Area IV SCD Cooperative Research Farm

USDA-ARS Northern Great Plains Research Laboratory

2006 Research and Cropping Results

Twenty-third Annual Progress Report
February 27, 2007

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ACKNOWLEDGMENTS

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Research Results & Technology Conference Agenda

8:30 Registration

8:55 Welcome – Marvin Halverson, Dr. Jon Hanson

9:00 <u>Crop Synergy from Non-Traditional Crop Rotations</u>

1. **Enhanced Production Efficiency – Dr. Don Tanaka**
2. **Crop Selection So Water Doesn't Run Out – Dr. Steve Merrill**
3. **Crop Stress Reduction – Dr. Joe Krupinsky**
4. **Economic Crop Sequencing Advantages – Dr. Dave Archer**

10:20 Break

10:40 Focusing Research for the Future – Dr. Jon Hanson

11:00 Farmer Panel: "What We Learned In 2006"
John Schmidt, Hazelton, ND
Doug Goehring, Menoken, ND
Daryl Simmons, Garrison, ND

11:30 Research: Meeting Customer's Needs – Dr. Mark Liebig

12:00 Lunch

1:00 Feeding the Beef Herd: What, When and Why
- Dr. Eric Scholljegerdes

1:20 Alternative Forages for Calf Backgrounding – Michele Stamm,
Assistant Animal Scientist at the NDSU Hettinger Research
Extension Center & Coordinator, Southwest Feeders Project

1:40 Monitoring Rangeland Condition and Carbon from the Sky
- Dr. Rebecca Phillips

2:00 Break

2:20 Farmer Panel: "Developing Crop/Cattle Systems to Reduce Risk"
Alvin Braun, Bismarck, ND
Troy Vollmer, Wing, ND
Myron Lick, Turtle Lake, ND

2:50 Reducing Risk through Management – Dr. Dave Archer

3:10 Research: Meeting Customer's Needs – Dr. Mark Liebig

3:30 Closing – Dr. Jon Hanson

Table of Contents

Message from Laboratory Director……………………………………………...……….2

Scientific Research Staff……………………………………………………..…..…3

Collaborators……………………………………………………………….....……..4

Cooperators………………………………………………………………..……..5

USDA-ARS Land Resources……………………………………………..……...6

Management Practices 2006 – Area IV SCD Cooperative Research Farm……………...7

Precipitation…………………………………………………………...……….8

2005 Area IV Farm Management Plan………………………………….…...…..…9

Crop Sequence Project, Phase 3B……………...…………………………………..…14

Management for Soil Quality……………………………………………………...23

Comparisons of Water Depletion, Root Growth, and Crop Production
at Two Diverse Soil Sites……………………………………………………………..26

Management of Wheat Straw Residue Can Reduce the Potential Tan Spot
Disease Risk for the Next Crop……………………………………………...….28

Economic Viability of No-Till and Strip-Tillage in West Central Minnesota………….30

Monitoring Rangeland Carbon and Condition from the Sky………………………...…32

Long-Term Grazing Effects on Soil Chemical Properties………………………...…34

Profitable Calf Backgrounding Integrating Annual Forage Crops……….…….………36

Evaluation of a New Awnletted Winter Wheat Variety:
"Willow Creek" in Southwestern North Dakota…………………….……….…....42

NDSU 2006 HRSW Variety Trial……………………………………………………48

NDSU 2006 Winter Wheat Variety Trial……………………………………………49

NDSU 2006 Durum Variety Trial……………………………………………………50

NDSU 2006 Oat Variety Trial……………………………………………………..51

NDSU 2006 Barley Variety Trial…………………………………………………..…52

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. We committed to our mission *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.* In the past, I emphasized that we must continue to strive to provide producers with alternatives in their management practices. That includes the use of a diversity of crops and animals 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.

To make informed public policy decisions, decision-makers need accurate information about economic and environmental consequences of agricultural systems. The information regarding agroecosystems is diverse. Each production system has unique characteristics with multiple interactions. No person can look at all of the information and draw complete conclusions. We have begun a cooperative research project with Montana State University professor Dr. John Antle to look at the "tradeoff" between environmental and economic components of agricultural systems. Tradeoff analysis (TOA) is a process designed to link decision makers to teams of scientists with tools that can provide information relative to specific systems. Some strengths of this approach include: (1) TOA approach is modular and therefore adaptable; (2) TOA allows for the identification of potential impacts, and (3) these impacts can be documented in qualitative terms. This information can be useful to producers and policy-makers.

We also have an opportunity to affect the policies that seem to drive agriculture. From our point of view, we need to begin conducting science that has direct ramifications on agricultural policy. Policy-relevant science will lead to more informed policy decisions that must balance competing interests. We have the responsibility to provide superior research information that will help producers and policy makers weed through the vast amount of information so that decisions can be made that are economically feasible and environmentally fit. Agricultural research of this nature is complex and it is best approached through a coordinated disciplinary team research. To that end, we added Dr. David Archer to our staff this past year. Dr. Archer will provide expertise in the areas of agricultural economics, systems design, and general agriculture.

Through this multidisciplinary approach we will be able to respond to such difficult questions as: (1) What science is available to predict the sustainability of a system? (2) How would farmers respond to specific incentives aimed at the adoption of more sustainable practices (especially on marginal lands)? (3) How will a particular system be impacted by external shocks (economic, technological, and environmental)?

By combining new lines of research with our current 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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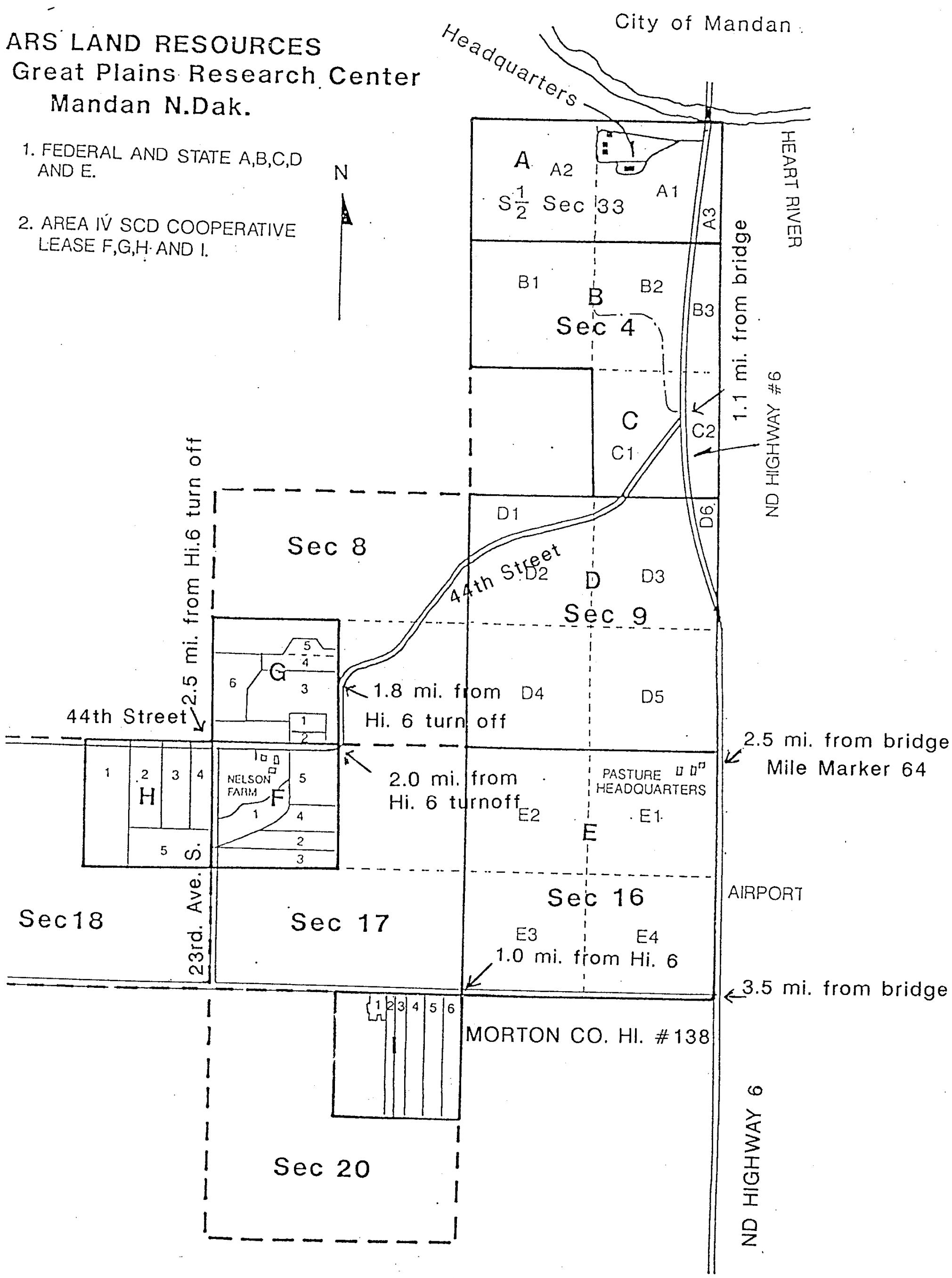
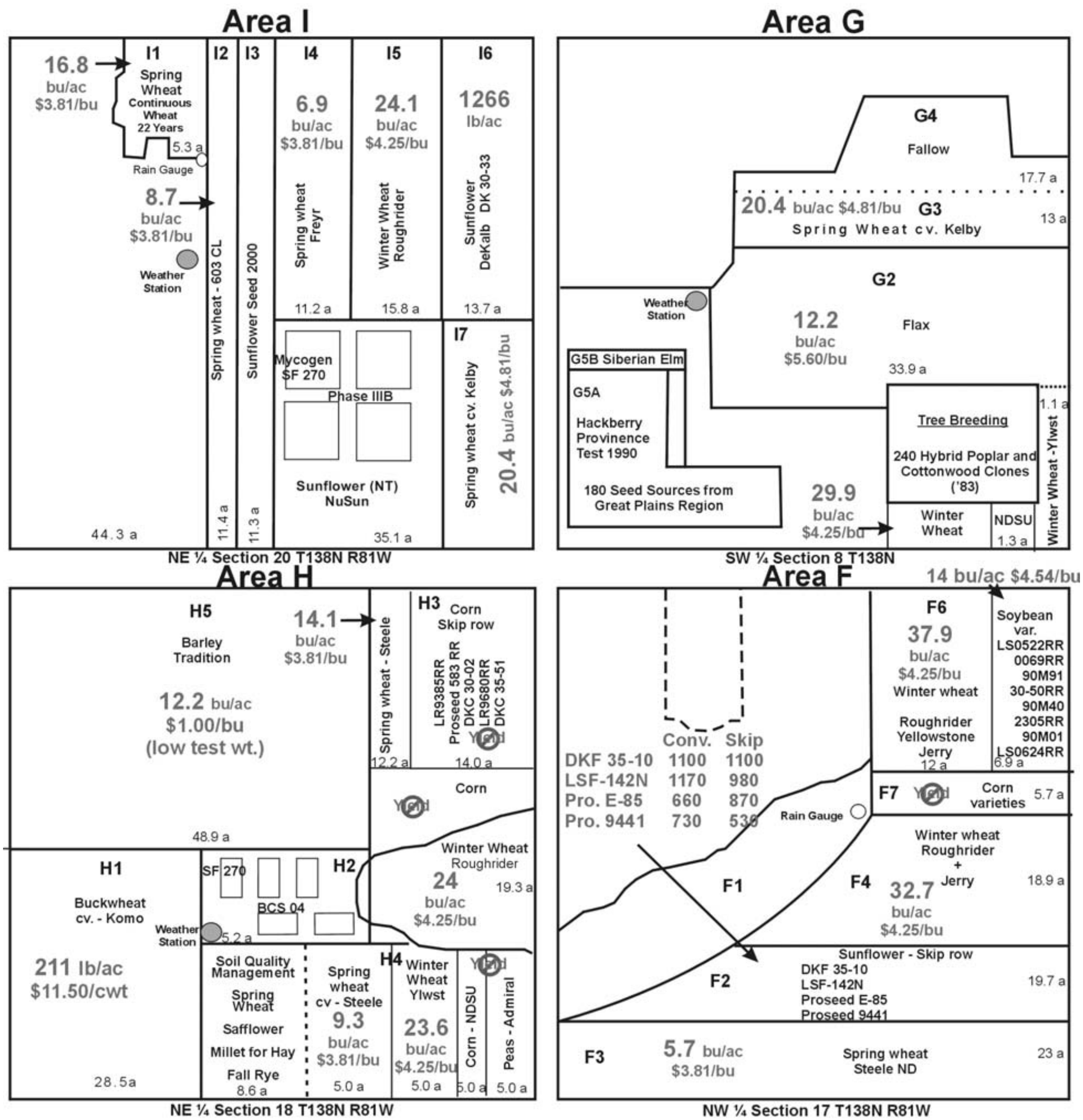
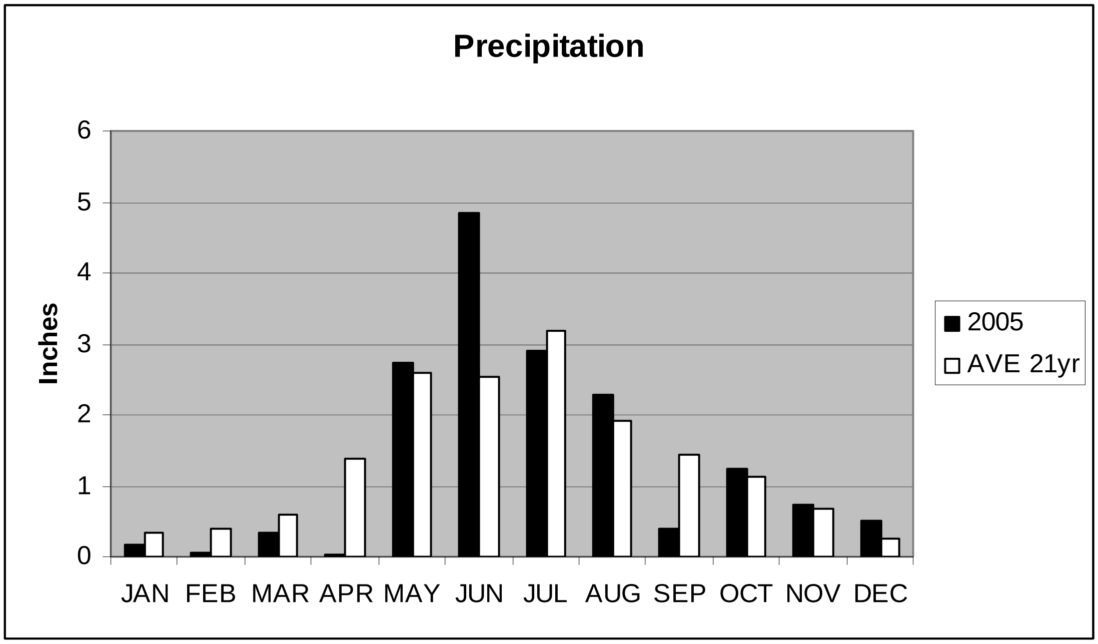
USDA-ARS LAND RESOURCES (FEDERAL & STATE) A, B, C, D, AND E
AREA IV SCD COOPERATIVE RESEARCH FARM
LAND RESOURCES F, G, H, AND I

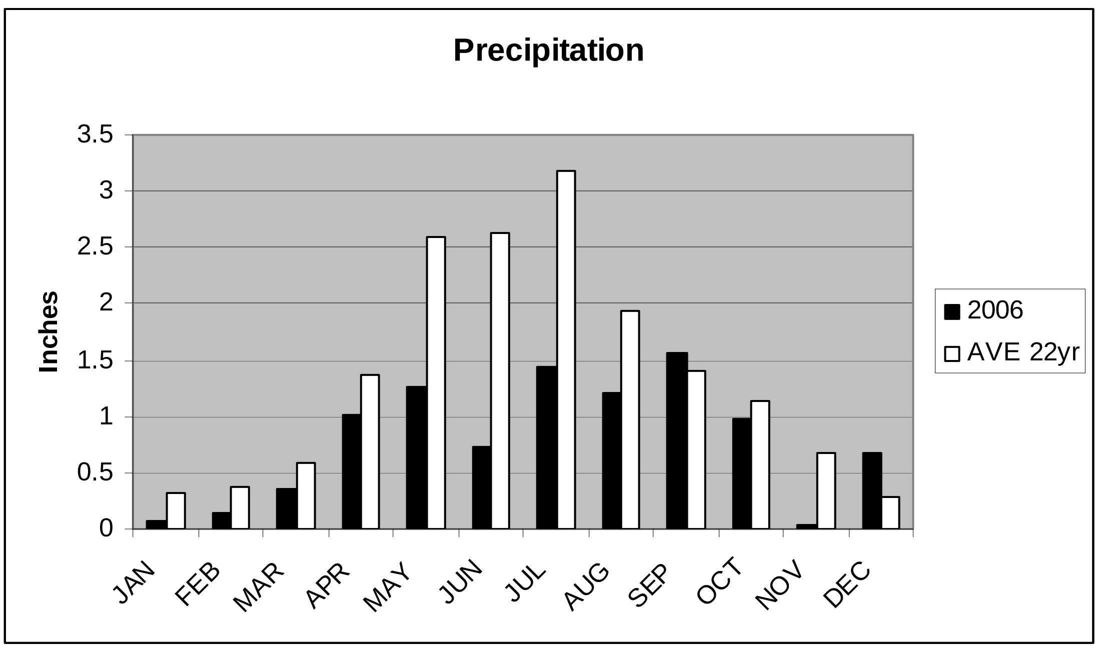


2006 Area IV Research Farm Crop Plan



Area 4 SCD Cooperative Research Farm Monthly Precipitation





MANAGEMENT PRACTICES – 2006
AREA IV SCD COOPERATIVE RESEARCH FARM

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

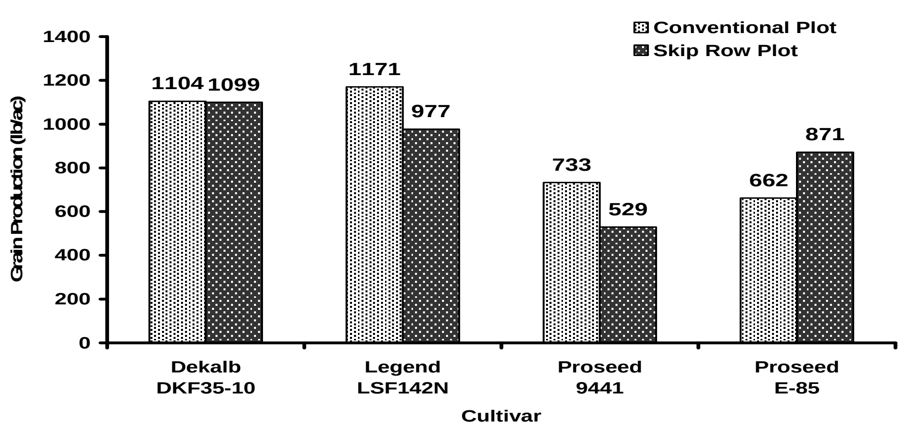
FIELD F1 This conservation bench terrace area has been excluded from the total acreage leased by AREA IV SCDs since 1987.

