1999 RESEARCH and CROPPING RESULTS
Area IV SCD/ARS Research Farm

Sixteenth Annual Progress Report
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NOTICE

Contents relate to a Cooperative Agreement between USDA-ARS and Area IV Soil Conservation Districts represented by the Area IV SCD Research Advisory Committee. **The preliminary results of this report cannot be used for publication or reproduction without permission of the research scientists involved.**

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OTHER RELATED NGPRL RESEARCH

INTRODUCTION
AREA IV SCD/ARS RESEARCH FARM

The Area IV SCD/ARS Research Farm is the result of a specific cooperative agreement between USDA-ARS and the twelve Soil Conservation Districts (SCDs) that make up Area IV. This agreement was put in place in 1984. Through this agreement, the Area IV SCDs lease cropland from the Nelson estate for the Northern Great Plains Research Lab, USDA-ARS, to conduct cooperative research projects with the Area IV SCDs. Total cropland leased by AREA IV SCDs is 382 acres. In addition, USDA-ARS has leased 55 acres in sec. 17 and sec. 18 for soil and water conservation research for many years and another 26 acres in sec. 8 for tree plantings since 1989. Total acreage leased for research purposes is 463 acres. The Area IV Research Farm is located southwest of the USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND (Figure 1). The general 1999 cropping plans are outlined on maps for the four field areas designated as F, G, H, and I (Figure 2). The precipitation pattern for the 1999 growing season and the total precipitation history (1984-1999) for the duration of the Area IV cooperative agreement is shown in Figure 3 and Figure 4.

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Market options

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Corn, soybean

FIG. 1. LOCATION OF ARS AND AREA IV RESEARCH FARM LAND RESOURCES

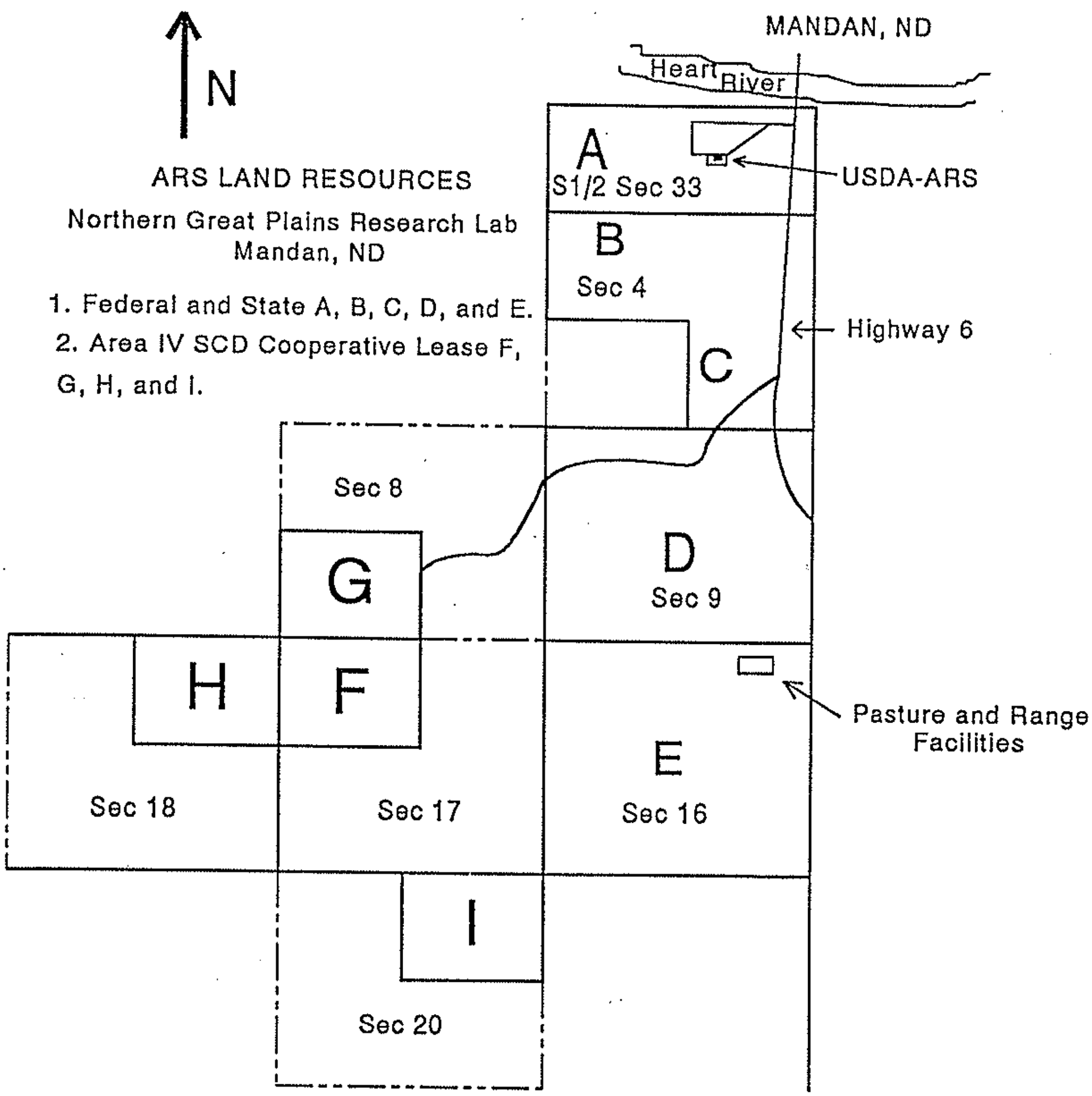


FIG. 2. AREA IV RESEARCH FARM CROP PLAN - 1999.

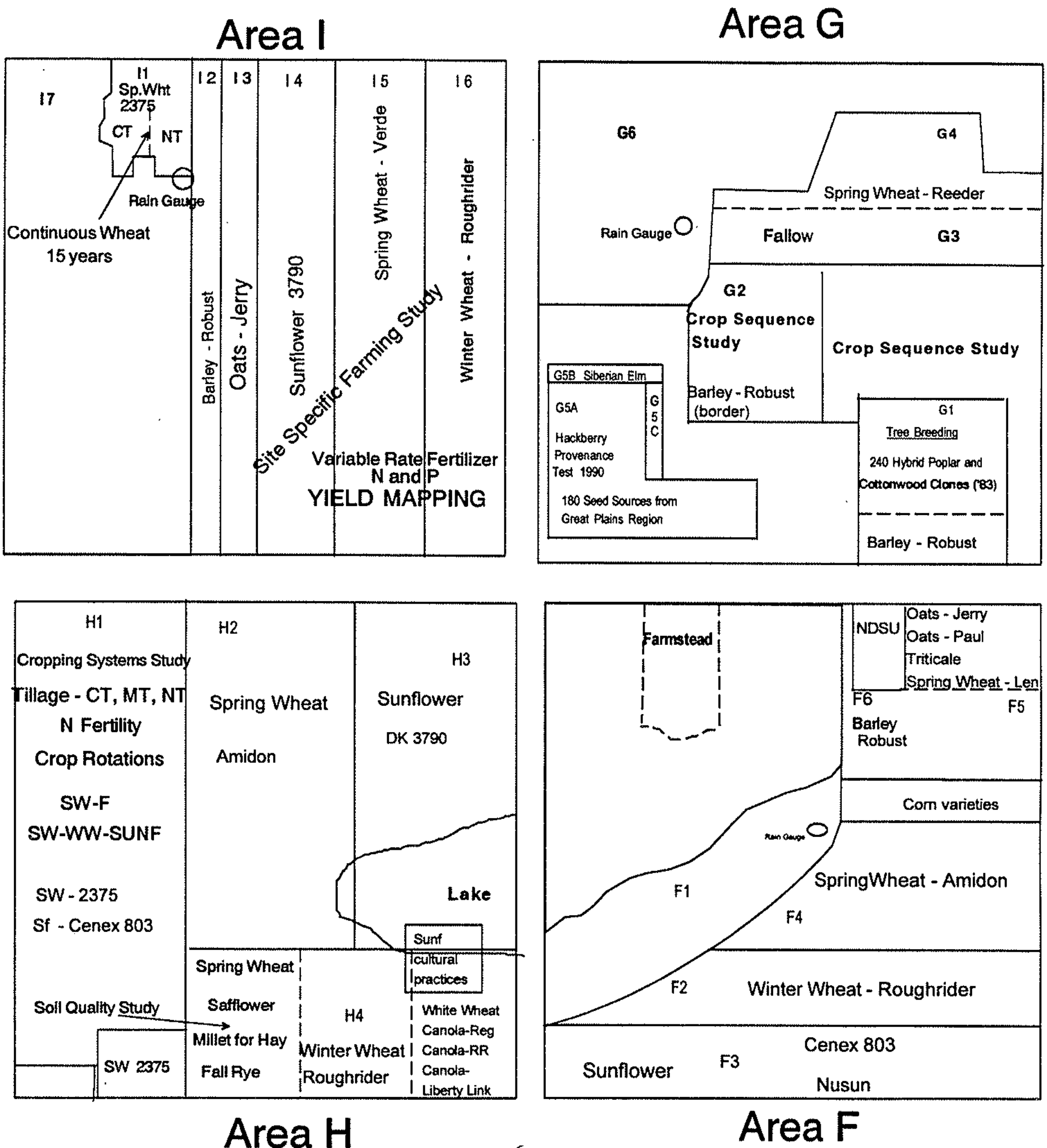


Fig. 3. Monthly Precipitation

Oct-98 through Sep-99
Field plots, Mandan, ND

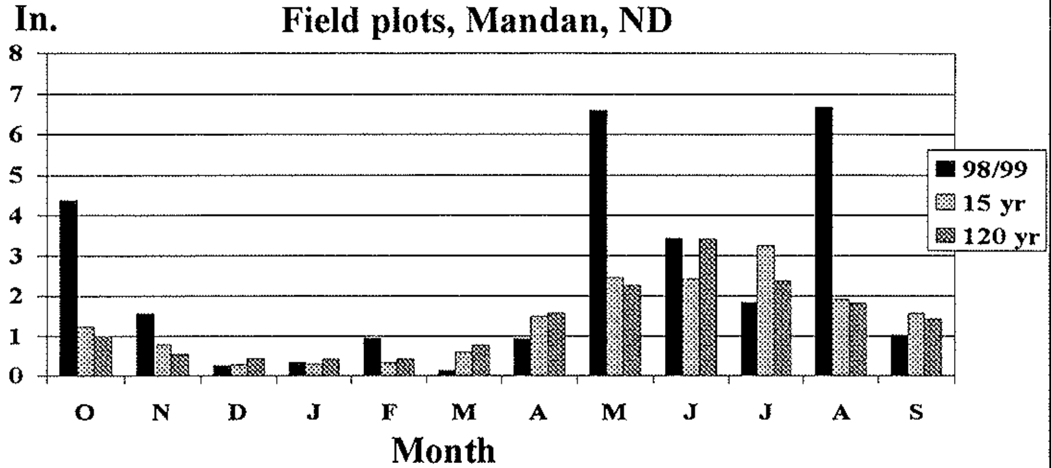
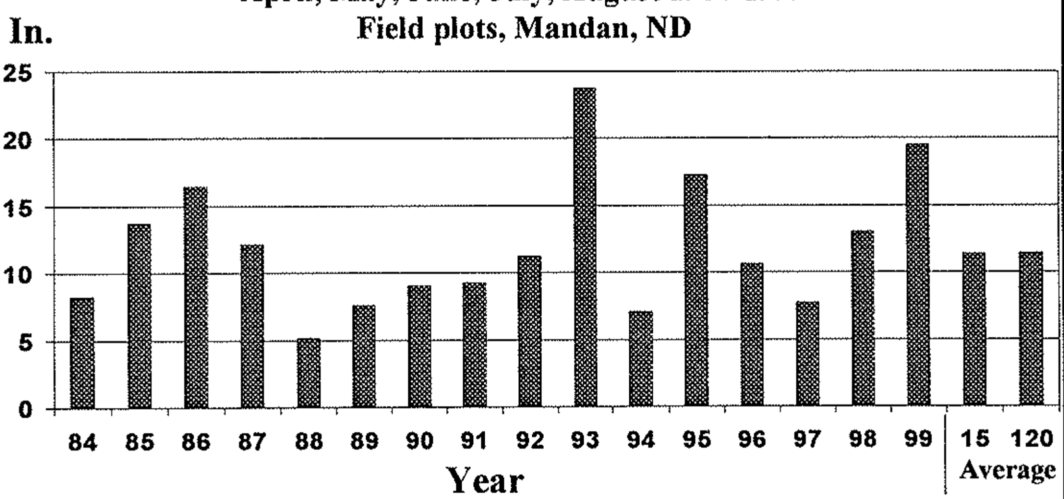


Fig. 4. Growing Season Precipitation

April, May, June, July, August 1984-1999
Field plots, Mandan, ND



MANAGEMENT PRACTICES
AREA IV SCD/ARS RESEARCH FARM

AREA-F FIELD OPERATIONS, NW 1/4 Section 17 (Fig. 2)

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

Field F2, Roughrider winter wheat. Amidon spring wheat (35.1 bu/a) was present in 1998. The field was sprayed with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) on September 3, 1998. On September 18, 1998, Roughrider winter wheat was seeded. The seeding rate was 1.3 million seeds/a and 18-46-0 was applied with the seed at a rate of 60 lb/a. The south half of the field was seeded with a Concord air seeder and the north side was seeded with a Haybuster 8000 drill. Both drills have hoe openers and 10-inch row spacing. Urea was contract broadcast at 70 lb N/a on March 30, 1999. The field received an aerial application of Buctril (16 oz product/a) plus 2,4-D (16 oz product/a) on May 12, 1999. The crop was swathed on July 23, 1999 and harvested on July 27, 1999. The Roughrider winter wheat yield was 44.3 bu/a with a test weight of 60 lb/bu and a protein content of 14%. Fall spraying with Roundup Ultra (24 oz product/a) was completed on September 10, 1999.

Field F3, Sunflower. Amidon spring wheat (30.5 bu/a) was grown in 1998. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was done on September 3, 1998. Anhydrous ammonia was contract applied at 70 lb N/a on April 4, 1999. Sonalan 10g was applied with a Gandy air applicator mounted on a Haybuster undercutter at 10 lb material/a on April 30, 1999. The second incorporation of the Sonalan was performed with a JD Mulchmaster on June 2, 1999. DeKalb's Nusun sunflower was planted in the south one third of the field on June 2, 1999. Cenex 803 sunflower was planted on the north side of the field on June 3, 1999. Both varieties were planted with a JD Maxemerge II planter in 30-inch rows at a population of 25,000 seeds/a. The field was sprayed with Assert (0.8 pint product/a) on June 30, 1999 and with Poast (1.5 pint product/a) plus Preference (1 quart product/a) on July 1, 1999. Asana (4.5 oz product/a) was contract sprayed on August 13, 1999. The Cenex 803 variety was harvested on October 19, 1999. The DeKalb's Nusun variety was harvested on October 22, 1999. The yields were estimated with a combine yield monitor. Cenex 803 and DeKalb's Nusun both yielded 1690 lb/a.

Field F4, Amidon spring wheat. The previous crop was sunflower (2231 lb/a). Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was done on October 22, 1998. Anhydrous ammonia was contract applied at 70 lb N/a on April 13, 1999. The field was reduced tilled with a JD Mulchmaster on May 20, 1999. On the same day, Amidon spring wheat was seeded with a JD 750 no-till disk drill with a 7.5-inch row space. The seeding rate was 1.3 million seeds/a and 11-52-0 fertilizer was placed with the seed at 50 lb/a. The north half of the field was sprayed with Puma (5 oz product/a) plus Bronate (16 oz product/a) on

June 10, 1999 and the south half was sprayed with Puma (5 oz product/a) plus Starane (0.67 pint product/a) on June 11, 1999. The crop was swathed on August 20, 1999 and harvested on September 1, 1999. The Amidon spring wheat yield was estimated at 30.8 bu/a with a combine yield monitor. The field was sprayed with Roundup Ultra (24 oz product/a) on September 15, 1999. The north side of the field was seeded to SD 92-107 winter wheat (a new unnamed hard red winter wheat recently released by South Dakota State University) and the south side was seeded to Roughrider winter wheat on September 24, 1999. All of the seeding was performed with a Haybuster 8000 hoe drill (10-inch row space). The planting rate was 1.3 million seeds/a and 11-52-0 fertilizer was applied with the seed at 50 lb/a.

Field F5 and F6, Robust barley. This area was in sunflowers (2500 lb/a) in 1998. The field was sprayed with Roundup Ultra (20 oz product/a) plus 2,4-D (16 oz product/a) on May 25, 1999. The area was reduced tilled with a JD Mulchmaster on May 26, 1999. Robust barley was seeded on May 27, 1999 with a Haybuster 1000 disk drill (7.5-inch row space). Urea was applied between the seed rows at 70 lb N/a and 11-52-0 was placed with the seed at 50 lb/a. The field was sprayed with Puma (5 oz product/a) plus Starane (0.67 pint product/a) on June 18, 1999. The crop was swathed on August 18, 1999. Harvest was completed on August 27, 1999. The Robust barley yielded 56.5 bu/a. The field was sprayed with Roundup Ultra (24 oz product/a) on September 16, 1999.

AREA-G FIELD OPERATIONS, SW 1/4 Section 8 (Fig. 2)

Field G1. Forage Grass Breeding and Genetics. The southwest corner of field G1 is being used as a holding nursery for approximately 300 parent clones of crested wheatgrass. Progenies of these clones, which were tested for forage yield in the past, are currently undergoing laboratory tests for forage quality. Based on these tests, the most promising of the 300 clones will be selected for inclusion in improved experimental strains of crested wheatgrass. Preliminary results indicate that forage digestibility of crested wheatgrass can be improved. Contact Dr. John Berdahl for additional information (refer to scientific staff listing).

Field G1. Hybrid Poplar Clonal Test. The north side of field G1 is a plantation of 240 hybrid poplar and cottonwood clones. Clones were evaluated for drought and cold hardy as well as resistant to damage from insects and diseases. One variety, CANAM poplar, has been identified and released. For additional information contact Dr. Richard Cunningham, retired, NGPRL.

Field G2. Alternative Crops/Crop Sequence Project. For information on cropping sequences with alternative crops check reports starting on page 14.

Field G3. Fallow. This field was previously in Verde spring wheat (53.8 bu/a). Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 16, 1998. The field was sprayed with Fallowmaster (32 oz product/a) on June 2, 1999 and

August 19, 1999. It was sprayed with Roundup Ultra (24 oz product/a) on September 21, 1999.

Field G4. Reeder spring wheat. This field was chemically fallowed in 1998. Reeder spring wheat was seeded on April 29, 1999 with a JD 750 no-till drill (7.5-inch row space). Urea was placed between the seed rows at 40 lb N/a and 11-52-0 was placed with the seed at 50 lb/a. The seeding rate was 1.3 million seeds/a. The field was sprayed with Puma (5 oz product/a) plus Bronate (16 oz product/a) on June 1, 1999. The crop was swathed on August 4, 1999. The harvesting was started on August 11 and was completed on August 24, 1999. The delay was due to wet weather. Reeder spring wheat yielded 38.6 bu/a. Fall spraying with Roundup Ultra (24 oz product/a) was completed on September 17, 1999.

