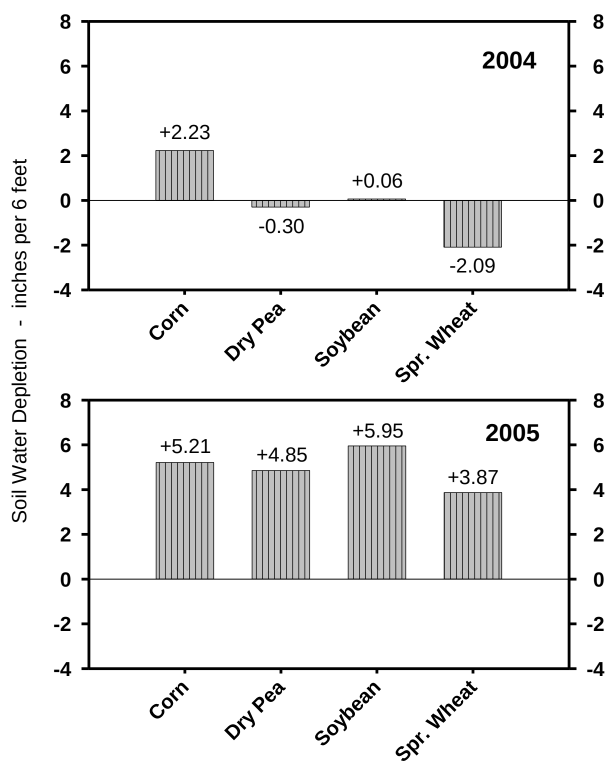


Figure A. Soil water depletion measured mid-May to mid-September at the sandy loam ASL site using a neutron moisture meter to a depth of 6 feet.

One of the goals of the ASL site work is to compare soil productivity at this sandy loam soil and land site with productivity at the Research Farm site with its nominally higher quality silt loam soil. Thus we show a comparison between the sites in distribution of SWD over the soil profile for spring wheat crops in spring wheat – spring wheat sequences (Fig. B). It is evident that a considerably larger proportion of SWD comes from lower in the profile in the case of the sandy loam ASL soil compared to the silt loam Research Farm soil. Provided there is an adequate minimum of water in the soil profile, roots will readily penetrate to depth in the sandy loam ASL site soil and deplete soil water. However, the glacial till subsoil at the Research Farm site with its higher clay content appears to be relatively more restrictive of root penetration. Root growth studies have shown that such crops as safflower, which has an aggressive taproot system, can readily penetrate the glacial till subsoil zone while non-taprooted crops such as spring wheat have difficulty penetrating glacial till subsoil when its soil strength becomes elevated due to lower precipitation and subsequent drying of the subsoil. A general conclusion from these results is that soil productivity/soil quality assessments should best include consideration of soil profile structure factors and landscape considerations such as the shelterbelt or lack of shelterbelt effects present in this study.

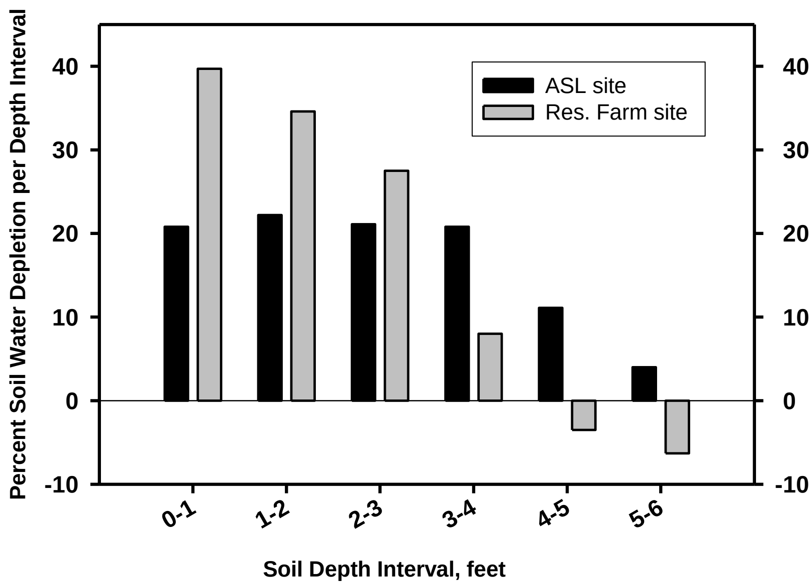


Fig. B. Patterns of soil water depletion measured from late May to early August 2005 under spring wheat crops at the ASL and Research Farm sites.

SATELLITE-BASED FORAGE ASSESSMENT FOR NORTHERN MIXED-GRASS RANGELANDS

Drs. Rebecca Phillips, Mark Liebig, Ofer Beeri
(University of North Dakota, School of Aerospace Sciences, Grand Forks, ND)

Rangeland forage quality, expressed as % crude protein, can be estimated for northern mixed-grass landscapes under variable plant moisture conditions using current satellite sensors with a model developed and tested on working rangelands. Experiments at plant, plot, and pasture scales were used to identify and evaluate spectra sensitive to plant carbon:nitrogen ratio (C:N) under variable drought stress for mixed-grass prairie rangelands. Formulae developed under controlled conditions were tested under field conditions to identify an optimum Rangeland C:N Formula (RCNF). RCNF predictions using Landsat 5 data were tested for differences among grazing treatments and intra-seasonally between April and September 2004. Grazing treatment differences were evident for both Landsat 5 estimated and measured canopy C:N ratios. Moreover, estimated C:N values decreased between April and September 2004, in agreement with ground-truth measurements, with lower crude protein values in April (6-8%) than in early September (9-12%). We tested the same model using ASTER satellite data acquired in May. Landsat 5 estimates were within 14% of actual plot-scale measurements (RMSE=3.1), while ASTER estimates were within 10% of actual (RSME=1.5). 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 (Figure 1). Results suggest forage crude protein content may be estimated for large landscapes with reasonable accuracy using current, economical satellite sensors for northern mixed-grass rangelands.

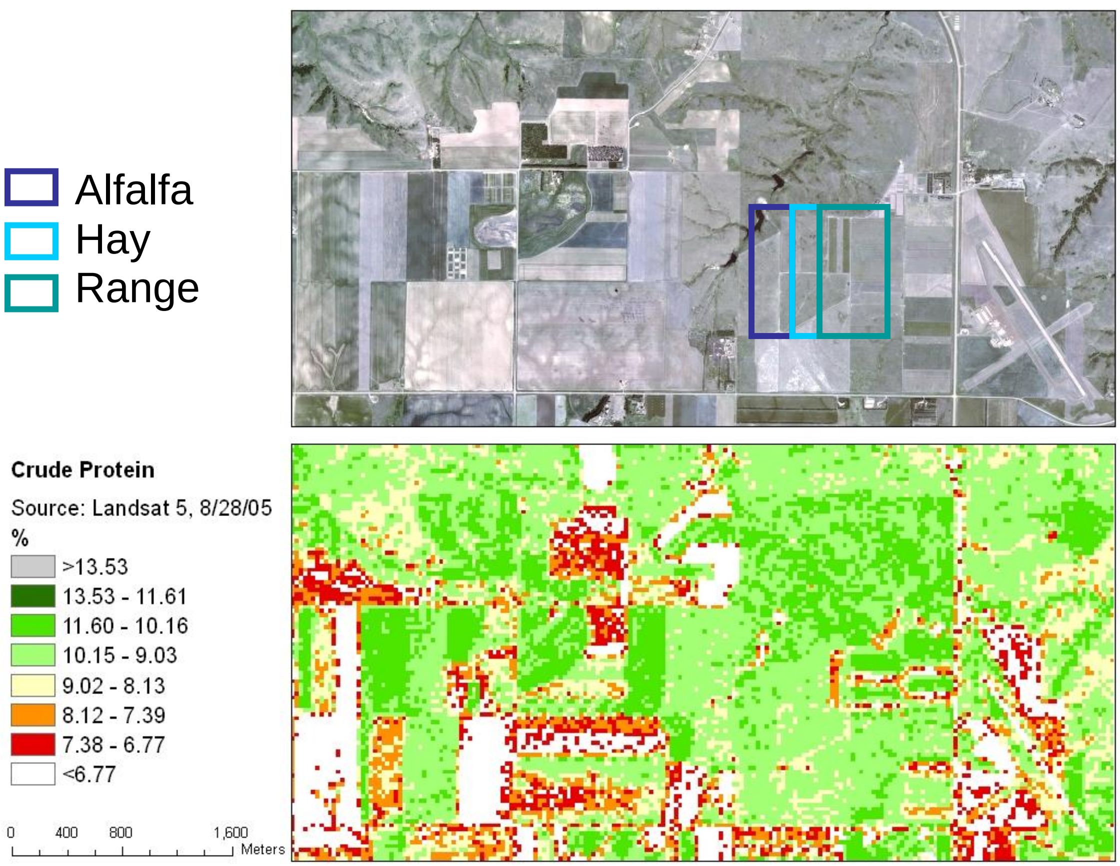


Figure 1. Aerial photograph taken in 2003 and satellite-based crude protein data collected August 28, 2005 for the Northern Great Plains Research Station in Mandan, ND and surrounding area. Estimates for crude protein are highlighted for three fields: alfalfa (pre-harvest), hay (post-harvest), and native rangeland.