FIELD F2, SKIP-ROW SUNFLOWER VARIETY TRIAL
(seed donated by DeKalb, Legend, and ProSeed)

Previous crop – Jerry winter wheat.

03/13/06 Contractor bulk spread Urea at 70 lbs N/a.
04/07/06 Sonalan 10G (donated by Dow AgroSciences) at 11 lb/a applied with undercutter.
05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).
06/01/06 The north one-third of the field was seeded to Dekalb DKF35-10 and 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.
The south two-thirds of the field was seeded to ProSeed E 85 and 9441 sunflowers in the same manner.
08/09/06 Contractor sprayed field with Asana XL (7 oz./a, insecticide).
10/24/06 Sunflowers were harvested. See chart below for results. Sunflowers were sold for $12.00/cwt.

2006 Sunflower Varieties (F2)



FIELD F3, STEELE SPRING WHEAT

Previous crop – skip-row sunflowers.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).
05/15/06 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.
06/12/06 South half of field sprayed with Bison (16 oz./a) and Axial (8.2 oz/a, donated by Syngenta).
06/13/06 North half of field sprayed with Bison (16 oz./a) and Puma (0.66 pt/a).
08/02/06 Field was straight combined and yielded 5.7 bu/a. Crop was sold for $3.81/bu.
08/29/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate

(5 gal/100 gal).

FIELD F4, ROUGHRIDER AND JERRY WINTER WHEAT

Previous management – chemical fallow.

09/28/05 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). Both varieties were treated with Raxil MD Extra and seeded at 1.3 million seeds/a.

03/13/06 Contractor bulk spread Urea at 70 lbs N/a.

05/10/06 Sprayed field with Puma (8 oz./a), Affinity (0.6 oz./a), and Salvo (8 oz./a).

07/25/06 Field was harvested. Yield was 32.7 bu/a. Wheat was sold for $4.25/bu.

09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD F5, SOYBEANS

Previous crop – Steele spring wheat

04/28/06 Sprayed field with Roundup Ultra Max II (20 oz/a), 2-4D-LV4 (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

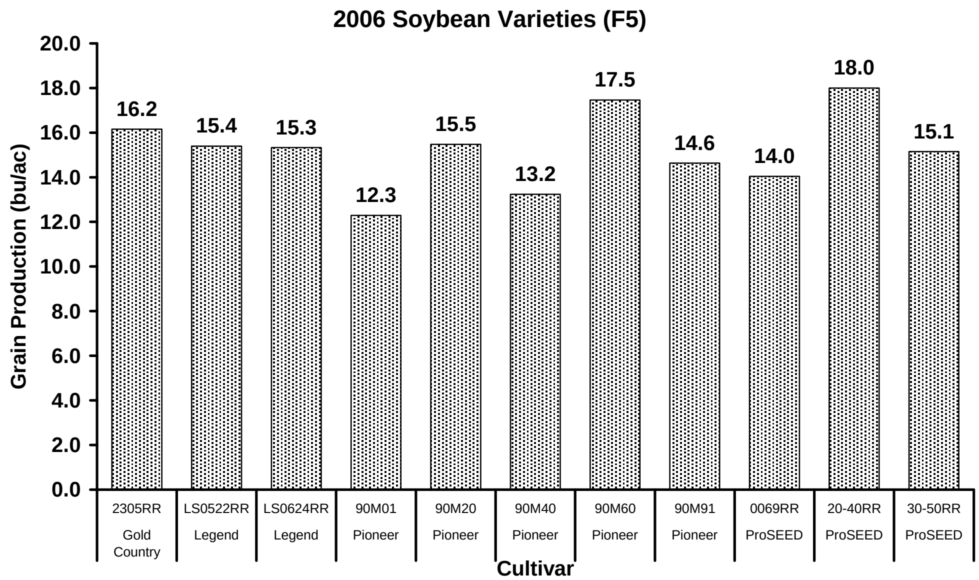
05/26/06 Seeded 11 varieties of soybean in 4 replications (seed donated by these respective companies):

Company	Variety
Gold Country	2305RR
Legend	LS0522RR
Legend	LS0624RR
PROSEED	0069RR
PROSEED	20-40RR
PROSEED	30-50RR
Pioneer	90M01
Pioneer	90M20
Pioneer	90M40
Pioneer	90M60
Pioneer	90M91

Varieties were planted at 180,000 seeds/a (6 rows, 30 inches apart) using a JD MaxEmerge II planter. Soybean varieties were inoculated with Tag Team donated by Philom Bios.

06/21/06 Contractor sprayed field with Credit Extra (glyphosate, 32 oz./a) and Ammonium sulfate (5 gal/100 gal).

10/05/06 Soybeans were harvested and yielded on average 14 bu/a (see Table below for individual yields). Soybeans sold for $4.54/bu.



FIELD F6, ROUGHRIDER, YELLOWSTONE, AND JERRY WINTER WHEAT

Previous crop – Omega flax

09/26/05 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.

03/13/06 Contractor bulk spread Urea at 70 lbs N/a.

05/10/06 Sprayed field with Puma (8 oz./a), Affinity (0.6 oz./a), and Salvo (8 oz./a).

07/25/06 Winter wheat was harvested and yielded 37.9 bu/a. Wheat was sold for $4.25/bu.

09/13/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD F7, CORN VARIETIES (seed donated by Pioneer)

Previous crop – Jagalene winter wheat.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).

05/23/06 Corn varieties were planted using a JD MaxEmerge II planter (6-row, 30 in spacing).

06/12/06 Contractor sprayed field with Credit Extra (glyphosate, 32 oz./a) and Ammonium sulfate (5 gal/100 gal).

Corn was not harvested.

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

FIELD G1, YELLOWSTONE WINTER WHEAT

Previous crop – Roughrider winter wheat.

09/25/05 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.

3/13/06 Contractor bulk spread Urea at 70 lbs N/a.

05/10/06 Sprayed field with Puma (8 oz./a), Affinity (0.6 oz./a), and Salvo (8 oz./a).

07/24/06 Field was harvested and yielded 29.9 bu/a. Wheat was sold for $4.25/bu.

FIELD G2, FLAX (seed donated by Dwight Johnson Farms)

Previous crop – AgriPro 603CL spring wheat.

04/26/06 Field sprayed with Roundup Ultra Max II (20 oz/a, donated by Monsanto), 2-4D-LV4 (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

05/04/06 Field was seeded with flax using a JD 750 no-till drill (7.5-inch row spacing) at 4 million viable seeds/a (l bu/a). Fertilizer, a blend of Urea (70 lb N/a) and 50 lb/a of 11-52-0, was side banded at seeding.

08/11-23/06 Flax was combined and yielded 12.2 bu/a. Flax was sold for $5.60/bu.

08/29/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD G3, KELBY SPRING WHEAT (seed donated by Gartner Seed Farm)

Previous management – fallow.

05/08/06 Seeded 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.

06/13/06 Field sprayed with Bison (16 oz/a) and Puma (8 oz./a).

07/31/06 Field was straight combined and yielded 20.4 bu/a. Spring wheat may be sold for seed.

09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD G4, FALLOW

Previous crop – AgriPro 603CL spring wheat

05/30/06 Field sprayed with Roundup Ultra Max II (20 oz/a, donated by Monsanto), 2-4D-LV4 (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

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

FIELD H1, KOMO BUCKWHEAT (south half of former H1, seed donated by Minn-Dak Growers, Ltd.)

Previous crop – Clearfield sunflower varieties.

06/06/06 Field sprayed with Roundup Ultra Max II (20 oz/a), 2-4D-LV4 (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

06/07/06 Chopped sunflower stalks with JD mulch master.

06/08/06 Seeded buckwheat at 1 million viable seeds/a using a JD 750 no-till drill. 50 lbs/a of 11-52-0 and 70 lbs N/a (Urea) were applied at seeding.

09/25/06 Buckwheat was swathed.

10/10/06 Buckwheat was harvested and yielded 211 lb/a. Buckwheat sold for $11.50/cwt.

FIELD H2, SCLEROTINIA BIOLOGICAL CONTROL STUDIES (seed donated by Mycogen)

Previous crop – barley

FIELD H3, STEELE SPRING WHEAT

Previous crop – soybeans.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).

05/12/06 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.

06/13/06 Field sprayed with Bison(16 oz/a) and Puma (8 oz/a).

08/03/06 Field was straight combined and yielded 14.1 bu/a. Wheat was sold for $3.81/bu.

09/25/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD H3, SKIP-ROW CORN (seed donated DeKalb, Legend, and ProSeed)

Previous crop – Mycogen 270 sunflowers (Phase IIIA).

03/13/06 Contractor bulk spread Urea at 80 lbs N/a.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).

5/23/06 Field was seeded at a rate of 25,000 viable seeds/a in both conventional and skip-row fashion with a JD Maxemerge II planter (6-row, 30-inch spacing).

06/12/06 Contractor sprayed field with Credit Extra (glyphosate, 32 oz./a) and Ammonium sulfate (5 gal/100 gal).
Corn was not harvested.

FIELD H3 SOUTH, ROUGHRIDER WINTER WHEAT (Intermittent water pond area)

Previous crop – winter wheat.

09/26/05 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.

3/13/06 Contractor bulk spread Urea at 70 lbs N/a.

05/10/06 Sprayed field with Rimfire (2 oz./a, donated by Bayer Crop Science), Affinity (0.6 oz./a), and MCPA Ester (8 oz./a).

07/27/06 Winter wheat was harvested and yielded 24 bu/a. Wheat was sold for $4.25/bu.

FIELD H4, SOIL QUALITY MANAGEMENT

See 'Management Strategies for Soil Quality' on page 23

FIELD H4, STEELE SPRING WHEAT

Previous crop – soybean protein enhancement.

04/26/06 Field sprayed with Roundup Ultra Max II (20 oz/a, donated by Monsanto), 2-4D-LV4 (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

05/11/06 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.

08/03/06 Field was straight combined and yielded 9.3 bu/a. Wheat was sold for $3.81/bu.

09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD H4, YELLOWSTONE WINTER WHEAT

Previous crop – Omega flax.

9/26/05 Seeded Yellowstone winter wheat at 1.3 million seeds/a using a Haybuster 8000 seeder (10-inch row spacing). Seed was treated Raxil MD Extra.

3/13/06 Contractor bulk spread Urea at 70 lbs N/a.

05/10/06 Sprayed field with Puma (8 oz./a), Affinity (0.6 oz./a), and Salvo (8 oz./a).

07/24/06 Field was straight combined and yielded 23.6 bu/a. Winter wheat was sold for $4.25/bu.

FIELD H4 EAST, NDSU CORN VARIETY TRIAL
(seed donated by DeKalb, Legend, ProSeed).

Previous crop Mycogen 270 sunflowers.

04/26/06 Field sprayed with Roundup Ultra Max II (20 oz/a donated by Monsanto), 2-4D-LV4 (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

05/05/06 Banded urea (70 lb N/a) with JD750 drill.

05/10/06 Planted corn varieties in four replications using a JD MaxEmerge II planter (6-row, 30 in. spacing).

06/02/06 Field sprayed with Roundup Ultra Max II (20 oz/a donated by Monsanto), Sterling (6 oz/a), and Ammonium sulfate (5 gal/100 gal).
Corn was not harvested.

FIELD H4 EAST, ADMIRAL PEAS (seed donated by Pulse USA)

Previous crop Mycogen 270 sunflowers.

04/26/06 Field sprayed with Roundup Ultra Max II (20 oz/a, donated by Monsanto), 2-4D-LV4 (8 oz/a), and Ammonium sulfate (5 gal/100 gal).

04/28/06 Peas were seeded using JD 750 drill (7.5-inch row spacing) at 300,000 seeds/a. Seed was inoculated with TagTeam (donated by Philom Bios).

06/06/06 Field was sprayed with Pursuit DG (2 oz/a), Assure II (8 oz/a), and Crop oil (1 qt/a). Field was not harvested.

FIELD H5, TRADITION BARLEY

(consolidation of north half of former H1 and all of H2)

Previous crops – Clearfield sunflower varieties (west) and NDSU corn study (east)

03/13/06 Contractor bulk spread Urea at 50 lbs N/a.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).

05/16/06 Tradition barley 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.

06/12/06 Sprayed east half of field with Bison (16 oz/a) and Puma (0.66 pt./a).

06/13/06 Sprayed west half of field with Bison (16 oz/a) and Axial (8.2 oz/a, donated by Syngenta).

08/04/06 Barley was harvested and yielded 12.2 bu/a. Barley was sold for $1.00/bu due to low test weight.

09/25/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

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

FIELD I1, SPRING WHEAT – AGRIPRO 603 CL

(Continuous spring wheat, 22 yrs, seed donated by Gartner Seed Farm).

Previous crop – Verde spring wheat.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).

05/18/06 AgriPro 603CL 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.

08/09/06 Spring wheat harvested and produced a yield of 16.8 bu/a. Crop sold for $3.81/bu.

09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD I2, AGRIPRO SPRING WHEAT (seed donated by Gartner Seed Farm)

Previous crop – Koto buckwheat.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).

05/18/06 Agripro 603 CL 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.

06/08/06 Sprayed field with Bison (16 oz,/a) and Axial (8.2 oz/a, donated by Syngenta).

08/10/06 Spring wheat harvested and produced a yield of 8.7 bu/a. Crop sold for $3.81/bu.

09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD I3, SUNFLOWERS (seed donated by Seeds 2000)

Previous crop – Roughrider winter wheat.

03/13/06 Contractor bulk spread Urea at 70 lbs N/a.
05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).
05/25/06 Contractor sprayed field with Spartan (3.4 oz./a).
06/01/06 Sunflowers were seeded (cv.: Seeds 2000 Charger) at 24,000 kernels/a using a JD MaxEmerge II planter (6-row, 30-inch spacing).
08/09/06 Contractor sprayed field with Asana XL (7 oz./a, insecticide).
11/07/06 Sunflowers were harvested and yielded 1378 lb/a. Sunflowers sold for $12.00/cwt.

FIELD I4, FREYR SPRING WHEAT (seed donated by Gartner Seed Farm)

Previous crop – Dekalb DK30-33 sunflowers.

05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).
05/18/06 Seeded Freyr 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.
06/13/06 Sprayed field with Bison (16 oz./a) and Puma (0.66 pt./a).
08/03/06 Field was straight combined and yielded 6.9 bu/a. Wheat was sold for $3.81/bu.

FIELD I5, ROUGHRIDER WINTER WHEAT

Previous crop – Verde spring wheat.

09/23/05 Roughrider winter wheat was seeded at 1.3 million viable seeds/a using the Bourgault air seeder (10-inch row spacing).
05/10/06 Contractor sprayed field with Rimfire (2 oz./a, donated by Bayer Crop Science), Affinity (0.6 oz./a), and MCPA Ester (8 oz./a).
07/27/06 Field was harvested. Yield was 24.1bu/a and sold for $4.25/bu.
09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD I6, SUNFLOWER (seed donated by DeKalb)

Previous crop – Roughrider winter wheat.

03/13/06 Contractor bulk spread Urea at 70 lbs N/a.
04/10/06 Sonalan 10G (donated by Dow AgroSciences) at 12 lb/a applied with undercutter.
05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).
05/31/06 Seeded Dekalb DK 30-33 sunflowers at 24,000 kernels/a using a JD MaxEmerge II planter (6-row, 30-inch spacing).
08/09/06 Contractor sprayed field with Asana XL (7 oz./a, insecticide).
10/13/06 Sunflowers were combined and yielded 1266 lb/a. Sunflowers were sold for $12.00/cwt.

FIELD I7, KELBY SPRING WHEAT (seed donated by Gartner Seed Farm)

Previous crop – Fallow (equipment demonstration area)

03/13/06 Contractor bulk spread Urea at 70 lbs N/a.
05/08/06 Contractor sprayed field with Glystar Plus (32 oz/a, glyphosate) and Ammonium sulfate (32 oz/100 gal.).
05/09/06 Field was seeded to Kelby spring wheat at a rate of 1.3 million viable seeds/a with a John Deere 750 no-till drill (7.5-inch row spacing). Seed was treated with Enhance.
06/13/06 Sprayed field with Bison (16 oz./a) and Puma (0.66 pt./a).
07/31/06 Combined spring wheat which yielded 20.4 bu/a. Wheat may be sold for seed.
09/12/06 Sprayed field with Roundup RT III (16 oz/a), Brash (16 oz/a), and Ammonium sulfate (5 gal/100 gal).