Field G5. Tree Germplasm Plantations, USDA-ARS leased land.
5a. Hackberry Provenance Test - This area serves as the site for a seed source trial of hackberry accessions collected from 180 native tree stands throughout the Great Plains.
5b. Siberian Elm Provenance Test - Seedlings from 18 sources from Russia were planted in 10 replications in the spring of 1992.
5c. Siberian Elm Clonal Test - Fifty-five trees, from windbreaks in North and South Dakota, selected for possible disease and insect resistance were planted in four replications in 1990. For additional information contact Dr. Richard Cunningham, retired NGPRL.

AREA-H FIELD OPERATIONS, NE 1/4 Section 18 (Fig. 2)

Field H1. Long-term cropping systems study, 65A study. For additional information check 'Long-term cropping study' starting on page 29.

Field H2. Amidon spring wheat. The Robust barley crop yielded 53.8 bu/a in 1998. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 10, 1998. Anhydrous ammonia was contract applied on April 13, 1999 at 70 lb N/a. The field was reduced tilled with a JD Mulchmaster on May 24, 1999. Amidon spring wheat was seeded on May 25, 1999 with a JD 750 no-till disk drill (7.5-inch row space). The seeding rate was 1.3 million seeds/a and 11-52-0 was applied with the seed at 50 lb/a. The field was sprayed with Puma (5 oz product/a) plus Bronate (16 oz product/a) on June 10, 1999. Swathing was completed on August 19, 1999. Harvest was started on September 1 and was completed on September 7, 1999. The delay was due to wet weather. The Amidon spring wheat yield was estimated at 20 bu/a with a combine yield monitor.

Field H3. Sunflower. Roughrider winter wheat (26.6 bu/a) was present in 1998. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 11, 1998. Anhydrous ammonia was contract applied at 70 lb N/a on April 13, 1999. Sonalan 10g was applied with a Gandy air applicator mounted on a Haybuster undercutter at 10 lb material/a on May 26, 1999. The field was reduced tilled with a JD Mulchmaster for the second incorporation of the Sonalan on June 4, 1999. DeKalb's 3790 sunflower was planted;

half of the field on June 4, and the remainder on June 10, 1999. The delay was due to rain showers. A JD Maxemerge II planter with 30-inch rows was used and the population was 25,000 seeds/a. A small area of the field was seeded with a Concord air seeder on June 11, 1999. The sunflowers were sprayed with Assert (0.8 pints product/a) on June 30 and Poast (1.5 pints product/a) plus Preference (1 quart product/a) on July 1, 1999. Four blocks (100' x 100') on the east side were sprayed with Warrior (2.56 oz product/a) on July 14, 1999 as part of cooperative insect study with the USDA-ARS Sunflower Lab, Fargo. The crop was contract sprayed with Asana (4.5 oz product/a) on August 13, 1999. The crop was harvested on October 20, 1999. A yield of 1990 lb/a was estimated with a combine yield monitor for the main field. A yield of 910 lb/a was estimated for the area seeded with the Concord air seeder. The field was sprayed with Roundup Ultra (24 oz product/a) on October 20, 1999.

Field H4. Soil Quality Study. A long-term study was initiated in the spring of 1993 to evaluate the influence of tillage and crop rotations on soil quality factors. For additional information see 'Management Strategies for Soil Quality' on page 37.

Field H4. Center Bulk Area, Roughrider winter wheat. Butte 86 spring wheat (30 bu/a) was the crop 1998. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 10, 1998. Roughrider winter wheat was seeded with a Haybuster 8000 drill on September 18, 1998. The drill has hoe openers with 10-inch row spacing. Fertilizer as 18-46-0 was applied with the seed at 60 lb/a. Urea fertilizer was contract applied at 70 lb N/a on March 30, 1999. The field received an aerial application of Buctril (16 oz product/a) plus 2,4-D (16 oz product/a) on May 12, 1999. Swathing was completed on July 23, 1999 and the crop was harvested on July 29, 1999. The Roughrider winter wheat yield was 31 bu/a and had a protein content of 13%. The field was sprayed with Roundup Ultra (24 oz product/a) on September 14, 1999.

Field H4. Sunflower cultural practices and Canola varieties. This area was planted to Canola varieties and a sunflower management trial. For more information see 'Cultural Systems for Sunflower' on page 39 and 'No-Till Canola Production' on page 42.

AREA-I FIELD OPERATIONS, NE 1/4 Section 20 (Fig. 2)

Field I1. Spring wheat 2375. This continuous spring wheat field provides a location for monitoring wheat diseases. Spring wheat 2375 (29.5 bu/a) was present in 1998. The no-till portion of the field was sprayed with Roundup Ultra (20 oz product/a) plus 2,4-D (16 oz product/a) on May 14, 1999 and the remainder of the field was reduced tilled with a JD Mulchmaster on May 20, 1999. Spring wheat 2375 was seeded with a Concord air seeder. The seeder has hoe openers with a 10-inch row space. The seeding rate was 1.3 million seeds/a. Urea was applied at 70 lb N/a and 11-52-0 was applied at 50 lb/a between the split seed row. The field was sprayed with Puma (5 oz product/a) plus Bronate (16 oz product/a) on June 10, 1999. The crop was swathed on August 23, 1999 and harvested on September 8, 1999. The 2375 spring wheat yield was 29 bu/a. Fall spraying with Roundup Ultra (24 oz product/a) was completed on September 20, 1999.

Field I2. Robust barley. Spring wheat 2375 (31.4 bu/a) was present in 1998. Anhydrous ammonia was contract applied at a rate of 70 lb N/a on April 13, 1999. The field was spot sprayed with Roundup Ultra (20 oz product/a) plus 2,4-D (16 oz product/a) on May 14, 1999. The field was reduced tilled with a JD Mulchmaster on May 19, 1999. Robust barley was seeded on May 20, 1999 with a Haybuster 1000 disk drill (7.5-inch row space). Fertilizer as 11-52-0 was applied with the seed at 50 lb/a. The field was sprayed with Puma (5 oz product/a) plus Bronate (16 oz product/a) on June 10, 1999. Swathing was completed on August 17, 1999. The crop was harvested on August 26, 1999. Robust barley yielded 76.7 bu/a. Fall spraying with Roundup Ultra (24 oz product/a) was completed on September 15, 1999.

Field I3. Jerry oat. This field was planted to spring wheat in a variable seeding rate test in 1998. Anhydrous ammonia was contract applied at a rate of 70 lb N/a on April 13, 1999. The field was spot sprayed with Roundup Ultra (20 oz product/a) plus 2,4-D (16 oz product/a) on May 14, 1999. The field was reduced tilled with a JD Mulchmaster on May 19, 1999. Jerry oats were seeded on May 20, 1999 with a JD 750 no-till drill (disk openers at 7.5-inch row space). Fertilizer as 11-52-0 was applied with the seed at 50 lb/a. The field was sprayed with MCPE (8 oz product/a) on June 18, 1999. The crop was swathed on August 9, 1999 and harvested on August 19, 1999. The Jerry oat yield was 92.7 bu/a. The field was sprayed with Roundup Ultra (24 oz product/a) on September 15, 1999.

Field I4. Site-Specific Farming Study, sunflower. Roughrider winter wheat (24 bu/a) was present in 1998. Sonalan 10g was applied at a rate of 10 lb material/a with a Gandy air applicator mounted on a Haybuster undercutter on April 29, 1999. Urea was applied at 115 lb N/a along with 40 lb/a of 11-52-0 on May 14, 1999. The second incorporation of the Sonalan was performed with a JD Mulchmaster on June 3, 1999. DeKalb's 3790 sunflower was planted on June 4, 1999 with a JD Maxemerge II planter. The seed population was 25,000 seeds/a in 30-inch rows. The sunflowers were spot sprayed with Assert (0.8 pints product/a) on June 30, 1999 and spot sprayed with Poast (1.5 pint product/a) plus Preference (1 quart product/a) on July 1, 1999. Four blocks (100 X 100 ft) on the east edge of the field were sprayed with Warrior (2.56 oz/a) on July 1, 1999 as part of cooperative insect study with the USDA-ARS Sunflower Lab, Fargo. Going south from the northeast corner the 1st block is located 100 ft from the north edge and is marked with a red flag; the NE corner of the 2nd block is located 300 ft from the north edge of the field etc. The field was contract sprayed with Asana (4.5 oz product/a) on August 13, 1999. The crop was combined on October 21, 1999 using GPS equipment and a combine yield monitor. The average yield of the DeKalb's 3790 sunflower was 2230 lb/a. For additional information on site-specific farming see the report 'Site-Specific Farming Project' on page 44.

Field I5. Site-Specific Farming Study, Verde spring wheat. A sunflower crop (936 lb/a) was present in 1998. Verde spring wheat was seeded with a Concord air seeder (hoe openers and 10-inch row spacing) on April 29, 1999. Urea was applied at 110 lb N/a and 11-52-0 was applied at 50 lb/a between the split seed row at planting. The seeding rate was 1.3 million seeds/a. The field was sprayed with Puma (5 oz product/a) plus Bronate (16 oz product/a) on June 1, 1999. The crop was swathed on August 6, 1999 and harvested using GPS equipment and a combine yield monitor to map the yields. The average yield of the Verde spring wheat was 51.8 bu/a. The field was sprayed with Roundup Ultra (24 oz product /a) on September 10, 1999 and again on September 28, 1999. For additional information on site-specific farming see the report 'Site-Specific Farming Project' on page 44.

Field I6. Site-Specific Farming Study, Roughrider winter wheat. Spring wheat 2375 (32.8 bu/a) was present in 1998. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 4, 1998. Roughrider winter wheat was seeded on September 17, 1998 with a Concord air seeder (hoe openers at 10-inch row space). The seeding rate was 1.3 million seeds/a and urea plus 11-52-0 were applied between the split seed row at variable rates determined by soil test and yield monitor maps. The field received an aerial application of Buctril (16 oz product/a) plus 2,4-D (16 oz product/a) on May 12, 1999. Swathing was completed on July 26, 1999. The crop was harvested on July 28, 1999 using GPS equipment and a combine yield monitor to map the yields. The average yield for Roughrider winter wheat was 36.6 bu/a with a protein content of 13%. The field was sprayed with Fallowmaster (32 oz product/a) on August 19, 1999 and with Roundup Ultra (24 oz product /a) on September 28, 1999. For additional information on site-specific farming see the report 'Site-Specific Farming Project' on page 44.

ALTERNATIVE CROPS/CROP SEQUENCE PROJECT

Drs. Donald Tanaka, Steve Merrill, Ron Ries, and Joe Krupinsky

INTRODUCTION

In 1998, phase II of the alternative crops research was initiated to determine the sequence crops should follow to take advantage of the previous crop and crop residues. In 1999, all ten crops were seeded into the crop residue of the same ten crop residues from the previous year (100 treatment combinations). Roundup (Table 2) was applied after seeding early season crops (canola, crambe, dry pea, flax, safflower, barley, and spring wheat) and before seeding late season crops (dry bean, sunflower, and soybean). All crops were seeded no-till with a JD-750 no-till drill and 60 lb N/a and 10 lb P/a were applied at seeding. Seeding date, harvest date, commodity price, and seeding rate are shown in Table 1 with herbicide rate and date shown in Table 2. Growing season precipitation (May through September) for 1999 was 179% of the long-term average (Fig. 1). The above-average precipitation for May delayed seeding of early season crops.

CROP PRODUCTION

Dr. Donald Tanaka

Crop and crop residues in no-till influenced crop production in 1999. In general, two years of the same crop resulted in close to the lowest seed yield (Table 3). An example is flax after flax, where seed yield was half the yield of flax after other crops. The exception was soybean after soybean. The greatest soybean seed yield was because soybean has not been previously grown in this field and seed inoculation may not have been adequate the first time, the second inoculation greatly benefitted soybean. Gross returns for each crop are shown in Table 4. Barley grown for malt produced greatest returns of all crops ($190.00/a or greater). **Caution should be used when evaluating seed yield and gross returns since weather and commodity price can greatly influence results.**

Table 1. Seeding Date, market price, and number of viable seeds per acre seeded for the 1999 altenative crops.

Crop	Seeding Date	Harvest Date	$/lb*	Viable Seeds/a
Canola (Dynamite)	May 26	August 23	$0.069	1 Million
Crambe (Meyer)	May 26	August 20	$0.100	800,000
Dry Bean (T39 Black Turtle)	June 2	September 23	$0.140	90,000
Dry Pea (Profi)	May 26	August 18	$0.046	350,000
Flax (Omega)	May 26	September 17	$0.063	4 Million
Safflower (Montola 2000)	May 26	September 15	$0.110	200,000
Soybean (Jim)	June 1	September 29	$0.063	200,000
Sunflower (Cenex 803)	June 1	October 6	$0.068	28,000
Wheat (Amidon)	May 25	September 1	$0.046	1.3 Million
Barley (Stander) -- Feed	May 26	August 19	$0.027	1.3 Million
Barley (Stander) -- Malt	May 26	August 19	$0.049	1.3 Million

*Market value from late November to early December, 1999, at Bismarck, ND.

Table 2. Date and type of chemical used for weed control in the 1999 alternative crops.

Crop	Date	Chemical/acre	Date	Chemical/a	Date	Chemical/a
Canola (Dynamite)	6/15/99	Poast (1pt)				
Crambe (Meyer)	6/15/99	Poast (1pt)				
Dry Bean (T39 Black Turtle)	6/24/99	Poast (1.5pt)	6/30/99	Basagran (1.5pt)		
Dry Pea (Profi)	6/15/99	Poast (1pt)				
Flax (Omega)	6/15/99	Poast (1pt)	7/1/99	Bornate (14 oz)		
Safflower (Montola 2000)	6/15/99 & 6/24/99	Post Emergence Herbicide				
Soybean (Jim)	6/24/99	Pinnacle (.5 oz)	6/24/99	Poast (1.5pt)	6/30/99	Basagran (1.5pt)
Sunflower (Cenex 803)	6/24/99	Poast (1.5pt)	7/1/99	Assert (13 oz)		
Wheat (Amidon)	6/10/99	Puma (5 oz) & Bronate (1 pt)				
Barley (Stander)	6/10/99	Puma (5 oz) & Bronate (1 pt)				
Alt Crop Study	5/28/99	Roundup (1 pt)				

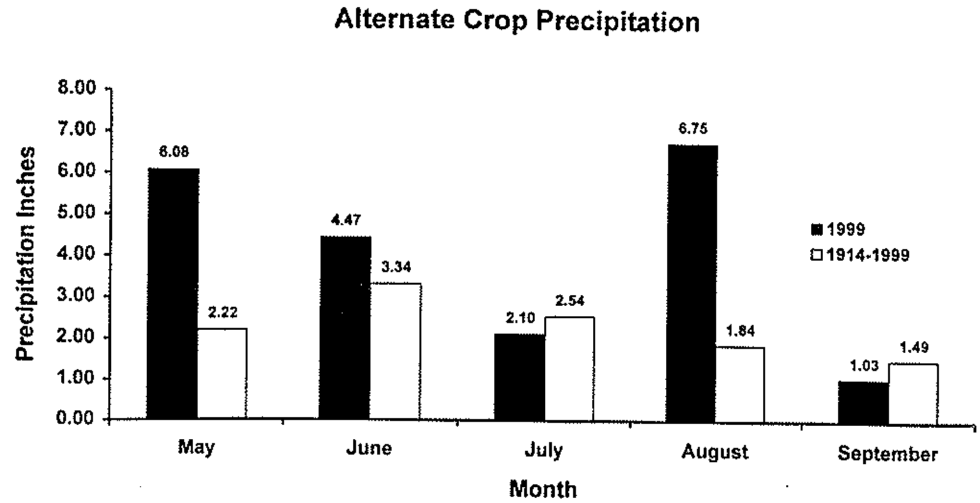


Figure 1. The 1999 and long-term precipitation for the growing season.

Table 3. Seed yield of 10 crops as influenced by the crop and crop residues of 10 crops from a previous year.

1999 Seed Yield (lbs/a)
1999 Crop

Crop Residue	Canola*	Crambe*	Dry Bean*	Field Pea*	Flax*	Safflower*	Soybean*	Sunflower*	Wheat*	Barley*
Canola	1260	1510	**1110**	2080	**1460**	**900**	1810	1420	**3200**	4170
Crambe	1150	1580	880	***1920***<	**1430**	780	1820	**1550**	2870	**4440**>
Dry Bean	1250	***1390***	1050	2270	1360	790	**2000**	1440	2950	***3740***<
Field Pea	**1360**	**2110**>	1080	2300	1280	**930**	**1880**	**1580**>	***2780***	4170
Flax	**1380**>	1600	1010	2370	***620***<	770	1780	**1580**>	**3260**>	4120
Safflower	***1090***<	***1350***<	***730***	2260	1240	***410***<	***1550***<	***1070***<	***2700***<	***4080***
Soybean	***1100***	1470	980	***2050***	**1560**>	790	**2230**>	1340	3090	***3890***
Sunflower	1220	1570	880	2330	**1450**	***680***	1740	***1170***	3020	**4330**
Wheat	1170	1680	***680***<	**2720**>	1400	**920**	***1640***	1340	3060	4220
Barley	1320	1810	**1190**>	2270	**1460**	**990**>	**1860**	**1570**	3020	***4000***

*Does not include Rep 1

Bold, Underlined = High end   > = Highest
Bold, Italicized = Low end   < = Lowest

Table 4. Gross returns for each of the 10 crops as calculated by multiplying seed yield by market price (from late November to early December, 1999).

1999 Gross Returns ($/a)
1999 Crop

Crop Residue	Canola*	Crambe*	Dry Bean*	Field Pea*	Flax*	Safflower*	Soybean*	Sunflower*	Wheat*	Barley* (feed)	Barley* (malting)
Canola	$86.94	$151.00	**$155.40**	$95.26	**$91.98**	**$99.00**	$114.03	$95.85	**$146.66**	$113.01	$204.16
Crambe	$79.35	$158.00	$120.40	***$87.93***<	**$90.09**	$85.80	$114.66	**$104.63**	$131.45	**$120.32**>	**$217.38**>
Dry Bean	$86.25	***$139.00***	$147.00	$103.97	$85.68	$86.90	**$126.00**	$97.20	$135.11	***$101.35***<	***$183.11***<
Field Pea	**$93.84**	**$211.00**>	$151.20	$105.34	$80.64	**$102.30**	**$118.44**	**$106.65**>	***$127.32***	$113.01	$204.16
Flax	**$95.22**>	$160.00	$141.40	$108.55	***$39.06***<	$84.70	$112.14	**$106.65**>	**$149.30**>	$111.65	$201.72
Safflower	***$75.21***<	***$135.00***<	***$102.20***	$103.51	$78.12	***$45.10***<	***$97.65***<	***$72.22***<	***$123.66***<	***$110.57***	***$199.76***
Soybean	***$75.90***	$147.00	$137.20	***$93.89***	**$98.28**>	$86.90	**$140.49**>	$90.45	$141.52	***$105.42***	***$190.45***
Sunflower	$84.18	$157.00	$123.20	$106.71	**$91.35**	***$74.80***	$109.62	***$78.98***	$138.32	**$117.34**	**$212.00**
Wheat	$80.73	$168.00	***$95.20***<	**$124.57**>	$88.20	**$101.20**	***$103.32***	$90.45	$140.15	$114.36	$206.61
Barley	$91.08	$181.00	**$166.60**>	$103.97	**$91.98**	**$108.90**>	**$117.18**	**$105.98**	$138.32	***$108.40***	***$195.84***

*Does not include Rep 1

Bold, Underlined = High end   > = Highest
Bold, Italicized = Low end   < = Lowest

WATER USE BY ALTERNATIVE CROPS

Drs. Steve Merrill, Donald Tanaka, and Ron Ries

We have measured the soil water depletion of alternative crops during the 1999 season using the neutron moisture meter method. The standard definition of crop water use is that it is the sum of precipitation and soil water depletion between seeding and harvest. This definition assumes that there is no runoff and that soil water does not drain out of the soil zone over which water depletion is measured (in our case, 0 to 8 feet depth).

