1998 Research and Cropping Results

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INTRODUCTION TO AREA IV RESEARCH FARM

The Area IV 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 of North Dakota. 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 breeding 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 (Fig. 1). The general 1998 cropping plans are outlined on maps for the four field areas designated as F, G, H, and I (Fig. 2). The precipitation pattern for the 1998 growing season and the total precipitation history (1984-1998) for the duration of the Area IV cooperative agreement is shown in Fig. 3.

FIELD F ACTIVITIES, 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. The previous crop was sunflower (1486 lb/a). The sunflower stubble was left standing over the winter to augment snow trapping and soil water storage. Anhydrous ammonia was custom applied to the north half (200') of the field on April 16, 1998 at a rate of 60 lb N/a. The field was worked with a John Deere (JD) Mulchmaster on April 21, 1998 and seeded to Amidon spring wheat on April 24, 1998. The seeding was performed with a Haybuster 107 disk drill with 7.5" row spacing and a seeding rate of 1.3 million seeds/a. Fertilizer as 18-46-0 was applied with the seed at a rate of 40 lb/a of material. Nitrogen as 46-0-0 was applied between the seed rows at a rate of 60 lb N/a to the south half only. The field was sprayed with Tiller plus Buctril (7.1 + 4 oz ai/a) on June 27, 1998. The spring wheat crop was combined (35.1 bu/a) on August 30, 1998. The north half of the field that received the anhydrous ammonia averaged 1 bu/a higher than the south half which received urea. No dockage or protein is reported from the individual fields because the grain could not be taken to the elevator from the field and had to be stockpiled. The field was sprayed with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) on September 3, 1998. On September 18, 1998 the field was seeded to Roughrider winter wheat. 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 a 10" row spacing.

Field F3. The previous crop was spring wheat (47.5 bu/a). The field was sprayed with Roundup Ultra (6 oz ai/a) on September 25, 1997. Downy brome, a winter annual

Fig. 1. Map of the Land Associated with the USDA-ARS Northern Great Plains Research Laboratory and the Area IV SCD-ARS Research Farm.

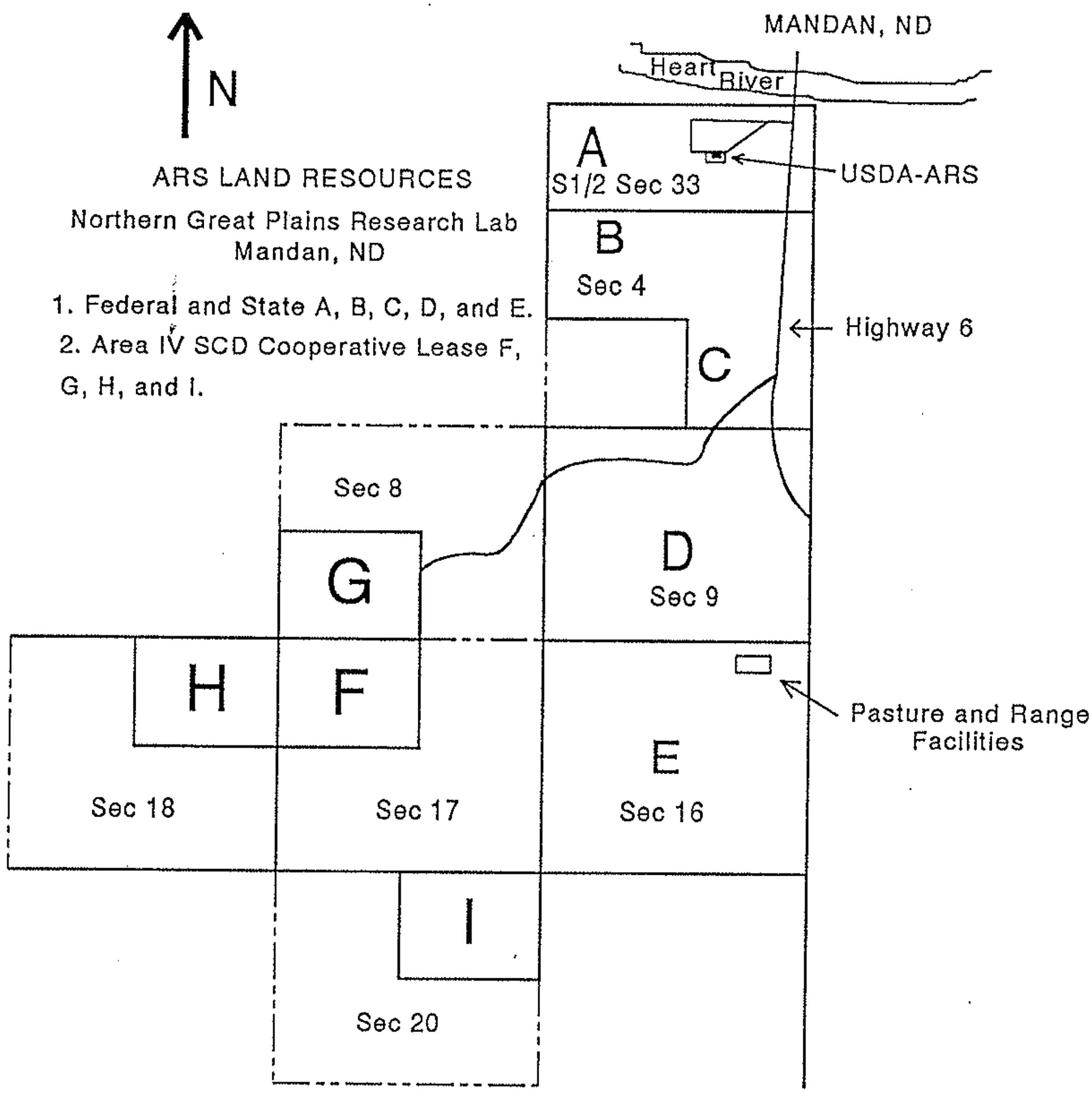


Fig. 2. Area IV Research Farm Crop Plan - 1998.

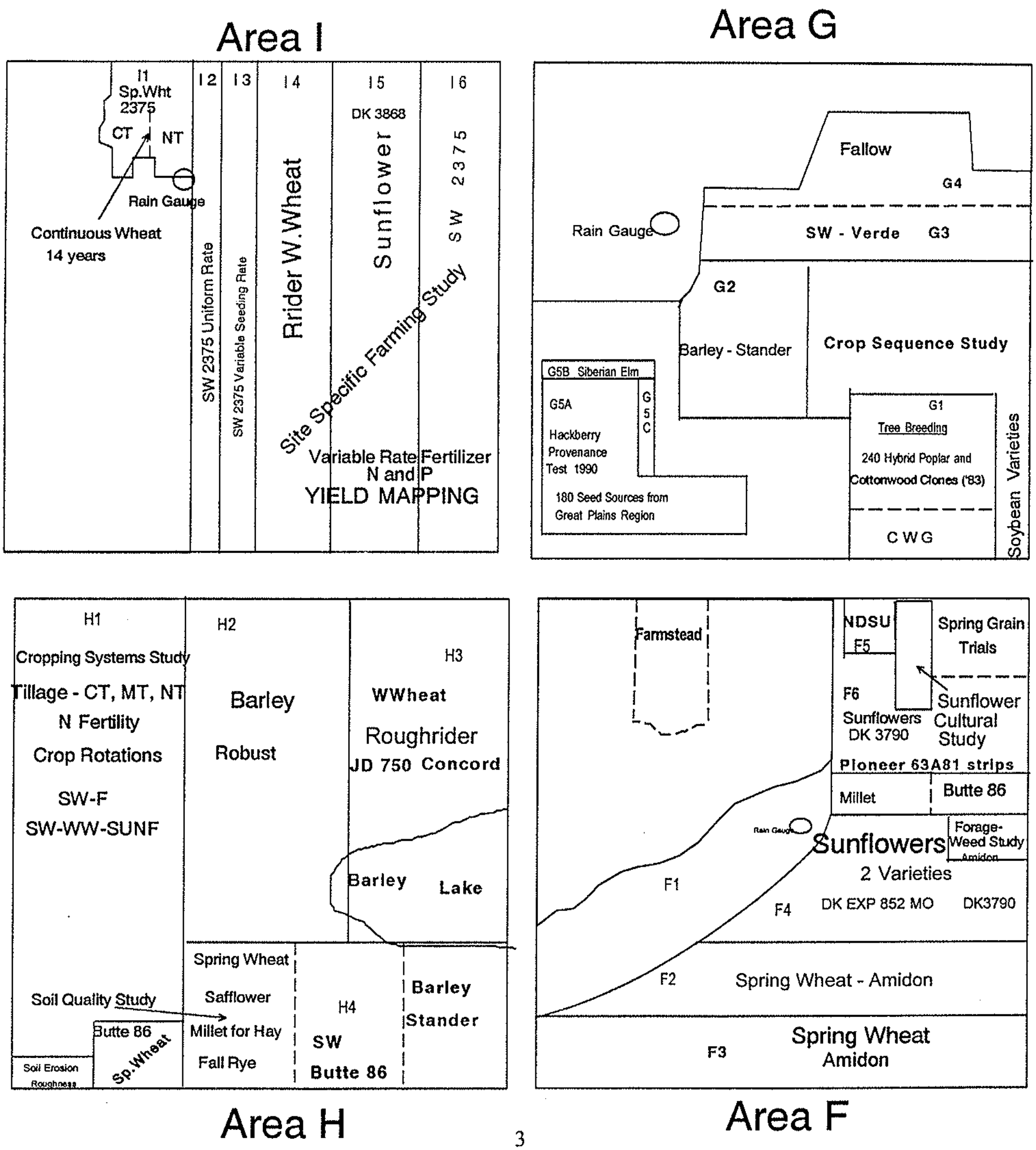
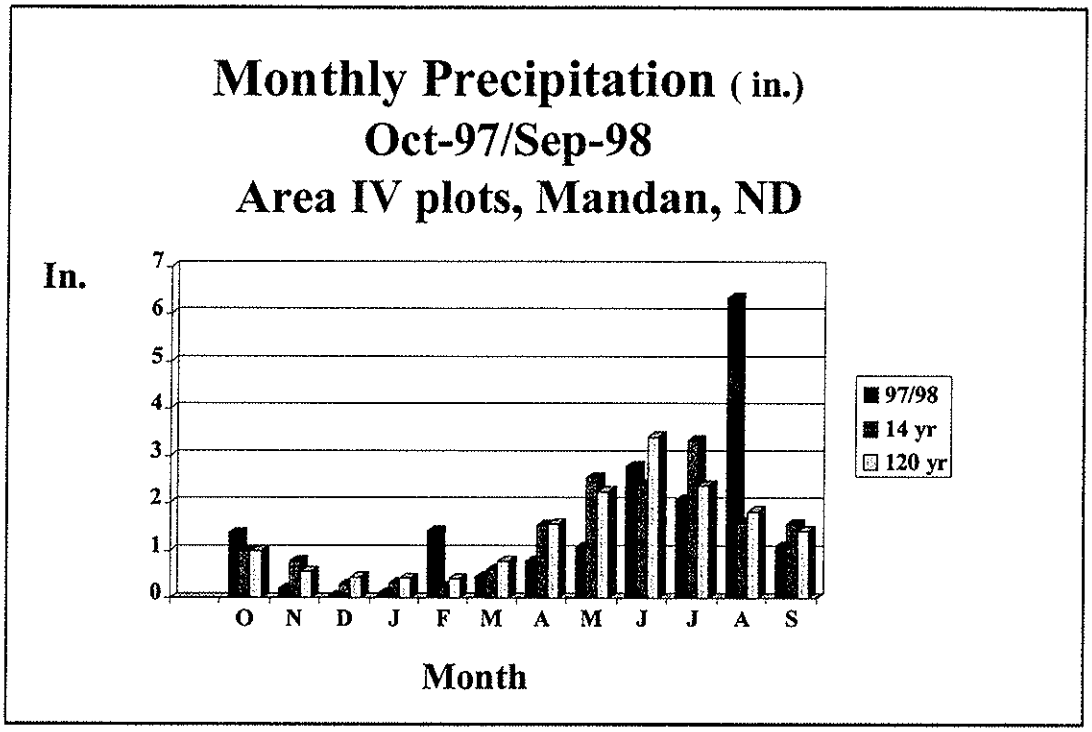
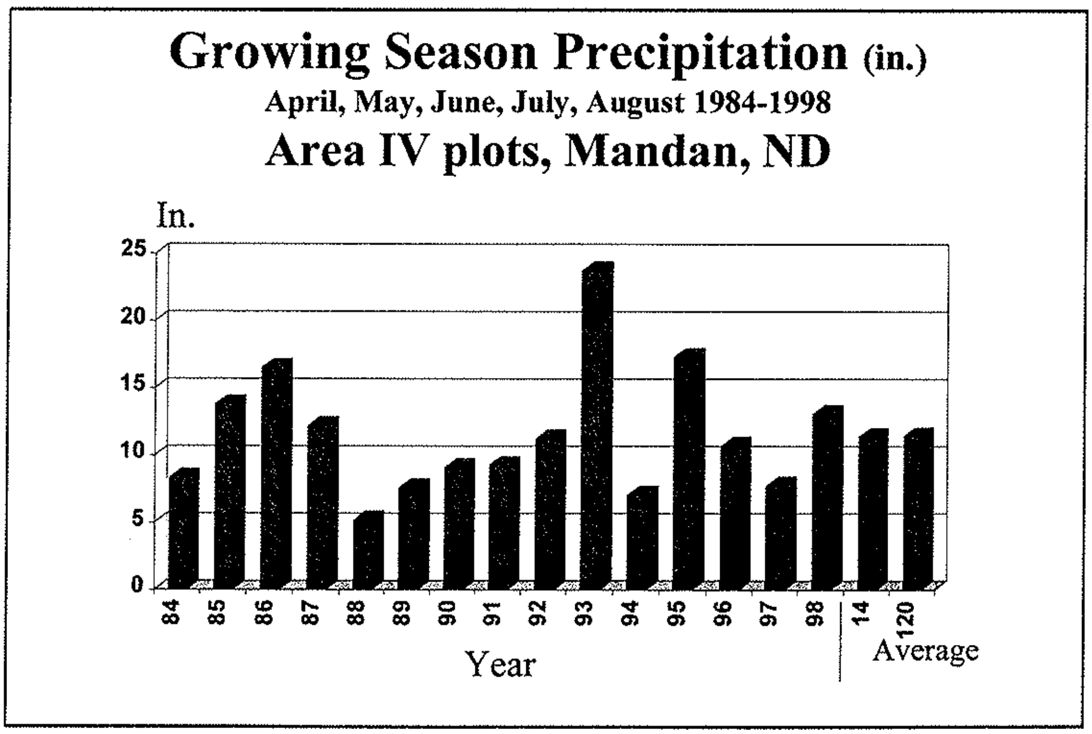


Fig. 3. Monthly Precipitation During the 1997-1998 Crop Year and Growing Season Precipitation at the Area IV SCD-ARS Research Farm.





weed, was in the 1 - 2 leaf stage at that time. Elkhorn winter wheat was seeded with a JD 750 no-till disk drill (7.5" row spacing). Nitrogen as 46-0-0 was applied between the seed rows (60 lb N/a) and as 18-46-0 was applied with the seed (50 lb/a) on October 2, 1997. The winter wheat stand was very poor in the spring, and the field was tilled with a JD Mulchmaster on April 30, 1998 and reseeded to Amidon spring wheat on May 1, 1998. The seeding was performed with a JD 750 no-till disk drill at a rate of 1.3 million seeds/a. No fertilizer was applied at this time. Spraying with Tiller plus Buctril (5.4 + 4 oz ai/a) took place on June 4, 1998. The field was combined on August 10, 1998 with a yield of 30.5 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) took place on September 3, 1998.