FIELD I7 CROP SEQUENCE PROJECT, PHASE III B
(sunflower seed donated by Mycogen)
See 'Crop Sequence Project' below

CROP SEQUENCE PROJECT (Phase III)

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

INTRODUCTION

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

Crop Sequence Project, Phase III

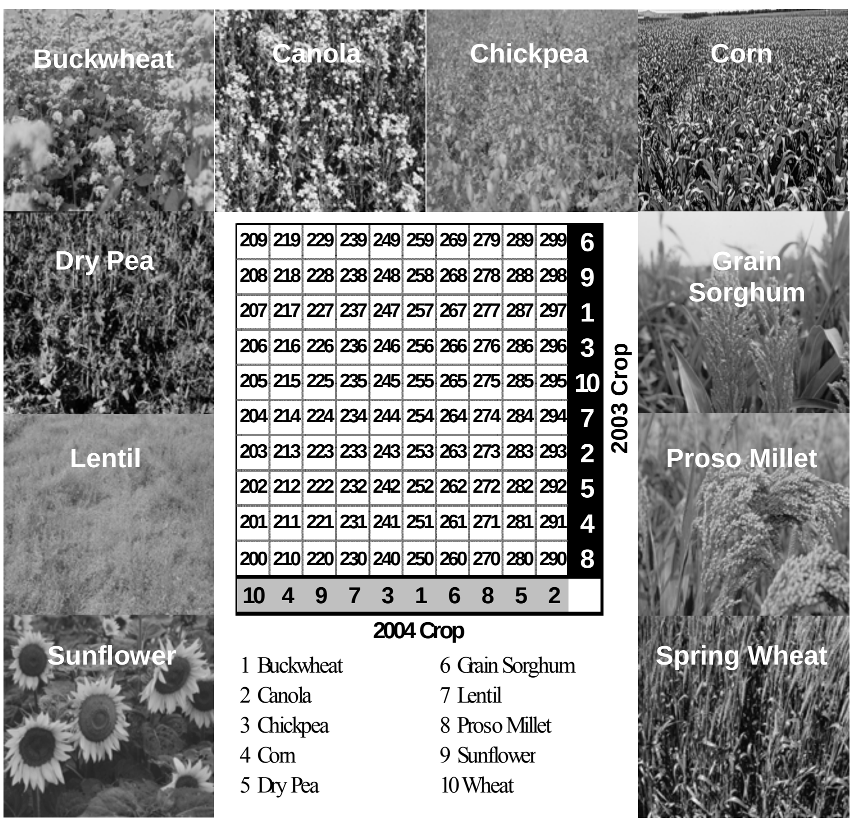


Figure 1. Design of one replicate of a crop by crop residue matrix used to evaluate the influence of crop sequence. During the first year, ten crops (numbered 1 through 10) were seeded into a uniform crop residue. During the second year, the same crops were no-till seeded perpendicular over the residue of the previous year's crop. Individual plot numbers were assigned for each of the four replications.

Phase III of the Crop Sequence Project (Figure 1.)

Phase III of the Crop Sequence Project was initiated in 2002 to continue determining the sequence crops should follow to take advantage of the previous crop and crop residues. Field plots were located on the Area IV ARS/SCD Research Farm located near the Northern Great Plains Research Laboratory, southwest of Mandan, ND. For Phase IIIa, ten crops (canola, dry pea, oilseed sunflower, hard red spring wheat, proso millet, grain sorghum, chickpea, lentil, corn, buckwheat) were direct seeded in an east-west direction with a JD 750 no-till drill in strips into wheat stubble in each of four replications in 2002. In 2003 all ten crops were again randomized and direct seeded into stubble from the previous crops in a north-south direction, perpendicular to the 2002 crop. This allowed every crop to be seeded on the residue of the all the other crops (100 treatments per replication). At another field site, Phase IIIb, the same ten crops were seeded in an east-west direction in 2003. The same crops were seeded in a north-south direction in 2004, which again allowed every crop to be seeded on the residue of the ten previous crops creating 100 treatment combinations for evaluation.

Table 1. Crop cultivars, viable seeds planted ha^{-1}, seeding date, and harvest date for crop sequence research at Mandan, ND.

			Seeding date		Harvest date		Crop Category		
Crop	Cultivar	Viable seeds ac^{-1}	2003	2004	2003	2004	Season length	Seeding time	Harvest time
Buckwheat	Koto	1.0 million	11-Jun	08-Jun	23-Oct	07-Sep	Short	Late	Late
Canola	357RR	1.0 million	21-May	15-Apr	15-Aug	19-Aug	Short	Early	Early
Chickpea	B-90	202,000	21-May	28-Apr	28-Aug	24-Aug	Short	Early	Early
Corn	TF2183	25,000	30-May	14-May	22-Oct	16-Nov	Long	Early	Late
Dry pea	DS Admiral	350,000	16-May	14-Apr	11-Aug	29-Jul	Short	Early	Early
Grain sorghum	DK28E	202,000	11-Jun	10-Jun	23-Oct	17-Nov	Long	Late	Late
Lentil	Richlea	690,000	20-May	28-Apr	22-Aug	12-Aug	Short	Early	Early
Proso millet	Earlybird	1.5 million	11-Jun	09-Jun	02-Oct	21-Sep	Short	Late	Late
Sunflower	63M91	28,000	17-Jun	10-Jun	21-Oct	09-Nov	Long	Late	Late
Spring wheat	Amidon	1.3 million	21-May	14-Apr	19-Aug	29-Jul	Short	Early	Early

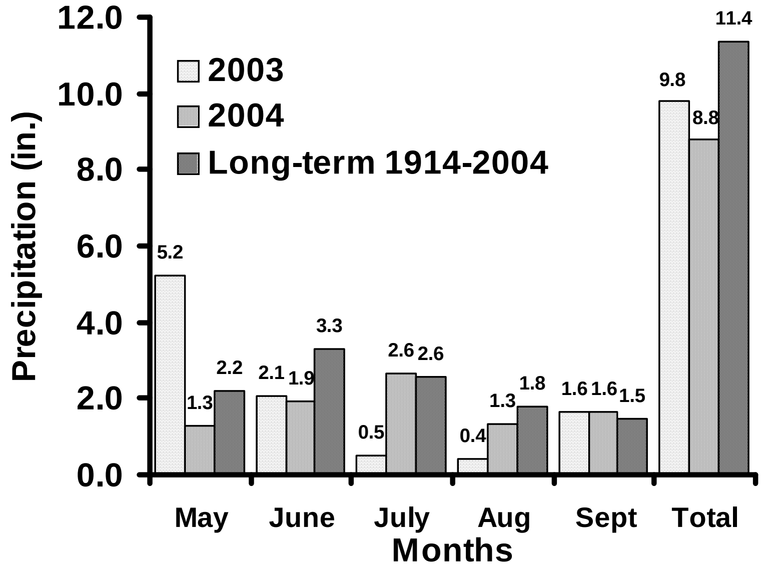


Figure 2. Monthly growing season precipitation for 2003, 2004, and long-term average at Mandan, ND.

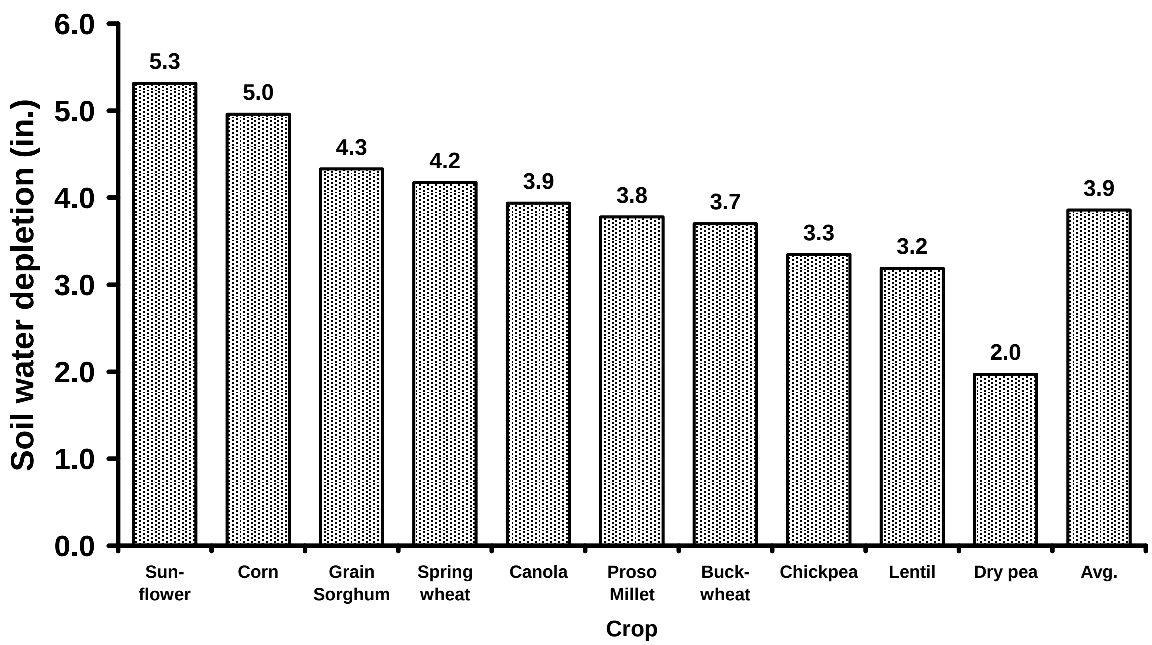


Figure 3. Average soil water depletion for 2002-2004 during the mid-May to mid-September growing period to a depth of 6 feet for 10 crops grown at Mandan, ND.

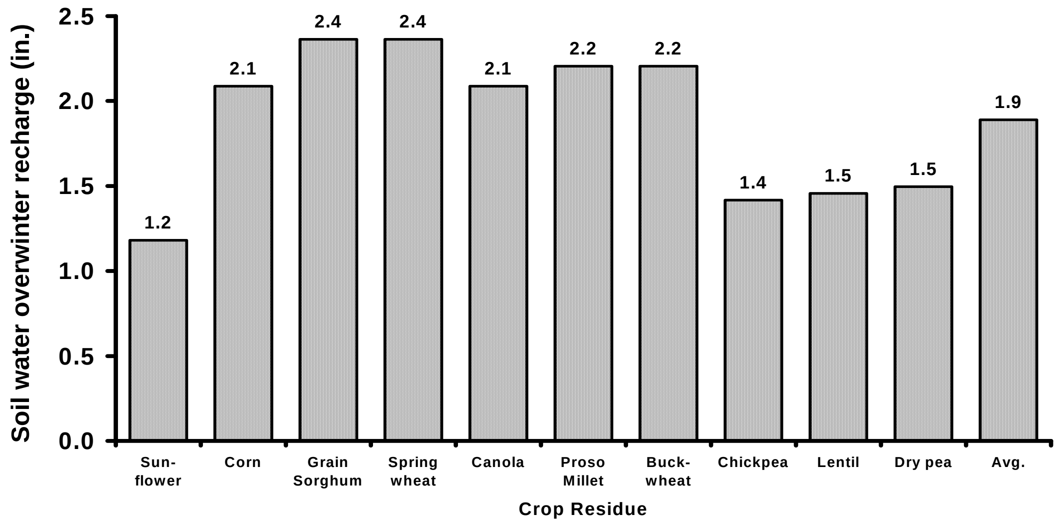


Figure 4. Average soil water recharge for the overwinter period from 2002-2005 to a depth of 6 feet for 10 crop residues at Mandan, ND.

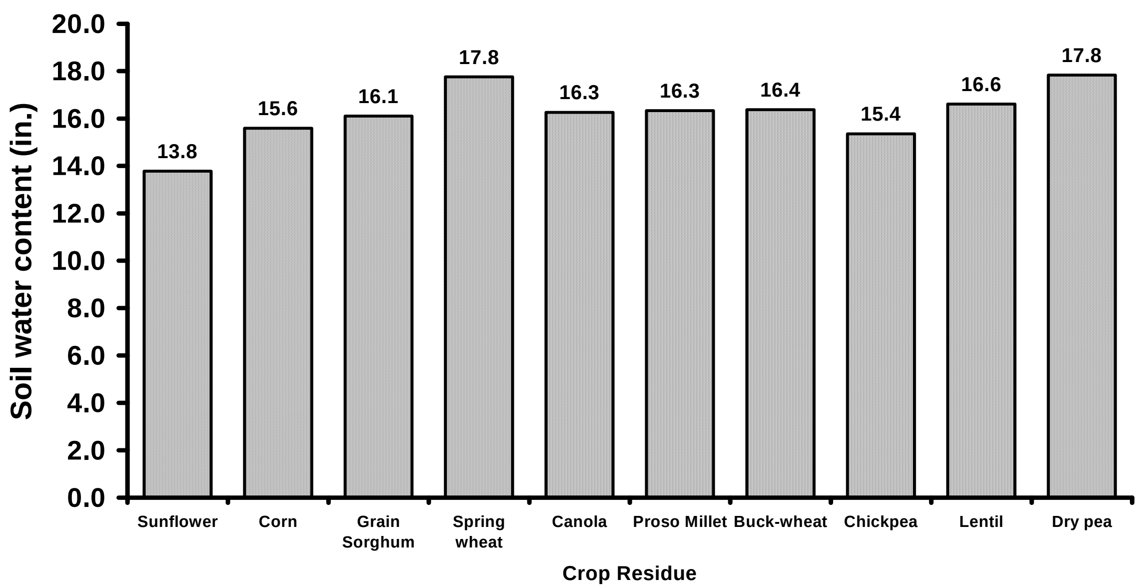


Figure 5. Average soil water content to a depth of 6 feet in mid-April just prior to seeding a crop for 10 crop residues at Mandan, ND.

Table 1. Average relative seed yield of 10 crops grown in 2003 and 2004 as influenced by crop residue at Mandan, ND.

		Crop (Second year)*									
		Buckwheat	Canola	Chickpea	Corn	Dry Pea	Grain Sorghum†	Lentil	Proso Millet	Sunflower	Wheat
Crop Residue (First year)	Buckwheat	**1.00**	**1.08**	**2.00**	**1.03**	**1.07**	**2.05**	**1.16**	**1.20**	**1.73**	**0.92**
	Canola	**1.08**	**1.00**	**2.15**	**2.20**	**1.07**	**3.04**	**1.34**	**1.26**	**2.28**	**0.92**
	Chickpea	**1.15**	**1.06**	1.00	**2.62**	**1.11**	**2.86**	**0.93**	**1.32**	**1.90**	**0.94**
	Corn	**1.05**	**0.99**	**1.79**	1.00	**1.08**	**1.52**	**1.20**	**0.97**	**1.50**	**0.86**
	Dry Pea	**1.62**	**1.15**	**2.23**	**2.65**	**1.00**	**3.87**	**1.46**	**1.50**	**2.35**	**1.06**
	Grain Sorghum	0.89	**0.79**	**1.60**	**1.65**	0.93	**1.00**	0.97	0.92	**1.92**	**0.86**
	Lentil	**1.15**	**1.14**	**1.27**	**2.42**	**1.20**	**3.94**	**1.00**	**1.39**	**2.34**	**1.03**
	Proso Millet	**1.10**	**1.01**	**2.03**	**1.27**	**1.49**	0.95	**1.41**	**1.00**	**2.11**	**0.93**
	Sunflower	**0.95**	0.74	**1.47**	**1.40**	**1.25**	**1.36**	**1.11**	**1.14**	1.00	0.85
	Wheat	**1.11**	**0.94**	**2.20**	**1.92**	**1.38**	**2.94**	**1.75**	**1.12**	**2.48**	**1.00**

* Underlined and non-bold numbers in a column are the maximum and minimum values, respectively, for that crop.
† Includes only 2003 data due to lack of seed production in 2004.

Table 2. Average precipitation-use efficiency (PUE) of seed for 10 crops grown in 2003 and 2004 as influenced by crop residue at Mandan ND. PUE was calculated by dividing the actual crop yield by the quantity of precipitation that occurred from the harvest of one crop to the harvest of the following crop (PUE = crop yield / precipitation from harvest to harvest).

		Crop (Second year)*									
		Buckwheat	Canola	Chickpea	Corn	Dry Pea	Grain Sorghum†	Lentil	Proso Millet	Sunflower	Wheat
		(lb/ac/in.)									
Crop Residue (First year)	Buckwheat	**64.2**	**62.6**	**96.7**	66.7	**101.5**	**75.7**	**69.2**	**146.9**	**33.9**	**156.6**
	Canola	**60.8**	**50.6**	**106.7**	**104.4**	**95.1**	**97.2**	**68.7**	**143.7**	**52.2**	**142.8**
	Chickpea	**52.0**	**48.4**	90.6	**134.5**	**97.9**	**102.6**	50.2	**142.2**	**51.5**	141.0
	Corn	**63.5**	**59.2**	**106.9**	**96.7**	**115.5**	**51.3**	**73.9**	129.7	**52.0**	**151.9**
	Dry Pea	**73.5**	**48.1**	**102.6**	**141.5**	85.4	**105.5**	**66.7**	**161.8**	**54.9**	**152.1**
	Grain Sorghum	51.5	**54.2**	**106.9**	**121.1**	**101.2**	**65.1**	**58.3**	**132.9**	**49.7**	**151.6**
	Lentil	**57.9**	**45.0**	**100.3**	**135.8**	**107.8**	**117.5**	**57.2**	**150.5**	**51.5**	**151.9**
	Proso Millet	**57.9**	**52.9**	**120.5**	**132.2**	**139.0**	42.3	**84.8**	**136.3**	**59.4**	**156.8**
	Sunflower	**61.2**	**46.3**	**105.1**	**99.7**	**133.3**	**61.0**	**67.8**	**142.6**	31.2	**150.3**
	Wheat	**64.4**	43.6	**108.5**	**132.7**	**117.1**	**96.5**	**84.1**	**131.1**	**57.4**	**149.4**
	2003 Crop Avg.	**19.1**	**71.9**	**136.1**	**57.0**	**113.0**	**81.7**	**80.7**	**99.5**	**54.4**	**146.0**
	2004 Crop Avg.	**102.4**	**30.5**	**73.3**	**176.5**	**106.3**	—	**55.7**	**184.7**	**44.5**	**155.6**
	Overall Avg.	**60.7**	**51.1**	**104.5**	**116.5**	**109.4**	**81.5**	**68.1**	**141.8**	**49.4**	**150.4**

* Underlined and non-bold numbers in a column are the maximum and minimum values, respectively, for that crop.
† Includes only 2003 data due to lack of seed production in 2004.

Broad Summary

Sustainable cropping systems in the northern Great Plains need to take into consideration crop sequence. Crop sequence influenced soil water depletion, soil water recharge, and soil water content at seeding as well as relative seed yield and PUE.

CROP SEQUENCE INFLUENCES:

1. Soil Water
   a. Greatest soil water depletion by sunflower and corn.
   b. Least soil water depletion by dry pea.
   c. Greatest soil water recharge when residues were grain sorghum and spring wheat.
   d. Least soil water recharge when residues were sunflower, chickpea, lentil, and dry pea.
   e. Soil water content in the spring prior to seeding was greatest for spring wheat and dry pea residues and least for sunflower residue.

2. Relative Seed Yield
   a. Crops most responsive to crop sequence – chickpea, corn, grain sorghum, and sunflower.
   b. Crops least responsive to crop sequence – canola, proso millet, and spring wheat.

3. Precipitation-use efficiency
   a. Most consistent for spring wheat, dry pea, and sunflower.
   b. Least consistent for buckwheat, canola, corn, grain sorghum, and proso millet.