The crop water use values measured in 1999 are shown in Figure A. Variation in water use, of course, is due to variation in measured amounts of the soil water depletion as a component of water use, as shown in Figure A. Precipitation during the 1999 growing season was significantly above average, and this caused the soil depletion component of water use to be less than would be expected on average. The crops are listed in Figure A in order of their measured or presumed maximum root growth depths, with the shallowest on the left and the deepest on the right. It can be seen that total seasonal water use doesn't correlate very well with characteristic root growth depth. The four crops with largest water use (soybean, flax, sunflower and safflower) had over 16 inches of use, and also had longer growing seasons, from 112 to 127 days (Table A). The three crops with the smallest water use (dry pea, crambe and barley) had from 13.3 to 14.1 inches of use, and had the shortest growing seasons, from 84 to 86 days.

A more direct way to compare the water use of alternative crops is to look at the amounts of soil water that they deplete over the same part of the growing season. Figure B shows soil water depletion over equal time periods, either the entire part of the year during which soil water measurements were made (21 May to 21 October), or over a part of the growing season in which precipitation was relatively lesser and water use was relatively higher (11 June to 08 August). For the full season period from May through October, the four crops with the least amount of soil water depletion (dry pea, crambe, spring wheat and barley, with about 1 to 1 ½ inches of depletion) had shorter seeding-to-harvest periods of 84 to 99 days. The period from 11 June to 08 August was one in which evapotranspiration (water loss from both soil and plants) was significantly ahead of precipitation. Eight out of ten crops depleted about 4 to 5 inches of water, but dry bean and soybean depleted about 2 to 3 inches in the same time period (Figure B). Both soybean and dry bean have relatively longer seasons, but are more shallowly rooted crops.

In order to compare total water use of alternative crops in 1999 with earlier results, we show in Figure C three-year average water use of seven alternative crops measured in 1995 through 1997. The range of water use values is lower than in 1999, running from 9.0 to 14.5 inches. However, three of crops (out of seven total) with the greatest water use in 1995-87 were soybean, sunflower, and safflower, which is in agreement with our 1999 results.

Figure D shows soil water depletion by depth increments for the same higher-evapotranspiration, lower-precipitation period (06 June through 08 August, 1999) as discussed previously. Dry bean has the least amount of depletion in the 1-2 foot depth increment of the crops, and both dry bean and soybean have relatively low depletions in the 2-3 foot increment compared to the other crops. This is apparently associated with the observation that dry bean and soybean had the lowest overall soil water depletions during this early June through early August period, and the fact that they are relatively shallow rooted.

Table A. Seeding dates, harvest dates and length of season between seeding and harvest for 1999 alternate crops.

CROP	Seeding Date	Harvest Date	Length of Season (Days)
Dry Bean	02 June	23 September	113
Dry Pea	26 May	18 August	84
Soybean	01 June	29 September	120
Canola	26 May	23 August	89
Crambe	26 May	20 August	86
Sp. Wheat	25 May	01 September	99
Barley	26 May	19 August	85
Flax	26 May	17 September	114
Sunflower	01 June	06 October	127
Safflower	26 May	15 September	112

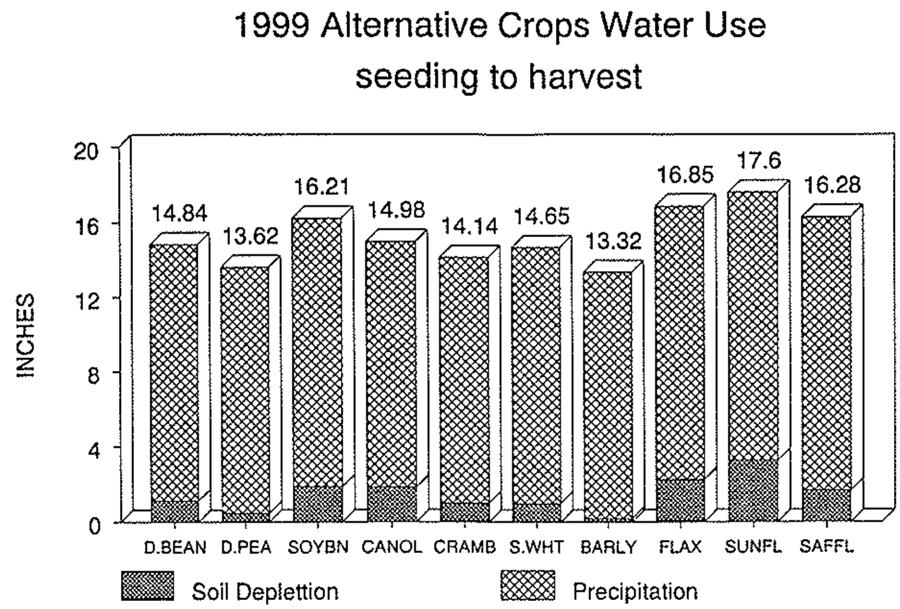


Figure A

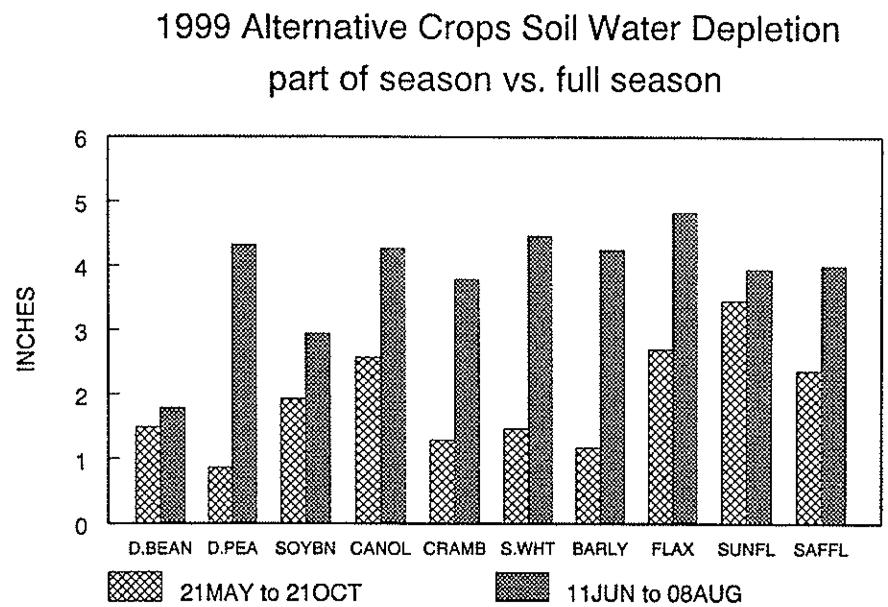


Figure B

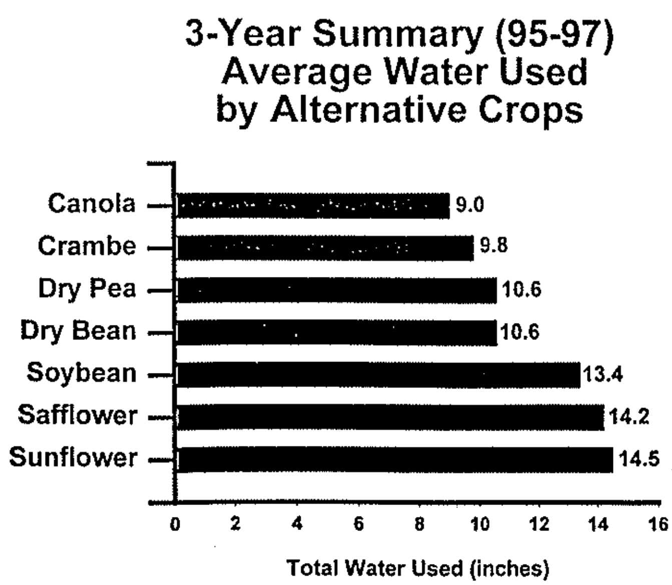


Figure C

Percent Soil Water Depletion at Depths (feet) - 06JUN to 08AUG

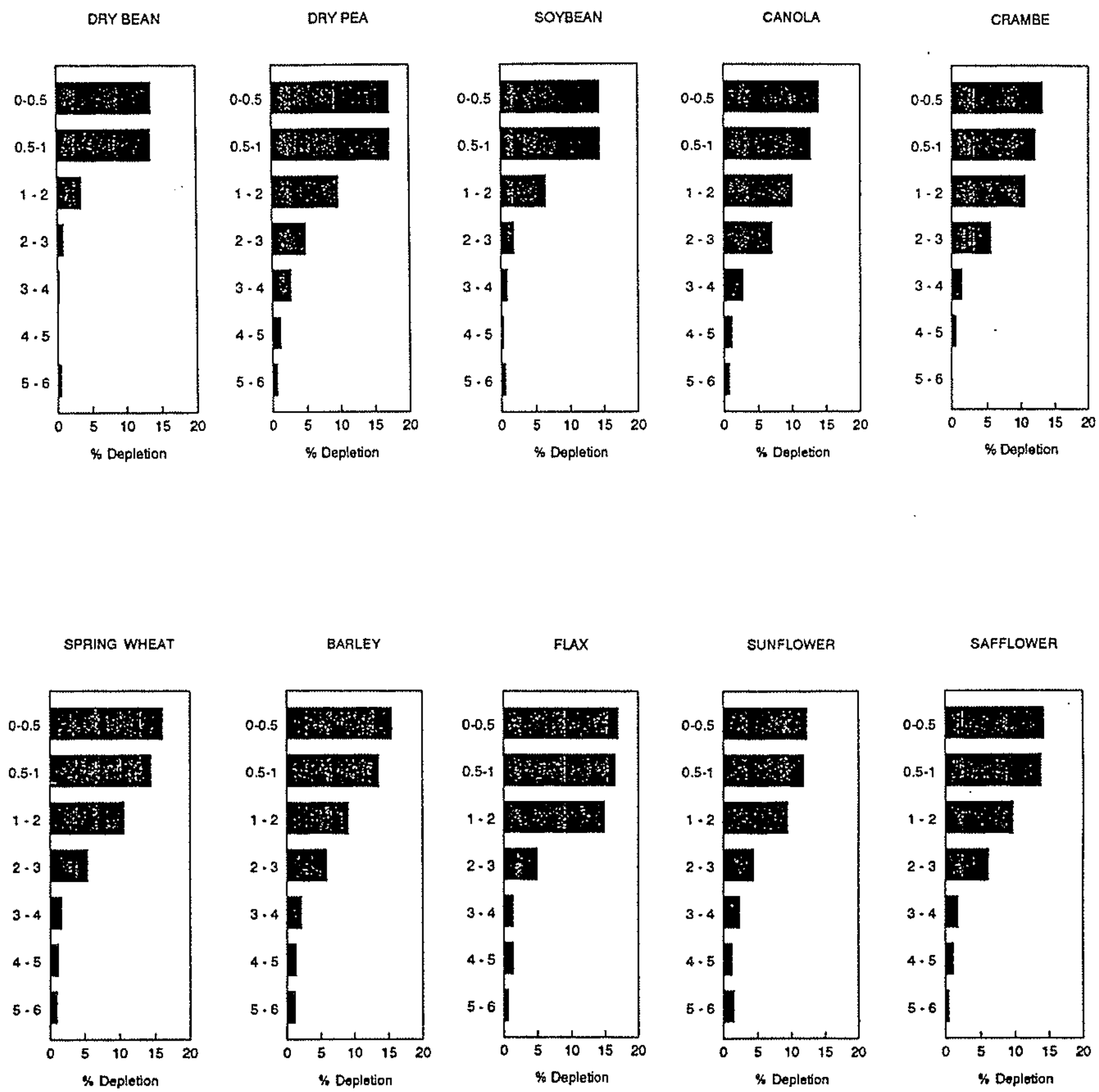


Figure D

ROOT GROWTH OF ALTERNATIVE CROPS

Drs. Steve Merrill and Donald Tanaka

This is an overview of our research on root growth of alternative crops. Minirhizotron technology, in which root growth is viewed with a miniature video camera in transparent tubes installed in the field, was used. The various alternative crops were grown with predominantly minimal-till management in spring wheat - winter wheat - alternate crop rotations. The root growth of spring wheat growing on fallow ground was observed for comparison with seven alternative crops.

Figure A summarizes measurements of maximum rooting depths of the crops for each year. As far as their ability to root deeply goes, the various crops fall into agronomic and botanical families. The annual legumes dry bean, dry pea, and soybean were the most shallow rooted at about 3 to 3 ½ feet. The mustard family oilseeds canola and crambe were next, with maximum rooting at 3 to 4 feet. Spring wheat, averaging about 4 feet, was slightly deeper than the mustard family crops. Most deeply rooted of all were sunflower, at about 4 to 5 ½ feet, and safflower, with maximum rooting depths of 5 to 6 feet. We carried out other root growth research with sunflower and safflower during 1992 and 1993, using both minirhizotrons and direct observations in trenches, and obtained about the same results as with the more recent studies. Our observations of safflower using a trench indicated that maximum rooting depth was about 6 ½ feet in the glacial till subsoil found at the Area IV ARS-SCD Cooperative Research Farm.

In general, the maximum root growth depths (Figure A) observed in 1995 were somewhat greater than those observed in 1996 or 1997. We believe this is associated with the fact that 1997 was a drier than average year, and that subsoil moisture was less available than in relatively wet 1995.

The median root growth depth is that depth at which half of the total root length measured is above a particular depth and half is below that depth. The 3-year average median root growth depths shown in Figure B follow the same trends among the alternative crops as our results with maximum rooting depths. The median depths shown are the greatest median depths for the crops observed, and are about half of the values of the maximum depths.

Figure C shows our results expressed as total root length per unit of land area (we use miles per square yard). Root systems grow and then decay, and our results show total root length measured at approximately the times of greatest root system size. The values vary considerably, from about 2 to 12 mile/yard^2. In 6 out of the 8 crops studied, total root length was greatest in 1997. We believe this is because precipitation during the 4-month May through August period in 1997 was approximately half of the average amount, and the crops were responding to this by putting out greater root length growth. Other researchers have published results showing cases of increased root growth under stressed conditions, such as during temporary, part-of-season droughts.

Maximum Root Depth by Year

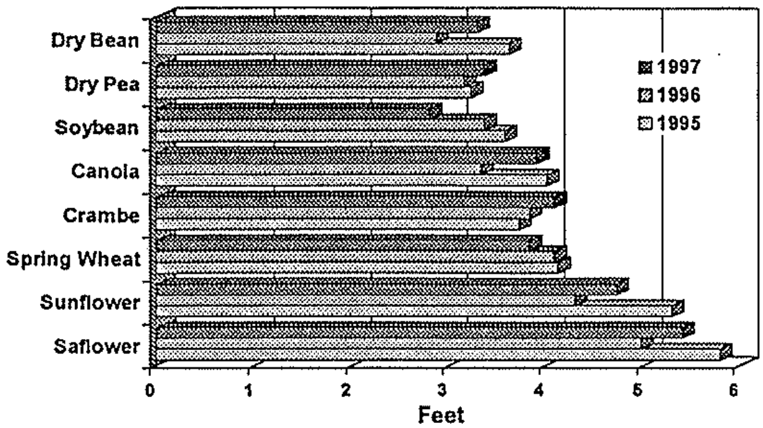
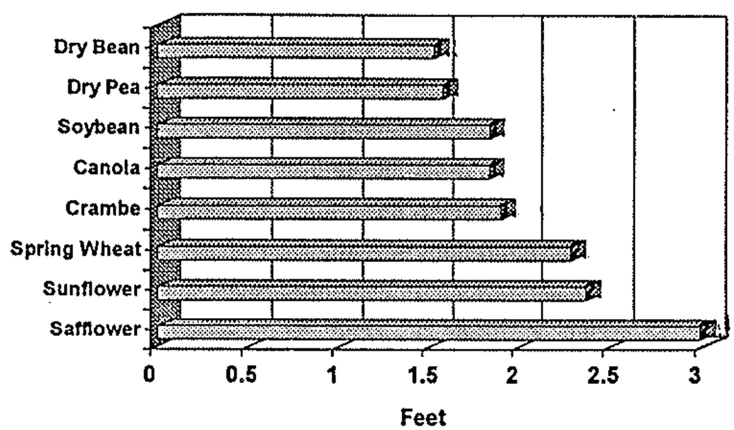


Figure A

1995-97 Median Root Depth

Figure B



Total Root Length by Year

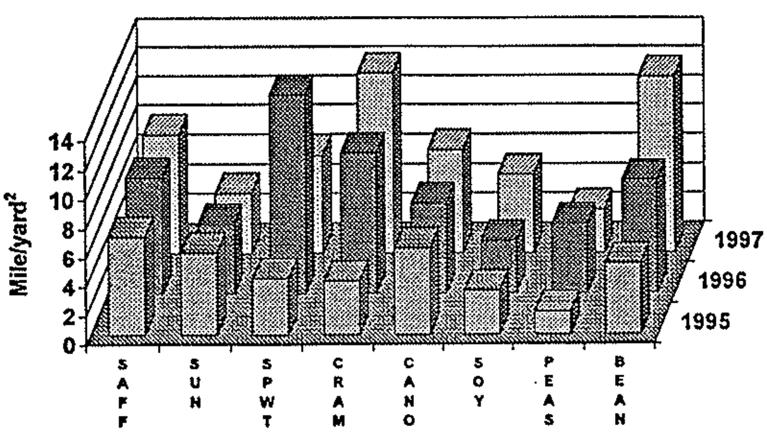


Figure C

WEED CONTROL IN SPRING WHEAT AFTER ALTERNATIVE CROPS

Drs. Donald Tanaka, Ron Ries, Steve Merrill, and Joe Krupinsky

In 1999, weed density measurements were taken 7 days after wheat emergence and 21 days after wheat emergence in an area that had been previously seeded to ten different crops. Herbicide application for weed control occurred after weed density measurements were made. The purpose of the weed density measurements was to determine if any of the crops influenced weed or volunteer control in a succeeding spring wheat crop. Preliminary information 7 days after wheat emergence suggests that wheat seeded into areas that were previously sunflower or dry bean had about 300% and 136%, respectively, more weeds than wheat after wheat. Wheat after barley and dry pea had 78% and 84%, respectively, less weeds than wheat after wheat. Results may vary depending on weather and previous weed control.

LEAF SPOT DISEASES ON WHEAT AND BARLEY WITH ALTERNATIVE CROPS

Drs. Joe Krupinsky and Donald Tanaka

Leaf spot diseases of spring wheat and barley were highest on wheat after wheat, and highest on barley after barley, respectively (Fig. K1 and K2), indicating lower leaf spot disease severity with crop rotation.

Wheat leaves from experimental plots were analyzed for plant pathogens present. Diseases found on wheat leaves include: Stagonospora nodorum blotch (*Stagonospora nodorum*), tan spot (*Pyrenophora tritici-repentis*), spot blotch (*Helminthosporium sativum*), stagonospora avenae leaf blotch (*Stagonospora avenae f. sp. triticea*), and septoria tritici blotch (*Septoria tritici*). Tan spot and stagonospora nodorum blotch were the most common diseases on wheat. Spot blotch was second followed by Septoria avenae blotch and septoria tritici blotch. Thus, the common leaf spot diseases on wheat are not caused by one pathogen but rather a complex of fungi.