Field F4. The previous crop was winter wheat which yielded 25.8 bu/a. Sonalan 10G (1 lb. ai/a) was applied with a Gandy air applicator mounted on a Haybuster undercutter on April 14, 1998. Anhydrous ammonia was custom applied at a rate of 60 lb N/a on April 16, 1998. The second incorporation of the Sonalan was performed on May 19, 1998 with a JD Mulchmaster. The field was divided and the north side was seeded to DeKalb Exp 852 MO (Nusun) and the south side was seeded to DeKalb 3790 sunflowers. Both varieties were seeded at a rate of 25,000 seeds/a in 30" rows with a JD MaxEmerge II planter. The field was sprayed with Assert (4 oz ai/a) on July 1, 1998 and Poast (3 oz ai/a) on July 7, 1998. The sunflowers were contract sprayed with Asana XL (5.8 oz product/a) on August 11, 1998. The DeKalb 3790 yield was 2231 lb/a and DeKalb Exp852 MO (Nusun) yield was 2171 lb/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) took place on October 22, 1998.

Field F5 and F6. Areas not used in small research plots were combined and seeded to sunflowers. Sonalan 10G (1 lb ai/a) was applied with a Gandy air applicator mounted on a Haybuster undercutter on April 14, 1998. The second incorporation of the Sonalan was performed with the JD Mulchmaster on May 20, 1998. Nitrogen as 46-0-0 was applied to the field at a rate of 60 lb/a on May 22, 1998. Dekalb 3790 sunflowers were planted on May 28, 1998 with a JD MaxEmerge II planter at a seeding rate of 25,000 seeds/a in 30" rows. The field was sprayed with Assert (4 oz ai/a) on July 1, 1998 and Poast (3 oz ai/a) on July 7, 1998. Roundup Ultra (26.2 oz ai/a) was sprayed between the rows with a hooded sprayer on July 15, 1998. The sunflowers were contract sprayed with Asana XL (5.8 oz product/a) on August 11, 1998. The sunflower yield was 2500 lb/a. A small area was seeded to Proso millet with a JD 750 no-till drill into spring wheat stubble on May 28, 1998. The millet was seeded at 20 lb/a. The plot was sprayed with 2,4-D plus Banvel (16 + 3 oz ai/a) on July 13, 1998. The millet yield was 1036 lb/a.

FIELD G ACTIVITIES, 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 (701-667-3004) for additional information.

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 hardiness as well as resistant to damage from insects and diseases. One variety, CANAM poplar, has been identified and released. Contact Dr. Richard Cunningham (701-667-3008) for additional information.

Field G2. The previous crop was winter wheat (32 bu/a). The field was sprayed with Roundup Ultra (6 oz ai/a) on April 23, 1998. The east side of the field was used for an Alternative Crops/Crop Sequence study. The west side of the field was tilled with a JD Mulchmaster on May 5, 1998. Stander barley was seeded with a Haybuster 107 disk drill (7.5" row space) on May 13, 1998. The seeding rate was 90 lb seed/a. Nitrogen as urea (46-0-0) was banded between the seed row at 53 lb N/a and 18-46-0 at 40 lb/a was placed with the seed. The field was sprayed with Buctril plus Puma (4 + 1.3 oz ai/a) on June 13, 1998. The barley was combined on August 12, 1998 with a yield of 63.2 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 16, 1998.

Field G3. This field was chemically fallowed in 1997. The field was tilled with a JD Mulchmaster on April 16, 1998. Verde spring wheat was seeded on April 17, 1998 with a JD 750 no-till disk drill (7.5" row space) at a seeding rate of 1.3 million seeds/a. Fertilizer as 18-46-0 was placed with the seed at 40 lb material/a and nitrogen as 46-0-0 was banded between the seed rows at 33 lb N/a. The field was sprayed with Tiller plus Buctril (5.4 + 4 oz ai/a) on May 20, 1998. The Verde spring wheat was combined on July 28, 1998 with a yield of 53.8 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 16, 1998.

Field G4. This field was chemically fallowed in 1998. The field was sprayed with Fallowmaster (10 oz ai/a) on May 14, June 15, and July 16, 1998. Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was sprayed on September 16, 1998.

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 (701-667-3008).

FIELD H ACTIVITIES, NE 1/4 Section 18 (Fig. 2)

Field H1. Long-term cropping systems study. For additional information see report entitled, "Long-term cropping systems study, 65A Study", p. 12.

Field H2. The previous crop was winter wheat (26 bu/a). The field was tilled with a JD Mulchmaster on May 18, 1998. Robust barley was seeded with a Haybuster 107 disk drill (7.5" row space) on May 19, 1998. The seeding rate was 90 lb seed/a. Fertilizer as 18-46-0 was applied with the seed at 40 lb material/a and nitrogen as 46-0-0 was banded between the seed rows at 53 lb N/a. The field was sprayed with Buctril plus Puma (4 + .66 oz ai/a) on June 15, 1998. The barley was combined on August 13, 1998 with a yield of 53.8 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 10, 1998.

Field H3. The previous crop was barley (78.7 bu/a). Roundup Ultra (6 oz ai/a) was sprayed of September 25, 1997 to control fall weeds. The field was seeded to Roughrider winter wheat on September 26, 1997. The west half of the field was seeded with a JD 750 no-till disk drill (7.5 inch row spacing) and the east half was seeded with a Concord air seeder with hoe openers (10 inch row spacing). Urea, 60 lb N/a, was banded between the seed rows and 50 lb/a 18-46-0 was applied with the seed. The field was sprayed with 2,4-D plus Buctril (4 + 4 oz ai/a) on May 14, 1998. The winter wheat was combined on July 23, 1998 with a yield of 26.6 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 11, 1998.

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 report entitled, "Management Strategies for Soil Quality", p. 30.

Field H4. Center Bulk Area. This area was used for the Alternative Crops For Dryland Rotations Study in 1997. The field was sprayed with Roundup Ultra (9 oz ai/a) on April 29, 1998. Butte 86 spring wheat was seeded with a Haybuster 107 disk drill (7.5" row space) on May 7, 1998. Fertilizer as 18-46-0 was applied with the seed at 40 lb material/a and nitrogen as urea (46-0-0) was banded between the seed row at 53 lb N/a. Tiller plus Buctril (7.1 + 4 oz ai/a) was sprayed on June 4, 1998. The field was combined on August 11, 1998 with a yield of 30 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 10, 1998.

Field H4. East Bulk Area. This area was planted to a sunflower row space demonstration study in 1997. The field was tilled with a JD Mulchmaster on April 21, and again on May 14, 1998. Stander barley was seeded with a Haybuster 107 disk drill (7.5" row space) on May 18, 1998. Fertilizer as 18-46-0 was applied with the seed at 40 lb/a and nitrogen as urea (46-0-0) was banded between the seed rows at 53 lb N/a. Buctril plus Puma (4 + 1.3 oz ai/a) was sprayed on June 4, 1998. The field was combined on August

11, 1998 with a yield of 50.2 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 10, 1998.

FIELD I ACTIVITIES, NE 1/4 Section 20 (Fig. 2)

Field I1. The west half of the field was mowed on April 22, 1998 to facilitate residue incorporation with disking (< 30% residue on surface) for the maximum till treatment. The field was disked with a JD offset disk on May 7, 1998. The west half was sprayed with Roundup Ultra (6 oz ai/a) on May 7, 1998. Both areas were seeded to spring wheat 2375 with a Concord air seeder (10" row space and hoe openers) on May 7, 1998. The seeding rate was 1.3 million seeds/a. Fertilizer as 11-52-0 at 40 lb/a and nitrogen as 46-0-0 at 60 lb N/a was placed between the split seed row. The entire field was sprayed with Tiller plus Buctril (7.1 + 4 oz ai/a) on June 4, 1998. Separate yields were not taken from the maximum till and no-till areas. The field was combined on August 10, 1998 with a yield of 29.5 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 16, 1998.

Field I2. This field produced a sunflower crop in 1997 (1704 lb/a). The field was tilled with a JD Mulchmaster on April 17, 1998. The field was seeded to 2375 spring wheat with a Concord air seeder with hoe openers (10" row space) on April 23, 1998. Fertilizer as 11-52-0 at 40 lb material/a and 46-0-0 at 60 lb N/a was placed between the split seed row. The seeding rate was 1.3 million seeds/a. Tiller plus Buctril (7.1 + 4 oz ai/a) was sprayed on May 26, 1998. The field was combined on July 28, 1998 with a yield of 31.4 bu/a. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 15, 1998.

Field I3. The south half of the field was seeded to peas and the north half was seeded to spring wheat in 1997. The field was sprayed with Roundup Ultra (6 oz ai/a) on April 22, 1998. A seeding rate demonstration with 2375 spring wheat was planted with a Concord air seeder with hoe openers (10" row space) on April 28, 1998. Fertilizer as 18-46-0 at 40 lb/a and 46-0-0 at 60 lb N/a was placed between the split seed row. The field was sprayed with Tiller plus Buctril (7.1 + 4 oz ai/a) on May 26, 1998. Combining operations were completed on August 7, 1998 and the yields are as follows;

Population	Spring wheat ground	Pea ground
0.7 million seeds/a	36.0 bu/a	46.4 bu/a
1.0 million seeds/a	40.0 bu/a	44.8 bu/a
1.3 million seeds/a	43.3 bu/a	46.7 bu/a
1.6 million seeds/a	43.3 bu/a	49.7 bu/a
1.9 million seeds/a	45.5 bu/a	47.0 bu/a

Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 15, 1998.

Field I4. Site-Specific Farming Study. The field was planted to spring wheat (37 bu/a) in 1997 and sunflowers (1870 lb/a) in 1996. The field was sprayed with Roundup Ultra + Banvel (4.5 + 3 oz ai/a) to control after harvest weeds on August 12, 1997. The field was sprayed again with Roundup Ultra (6 oz ai/a) on September 24, 1997 to control downy brome at the 1-2 leaf stage. Roughrider winter wheat was seeded with a Concord air seeder (10 inch row spacing) equipped with variable rate application equipment/controls on September 30, 1997. Urea (46-0-0) and 11-52-0 were applied at variable rates determined by soil test results and spring-wheat yield maps. The seeding rate was 1.3 million seeds/a. The field was sprayed with 2,4-D plus Buctril (4 + 4 oz ai/a) on May 14, 1998. The field was harvested on July 27, 1998 with a yield of 24 bu/a. The grain yields were mapped using a grain yield monitor and GPS equipment. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 4, 1998.

Field I5. Site-Specific Farming Study. This was planted to winter wheat (27.8 bu/a) in 1997. Sonalan 10G (1 lb ai/a) was applied with a Gandy air applicator mounted on a Haybuster undercutter on April 10. 1998. The variable rate fertilizer was applied with a Concord air seeder on May 5, 1998. The second incorporation of the Sonalan was performed with a JD Mulchmaster on May 18, 1998. The field was seeded to sunflowers (DeKalb 3868) on May 19, 1998 with a JD MaxEmerge II planter using 30" rows and a seeding rate of 25,000 seeds/a. The field was contract sprayed with Asana XL (5.8 oz product/a) on August 11, 1998. The field was combined on October 14, 1998 using a grain yield monitor and GPS equipment. The harvested yield was 935.9 lb/a. The low yield is attributed to a heavy infestation of stem weevils that attacked the plants during a period of early season moisture stress. Fall spot spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on October 30, 1998.

Field I6. Site-Specific Farming Study. This field was in sunflowers (1954 lb/a) in 1997. The field was tilled with a JD Mulchmaster on April 17, 1998. The field was seeded to 2375 spring wheat using a Concord air seeder with variable rate applicator equipment on April 24, 1998. The seeder has hoe openers and a 10" row space. The seeding rate was 1.3 million seeds/a and fertilizer as 11-52-0 and 46-0-0 were applied at variable rates based on GPS coordinates. Tiller plus Buctril (5.4 + 4 oz ai/a) was applied on May 28, 1998. The field was combined on August 6, 1998 with a yield of 32.8 bu/a. The yields were mapped using a grain yield monitor and GPS equipment. Fall spraying with Roundup Ultra plus 2,4-D (6 + 4 oz ai/a) was completed on September 4, 1998.

For additional information on site-specific farming see the report entitled, "Site-Specific Research, 1995-1998."

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

Drs. Joe Krupinsky, Donald Tanaka, Ron Ries, Steve Merrill,
and Ardell Halvorson (USDA-ARS, Ft. Collins, CO)

Field H1. 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 [SW-F] and spring wheat-winter wheat-sunflower [SW-WW-SUN]), three tillage systems (conventional-till [CT], minimum-till [MT] and no-till [NT]), and three nitrogen (N) 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, only spring wheat, winter wheat, and sunflower crops were grown. The grain yields for the spring wheat, winter wheat, and sunflower for each rotation are reported in Tables 1 and 2.

Two-Year Rotation, Spring Wheat-Fallow Rotation.

In 1998 spring wheat was grown after fallow and after peas. Amidon spring wheat was seeded with a JD 750 disk drill (7.5" row spacing) with a seeding rate of 1.3 million seeds/a on April 30, 1998. According to the nitrogen treatment, nitrogen was banded at 0, 20, and 40 lb/a. All plots were sprayed with Tiller (9.2 oz ai/a) plus Buctril (4 oz ai/a) on June 4, 1998. Plots were combined on August 13, 1998. The yields for spring wheat grown on fallow ground were significantly higher than the yield of spring wheat grown on pea ground (Tab.1 and Fig. 1). Overall, there were significant differences among the nitrogen treatments but there were no significant differences among tillage treatments (Tab. 1 and Fig. 2).

Three Year Rotations, Spring Wheat-Winter Wheat-Sunflower Rotation.

Spring wheat. Amidon spring wheat was seeded with a JD 750 disk drill (7.5" row spacing) with a seeding rate of 1.3 million seeds/a on April 29, 1998. According to the nitrogen treatment, nitrogen was banded at 30, 60, and 90 lb/a. All plots were sprayed with Tiller (9.2 oz ai/a) plus Buctril (4 oz ai/a) on June 4, 1998. Plots were combined on August 20, 1998. The yields for spring wheat grown on pea ground were significantly higher than the yield of spring wheat grown on sunflower ground (Tab. 2 and Fig. 3). Overall, there were no significant differences among the nitrogen treatments or among the tillage treatments (Tab. 2 and Fig. 4).

Winter wheat. Roughrider winter wheat was seeded with a JD 750 disk drill (7.5" row spacing) with a seeding rate of 1.3 million seeds/a on September 1, 1997. According to the nitrogen treatment, nitrogen was banded at 30, 60, and 90 lb/a. All plots were sprayed with 2-4D (4 oz ai/a) plus Buctril (4 oz ai/a) on May 13, 1998. Plots were combined on August 13, 1998. Winter wheat was only grown on spring wheat ground. Overall, there were significant differences among the tillage treatments (no-till yielded higher than minimum till) but there were no significant differences among the nitrogen treatments (Tab. 2).

Sunflower. Cargill 270 was seeded with a JD MaxEmerge II planter with a seeding rate of 25,000 seeds/a in 30" rows on May 19, 1998. Minimum till and no-till plots were sprayed with Roundup Ultra (9 oz ai/a) on May 21, 1998. All plots were sprayed with Assert (4 oz ai/a) on July 1, 1998 and Poast (3 oz ai/a) on July 8, 1998. Roundup Ultra (10.2 oz ai/a) was sprayed between the rows with a hooded sprayer on July 15, 1998. Asana (5.28 oz material/a) was applied by aerial application on August 11, 1998. Combine harvest was completed on September 22, 1998. Sunflower yields from corn ground and winter wheat ground were similar (Tab. 2). Overall, there were significant differences among the tillage treatments (no-till and minimum till yielded higher than conventional till) but there were no significant differences among the nitrogen treatments (Tab. 2).

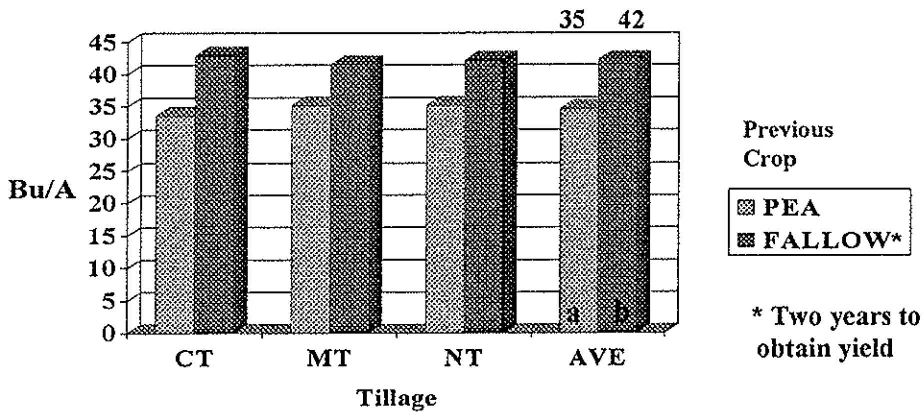
Acknowledgments: We thank J. Harms, M. Hatzenbuhler, L. Hatzenbuhler, C. Klein, J. Patzner, L. Renner, D. Schlenker, D. Wetch, and K. Kalvoda for their efforts in conducting this cropping systems study and collection of field data.