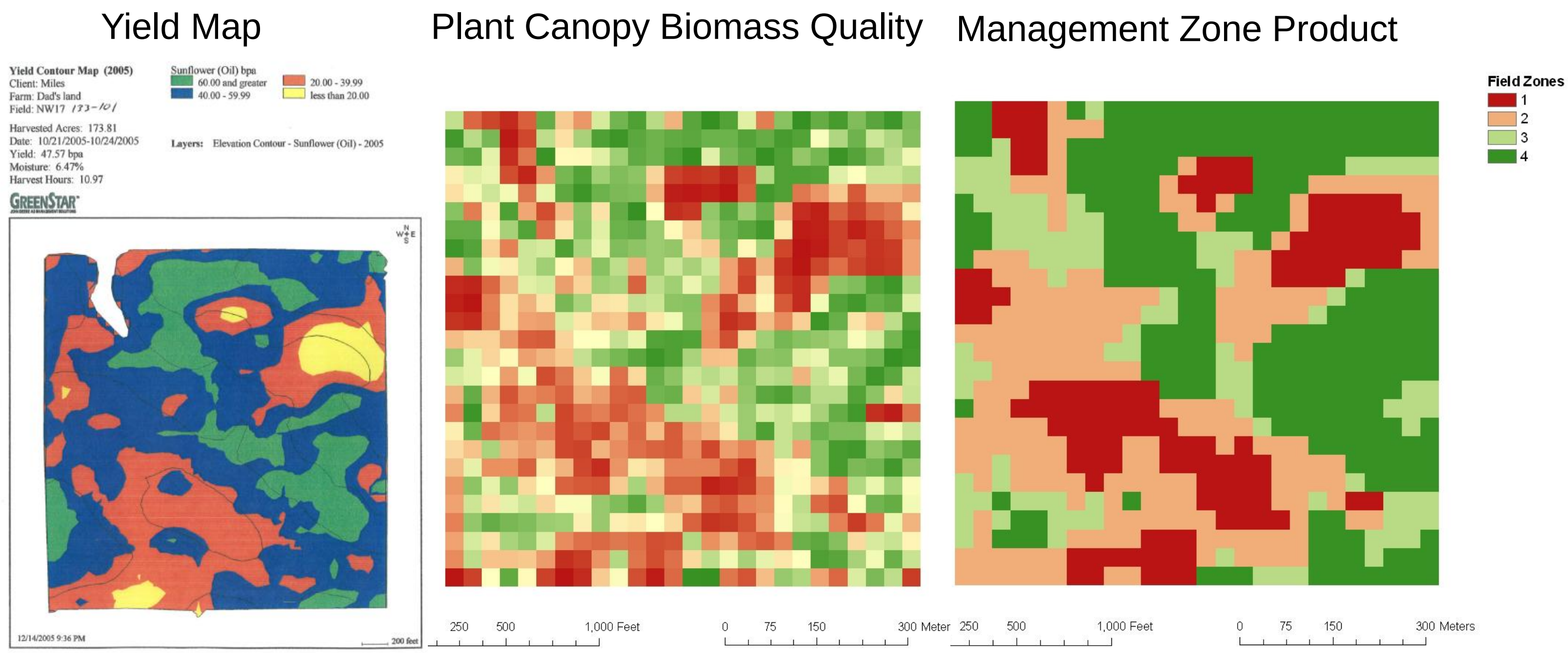
NEW SATELLITE-BASED METHOD FOR SPATIAL CROP MANAGEMENT ZONE DELINEATION

Drs. Rebecca Phillips and Ofer Beeri[2]
[2]University of North Dakota, School of Aerospace Sciences, Grand Forks, ND

Strategic spatial management (also referred to as variable-rate or precision agriculture) offers the capacity to improve farmer profits by reducing nutrient inputs. However, on-farm application is hindered not only by the cost of variable-rate technology, but also by the lack of a clear and consistent methodology for zone delineation. With rising fertilizer costs, producers are now looking more closely at reducing inputs through spatial management. Consequently, there is an increasing need for affordable and reliable geospatial information products to support crop production decisions. While soil heterogeneity can be identified with grid sampling or with electrical conductivity measurements, the costs associated with these techniques can be prohibitive and results may not necessarily correspond to plant growth. In this demonstration, we utilize geospatial analysis of plant biomass quality to designate within-field management zones for large landscapes through application of satellite-based technology. An example of model results for defining within-field heterogeneity as compared to crop yield is given using producer fields in the Dickinson (Figure 2) area.

Zone delineation was developed through application of a new satellite-based model for estimating canopy carbon:nitrogen (C:N) ratio, referred to as biomass quality. These values were determined using plant spectral signatures, from which canopy nitrogen (N) content was derived based on homogenous crop cover. We then evaluated canopy N according to field variability (coefficient of variation) to determine the number of field zones required. Data were clustered into manageable units (zones) according to percent data distribution and nearest neighbor analysis. Within-field patterns based on satellite-derived canopy N content track topography and yield in this example (Figure 2). Further application and testing will be performed in cooperation with NDSU on several farms during a 2006 field trial to determine if spatial management lowers costs and improves profits.

Figure 2. Data for 2005 sunflower fields near Dickinson: 1) yield map, 2) satellite-based canopy biomass quality estimates, and 3) clustered spatial management zones necessary for variable-rate fertilizer application.



FATE OF FALL-APPLIED ORGANIC FERTILIZER IN RED RIVER VALLEY CROP FIELDS

Dr. Rebecca Phillips and Mr. Scott Bylin

Organic fertilizers are commonly applied to crop fields during the late-fall with the expectation that over-winter nutrient losses are minimal when soils are below freezing. Although fall application is common and often recommended, there are few reports for the fate of fall-applied nutrients. We determined the amount of residual fertilizer in soil following five months of winter with fall-application of partially-composted manure to field plots in Clay County, MN. We hypothesized that soils amended with manure would be higher in organic matter and inorganic soil nitrogen, compared with adjacent control soils.

We conducted an on-farm experiment to address this question under realistic field conditions. We identified a pair of 20-acre fields with similar soil characteristics, including series, texture, nutrients, microbiological activity, organic matter, crop rotation, microbial biomass, and tillage. Both field had not been fertilized for 1.5 yr prior to the experiment and were previously planted in soybeans. Management differed between fields only with respect to fertilizer production application and pesticide use. Field 1 is managed to produce certified organic crops, and Field 2 is managed to produce conventional crops. The organic Field 1 is typically fertilized with manure in the fall, while the conventional Field 2 is typically fertilized with urea in the spring.

The organic fertilizer was applied on Nov 20, 2004 and worked by hand into the topsoil on ten randomly selected 1-m^2 plots at a rate of 1200 lb per acre. Adjacent to each fertilized plot was an unfertilized, within-field control. The conventionally managed field was not fertilized. Soil trace gas fluxes were measured one-week prior to fertilization and at several times thereafter during the winter. Following thaw and before tillage on April 9, 2005, soil samples were collected and analyzed for carbon, nitrogen, and micronutrients at three depth increments. Results for topsoil (0-15 cm) and mid-soil (15-30 cm) depths indicated no differences between conventional, organic, and control soils for inorganic N, nitrate (NO_3^-) or ammonium (NH_4^+). Significant differences in soil N were recovered at the 30-50 cm soil depth, with greater levels of NH_4^+ for organic fertilized soils than for conventional and control soils. Soil organic matter content (both organic and inorganic) was similar among treatments at all depths. Micronutrients (manganese, boron, iron) were greater for organically managed soils, compared with conventional. Results indicate manure organic matter applied in the fall was not retained by these soils. Moreover, greater levels of soil ammonium at 30-50 cm depths suggest that >70% of fall-applied nitrogen may have leeched below the plow layer.

MANAGEMENT STRATEGIES FOR SOIL QUALITY

Drs. Donald Tanaka, Steve Merrill, Mark Liebig, and Joe Krupinsky

A long-term study was initiated in the spring of 1993 to evaluate the influences of residue management and crop rotations on soil quality. Tillage, crops, and crop residue were all in the appropriate places in 1994. Treatments for the 2005 crop included minimum- and no-till for the following crop rotations:

1. Continuous spring wheat (CSW+); straw chopped and spread
2. Continuous spring wheat (CSW-); stubble left in place, straw removed
3. Spring wheat – millet for hay (SW-M)
4. Spring wheat – safflower – fallow (SW-S-F)
5. Spring wheat – safflower – rye (partial fallow, cover crop) (SW-S-R)
6. Spring wheat – fallow (SW-F)

Spring wheat (cv. Parshall) was seeded on May 16 at 1.3 million viable seeds per acre. Safflower (cv. Montola 2003) was seeded on May 5 at 300,000 viable seeds per acre. Millet for hay was seeded at 4 million viable seeds per acre on June 17 and reseeded July 6 on no-till plots. Residue from previous crops was uniformly distributed at harvest. All no-till plots were sprayed with Roundup (0.375 lb ai/a) prior to seeding while minimum-till plots were tilled with an undercutter about 3 inches deep prior to seeding. Spring wheat, safflower, and millet were seeded with a JD 750 no-till drill with N fertilizer banded at seeding and P applied with the seed at seeding. Recrop plots received 60 lb N/a and 10 lb P/a while fallow or partial fallow plots received 30 lb N/a and 10 lb P/a at seeding. Rye was seeded on September 28, 2004 at 1.3 million viable seeds per acre with a Haybuster 8000.

Summary: 1. Growing season precipitation (May through August) for 2005 was 128% of the long-term average 9.93 inches.

2. Spring wheat in SW-S-F and SW-S-R systems had yields similar to SW-F.

3. Residue removal (CSW-) appears to reduce spring wheat yields when compared to leaving the residue in place (CSW+).

4. Safflower seed yield was similar for SW-S-F and SW-S-R systems.

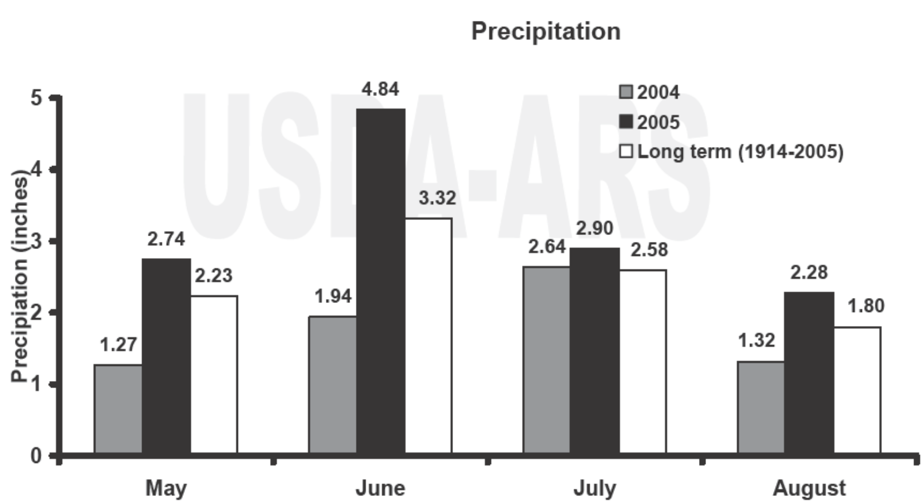


Figure 1. Growing season precipitation (May – August) for 2004, 2005, and long-term average growing precipitation at Mandan, ND.