MANAGEMENT STRATEGIES FOR SOIL QUALITY

Dr. Donald Tanaka, Dr. Steve Merrill, Dr. Mark Liebig, and Dr. 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 2006 crop included minimum- and no-till for the following crop rotations:

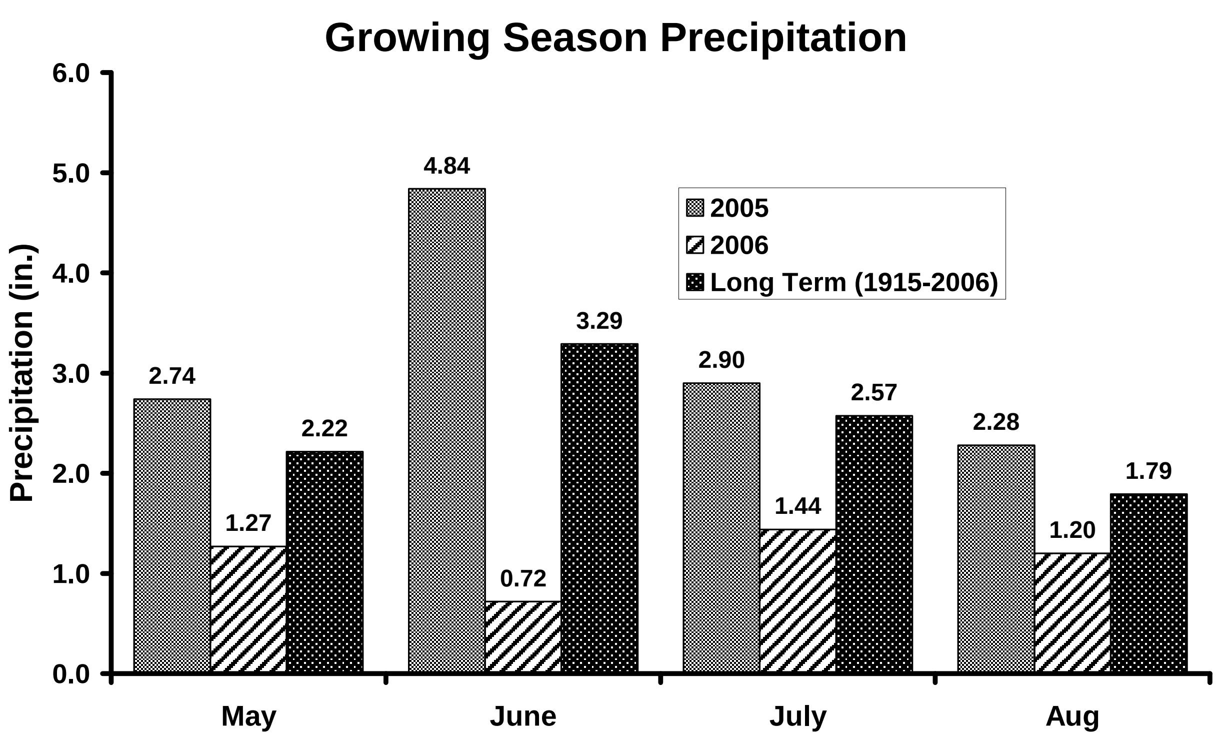
1. Continuous spring wheat (CSW+); straw chopped and spread
2. Continuous spring wheat (CSW–); stubble left in place, straw removed
3. Spring wheat – millet for hay (SW-M)
4. Spring wheat – safflower – fallow (SW-S-F)
5. Spring wheat – safflower – rye (partial fallow, cover crop) (SW-S-R)
6. Spring wheat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

Spring wheat (cv. Parshall) was seeded on May 4 at 1.3 million viable seeds per acre. Safflower (cv. Montola 2003) was also seeded on May 4 at 300,000 viable seeds per acre. Millet for hay was seeded at 4 million viable seeds per acre on June 9. Residue from previous crops was uniformly distributed at harvest. All no-till plots were sprayed with Roundup Ultra MaxII (20 oz./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. The N source was urea and the P source was 0-44-0. Rye was seeded on October 14, 2005 at 1.3 million viable seeds per acre with a Haybuster 8000.

Summary:

1. Growing season precipitation (May through August) for 2006 was 47% of the long-term average 9.87 inches.
2. Spring wheat in SW-M had the greatest seed yield (25.1 bu/a). Spring wheat after fallow did not yield more than SW in annual cropping systems.
3. Residue removal (CSW-) appears to reduce spring wheat yields when compared to leaving the residue in place (CSW+).
4. Safflower seed yield was greater for SW-S-R than SW-S-F.

Figure 1. Growing season precipitation (May – August) for 2005, 2006, and long-term average growing precipitation at Mandan, ND.



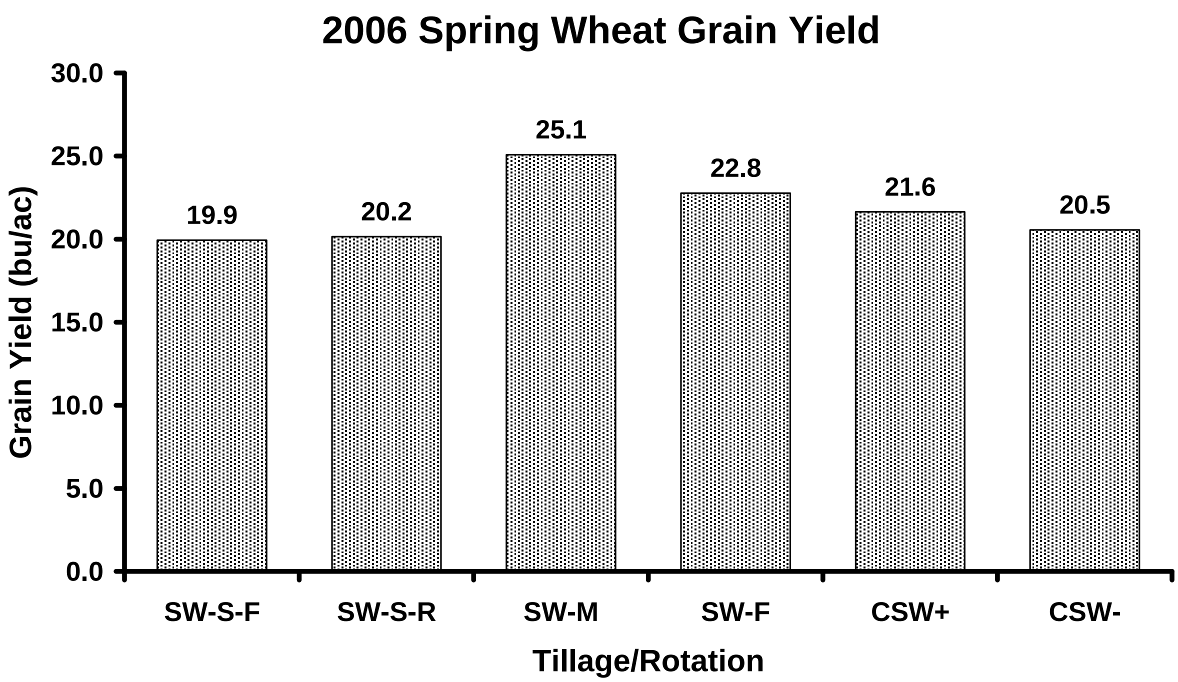


Figure 2. Spring wheat grain yield as influenced by cropping system. Yields are the average of minimum and no-till.

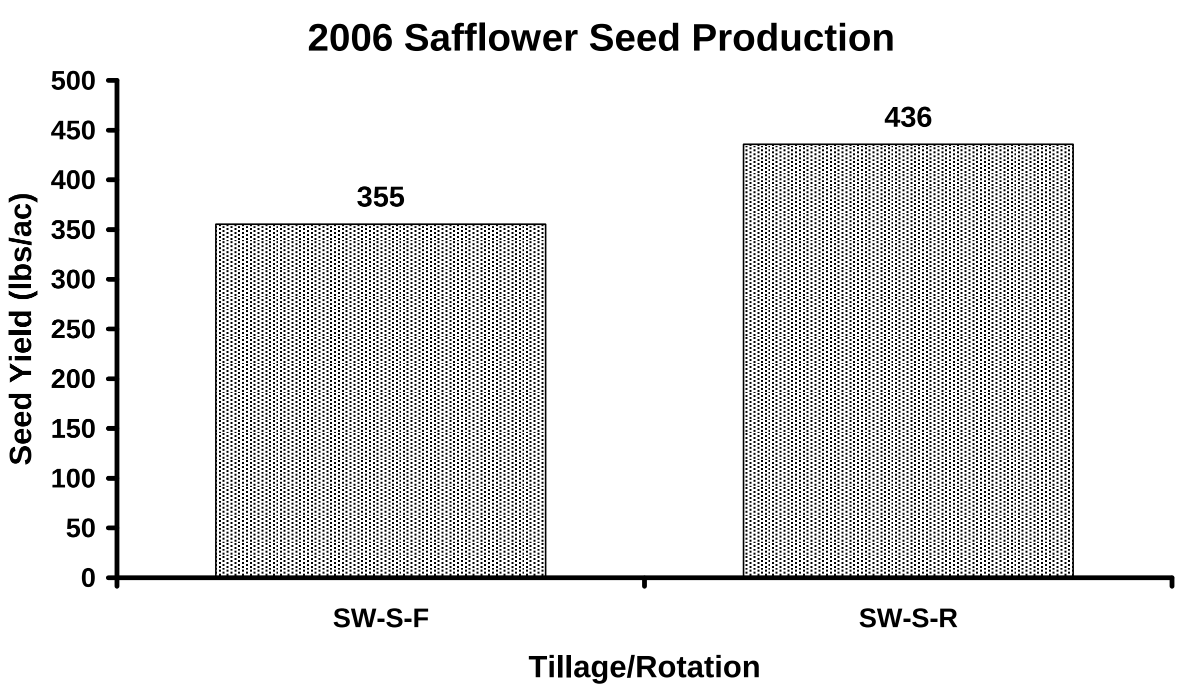


Figure 3. Safflower seed yield as influenced by cropping system. Yields are the average of minimum and no-till.

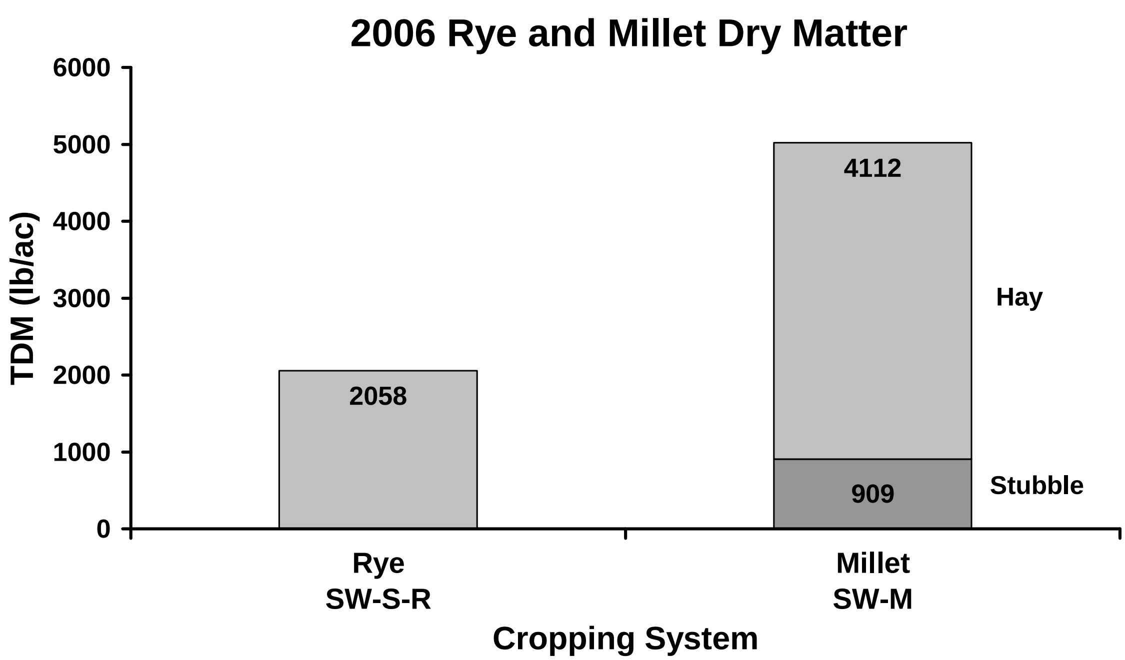


Figure 4. Total dry matter production for rye used as partial fallow and Siberian millet used for hay.

COMPARARISON OF WATER DEPLETION, ROOT GROWTH, AND CROP PRODUCTIVITY AT TWO DIVERSE SOIL SITES

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

Our 4 x 4 crop sequence experiment on sandy loam alluvial-type soil (ASL site) was in crop matrix phase in 2004 and 2005, and had 3 crops in common with the 10 x 10 Phase 3 (Ph 3) crop sequence experiment (CSE; in crop matrix 2003 and 2004) on silt loam soil at the Area IV SCD Cooperative Research Farm (see Table A). Differences in seasonal soil water depletion (SWD) indicate differences in crop water use, and are the principal determinant of differences in soil water available to new crops in the following springtime. Measurements of SWD taken with neutron moisture meter technique in the Ph 2 and Ph 3 CSE's have consistently indicated that dry pea had lowest SWD. However, dry pea had greater SWD than spring wheat at the ASL site (Table B), a result believed related to greater postharvest weed growth in dry pea at the sandy soil site. Consistent with Ph 3 CSE results, the ASL results show corn to be a relatively heavy water user. The ASL results also confirm observations in the Ph 2 CSE showing soybean to be a moderately heavy water user.

Springtime soil water was low in 2004, but subsequent precipitation supported mid- to later-season growth. The heavier water use of corn was more of a detriment to following crops at the glacial till Research Farm site than at the ASL site as shown by the lower Ph 3/ASL production ratios for dry pea and spring wheat following corn in 2004 compared to ratios following less water-depleting spring wheat (Table C). The Ph 3 Research Farm site has inherently higher soil quality than the ASL site, but under relative water stress as in 2004, the ASL site can outperform the Farm site in corn production. This is apparently due to higher crop water-supplying capacity of the ASL site, which would include such soil and land quality factors as presumptive high water-conductive subsoil, prior long-term grass growth and tree shelterbelts. Under more average precipitation, as in 2005, the Farm site can outperform the ASL site in spring wheat production.

Depth profiles of SWD are available for both sites in 2003 and for the ASL site in 2005 (see Figure). Due to a relatively dry soil in spring followed by midseason rains, useful SWD depth profiles could not be derived for 2004. The SWD profiles reflect complex patterns of soil water flow and root water uptake. Clearly, uptake and flow are relatively restricted (but by no means stopped) in the glacial till zone of the Farm soil (generally > 2-3 ft. depth) compared to the ability of the ASL soil to support flow and uptake in deeper subsoil. Corn and spring wheat are known to be more deeply rooted than dry pea, and these crops had marginally greater SWD below 5 ft. depth than dry pea at the ASL site.

Measurements of root growth by recovery-from-soil (washroot) techniques were made at both sites in 2004. The ASL site soil was apparently able to support root growth of both corn and spring wheat at soil depths exceeding 2.5 ft., whereas root growth below this depth at the Research Farm site was clearly less or not observable. The distinction in root growth profiles between the two sites was less for the more shallow-rooted dry pea crop. Our root measurement technique includes careful removal of black-appearing dead roots. In northern climates, dead root material can persist and this can be a source of inaccuracy for washroot-based measurements. However, the level of root length density (RLD) values obtained for corn and spring wheat at depths greater than 2 ft., a number of which were greater than 1 cm/cm^3, and the differences between the ASL site corn and spring wheat RLD profiles compared to those of dry pea would appear to argue for the relative credibility of this data.

Table A. Comparison of soil and land quality characteristics at the two sites.

		Research Farm, Phase 3 10x 10 crop sequence expt.	Alternative Soil Location (ASL) 4 x 4 crop sequence experiment
Properties		higher topsoil organic C, higher water-holding capacity	lower topsoil organic C, lower water-holding capacity
Texture		silt loam	sandy loam
Soil profile characteristics		Aeolian-derived overlayer over glacial till subsoil	Alluvial-type soil with entisolic character
Prior land use		Cropland since 1920's	> 20 years in grass, tilled 2000
Tree sheltering		Open 500 – 1500 m	Shelterbelts E and W

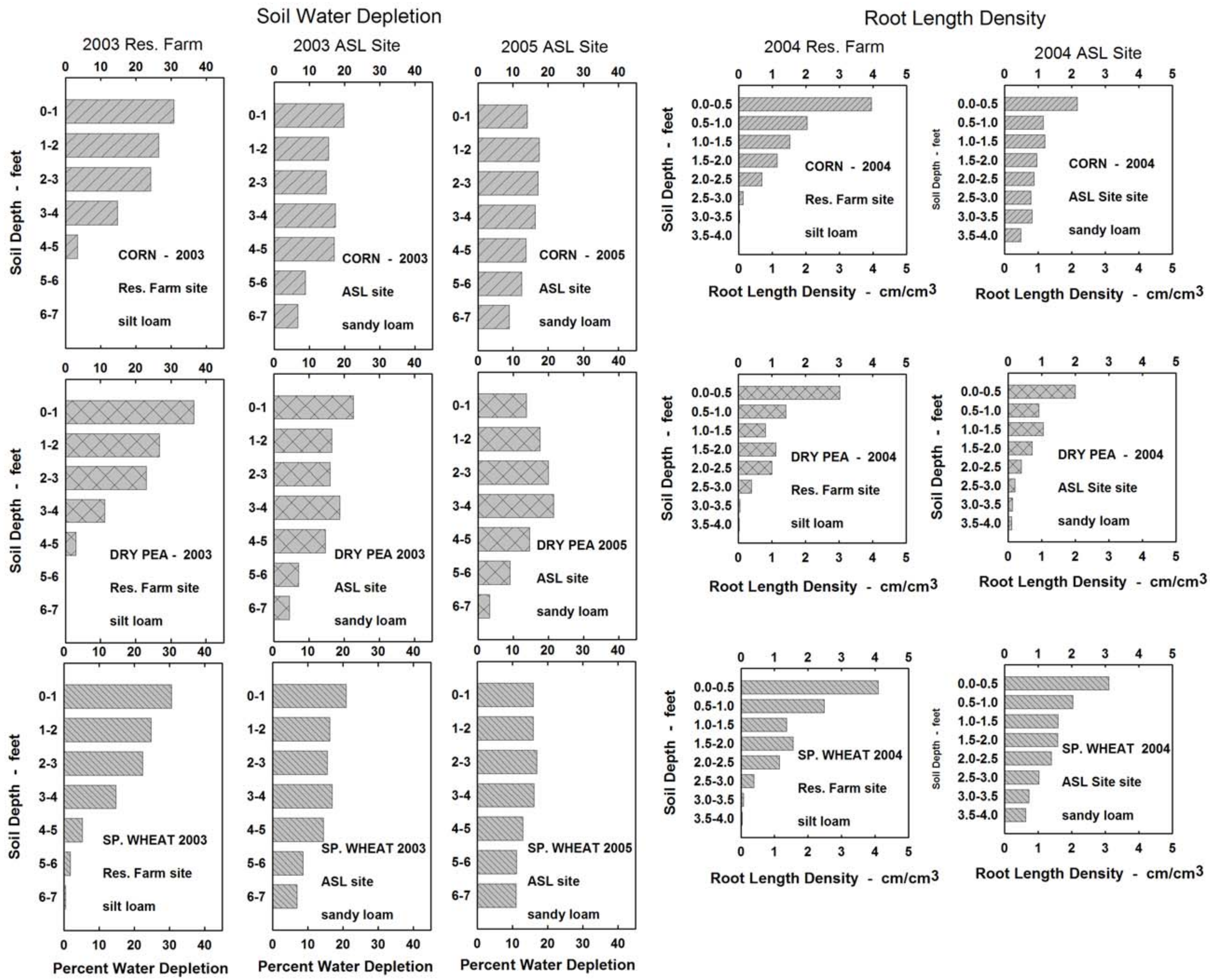
Table B. Soil water depletion to a soil depth of 6 ft. (1.8 m) between mid-May to mid-Sept.