Table 1. Combine grain yields for the two-year rotation crops in 1998.				
Tillage	N Rate	Spring Wheat		
		After fallow	After pea	Overall
	lb/a	bu/a	bu/a	bu/a
CT	0	40.9	28.8	----
CT	20	43.3	34.8	----
CT	40	44.4	37.2	----
MT	0	39.4	30.3	----
MT	20	44.4	36.8	----
MT	40	40.4	38.3	----
NT	0	43.0	28.5	----
NT	20	41.3	37.4	----
NT	40	42.1	39.6	----
CT	AVG	42.9	33.6	38.2
MT	AVG	41.4	35.1	38.3
NT	AVG	42.1	35.2	38.6
AVG	0	41.1	29.2	35.1
AVG	20	43.0	36.3	39.7
AVG	40	42.3	38.4	40
SW-F (No Residue)				
NR	0	36.3	----	----
NR	20	37.2	----	----
NR	40	35.9	----	----

Table 2. Combine grain yields for the three-year rotation crops in 1998.							
Tillage	N Rate	W.Wheat	Sunflower		Spring Wheat		
			After Corn	After WW	After Pea	After Sunflower	Overall
	lb/a	bu/a	lb/a		bu/a	bu/a	bu/a
CT	30	12.9	1493	1416	30.8	25.6	----
CT	60	15.6	1460	1263	38.3	27.6	----
CT	90	13.4	1143	1326	37.5	27.7	----
MT	30	12.9	1750	1599	34.7	26.1	----
MT	60	13.2	2052	1751	39.8	23.5	----
MT	90	12.2	1572	1614	33.5	28.6	----
NT	30	12.7	1496	1481	36.9	27.4	----
NT	60	18.7	1621	1824	37.1	34.9	----
NT	90	14.2	1736	1801	40.7	25.6	----
CT	AVG	14.0	1350	1335	35.5	27.0	31.2
MT	AVG	12.8	1723	1655	36.0	26.1	31.0
NT	AVG	15.2	1660	1702	38.2	29.3	33.8
AVG	30	12.8	1580	1553	34.1	26.4	30.2
AVG	60	15.8	1711	1720	38.4	28.7	33.5
AVG	90	13.2	1484	1575	37.3	27.3	32.3

Fig. 1. Spring wheat yields following fallow or pea.

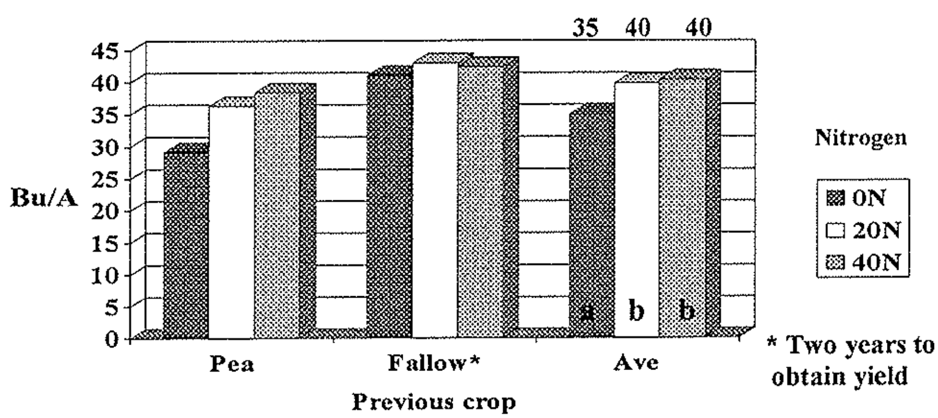
Two-yr rotation with three tillage treatments.
Combine yields, 8/13/98



3922

Fig. 2. Spring wheat yields following fallow or pea.

Two-yr rotation with three nitrogen treatments.
Combine yields, 8/13/98



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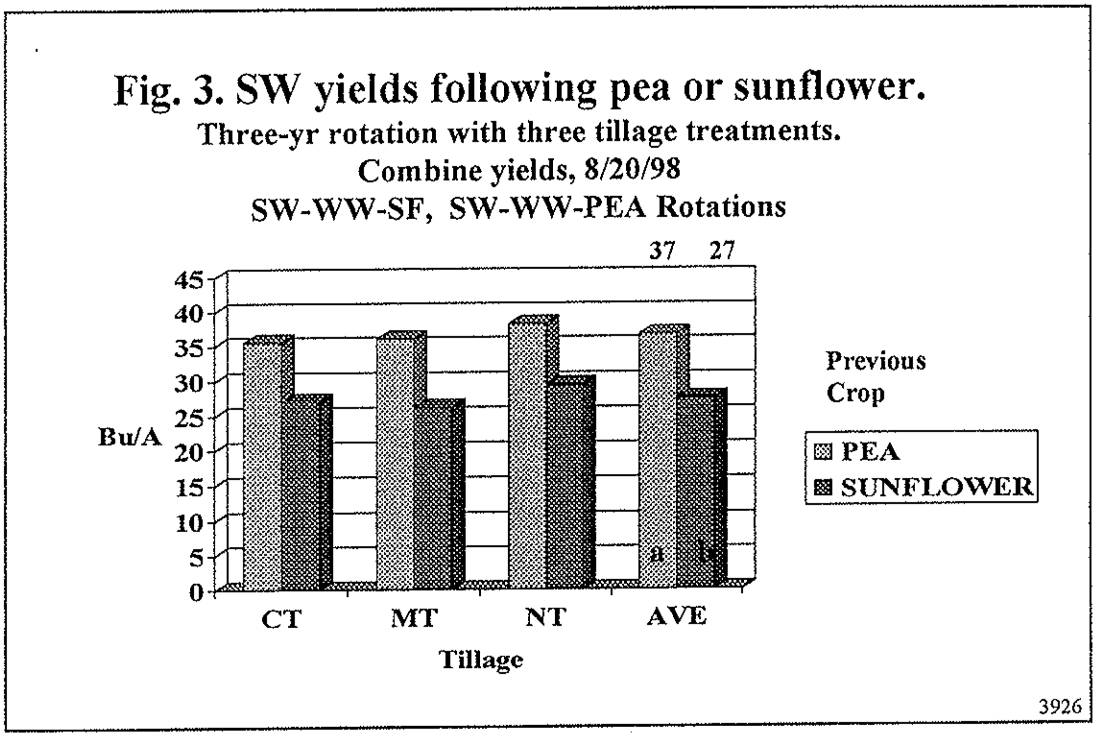


Fig. 3. SW yields following pea or sunflower.
Three-yr rotation with three tillage treatments.
Combine yields, 8/20/98
SW-WW-SF, SW-WW-PEA Rotations
37 27
45
40
35
30
25
20
15
10
5
0
Bu/A
a b
CT
MT
NT
AVE
Tillage
Previous Crop
PEA
SUNFLOWER
3926

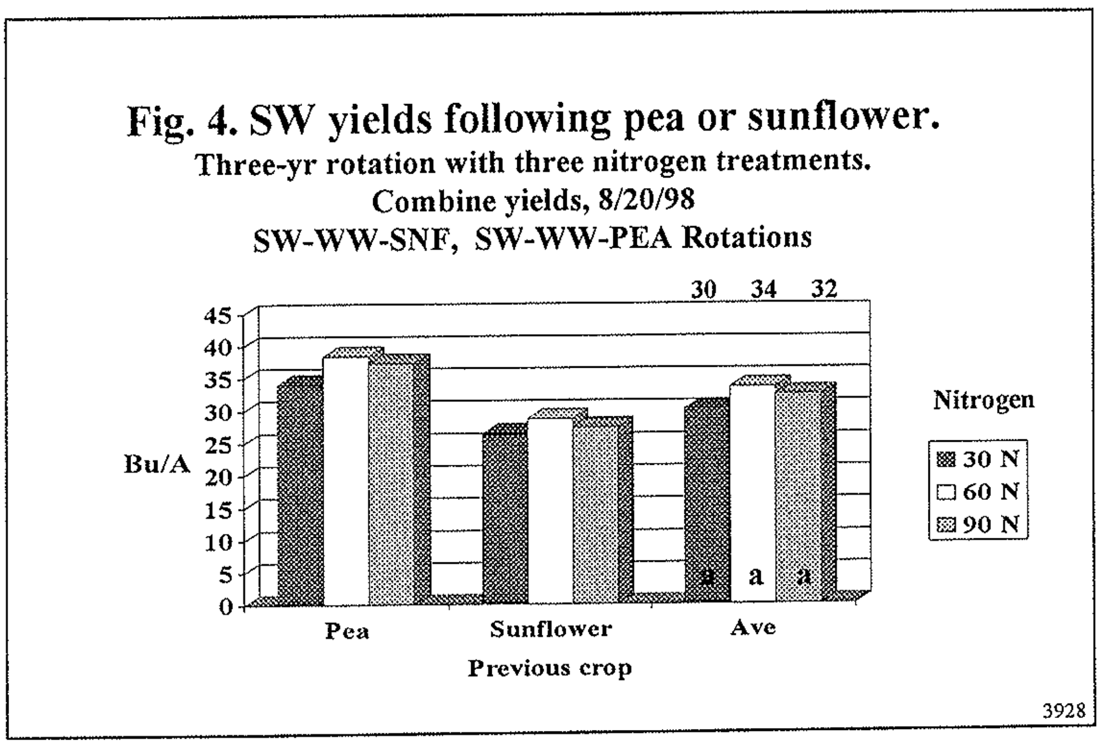


Fig. 4. SW yields following pea or sunflower.
Three-yr rotation with three nitrogen treatments.
Combine yields, 8/20/98
SW-WW-SNF, SW-WW-PEA Rotations
30 34 32
45
40
35
30
25
20
15
10
5
0
Bu/A
a a a
Pea
Sunflower
Ave
Previous crop
Nitrogen
30 N
60 N
90 N
3928

LEAF SPOT DISEASES ON WHEAT

Dr. Joe Krupinsky

LEAF SPOT PATHOGENS COMMON ON WHEAT

Spring wheat and winter wheat leaves from experimental plots were analyzed for plant pathogens present. Diseases found on wheat leaves include: Septoria nodorum blotch (*Septoria nodorum* or *Stagonospora nodorum*), tan spot (*Pyrenophora tritici-repentis* or *Drechslera tritici-repentis*), spot blotch (*Helminthosporium sativum* or *Bipolaris sorokiniana*), Septoria avenae blotch (*Septoria avenae* f. sp. *triticea*), and Septoria tritici blotch (*Septoria tritici*). Septoria nodorum blotch and tan spot were the most common diseases on spring wheat and winter wheat and thus the two main components of a leaf spot complex present on wheat. Septoria tritici blotch ranked third. Ordinarily Septoria tritici blotch is rarely found in our field plots but this year was an exception. Spot blotch and Septoria avenae blotch were both detected but at lower levels. This again indicates that leaf spot diseases on wheat are not caused by one pathogen but rather a complex of fungi.

Since precipitation levels were generally lower than normal at the beginning of the season in the Mandan area (Figure 3, page 4), leaf spot diseases developed rather slowly at the beginning of the season. The heavy precipitation in August came after the wheat crop had nearly completed its life cycle. In general, leaf spot diseases were not severe enough for rating wheat early in the season.

LONG-TERM CROPPING SYSTEMS STUDY, Field H1
(For more information see Long-term Cropping Systems Study, p. 12)

With below average precipitation early in the season, leaf spot diseases came on slow early in the season. Although there were some significant differences between tillage treatments and nitrogen treatments, results were not consistent across all parts of the study.

SPRING WHEAT TRIALS AND CHLORIDE. Field F5.
Drs. Joe Krupinsky and Donald Tanaka
(For more information see Spring Wheat in Conservation Tillage, p. 34)

Chloride application, such as potassium chloride, has been reported to reduce foliar diseases and root-rot diseases of small grains in the northern Great Plains area if chloride levels are low (less than 30 lb/a) but the results are always not consistent. For example, common root rot of wheat and barley may or may not be reduced with chloride application (Tinline. Can. J. Plant Pathol. 15:65-73). Results can vary depending on the cultivars, soil types, location, and/or year. Response to chloride application is not affected by tillage.

Potassium chloride was applied across varieties in a spring wheat trial. Varieties with KCl and without KCl were rated four times during the growing season. There were differences among varieties in amount of leaf spot disease present and in how they responded to the KCl treatment. Some varieties had reduced disease severity with the KCl treatment where as others had an increase in disease severity with KCl. Results point out the importance of knowing how a particular variety will respond before applying KCl for it to be effective in reducing leaf spot diseases.

MANAGEMENT STRATEGIES FOR SOIL QUALITY. Field H4.
Drs. Joe Krupinsky and Donald Tanaka
(For additional information see Management Strategies for Soil Quality, p. 30)

In 1998, Amidon spring wheat was evaluated under various crop rotations and two tillage types, minimum till and no till. Crop rotations included: spring wheat (SW)- fallow (F); SW-safflower (S)- rye; SW-S-F; SW-millet; continuous SW with residue; and continuous SW with residue removed. The amount to leaf spot diseases on zero-till and minimum till were similar. There were statistical differences among the spring wheat crops within the different crop rotations in 3 of the 4 ratings. The continuous SW rotations had a higher severity of leaf spot diseases than other crop rotations early in the season.

CONVERSION OF CRP TO CROP PRODUCTION.
Drs. Joe Krupinsky and Donald Tanaka
(For additional information see Conversion of CRP to Crop Production, p. 39)

In 1998, Roughrider winter wheat was evaluated twice on CRP land with three tillage treatments, 2 nitrogen treatments, on plots that had been hayed and not hayed. The amount of leaf spot diseases was similar on the nitrogen and hayed treatments. Significant differences were found with one tillage treatment for one rating. Again, with below average precipitation early in the season, leaf spot diseases came on slow early in the season making treatment differences difficult to detect.

MANAGE TO MINIMIZE DISEASES
Important management decisions that need to be considered in your operation include: using crop rotation; using tolerant or disease resistant varieties adapted to your area; using pathogen-free seed with high germination; eliminating volunteer plants that can harbor diseases; weather permitting, planting at the proper time and at seeding rates recommended for your area; using a proper balance of fertilizers, especially nitrogen; and monitoring your fields, if foliar diseases are present and your yield potential is high, the use of fungicides is an option. These management decisions will reduce the disease potential in all tillage systems not just no-till. Since diseases can have a negative impact on your crop, decisions that lower the disease potential in your crop will increase your yield potential and profit margin.

ACKNOWLEDGMENTS

We thank Dawn Wetch, Christina Foy, Stacy Heinert, Jessica Lussenden, Scott Tschaekofske, and Crystal Urlacher for technical assistance in plant pathology, and Gary Richardson for statistical advice.

LEAF SPOT DISEASE SURVEY FOR BARLEY, 1998

Drs. Joe Krupinsky and Brian Steffenson (NDSU, Dept. of Plant Pathology, Fargo, ND)

A cooperative survey was undertaken with Dr. Brian Steffenson, NDSU, Fargo, to determine which leaf spot diseases are most common on barley in North Dakota and which fungi should be used when selecting for Septoria or Stagonospora disease resistance. Seventy collections of diseased barley leaves were collected from North Dakota. These collections included samples from southwestern, central, northeastern, and eastern areas of North Dakota. Fungi were identified on over 500 leaves.