Barley leaves from experimental plots were analyzed for plant pathogens present. Diseases found on barley leaves include: net blotch (*Helminthosporium teres*), spot blotch (*Helminthosporium sativum*), stagonospora avenae leaf blotch (*Stagonospora avenae f. sp. triticea*), septoria speckled leaf blotch (*Septoria passerinii*), and stagonospora nodorum blotch. Net blotch and spot blotch were the most common diseases on barley. These results also show that the common leaf spot diseases on barley are not caused by one pathogen but rather a complex of fungi.

SCLEROTINIA IN THE ALTERNATIVE CROPS STUDY

Drs. Joe Krupinsky and Donald Tanaka

Sclerotinia diseases of oilseed and pulse crops (i.e. white mold, stem rot, wilt, caused by

Sclerotinia sclerotiorum) have the potential to cause substantial losses in yield. Sclerotia produced in or on infected tissue contaminate soil, stubble and harvested seed. Sclerotia are hard fungal bodies that may survive for 4-7 yr in the soil and pose a threat to subsequent susceptible crops. Sclerotinia disease has a wide host range on broadleaf crops but it does not affect cereals and grasses. Crop diversification has increased the risk of sclerotinia diseases by bringing more broadleaf crops into traditional cereal-growing regions. The use of a broadleaf crop with less susceptibility or one that produces fewer sclerotia may be important for the next broadleaf crop grown in the rotation. The following data only refers to the 1999 crop, another year of data is needed to determine how consistent the results are over years.

Canola, crambe, sunflower, and safflower grown after 10 different crops were evaluated for Sclerotinia (white mold). Plants were randomly sampled and evaluated in the field, 3000 plants for canola and crambe and approximately 1500 plants for sunflower and safflower. Sunflower stalks were collected and brought into the lab for evaluation. The base of the stalks were split open to evaluate for sclerotinia, as well as charcoal rot and verticillium.

The greatest number of canola plants infected with sclerotinia followed a safflower crop (Figure K-3) and the lowest yield of canola was after a safflower crop (Figure K-4). Similarly, the greatest number of crambe plants infected with sclerotinia followed a safflower crop (Figure K-5) and the lowest yield of canola followed a safflower crop (Figure K-6). A few sunflower plants infected with sclerotinia could be found in the field when looking for diseased plants but when sunflower plants were randomly sampled from each plot neither sclerotinia, charcoal rot, or verticillium were observed. Other sunflower leaf and stalk diseases were highest with sunflower after a sunflower crop (Figure K-7 and K-8). Sunflower yield was lowest after sunflower and safflower crops (Figure K-9). Considering the amount of sclerotinia on other crops following a safflower crop, it was surprising that few safflower plants were infected with sclerotinia (Figure K-10). Safflower yields were lowest following safflower and sunflower (Figure K-11).

FLAX ON FLAX IN THE ALTERNATIVE CROPS STUDY
Drs. Joe Krupinsky and Donald Tanaka

As evident in the yield data for flax after a flax crop (Figure K-12) the severity of flax diseases for flax after flax were dramatically high. The diseases most evident on flax were Fusarium wilt (*Fusarium oxysporum f. sp. lini*) and Pasmo (*Mycosphaerella linicola*). The fungi causing these diseases can easily carry over on infested residue. Thus, the residue from the 1998 flax crop probably provided inoculum for the 1999 flax crop.

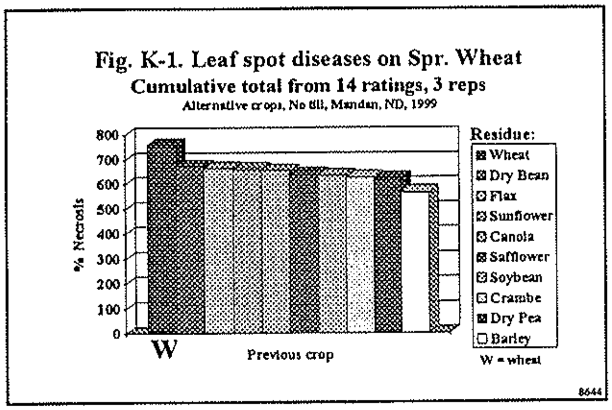


Fig. K-1. Leaf spot diseases on Spr. Wheat
Cumulative total from 14 ratings, 3 reps
Alternative crops, No till, Mandan, ND, 1999
% Necrosis
800
700
600
500
400
300
200
100
0
W
Previous crop
Residue:
Wheat
Dry Bean
Flax
Sunflower
Canola
Safflower
Soybean
Crambe
Dry Pea
Barley
W = wheat
8644

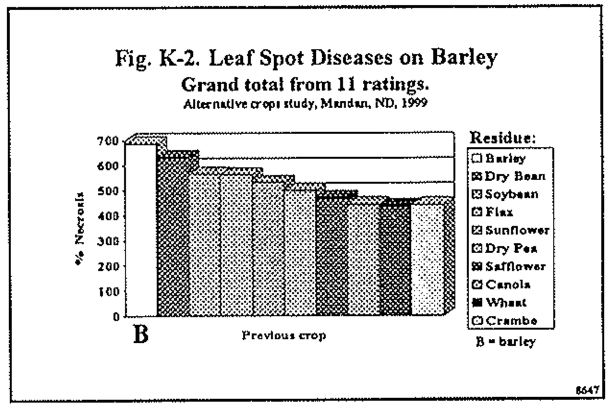


Fig. K-2. Leaf Spot Diseases on Barley
Grand total from 11 ratings.
Alternative crops study, Mandan, ND, 1999
% Necrosis
700
600
500
400
300
200
100
0
B
Previous crop
Residue:
Barley
Dry Bean
Soybean
Flax
Sunflower
Dry Pea
Safflower
Canola
Wheat
Crambe
B = barley
8647

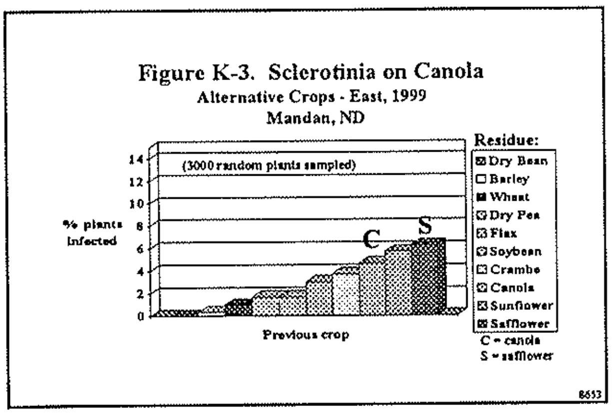


Figure K-3. Sclerotinia on Canola
Alternative Crops - East, 1999
Mandan, ND
(3000 random plants sampled)
% plants infected
14
12
10
8
6
4
2
0
C
S
Previous crop
Residue:
Dry Bean
Barley
Wheat
Dry Pea
Flax
Soybean
Crambe
Canola
Sunflower
Safflower
C = canola
S = safflower
8653

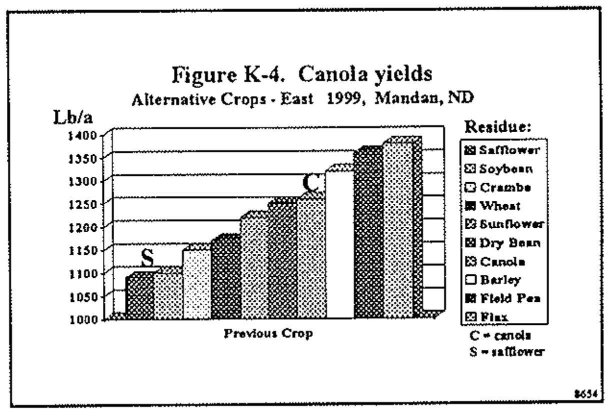


Figure K-4. Canola yields
Alternative Crops - East 1999, Mandan, ND
Lb/a
1400
1350
1300
1250
1200
1150
1100
1050
1000
S
C
Previous Crop
Residue:
Safflower
Soybean
Crambe
Wheat
Sunflower
Dry Bean
Canola
Barley
Field Pea
Flax
C = canola
S = safflower
8654

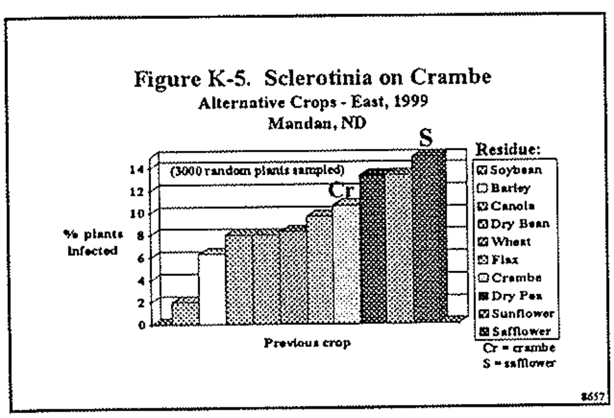


Figure K-5. Sclerotinia on Crambe
Alternative Crops - East, 1999
Mandan, ND
(3000 random plants sampled)
% plants infected
14
12
10
8
6
4
2
0
Cr
S
Previous crop
Residue:
Soybean
Barley
Canola
Dry Bean
Wheat
Flax
Crambe
Dry Pea
Sunflower
Safflower
Cr = crambe
S = safflower
8657

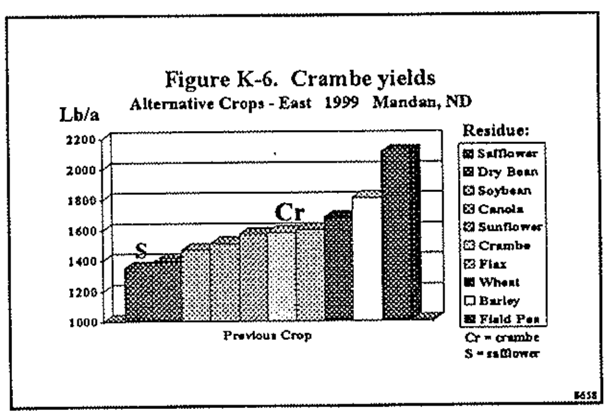


Figure K-6. Crambe yields
Alternative Crops - East 1999 Mandan, ND
Lb/a
2200
2000
1800
1600
1400
1200
1000
S
Cr
Previous Crop
Residue:
Safflower
Dry Bean
Soybean
Canola
Sunflower
Crambe
Flax
Wheat
Barley
Field Pea
Cr = crambe
S = safflower
8658

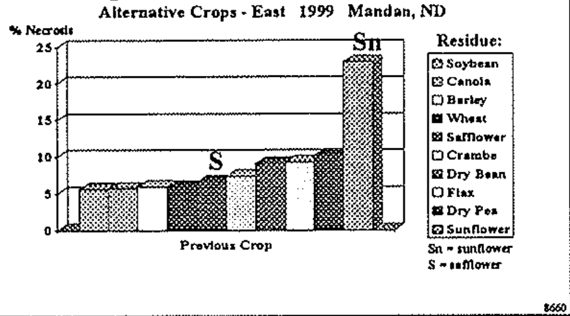


Figure K-7. Sunflower Leaf Diseases
Alternative Crops - East 1999 Mandan, ND

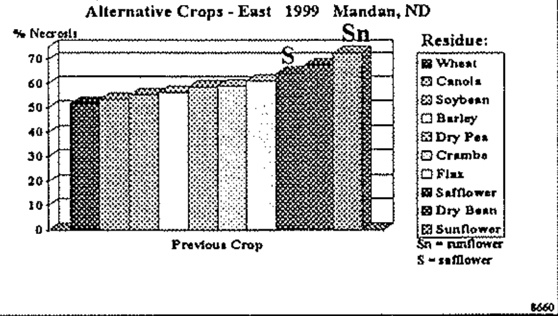


Figure K-8. Sunflower Stalk Diseases
Alternative Crops - East 1999 Mandan, ND

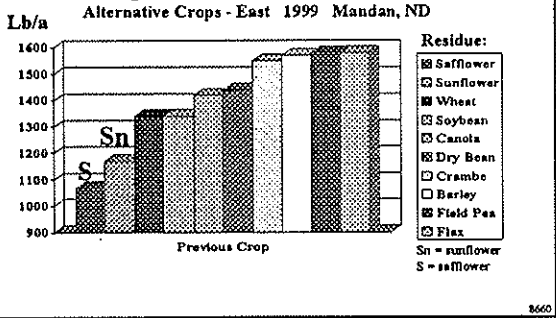


Figure K-9. Sunflower yields
Alternative Crops - East 1999 Mandan, ND

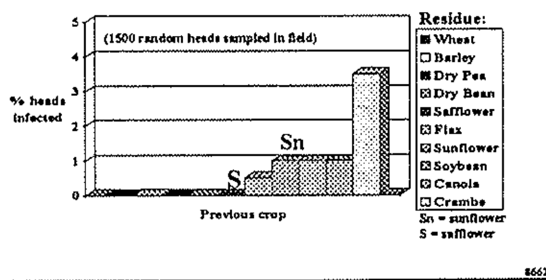


Figure K-10. Sclerotinia on Safflower
Alternative Crops - East, 1999
Mandan, ND

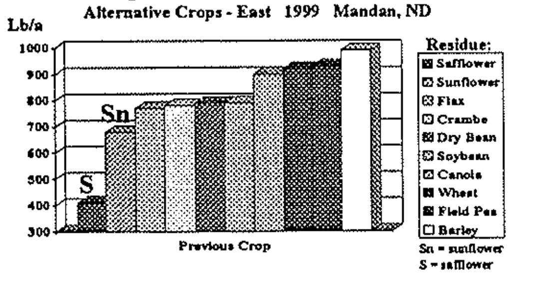


Figure K-11. Safflower yields
Alternative Crops - East 1999 Mandan, ND

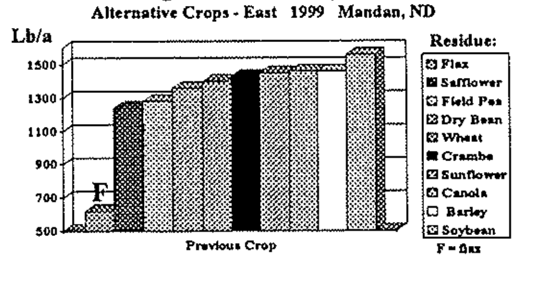


Figure K-12. Flax yields
Alternative Crops - East 1999 Mandan, ND

LONG-TERM ALTERNATIVE CROP IMPACTS

Drs. Donald Tanaka and Steve Merrill

In a related alternative crops study, eight alternative crops were minimum-till seeded in 1997 into a three-year crop rotation to evaluate alternative crop production and gross returns and determine the influences of each alternative crop in production systems. The three-year rotation was alternative crop-spring wheat-winter wheat. Seed yields for each year and the total for three years are shown in Figure 1. Gross returns were calculated by multiplying the seed yield by the commodity price for that year if the commodity were sold in Bismarck, ND from late November to early December (Fig. 2). Commodity prices used to calculate gross returns ($/lb) were dry bean, $0.180; soybean, $0.096; flax, $0.100; sunflower, $0.100; crambe, $0.120; canola, $0.111; dry pea, $0.046; safflower, $0.120; 1998 spring wheat, $0.0525; and 1999 winter wheat, $0.036. Total gross returns for the 3 years ranged from $453.00/a to $294.00/a. Total gross returns were greatly influenced by the seed yield and crop price of the particular alternative crop grown during that year; therefore, **caution** needs to be used when looking at the data.

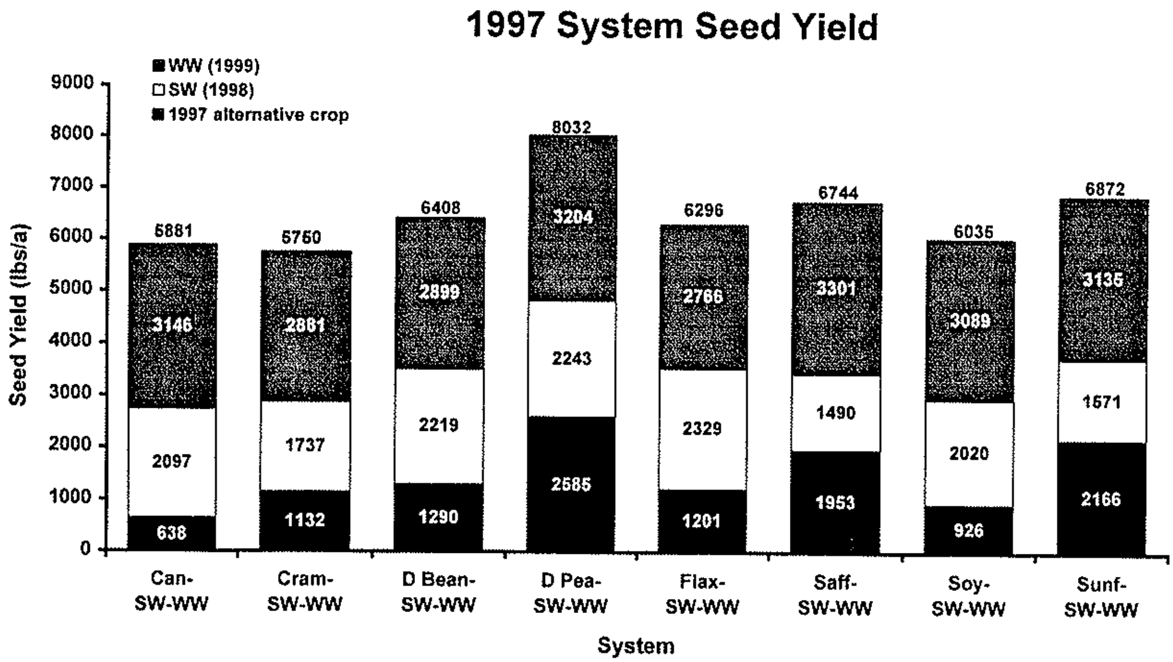


Figure 1. Seed yield for alternative crop-spring wheat(SW)-winter wheat(WW) three-year crop production systems. Alternative crops were canola (can), crambe (cram), dry bean (D bean), dry pea (D pea), flax (flax), safflower (saff), soybean (soy), and sunflower (sunf).