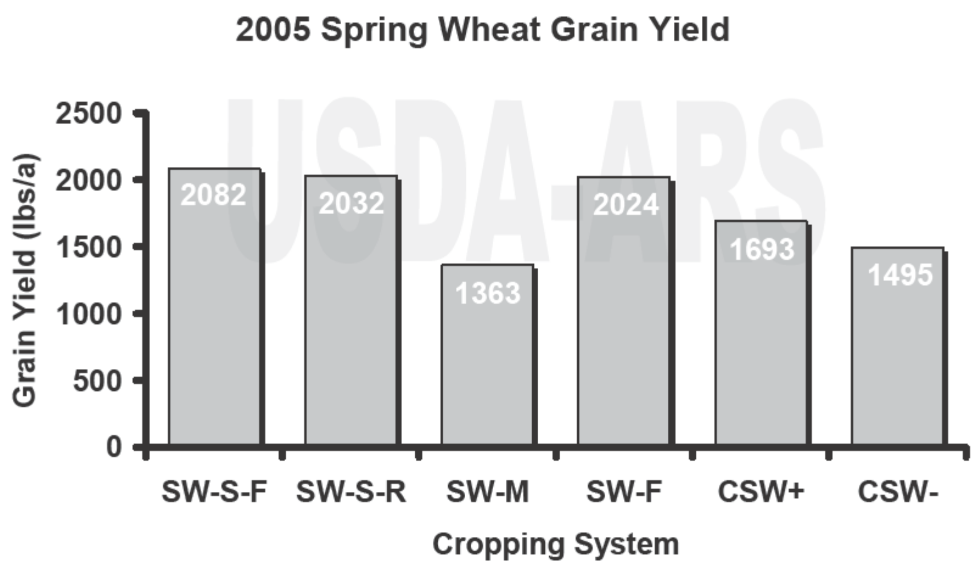


Figure 2. Spring wheat grain yield as influenced by cropping system. Yields are the average of minimum and no-till.

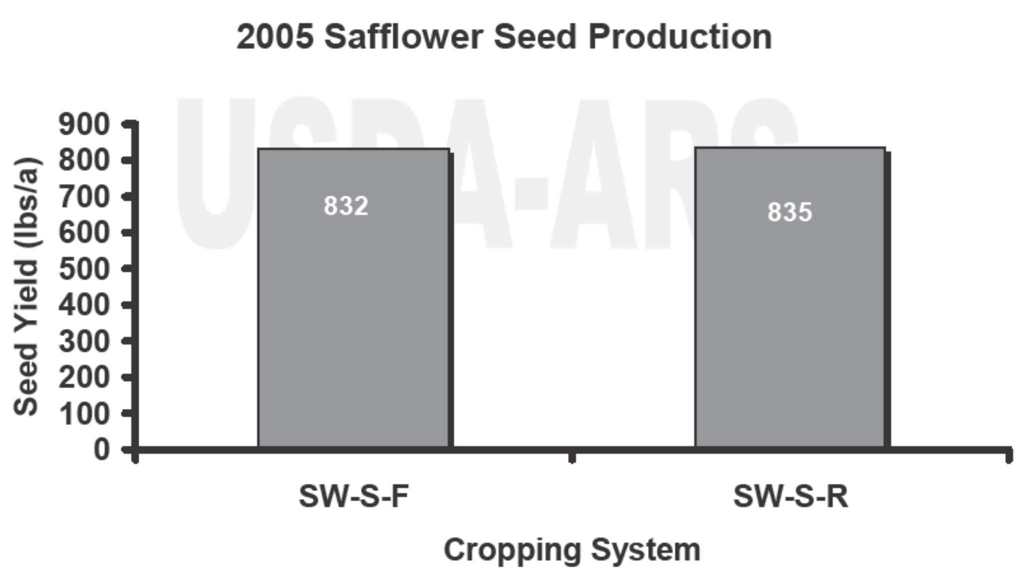


Figure 3. Safflower seed yield as influenced by cropping system. Yields are the average of minimum and no-till.

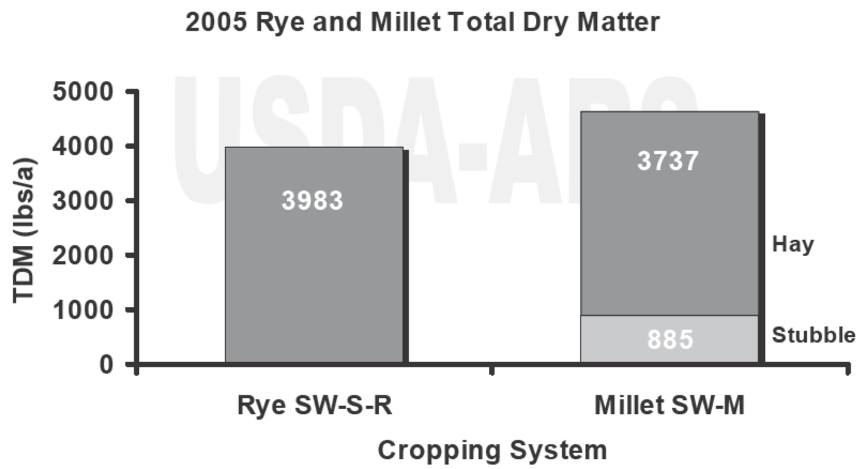


Figure 4. Total dry matter production for rye used as partial fallow and Siberian millet used for hay.

FORAGE BREEDING AND GENETICS RESEARCH

Drs. John Berdahl, John Hendrickson, Joe Krupinsky, Scott Kronberg, and Eric Scholljegerdes

NEW INTERMEDIATE WHEATGRASS CULTIVAR

The Northern Great Plains Research Laboratory in cooperation with the NRCS Bismarck Plant Materials Center and the North Dakota Agricultural Experiment Station will propose release of an experimental intermediate wheatgrass population, Mandan I1871. A cultivar name has not been assigned, and release is planned in 2008. Mandan I1871 has had high hay yields over a wide geographic area and improved persistence under grazing compared with current cultivars. Forage quality has been adequate for beef cattle, but not above the overall average for a representative sample of intermediate wheatgrass cultivars and experimental populations. We anticipate that Mandan I1871 will be grown in mixtures with alfalfa for hay and pasture. Mandan I1871 is made up of 12 parent clones from germplasm collected by the late Douglas Dewey near Stavropol and Svetlograd, in the Caucasian region of Russia. The collection sites have a climate similar to the northern Great Plains of North America and a long history of sheep grazing.

OTHER DEVELOPMENTS

Experimental populations of long-lived, grazing-type alfalfa are being tested locally and regionally. Seed of one population, Mandan A1991, is being increased for possible cultivar release.

Experimental Russian wildrye populations with twice the normal chromosome number and improved seedling vigor have been developed. This germplasm will require 4 to 5 years of testing before cultivar release.

Hay yields, forage quality traits, and tiller replacement ratios of intermediate wheatgrass cultivars.

Entry	Dry matter yield (Tons/acre)	IVDMD (%)	NDF (%)	Crude protein (%)	Tiller replacement ratio
Mandan I1871	2.33	65.1	69.8	9.1	0.85
Reliant	2.13	66.0	69.1	9.5	0.59
Haymaker	2.10	65.1	68.9	9.4	--
Oahe	2.09	64.1	69.1	8.9	0.75
Manska	1.98	66.3	68.3	9.7	0.77
Beefmaster	1.98	66.5	68.7	9.3	--
LSD (0.05)	0.14	0.92	0.43	0.50	
Station years	18	4	4	4	3

SWITCHGRASS INCREASES SOIL ORGANIC CARBON

Drs. Mark Liebig, Jon Hanson, Al Frank, and Ms. Holly Johnson

Concerns regarding negative social and environmental consequences of a fossil fuel-based economy have increased interest in developing a bioenergy industry in the USA. Bioenergy-based products have been purported to have significant environmental and economic benefits to society, including near-zero net emissions of greenhouse gases, improved soil and water quality, and increased net economic returns to rural communities. Of the numerous cellulosic feedstocks considered for use as bioenergy crops, switchgrass (*Panicum virgatum* L.) has been identified as having significant potential in meeting these desired outcomes across a wide geographical range in the USA.

Switchgrass is a highly productive bioenergy feedstock that has a deep and extensive root system. Switchgrass roots account for up to 80% of total plant biomass, and can extend over eight feet into the soil profile. As a result, switchgrass has the potential to increase soil carbon. Management practices that increase soil carbon impart a dual benefit to agriculture and society by mitigating the greenhouse effect and improving soil quality. To evaluate the soil carbon storage potential of switchgrass, a study was undertaken to quantify soil carbon stocks within established switchgrass stands and nearby cultivated cropland on 42 farms in North Dakota, South Dakota, and Minnesota.

Switchgrass stands were found to have greater soil organic carbon than cultivated cropland near the soil surface (0-2 inches) as well as lower depths in the soil profile (1-3 feet) (Figure 1). Differences in soil organic carbon between switchgrass and cropland were especially pronounced at deeper soil depths, where treatment differences were 3.5 and 2 tons per acre for the 1-2 and 2-3 foot depths, respectively. Over the four foot sampling depth, switchgrass stands averaged 6.8 tons per acre more soil organic carbon than cultivated cropland.

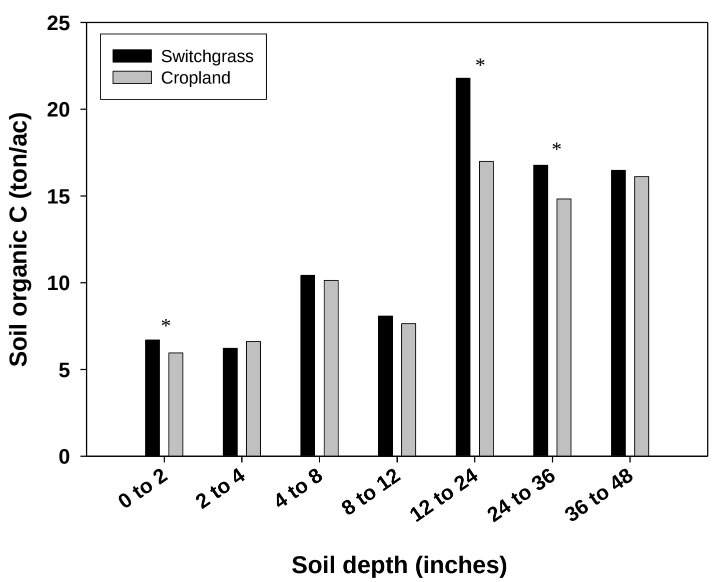


Figure 1. Mean values for soil organic C for switchgrass stands and cultivated cropland across sites. Treatments within a soil depth designated with an asterisk (*) are significantly different at P<0.1.

Results from this study indicate switchgrass is effective at storing soil organic carbon not just in near-surface depths as found in other evaluations, but also at depths below 12 inches. Deep storage of soil organic carbon is particularly beneficial from the standpoint of carbon sequestration, because carbon stored at deeper soil depths is less susceptible to mineralization and loss.