The most common diseases were net blotch (*Helminthosporium teres*), spot blotch (*Helminthosporium sativum*), septoria speckled leaf blotch (*Septoria passerinii*) and stagonospora avenae leaf blotch (*Stagonospora avenae f. sp. triticea*). These four diseases make up the major components of the leaf spot complex on barley in North Dakota. Because of the importance of both *Septoria passerinii* and *Stagonospora avenae* f. sp. *triticea* on barley, selecting barley for Septoria/Stagonospora resistance will be more complex, requiring the use of two pathogens rather than one. It is interesting to note that two of the important diseases on barley, spot blotch and stagonospora avenae leaf blotch, are minor diseases on wheat in central ND (see additional information on Leaf Spot Diseases Common on Wheat). This information is helpful when evaluating how barley fits into a crop rotation/crop sequence plan.

Stagonospora leaf blotch (*Stagonospora nodorum*) and tan spot (*Helminthosporium tritici-repentis*), which are major diseases on wheat (see additional information on Leaf Spot Diseases Common on Wheat), were detected but at low levels. At the present time, Stagonospora leaf blotch and tan spot are not serious disease problems on barley.

CHARCOAL ROT SURVEY FOR SUNFLOWERS, 1998

Drs. Tom Gulya (USDA-ARS, Fargo, ND) and Joe Krupinsky

A cooperative survey was undertaken with Dr. Tom Gulya to determine if charcoal rot was present on sunflowers in North Dakota. Charcoal rot is a fungus disease caused by *Macrophomina phaseolina*. Charcoal rot disease has the ability to attack a wide range of hosts, including corn and beans. High temperatures and drought stress, and continuous cultivation of susceptible crops (i.e. corn, soybeans, sunflower) will promote disease development. Observations made by USDA scientists in Texas have shown that the fungus causing charcoal rot is carried by the sunflower stem weevil. Tunneling by stem weevil larva also helps spread the fungus within the plant, and thus intensifies the impact of the disease. Thus, management of charcoal rot should include rotations of at least two years without sunflower, corn, or soybeans, and attention should be paid to the level of stem weevil infestation. Although the disease can cause substantial losses on sunflower in warmer areas such as California or Texas, the impact of charcoal rot on sunflower in the Northern Great Plains is unknown at the present.

All sunflower fields on the Area IV Farm were sampled. Twenty-five fields were sampled in central North Dakota, near the towns of Anamoose, Balfour, Bowdon, Center, Chaseley, Denhoff, Fessenden, Goodrich, Harvey, Hensler, Hurdsfield, Kief, Killdeer, Mandan, Martin, McClusky, Riverdale, Turtle Lake, Underwood, and White Shield. An additional 25 fields were inspected in eastern and east central North Dakota. Fields were sampled in Northcentral South Dakota, near the towns of Bullhead, McLaughlin, McIntosh, and Wautaga.

No charcoal rot was detected in over 1000 samples from the Area IV Farm. Charcoal rot was not present in 300 samples from 25 different fields that were processed at the Northern Great Plains Research Lab. No charcoal rot was found in any of the fields sampled in eastern and east-central North Dakota. Charcoal rot was present in fields sampled in South Dakota and in fields near Reeder, ND and Flasher, ND. Thus, it appears that charcoal rot is limited to the southwestern area of North Dakota and adjacent South Dakota.

Management practices that can be used to minimize charcoal rot on sunflowers include: 1) crop rotation, rotations should not include a susceptible crop (e.g. sunflower, corn, soybean, or bean) for two years; 2) use a balanced fertilizer program, heavy nitrogen applications may promote this disease; and 3) use management practices that reduce moisture stress.

ROOT GROWTH OF CROPS THAT ARE ALTERNATIVES TO WHEAT

Drs. Steve Merrill and Donald Tanaka

Direct observation of the rooting characteristics of crops proposed for inclusion in wheat-based dryland rotations enables us to better understand the way that they use soil nitrogen and water, and thus, we will be able to better understand how individual crop species interact with each other in the rotations.

We have summarized root growth data for the 1995 through the 1997 field seasons of a study of crops that can be used in dryland rotations as alternatives to wheat. Other results of this study are the subject of an article given elsewhere in this report. The crops in this study followed winter wheat, which in turn followed spring wheat. A different site on the Area IV ARS-SCD Cooperative Research Farm was used for the study each year.

A microvideo camera system was used with two different types of minirhizotron tubes that are installed in the field. The majority of the minirhizotrons were 6 feet long, have an inside diameter of 2 inches, and are made of rigid and durable plastic. A minority of the tubes were either 6 or 9 feet in length, have a moderately rigid inner plastic tube of 3 inch diameter, and are enclosed in a flexible, outer wall of polyvinyl plastic sheeting. This outer wall is constantly pressurized at about 2 to3 psi with solar panel-driven air pumps.

A total of 8 minirhizotrons were installed in plots of each of 7 alternative crops in 1995 and 1996. For the 1997 field season, a total of 12 minirhizotrons were installed in each of the 7 crops. Roots growing against the minirhizotrons are measured from video tapes. For purposes of comparison, root growth was measured in spring wheat crops growing on fallow ground at other sites on the Research Farm. In both 1997 and 1998, observations were made on root growth of the flax crop, and comparative measurements were also made on spring wheat in the latter year.

One of the most important characteristics of a root growth system is the average maximum depth that is attained. An equally important characteristic of a root growth system is the median depth of root length growth – that depth above which 50% of the total root length growth has occurred. The time courses of median and maximum root growth depths for 3 years are shown in Figure 1. Table 1 shows the greatest median and maximum depths that occurred each year for each crop.

The crops studied here fall quite well into botanical and agronomic groups when ranked by their maximum rooting depths. The legume crops -- blackbean, soybean, and pea -- are the most shallowly rooted, with maximum depths observed over 3 years ranging from 3.0 to 4.1 feet. The mustard family crops crambe and canola are the next group, with maximum rooting depths ranging from 3.6 to 4.3 feet. The oilseed crops sunflower and safflower are the most deeply rooted, with maximum rooting depths observed over the 3 years to be 4.6 to 6.0 feet.

Spring wheat reached maximum depths of 4.0 to 4.3 feet. Observations of flax rooting in 1997 showing a maximum of 3.6 feet and a median of 1.4 feet, indicate that the performance of this crop is comparable to that of the legume crops

The median depths of root length growth fall approximately in the same order by crop as do the maximum depths. It is notable that the median depth for safflower is greater than 50% of the maximum, while the median depth for sunflower is less than 50% of its maximum.

Observations made in trenches in 1993 showed that sunflower roots can reach slightly more than 6 feet deep and that safflower can reach 7 feet deep in our glacial-till type soil.

The time courses of maximum and median depths show dynamic changes within seasons and some variation in results among the years. The average maximum depths of root growth for the years 1995, 1996, and 1997 were 4.61, 4.12, and 4.05 feet, respectively. The average median depths for 1995, 1996, and 1997 were 2.09, 1.99, and 1.72 feet, respectively. This is associated with a climatic pattern in which precipitation during the May to September growing season was above average, near the average, and below average, respectively, for 1995, 1996, and 1997.

The root systems of the oilseed crops sunflower and safflower are notably different from the root system of spring wheat and other small grain crops. As wheat plants develop, they depend more upon finely branched, adventitious roots originating at the crown area near the soil surface. Both sunflower and safflower possess taproots, which can penetrate deeply into subsoil and then extend lateral roots. The safflower plant in particular has the potential ability to make use of subsoil water and nutrient resources, as shown by the relatively deep maximum and median depths of its rooting.

These results indicate that the oilseed crops sunflower and safflower can usually be depended upon to utilize both subsoil water and nitrogen to consistently greater depths and to a greater extent than other crops commonly proposed as alternatives to wheat in dryland crop rotations.

Table 1. Maximum and median depths of alternative crops of alternative crops observed by minirhizotron technology in 1995-1997.								
CROP	MAXIMUM Rooting Depth (feet)				MEDIAN Rooting Depth (feet)			
	1995	1996	1997	AVG.	1995	1996	1997	AVG.
Blackbean	4.12	3.13	3.69	3.65	1.69	1.47	1.53	1.56
Pea	3.84	3.84	3.55	3.74	1.77	1.50	1.13	1.46
Soybean	4.12	3.98	2.98	3.69	2.33	2.04	1.12	1.83
Canola	4.12	3.55	4.12	3.93	1.79	1.56	1.72	1.69
Crambe	4.12	4.26	4.26	4.21	1.35	2.03	2.05	1.81
Spring Wheat	4.26	4.26	3.98	4.17	2.24	1.99	2.39	2.21
Sunflower	5.97	4.55	5.40	5.31	2.21	2.88	1.62	2.24
Safflower	5.97	5.40	5.68	5.68	3.51	2.42	2.92	2.95
Flax			3.55				1.42	

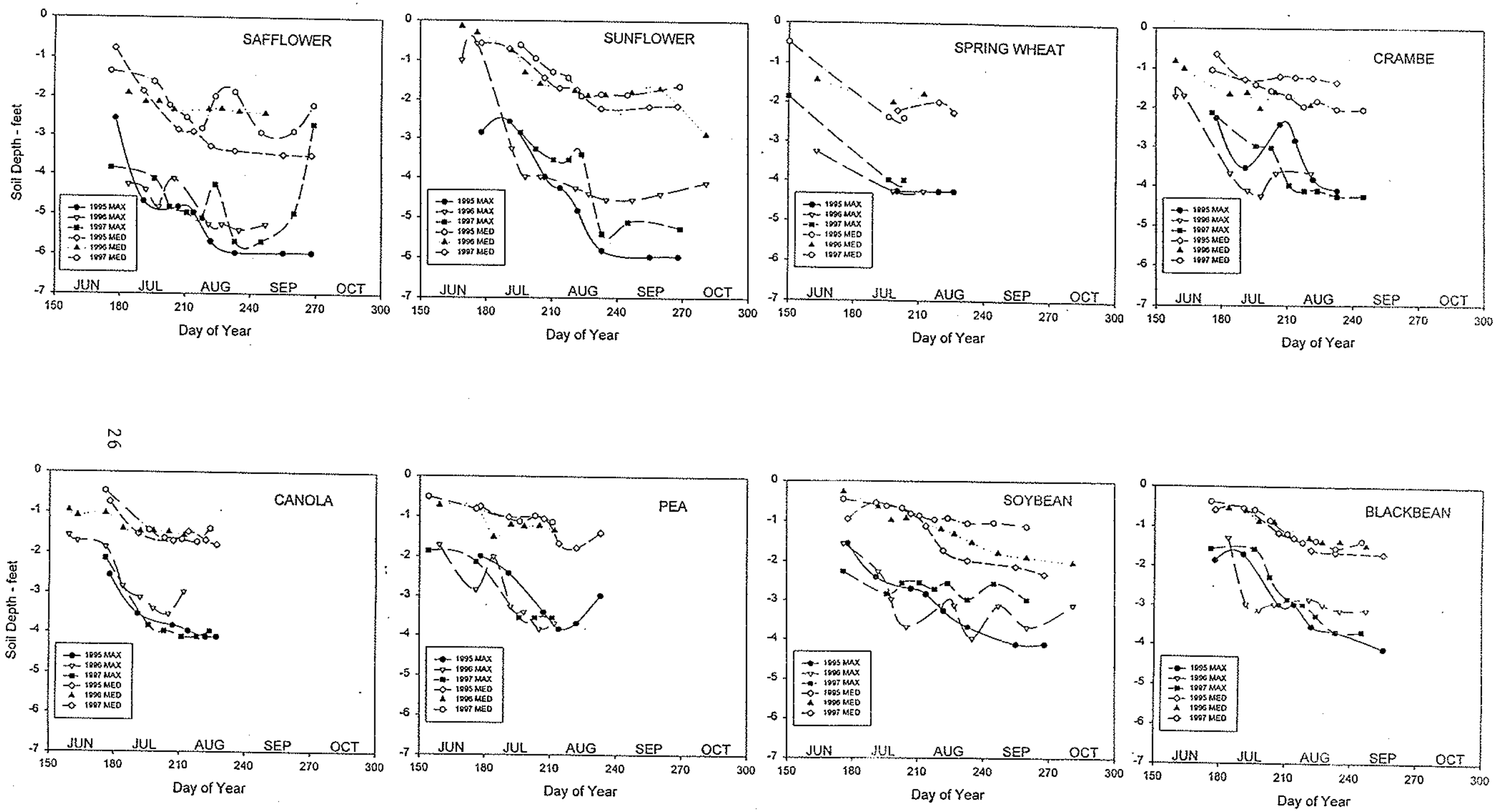


Figure 1. Time courses of maximum and median root growth depths observed in alternative crops with minirhizotron technology.

SOIL-INHERENT WIND ERODIBILITY AS A SOIL QUALITY FACTOR

Drs. Steve Merrill and Donald Tanaka

Field F3. Dry aggregate size distribution (abbreviated as ASD) measurements are the most characteristic indication of soil-inherent wind erodibility. ASD measurements have been made by rotary sieving on samples taken in the Soil Quality Management Experiment from the fall of 1993 through the 1998 cropping season. The upper inch of soil has been sampled in spring, generally in late May, and in October in tillage treatments (minimum-till (undercutter) and no-till) in all rotations: (a) continuous spring wheat, residue undisturbed (SpW+Res); (b) continuous spring wheat, residue removed (SpW-Res); (c) spring wheat - safflower - rye (SpW-Saffl-Rye); (d) spring wheat - safflower - fallow (SpW-Saffl-Fall); (e) spring wheat - millet (SpW-Mill); (f) spring wheat - fallow (SpW-Fall).

Geometric mean diameter (GMD) and erodible fraction (EF) are measures of ASD as soil-inherent wind erodibility. Data for these qualities are shown in Table 1 averaged over year and season. EF can be taken as a measure of immediate wind erodibility, and GMD is more a measure of potential wind erodibility and state of surface soil tilth. Continuous spring wheat with undisturbed residue showed the highest average GMD value and the lowest average EF value among the crop rotations. For all rotations, the tillage averages showed that GMD was higher and EF was lower in no-till than in minimal-till.

Soil-inherent wind erodibility (as ASD) is subject to chaotic changes induced by the weather. This is shown by the data in Table 2 giving annual averages. Annual variations in GMD are of the same general size as greatest rotation and tillage differences, while annual variations in EF are somewhat greater than largest rotation differences and generally greater than tillage differences.

Higher GMD values measured in undisturbed continuous spring wheat are an indication of a positive soil quality effect of maximum cropping intensity. Removal of residue from continuous spring wheat causes it to show approximately the same GMD values as the less intensively cropped rotations.

It should be noted that ASD measurements that have been made on Research Farm soils since approximately 1993 have given generally nonerodible values, but many of the measurements made in 1989 and 1990, and to a lesser extent, in 1991 and 1992, showed near erodible to erodible values. This was caused by the drought that occurred in the period from 1988 through 1990. This drought appeared to be the second most important one that occurred in this area in the 20th century.

Table 1. Soil-inherent wind erodibility measurements from samples taken in spring (generally late May) and fall (October) from 1993 through 1998*.

Rotation	Phase	Geom. Mean Diam. (mm)			Erodible Fraction (%)		
		Min-Till	No-Till	Avg.	Min-Till	No-Till	Avg.
SpW +Res	Continuous	**12.9**	**21.2**	**17.1A**	**20.3**	**16.2**	**18.2B**
SpW -Res	Continuous	**7.0**	**11.1**	**9.1B**	**23.9**	**20.0**	**21.9A**
SpW-Saffl-Rye	SpW	5.5	7.5	6.5	27.7	24.0	25.9
	Saffl	7.4	9.4	8.4	24.0	20.2	22.1
	Rye	10.0	13.8	11.9	23.3	18.7	21.0
	Avg.	**7.6**	**10.2**	**8.9B**	**25.0**	**21.0**	**23.0A**
SpW-Saffl-Fall	SpW	6.0	8.3	7.2	28.0	26.4	27.2
	Saffl	7.3	10.6	8.9	24.7	21.4	23.0
	Fall	12.8	12.5	12.7	23.8	21.0	22.4
	Avg.	**8.7**	**10.4**	**9.6B**	**25.5**	**22.9**	**24.2A**
SpW-Mill	SpW	7.7	9.5	8.6	22.7	22.8	23.3
	Mill	11.7	10.9	11.3	23.8	21.3	22.6
	Avg.	**9.7**	**10.2**	**9.9B**	**23.3**	**22.0**	**22.7A**
SpW-Fall	SpW	6.6	7.9	7.2	26.2	23.4	24.8
	Fall	9.6	13.2	11.4	23.0	20.3	21.6
	Avg.	**8.1**	**10.6**	**9.3B**	**24.6**	**21.8**	**23.2A**
Average		**8.7B**	**11.3A**	**10.0**	**24.3A**	**21.3B**	

*Values in a column or in a group of two followed by different letters are significantly different at the 10% probability levels.