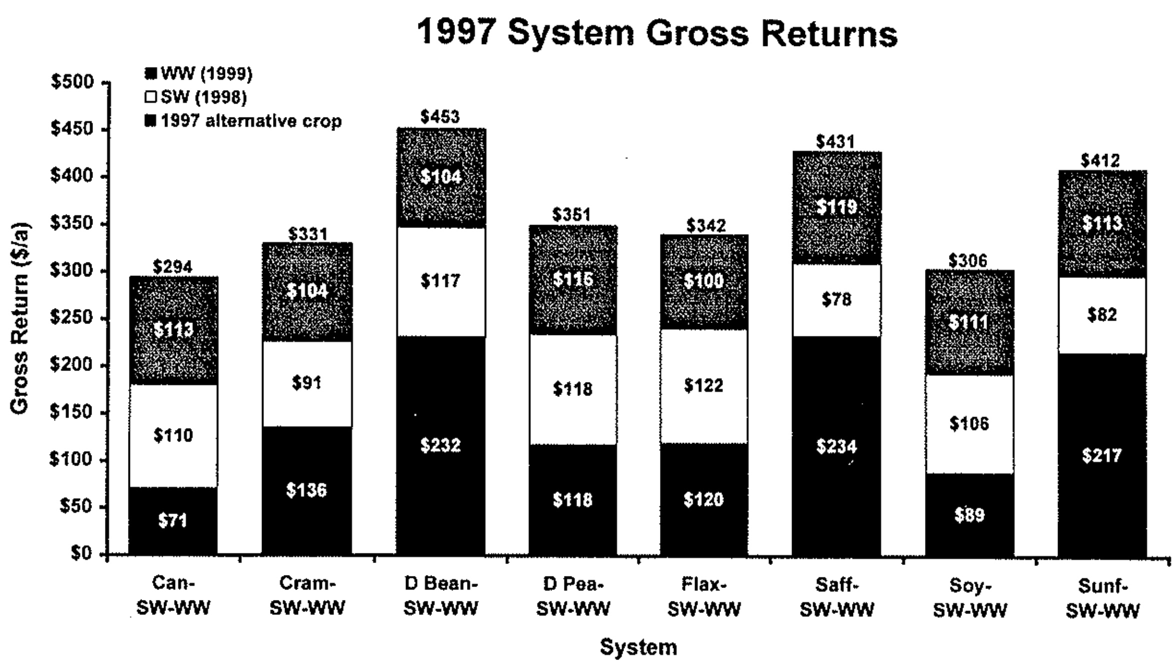


Figure 2. Gross returns for alternative crop-spring wheat(SW)-winter wheat(WW) three-year crop production systems. Alternative crops were canola (can), crambe (cram), dry bean (D bean), dry pea (D pea), flax (flax), safflower (saff), soybean (soy), and sunflower (sunf).

LONG-TERM CROPPING SYSTEMS STUDY
65A STUDY, FIELD H1

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

INTRODUCTION

A long-term cropping systems—conservation tillage and nitrogen study was initiated in field H1 in 1984. This study involves two cropping systems (spring wheat-fallow [CF] and spring wheat-winter wheat-sunflower [CC], three tillage systems (conventional-till [CT], minimum-till [MT] and no-till [NT]), and three nitrogen fertilizer levels (0, 20, and 40 lb N/a for spring wheat-fallow, and 30, 60, and 90 lb N/a for the 3-yr annual crop rotation) and two varieties of each crop from 1985 through 1996. This study also includes a no-residue spring wheat-fallow treatment to serve as a check plot for assessing wind erodibility and plant diseases. In 1997, only one cultivar was used in each of the rotations. In 1997, peas and corn were substituted for one of the cultivar treatments, thus in 1998 spring wheat was grown on pea ground in addition to the regular fallow (two-yr rotation) and sunflower ground (three-year rotation). In 1998 and 1999, only spring wheat, winter wheat, and sunflower crops were grown. In 1999, only one fertility level was applied, 60 lb/a for the continuous cropping system and 20 lb/a for the crop-fallow system.

CROP PRODUCTION

The grain yields for the spring wheat, winter wheat, and sunflower crops are reported in Tables 1 and 2. The overall means were statistically compared with the Student-Newman-Keuls test; average means followed by a letter in common are not significantly different at $P = 0.05$. The winter wheat (CC) yield was significantly higher with CT compared to MT and NT. The spring wheat yield with CC was higher with NT compared to CT and MT. The spring wheat yield with CF was highest with CT compared to NT and similar to MT. Sunflower yields were similar across tillage treatments. As expected, no differences among the original fertilizer treatments were detected because of the application of a uniform fertilizer rate in 1999.

SOIL QUALITY INDICATORS

Drs. Mark Liebig and Steve Merrill

Soil quality indicators were evaluated in 1999 on selected treatments in the long-term cropping systems. Evaluations were conducted as part of the USDA-ARS Great Plains Systems Network Soil Quality Project. The primary objective of the project is to quantify the temporal dynamics of soil quality indicators in treatments of contrasting management intensity for established cropping systems in the Great Plains and western Corn Belt. The first year of the project was 1999.

Included in the project from the long-term cropping systems study were crop–fallow/conventional tillage (CF/CT) and continuous crop/no-till (CC/NT) treatments. Sampling for soil quality indicators was conducted in the spring, summer, and fall.

For the spring sampling, there was 30% more organic carbon (16,037 lb/ac) and 26% more total nitrogen (1,236 lb/ac) in the CC/NT treatment than the CF/CT treatment across depths (Table 3). The CC/NT treatment also had higher levels of microbial biomass carbon and nitrogen as well as potentially mineralizable nitrogen as compared to the CF/CT treatment. Soil pH was similar in both treatments, while soil bulk density was lower and wet aggregate stability higher in the surface six inches of the CC/NT treatment.

The status of soil quality indicators from the spring sampling indicates the CC/NT treatment creates a more favorable soil condition for plant growth. No-tillage and continuous cropping contributed to this improvement in soil condition.

Field Operations for 65-acre study, field H1

9/21/98	T-1 winter wheat plots were tilled with a JD Mulchmaster and T-2 winter wheat plots were tilled with a Haybuster undercutter.
9/22/98	Roughrider winter wheat was seeded with a Haybuster 8000 drill with hoe openers and 10-inch row spacing.
4/23/99	Nitrogen (60 lb N/a) was broadcast on winter wheat plots.
5/14/99	All plots were sprayed except winter wheat with Roundup Ultra (20 oz product/a) plus 2,4-D (1 pint product/a).
5/21/99	Sprayed sunflower no-till plots with Roundup Ultra (1 pint product/a) plus Prowl (3.6 pint product/a) (6 oz + 24 oz active ingredient/a).
5/25/99	Sprayed sunflower plots plus spring wheat on fallow and spring wheat after sunflower no-till plots with Roundup Ultra (20 oz product/a) plus 2,4-D (1 pint product/a).
5/26/99	Sonalan (10 lb product/a) was applied with Gandy air applicator mounted on a Haybuster undercutter to sunflower T-1 and T-2 plots.
5/27/99	Spring wheat 2375 was seeded on fallow plots with JD 750 no-till drill. Urea was applied between the seed rows at 60 lb N/a.
5/28/99	Spring wheat 2375 was seeded on plots after sunflower and no residue plots with JD 750 no-till drill. Urea was applied between the seed rows at 60 lb N/a.
6/15/99	T-1 and T-2 sunflower plots were tilled. Cenex 803 sunflower was seeded with JD 750 drill in 15-inch rows with 60 lb N/a.
6/16/99	Robust barley was seeded in alleyways. Sprayed all spring wheat plots with Puma (5 oz product/a) plus Starene (0.66 pint product/a).
7/01/99	Fallow plots were sprayed with Fallowmaster (40 oz product/a). No-till sunflowers were sprayed with Poast (1 quart product/a).
7/16/99	T-4 plots were disked.

7/28-29/99 Hand samples were taken from the winter wheat plots.
7/30/99 Winter wheat plots were combined with the small plot combine.
8/02/99 Cleanup of the winter wheat plots.
Undercut T-1 fallow plots.
8/19/99 Fallowmaster was sprayed to fallow and winter wheat plots (40 oz product/a).
8/20/99 Hand samples were taken from the spring wheat plots.
8/25/99 Plots were combined with the small plot combine.
9/07/99 Cleanup of the spring wheat plots.
T-4 plots were cultivated.
9/14/99 All the plots were sprayed except sunflowers with Roundup Ultra (24 oz product/a).
9/22/99 T-1 plots were tilled with the JD mulchmaster and T-2 plots with the Haybuster undercutter. Roughrider winter wheat was seeded with a Haybuster 8000 hoe drill (10-inch row space) at 1.3 million seeds/a. Fifty lb/a of 0-44-0 was applied with the seed.
9/30/99 All plots were spot sprayed except sunflowers with Roundup Ultra (24 oz product /a).
10/05/99 Hand samples were taken from the sunflower plots.
10/20/99 Cleanup of sunflower plots.

Acknowledgments: We thank J. Bosworth, J. Bullinger, J. Harms, L. Hatzenbuhler, M. Hatzenbuhler, C. Klein, L. Renner, D. Schlenker, and D Wetch for their efforts in conducting this cropping systems study and collection of field data.

Table 1. Combine grain yields for the two-year rotation crops in 1999.		
Tillage	N Rate	Spring Wheat (2375) After fallow
	lb/a	bu/a
CT	0	23.1
CT	20	24.3
CT	40	22.2
MT	0	20.0
MT	20	20.3
MT	40	22.4
NT	0	19.1
NT	20	18.9
NT	40	19.2
CT	AVG	23.2a
MT	AVG	20.9ab
NT	AVG	19.1b
AVG	0	20.7a
AVG	20	21.2a
AVG	40	21.2a
SW-F (No Residue)		
NR	0	24.1
NR	20	25.8
NR	40	22.6

Table 2. Combine grain yields for the three-year rotation crops in 1999.

Tillage	N Rate	W. Wheat (Roughrider) after SW	Sunflower (Cenex 803) after WW	Spring Wheat (2375) after Sunflower
	lb/a	bu/a	lb/a	bu/a
CT	30	54.4	1322	21.9
CT	60	56.5	1596	21.7
CT	90	55.2	1541	23.4
MT	30	45.9	1290	22.5
MT	60	43.5	1444	22.5
MT	90	47.2	1497	22.7
NT	30	44.9	1407	25.8
NT	60	42.1	1302	24.9
NT	90	42.9	1306	24.9
CT	AVG	55.4a	1486a	22.3b
MT	AVG	45.5b	1410a	22.6b
NT	AVG	43.3b	1338a	25.2a
AVG	30	48.4a	1340a	23.4a
AVG	60	47.4a	1447a	23.0a
AVG	90	48.4a	1448a	23.7a

Table 3. Status of soil quality indicators at three depths for crop-fallow/conventional tillage (CF/CT) and continuous crop/no-till (CC/NT) treatments in the long-term cropping systems study.

Treatment	Soil[†] bulk density	Wet aggregate stability	Soil pH	Organic carbon	Total nitrogen	Potentially mineralizable nitrogen	Microbial biomass carbon	Microbial biomass nitrogen
	(g/cm^3)	(%)		(lb C/ac)	(lb N/ac)	(lb N/ac)	(lb C/ac)	(lb N/ac)
	0 to 3 inches							
CF/CT[‡]	1.24	5	5.8	16,783	1,446	22	350	23
CC/NT[§]	1.16	21	5.9	21,638	1,796	42	501	60
	3 to 6 inches							
CF/CT	1.26	6	6.3	14,272	1,274	7	193	11
CC/NT	1.20	22	6.1	17,676	1,536	17	286	18
	6 to 12 inches							
CF/CT	1.13	22	6.5	20,890	1,915	5	243	19
CC/NT	1.18	21	6.2	28,668	2,539	20	457	31

[†] First year results from the USDA-ARS Great Plains Systems Network Soil Quality Project. Samples collected on May 6, 1999.
[‡] CF/CT = Crop-fallow/conventional tillage treatment (Spring wheat – Fallow, Conventional tillage, 20 lb N/ac).
[§] CC/NT = Continuous crop/no-till treatment (Spring wheat – Winter wheat – Sunflower, No till, 60 lb N/ac).

OTHER AREA IV RESEARCH STUDIES

CONVERSION OF CRP TO CROP PRODUCTION

Drs. Donald Tanaka, Steve Merrill, and Joe Krupinsky

In October 1994, a cooperative study was initiated to determine techniques for conversion of CRP land to crop production. Cooperators included NRCS, Consolidated Farm Service Agency, and the farm cooperators, Mr. Keith Boehm and Lyle Boehm. Treatments were: 1) hayed or nonhayed prior to tillage or spray operations; 2) residue management, conventional-till (<30% surface cover), minimum-till (30-60% surface cover) and no-till (>60% surface cover); and 3) nitrogen fertilizer, 0 and 60 lb N/a. Reference treatments included permanent hay (PH) and cover (PC). Plots were hayed on October 11, 1994 and tillage and spray operations were done on October 14, 1994.

The 1999 winter wheat crop was seeded on September 17, 1998 and had to be reseeded on September 30, 1999. All tillage and spraying was conducted prior to the September 17, 1998 seeding. Winter wheat grain and straw production are shown in Figure 1. Grain yield was the greatest for conventional-till with 60 lb N/a (38 bu/a) and lowest for no-till without N fertilizer (19 bu/a). The addition of 60 lb N/a increased grain yields by at least 12 bu/a. The above-average rainfall in May could have been detrimental to no-till, since soil water storage for no-till was greater than soil water storage for conventional-till and surface residues maintained a moist environment.

Hay production from CRP ranged from 5100 to 1462 lb/a from 1995 through 1999. Hay production was the greatest in 1999. Total hay production from 1995 through 1999 was increased by only 300 lb/a with the addition of N fertilizer. This could be due to the grass-alfalfa mix used in the CRP.

Leaf spot diseases on winter wheat. In 1999, Roughrider winter wheat was evaluated on post-CRP land with three tillage treatments, 2 nitrogen treatments, and on hayed and non-hayed plots. The amount of leaf spot diseases was similar on the hayed and non-hayed plots. Leaf spot diseases on winter wheat were higher on plots with no nitrogen compared to plots with 60 lb N/a, similar to the winter wheat crop in 1996. Leaf spot diseases were also higher on the no-till plots compared to the conventional and minimum-till plots. In 1996, differences among tillage treatments were not evident.

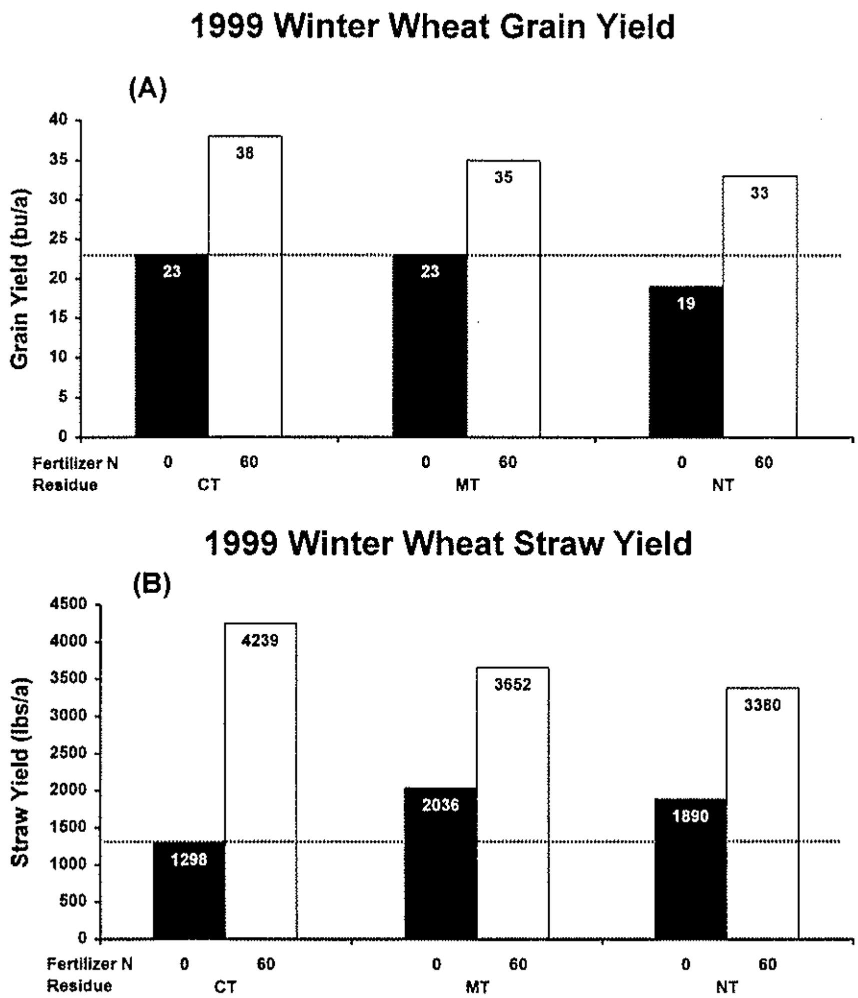


Figure 1. Winter wheat grain (A) and straw yield (B) as influenced by nitrogen fertilizer and conventional- (CT), minimum- (MT), and no-till (NT).

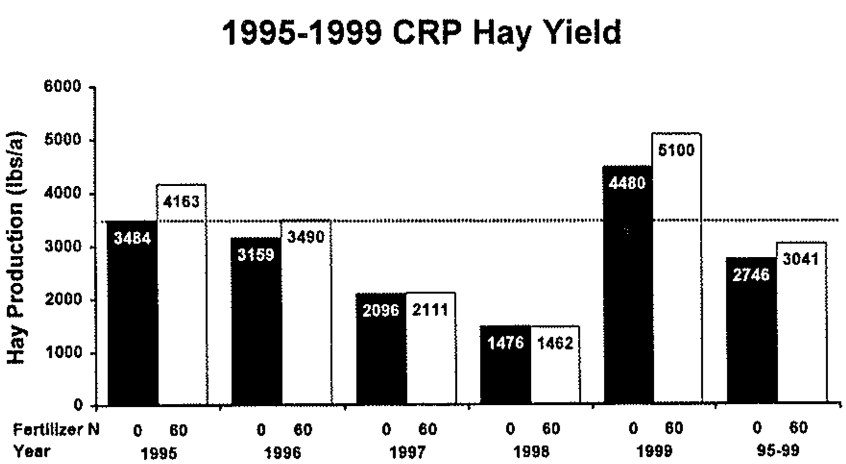


Figure 2. Hay production on CRP from 1995 through 1999 for zero and 60 pounds of N per acre.

MANAGEMENT STRATEGIES FOR SOIL QUALITY

Drs. Donald Tanaka, Steve Merrill, and Joe Krupinsky

A long-term study was initiated in the spring of 1993 to evaluate the influences of residue management and crop rotations on soil quality. Tillage, crops, and crop residues were all in the appropriate places in 1994. Treatments for the 1999 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)

Because of the wet May (over three times the average precipitation), spring wheat (cv. Pioneer 2375) was seeded at 1.3 million viable seed per acre on May 18. Safflower was also seeded on May 18 at 200,000 viable seeds per acre. Millet was seeded at 4 million viable seeds per acre on June 4. No-till plots were sprayed with Roundup (0.375 lb ai/a) prior to seeding while minimum-till plots were tilled with an undercutter prior to seeding. Spring wheat, safflower, and millet were seeded with a JD-750 no-till drill. Rye was seeded on September 28, 1998 at 1.3 million viable seeds per acre with a Haybuster 8000. Recrop plots received 60 lb N/a and 10 lb P/a at seeding.

With three times the average precipitation for May and August, crop performance was greatly influenced. Rye was able to take advantage of the May precipitation and produced 3731 lb/a of dry matter for soil and water conservation while millet for hay could not handle all the rain in August and produced 2396 lb/a of hay and 793 lb/a of stubble for erosion control (Fig. 1). Safflower seed yield and quality was greatly influenced by the August rains (Fig. 2). August rains increased crop disease (Alternaria leaf spot) which forced premature crop maturity and discolored seeds. Spring wheat grain yields ranged from 1761 to 1417 lb/a (Fig. 3). Greatest yields were from two- and three-year annual crop rotations with continuous wheat having the lowest yield. Leaf rust on wheat developed early in the season and caused a serious problem that greatly reduced yields.