SOIL RESIDUE COVERAGE FOLLOWING 100 CROP SEQUENCES (TEN CROPS), 2005

Drs. Joe Krupinsky, Don Tanaka, Steve Merrill, Mark Liebig, and Jon Hanson

Crop diversification with alternative crop species can influence soil residue coverage in no-till cropping systems. Soil residue coverage protects soil resources from erosion, conserves soil water, and maintains soil quality. The influence of crop sequencing with 10 crops (buckwheat [*Fagopyrum esculentum* Moench], canola [*Brassica napus* L.], chickpea [*Cicer arietinum* L.], corn [*Zea mays* L.], dry pea [*Pisum sativum* L.], grain sorghum [*Sorghum bicolor* (L.) Moench], lentil [*Lens culinaris* Medik.], oil seed sunflower [*Helianthus annuus* L.], proso millet [*Panicum miliaceum* L.], and hard red spring wheat [*Triticum aestivum* L.]) on soil residue coverage was evaluated when the 10 crops were direct seeded (no-till) into the crop residue of the same 10 crops. Soil residue coverage was measured with a transect technique. Soil residue coverage varied following different crop species. Soil residue coverage was greater early in the season, e.g. after seeding spring wheat, compared to later in the season, e.g. after seeding sunflower. When evaluating two-year crop sequences, the difference in soil residue coverage was more clearly associated with the second-year crop than with the first-year crop of the sequence. In 2005, soil residue coverage following 58 out of 100 crop sequences was lower than a continuous wheat treatment at one site (Figure 1).

In general, soil residue coverage after spring wheat seeding indicated that crop sequences composed of wheat, proso millet, and grain sorghum had the higher soil residue coverage compared to sequences composed of the other alternative crops. When soil residue coverage associated with three higher-residue crops (proso millet, grain sorghum, and spring wheat) and three lower-residue crops (lentil, chickpea and sunflower) were analyzed as a subset to compare various crop sequence combinations (high/high, low/high, high/low, and low/low), the residue coverage ranged from 56% to 94% in 2005. With an apparent relationship between soil residue coverage and the development of subsequent wheat crop (growth stage), two high residue crops in sequence may contribute to a delay in spring wheat development.

First year crop residue	Second year crop residue									
	Corn	Chick-pea	Sun-flower	Dry Pea	Lentil	Canola	Buck-wheat	Millet	Sor-ghum	Wheat
Corn	59**	61**	42**	67**	62**	75**	73**	94	92	85
Chickpea	77*	54**	44**	57**	54**	73**	76**	97	95	80
Sunflower	69**	65**	57**	62**	59**	66**	73**	94	92	83
Dry Pea	76**	65**	52**	58**	56**	72**	75**	98	95	88
Lentil	70**	65**	54**	63**	65**	75**	69**	97	95	87
Canola	65**	73**	52**	73**	61**	70**	77*	94	97	86
Buckwheat	76*	72**	73**	69**	70**	78*	79	95	91	88
Millet	85	78*	51**	76**	79	80	81	95	95	90
Sorghum	79	74**	69**	76*	70**	80	88	96	96	88
Wheat	83	77*	64**	83	77*	84	83	94	96	95

Figure 1. Soil residue coverage measured after seeding spring wheat into the residue of 100 crop sequences (3rd yr of Crop Sequence Project, Phase IIIb, 2005). Shaded treatments have less soil residue coverage than the continuous wheat treatment (* = $P \leq 0.05$; ** $P \leq 0.01$)

SCLEROTINIA (WHITE MOLD) RESEARCH, 2005

Drs. Joe Krupinsky, Don Tanaka, Mark Liebig, Steve Merrill, Jon Hanson, & Tom Gulya (Northern Crop Science Laboratory, Fargo, ND)

A **Crop Sequence Project** (Phase IIIa) was conducted to evaluate the impact of previous crops (buckwheat, chickpea, corn, lentil, proso millet, grain sorghum, canola, dry pea, sunflower, and wheat) and crop residue on Sclerotinia diseases. In 2005, 400 sunflower plots were evaluated for disease (29,380 plants rated per evaluation) and harvested. The percentage of Sclerotinia basal stalk rot ranged from 0.6% for the grain sorghum/grain sorghum/spring wheat/sunflower sequence to 17% for the sunflower/sunflower/spring wheat/sunflower sequence (Figure 1). Plots following two years of sunflower were highest for stalk rot compared to two years of the other crops (Figure 2). Crop sequences with spring wheat and grain sorghum in the 1st and/or 2nd year ranked lowest for percentage of stalk rot.

The **Biological Control Project** was evaluated to determine the efficiency of *Coniothyrium minitans* applications under dryland conditions. Treatments after uniform application of sclerotia included: susceptible and resistant crops, and the timing of *C. minitans* (Contans WG®) applications. Sunflower was used as an indicator crop. The percentage of Sclerotinia basal stalk rot for treatments ranged from 0 to 15% for one study. Although statistical differences among treatments were not evident, there was a trend for higher disease levels following crambe. Also, combine yield data showed a lower sunflower yield following crambe compared to the other crops. A total of 228 plots were harvested in 2005 for three studies and samples are being processed. One study will be seeded to canola in 2006 for further evaluation. Another study will be seeded to sunflower in 2006 for further evaluation. Minor differences in soil water measurements were detected among plots. Soil properties were generally not affected by treatments. Soil pH decreased over time in all treatments and crops, with the strongest trend at 0-5 cm. Among crops, soil nitrate increased at all depths under dry pea.

A **Sclerotinia Inoculum Density Project** was evaluated to determine the impact of sclerotia density and tillage on Sclerotinia disease severity under dryland conditions. In 2005, the percentage of basal stalk rot on sunflower under tillage averaged 9% compared to 3% for no-till. Treatments will be evaluated with canola in 2006. This research will contribute to a better understanding of how sclerotia density and tillage influences the incidence of Sclerotinia disease and yield components under dryland field conditions.

Figure 1. Sclerotinia stalk rot on sunflower following 25 crop sequences out of 100 crop sequences evaluated in 2005.

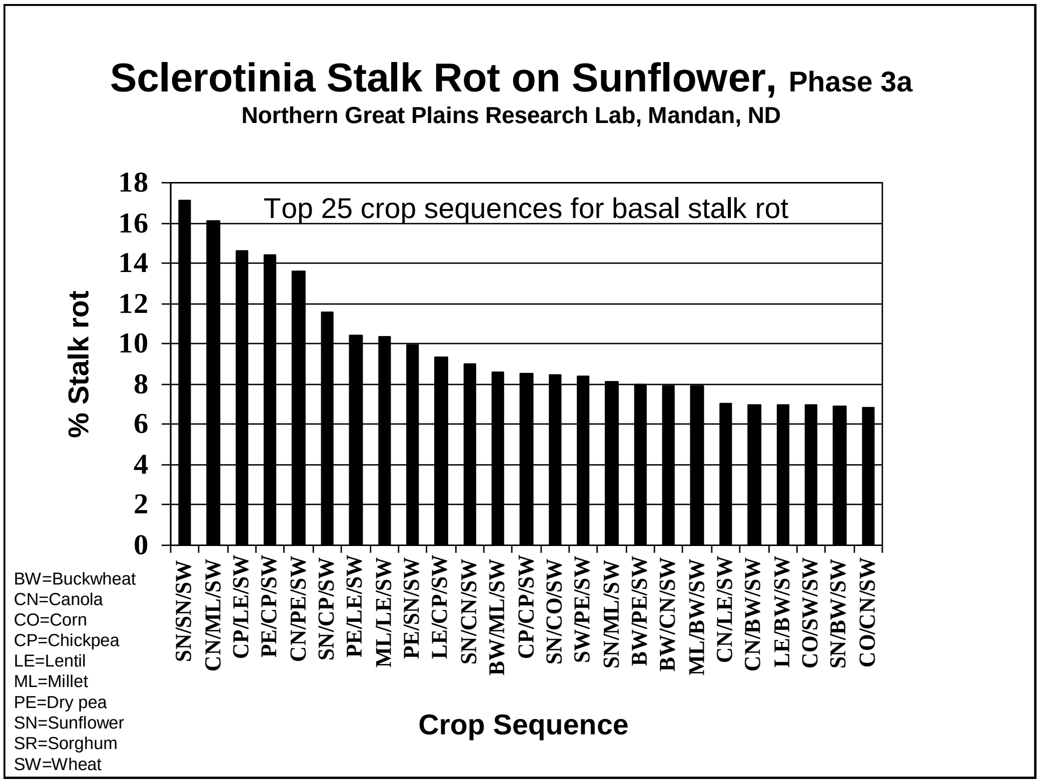
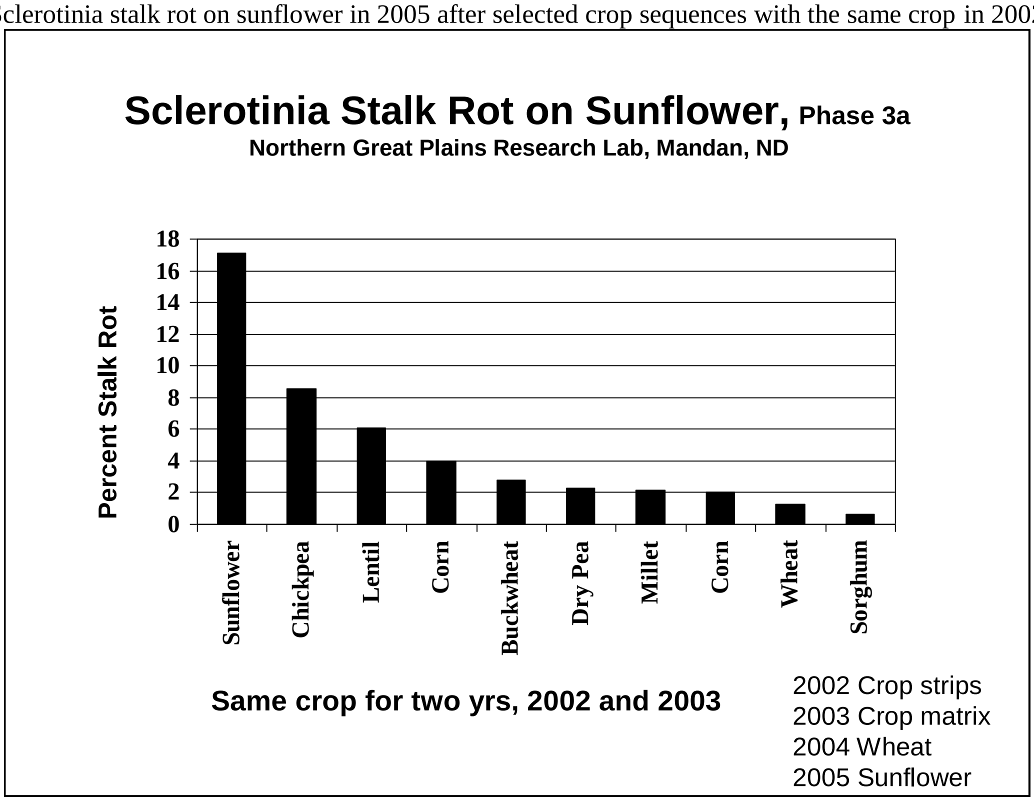


Figure 2. Sclerotinia stalk rot on sunflower in 2005 after selected crop sequences with the same crop in 2002 and 2003.