Crop		2003 ASL	2003 Phase 3	2004 ASL	2004 Phase 3	2005 ASL
	- - - - - - - - - - - - - - cm - - - - - - - - - - - - - -					
Corn		15.3	15.7	5.7	4.1	12.1
Dry Pea		13.3	11.5	-0.8	-6.8	11.0
Soybean		9.3*	---	0.2	---	13.8
Sp. Wheat		11.7	15.0	-5.3	4.1	8.8

* Soybean at this site was continuously grazed by deer and other wildlife in 2003.

Table C. Ratios of seed yield from Phase 3 Research Farm crops to yield from the corresponding crops at the ASL site.

	- - - - - - - - 2004 crop - - - - - - -				2005 crop
2003 crop	Corn	Dry pea	Sp. wheat	2004 crop	Sp. wheat
Corn	0.46	0.86	0.61	Corn	1.43
Dry pea	0.72	0.97	1.08	Dry pea	1.42
Sp. Wheat	0.70	1.3	1.02	Sp. Wheat	1.43


Soil Water Depletion
2003 Res. Farm
2003 ASL Site
2005 ASL Site
Soil Depth - feet
0-1
1-2
2-3
3-4
4-5
5-6
6-7
CORN - 2003
Res. Farm site
silt loam
CORN - 2003
ASL site
sandy loam
CORN - 2005
ASL site
sandy loam
DRY PEA - 2003
Res. Farm site
silt loam
DRY PEA 2003
ASL site
sandy loam
DRY PEA 2005
ASL site
sandy loam
SP. WHEAT 2003
Res. Farm site
silt loam
SP. WHEAT 2003
ASL site
sandy loam
SP. WHEAT 2005
ASL site
sandy loam
Percent Water Depletion
Root Length Density
2004 Res. Farm
2004 ASL Site
0.0-0.5
0.5-1.0
1.0-1.5
1.5-2.0
2.0-2.5
2.5-3.0
3.0-3.5
3.5-4.0
CORN - 2004
Res. Farm site
silt loam
CORN - 2004
ASL Site site
sandy loam
DRY PEA - 2004
Res. Farm site
silt loam
DRY PEA - 2004
ASL Site site
sandy loam
SP. WHEAT 2004
Res. Farm site
silt loam
SP. WHEAT 2004
ASL Site site
sandy loam
Root Length Density - cm/cm3

MANAGEMENT OF WHEAT STRAW RESIDUE CAN REDUCE THE POTENTIAL TAN SPOT DISEASE RISK FOR THE NEXT CROP

Dr. Joe Krupinsky

*Drechslera tritici-repentis (*Died.) Shoem., the causal organism of tan spot disease, survives on infested straw residue. Considering the importance of wheat residue for the carryover of *D. tritici-repentis* inoculum, a spore monitoring project was undertaken to determine how spore recovery from infested straw residue is influenced by the age of the infested straw, the position of straw in the field after harvest (upright or prostrate), and the cultivar from which the straw was obtained. Infested straw samples were placed on support frames and monitored for spore recovery. The aging of the straw residue influenced spore recovery. Recovery of Dtr conidia was greatest during the first year after harvest and declined for each succeeding year under our conditions (Fig. 1), in other words, increasing the time interval between wheat crops will reduce the potential disease inoculum for the next crop. Spore recovery was influenced by the over wintering position of naturally infested straw, either as standing straw residue or straw residue laying on the soil surface. Recovery of Dtr conidia was greater on straw left standing compared with straw on the soil surface (Fig. 2), showing that straw on the soil surface will have less potential for producing inoculum for the next wheat crop. Recovery of Dtr conidia was also influenced by the cultivar of wheat (Fig. 3), indicating that the selection of cultivar can not only impact the resistance of the crop when it is being grown but also the following wheat crop by the amount of inoculum being produced. Knowledge of influencing factors on the carry over of Dtr inoculum on straw residue benefits the producer with his management decisions. Using management practices that take advantage of these results will lessen producer's risk of leaf spot diseases when growing wheat under our conditions.

Fig. 1. Spore recovery decreases with age of straw

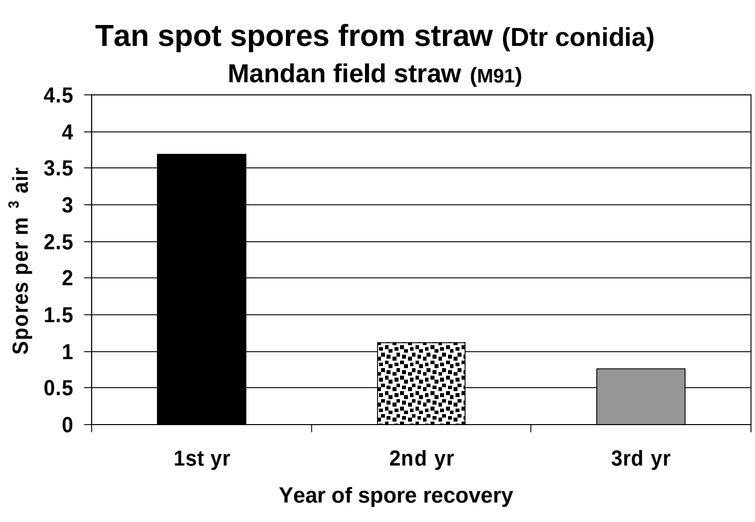


Fig. 2. Less spore recovery from straw on soil surface

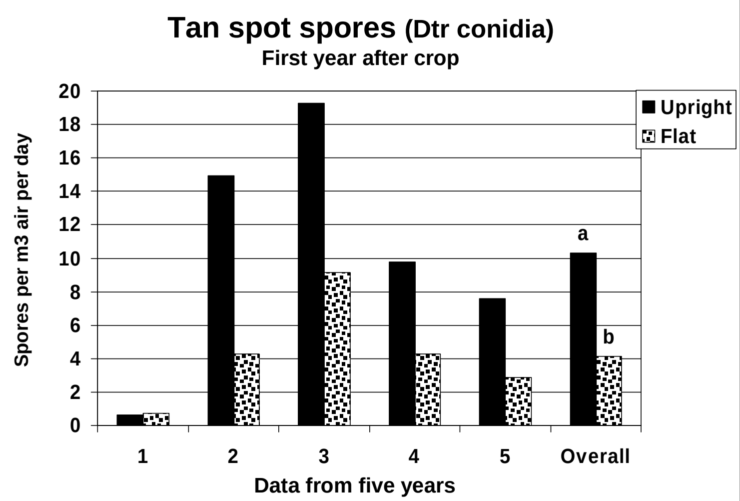
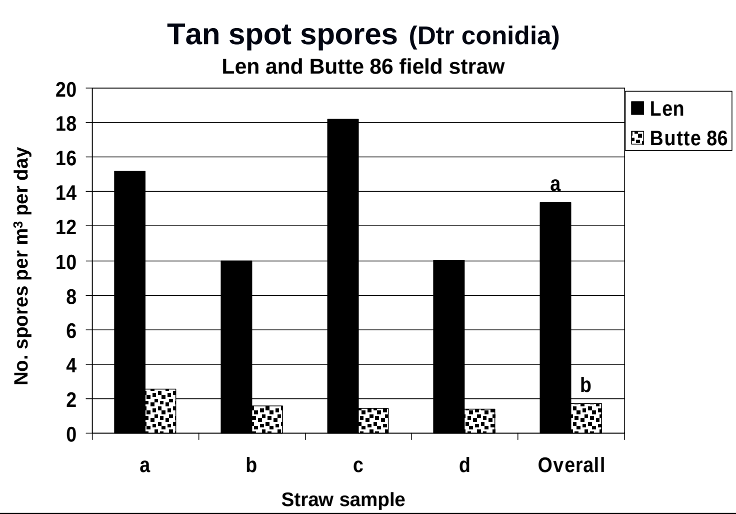


Fig. 3. Wheat cultivar can impact spore recovery.



ECONOMIC VIABILITY OF NO-TILL AND STRIP-TILLAGE IN WEST CENTRAL MINNESOTA

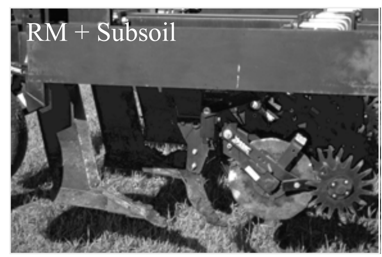
Dr. Dave Archer and Dr. Don Reicoscky. USDA-ARS North Central Soil Conservation Research Laboratory, Morris, MN

BACKGROUND

Despite relatively rapid adoption of less-intensive tillage practices in other parts of the country, the northern Corn Belt continues to rely heavily on intensive tillage. This is primarily due to the challenges in dealing with cool, wet spring conditions, particularly with no-till, which can sometimes lead to reduced yields. Strip tillage has been developed as an alternative that may provide many of the conservation benefits of no-till while maintaining productivity and economic returns.

APPROACH

A tillage study was conducted from 1997-2003 at the Swan Lake Research Farm near Morris, MN. The study included 8 tillage system treatments in a corn-soybean rotation. The tillage system consisted of: No-till, Moldboard Plow, Chisel Plow, and 4 strip tillage alternatives: Fall Residue Manager (RM), Fall RM + Mole Knife, Spring RM, Spring RM + Mole Knife, and Fall RM + Subsoil. The goal was to identify how much disturbance was necessary realizing that 1) reducing surface disturbance reduces soil erosion, 2) carbon loss is proportional to the volume of soil disturbed, and 3) more intensive tillage may require heavier, more expensive equipment and increase fuel use.



RESULTS

Highest average corn yields were obtained under the Fall RM + Mole Knife tillage system (Table 1), while the Moldboard Plow system had the lowest year-to-year corn yield variability. Highest average soybean yields were obtained under the Moldboard Plow system, with the lowest soybean yield variability obtained with the Fall RM tillage system. The No-Till system showed the highest average net returns, but also the highest variability of net returns. Four of the strip-tillage systems had net returns comparable to the No-Till system, but with lower risk. The Moldboard Plow system had the lowest average net returns and the highest diesel fuel costs (Figure 1). The No-Till and strip till systems all had lower fuel costs than the conventional systems, and were much less sensitive to changes in fuel prices. Growers in the Northern Corn Belt may be able to reduce tillage while increasing economic returns and reducing risk.

Table 1. 1997-2003 average crop yields, fuel use and net returns for alternative tillage system treatments.

Tillage System	Corn Yield (bu/ac)		Soybean Yield (bu/ac)		Net Returns ($/ac)	
	mean	stdev	mean	stdev	mean	stdev
No-till	157.3	20.8	44.1	3.1	153.65	28.78
Moldboard Plow	158.8	8.8	45.9	4.6	138.44	21.43
Chisel Plow	159.7	12.4	45.4	5.4	146.47	27.50
Fall RM	160.3	14.2	44.5	3.0	152.09	19.48
Fall RM + Mole Knife	161.6	13.0	44.0	3.7	152.56	22.62
Spring RM	153.1	15.4	43.2	4.1	142.20	21.62
Spring RM + Mole Knife	158.2	12.9	44.7	3.0	150.94	20.39
Fall RM + Subsoil	159.6	10.0	45.7	5.3	151.41	20.56

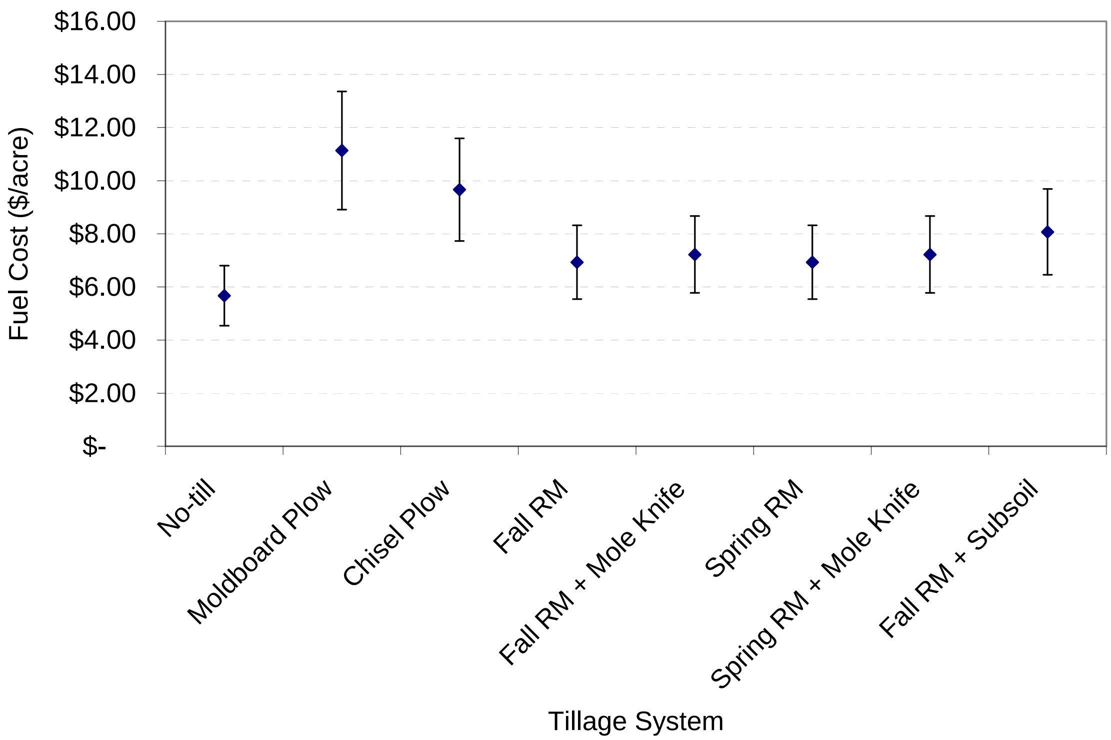


Figure 1. Sensitivity of average fuel costs per acre to diesel fuel prices for a fuel price of $2.50 per gallon ± $0.50 per gallon.

MONITORING RANGELAND CARBON AND CONDITION FROM THE SKY

Dr. Rebecca Phillips and Dr. Ofer Beeri, University of North Dakota School of Aerospace

Producers need to know how to remotely assess rangeland carbon and condition at a low cost and without investing time in computer programs, training classes, and image processing. We present two complementary solutions to remote rangeland assessment and monitoring problems in the Northern Great Plains.

First, most remote-based data products do not provide hard data. Instead, they reflect subjective, relative values (0-100) for vegetation, rather than in management units (e.g., kilograms per hectare). These relative data are limited because they delineation ostensible differences in vegetation "health" while providing little information regarding range production. The ARS, in collaboration with UND School of Aerospace, has addressed this first problem by developing methods to quantify rangeland nutrient status and production using satellite and aerial information only. Three years of seasonal field survey data indicate our remote estimates of pasture biomass and canopy nitrogen content were within 10 to 25% of values measured from clipped plots. We are now in the process of testing the capacity of these new data products to operate as forecast tools for animal production and to determine carrying capacity.

Second, processing and manipulation of remote-based data is time-consuming and not practical for individuals to perform regularly for their land management units. We suggest a framework for monitoring rangeland condition, with information delivered in a manner similar to weather stations. We consider "reference sites", or areas of consistent management practices, as indicators of baseline range condition. By plotting early-season production and plant nutrient status every year for ten years, we have the ability to quantitatively evaluate range condition, including carbon and nitrogen stocks, for multiple reference sites. These baseline data can then be used a "markers" against which producers use can gauge their own management units.

Below is an example of a reference site and data derived from these products for a ten-year time series. A network of reference sites depicting similar data could be constructed across the region and made available on the web. We suggest land managers purview these data for their area of interest just as they would weather stations. The site would be updated similarly every spring with the latest biomass and nutrient status information. By contrasting current spring condition with previous spring condition, managers could use this information to monitor their own range condition relative to the baseline reference sites.

Figure 1. Aerial photograph for a section of State School Land located in Central ND. Site is annually grazed from June to August.

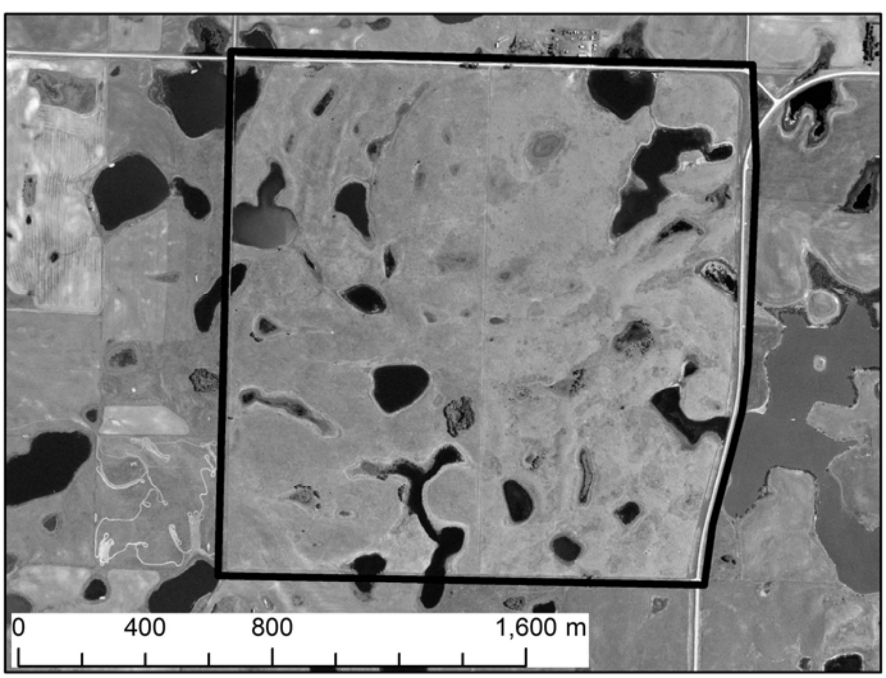


Figure 2. Satellite estimates for live biomass collected in early spring are plotted against growing degree days on the day of acquisition.