Table 2. Soil-inherent wind erodibility measurements averaged by season and year of sampling.							
	Season	1993	1994	1995	1996	1997	1998
Geometric Mean Diameter (mm)	Spring	–*	7.6	8.2	10.7	18.1	10.6
	Fall	11.1	6.1	6.8	17.9	3.6	9.5
	Avg.	**11.1**	**6.9**	**7.5**	**14.3**	**10.8**	**10.0**
Erodible Fraction (%)	Spring	–	24.5	25.3	18.8	21.5	23.5
	Fall	18.0	25.2	22.6	16.3	31.4	22.2
	Avg.	**18.0**	**24.9**	**24.0**	**17.6**	**26.5**	**22.8**

*Measurements were not taken in spring of 1993.

MANAGEMENT STRATEGIES FOR SOIL QUALITY

Drs. Donald Tanaka and Steve Merrill

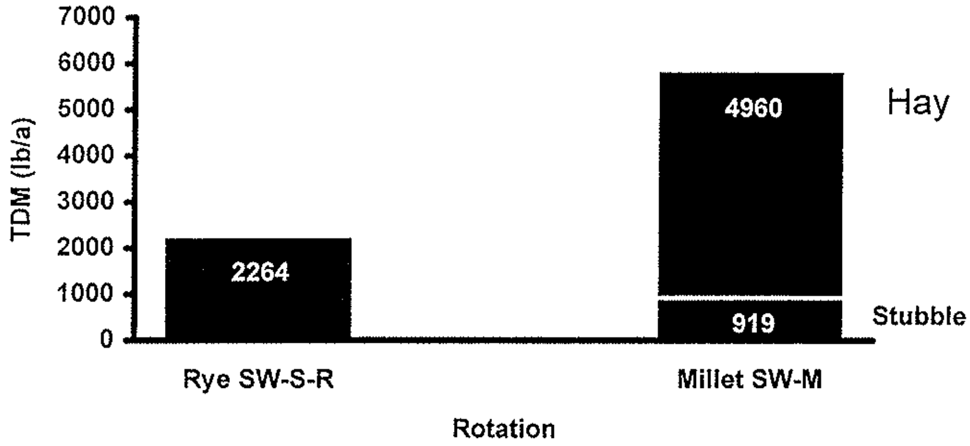
A long-term study was initiated in the spring of 1993 to evaluate the influences of residue management and crop rotations on soil quality. Tillage, crops, and crop residues were all in the appropriate places in 1994. Treatments for the 1995 crop included minimum- and no-till for the following crop rotations:

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

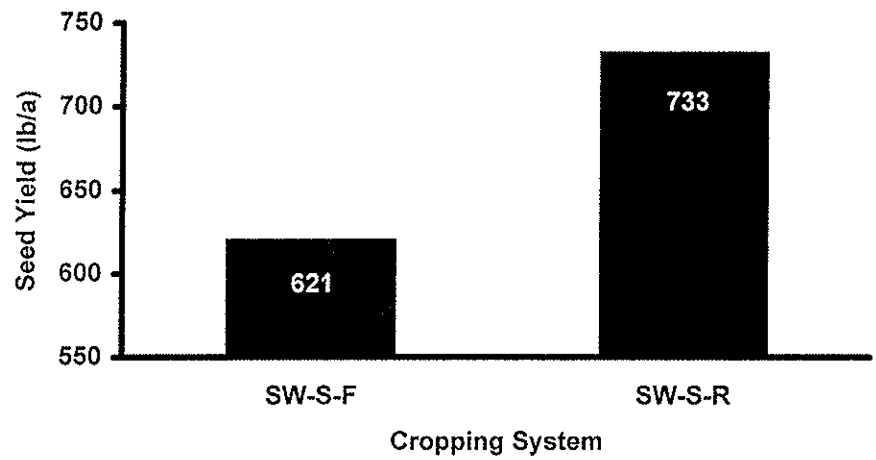
Spring wheat (cv. Amidon) was seeded at 1.3 million viable seeds per acre on April 23. Safflower was seeded at 200,000 viable seeds per acre on April 23. Millet was seeded at 4 million viable seeds per acre on June 5. No-till plots were sprayed with roundup (0.375 lb ai/a) prior to seeding while minimum-till plots were tilled with an undercutter prior to seeding. Spring wheat, safflower, and millet were all seeded with a JD 750 no-till drill. Rye was seeded on September 25, 1997 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 while crops seeded after fallow or partial fallow received 30 lb N/a and 10 lb P/a at seeding. Growing season precipitation from May through July was 5.94 inches compared to 8.07 inches for the long-term. August precipitation was 6.35 inches, well above the long-term average of 1.73 inches.

Spring wheat gain yields ranged from 3588 to 2296 lb/a. Greatest wheat yields were after fallow. This was because of a dry open winter and a soil profile that was not full of water at spring wheat seeding. Lowest wheat yields were for the CSW- and CSW+ systems. Safflower seed yields were greatly influenced by the lack of soil water and the 6.35 inches of precipitation in August. August precipitation increased crop diseases, forcing premature crop maturity. Lack of soil water and below average spring precipitation resulted in termination of rye 2 to 3 weeks early (June 4 instead of June 20). Rye produced 2264 lb/a of dry matter for soil and water conservation while millet produced 4960 lb/a of hay and 919 lb/a of stubble for erosion control.

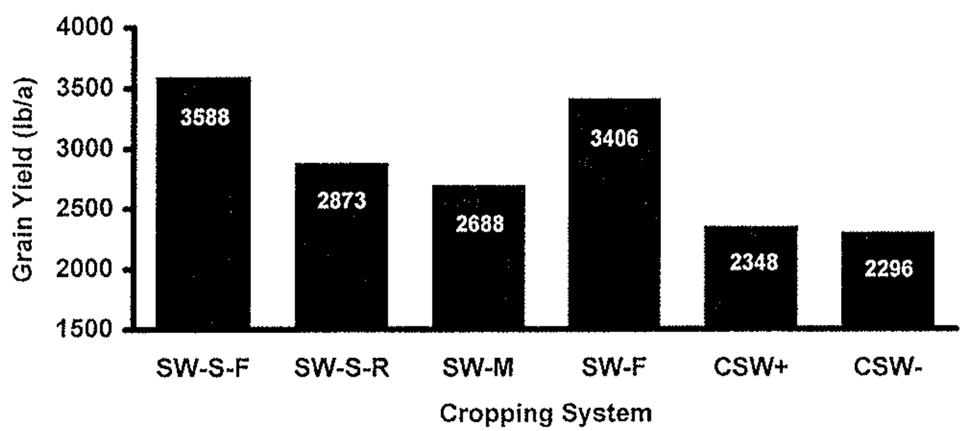
1998 Rye and Millet Total Dry Matter



1998 Safflower Seed Yield



1998 Spring Wheat Grain Yields

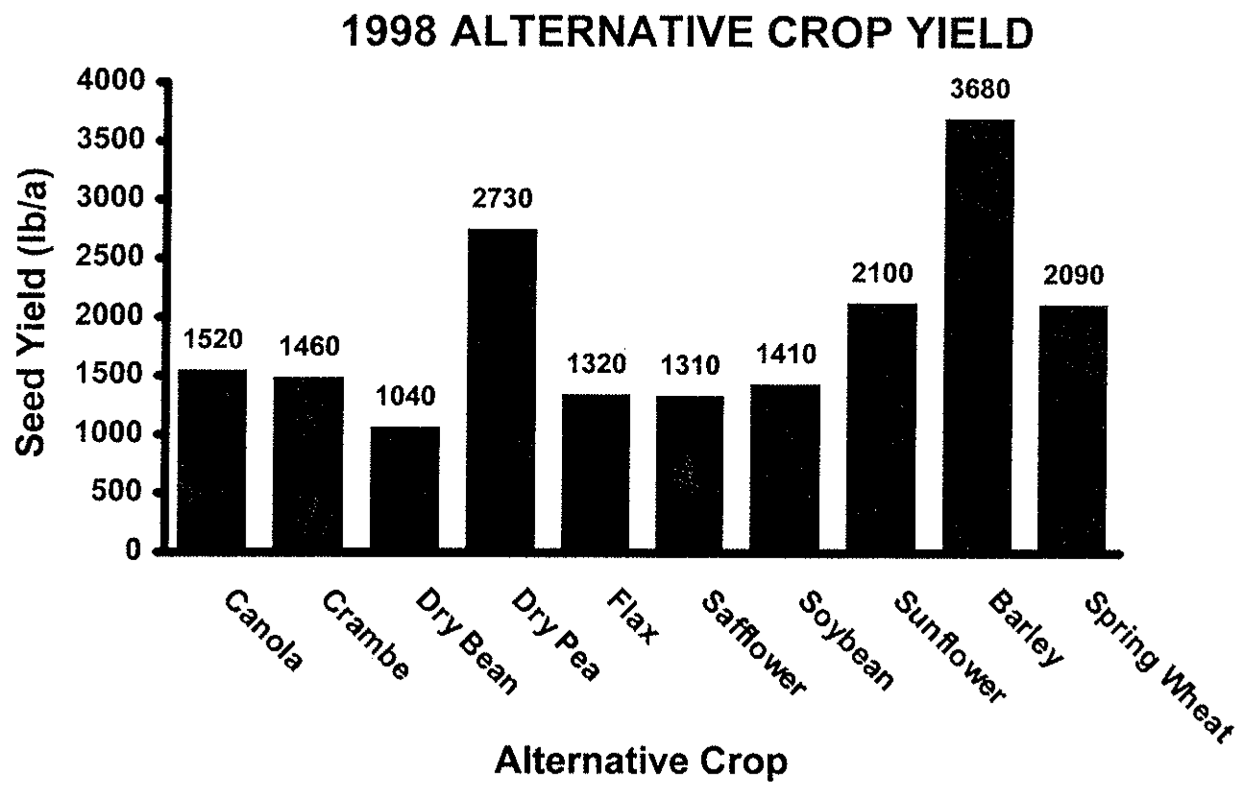


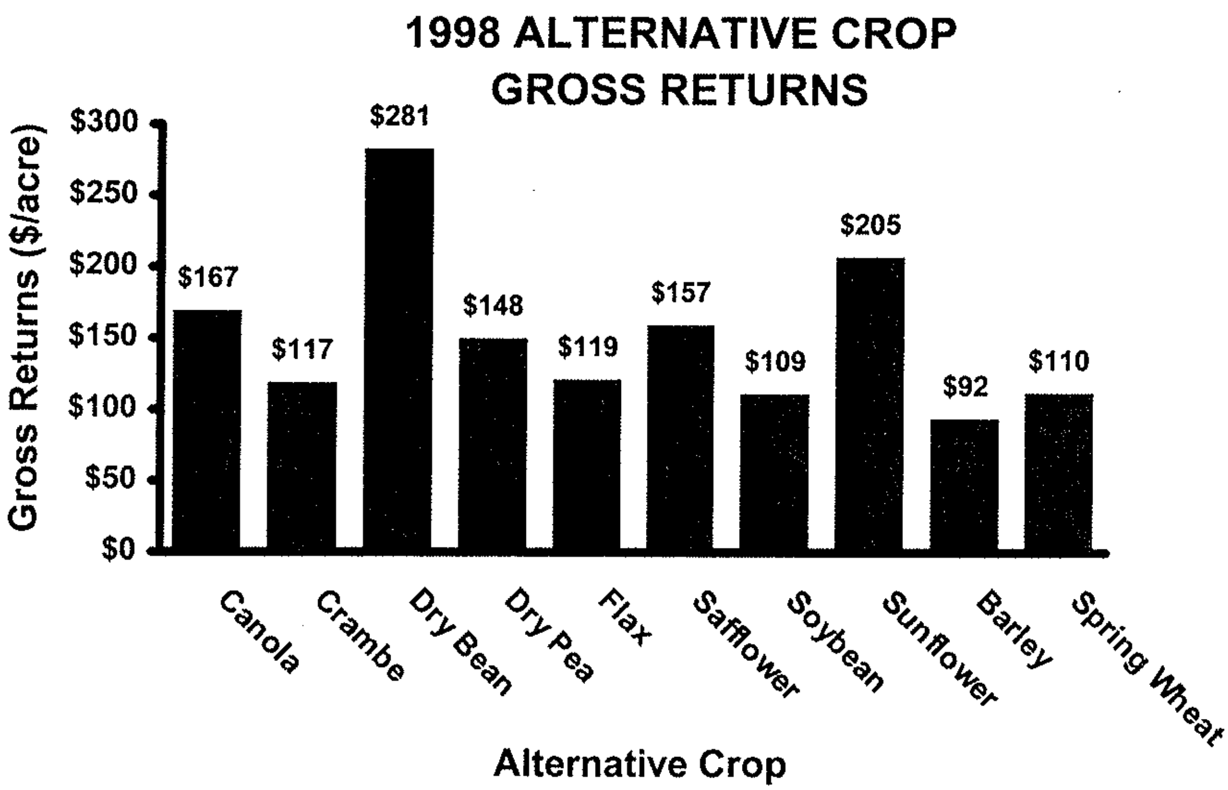
ALTERNATIVE CROPS IN SEQUENCE

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

Phase I of the alternative crops research was initiated in 1995 to produce and harvest alternative crops using small grain equipment. In 1998, phase II of the research was initiated to determine the sequence crops should follow to take advantage of the previous crop. All crops were seeded no-till with a JD 750 no-till drill into an area that had been in a 3-year rotation (spring cereal-winter cereal-alternative crop). Roundup was applied prior to or shortly after seeding each crop. Early season crops (canola, crambe, dry pea, flax, safflower, barley, spring wheat) were seeded on May 13. Late season crops (dry bean, sunflower, soybean) were seeded on May 20. Because of a frost on June 1 and 2, dry bean were reseeded on June 15. Frost also hurt isolated areas of crambe and sunflower.

Below-average precipitation in May, June, and July resulted in only average yields of dry pea, canola, crambe, safflower, and flax. Barley and spring wheat produced good yields for such a dry spring. The 6.35 inches of August precipitation benefitted soybean (1410 lb/a) and sunflower (2100 lb/a) the most. Dry bean yields were the lowest of the 4 years alternative crops had been grown. This could have been due to frost damage on June 1 and 2. Gross dollar returns for all alternative crops were grater than either gross returns for barley or spring wheat. Greatest returns were for dry bean ($281/a). Lowest gross returns were for barley ($92/a).


1998 ALTERNATIVE CROP YIELD
Seed Yield (lb/a)
4000
3500
3000
2500
2000
1500
1000
500
0
1520
1460
1040
2730
1320
1310
1410
2100
3680
2090
Canola
Crambe
Dry Bean
Dry Pea
Flax
Safflower
Soybean
Sunflower
Barley
Spring Wheat
Alternative Crop


1998 ALTERNATIVE CROP
GROSS RETURNS
Gross Returns ($/acre)
$300
$250
$200
$150
$100
$50
$0
$167
$117
$281
$148
$119
$157
$109
$205
$92
$110
Canola
Crambe
Dry Bean
Dry Pea
Flax
Safflower
Soybean
Sunflower
Barley
Spring Wheat
Alternative Crop

SPRING WHEAT IN CONSERVATION TILLAGE

Drs. Donald Tanaka and Joe Krupinsky

Spring wheat trials were initiated in 1979 and have continued with the cooperation of the Williston Research Center. Russ, Verde, Kari, and Hagar were the new varieties for 1998. Varieties were seeded with a 7-foot Kirschmann drill in 6-inch rows on April 24 and 29 at a rate of 1.3 million viable seeds per acre. The field had been chemically fallowed the previous year and weed control prior to seeding was done with a JD mulch master at 1½ inch depths. Fifty pounds of N and 10 pounds of P were applied at seeding. Potassium chloride (KCl), at a rate of 200 lb/a of material, was applied to part of all four replicates before tillage.