LEAF SPOT DISEASES ON SPRING WHEAT AND CROP SEQUENCES, 2005

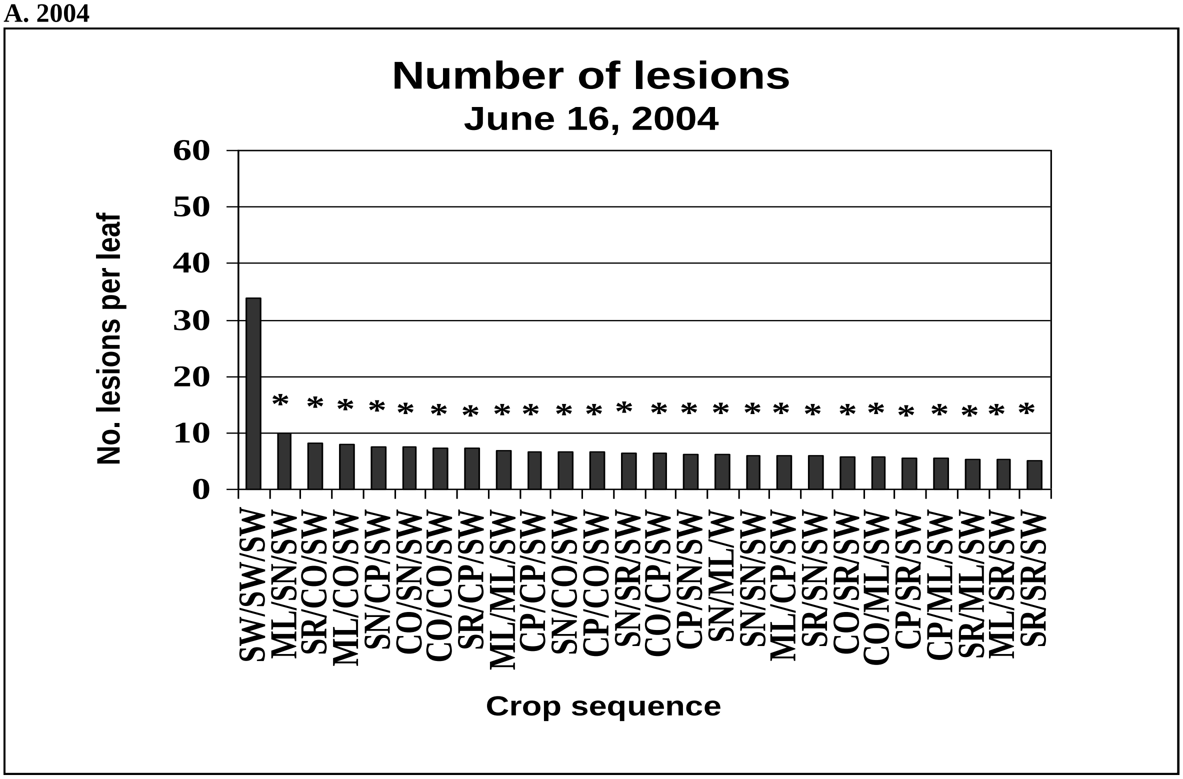
Drs. Joe Krupinsky, Don Tanaka, Steve Merrill, Mark Liebig, and Jon. Hanson

Crop diversification and crop sequencing/crop rotation can influence leaf spot diseases on hard red spring wheat (*Triticum aestivum* L.). Field research was conducted to determine the influence of crop sequences on leaf spot diseases of wheat. Spring wheat was direct seeded (no-till) in the crop residue of ten crops (buckwheat [*Fagopyrum esculentum* Moench], canola [*Brassica napus* L.], chickpea [*Cicer arietinum* L.], corn [*Zea mays* L.], dry pea [*Pisum sativum* L.], grain sorghum [*Sorghum bicolor* (L.) Moench], lentil [*Lens culinaris* Medik.], oil seed sunflower [*Helianthus annuus* L.], proso millet [*Panicum miliaceum* L.], and hard red spring wheat and evaluated for disease severity. *Pyrenophora tritici-repentis* [Died.] Drechs., the cause of tan spot, was the most common fungus followed by *Phaeosphaeria nodorum* [E. Müller] Hedjaroude, the cause of stagonopora nodorum blotch.

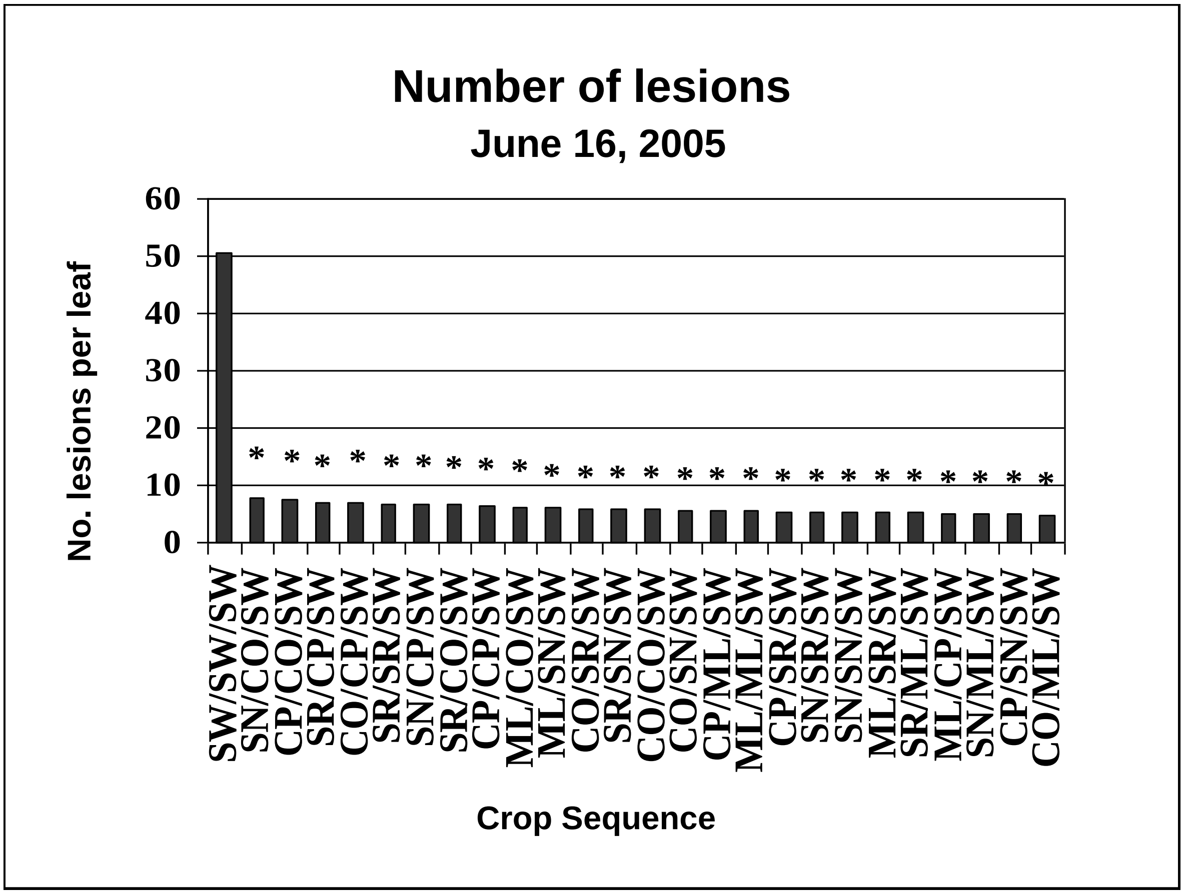
In general, spring wheat following crop sequences with alternative crops had lower levels of disease severity compared to a continuous wheat treatment (Figure 1). Disease severity was not associated with quantity of crop residues present early in the season. Overall, crop sequence is an important management practice, which should be combined with other management practices, to lower the risk for leaf spot diseases of spring wheat.

Figure 1. Number of lesions on spring wheat leaves following two years of an alternative crop; CO = corn, CP = chickpea, ML = proso millet, SN = sunflower, SR = grain sorghum, and SW = spring wheat. * = significantly different from the continuous wheat treatment.

A. 2004



B. 2005



Number of lesions
June 16, 2005
No. lesions per leaf
60
50
40
30
20
10
0
SW/SW/SW
SN/CO/SW
CP/CO/SW
SR/CP/SW
CO/CP/SW
SR/SR/SW
SN/CP/SW
SR/CO/SW
CP/CP/SW
ML/CO/SW
ML/SN/SW
CO/SR/SW
SR/SN/SW
CO/CO/SW
CO/SN/SW
CP/ML/SW
ML/ML/SW
CP/SR/SW
SN/SR/SW
SN/SN/SW
ML/SR/SW
SR/ML/SW
ML/CP/SW
SN/ML/SW
CP/SN/SW
CO/ML/SW
Crop Sequence

ARBUSCULAR MYCORRHIZAL FUNGI, GLOMALIN AND WATER-STABLE AGGREGATION MEASUREMENTS AT THE NORTHERN GREAT PLAINS RESEARCH LABORATORY

Drs. Kris Nichols, John Berdahl, John Hendrickson, Mark Liebig, and Ms. Holly Johnson

SOIL MICROBIOLOGY AT NGPRL

The soil microbiology program at NGPRL is centered on the study of arbuscular mycorrhizal (AM) fungi, glomalin, and water-stable aggregation (WSA). Arbuscular mycorrhizal fungi (arbuscular meaning tree-like and mycorrhizal meaning fungus root) are a group of organisms whose thread-like hyphal body branches out into soil to acquire nutrients that are normally not accessible to plant roots. The hyphae penetrate root cells and deliver the nutrients directly to the plant in exchange for simple sugars. The mycorrhizal relationship has been shown to improve the mineral nutrient and water status of the plant host as well as confer disease resistance. Glomalin is a sugar-protein produced by AM fungi that helps to protect the hyphae from nutrient loss, to stick organic matter and soil minerals together in aggregates, and to help make soil aggregates water-stable. The formation and stabilization of soil aggregates is an important component to forming fertile and productive soils. Soil aggregates are pellets of various shapes and sizes that create pores in the soil for better water infiltration, aeration, water- and nutrient-holding capacity, and root growth. Stable aggregates are large enough to resist erosion and protect organic matter from rapid decomposition while providing a home for a variety of soil organisms involved in nutrient cycling. Measurements of glomalin, AM fungi, and WSA are made in three overlapping research areas: 1) AM fungi and biofuel feedstock production, 2) AM fungi, glomalin, and soil quality in cropping, rangeland and forage systems, and 3) AM fungi and glomalin impacts on soil aggregation.