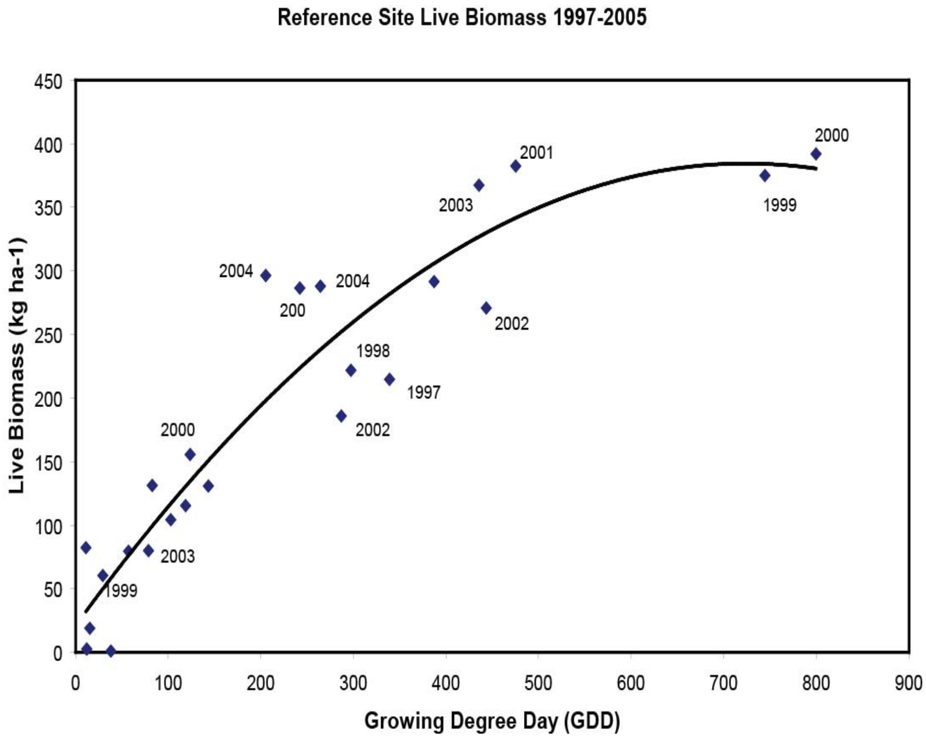
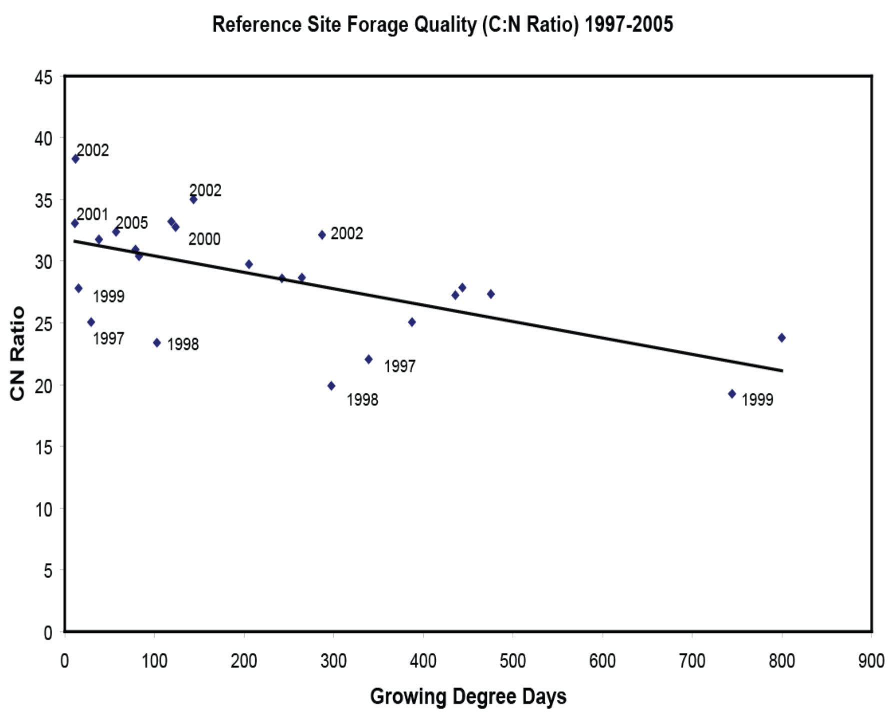


Figure 3. Satellite estimates for C:N ratio collected in early spring are plotted against growing degree days on the day of acquisition. Low carbon:nitrogen ratios indicate greater forage quality.



LONG-TERM GRAZING EFFECTS ON SOIL CHEMICAL PROPERTIES

Dr. Mark Liebig, Mr. Jason Gross, Dr. Scott Kronberg, Dr. Jon Hanson, Dr. Al Frank, and Dr. Rebecca Phillips

Sustainable use of grazing lands requires management strategies that do not compromise the capacity of soil to function over the long-term. Both positive and negative effects of grazing on soil attributes can occur. Generally, grazing has been found to affect near-surface soil physical condition by hoof action, as well as nutrient storage and cycling potential through grazing intensity and urine and dung deposition. Accordingly, changes in soil attributes resulting from grazing affect vegetation composition, forage quality, and movement of water within and across landscapes.

Evaluation of grazing management effects on soil attributes often requires many years before measurable differences are detectable. In 1916 and 1932, long-term grazing trials were established at NGPRL on mixed-grass prairie vegetation and a seeded crested wheatgrass pasture. Though the trials were originally established to assess the effects of grazing intensity on animal performance and vegetation characteristics, the age of the trials and the consistency of the applied treatments over time make them an ideal setting to evaluate grazing management effects on soil. In light of this opportunity, an evaluation was conducted to determine the effect of the grazing trials on soil attributes, with particular emphasis on soil chemical properties.

Effects of grazing management systems on selected soil chemical properties (0 to 2 inch depth).

Soil property (0 to 2")	Crested wheatgrass	Heavily grazed	Moderately grazed
Soil pH (-log[H^+])	5.10 a†	6.62 b	6.44 b
Exch. Ca (cmol kg^{-1})	6.39 b	12.06 a	11.37 a
Exch. Mg (cmol kg^{-1})	2.64 c	4.84 a	4.50 b
Exch. K (cmol kg^{-1})	1.31	1.26	1.38
Exch. Na (cmol kg^{-1})	0.10	0.06	0.04
CEC (cmol kg^{-1})	10.44 b	18.21 a	17.29 a
Soil organic carbon (Mg ha^{-1})	28.6 a	28.4 a	22.8 b
Total nitrogen (Mg ha^{-1})	2.3 a	2.1 a	1.8 b

† Means in a row with unlike letters differ ($P<0.05$).

Grazing management effects on soil chemical properties were largely limited to the surface two inches of soil. Relative to the native vegetation pastures, soil under crested wheatgrass was more acidic, possessed lower levels of basic cations (e.g., calcium and magnesium), and had lower cation exchange capacity. The crested wheatgrass and heavily-grazed pastures had greater soil organic carbon (SOC) and total nitrogen (TN) at 0 to 2 inches than the moderately grazed pasture. Additionally, the crested wheatgrass pasture had greater SOC from 12 to 24 inches than the native vegetation pastures (data not shown).

Differences in soil chemical properties between the grazing management systems were largely brought about by a) fertilization in the crested wheatgrass pasture, and b) differences in grazing intensity among pastures. Annual application of nitrogen fertilizer caused the acidification and subsequent decline in exchangeable cations under the crested wheatgrass pasture. Elevated levels of SOC and TN in the crested wheatgrass and heavily-grazed pastures relative to the moderately-grazed pasture likely occurred by different mechanisms. For the crested wheatgrass pasture, greater SOC and TN was caused by greater biomass production from nitrogen fertilizer application, whereas for the heavily-grazed pasture, greater SOC and TN was caused by the predominance of blue grama, a mat-forming grass that transfers most of its photosynthate belowground to root biomass.

Results from this study suggest fertilization of crested wheatgrass enhances near-surface and deep storage of soil organic carbon, but contributes to acidification and decreases in exchangeable cations relative to native nonfertilized pastures. Given that soil pH and cation exchange capacity are surrogate indicators of nutrient cycling and storage potential, nitrogen fertilization of semiarid pastures appears to lack viability from the perspective of keeping soil chemical properties within reasonable thresholds for maintaining long-term rangeland health.

Crested Wheatgrass Pasture

- Established in 1932.
- Composed of crested wheatgrass and blue grama.
- Grazed at 1 ac/steer in the late-spring/early-summer, and at 2.2 ac/steer for the remainder of the grazing season.
- Receives 40 lb N/ac/yr.

Heavily-grazed pasture

- Established in 1916.
- Composed of blue grama and carex.
- Grazed at 2.2 ac/steer.

Moderately-grazed pasture

- Established in 1916.
- Composed of blue grama, needle-and-thread, western wheatgrass, prairie junegrass, Kentucky bluegrass, and carex.
- Grazed at 6.4 ac/steer.

PROFITABLE CALF BACKGROUNDING INTEGRATING ANNUAL FORAGE CROPS[1]

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ABSTRACT: In the four-state region of MT, ND, SD, and WY, cereal forages have become an increasingly important crop for livestock producers. Some small grains cut for hay have rough awns which can affect palatability and cause mouth irritation in cattle. New cereal forage cultivar development has only focused on the absence of awns or biomass production and not animal feeding performance. Our study objectives were to: 1) obtain animal performance comparisons of experimental and traditionally grown cereal forages; 2) demonstrate animal performance for an experimental awnless winter wheat cultivar; and 3) evaluate steer cost of gain for the experimental and traditionally grown cereal forages. A 57 d backgrounding performance study was conducted using 80 purchased crossbred weaned steer calves (678 ± 8.4 lbs body weight, BW). Calves were stratified by BW, randomly allotted to pens, and assigned to one of four cereal forage dietary treatments (n = 4): 1) barley harvested as hay (BH); 2) barley harvested as silage (BS); 3) oat harvested as hay (OH); and 4) awnless winter wheat cultivar harvested as hay (WH). Steers were fed once daily (0900) and given ad libitum access to their roughage source, 8 lbs•head^{-1}•d^{-1} of rolled barley grain, and 1.0 lbs•head^{-1}•d^{-1} of a 30% CP supplement containing Rumensin®. Diets were formulated to target an ADG of 2.60 lbs. Two-day un-shrunk weights were recorded on d 0, 28, and 57. Diet, ort, and fecal samples were collected on d 0, 28, and 57. Diet samples were composited by pen and analyzed for dry matter (DM), organic matter (OM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid insoluble ash (AIA), and indigestible acid detergent fiber (IADF). Indigestible acid detergent fiber was used as an internal marker to estimate fecal output (FO) and calculate apparent nutrient digestibility. Steers consuming BH and BS had similar ($P > 0.10$) final BW. Dry matter intakes were not affected by treatment ($P = 0.33$). Calves consuming BS had the highest ($P < 0.01$) total gain and ADG of all four treatments. Calves consuming BS had the highest G: F ($P = 0.02$). Steers consuming WH had the highest feed cost of gain ($P = 0.04$) and total cost of gain ($P = 0.03$) of all four dietary treatments. Barley harvested as silage demonstrated greater potential as a backgrounding feedstuff as compared to the barley, oats or awnless winter wheat harvested as hay.

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[1] *Acknowledgements: We would like to thank the South Dakota Agricultural Experiment Station and the Four-State Ruminant Consortium for funding this project.*

INTRODUCTION

In the four-state region of MT, ND, SD, and WY, cereal forages have become an increasingly important crop to livestock producers. Few statistics are available, but cereal hays are harvested on over 500,000 acres in this region. One explanation for the popularity of cereal forages may be the current drought conditions and their use as an emergency hay crop. Small grains are used in crop rotations to renovate alfalfa stands and are an effective way to reduce costs associated with weed and disease control. Cereal hays are a significant source of winter forage for livestock producers in this area. Cereal forages can be an inexpensive, readily available feed source since they are easier to grow when compared to alfalfa regarding costs of seed drills, herbicides, risk and require similar harvesting techniques as legumes (Helsel and Thomas, 1987). Winter cereals have advantages over spring cereals concerning production, water use efficiency and seasonal distribution of workload.

Previous research has shown differences in feeding value among cereal forage species and across maturity stages at harvest. Barley forage has often been determined to have higher quality when compared to oat, wheat, or triticale forages (Cherney and Martin, 1982; Cherney et al., 1983; McCartney and Vaage, 1994; Khorasani et al., 1997). Some cereal grain seed heads contain rough awns. Awns can affect palatability and cause mouth irritation in livestock. Bolsen and Berger (1976) found lambs consuming awned wheat silage had decreased dry matter intake (DMI) compared to lambs consuming awnless wheat silage. New cultivar development has focused on awn absence or biomass production and not animal feeding performance.

We designed and conducted steer backgrounding feeding trials to evaluate the following objectives: obtain animal performance comparisons of experimental and traditional cereal forages; demonstrate animal performance for an experimental awnless winter wheat cultivar; and evaluate steer cost of gain for experimental and traditional cereal forages.

MATERIALS AND METHODS

A backgrounding performance study was conducted using 80 purchased crossbred weaned steer calves (initial BW 678 lbs ± 8.4 lbs). Calves were stratified by BW, randomly allotted to one of 16 pens (5 steers/pen), and assigned to one of four cereal forage dietary treatments (n = 4): 1) barley harvested as hay (**BH**); 2) barley harvested as silage (**BS**); 3) oat harvested as hay (**OH**) and 4) awnless winter wheat cultivar harvested as hay (**WH**). The barley variety used for silage and hay was 'Robust'; the oat variety used for hay was 'Loyal'; and the winter wheat variety used for hay was 'Willow Creek'. This awnless winter wheat was an experimental variety developed by Montana State University in Bozeman, MT. Cereal forages utilized in the feeding trial were seeded at the recommended rates for the soil types and environments of southwest ND and Miles City, MT. Barley hay, BS, and OH harvest were conducted at the same stage of maturity (soft dough stage) during the months of June and July 2005. The WH cultivar was grown and harvested at flowering near Miles City, MT by a commercial farmer and delivered to the Hettinger Research Extension Center prior to the start of the trial.

Upon arrival, steer calves were weighed and rectal body temperatures taken to determine the incidence of respiratory illness (BRD complex). Steers having a rectal body temperature of 104^{o} F or greater were given a s. c. injection of Excede™ (Ceftiofur Crystalline Free Acid, Pfizer Animal Health, Exton, PA) antibiotic in the middle one-third posterior aspect of the ear. At processing, calves were vaccinated twice with Pyramid® 5 vaccine (Bovine Rhinotracheitis-Virus Diarrhea-Parainfluenza-3-Respiratory Syncytial Virus; modified live virus; Fort Dodge Animal Health, Ft. Dodge, IA) and Ultrabac® 7 Clostridial vaccine (Pfizer Animal Health, Exton, PA); vaccinated once with One Shot® bacterin-toxid for *Mannheimia haemolytica* (Pfizer Animal Health, Exton, PA), and poured with Dectomax® Pour-On dewormer (doramectin; Pfizer Animal Health, Exton, PA) for internal and external parasites. Calves were implanted with a Ralgro® implant (Schering-Plough Animal Health Corporation, Kenilworth, NJ) at the beginning of the backgrounding study.

Steers were fed once daily (0900) based on individual pen bunk calls and given ad libitum access to their roughage source, 8 lbs of rolled barley grain, 1.0 lbs of a 30% CP supplement containing Rumensin®, and fresh water. Diets were formulated to target an ADG of 2.60 lbs. Deccox® medicated crumbles were fed during the study for coccidiosis prevention. All hays were chopped to a 2 inch length prior to feeding. Two-day un-shrunk weights were recorded on d 0, 28 and 57. A health protocol was established through a local veterinary clinic which included a monthly pen walk-through by the attending veterinarian. Diet, ort, and fecal samples were collected on d 0, 28, and 57. Diet samples were composited by pen and analyzed for DM, OM, N (AOAC, 2000), NDF, and ADF (Van Soest et al, 1991), AIA (Van Keulen and Young, 1977) and IADF (Bohnert et al., 2002). Indigestible ADF was used as an internal marker to estimate fecal output and to calculate apparent digestibility

Backgrounding performance, feed intake, and nutritional data were analyzed as a randomized complete design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC) to test the main effect of dietary forage source using pen as the experimental unit. Planned pairwise comparisons (LSD) were used to separate forage least square means when the protected F-test was significant ($P < 0.10$).

RESULTS AND DISCUSSION

Dietary treatment nutrient compositions are displayed in Table 1. In this study, BS had the highest CP, NE_g, and the lowest OM, NDF, and ADF, with BH and WH being intermediate, and OH having the lowest CP, NE_g and highest OM, NDF, and ADF levels of the dietary treatments (Table 1). High ash content indicates the likelihood the OH diet in this study was contaminated with soil which resulted in elevated ADF and NDF levels. According to Rankin (2003), oat forage harvested during the dough stage typically has NDF levels ranging from 59 to 61%. Previous agronomy research has shown that the chemical compositions of forages are affected by a variety of factors such as species, varieties within species, stage of growth or maturity, as well as environmental conditions. According to Watson et al. (1993), hay forage quality is more dependent on stage of maturity at harvest than silage forage.

Khorasani and Kennelly (1997) in their review on optimizing cereal silage quality found that CP and NDF are good indicators of stage of maturity of cereal forages at harvest and ADF may not be a good indicator of the net energy of cereal silages.