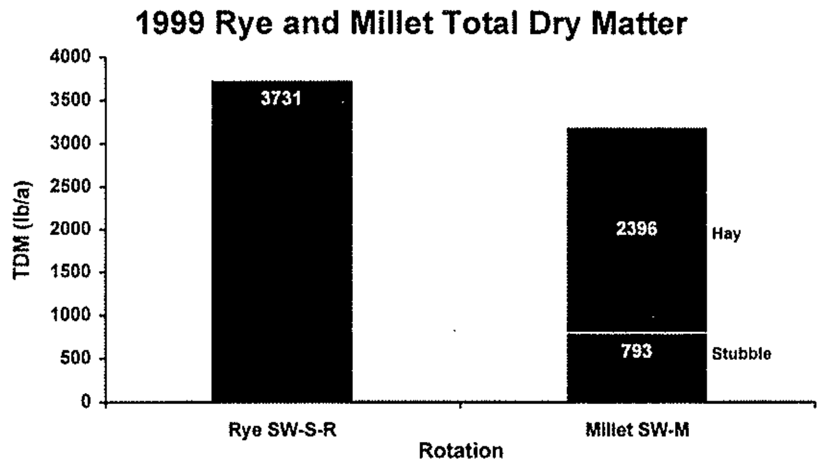


Figure 1. Total dry matter production for rye used as a partial fallow and siberian millet used for hay.

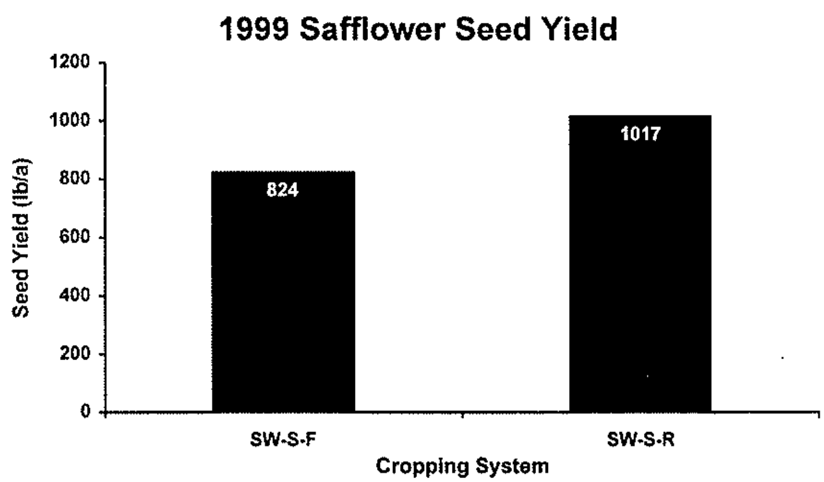


Figure 2. Safflower seed yield as influenced by crop rotation. The average of minimum- and no-till.

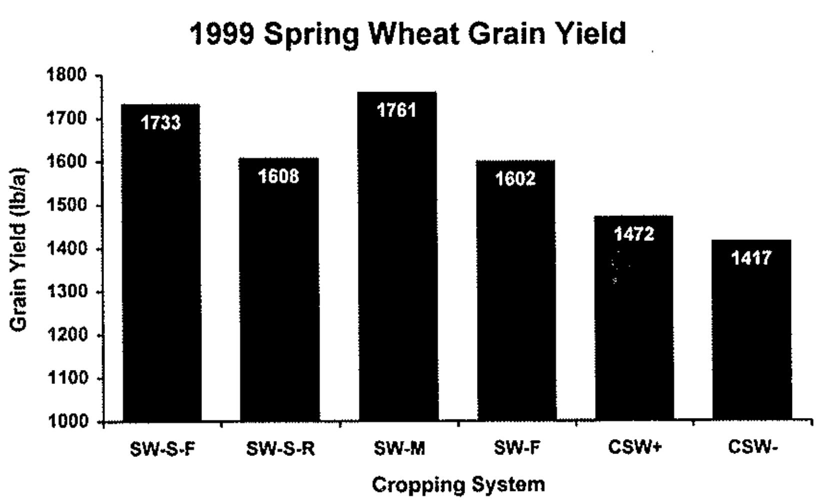


Figure 3. Spring wheat grain yield as influenced by crop rotation. The average of minimum- and no-till.

CULTURAL SYSTEMS FOR SUNFLOWER
Drs. Donald Tanaka, Joe Krupinsky, and Randy Anderson (USDA-ARS, Akron, CO)

Over the past 3 to 4 years, cultural practices have been evaluated to determine their influence on sunflower production. In 1999, an integrated approach to weed control using cultural practices was developed (Table 1).

Table 1. Integrated treatments for no-till sunflower production.

	Treatment	Plant Population (plants/a)	Row Spacing	Rye Control Date	Nitrogen (60 lb N/a)
1.	Control	22,000	30"	No Rye	Broadcast
2.	Culture I	28,000	15"	No Rye	Band
3.	Culture II	22,000	30"	May 25	Band
4.	Culture III	28,000	15"	May 25	Band
5.	Culture IV	28,000	15"	May 25	Band (lentils interseeded)

Spartan (0.20 lb/a) was applied to part of all treatments on May 14. Sunflower in the control and Culture I treatments were seeded on June 1, while Culture II, III, and IV treatments were seeded on June 18. In Culture IV, lentils were seeded between the 15" sunflower rows.

Weed biomass was greatly reduced by seeding sunflower on June 18 rather than June 1 (Fig. 1). Spartan application did not impact weed biomass and may be due to the 6.08 inches of rain in May. Greater than expected pesticide movement and degradation may have occurred. Sunflower seed yields were 50% greater for the control and 30% greater for Culture I when Spartan was applied (Fig. 2). Spartan did not influence seed yields for Culture II, III, and IV.

On September 29, 1999 the sunflower plots were evaluated for amount of leaf diseases. There was a higher severity of leaf diseases on the control and the culture I treatment compared to the other three treatments (Fig. 3).

1999 SCP Weed Biomass

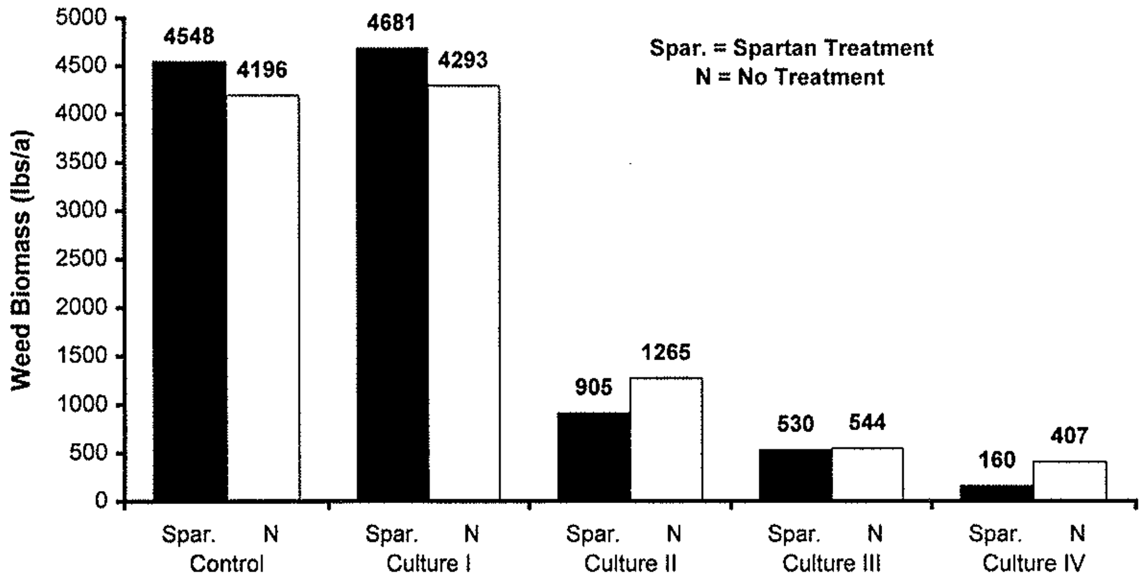


Figure 1. Weed biomass at sunflower plant development stage R1 as influenced by the control and each practice with and without hebicide.

1999 SCP Seed Yield

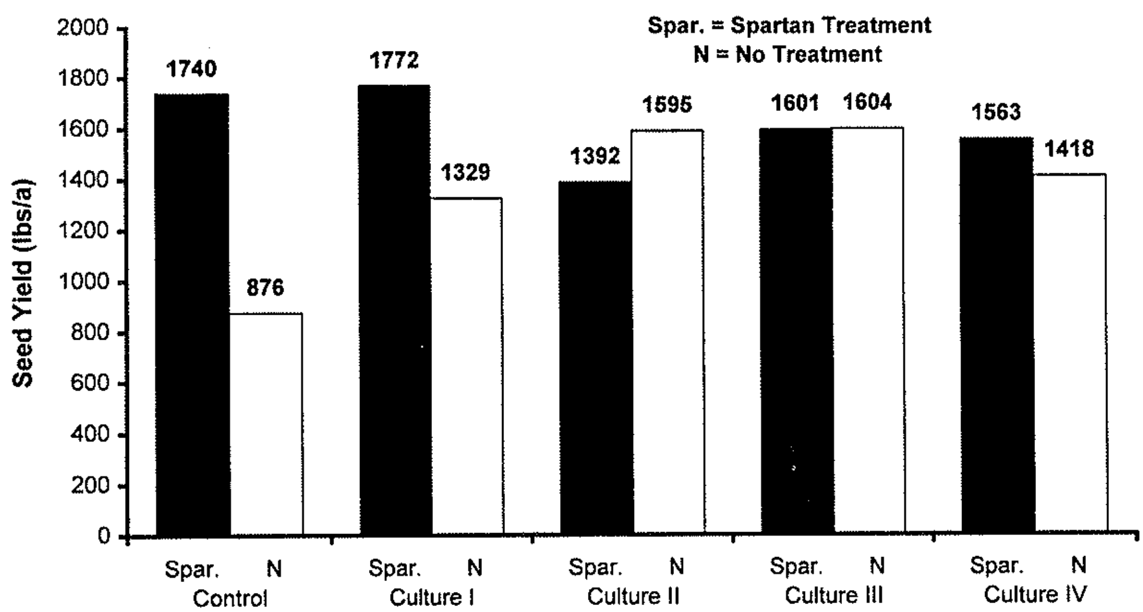


Figure 2. Sunflower seed yield for the control and each cultural practice with and without spartan herbicide.

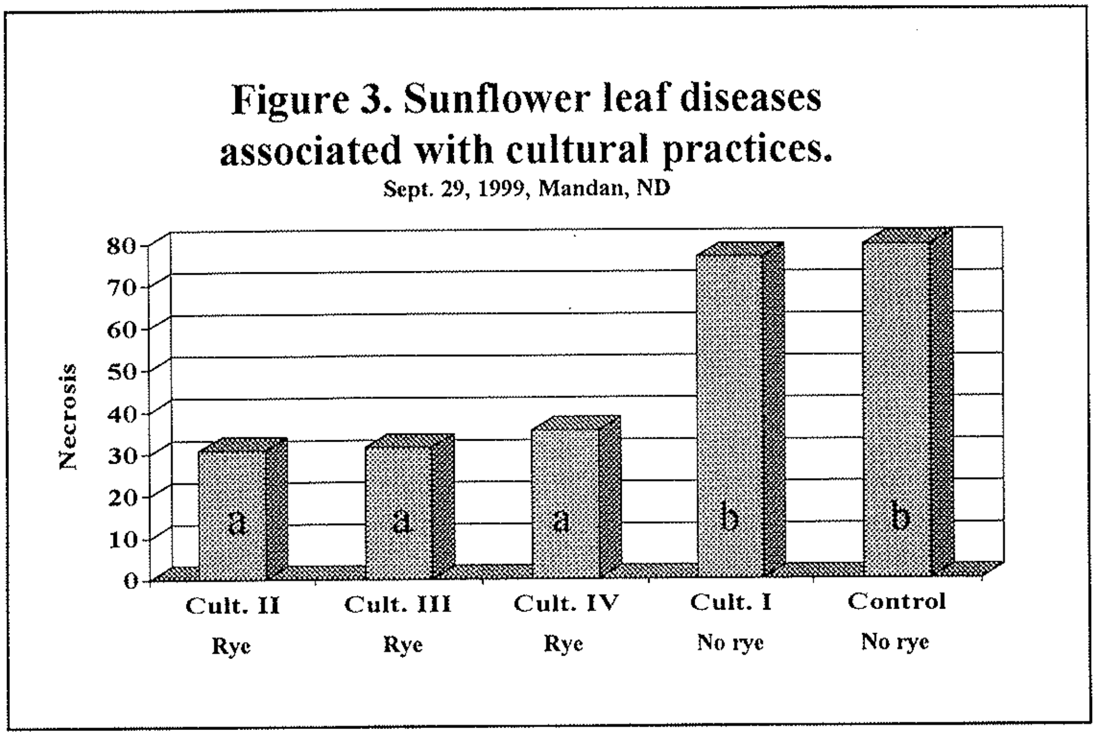


Figure 3. Sunflower leaf diseases associated with cultural practices.
Sept. 29, 1999, Mandan, ND
Necrosis
80
70
60
50
40
30
20
10
0
a
a
a
b
b
Cult. II
Rye
Cult. III
Rye
Cult. IV
Rye
Cult. I
No rye
Control
No rye

NO-TILL CANOLA PRODUCTION

Drs. Donald Tanaka and Joe Krupinsky

New technology in canola production has made it easier for producers to grow no-till canola. To determine the advantages or disadvantages of some of the newer canola types, we divided field H4 into four equal areas of about 1.5 acres and seeded to three herbicide tolerant canola types and compared them to a conventional canola type. All canola types were grown no-till. Canola types, herbicide applications and some agronomic characteristics of each canola type are shown in Table 1. Canola did not emerge until May 28 because of soil crusting problems. All canola types were rolled on May 21 to break the soil crust. Seed yield ranged from 1639 to 855 lb/a depending on the canola type. With good management, weeds can be controlled in all canola types. Canola varieties were evaluated for plants infected with sclerotinia (i.e. white mold, stem rot, caused by *Sclerotinia sclerotiorum*). Incidence of sclerotinia was higher with the north replicate compared to south replicate (Fig. 1). Considering that the north replicate was next to a body of water, it is speculated that the north replicate had a more humid environment.

Table 1. Comparison of herbicide tolerant canola with a conventional canola type (Dynamite).

1999 Canola Varieties

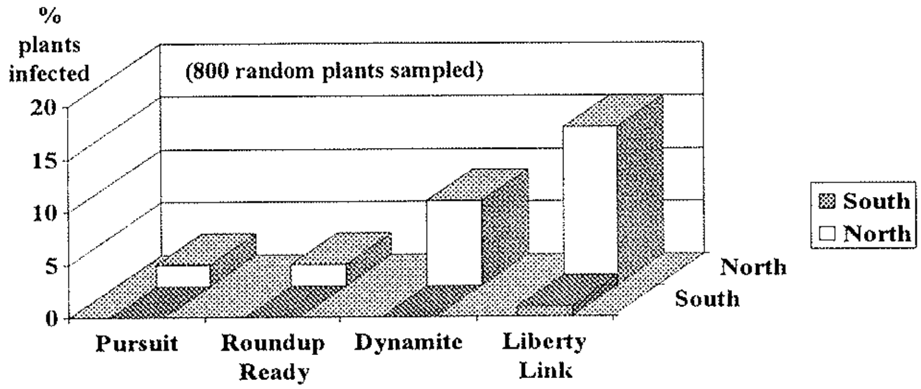
Variety	Treatment	Moisture (%)*	Test Weight (lb/bu)*	[1]Yield (lb/a)	[1]Yield (bu/a)	Plants/m^2	Plants/acre	Viable Seeds/a
Conventional-(Dynamite)	Sonalan	*14.0*	*49.2*	*1137*	*23*	*86*	*348837*	**1 Million**
	No Sonalan	*15.2*	*48.5*	*964*	*19*	*65*	*261628*	**1 Million**
Roundup Ready-(Interstate, SW Rider)	Sonalan	*17.1*	*46.2*	*975*	*20*	*57*	*232558*	**1 Million**
	No Sonalan	*15.9*	*47.2*	*855*	*17*	*49*	*197675*	**1 Million**
Liberty Link-(Invigor, 2373)	Sonalan	*17.5*	*49.2*	*1659*	*33*	*55*	*220930*	**1 Million**
	No Sonalan	*15.9*	*51.0*	*1415*	*28*	*82*	*331395*	**1 Million**
Raptor (IMI)-(Pioneer 46A76)	Sonalan	*16.3*	*42.5*	*1234*	*25*	*77*	*313953*	**1 Million**
	No Sonalan	*16.8*	*44.7*	*1125*	*23*	*75*	*302326*	**1 Million**

Seed Date - 5/14/99 (60 lb N/a and 10 lb P/a at seeding)
*Moisture & test weight from grain moisture analyser
Harvest Date - 8/17/99 Applied Sonalan - 4/19/99
[1]Adjusted to reflect 12% moisture
Stand Counts - 6/23/99 Roundup (1pt) & 2,4-D (0.5pt) - 5/12/99

Canola	Post emergence herbicide (6/15/99)
Roundup Ready --------------	Roundup (1pt/a) + Ammonium sulfate (5gal/100gal)
Liberty --------------------------	Liberty (34oz/a) + Poast (0.5pt/a) + Ammonium sulfate (3 lb/a)
Raptor --------------------------	Raptor (4oz/a) + Preference (1qt/a) + Ammonium sulfate (2.5qt/a)
Conventional ----------------	Poast (1pt/a)

Figure 1. Sclerotinia on Canola varieties

Field H, 1999, Mandan, ND



SITE-SPECIFIC FARMING PROJECT - 1999

Vern Hofman, Ext. Agricultural Engineer
Dr. Dave Franzen, Ext. Soils Specialist
North Dakota State University, Fargo

Introduction

The site-specific farming project in cooperation with the Area IV SCD and USDA-ARS has conducted intensive soil sampling, variable-rate fertilizer application, yield monitoring and map interpretation on 3 of the I fields. These 3 fields consist of about 76 acres split into individual fields of approximately I4-20 acres, I5-29 acres and I6-27 acres in size.

Site-specific management is a practice that allows farming fields as zones within a field as compared to the conventional method of farming fields uniformly. Site-specific farming suggests that plant nutrients may be better utilized if fields are sampled and fertilizer is applied to take advantage of differences within a field. The success of site-specific farming depends on the level of variability within a field, the economic and environmental benefits of determination and managing the variability.

The project objective is to demonstrate site-specific farming techniques and to gather data to support soil sampling techniques, profitability and changes in soil test levels through a cropping rotation.

Previous work has shown that topography based soil sampling provides as good or better soil nutrient information as dense grid sampling at a fraction of the samples (cost) needed to determine field nutrient levels. Profitability of variable - rate fertilizer application has been erratic. Some fields (small grain) of the study had hail damage or low yields which does not provide an accurate assessment regarding profitability. Sunflower data did show a net increase in return for topography directed fertilizer application over a uniform application and a grid based application.

Some preliminary data is showing that sunflower is recycling fertilizer nutrients from deeper soil (2 to 6 ft.) depths. Nutrients are deposited on the soil surface in residue from the previous crop. Soil tests taken after harvest is showing low nitrates in the soil but after breakdown during the next growing season, nutrients are becoming available for the next years crop.

Variable-rate studies from the previous years have shown that for profitable returns from variable-rate application, N levels in the top 24 inches of the soil need to vary by more than 30 lbs/ac. If yields are low due to environmental factors, variable-rate application will probably not be cost effective. Variable-rate application will be most effective when high variability of a nutrient is present, the nutrient is variable within a zone where adjustment impacts crop yield and environmental conditions allow yields to achieve those considered in yield goals based on nutrient requirement predictions.