AM FUNGI AND BIOFUEL FEEDSTOCK DEVELOPMENT

AM fungi are strongly associated with grasses, especially warm-season grasses. The mycorrhizal relationship may assist these grasses in surviving adverse conditions, such as droughts and nutrient deficiencies. The mycorrhizal relationship and especially the formation of glomalin may increase the ability of these perennial grasses to store carbon belowground. Therefore, in addition to helping biofuel feedstocks grow and flourish even under adverse conditions, this relationship will close the carbon cycle by storing carbon released as carbon dioxide during the burning of biofuels for energy.

Researchers at NGPRL are measuring the level of water-stable aggregation and glomalin on a variety of warm- and cool-season grasses and alfalfa grown in monoculture stands in the field and in single plant species pot cultures in the greenhouse. Preliminary results from the field indicate that warm-season grasses, such as switchgrass and big bluestem, have higher levels of glomalin and WSA than cool-season grasses, such as the wheatgrasses (intermediate, western, and crested) and Russian wild rye, in a sandy loam soil. The level of root colonization by AM fungi and AM fungal diversity are being assessed in the pot culture experiments.

AM FUNGI AND CROPPING, LIVESTOCK, AND FORAGE SYSTEMS

About 80% of all plants are associated with AM fungi, including most crop plants. Some notable exceptions are members of the Brassicaceae family, such as canola and crambie. In addition, as mentioned above, these fungi are highly associated with grasses and forage crops.

Soil samples have been collected from three collaborative research projects in the Northern Great Plains – a Rangeland Restoration Study at NGPRL, a Cropping and Rangeland Management Study near Platte, SD, and a Rangeland Management Study at Streeter, ND. The Rangeland

Restoration Study compared the ability of two treatments (chemical application and burning) and an untreated control to alter plant species composition and promote native plant species in five different vegetative communities. Plant communities, as determined by a visual estimate of vegetation in 2002, were dominated by 1) native warm-season grasses, 2) Kentucky bluegrass, 3) smooth bromegrass, 4) Kentucky bluegrass and smooth bromegrass, and 5) Kentucky bluegrass, smooth bromegrass and other introduced species. Burning treatments were conducted in all communities in late April, 2003 and repeated in the native communities in late April 2004. Chemical treatments were applied using 6 oz ai/acre of Plateua® (imazapic) when smooth brome was 10 to 16 cm tall in the spring of 2003 and 2004. Preliminary data in the Rangeland Restoration study showed that the glomalin concentrations were higher in the chemical and burn treatments than the control and highest in the burn treatment with native warm-season plant species composition. For all three treatments – burn, chemical, and control, glomalin concentrations were highest when the plant species composition was dominated by natives.

The Platte, SD study had six treatments – three cropping treatments (no-till, conventional till, and conventional till with manure application) and three rangeland treatments (native grass with rotational grazing, tame grass with heavy grazing, and tame grass with rotational grazing). Results showed that there was a strong correlation (r = 0.7669) between glomalin and WSA for all treatments, except the tame grass, rotational grazing treatment (Fig. 1). When the tame grass, rotational grazing treatment was removed, the relationship between glomalin and WSA was very strong (r = 0.9493). In the tame grass, rotational grazing treatment either some other biomolecule from the plant or soil biota is stabilizing the soil aggregates, all of the glomalin produced is used to stabilize aggregates resulting in little accumulation in the soil, or the glomalin is in a state that it cannot be extracted and measured. The native grass, rotational grazing treatment had the highest glomalin and WSA values while the conventional till and no-till treatments had the lowest values.

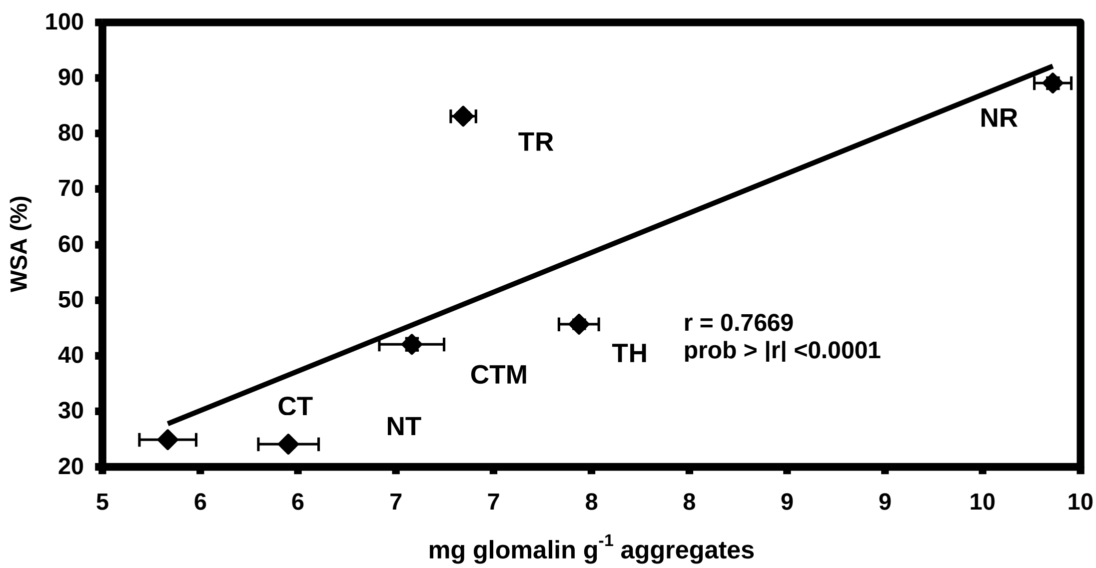


Figure 1. Relationship between the percentage of water-stable aggregates (%) and amount of glomalin extracted from 1 to 2 mm aggregates. The treatments included no-till (NT), conventional till (CT), conventional till with manure application (CTM), native grass with rotational grazing (NR), tame grass with heavy grazing (TH), and tame grass with rotational grazing (TR). (Means ± Mean Standard Error)

The rangeland management study near Streeter, ND has three grazing management treatments – idle (no grazing), rotational, and season-long. Soil samples were collected at seven depths (0-5, 5-10, 10-25, 25-50, 50-75, 75-100, and 100-125 cm) and separated into four aggregate sizes (9.5-

2, 2-1, 1-0.25, and 0.25-0.053 mm). Each group of aggregates is currently being analyzed for WSA and glomalin. Results on the 9.5-2 and 2-1 mm aggregate sizes indicate that both WSA and glomalin decline with depth and that the idle treatment has the highest WSA values.

Results from these three studies indicate that grazing management strategies and plant species composition impact glomalin concentrations and WSA. Plots with native species composition in both the Rangeland Restoration and Platte, SD studies had greater WSA and glomalin values. In addition, less intensive or no grazing at Platte, SD and Streeter, ND resulted in greater WSA and glomalin values.

AM FUNGI AND SOIL AGGREGATION

Previous studies have found the relationship between glomalin and WSA to be inconsistent. Glomalin research is in its infancy with critical problems associated with glomalin extraction, quantification, and purification. Different extractants and extraction conditions vary in their ability to remove glomalin from hyphal and soil samples. Glomalin typically is quantified on raw extracts using a Bradford total protein assay and ELISA with a monoclonal anti-glomalin antibody. Both of these procedures have methodological problems due to the complex and not well understood nature of the glomalin molecule. In addition, the processes involved in the formation and stabilization of soil aggregates are not well understood and differ with soil properties, management, and aggregate size. Several recent studies have indicated that particulate organic matter (POM), consisting of relatively undecomposed plant debris, is a major factor in aggregate formation and stabilization.

A recently accepted manuscript from the Soil Microbiology lab at NGPRL showed that glomalin is present in the POM fraction (Nichols and Wright, 2006). A collaborative project between NGPRL and scientists at USDA-ARS in Brookings, SD and South Dakota State University measured glomalin concentrations in POM fractions isolated from 2.0 to 6.4 mm soil aggregates collected at conventional till and no-till sites. Aggregates were separated into water-stable aggregates that remained on top of a sieve (TS) and unstable aggregates below the sieve. Visible residue (VR) was hand separated from the TS aggregates. The remaining TS aggregates and unstable aggregates were treated to separate fine POM (FPOM) and coarse POM (CPOM). Glomalin concentrations were higher in the stable aggregates (TS) than the unstable aggregates (Fig. 2). In the stable aggregates, glomalin values were highest in hand-picked visible residue and lowest in the fine POM. The no-till system had higher glomalin values in the visible residue (VRTS) and fine POM (FPOMTS and FPOM) fractions, but less in the coarse POM (CPOMTS and CPOM) fractions