The diets in this study were formulated to achieve a 2.60 lb ADG; however, the BS treatment had higher NE_g values during the feeding trial as compared to the other three dietary treatments which resulted in higher gain and ADG (Tables 1 and 2). Although the BS diet had the lowest inclusion level of rolled barley grain in the total diet, BS forage possibly had higher starch content (greater grain-to-forage ratio) at harvest from seed head fill as compared to the other three forages, thus increasing the overall diet's energy content. Collar et al. (2004) reported that when grain development occurs in cereal forages, the grain seed contributes to non-fibrous (non-structural) carbohydrate (starch) which dilutes the fiber component of the maturing cereal plant. In their study of cereal forages harvested at various growth stages (boot, flower, milk and soft dough), Collar and colleagues (2004) found that even slight differences in maturity could account for differences in chemical components among cereal cultivars at various harvest stages.

Performance, intake, diet digestibility, and digestible intake data are summarized in Table 2. Steers consuming BH and BS had similar final weights; however, steers consuming BS had higher final weights as compared to the steers fed OH and WH ($P < 0.10$). Both gain and ADG were influenced by dietary treatments ($P \leq 0.01$). Calves consuming BS diet had the highest gain and ADG of all four treatments, with no difference between BH, OH and WH fed steers ($P > 0.10$). Dry matter intake was not affected by treatment ($P = 0.33$) and averaged 2.56% body weight; however, BH steers had DMI that was numerically higher than the other three treatments. Gain to feed ratios were the highest for BS steers ($P = 0.02$) as compared to the OH, BH and WH steers (Table 2). McCarney and Vaage (1994) found ADG and subsequent animal performance was highest for growing beef heifers consuming barley silage as compared to oat or triticale silage. Todd et al. (2003) had similar DMI values (22.5, 24, 22.7, and 18.5 lbs/d, respectively) for steers consuming four different irrigated BH varieties (MT 981060, Valier, Haybet and Westford). Umoh et al. (1982) reported similar DMI values for steers fed Horsford and Stepford barley hay.

Barley silage had the highest N and lowest ADF and NDF intakes as compared to the dry hay diets (BH, OH, and WH; $P < 0.05$). Diet digestibilities for DM, OM, and N were highest for BS, intermediate for OH and WH, and the lowest for BH ($P < 0.005$); however ADF and NDF digestibilites were not significantly different between diets ($P > 0.10$). Barley silage had the highest DM, OM, and N digestible intakes and the lowest ADF digestible intake as compared to the other three treatments ($P = 0.02$). In this study, N intake appears to have had the greatest impact on animal performance ($P < 0.005$) with these cereal forage treatments. Steers consuming WH had the highest feed cost of gain ($P = 0.04$) and total cost of gain ($P = 0.03$; Table 2) of all four dietary treatments. One explanation for the high feed and total costs for WH may be due to transportation costs from Miles City, MT to Hettinger, ND. Transportation costs added an additional \$0.02/lbs to the final cost of WH, which the other three dietary treatments did not incur since they were grown and harvested at the Hettinger Research Extension Center.

During the study, all three dry hay diets had large amounts of fines present in their feed bunks during orts (feed refusals) collections as compared to the BS steers (data not reported). It appears that the BS steers possibly did not sort as much and consumed a more consistent portion of their total daily feed allotment as compared to the other three treatments, thus improving BS steers gain: feed and overall feed efficiencies, despite having lower DMI.

IMPLICATIONS

In this backgrounding study, barley harvested as silage demonstrated greater potential as a backgrounding feedstuff as compared to barley, oats, or awnless winter wheat harvested as hay. More research is needed to further define the effects these cereal grain varieties have on backgrounding steer performance. Utilizing cereal grains as forage crops in post-weaning cattle rations offers unique business opportunities to producers in this region, especially in periods of drought.

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Table 1. Dietary ingredient and nutrient compositions of diets fed to crossbred steer calves (DM basis)

	Diets			
Ingredient	Barley Silage	Barley Hay	Oat Hay	Wheat Hay
Barley Silage, %	63.30	---	---	---
Barley Hay, %	---	56.08	---	---
Oat Hay, %	---	---	54.27	---
Wheat Hay, %	---	---	---	58.75
Barley grain, %	31.48	37.67	39.22	35.38
30% CP supplement[a] , %	4.02	4.82	5.01	4.52
Deccox medicated crumbles, %	1.2	1.43	1.49	1.35
Nutrient Concentration				
DM, %	58.2	84.5	83.8	87.7
CP, %	13.6	12.4	9.56	11.2
NE_m , Mcal/lb	0.76	0.62	0.53	0.72
$NE_{g,}$, Mcal/lb	0.50	0.36	0.27	0.45
OM, %	89.8	78.1	71.6	85.2
NDF, %	30.6	39.1	62.4	46.2
ADF, %	18.0	24.7	46	26.2
Ca, %	1.24	1.02	0.93	0.71
P, %	0.4	0.3	0.28	0.3
Nitrate, ppm	900	400	500	300
Deccox, mg	170	170	170	170
Rumensin, mg	213	213	213	213

[a] 30% Commercial supplement (as fed): 29.0% CP, Ca 17.0%, P 0.45%, K 1.2%, Mg 0.7%,Vitamin A 110,000 IU/kg, Vitamin D_3 11,000 IU/kg, Vitamin E 330 IU/kg, Cu 550 ppm, Zn 930 ppm, and Mn 1000 ppm.

Table 2. The influence of forage source on backgrounding steer performance

Item	BH	BS	OH	WH	SEM[b]	*P* -value[c]
	Treatments[a]					
Initial Wt, lbs	686	674	674	677	8.4	0.74
Final Wt, lbs	844^{xy}	858^{y}	824^{x}	820^{x}	11.6	0.07
Feed intake as % BW	2.66	2.48	2.65	2.44	0.097	0.31
Gain, lbs	159^{x}	183^{y}	150^{x}	143^{x}	7.02	≤ 0.01
ADG, lbs/d	2.78^{x}	3.22^{y}	2.63^{x}	2.51^{x}	0.122	≤ 0.01
Gain: feed	0.138^{x}	0.17^{y}	0.135^{x}	0.135^{x}	0.009	0.02
Feed cost of gain, $/lbs	0.34^{x}	0.35^{x}	0.32^{x}	0.41^{y}	0.02	0.04
Total cost of gain, $/lbs	0.51^{x}	0.49^{x}	0.52^{x}	0.62^{y}	0.03	0.03
Dietary Intake, lbs/d						
DM	20.4	19.0	19.8	18.3	0.821	0.33
OM	14.8	15.8	15.2	14.8	0.80	0.78
N	0.35^{x}	0.39^{y}	0.32^{x}	0.32^{x}	0.017	0.03
ADF	5.92^{x}	4.45^{y}	6.11^{x}	6.72^{x}	0.356	< 0.01
NDF	9.92^{x}	8.12^{y}	10.0^{x}	10.64^{x}	0.575	< 0.05
In vivo digestibility, %						
DM	41.7^{x}	57.1^{y}	50.0^{z}	48.0^{z}	1.50	< 0.005
OM	41.5^{x}	59.6^{y}	51.4^{z}	48.1^{z}	2.05	< 0.005
N	25.2^{x}	52.0^{y}	40.3^{z}	37.5^{z}	2.45	< 0.005
ADF	29.5	26.5	28.6	31.8	1.88	0.29
NDF	37.0	42.8	39.9	41.4	1.74	0.17
Digestible intake, lbs/d						
DM	8.09^{xz}	10.92^{y}	9.77^{yz}	9.25^{xyz}	0.52	0.02
OM	6.12^{xz}	9.42^{y}	7.87^{z}	7.09^{xz}	0.53	< 0.01
N	0.09^{x}	0.21^{y}	0.13^{z}	0.12^{z}	0.009	< 0.005
ADF	1.75^{x}	1.19^{y}	1.76^{x}	2.14^{x}	0.168	0.013
NDF	3.67	3.49	4.03	4.39	0.302	0.214

[a] BH = Barley Hay; BS = Barley Silage; OH = Oat Hay; WH = Awnless Winter Wheat Hay.
[b] n = 4.
[c] *P*-value for *F*-test of treatment.
[x,y,z] Within a row, means without a common superscript differ ($P < 0.10$).

EVALUATION OF A NEW AWNLETTED WINTER WHEAT VARIETY: "WILLOW CREEK" IN SOUTHWESTERN NORTH DAKOTA

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INTRODUCTION

In the four-state region of Montana, North Dakota, South Dakota and Wyoming, cereal forages have become an increasingly important crop to area livestock producers. Few statistics are available, but cereal hays are harvested on over 500,000 acres in the region. Typically, small grains are used in crop rotations to renovate alfalfa stands and are an effective means to reduce costs associated with weed and disease control. A possible explanation for the increasing popularity of cereal forages may be due to current drought conditions and their use as an emergency hay crop. As a result, cereal hays have become a significant source of winter forage for regional livestock producers.

New and improved cereal forage varieties continue to be developed. New cultivar development focuses primarily on the absence of awns or biomass production and not forage quality or animal feeding performance. Recently, Montana State University developed a new awnless variety of winter wheat called 'Willow Creek'. According to Cash (2006), 'Willow Creek' winter wheat is a hard red wheat variety that is tall, late-maturing, awnletted, fine stemmed and has fairly light-colored chaff. Both Montana State University and NDSU Hettinger Research Extension Center have conducted feeding trials with beef cattle using 'Willow Creek' winter wheat. In replicated calf backgrounding trials at Bozeman, MT and Hettinger, ND, 'Willow Creek' winter wheat hay averaged 2.50 lbs ADG (average daily gain) for growing beef calves when compared to barley hay (2.80 lbs ADG), and oat hay (2.60 lbs ADG; Surber et al, 2006; Stamm et al., 2006); 'Willow Creek' winter wheat shows potential as a possible forage option in calf backgrounding and cow maintenance rations. In the early 2000s, Montana State University (MSU) conducted numerous growing and performance trials with 'Willow Creek' winter wheat at various locations throughout Montana, including eastern MT, in which this winter wheat variety was grown under both dryland and irrigated conditions. However, very little is known on how 'Willow Creek' winter wheat will perform under southwestern ND environmental conditions. This paper details how 'Willow Creek' winter wheat performed and compared to other cereal varieties in a dryland growing trial at Hettinger, ND.

MATERIALS AND METHODS

In the fall of 2005 and spring of 2006, an experiment was conducted at the Hettinger Research Extension Center's Agronomy plots to investigate and compare the growth, vigor, winter hardiness, and maturity of five winter and spring cereal varieties under southwestern ND growing conditions: 'Ransom' winter wheat, 'Willow Creek' winter wheat, 'Monida' oat, 'Trical 2700' triticale, and 'Hays' forage barley. These four cereal varieties were chosen for comparison against 'Willow Creek' winter wheat since they are typical grains grown under no till practices for grain or forage production in ND's southwestern region. All cereal varieties were grown in research plots measuring 5 ft wide by 25 ft long and replicated four times.

The winter wheat varieties ('Ransom' and 'Willow Creek') were planted on September 25, 2005 at a seeding rate of 1 million live seeds per acre (approximately 1.4 bu/A). The plot locations where the winter wheat varieties were grown had been in soybean production previously. At time of planting, 26 lbs/A phosphorus and 5.5 lbs/A of nitrogen was applied with the seed. The following spring, an additional 115 lbs/A of nitrogen was broadcast on the winter wheat plots. Winter wheat varieties were sprayed with 1 pint/A WideMatch® Herbicide (Dow AgroSciences) and 2/3 pint/A Puma® Herbicide (Bayer Crop Science) for weed control. Winter wheat varieties went into winter dormancy in fair condition. The following spring, only 57% 'Ransom' and 50% 'Willow Creek' winter wheat varieties survived, possibly due to warm weather in January 2006.

The spring cereal varieties were planted on May 11, 2006 at a seeding rate of 750,000 live seeds/acre (approximately 1.7 bu/A) for the oat and (approximately 1.4 bu/A) barley grains and at 1 million live seeds/acre (approximately 1.4 bu/A) for the triticale. The plot locations where the triticale, oat and barley varieties were planted had previously been in soybean production. At the time of planting, 92 lbs/A nitrogen and 26 lbs/A phosphorus was applied to the spring cereal plots. The spring cereal plots were treated with 1 pint/A Roundup® UltraMax Herbicide (Monsanto) pre-emergence shortly after seed sowing. All spring cereals were treated with 1 pint/A WideMatch® Herbicide (Dow AgroSciences) and the triticale and barley plots also received 2 pints/A Hoelon® 3EC Herbicide (Bayer Crop Sciences Corp.).

All cereal varieties were harvested between milk and soft dough stages in late June and early July 2006 with a small flail-type forage harvester, where the whole plant was collected at harvest. After harvest, plant tissue was dried in a forced air oven for 48 hrs at 150º F to determine moisture content. Plant tissues were analyzed for dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), calcium (Ca), phosphorus (P), potassium (K), and nitrate concentration by a commercial laboratory (Midwest Laboratories, Omaha, NE) using AOAC (2000) methods.

RESULTS AND DISCUSSION

Regarding winter survivability, there was no statistical difference between the 'Ransom' or 'Willow Creek' winter wheat varieties ($P > 0.05$; table 1). Heading date, plant height at harvest, and DM forage yield was statistically different for the five cereal varieties ($P < 0.05$). Heading date was the earliest for 'Ransom' winter wheat, followed by 'Willow Creek' winter wheat, 'Trical 2700' triticale and 'Monida' oats and 'Hays' forage barley had the latest heading date ($P < 0.05$; table 1). 'Willow Creek' winter wheat had the highest plant height at harvest, with 'Monida' oat and 'Hays' forage barley being the shortest (table 1). 'Willow Creek' winter wheat had the highest DM forage yield per acre (1.71 tons), followed by 'Ransom' winter wheat (1.43 tons), 'Hays' forage barley (1.36 tons), 'Monida' Oats (0.94 tons), with 'TriCal 2700' triticale (0.70 tons) having the lowest herbage yield. In winter wheat growing trials in Gallatin County, MT during 2003 to 2004, MSU researchers found similar survivability results for 'Willow Creek' winter wheat (Reich and Carlstrom, 2005). Cash and associates (2005) found that 'Willow Creek' winter wheat had a very rapid growth rate (3/4 inch height equating to 140 lbs of dry matter accumulation/day) when it was clipped which may account for 'Willow Creek' having the highest plant height at harvest and highest DM forage yield per acre. Additionally, Cash and colleagues (2005) found that 'Willow Creek' produced forage yields ranging from 2.2 to 4.1 tons per acre at the ten Montana locations in early July. In this trial, forage yields were positively impacted by good moisture levels through the winter and spring. Of the ten location sites, one site was an irrigated site with the other nine sites being dryland locations. In general, cereal varieties that are developed for forage production typically have higher herbage production compared to their cereal grain counterparts.

In this study, the nutritional data was not analyzed statistically; however general trends can be noted with the data. 'Hays' forage barley had the highest crude protein (CP) level (22.3%), followed by 'Monida' oat (21.1%), 'Trical 2700' triticale (19.7%), 'Willow Creek' winter wheat (16.9%) and 'Ransom'winter wheat (13.7%; table 2). Generally speaking, these protein levels would be more than adequate for either growing/finishing feedlot cattle or brood cows and would require very little additional protein supplementation in feeding rations for these animals.

For the five cereal forage varieties, 'Ransom' winter wheat had the highest ADF level (35.1%), followed by 'Willow Creek' winter wheat (33.8%), 'Trical 2700' triticale (31.5%), 'Monida' oat (27.7%), and 'Hays' forage barley having the lowest ADF level (26.3 %; table 2). This analysis indicates the relative digestibility of forages, with higher ADF levels being negatively correlated to digestibility (Van Soest, 1982; Fahey and Berger, 1988). Acid detergent fiber analysis digests the hemicellulose and cell wall proteins, leaving the cellulose, lignin and lignified nitrogen as a residue (Van Soest, 1982). As the ADF level increases, the forage becomes less digestible. 'Hays' forage barley would be predicted to have the highest digestibility, followed by 'Monida' oat, 'Trical 2700' triticale, 'Willow Creek' winter wheat, and 'Ransom' winter wheat being the least digestible.

In this study, 'Ransom' winter wheat had the highest NDF level (62%), followed by 'Willow Creek' winter wheat (60.8%), 'Trical 2700' triticale (58.8%), 'Monida' oat (54.2%), and 'Hays' forage barley the lowest NDF (53.8%; table 2). This analysis measures plant cell wall constituents, such as cellulose, hemicellulose, and lignin, which are partially digestible due to microbial breakdown. Cell walls or NDF level determines the volume of feed and its capacity to fill the rumen (Mertens, 2000). The rumen has an upper limit on its physical fill capacity: as the rate of ruminal fiber digestion decreases, the amount of slowly digestible organic matter remaining in the rumen increases (Zinn et al., 2004). Other influencing factors on the rate of fiber digestion include: the length of time the fiber is exposed to the fiber degradation process; fiber particle size; rate of particle size reduction via chewing and rumination; particle density, and rate of digestion (Zinn et al., 2004). This analysis is a predictor of voluntary forage intake and the availability of net energy: as the NDF level in forage increases, animals will consume lesser amounts of high NDF forage. Of the cereal varieties grown, 'Hays' forage barley would have the highest forage intake, followed by 'Monida' oat, 'Trical 2700, 'Willow Creek' winter wheat, and 'Ransom' winter wheat would be the lowest due to NDF levels (table 2). In this study, it is possible both winter wheat varieties were harvested in later pheneological stages as compared to the other cereal varieties which would account for their lower CP levels and higher ADF and NDF levels. As a plant matures (ages) and its support structures become more lignified, crude protein levels typically decrease and ADF and NDF levels increase. Cash and collaborators (2005) found similar results for 'Willow Creek' winter wheat grown across 10 different MT locations: in early growth stages of 'Willow Creek' winter wheat (late May), this variety was analyzed to have 25.4% CP, 22.5% ADF and 42.9% NDF; in later growth stages (late June), 'Willow Creek' winter wheat had a CP level of 14.2%, 39.9% ADF, and 60.2% NDF (2005).

The relative feed values (RFV) for the cereal varieties ranged from 92 to 118; 'Willow Creek' winter wheat had an RFV of 96 (table 2). 'Hays' forage barely had the highest RFV, with 'Ransom' winter wheat having the lowest RFV. A baseline RFV level is represented by any forage having an RFV of 100 and an NDF value of 53% and ADF value of 41%. Forages with RFV greater than 100 are considered higher quality and consequently, poorer quality forages are forages with RFV below 100. The forage RFV has been shown to be negatively associated with cell wall contents: as the ADF and NDF values go up, the forage's energy value decreases. However, forage CP levels are not part of the RFV calculation, even though CP has a direct impact on forage quality. Relative Feed Value was developed for the dairy industry to compare the energy intake potential of two or more like forages by lactating dairy cows. The RFV works extremely well in comparing legumes; however it has problems with grass hays (Anderson, 2006) since grass hays have more digestible fiber than alfalfa hay, which results in lower RFV for grass hays. Additionally, RFV doesn't predict performance as well by other types of animals such as beef cows, since potential energy intake has little influence on beef cow performance (Anderson, 2006). As a result, cattle producers typically focus on the TDN and CP levels in evaluating forage quality for brood cows.