Grain yields varied from 50 bu/a for Keene (KCl) to 24 bu/a for Len (no KCl). Plants per square yard for most varieties were about half of the ideal, 200 plants per square yard. Poor stands could have been due to a dry seedbed and crusting problems prior to emergence. Addition of KCl benefitted Vance the most (10 bu/a) and had no influence on others like Russ.

Table 1. Spring wheat agronomic measurements when no potassium was applied in 1998 at Mandan, ND.

Variety	Grain Yield (bu/a)	Straw Yield (lb/a)	Total Dry Matter (lb/a)	Protein[1] (%)	Test Wt. (lb/bu)	Straw to Grain Ratio	Plants per $yard^2$	1000 Kernel Wt. (g)	Heads per $yard^2$	Kernels per Head	Plant Height (inches)	Plants per Viable Seed (%)
Russ	47	3896	6706	—	58	1.38	206	28.5	372	24	39	77
2398	46	3332	6064	—	58	1.22	96	30.5	316	26	36	36
Keene	44	4444	7111	—	60	1.66	124	26.4	347	28	35	46
Kari	44	3074	5754	—	60	1.14	218	33.4	336	22	33	81
Verde	44	3676	6346	—	59	1.38	168	27.9	343	27	36	63
Butte 86	44	3488	6140	—	59	1.31	138	28.8	376	23	34	52
Hagar	40	3568	5986	—	60	1.56	90	28.7	298	26	36	33
2375	40	3136	5554	—	60	1.29	101	29.5	292	26	32	38
Kulm	38	3558	5871	—	61	1.54	88	26.2	359	23	40	33
Stoa	38	3220	5485	—	58	1.42	79	26.2	248	33	34	29
Amidon	36	4166	6374	—	60	1.98	94	26.8	306	25	34	35
Prospect	36	3552	5727	—	60	1.66	58	26.5	228	34	33	21
Trenton	36	3559	5714	—	60	1.64	80	30.3	247	28	39	30
Ernest	36	3862	5992	—	60	1.84	92	27.3	281	26	37	34
Teal	32	3552	5467	—	59	1.84	112	27.3	332	20	36	42
Coteau	32	3409	5313	—	58	1.80	66	25.6	234	29	38	25
Vance	28	3348	4982	—	58	2.04	62	27.3	222	26	32	23
Len	24	3112	4550	—	58	2.16	84	26.5	232	22	36	32
$LSD_{0.05}$	8	498	830	—	1	0.33	21	2	56	4	3	—

[1]Protein analysis courtesy of Heartland, Inc., Bismarck, ND.

Table 2. Spring wheat agronomic measurements when potassium was applied in 1998 at Mandan, ND.

Variety	Grain Yield (bu/a)	Straw Yield (lb/a)	Total Dry Matter (lb/a)	Protein[1] (%)	Test Wt. (lb/bu)	Straw to Grain Ratio	Plants per yard^2	1000 Kernel Wt. (g)	Heads per yard^2	Kernels per Head	Plant Height (inches)	Plants per Viable Seed (%)
Russ	46	3242	5977	—	58	1.18	204	29.8	358	24	36	76
2398	42	3270	5778	—	59	1.34	90	30.7	304	25	36	33
Keene	50	3768	6761	—	62	1.26	107	28.1	353	28	34	40
Kari	40	2710	5068	—	60	1.14	194	34.8	303	20	32	72
Verde	47	3486	6316	—	58	1.22	166	28.7	374	24	36	62
Butte 86	41	3164	5636	—	58	1.28	136	28.5	314	26	35	50
Hagar	44	3345	5968	—	60	1.32	80	29.5	321	26	36	30
2375	40	2930	5348	—	59	1.21	102	28.0	338	24	32	38
Kulm	36	3306	5446	—	61	1.57	92	26.1	347	22	40	34
Stoa	34	3177	5219	—	57	1.56	87	26.3	270	26	36	32
Amidon	39	3786	6116	—	60	1.62	102	27.2	325	25	34	38
Prospect	36	3076	5240	—	59	1.41	54	28.7	222	32	33	20
Trenton	42	3376	5874	—	59	1.36	82	30.9	299	26	38	31
Ernest	36	3381	5520	—	60	1.60	88	28.2	276	26	36	33
Teal	32	3252	5182	—	60	1.68	104	27.6	339	19	35	39
Coteau	30	3243	5072	—	56	1.84	56	26.3	240	27	37	21
Vance	38	3318	5555	—	58	1.49	62	28.6	252	29	32	23
Len	28	3260	4924	—	58	2.08	76	26.4	255	23	34	28
$LSD_{0.05}$	8	425	778	—	1.3	0.34	18	2.4	48.8	4.2	3	—

[1]Protein analysis courtesy of Heartland, Inc., Bismarck, ND.

CULTURAL SYSTEMS FOR SUNFLOWER

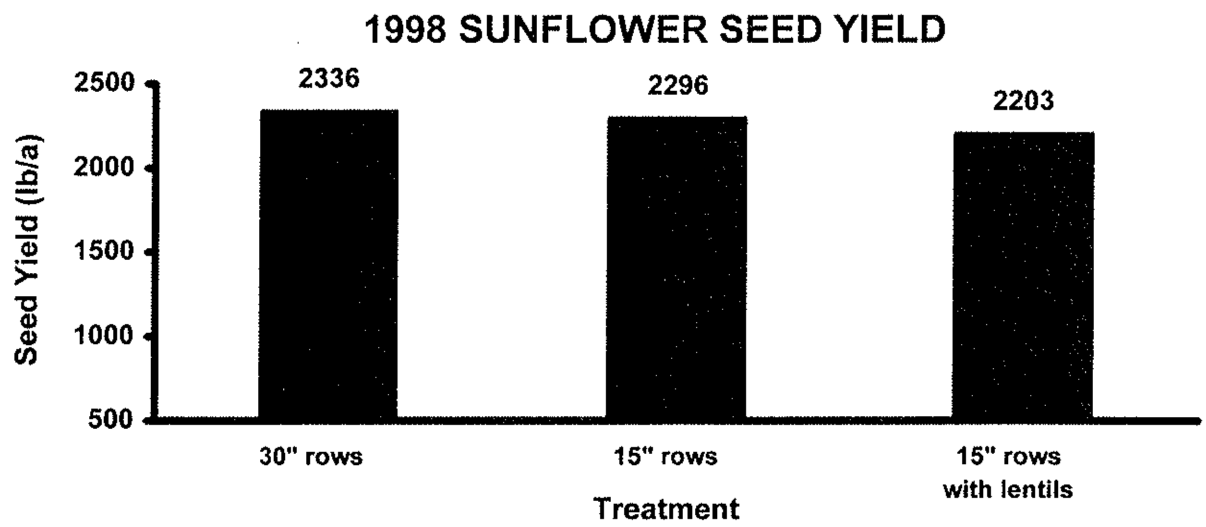
Drs. Donald Tanaka and Randy Anderson (USDA-ARS, Akron, CO)

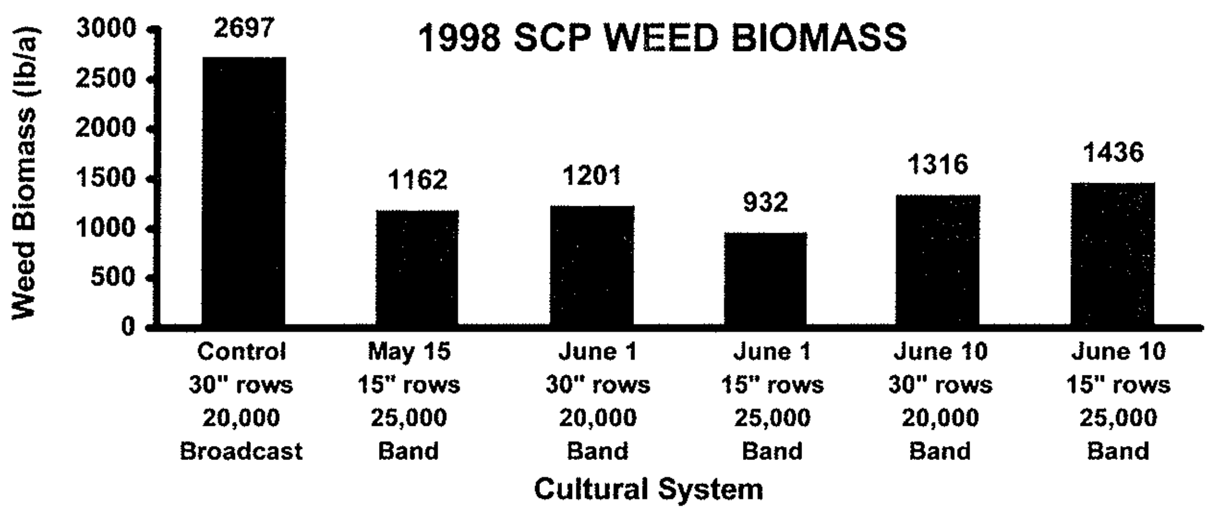
Cultural systems research in 1998 looked at 1) influence of row spacing, plant population, and interseeding lentils into sunflower and 2) development of cultural weed control guidelines for sunflower production. Preliminary results indicates that when Pioneer 63A81 is interseeded with lentils, seed yield is not influenced.

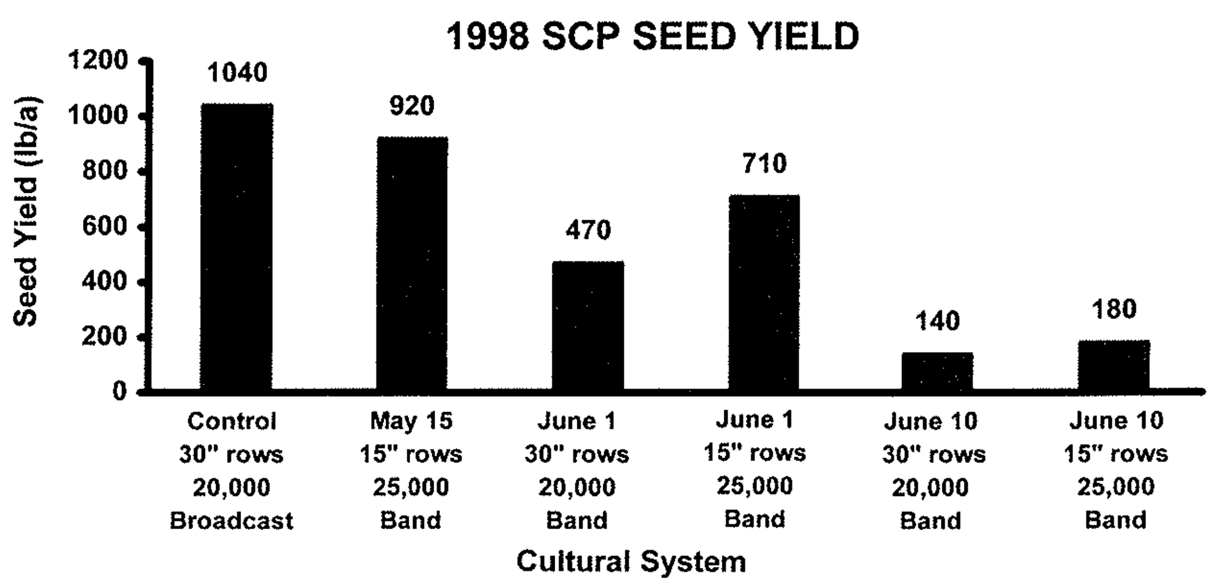
Table 1. Cultural system treatment descriptions for no-till sunflower at Mandan, ND in 1998.

Cultural Treatment Code	Rye Kill Date	Row Spacing (inches)	Plant Production	Fertilizer Application (N)
1.	Prowl (1.5 lb ai/a) no rye	30	20,000	broadcast
2.	15 May 1998 (Feeks 5)	15	25,000	band
3.	1 June 1998 (Feeks 10)	30	20,000	band
4.	1 June 1998 (Feeks 10)	15	25,000	band
5.	10 June 1998 (Feeks 10.5.1)	30	20,000	band
6.	10 June 1998 (Feeks 10.5.1)	15	25,000	band

Treatments used to develop cultural weed control guidelines are show in Table 1. All sunflower were seeded with a JD 750 no-till drill. Sunflower hybrid, Cenex 803, was seeded on June 11. Rye effectively reduced weed biomass in sunflower cultural practices (SCP) by 50% when compared to the control. When rye was left to grow past May 15, sunflower seed yields were greatly influenced. This was due to greater water use by rye at advanced plant development stages and below average precipitation for May, June, and July.


1998 SUNFLOWER SEED YIELD
Seed Yield (lb/a)
2500
2000
1500
1000
500
2336
2296
2203
30" rows
15" rows
15" rows with lentils
Treatment


1998 SCP WEED BIOMASS
Weed Biomass (lb/a)
3000
2500
2000
1500
1000
500
0
2697
1162
1201
932
1316
1436
Control 30" rows 20,000 Broadcast
May 15 15" rows 25,000 Band
June 1 30" rows 20,000 Band
June 1 15" rows 25,000 Band
June 10 30" rows 20,000 Band
June 10 15" rows 25,000 Band
Cultural System

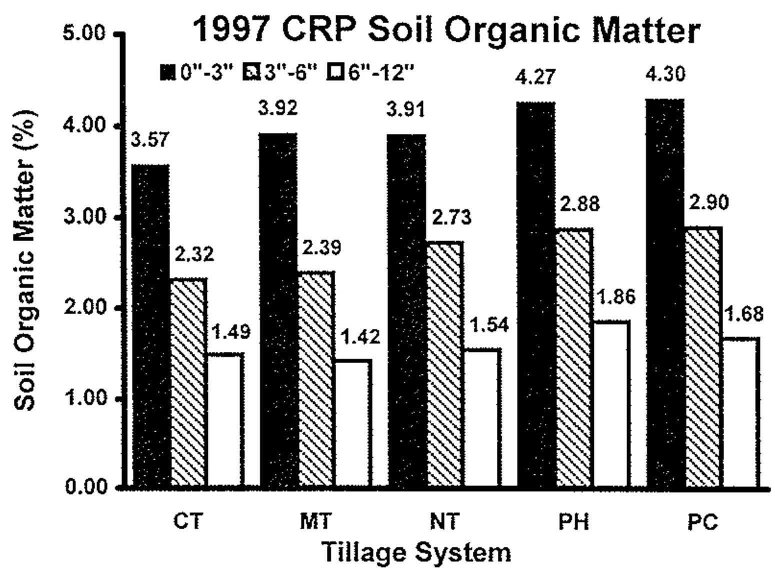

1998 SCP SEED YIELD
Seed Yield (lb/a)
1200
1000
800
600
400
200
0
1040
920
470
710
140
180
Control 30" rows 20,000 Broadcast
May 15 15" rows 25,000 Band
June 1 30" rows 20,000 Band
June 1 15" rows 25,000 Band
June 10 30" rows 20,000 Band
June 10 15" rows 25,000 Band
Cultural System