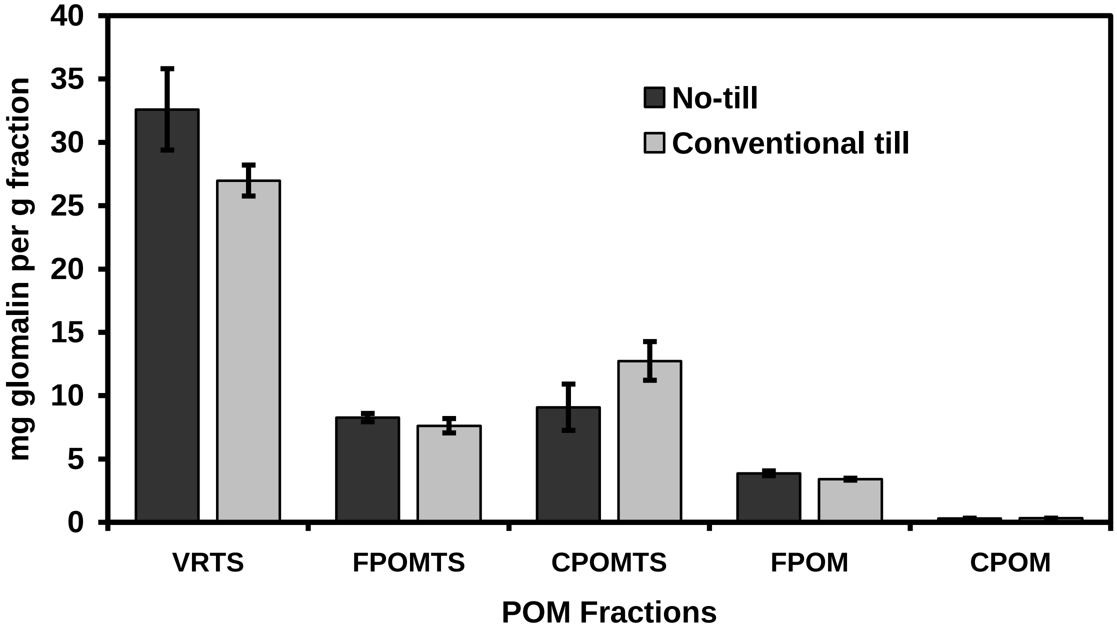


Figure 2. Concentrations of glomalin extracted from particulate organic matter (POM) fractions collected from stable (TS) and unstable 2.0 to 6.4 mm aggregates from no-till and conventional till sites. The POM fractions consisted of visible residue (VRTS), fine POM (FPOMTS), and coarse POM (CPOMTS) in the stable aggregates and fine POM (FPOM) and coarse POM (CPOM) in the unstable aggregates.

As mentioned above, a well aggregated soil will improve water infiltration and water-holding capacity. A procedure was designed to demonstrate this concept in field and classroom setting. Briefly, soil samples at surface depths (0-5, 0-10, and 0-15 cm) were collected from four studies in North and South Dakota - a long-term management strategies for Soil Quality Study at NGPRL and three studies mentioned above (the Rangeland Restoration Study, Cropping and Rangeland Management Study near Platte, SD, and Rangeland Management Study near Streeter, ND). The Soil Quality Study had side-by-side comparisons between no-till and conventional till treatments. In the laboratory, soil (both field-moist and air-dried) was placed in a 5 oz (148 ml) paper cup with a perforated bottom. This cup was inserted into the upper rim of a 3 oz (89 ml) paper cup. Water equivalent to 2.54 cm (1 in) was added and the infiltration rate was measured. For the air-dried samples, another 2.54 cm of water was added. Water collected in the bottom cup was measured using a graduated cylinder. Soil in the top cup was incubated in the laboratory to measure the rate at which the soil returned to an air dry state. Preliminary results show infiltration rates in the rangeland soils were faster than in the cropland soils for both the first and second 2.54 cm. In the field-moist samples from the Soil Quality Study at NGPRL, the no-till treatment had an infiltration rate more than three times that of the conventional till treatment. There was no difference in the amount of water collected in the bottom paper cup among all treatments. However, laboratory incubation studies have demonstrated a difference in the time required for the soils to return to an air-dried state, and on-going trials in the field have shown a difference in the amount of water collected in paired cropland and rangeland studies with the rangeland treatments retaining more water in the soil. As discussed above, glomalin and WSA are also being measured on soils used in this study.

FUTURE OF SOIL MICROBIOLOGY AT NGPRL

BIOFUEL FEEDSTOCKS

A collaborative project, involving The North Dakota (ND) Natural Resources Trust; North Dakota State University (NDSU) Research Extension Centers at Hettinger, Williston, Minot, Carrington, and Streeter; the Northern Prairie Wildlife Research Center; and the NGPRL has been designed to study dedicated bioenergy crops (including switchgrass, tall wheatgrass, intermediate wheatgrass, alfalfa, sweetclover, big bluestem, alti wildrye, and basin wildrye) to determine the appropriate grass species, harvest methods, and management practices to maintain productive stands. The economics for production of a bioenergy crop will be evaluated, as well as the impact on soil organic matter and carbon storage. This is a ten-year project and baseline soil sampling will begin in the spring of 2006.

CROPPING, RANGELAND, AND FORAGE SYSTEMS

In addition to completing the studies discussed above, glomalin, AM fungi, and WSA measurements will begin at sites sampled as part of three new studies. The first study will examine archived and freshly-collected soil samples from three long-term agroecosystem experiments at NGPRL related to different grazing management - two native vegetation moderately grazed pasture and heavily grazed pasture established in 1916, and one seeded crested wheatgrass [*Agropyron desertorum* (Fisch. ex. Link) Schult.] pasture established in 1932. The second study is an on-farm cooperative project will be established with agricultural producers following different management strategies in six Major Land Resource Areas (MLRA) in North Dakota. Specifically, three management treatments will be compared over time: 1) continuous cropping with high crop diversity under no-till management, 2) continuous cropping with low crop diversity under no-till management, and 3) undisturbed rangeland or seeded pasture. The third study will use soils collected from the 25 year old Farming Systems Trial™ (FST) at the Rodale Institute® in Kutztown, PA. This trial has been comparing three conventional or organic systems on a 6.1 ha plot: 1) conventional, 2) animal manure and legume-based organic, and 3) legume-based organic. Soil samples will be collected at five depth increments (0-20, 20-40, 40-60, and 60-80 cm)and separated into four aggregate sizes (9.5-2 mm, 2-1 mm, 1-0.25 mm, and 0.25-0.053 mm).

SOIL AGGREGATION

The roles of glomalin and AM fungi in the formation and stabilization of soil aggregates will be examined using three approaches. The first approach will be an indepth comparison of stable and unstable aggregates. The second approach will examine the impact that soil properties have on AM fungi, glomalin, and WSA under controlled conditions in the laboratory and greenhouse. This approach will test how AM fungi may act as soil engineers - manipulating their environment by forming fungal hyphae and producing glomalin to create a suitable environment for proliferation and aggregate formation. Finally, the last approach will use a variety of laboratory techniques to learn more about the glomalin molecule for a better understanding of its role in aggregate formation and stabilization.

SUMMARY

The Soil Microbiology lab at NGPRL examines AM fungi, glomalin, and WSA in a variety of crop and rangeland management systems. Research is designed to improve plant productivity while maintaining the soil resource by defining management systems, such as increased plant cover, reduced tillage, reduced synthetic inputs, and diverse crop rotation systems, that increase belowground carbon flow and improve the proliferation of soil biota, including mycorrhizal fungi.

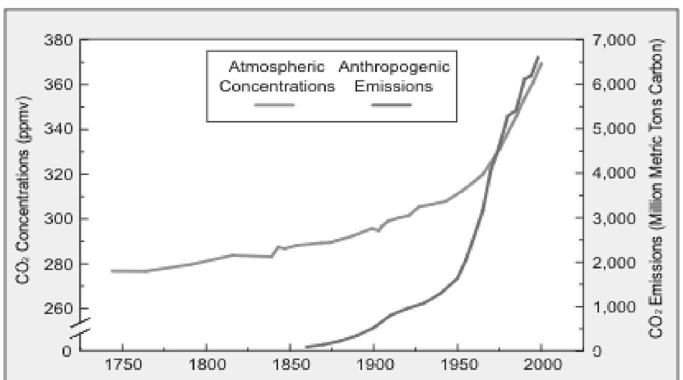
GREENHOUSE GASES AND AGRICULTURE: A PRIMER

Dr. Mark Liebig

Last year was one of the hottest years on record. There were also some devastating weather events in 2005, causing billions of dollars in damage worldwide. These events have many people suggesting that global warming is causing the earth's climate to change. Fueling this change in climate is the increasing concentration of greenhouse gases in the atmosphere.

What are greenhouse gases?
Greenhouse gases are gases capable of absorbing infrared radiation. Infrared radiation is created when some of the sunlight that strikes the earth's surface is reflected back towards space. Greenhouse gases absorb this reflected infrared radiation. In doing so, they trap heat in the atmosphere (hence, the term greenhouse effect, because the gases trap heat like the glass walls of a greenhouse). Greenhouse gases essentially act as an insulating blanket in the atmosphere, trapping sufficient solar energy to keep the earth's average temperature within a pleasant range.

On one hand, we should be thankful for greenhouse gases, because without them, our planet would be inhabitable (such as Mars, which has a surface temperature of minus 63°F …That's cold, even by North Dakota standards!). On the other hand, when the concentration of greenhouse gases increases, so does the amount of trapped infrared radiation, meaning more heat in the atmosphere. The long-term effects of this trapped heat on the earth's climate is the source of debate among scientists, but most agree that global warming and a greater frequency of severe weather events are eventual consequences of this atmospheric trend.



Source: Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, http://cdiac.esd.oml.gov/.

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 23, 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.

Can agriculture benefit by mitigating the greenhouse effect?
Agricultural activities account for approximately 9% of all U.S. greenhouse gas emissions. Among the three greenhouse gases, CO_2 represents a small proportion of the total agricultural greenhouse gas emissions (9%), while shares of CH_4 (31%) and N_2O (60%) are far more significant. Major sources of CH_4 emissions from agriculture include enteric fermentation (i.e., digestion by ruminant livestock), manure management, and rice cultivation, while sources of N_2O emissions emanate almost entirely from applications of N fertilizer.

With agricultural activities responsible for only 9% of all U.S. greenhouse gas emissions, one might think there's little incentive for agriculture to reduce greenhouse gas emissions. In fact, the opposite is true. Not only can agriculture minimize its impact on the global environment by reducing greenhouse gas emissions from current levels, but there are significant productivity and environmental quality benefits to be realized from doing so.

For example, management practices that take up more CO_2 than they release sequester carbon, thereby increasing soil organic matter. Increases in soil organic matter improve soil quality, as expressed through better soil structure, improved water flow into and through the soil, and increased nutrient cycling capacity. These improvements in soil attributes generally have a positive effect on productivity and environmental quality, benefiting both the producer and society. Management systems that limit the amount of soil compaction (say, from either hoof or tractor traffic) reduce the potential for CH_4 and N_2O emissions, and also create a better soil environment for root growth and water infiltration. Finally, agricultural practices that limit the amount of available N in the soil not only reduce N_2O emissions, but can lower input costs and improve N-use efficiency. Collectively, then, reducing greenhouse gas emissions from agriculture can significantly improve production efficiency on the farm/ranch, while having positive effects on the local, regional, and global environment.