The TDN (total digestible nutrients) levels ranged from 61.3 % ('Hays' forage barley) to 64.2% ('Ransom' winter wheat; table 2) with an average TDN level of 62.5%; 'Willow Creek' winter wheat had 63.4% TDN. Typically, forages containing TDN levels of 52% or less are classified as low quality forages; forages containing TDN levels between 53 and 59% are classified as average quality forages, and forages with TDN levels greater than 59% are classified as high quality forages. All five cereal varieties, including 'Willow Creek' winter wheat, would be classified as high quality forages due to their TDN content. Total Digestible nutrients are estimated from a feed's protein, fiber, nitrogen-free and ether extracts concentrations. A major drawback of TDN as an energy estimate is that it does not take into account all the major losses of energy associated with digestion and metabolism of feed. Because of this, TDN values overestimate the usable energy value of hays, straws and other roughages when compared to concentrates (grains). In the late 1960s, a system using net energy was developed by Lofgreen and Garrett (1968) called the net energy system. The net energy system represents the energy fraction in a feed that is left after accounting for all energy losses from feed digestion and metabolism. This energy is available to the animal for maintenance (NEm) for muscular work, maintenance and repair of tissues, for maintaining a stable body temperature or various productive purposes such as lactation (NE_l) or weight gain (NE_g). Net energy levels for maintenance and gain are listed for the five cereal varieties in table 2.

Nitrate concentrations for the five forages are reported on parts per million (ppm) basis (table 2). In this trial, nitrate concentrations ranged from 400 to 5300 ppm with an average of 2620 ppm. Both the 'Hays' barley and 'Monida' oat had the highest nitrate levels, 'Trical 2700' triticale was moderate, and 'Ransom' and 'Willow Creek' winter wheat varieties had the lowest nitrate levels (table 2). The winter wheat varieties may have lower nitrate levels due to being more mature than the spring cereals in this study. In addition to cereal grain varieties, some grass species and several weed varieties can accumulate nitrates in high levels under unusual growing conditions. Plants take up nitrogen in the form of nitrates from the soil through the plant's roots. During photosynthesis, these nitrates migrate from the roots into plant tissues and are converted into nitrites (an intermediate); the nitrites are further broken down to amino acids (protein) and ammonia (Cash et al., 2006). Nitrate levels become excessive when a plant accumulates nitrates faster than it can convert the nitrates into protein, leading to increased nitrate levels in plant tissue structures. Unusual growing conditions such as drought, frost, disease, high soil nitrogen levels, soil mineral deficiencies, and herbicide damage can lead to high nitrate accumulation. According to Cash and colleagues (2006), nitrate levels are highest in immature plant tissues (vegetative to boot stage in small grains) and decrease as plants mature (milk to dough stage in small grains). Stems (specifically the lower third) and nodes contain the highest nitrate concentrations, with leaves being intermediate and grain (seed heads) containing very little nitrates (Cash et al., 2006).

When nitrate forages are consumed by ruminants, rumen microorganisms incorporate nitrates into microbial protein by converting it into ammonia; however, only so much nitrate can be converted in a short time (Patterson, 2002). If too much nitrate is ingested, the nitrate will only be converted into a nitrite, an intermediate compound that is toxic to animals (Patterson, 2002). The excess nitrite is absorbed into the animal's bloodstream and combines with hemoglobin to form methemoglobin, which reduces the ability of blood to carry oxygen from the lungs to body tissues, resulting in suffocation (Cash et al., 2006). Early or chronic signs of nitrate poisoning include watery eyes, decreased appetite, rough hair, unthrifty appearance, weight loss or no weight gain, abortion, and Vitamin A deficiency. Signs of acute toxicity include increased pulse rate, labored breathing, shortness of breath, muscle tremors, weakness, staggering gait, membranes of the tongue, mouth, vulva and whites of the eyes turn blue (cyanosis), and death (Cash et al., 2006).

Possible explanations for the nitrate levels seen in this study include a legume (soybeans) being planted in the plots a year earlier, nitrogen application levels, and prolonged drought. All cereal varieties evaluated in this trial were grown in plots which had been in soybean production a year earlier; however, soil tests were conducted the previous fall on the plots and these tests would have accounted for the nitrogen fixing capacity of the soybean plants. Additionally, nitrogen fertilizer application rates were applied at levels to maximize grain production which may have impacted nitrate levels. And lastly, southwestern ND has had four years of prolonged drought where the local soils contain little subsoil moisture and have been unable to recharge soil moisture which may have also contributed to the nitrate levels. Nitrate levels of 1500 ppm to 5000 ppm nitrate are considered safe for non-pregnant livestock (Cash et al., 2006); however nitrate levels above 750 ppm nitrate are considered unsafe or toxic for pregnant cattle and ewes in late pregnancy (Patterson, 2002). If the 'Hays' barley and 'Monida' oat were to be used as a forage source for livestock, especially cattle and sheep, these varieties would require further dilution with other feed ingredients to lower their nitrate levels during feeding; 'Willow Creek' winter wheat would not require dilution if fed to non-pregnant animals but would require a small amount of dilution when fed to pregnant livestock. This dilution would enable the rumen microbes' time to convert ingested nitrates into ammonia. When readily fermentable starches, such as grain are also included in the diet, this nitrate conversion process is further enhanced and speeded up.

CONCLUSIONS

The winter wheat variety 'Willow Creek' can grow and perform under southwestern ND environmental conditions. 'Willow Creek' had the second earliest heading date, highest plant height at maturity and the highest DM forage yield per acre of the five cereal varieties evaluated in this study. This variety of winter wheat appears to have comparable nutritional attributes (crude protein, ADF, NDF, TDN and nitrate levels) to the other four cereal varieties tested. Since 'Willow Creek' is a winter cereal, its workload distribution (fall planting) is highly attractive to livestock producers. 'Willow Creek' winter wheat would be a potentially viable forage alternative for livestock producers in southwestern North Dakota.

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Crop	Variety	Winter Survival, %	Heading Date	Plant Height, inches	Harvest Moisture, %	Forage Yield, Tons/A[a]
Winter Wheat	Willow Creek	50	June 16	35	62	1.71
Winter Wheat	Ransom	57	June 8	25	58	1.43
Forage Barley	Hays	---	July 3	20	65	1.36
Oat	Monida	---	July 3	20	70	0.94
Triticale	Trical 2700	---	June 30	32	71	0.70
Trial Mean		53	June 25	26	65	1.19
C.V., %		7.7	1.4	5.9	---	21.0
LSD .05		NS[b]	1 day	2	---	0.39
LSD .01		NS[b]	1 day	3	---	0.56

Table 1. Comparison of Five Annual Winter and Spring Cereal Varieties: Harvest Quality
[a] Forage yields reported on a dry matter (DM) basis.
[b] NS = no statistical difference between varieties.

Table 2. Comparison of Five Annual Winter and Spring Cereal Varieties: Nutritional Quality

Cereal Variety	CP, %	ADF, %	NDF, %	TDN, %	NEm, Mcal/cwt	NEg, Mcal/cwt	Ca, %	P, %	K, %	RFV	Nitrate, ppm
Willow Creek	16.9	33.8	60.8	63.4	65	37	0.28	0.28	1.98	96	800
Ransom	13.7	35.1	62.0	64.2	66	38	0.27	0.24	1.57	92	400
Hays	22.3	26.3	53.8	61.3	62	34	0.36	0.32	3.15	118	5300
Monida	21.1	27.7	54.2	61.8	62	35	0.39	0.30	3.86	116	5100
Trical 2700	19.7	31.5	58.8	62.0	63	35	0.32	0.31	3.13	102	1500
Trial Mean	18.7	30.9	57.9	62.5	64	36	0.32	0.29	2.74	105	2620

NDSU 2006 HRSW Variety Trial - Continuously Cropped - No-till
Area 4 SCD Cooperative Research Farm @ Mandan, ND

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Eric Ericsmoen, NDSU Agronomist

Variety	Test Weight	Grain Protein	---- Grain Yield ---- 2004	2005	2006	Average Yield 2 yr	3 yr
	Lbs/bu	%	----------- Bushels per acre -----------				
Briggs	55.0	16.3	45.7	66.3	27.9	47.1	46.6
Mercury	54.5	16.3	43.5	57.6	28.1	42.8	43.1
Reeder	53.3	16.6	45.0	49.3	33.0	41.2	42.4
Oxen	53.9	16.0	41.7	49.3	31.6	40.4	40.9
Fryer	54.2	16.5		64.8	30.0	47.4	
Glenn	55.1	16.5		63.7	30.2	47.0	
Granger	55.6	16.5		63.3	30.4	46.8	
Howard	53.4	16.2		61.9	30.4	46.2	
Steele-ND	54.0	16.4		62.0	29.6	45.8	
Traverse	51.7	15.6			31.6		
Trial Mean	54.1	16.2	40.1	58.7	29.7	--	--
C.V. %	1.2	2.9	9.4	7.3	9.3	--	--
LSD .05	1.1	NS	6.4	7.2	4.7	--	--
LSD .01	1.5	NS	8.6	9.8	6.3	--	--

Planting Date: April 25, 2006
Harvest Date: August 4, 2006
Seeding Rate: 1.1 million live seeds / acre (approx. 1.6 bu/A).
Previous Crop: 2003 = Barley, 2004 = Lentil, 2005 = hrww.
NS = no statistical difference between varieties.
Note: The 2006 trial sustained severe heat and moisture stress.

NDSU 2006 WINTER WHEAT VARIETY TRIAL - CONTINUOUSLY CROPPED - NO-TILL
AREA 4 SCD COOPERATIVE RESEARCH FARM @ MANDAN, ND
This trial was funded by Ducks Unlimited, Bismarck

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Eric Ericsmoen, NDSU Agronomist

Variety	Winter Surv.	Test Weight	Grain Protein	---- Grain Yield ---- 2004	2005	2006	Average Yield 2 yr	3 yr
	%	Lbs/bu	%	----------- Bushels per acre -----------				
Harding	88	56.6	13.3	52.6	52.8	36.5	44.6	47.3
Jerry	93	55.4	14.5	54.3	46.1	39.1	42.6	46.5
Millennium	87	57.3	12.5	55.0	40.0	36.9	38.4	44.0
Roughrider	83	58.1	13.9	44.2	36.1	37.2	36.6	39.2
Expedition	90	58.8	12.6	50.0	27.4	36.9	32.2	38.1
Ransom	85	54.4	13.2	51.1	32.2	30.9	31.6	38.1
Wesley	83	56.7	13.8	49.5	12.8	41.1	27.0	34.5
CDC Falcon	90	55.0	14.1	48.0	16.9	37.4	27.2	34.1
CDC Buteo	87	58.3	13.1		32.8	38.3	35.6	
McClintock	78	57.4	14.3		21.7	35.7	28.7	
Wendy*	90	58.5	12.7		17.8	39.5	28.6	
Yellowstone	67	55.6	14.0		12.5	34.5	23.5	
Alice*	90	57.6	12.2			43.5		
Jagalene	82	58.6	12.6	52.2		42.0		
Paul	87	54.1	13.4			41.5		
Radiant	85	55.8	14.4			36.5		
Goodstreak	80	55.2	12.1			34.5		
Trial Mean	85	56.7	13.4	51.0	27.4	37.5	--	--
C.V. %	13.8	1.4	5.2	6.7	20.7	16.5	--	--
LSD .05	NS	1.3	1.1	5.7	9.5	NS	--	--
LSD .01	NS	1.7	1.5	7.6	12.9	NS	--	--

* Hard white winter wheat

Planting Date: September 20, 2005 Harvest Date: August 4, 2006
Seeding Rate: 1 million live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2003 = barley, 2004 = lentil, 2005 = HRWW.
Notes: Trial sustained severe late season heat and moisture stress.

NDSU 2006 DURUM VARIETY TRIAL - CONTINUOUSLY CROPPED - NO-TILL
AREA 4 SCD COOPERATIVE RESEARCH FARM @ MANDAN, ND

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Variety	Test Weight	Grain Protein	---- Grain Yield ---- 2004	2005	2006	Average Yield 2 yr	3 yr
	Lbs/bu	%	----------- Bushels per acre -----------				
Mountrail	49.4	17.8	37.6	67.2	27.3	47.2	44.0
Grenora	52.3	17.3	38.3	67.6	25.7	46.6	43.9
Ben	52.1	18.9	34.4	68.7	28.6	48.6	43.9
Lebsock	55.0	17.2	32.6	68.5	27.5	48.0	42.9
Alkabo	52.3	18.5		69.1	28.1	48.6	
Divide	50.6	18.2		67.0	26.7	46.8	
Trial Mean	51.9	18.0	34.8	68.0	27.3	--	--
C.V. %	1.4	4.2	13.5	2.4	7.6	--	--
LSD .05	1.4	NS	NS	NS	NS	--	--
LSD .01	1.9	NS	NS	NS	NS	--	--

Planting Date: April 25, 2006
Harvest Date: August 4, 2006
Seeding Rate: 1.25 million live seeds / acre (approx. 2.2 bu/A).
Previous Crop: 2003 = Barley, 2004 = Lentil, 2005 = hrww.
NS = no statistical difference between varieties.

NDSU 2006 OAT VARIETY TRIAL - CONTINUOUSLY CROPPED - NO-TILL
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Variety	Test Weight	---- Grain Yield ---- 2003	2004	2006	Average Yield 2 yr	3 yr
	Lbs/bu	----------- Bushels per acre -----------				
Killdeer	32.5	92.5	86.1	53.3	69.7	77.3
Beach	33.5	85.4	64.2	44.4	54.3	64.7
Morton	30.4	77.5	60.8	47.0	53.9	61.8
Jerry	33.5			54.8		
Maida	33.0			51.1		
Souris	33.3			50.4		
Trial Mean	32.7	80.8	67.0	50.2	--	--
C.V. %	2.1	6.3	9.5	11.3	--	--
LSD .05	1.3	7.9	11.6	NS	--	--
LSD .01	1.8	11.0	16.5	NS	--	--

Planting Date: April 25, 2006 Harvest Date: August 4, 2006
Seeding Rate: 750,000 live seeds / acre (approx. 1.7 bu/A).
Previous Crop: 2002 & 2003 = Barley, 2005 = hrww.
NS = no statistical difference between varieties.
Notes: The 2006 trial sustained severe heat and moisture stress.

NDSU 2006 BARLEY VARIETY TRIAL - CONTINUOUSLY CROPPED - NO-TILL
AREA 4 SCD COOPERATIVE RESEARCH FARM @ MANDAN, ND

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Variety	Test Weight	% Plump	Grain Protein	---- Grain Yield ---- 2004	2005	2006	Average Yield 2 yr	3 yr
	Lbs/bu	>6/64	%	----------- Bushels per acre -----------				
2 Row Types								
Rawson	42.6	76	13.5	48.2	79.5	42.7	61.1	56.8
Haxby	41.0	24	15.4	56.1	60.0	34.8	47.4	50.3
Conlon	38.9	24	14.8	24.7	37.3	36.8	37.0	32.9
Eslick	41.3	19	14.9		76.6	47.4	62.0	
6 Row Types								
Tradition	41.7	30	14.3	41.3	65.9	46.4	56.2	51.2
Drummond	42.7	40	13.8	48.1	33.8	46.2	40.0	42.7
Robust	40.3	42	14.4	43.2	47.2	37.0	42.1	42.5
Stellar-ND	41.5	39	14.9		72.4	40.3	56.4	
Trial Mean	41.2	36	14.6	43.6	59.1	41.1	--	--
C.V. %	5.2	16.5	9.4	16.3	13.3	11.4	--	--
LSD .05	NS	10	NS	12.9	13.8	8.1	--	--
LSD .01	NS	14	NS	18.4	19.1	NS	--	--

Planting Date: April 35, 2006
Harvest Date: August 4, 2006
Seeding Rate: 750,000 live seeds / acre (approx. 1.4 bu/A).
Previous Crop: 2003 = barley, 2004 = lentil, 2005 = hrww.
NS = no statistical difference between varieties.
Note: The 2006 trial sustained severe heat and moisture stress.

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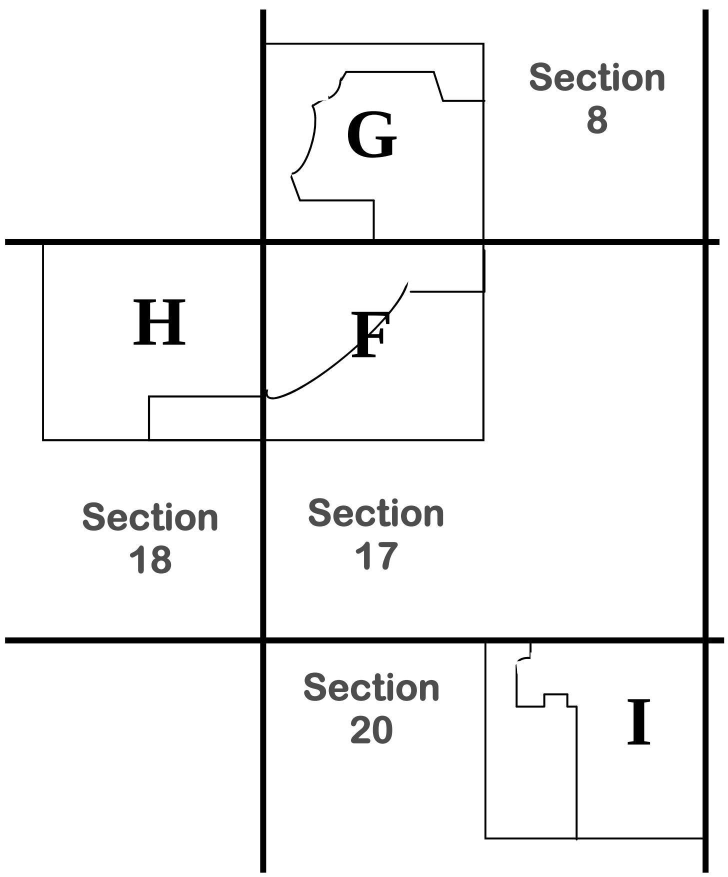

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