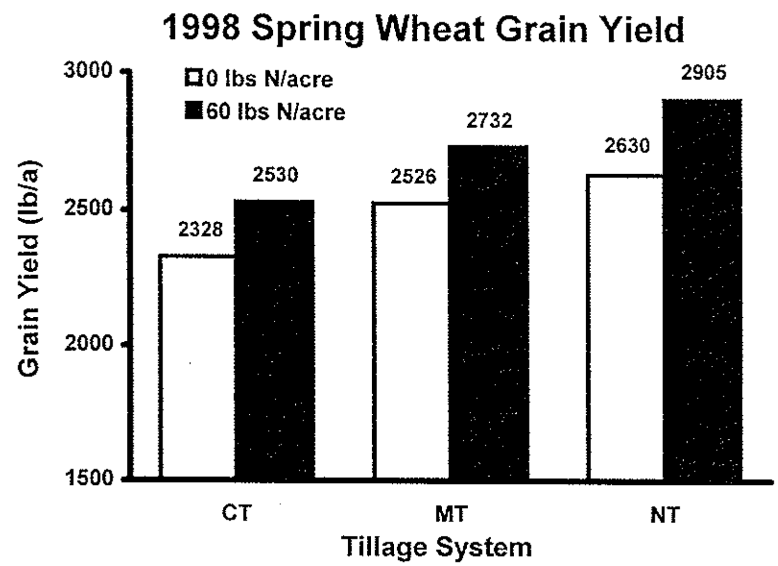
CONVERSION OF CRP TO CROP PRODUCTION

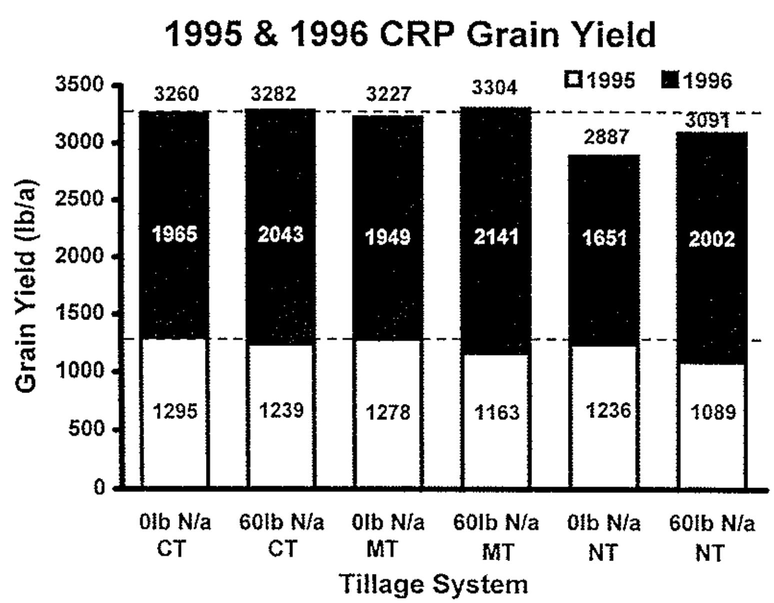
Drs. Donald Tanaka and Steve Merrill

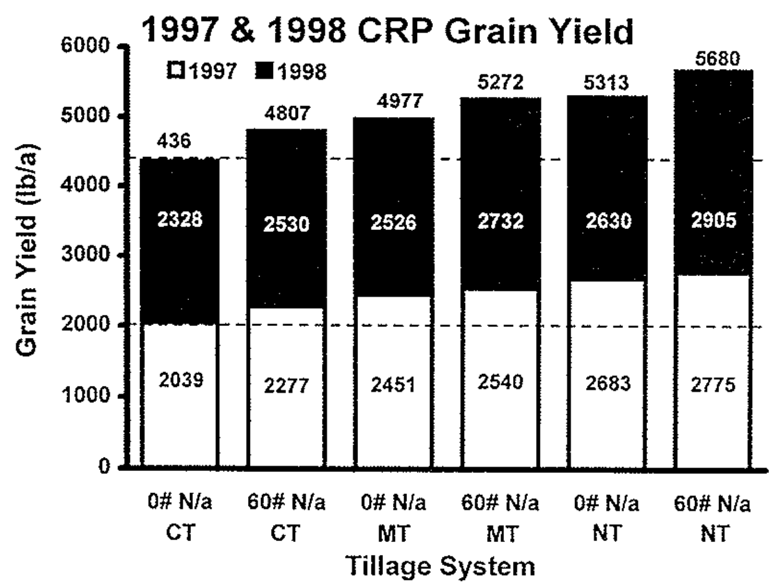
In October 1994, a cooperative study was initiated to determine techniques for conversion of CRP land to crop production. Cooperators included NRCS, Consolidated Farm Service Agency, and the farm cooperators, Mr. Keith Boehm and Lyle Boehm. Treatments were: 1) hayed or nonhayed prior to tillage or spray 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 1998 crop was the beginning of the second cycle of the three-year rotation. In the fall of 1997, soil samples were collected to monitor soil organic matter changes. Greatest organic matter decreases occurred for conventional-till (CT). The lower soil organic matter may have influenced the 1998 spring wheat yields. Conventional-till had the lowest and no-till the highest spring wheat yield. Over the 4-years of the study, CT produced better yields the initial two years, but no-till (NT) and minimum-till (MT) have resulted in better yields the last two years. Averaged over the 4-year period, NT has resulted in 573 lb/a more grain for 0 lb N/a and 682 lb/a more grain for 60 lb N/a when compared to CT. NT appears to sustain production on CRP better than CT.


1997 CRP Soil Organic Matter
0"-3" 3"-6" 6"-12"
Soil Organic Matter (%)
5.00
4.00
3.00
2.00
1.00
0.00
3.57 2.32 1.49
3.92 2.39 1.42
3.91 2.73 1.54
4.27 2.88 1.86
4.30 2.90 1.68
CT MT NT PH PC
Tillage System


1998 Spring Wheat Grain Yield
0 lbs N/acre
60 lbs N/acre
Grain Yield (lb/a)
3000
2500
2000
1500
2328 2530
2526 2732
2630 2905
CT MT NT
Tillage System


1995 & 1996 CRP Grain Yield
1995 1996
Grain Yield (lb/a)
3500
3000
2500
2000
1500
1000
500
0
3260 1965 1295
3282 2043 1239
3227 1949 1278
3304 2141 1163
2887 1651 1236
3091 2002 1089
0lb N/a CT
60lb N/a CT
0lb N/a MT
60lb N/a MT
0lb N/a NT
60lb N/a NT
Tillage System


1997 & 1998 CRP Grain Yield
1997 1998
Grain Yield (lb/a)
6000
5000
4000
3000
2000
1000
0
436 2328 2039
4807 2530 2277
4977 2526 2451
5272 2732 2540
5313 2630 2683
5680 2905 2775
0# N/a CT
60# N/a CT
0# N/a MT
60# N/a MT
0# N/a NT
60# N/a NT
Tillage System

SOYBEAN FOR NO-TILL

Drs. Donald Tanaka, Joe Krupinsky, and Steve Merrill

Research in alternative crops since 1995 has suggested soybean has the potential to be a profitable alternative crop if the correct variety can be found. In 1998, with the aid of Mr. Doug Goehring, selected soybean varieties were evaluated for their adaptability to no-till production practices. Soybean were seeded into an area that has been in a three-year crop rotation (spring cereal-winter cereal-alternative crop). Weeds prior to soybean seeding were controlled using roundup (0.375 lb ai/a). All varieties were seeded no-till into winter wheat residue with a JD 750 no-till drill.

Soybean were seeded on May 22 at 200,000 viable seeds per acre. All seed was inoculated prior to seeding. The above-average August precipitation (6.35 inches) influenced soybean yields. Seed yield ranged from 28.5 bu/a for Pioneer 9042 to 22.7 bu/a for TF 6056.

Table 1. Grain yield, test weight, and seed weight for selected soybean varieties at Mandan, ND in 1998.

	Seed yield	Test weight	Seed weight
	(bu/a)	(lb/bu)	(mg/seed)
Pioneer 9042	28.5	56.7	119
McCall	27.9	56.3	130
NK 508-80	27.4	58.6	167
TF 5072	27.0	57.0	125
Dekalb CX025	26.6	57.2	114
TF 6038	26.4	57.0	109
TF 6035	25.0	58.0	110
S 34	24.7	56.4	125
Jim	23.5	55.7	129
TF 6056	22.7	56.6	130
$LSD_{0.05}$	3.4	1.2	8

THE GPFARM DECISION SUPPORT SYSTEM FOR STRATEGIC FARM AND RANCH PLANNING IN THE GREAT PLAINS

Dr. Jon Hanson

The Great Plains is generally defined as North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, the Texas Panhandle, the southern part of Manitoba, Canada, and eastern Colorado, Wyoming, and Montana. Sustainable agriculture in the Great Plains has become a complex problem that demands consideration of many interrelated factors, processes, and institutions. Across the Plains, agriculture is limited by the availability of water and nitrogen. Using and supplementing these resources to enhance production 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, react to trends in Federal and State legislation, and respond to perceptions by the urban public. The ability to wisely 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 groundwater resources, will determine whether an agricultural enterprise system survives or perishes. To help produces remain economically viable while sustaining the environment, we have developed a computer assisted decision support system called GPFARM. The objective of the program is to develop a resource management decision support system that is capable of analyzing 1-10 year farm/ranch level production plans with respect to water, nutrient, and pest management along with associated economics, government regulations, and environmental risks.

GPFARM integrates the most appropriate research findings and associated economic and environmental risks into a whole-system package. Results from the DSS provide agricultural consultants, producers, and action agencies with information for making management decisions that promote sustainable agriculture. The program provides feedback concerning the most effective technology and assists in determining areas requiring further research and development. This is an evolutionary process that will tie research and technology transfer closely together.

WEED POPULATIONS IMPACTED BY CROP ROTATIONS

Drs. Ron Ries, Donald Tanaka, and Ardell Halvorson, (USDA-ARS, Ft. Collins, CO)

There is a need to develop new theories, knowledge, and techniques for weed management in crop and forage systems. Weeds in crops and forages can cause decreased production and a lessening of crop and forage quality. Research is needed to evaluate the importance of inserting annual forage crops into spring wheat and sunflower crop rotations for farm/ranch income and better options for efficient weed control. A study was initiated in 1996 by seeding several annual forage crops into spring wheat and sunflower stubble produced in 1995. Annual forage crops minimum till seeded into the spring wheat stubble were lentil 'CDC Richly', sudan grass 'Piper', millet 'Siberian', annual alfalfa 'Sava Snail', oat/pea 'Dupond & Trapper', leafless pea 'Profi', vine pea 'Arvia', and spring wheat 'Amidon'. Also included was a chemical fallow treatment. The annual alfalfa stand failed in spring wheat stubble and this plot area was then conventionally fallowed. Lentil, sudan grass, millet, annual alfalfa, and spring wheat were also minimum till seeded into sunflower stubble. A chemical fallow area was also included. All annual forage crops and the spring wheat were managed using the best practices for each of the crops.

Fig. 1 show weeds present in stubble after each of the forage crops harvested for grain in 1996 grown after spring wheat in 1995 and prior to minimum till seeding of all plots to spring wheat in 1997. Lentil plots were more weedy with about 2.8 million broadleaf weed plants per acre. Horseweed *(Conyza canadensis)* and tansy mustard or flixweed (*Descurainia sophia*) accounted for 96% of all weed plants present. The rest of the forage crop plots had broadleaf weed numbers less than chemical fallow which had about 1.3 million plants per acre. Fairy candelabra (*Androsace occidentalis*) accounted for 92% of the weed plants found in the chemical fallow plots. Leafless pea plots had the most grassy weeds at about 1.0 million per acre with 65% of all grassy weeds made up of green and yellow foxtail (*Setaria viridis & Setaria glauca*), while, chemical fallow plots had no grassy weeds observed.

Weeds in annual forage crop stubble grown after spring wheat in 1996 for hay had lentil and oat/pea plots with the most broadleaf weed with 1.7 and 1.8 million per acre, respectively (Fig. 2). This compares with 1.3 million broadleaf weeds found in the stubble of 1996 chemical fallow plots. Horseweed and pepperweed (*Lepidium spp.*) accounted for 72% of the broadleaf weeds after lentil. Horseweed, flixweed, and fairy candellabra made up 95% of the broadleaf weeds found after oat/pea. Broadleaf weeds in the chemical fallow stubble from 1996 was composed of 92% fairy candelabra. Grassy weeds were most in leafless pea with about 161,000 plants per acre composed of 88% green and yellow foxtail and chemical fallow plots had no observed grassy weeds.

Fig. 3 show weeds present in stubble after each of the forage crops harvested for grain in 1996 grown after sunflowers in 1995 and prior to minimum till seeding of all plots to spring wheat in 1997. Lentil plots again had the most broadleaf weeds with about 1.1 million per acre composed of 80% yellow mustard (*Brassica kaber*), fairy candelabra, and tansy mustard but still less than chemical fallow which had about 1.5 million per acre composed of 95% yellow mustard and fairy candelabra. Most grassy weeds were found in millet at 257,000 per acre, made up of 100% green and yellow foxtail. A trace of grassy weeds were observed on 1996 chemical fallow plots.

Weeds in annual forage crop stubble grown after sunflowers in 1996 for hay had lentil plots again with the most broadleaf weed of 1.3 million per acre composed of 82% fairy candelabra and yellow mustard but with less broadleaf weeds than chemical fallow which had about 1.5 million plants per acre made up of 95% fairy candelabra and yellow mustard (Fig. 4). Grassy weeds were minimal after all annual forage crops with annual alfalfa plots having about 139,000 grassy weeds per acre compose of 100% green and yellow foxtail.

Data collected in this study show that weed populations after the various forage crops were different. Differences can be attributed to the competitiveness of the forage crops with weeds, environmental conditions during the growing of the annual forage crops, and whether hay or grain was harvested from the annual forage crops. Our current research is directed towards more in depth evaluation of weed populations in spring wheat grown after several alternative crops to better define the factors involved in the development of different weed populations. Factors being evaluated are the alternative crop, precipitation and soil water, soil and air temperature, soil seedbank seed quantities, and effect of various cultural practices.

Fig. 1

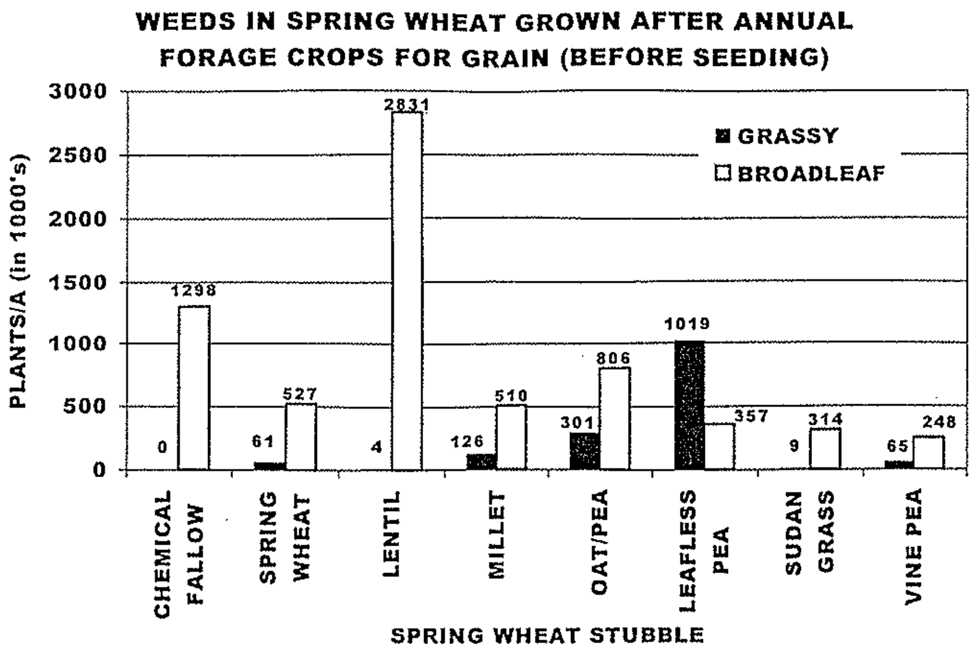

WEEDS IN SPRING WHEAT GROWN AFTER ANNUAL FORAGE CROPS FOR GRAIN (BEFORE SEEDING)
PLANTS/A (in 1000's)
3000
2500
2000
1500
1000
500
0
GRASSY
BROADLEAF
0
1298
61
527
4
2831
126
510
301
806
1019
357
9
314
65
248
CHEMICAL FALLOW
SPRING WHEAT
LENTIL
MILLET
OAT/PEA
LEAFLESS PEA
SUDAN GRASS
VINE PEA
SPRING WHEAT STUBBLE