Glossary

Climate – The average condition of the weather at a place over a period of years exhibited by temperature, wind velocity, and precipitation.

Global warming potential – The potential for global warming per unit mass relative to carbon dioxide.

Carbon dioxide – A colorless, odorless gas found in the air. Absorbed by plants and exhaled by animals. Has a global warming potential of 1 over a 100-year time period.

Carbon sequestration – Refers to the process by which atmospheric carbon is absorbed into carbon sinks such as the oceans, forests, and soil.

Greenhouse effect – The warming of the atmosphere by the trapping of longwave radiation being radiated to space.

Greenhouse gas – A gas that has the capacity to trap infrared radiation. CO_2, CH_4, and N_2O are greenhouse gases.

Infrared radiation – Electromagnetic radiation whose wavelength is longer than that of visible light, and is responsible for the transmission of radiant heat.

Methane – A colorless, odorless, and flammable gas. A major hydrocarbon component of natural gas. Has a global warming potential of 23 over a 100-year time period.

Nitrous oxide – A colorless, nonflammable gas with a slightly sweet odor. Commonly known as "laughing gas", and sometimes used as an anesthetic. Has a global warming potential of 296 over a 100-year time period.

What about water vapor?

Water vapor is a natural greenhouse gas which, of all greenhouse gases, accounts for the largest percentage of the greenhouse effect. Water vapor levels fluctuate regionally, but in general humans do not have a direct effect on water vapor levels. In climate models, an increase in atmospheric temperature caused by the greenhouse effect due to anthropogenic gases will in turn lead to an increase in the water vapor content in the atmosphere. This in turn leads to an increase in the greenhouse effect and thus a further increase in temperature, and thus an increase in water vapor, until equilibrium is reached. Consequently, water vapor acts as a positive feedback to the greenhouse effect caused by anthropogenic-released greenhouse gases such as CO_2, CH_4, and N_2O.

Adapted from the *National Oceanic and Atmospheric Administration*.

NDSU HETTINGER RESEARCH EXTENSION CENTER TEST PLOTS ON AREA IV SCD COOPERATIVE RESEARCH FARM

Eric Ericksmoen
NDSU Agronomist

2005 Winter Wheat Variety Trial - Continuously Cropped - No-till   Mandan
Cooperator: USDA-ARS, Mandan
This trial was funded by Ducks Unlimited, Bismarck

Variety	Winter Surv.	Plant Height	Test Weight	Grain Protein	Grain Yield 2004	Grain Yield 2005	Avg Yield 2 Year
	%	inches	Lbs/bu	%	--- Bushels per acre ---		
Harding	67	38	56.4	11.7	52.6	52.8	52.7
Jerry	62	36	53.8	12.0	54.3	46.1	50.2
Millennium	32	32	55.9	11.9	55.0	40.0	47.5
Ransom	60	35	51.2	12.2	51.1	32.2	41.6
Arapahoe	44	39	54.0	12.4	51.9	29.4	40.6
Roughrider	57	42	55.7	11.5	44.2	36.1	40.2
Expedition	72	30	52.5	11.5	50.0	27.4	38.7
CDC Falcon	17	29	51.4	13.0	48.0	16.9	32.4
Wahoo	20	29	48.9	12.5	50.0	14.4	32.2
Wesley	43	25	50.7	12.9	49.5	12.8	31.2
Jagalene	12	No harvest data			52.2		
CDC Buteo	63	34	54.6	11.8		32.8	
McClintock	20	36	52.1	12.4		21.7	
Wendy*	20	27	51.2	12.8		17.8	
NuSky*	35	36	51.2	12.5		15.6	
Yellowstone	38	31	47.6	13.1		12.5	
Trial Mean	44	33	52.4	12.1	51.0	27.4	--
C.V. %	37.6	5.6	1.1	2.1	6.7	20.7	--
LSD .05	35	3	0.9	0.4	5.7	9.5	--
LSD .01	46	4	1.3	0.6	7.6	12.9	--

* Hard white winter wheat

Planting Date: September 21, 2004   Harvest Date: August 15, 2005
Seeding Rate: 1 million live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2004 = barley, 2005 = lentil.

2005 HRSW Variety Trial - Continuously Cropped - No-till Mandan

Cooperator: USDA-ARS, Mandan

Variety	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2003	2004	2005	Average Yield 2 yr	3 yr
	inches	Lbs/bu	%	----------- Bushels per acre -----------				
Briggs	37	57.2	14.8	40.8	45.7	66.3	56.0	50.9
Mercury	29	55.8	14.7	42.3	43.5	57.6	50.6	47.8
Oxen	33	51.0	14.8	45.8	41.7	49.3	45.5	45.6
Reeder	35	54.7	13.9	40.7	45.0	49.3	47.2	45.0
Parshall	39	56.6	14.4	40.5	42.0	50.2	46.1	44.2
Granite	33	57.0	16.0		32.2	48.5	40.4	
Fryer	35	56.5	14.1			64.8		
Glenn	39	59.9	15.1			63.7		
Granger	38	58.0	14.5			63.3		
Steele ND	35	58.0	15.2			62.0		
Trial Mean	35	56.7	14.7	40.5	40.1	58.7	--	--
C.V. %	2.6	1.7	2.4	7.3	9.4	7.3	--	--
LSD .05	2	1.6	0.6	4.3	6.4	7.2	--	--
LSD .01	2	2.2	0.8	NS	8.6	9.8	--	--

Planting Date: April 11, 2005
Harvest Date: August 15, 2005
Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).
Previous Crop: 2003 & 2004 = Barley, 2005 = Lentil.
NS = no statistical difference between varieties.

2005 Durum Variety Trial - Continuously Cropped - No-till Mandan

Cooperator: USDA-ARS, Mandan

Variety	Plant Height	Test Weight	Grain Protein	---- Grain Yield ---- 2003	2004	2005	Average Yield 2 yr	3 yr
	inches	Lbs/bu	%	----------- Bushels per acre -----------				
Ben	41	57.3	15.1	44.9	34.4	68.7	51.6	49.3
Mountrail	38	55.2	14.4	42.4	37.6	67.2	52.4	49.1
Lebsock	38	57.6	14.8	40.4	32.6	68.5	50.6	47.2
Grenora	36	55.5	14.1		38.3	67.6	53.0	
Alkabo	38	57.3	14.1			69.1		
Divide	39	55.4	14.3			67.0		
Trial Mean	38	56.4	14.5	41.7	34.8	68.0	--	--
C.V. %	3.4	1.1	5.1	2.8	13.5	2.4	--	--
LSD .05	2	1.2	NS	1.7	NS	NS	--	--
LSD .01	NS	1.7	NS	2.4	NS	NS	--	--

Planting Date: April 11, 2005
Harvest Date: August 15, 2005
Seeding Rate: 1.25 million live seeds / acre (approx. 2.2 bu/A).
Previous Crop: 2003 & 2004 = Barley, 2005 = Lentil.
NS = no statistical difference between varieties.

2005 Winter Wheat Variety Trial - Continuously Cropped - No-till   Mandan

Cooperator: USDA-ARS, Mandan

This trial was funded by Ducks Unlimited, Bismarck

Variety	Winter Surv.	Plant Height	Test Weight	Grain Protein	Grain Yield 2004	Grain Yield 2005	Avg Yield 2 Year
	%	inches	Lbs/bu	%	--- Bushels per acre ---		
Harding	67	38	56.4	11.7	52.6	52.8	52.7
Jerry	62	36	53.8	12.0	54.3	46.1	50.2
Millennium	32	32	55.9	11.9	55.0	40.0	47.5
Ransom	60	35	51.2	12.2	51.1	32.2	41.6
Arapahoe	44	39	54.0	12.4	51.9	29.4	40.6
Roughrider	57	42	55.7	11.5	44.2	36.1	40.2
Expedition	72	30	52.5	11.5	50.0	27.4	38.7
CDC Falcon	17	29	51.4	13.0	48.0	16.9	32.4
Wahoo	20	29	48.9	12.5	50.0	14.4	32.2
Wesley	43	25	50.7	12.9	49.5	12.8	31.2
Jagalene	12	No harvest data			52.2		
CDC Buteo	63	34	54.6	11.8		32.8	
McClintock	20	36	52.1	12.4		21.7	
Wendy*	20	27	51.2	12.8		17.8	
NuSky*	35	36	51.2	12.5		15.6	
Yellowstone	38	31	47.6	13.1		12.5	
Trial Mean	44	33	52.4	12.1	51.0	27.4	--
C.V. %	37.6	5.6	1.1	2.1	6.7	20.7	--
LSD .05	35	3	0.9	0.4	5.7	9.5	--
LSD .01	46	4	1.3	0.6	7.6	12.9	--

* Hard white winter wheat

Planting Date: September 21, 2004   Harvest Date: August 15, 2005
Seeding Rate: 1 million live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2004 = barley, 2005 = lentil.

2005 Barley Variety Trial - Continuously Cropped - No-till Mandan

Cooperator: USDA-ARS, Mandan

Variety	Plant Height	Test Weight	% Plump	Grain Protein	---- Grain Yield ---- 2003	2004	2005	Average Yield 2 yr	3 yr
	inches	Lbs/bu	>6/64	%	----------- Bushels per acre -----------				
2 Row Types									
Conlon	33	45.0	89	11.6	42.9	24.7	37.3	31.0	35.0
Rawson	33	45.4	93	10.8		48.2	79.5	63.8	
Haxby	33	46.3	84	11.4		56.1	60.0	58.0	
Eslick	32	46.5	87	11.1			76.6		
6 Row Types									
Robust	36	46.4	89	11.9	43.5	43.2	47.2	45.2	44.6
Tradition	33	45.8	89	10.5		41.3	65.9	53.6	
Drummond	35	45.2	91	11.7		48.1	33.8	41.0	
Stellar	33	45.9	95	11.3			72.4		
Trial Mean	34	45.8	90	11.3	45.2	43.6	59.1	--	--
C.V. %	5.5	1.6	2.4	4.0	11.7	16.3	13.3	--	--
LSD .05	NS	NS	4	0.8	NS	12.9	13.8	--	--
LSD .01	NS	NS	5	NS	NS	18.4	19.1	--	--

Planting Date: April 11, 2005
Harvest Date: August 15, 2005
Seeding Rate: 750,000 live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2003 & 2004 = barley, 2005 = lentil.
NS = no statistical difference between varieties.