1999 Methods

In 1999 deep soil sampling down to 6 feet deep was started. This project is designed to demonstrate the reduction of N fertilizer movement through the soil profile by variable rate application. During previous years studies, variable rate application was showing reduced amounts of N fertilizer remaining in the top 24 in. of the soil profile. This project is intended to show this concept in deeper soil levels. In western ND high nitrates have been found in underground water supplies. Variable-rate fertilizer application may help reduce the nitrates getting into water supplies. This past cropping year, variable-rate fertilizer application was done on the east field (I6) only. The average application was about 120 lb/ac. This field was planted to winter wheat in 1998. The other 2 fields were found to have very low (less than 30 lbs) variability of nitrogen. Most of the area in the fields showed low N variability so fertilizer was applied at a uniform rate in 1999. The I4 field (west) was fertilized with 120 lbs of N and 21 lbs of P per acre. The I5 field was fertilized at 115 lbs. of N and 26 lbs. of P. Spring wheat was planted in the middle field and sunflower in the west field. Rainfall during the growing season of March through September was 20.6 inches which is considerably more than the 15 year average of 13.7 inches for the same period.

Results

The 1999 crop yields are shown in figure 1. The sunflower in the I4 field averaged 2230 lbs/acre, the spring wheat (I5) averaged 51.8 bu/ac and the winter wheat (I6) averaged 46.0 bu/ac. The sunflower field shows relatively uniform yield throughout most of the field in the 23 cwt. range. The spring wheat field shows a large area of 50+ bu/ac and a smaller area of slightly less yield. The winter wheat shows a majority of the field in the 35 to 50 bu/ac. range. Some small areas of light color is due to wet areas and low yields.

The majority of the nitrogen applied to the three fields was used by the crop. To produce a crop of wheat, it requires 2½ lbs of nitrogen to produce a bushel of grain. To produce a 46 bu/ac yield, it would take 115 lbs of N per acre. To produce 51.8 bu/ac yield, it would take 130 lbs of N. Sunflower requires about 100 lbs. of N per acre to produce a 2000 lb./ac yield.

Deep soil sampling down to 6 ft. was started after the 1999 crop was harvested. This was done so movement of N can be traced. The soil tests this year will provide a baseline to compare future years test results. This is being done to demonstrate the reduced N movement when variable rate application is used. Previous years work has shown a reduction in residual soil stored N under variable application. Less N in the soil means less N is available to move through the soil to cause potential buildup of nitrates in underground water supplies. This will demonstrate to producers that variable-application can help reduce pollution to water supplies and help provide added economic benefit.

Figures 2, 3 and 4 show the residual amounts of N in the top 6 ft. of the soil profile. Figure 2 shows N fertilizer in the top 24 in. for all three fields (I4, I5, and I6). The average amount of N in this top layer was 28 lbs/acre. The maps show that about 90% of the 3 fields contained 15 to 35 lbs. of N. The I4 field shows a large area with less than 25 lbs./ac of N and a very small area of more that 35 lbs./ac in the extreme North end of the field. The average amount of N in the top 2 ft. Of I4 field is 26.1 lbs./ac. The I5 and I6 fields indicate a large area with 25 to 35 lbs of N per acre and a smaller area with 15 to 25 lbs. of N per acre.

Figure 3 indicates the residual N left in the 24 to 48 in. level of all three fields. The average for all 3 fields was 16.9 lb/ac. The I4 field shows that about ½ or more of the field had less than 15 lbs/ac of N while the remaining part had 15 to 30 lbs/ac. The I5 and I6 fields indicate that slightly less than ½ the fields had less than 15 lbs/ac of N while the remainder had over 15 lbs/ac. A few limited areas had over 60 lbs/ac. and do not represent much area in the field.

Figure 4 shows the residual N in the 48 to 72 in. level in the field. The average amount of N in all three fields was 22.2 lbs/ac. All fields indicate about 17 to 29 lbs/ac. of N except for lesser amounts in the I5 field and more than 41 lbs. of N in the south end of the I6 field.

The soil fertility tests indicate the largest amount of N was found in the top 24 in. of the soil profile. Less N was found deeper in the soil. Previous work has indicated that sunflower tends to recycle N from deeper soil depths because of it's tap root system. This did happen at the 2 to 4 ft. level. In figure 3, a large area at the 2 to 4 ft. level shows low N levels. The average pounds of N in this field at the 2 to 4 ft. level was 14.4 lbs/ac. This is 2.5 lbs/ac. less than the average for the 3 fields. The N was recycled from this area rather than from the 4 to 6 ft. level. This was due to the above normal rainfall causing the sunflower to root to only the 2 to 4 foot level.

The soil tests indicate very little N left in each of the 2 ft. increments of the top 6 ft. of the soil profile. The top 2 ft. indicated the highest average amount of N while the lower 2 to 6 ft. levels were less. All three fields show very low and relatively uniform amounts of N. To justify variable application, reasonably large areas with high and low N is needed. It was not found in this field. This is because of variable application during the previous years. Soil tests in 1995 and 1996 show areas in the top 24 in. of the fields with well over 30 lbs. of N per acre. Variable application reduced this amount.

Conclusion

Crop yields in 1999 on the 3 I fields on the Area IV farm near Mandan were very good. Above normal rainfall, significant fertilizer applications and a good growing season produced very good yields on all three of the I fields studied.

Deep soil sampling was done to 6 ft. This was done to establish a baseline for future years demonstration work. Previous years soil sampling indicate reduced amounts of N in the top 2 ft. of the soil profile. This should show up at deeper depths depending on rainfall. Reduced amounts of N in the soil should result in less N ending up in groundwater causing pollution.

Soil tests after a sunflower crop is showing the recycling of N from deeper depths to the soil surface in the form of residue. Tests in 1999 show less N in the top 4 ft. of the soil profile but no change in the 4 to 6 ft. levels as compared to tests done on the wheat fields. It is planned to continue this work for another 5 years to demonstrate the reduced amounts of residual N in the soil from variable rate application and the recycling affect of sunflower removing N from deep soil depths (2 to 6 ft depths) bringing them to the surface.

Figure 1
I4, I5 & I6 Fields
1999 Crop Yields

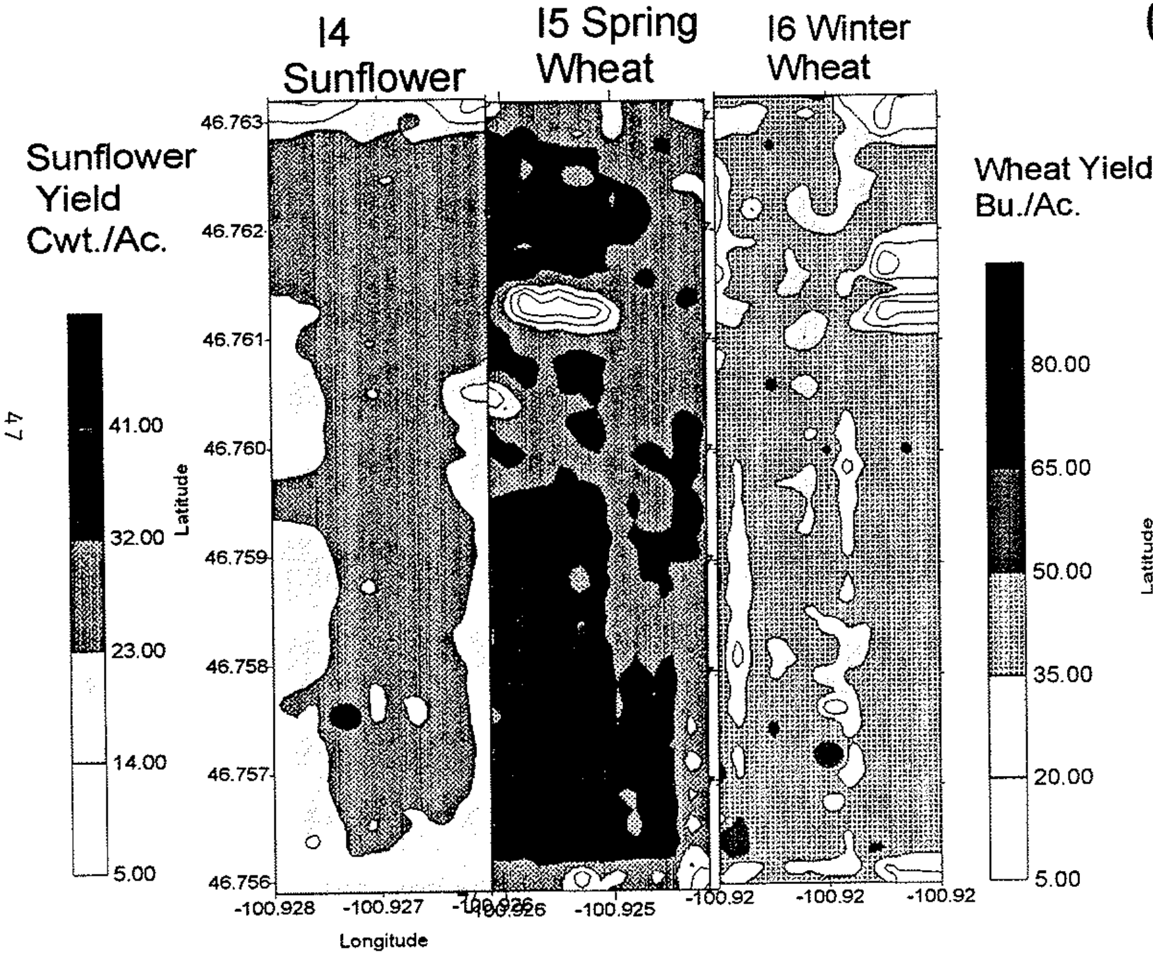


Figure 2
I4,I5,I6 Fields
1999 Residual Nitrogen
0 to 24 inch Level

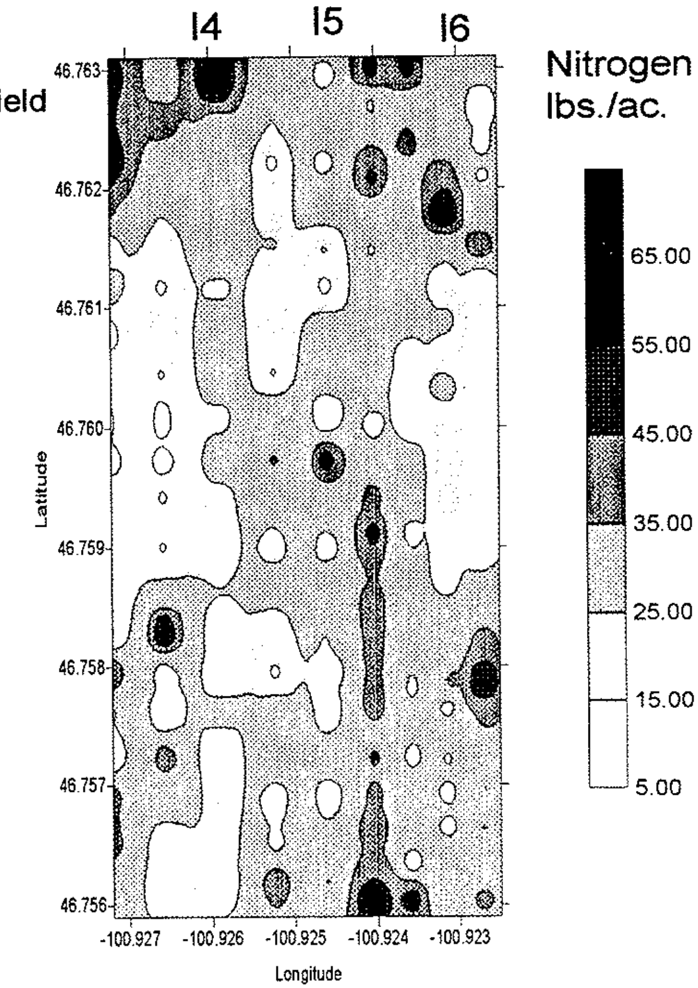


Figure 3
I4, I5, I6 Fields
1999 Residual Nitrogen
24 to 48 inch Level

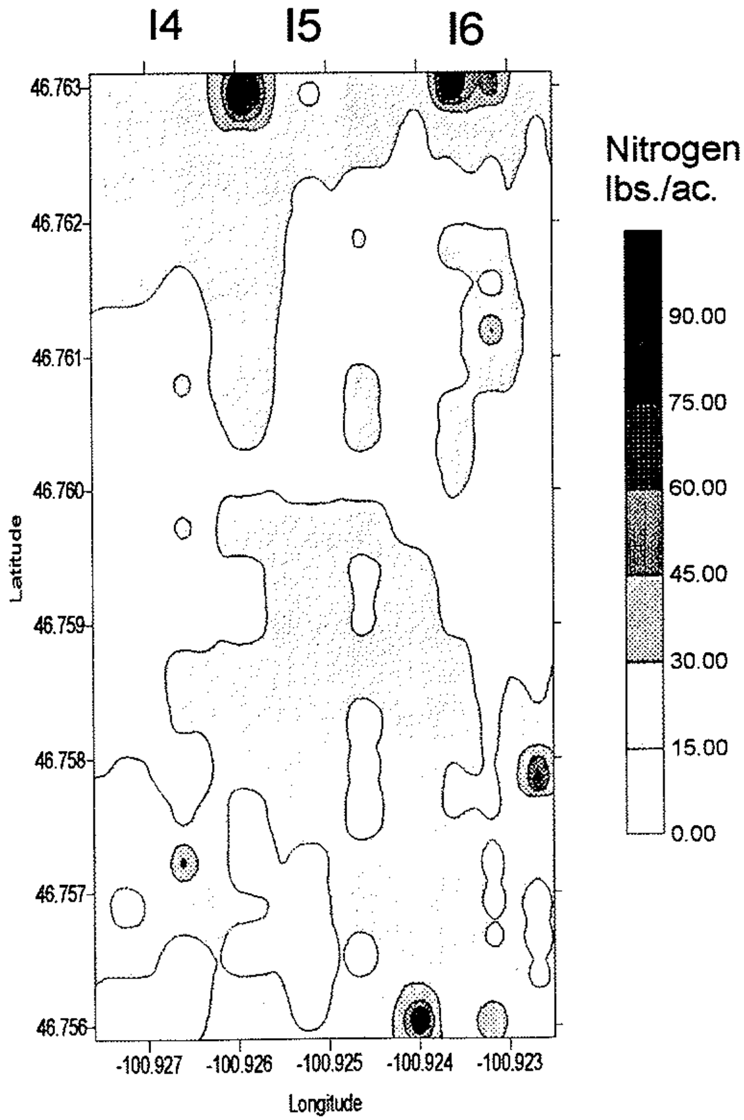
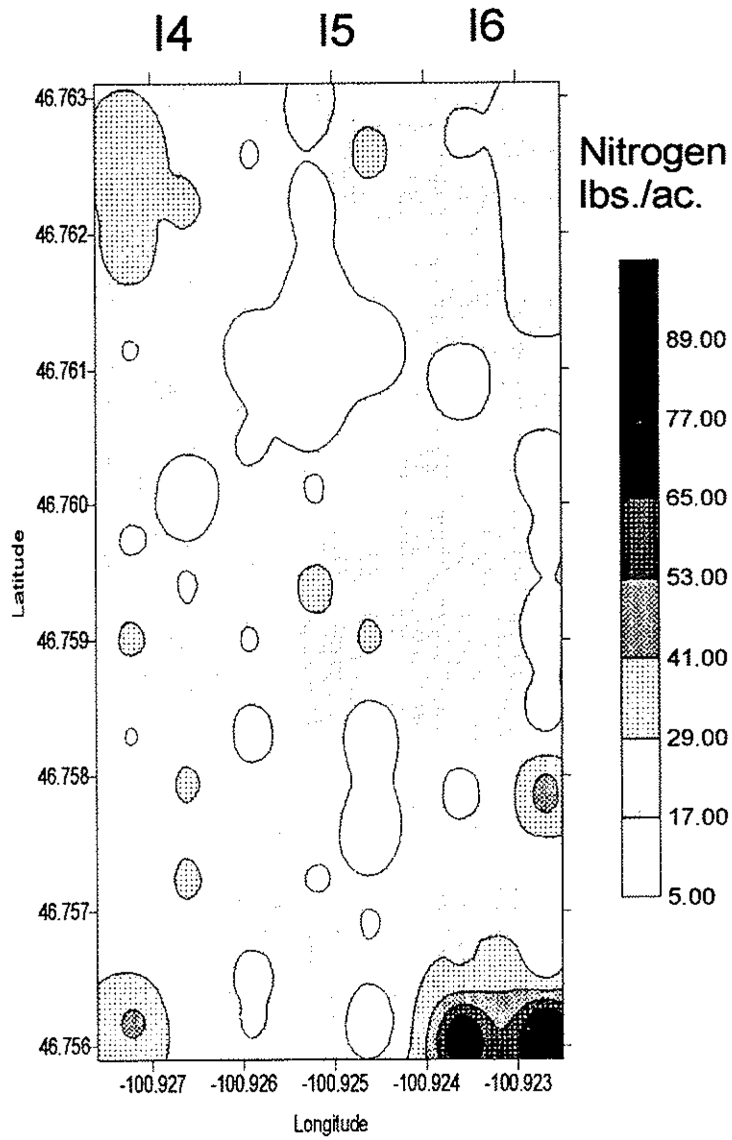


Figure 4
I4, I5, I6 Fields
1999 Residual Nitrogen
48 to 72 inch Level.



SMALL GRAIN VARIETY EVALUATIONS

Mr. Eric Eriksmoen, NDSU, Hettinger, ND

Hard Red Spring Wheat - No-till Recrop	Mandan

Variety	Plant Height	Test Weight	Protein	Grain Yield 1997	Grain Yield 1998	Grain Yield 1999	Average Yield 2 year	Average Yield 3 year
	in	lbs/bu	%	bu/ac				
Forge	36	58.1	13.1	37.8	56.3	45.6	51.0	46.6
2375	32	57.1	12.5	38.4	55.2	39.2	47.2	44.3
2398	32	53.7	12.7	29.3	58.8	38.5	48.6	42.2
Oxen	32	53.1	11.6	37.3	52.6	36.0	44.3	42.0
Trenton	42	58.4	12.3	27.8	52.0	44.1	48.0	41.3
Keene	40	59.1	12.4	32.6	50.4	39.8	45.1	40.9
Ernest	39	57.4	12.1	28.7	46.9	34.9	40.9	36.8
Grandin	33	53.2	14.2	32.5	45.2	23.4	34.3	33.7
Argent HWSW	35	56.5	12.9		42.9	36.8	39.8	
Reeder	33	57.7	12.6			46.9		
HJ98	30	55.3	12.1			44.1		
Parshall	36	60.2	13.4			42.9		
Trial Mean	35	56.6	12.7	34.0	50.2	39.3	--	--
C.V. %	5.6	1.6	--	20.7	7.0	12.5	--	--
LSD .05	3	1.6	--	NS	6.0	8.3	--	--
LSD .01	4	2.1	--	NS	8.0	11.3	--	--

Planting Date: April 29, 1999
Seeding rate: 1.1 million live seeds/A (approx. 1.6 bu/A).
Yields are adjusted to 12% moisture.
NS = no statistical difference between varieties.

Harvest Date: August 18, 1999
Previous Crop: 1997 = Corn
1998 = HRSW
1999 = Rye

Barley - No-till Recrop	**Mandan**

Variety	Plant Height	Test Weight	Protein	--Grain Yield -- 1997	1998	Average Yield 2 year
	in	lbs/bu	%	---------- bu/ac		----------
Logan	25	51.3	12.4	46.7	77.2	62.0
Conlon	23	50.8	12.0	47.3	75.3	61.3
Bowman	22	50.9	11.7	51.2	71.0	61.1
Stark	27	51.3	11.1	36.1	77.6	56.8
Trial Mean	25	50.9	11.6	46.1	73.2	--
C.V. %	7.4	0.5	--	29.3	9.4	--
LSD .05	3	0.4	--	NS	NS	--
LSD .01	NS	0.5	--	NS	NS	--

Planting Date: April 15, 1998
Seeding rate: 750,000 live seeds/A (approx. 1.4 bu/A).
Harvest Date: August 10, 1998
Previous Crop: 1997 = corn
1998 = HRSW
Yields are adjusted to 12% moisture.
NS = no statistical difference between varieties.

1999 Mandan barley variety trial was destroyed by severe bird depredation.

Barley in Southwestern North Dakota
Combined Means

Variety	Days to Head	Plant Height	Test Weight	Protein	Grain Yield 1997	1998	1999	Average Yield 2 year	3 year
		in	lbs/bu	%	----------		bu/ac		----------
Logan	62	25	49.5	15.2	85.6	72.9	83.9	78.4	80.8
Conlon	59	25	49.0	14.8	81.2	68.2	77.4	72.8	75.6
Stark	62	27	49.7	15.3	81.9	67.9	75.9	71.9	75.2
Bowman	61	24	49.0	15.6	75.1	69.6	77.2	73.4	74.0
# of Locations	2	6	6	6	6	10	6	10	22

Durum - No-till Recrop	Mandan

Variety	Plant Height	Test Weight	Protein	Grain Yield 1997	Grain Yield 1998	Grain Yield 1999	Average Yield 2 year	Average Yield 3 year
	in	lbs/bu	%	bu/ac				
Ben	38	60.2	13.2	42.5	53.6	59.0	56.3	51.7
Renville	43	58.8	13.5	40.9	52.1	58.0	55.0	50.3
Belzer	39	57.3	12.8	31.8	45.0	50.9	48.0	42.6
Mountrail	38	58.8	13.0		57.0	60.5	58.8	
Maier	37	58.4	13.7		54.6	51.9	53.2	
Lebsock	37	60.0	12.9			55.0		
Plaza	31	56.9	12.8			45.3		
Trial Mean	38	58.6	13.1	37.5	52.3	54.4	--	--
C.V. %	4.8	0.7	--	15.7	5.2	8.9	--	--
LSD .05	3	0.8	--	NS	4.0	8.6	--	--
LSD .01	4	1.1	--	NS	5.5	NS	--	--

Planting Date: April 29, 1999 Harvest Date: August 18, 1999
Seeding rate: 1.25 million live seeds/A (approx. 2.2 bu/A). Previous Crop: 1997 = Corn
Yields are adjusted to 12% moisture. 1998 = HRSW
NS = no statistical difference between varieties. 1999 = Rye

Durum in Southwestern North Dakota
Combined Means

Variety	Days to Head	Plant Height	Test Weight	Grain Yield 1997	Grain Yield 1998	Grain Yield 1999	Average Yield 2 year	Average Yield 3 year
		in	lbs/bu	bu/ac				
Ben	68	35	59.6	48.1	47.6	50.7	49.2	48.8
Belzer	68	36	56.8	45.8	43.3	48.8	46.0	46.0
Renville	68	37	58.5	46.5	44.2	44.3	44.2	45.0
Mountrail	69	34	58.4		48.9	48.5	48.7	
Maier	68	33	59.2		48.8	45.0	46.9	
Lebsock	67	33	59.9			45.4		
Plaza	69	29	57.4			44.5		
# of locations	2	8	10	4	9	10	19	23

Oats - No-till Recrop	**Mandan**

Variety	Plant Height	Test Weight	Grain Yield 1997	Grain Yield 1998	Grain Yield 1999	Average Yield 2 year	Average Yield 3 year
	inches	lbs/bu	bu/ac				
Jud	46	35.5	53.4	112.9	91.0	102.0	85.8
Jerry	44	36.5	40.2	125.2	58.7	92.0	74.7
Paul*	49	43.6	33.8	93.3	48.3	70.8	58.5
Ebeltoft	39	36.0			99.2		
Youngs	46	34.8			84.1		
Trial Mean	45	37.3	50.4	116.9	76.3	--	--
C.V. %	5.2	1.0	15.6	7.8	5.9	--	--
LSD .05	4	0.7	11.6	13.6	8.3	--	--
LSD .01	6	1.0	15.8	18.7	11.9	--	--

Planting Date: April 29, 1999 Harvest Date: August 18, 1999
Seeding rate: 750,000 live seeds/A (approx. 1.7 bu/A).
Previous Crop: 1997 = Corn
1998 = HRSW
1999 = Rye
Yields are adjusted to 12% moisture. * Naked (hulless) type.

Oats in Southwestern North Dakota
Combined Means

Variety	Days to Head	Plant Height	Test Weight	Grain Yield 1997	Grain Yield 1998	Grain Yield 1999	Average Yield 2 year	Average Yield 3 year
		in	lbs/bu	bu/ac				
Jud	72	42	35.0	93.8	89.5	79.7	84.6	87.7
Jerry	68	39	38.5	92.8	89.7	77.9	83.8	86.8
Paul*	74	40	41.3	59.3	65.5	42.0	53.8	55.6
Ebeltoft	72	35	35.5			76.9		
Youngs	72	42	34.8			74.5		
# of locations	2	6	10	6	7	10	17	23

*Naked (hulless) type.

OTHER RELATED NGPRL RESEARCH

INTEGRATED CROP/LIVESTOCK SYSTEMS

Drs. Donald Tanaka, Jim Karn, and Ron Ries

In the spring of 1999, two 15-acre crested wheatgrass pastures were put into no-till annual grain and forage production. Both pastures were sprayed with Roundup (20 oz/a) plus 2, 4-D ester (16 oz/a) on May 13 and again on May 19. On May 24, one-third of the area was seeded to an oat/pea mixture (Paul oat/Arvika pea) at a seeding rate of 50 lb/a of oats and 60 lb/a of peas and one-third of the area was seeded to triticale (Trical 2700) at a seeding rate of 100 lb/a and under seeded with sweet clover (8 lb/a). The remaining one-third was sprayed with Fallowmaster (32 oz/a) on June 2 and seeded to corn (100 or 112 day) for forage on June 8. All crops received 60 lb N/a as urea and 50 lb/a of 11-52-0 at seeding. No other fertilizer or herbicides for weed control were used. Oat/pea and triticale were harvested for grain on September 10 with the straw left in a windrow. Corn was swathed on September 16.

Grain and straw production for the oat/pea mixture and triticale are shown in Figure 1A and B. Grain yields were lower than expected considering precipitation was much above average, but protein in the grain was high. The straw was used to overwinter dry bred beef cows during the 1999-2000 winter with the grain feed as a supplement. Because crude protein was low in oat/pea and triticale straw, grain was added to increase crude protein to meet animal requirements. Corn produced the highest total dry matter of the three crops (18,138 lb/a) with a crude protein of 6.156% (Figure 1C and D). In 2000, the research will be conducted again.

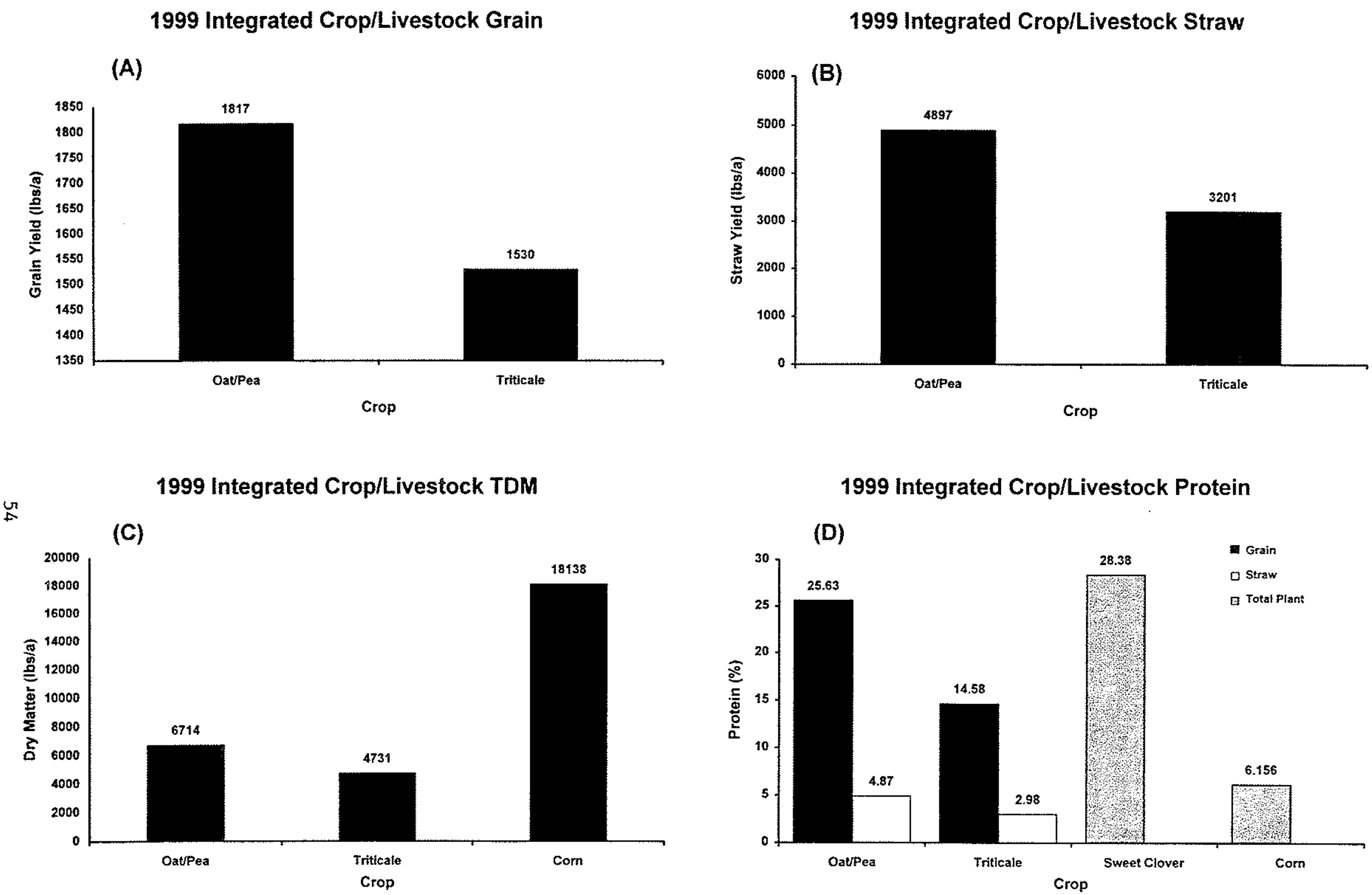


Figure 1. Grain and straw yield for oat/pea and triticale (A and B); total dry matter produced (grain plus straw), and protein concentration for oat/pea, triticale/sweet clover, and corn for forage (C and D).

FORAGE BREEDING RESEARCH

Dr. John Berdahl

Perennial forage grass and alfalfa germplasm and cultivars are being developed with improved stand establishment capability, nutritive quality, and traits associated with productivity and persistence for our highly variable climate and soils in the Northern Great Plains. The objective is to develop forages that will complement our native grasslands and provide additional management options for integrated forage-crop-livestock production systems. Current forage breeding efforts are centered on development of Russian wildrye cultivars with improved seedling vigor and alfalfa cultivars that are adapted to dryland pasture and hay. Two recently released cultivars of intermediate wheatgrass, Reliant and Manska, were selected for improved persistence and nutritional quality. These two cultivars have maintained high yields in grass-alfalfa mixtures. Yields of the grass component in simple grass-alfalfa mixtures averaged 35% of total yield for both Reliant and Manska intermediate wheatgrass, 33% for Lincoln smooth bromegrass, and 30% for Nordan crested wheatgrass in the fifth production year. Persistent grass-alfalfa mixtures produce hay with excellent nutritive quality for beef cattle and have both economic and environmental advantages over grass in pure stands. In tests with Reliant and Manska, total seasonal dry-matter yields from two cuttings averaged 3.9 and 1.2 tons per acre, respectively, for grass-alfalfa mixtures and grass alone with no supplemental nitrogen fertilizer. With annual applications of 45 lb nitrogen per acre, grass- alfalfa mixtures and grass stands averaged 3.9 and 2.3 tons per acre, respectively.

CARBON SEQUESTRATION IN NORTHERN GREAT PLAINS GRASSLANDS

Dr. Al Frank

Grasslands make up about 32% of the earth's natural vegetation. Some suggest that the large land area occupied by grasslands may serve as a carbon sink that could be important in balancing the global carbon budget. Carbon dioxide exchange by grasslands and associated plant and soil processes must be understood to accurately predict future levels of atmospheric carbon dioxide which is increasing at about 1.5 ppm per year. This study is associated with the USDA-Agricultural Research Service Carbon Dioxide Flux Network involving 11 rangeland research locations in the Great Plains and western USA. The goal is to determine the role of grasslands in the global carbon cycle. Objectives of this study were to compare carbon dioxide fluxes over moderately grazed and nongrazed native mixed grass prairie pastures at the NGPRL. Carbon dioxide fluxes were measured over two years from mid April to November using Bowen ratio-energy balance methods. Forage production from these pastures averaged 1187 and 1009 lb/acre, leaf area index was 0.47 and 0.40, and root dry weights to 12-inch depth averaged 9966 and 9680 lb/acre for the grazed and nongrazed pastures, respectively. Net April-November carbon dioxide fluxes were 2607 and 3045 lb/acre for the grazed and nongrazed pastures, respectively. The amount of sequestered carbon available for soil storage during the April to November period would be 711 and 831 lb/acre for the grazed and nongrazed pastures, respectively. These results suggest that these grasslands, which are typical of the native grassland ecosystems of the Northern Great Plains, are potential sinks for carbon.

COMPUTER SIMULATION AND DECISION SUPPORT

Dr. Jon Hanson

Problem Definition

Maintenance of sustainable agriculture in the Northern Great Plains has become a complex problem demanding consideration of a range of interrelated factors, processes, and institutions. Across the Plains, agriculture is limited by the supplies of water and nitrogen that are available from the natural system. Supplementing these scarce resources without damaging the environment is a major challenge. Past management practices and Federal programs have created special environmental, managerial, economic, and political considerations that must be addressed. Producers must be able to adapt to fluctuations in weather and commodity prices, plus react to trends in Federal and State legislation, and to perceptions by the urban public. In the immediate future, the ability to quickly modify farm and ranch management practices *to take advantage of*

- the global economy;
- new cropping, pest management, and tillage systems; and
- new legislation

while protecting soil, air, and ground water resources will determine whether an agricultural enterprise system survives or perishes.

Several computer programs can be modified for use in these harsh and unpredictable environments. Two that can be quickly modified to assist land managers of the Northern Great Plains include GPFARM and RZWQM.

GPFARM

The goal of GPFARM is to provide an operational framework for a whole farm/ranch decision support system across the Great Plains including site-specific management, economic, social, and environmental considerations; site database generation; and risk analysis from which alternative agricultural strategies can be developed and tested. The ultimate challenge of GPFARM is to develop a product that implements the concepts of the systems approach to address the problems of Great Plains agriculture today and in the future. GPFARM incorporates algorithms to address the major components of the decision making process. These include:

1. *Fact gathering.* Using a series of user friendly screens, input data, existing data bases, and simulation models are used to investigate the effect of various management options on user-defined scenarios.

2. *Data organization.* Data is subsequently organized to answer specific questions relating to production, economic, and environmental and economic risk of each tested scenario.

3. *Data analysis.* Multi-criteria decision analysis is used to determine "best" management strategies for the set of scenarios being investigated.

4. *Presentation of results.* Results are presented to the user in the form of tables and graphics with adequate interpretation to assist the manager in making the best decision based on the test scenarios.

The conceptual basis and recognized need for a systems approach and networking of scientists for agricultural research in the Great Plains dates back at least 10-15 years and was emphasized at a regional symposium "Sustainable Agriculture for the Great Plains" (Hanson et al. 1991) held in 1989 in Fort Collins. Subsequent to the conference, a report entitled Great Plains Agroecosystems Project outlined the basic components and key institutions needed in a regional project that would tie together the research efforts across the Plains. Central to these efforts, a need was identified to develop a computer-based decision support system (DSS) for Great Plains agriculture. The system provides management support at the whole-farm level with emphasis on water and nutrient management and strong ties to pest management, economics, environmental considerations, and risk analysis. The computer program should be most useful to agricultural consultants and computer-oriented producers. The feasibility of a DSS for the Great Plains has been previously demonstrated.

Our premise has been that many farmers and ranchers are not accurately assessing production systems for resource use, economics, or the ecological impacts of their current management practices. This statement is supported by direct responses from producers and by environmental and economic studies. Producers say they wish to optimize their production systems, but do not have access to the research information they need, nor to methods that provide site-specific analyses, tests, and applications of this information. Decision support systems can be applied at the whole farm-ranch level to assist producers, consultants, Extension, and NRCS personnel in making timely management decisions about mid- and long-term practices (up to 10 years) that will result in sustainable agricultural enterprises. GPFARM works exactly in this are since it is a decision support system capable of analyzing 1-10 year farm level, management plans based on the predicted productivity of selected management options and associated environmental and economic risks.

Support for development and use of a DSS has been strong among agricultural producers, resource managers, and scientists in the region. For example, producers view such tools as a means of accessing on-farm management information not previously available. GPFARM was developed under these guidelines and version 1 of the model is currently available for users in Colorado. The purpose of our work at the Northern Great Plains Research Laboratory is to modify the databases and other input data so the program can be used to assist land managers as they make decisions on range, pasture, and crop lands of the Northern Great Plains.

RZWQM

In response to increased demand for food and fiber, current agricultural management practices encourage intensive use of available soil, water, plant, and chemical resources. Several decades of strategically increasing agricultural production has deteriorated our natural resources. In many situations, increases in soil erosion and harmful levels of nutrients, pesticides, and salinity in surface and ground water have decreased the efficiency of crop production. An interactive use of experimentation and ecosystem-level modeling can be used to develop new management practices and cropping systems for sustainable agriculture and enhanced environmental quality. Models are also used to investigate interactions between fundamental physical, chemical, and biological processes, to extrapolate management impacts to other locations, and to assess long-term effects of alternative management strategies.

The Root Zone Water Quality Model (RZWQM) is a research model developed to address these concerns. Additional features incorporated into RZWQM for simulating management impacts included chemical transport via macropores, run-off water, and tile drainage; advanced soil chemistry and nutrient transformations; improved pesticide dynamics; and generic crop production. The model has undergone extensive verification, evaluation, and refinement in cooperation with five MSEA (Management Systems Evaluation Areas) water quality projects in the Midwestern States. Currently, the model simulates corn and soybeans growing across the heart of the country (Hanson, et al. 1999, RZWQM Development Team 1998). The goal of the Northern Great Plains Research Laboratory is to extend the usefulness of the model by parameterizing and testing the model for variety of crops included in the Alternative Crops Project reported earlier in this document.

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