Fig. 2

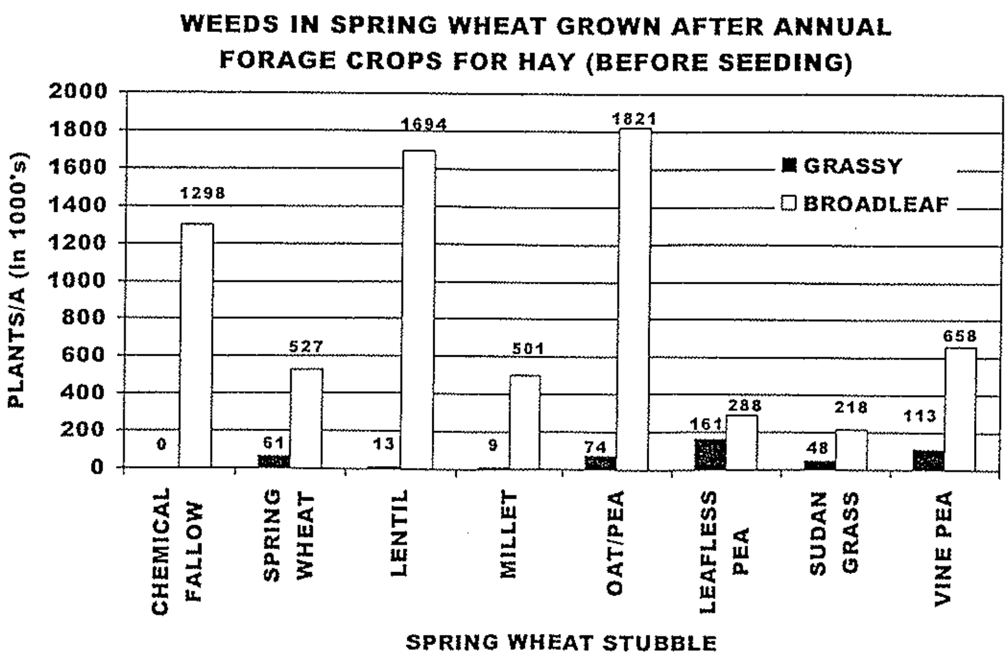

WEEDS IN SPRING WHEAT GROWN AFTER ANNUAL FORAGE CROPS FOR HAY (BEFORE SEEDING)
PLANTS/A (in 1000's)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
GRASSY
BROADLEAF
0
1298
61
527
13
1694
9
501
74
1821
161
288
48
218
113
658
CHEMICAL FALLOW
SPRING WHEAT
LENTIL
MILLET
OAT/PEA
LEAFLESS PEA
SUDAN GRASS
VINE PEA
SPRING WHEAT STUBBLE

Fig. 3

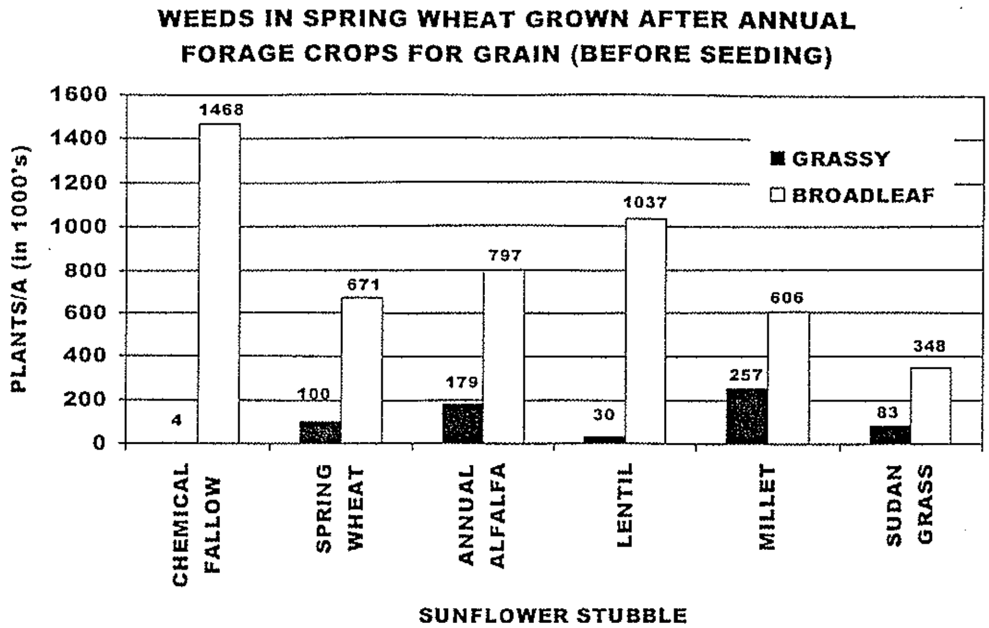
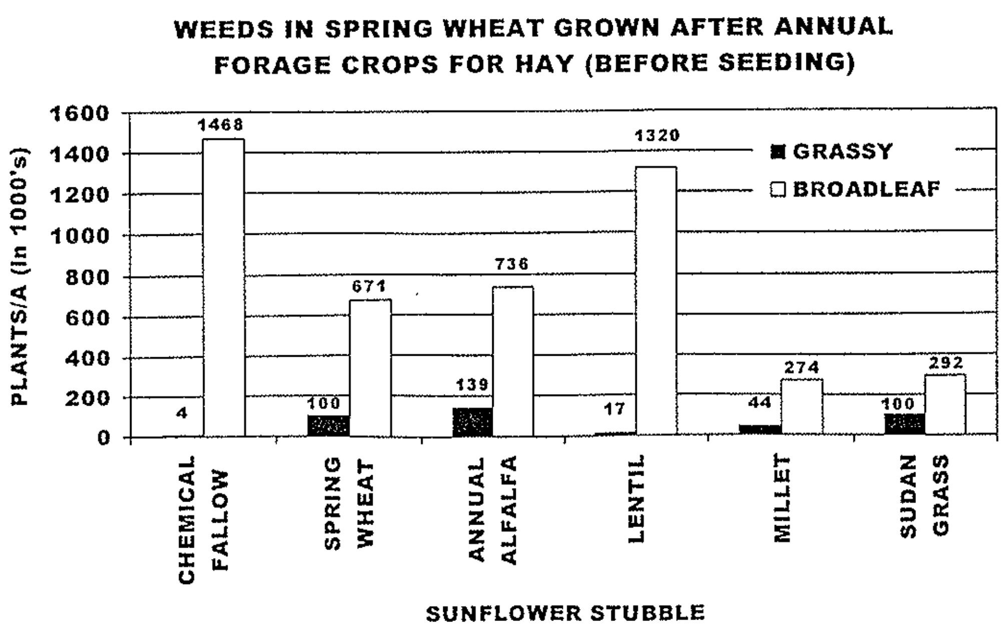

WEEDS IN SPRING WHEAT GROWN AFTER ANNUAL FORAGE CROPS FOR GRAIN (BEFORE SEEDING)
PLANTS/A (in 1000's)
1600
1400
1200
1000
800
600
400
200
0
GRASSY
BROADLEAF
4
1468
100
671
179
797
30
1037
257
606
83
348
CHEMICAL FALLOW
SPRING WHEAT
ANNUAL ALFALFA
LENTIL
MILLET
SUDAN GRASS
SUNFLOWER STUBBLE

Fig. 4


WEEDS IN SPRING WHEAT GROWN AFTER ANNUAL FORAGE CROPS FOR HAY (BEFORE SEEDING)
PLANTS/A (in 1000's)
1600
1400
1200
1000
800
600
400
200
0
GRASSY
BROADLEAF
4
1468
100
671
139
736
17
1320
44
274
100
292
CHEMICAL FALLOW
SPRING WHEAT
ANNUAL ALFALFA
LENTIL
MILLET
SUDAN GRASS
SUNFLOWER STUBBLE

ANNUAL FORAGE CROP QUALITY

Drs. Ron Ries, Donald Tanaka, Jim Karn, and
Ardell Halvorson, (USDA-ARS, Ft. Collins, CO)

Research is needed to evaluate the importance of inserting annual forage crops into spring wheat and sunflower crop rotations for farm/ranch income and better options for efficient weed control. During the 1996 growing season, annual forage crops were minimum till seeded into spring wheat and sunflower stubble. Lentil, sudan grass, millet, annual alfalfa, oat/pea, leafless pea, and vine pea were evaluated for yield and quality after spring wheat and lentil, sudan grass, millet, and annual alfalfa were evaluated after sunflowers. It became evident that both a hay and grain crop could be taken 1996 for all the forage crops being studied because of favorable precipitation and soil water. To further the information gained from this study, the forage crops were harvested at the recommended time for peak yield and quality along with weekly sampling conducted several weeks before and after the recommended time. Results concerning hay and grain yields, crop value based on December 1996 prices, and weeds present after these forage crops have been reported in past Area IV Farm reports. The purpose of this report is to focus on the quality of annual forage crops for hay.

Lentil yield was less after sunflowers than after spring wheat as shown in Table 1. Lentil grown in spring wheat stubble had a yield of 2000 lb/a at first flower which is the recommended time to harvest lentil for maximum yield and quality. Lentil hay at first flower had 10 % protein and .24 % phosphorus. By harvesting lentil hay one week before first flower, yield was about 400 lb/a less with 2.0 % more protein and .02% more phosphorus. Lentil yield at first flower after sunflowers was 1700 lb/a with 9 % protein and .21 % phosphorus. Lentil hay grown in sunflower stubble harvested two weeks before first flower produced 200 lb/a less with 4 % more protein and .07 % more phosphorus.

Millet yield was also less after sunflowers than after spring wheat (Table 2). Millet yield in spring wheat stubble at the start of heading of the millet produced 4200 lb/a of hay with 8 % protein and .14 % phosphorus. One week before the start of heading, millet hay was about 200 lb/a less with 2 % more protein and .04 % more phosphorus. Millet hay grown in sunflower stubble at the start of heading yielded 3900 lb/a with 10 % protein and .14 % phosphorus. No better protein or phosphorus quality was found by harvesting earlier than at start of heading.

Sudan grass grown after spring wheat had a yield of 5200 lb/a when it was 36-48 inches high, the recommended time to harvest for quality and yield (Table 3). At this time, sudan had 6 % protein and .14 % phosphorus. If the sudan grass was harvested two weeks earlier, the yield was 4000 lb/a with 10 % protein and .18 % phosphorus. Yield of sudan grass grown after sunflowers was 4800 lb/a when its height was 36 - 48 inches with 8 % protein and .12 % phosphorus. Two weeks earlier it yielded 3200 lb/a with 12 % protein and .17 % phosphorus.

Vine pea, leafless pea, and oat/pea were only grown after spring wheat because of disease problems that are expected if you follow sunflowers with these legumes. Vine pea yield at first flower, the recommended time to harvest for maximum yield and quality, was 4000 lb/a with 10 % protein and .17 % phosphorus (Table 4). When harvested for hay one week before first flower, yield was 200 lb/a less, protein was 4 % more, and phosphorus was .09 % more.

Leafless pea produced less than vine pea as shown in Table 5. Leafless pea yield at first flower was 3000 lb/a with 10 % protein and .18 % phosphorus. A week earlier, yield was 2000 lb/a with 12 % protein and .25 % phosphorus.

Oat/pea grown in spring wheat stubble yielded 3200 lb/a at the time the oat is in late boot (Table 6). Protein was 13 % and phosphorus was .22 %. One week before late boot for oat, yield was 2800 lb/a with 16 % protein and .28 % phosphorus. Oat/pea straw at the time of oat/pea grain harvest had a yield of 5000 lb/a with 8 % protein and .17 % phosphorus.

Annual alfalfa was difficult to establish in our study during 1996. We have tried to establish it again in 1997 with limited success. More establishment trials are needed before we can accurately evaluate its place as an annual forage or green manure crop. In 1996, our stand of annual alfalfa failed in the spring wheat stubble. In sunflower stubble, we established a 75 % stand. In this stand, yield was 1000 lb/a at one tenth bloom with 12 % protein and .19 % phosphorus (Table 7).

We believe that annual forage crops offer an opportunity to include more diverse crops to spring wheat/sunflower crop rotations. It appears that the quality of the annual forage hay can be significantly influenced by fertility management and close monitoring of harvest date. Data show that earlier and later harvest of the various annual forage crops for hay results in different yields and quality for the hay. Often the reduction in yield is minor when harvested earlier and the increase in protein or phosphorus can be considerable. Excellent quality hay with good yields can be harvested and used for sale as a cash crop and/or used to feed on the farm/ranch livestock. These crops may be more important and economical when operators are interested in integrated forage/crop/livestock production systems.

Table 1

LENTIL

HARVEST TIME	HAY PROD.(LB/A)	PROTEIN (%)	PHOS. (%)
SPRING WHEAT STUBBLE			
1ST FLOWER	2000	10	.24
1 WK BEFORE	1600	12	.26
SUNFLOWER STUBBLE			
1ST FLOWER	1700	9	.21
2 WKS BEFORE	1500	13	.28

Table 2

MILLET

HARVEST TIME	HAY PROD.(LB/A)	PROTEIN (%)	PHOS.(%)
SPRING WHEAT STUBBLE			
START OF HEADING	4200	8	.14
1 WK BEFORE	4000	10	.18
SUNFLOWER STUBBLE			
START OF HEADING	3900	10	.14

Table 3

SUDAN GRASS

HARVEST TIME	HAY PROD.(LB/A)	PROTEIN (%)	PHOS.(%)
SPRING WHEAT STUBBLE			
36-48" HIGH	5200	6	.14
2 WKS BEFORE	4000	10	.18
SUNFLOWER STUBBLE			
36-48" HIGH	4800	8	.12
2 WKS BEFORE	3200	12	.17

Table 4

VINE PEA

SPRING WHEAT STUBBLE			
HARVEST TIME	HAY PROD. (LB/A)	PROTEIN (%)	PHOS. (%)
1ST FLOWER	4000	10	.17
1 WK BEFORE	3800	14	.26

Table 5

LEAFLESS PEA

SPRING WHEAT STUBBLE			
HARVEST TIME	HAY PROD.(LB/A)	PROTEIN (%)	PHOS. (%)
1ST FLOWER	3000	10	.18
1 WK BEFORE	2000	12	. 25

Table 6

OAT/PEA

SPRING WHEAT STUBBLE			
HARVEST TIME	HAY PROD.(LB/A)	PROTEIN (%)	PHOS. (%)
OAT AT LATE BOOT	3200	13	.22
1 WK BEFORE	2800	16	.28
STRAW AT GRAIN HARVEST	5000	8	.17

Table 7

ANNUAL ALFALFA (75% STAND)

SUNFLOWER STUBBLE			
HARVEST TIME	HAY PROD.(LB/A)	PROTEIN (%)	PHOS. (%)
1/10 BLOOM	1000	12	.19

SYNERGISTIC EFFECTS OF A BEEF CATTLE-CROP PRODUCTION SYSTEM

Dr. Jim Karn

Most farm and livestock operators have tried to maintain or increase their income by Maximizing production. The result has been an abundance of low priced food for U. S. consumers, but producers have often not benefitted from their improved productivity. New research at the Northern Great Plains Research Laboratory will focus on reducing production input costs and optimizing net income per unit of land by systematically combining crop and beef cattle production operations to enhance the efficiency of the overall farm enterprise. Recent innovations in no-till seeding techniques and development of crop rotations which include annual and perennial grasses and legumes and use of animal manure will play an important role in facilitating production of forages for use by beef cattle during critical periods of their production cycle.

One of the keys to improving the efficiency of beef-cattle production is the development of a year-round feeding scheme which more nearly meets animal nutritional requirements without over or under feeding. Perennial forages afford a high quality diet from early May until about the last of July in the Northern Great Plains, but from the first of August until the middle of October perennial forages generally decline in nutritive quality and often do not meet the nutritive requirements of lactating cows. From weaning until at least the last trimester, the nutritive requirements of dry bred cows are relatively low and can be met with lower quality forages, but this is traditionally the time when relatively expensive hay is fed. Annual forages which can improve the quality of cattle diets during the fall and winter and complement small grain crops in rotations should be beneficial in a combined beef cattle crop production system.

A preliminary study to determine the feasibility of wintering dry bred cows on swaths of crested wheatgrass or foxtail millet is in progress. Cows were turned on crested wheatgrass swaths on November 23, 1998 and on foxtail millet swaths on December 14, 1998. Cows were weighed and condition scored when the study was initiated and will be weighed and condition scored again when swath grazing is terminated. Crested wheatgrass crude protein ranged from 5.4 to 7.5 % with an average of 6.5 % while foxtail millet crude protein ranged from 6.0 to 9.5 % with an average of 8.0 %. The objective of this preliminary work is to determine some of the simple mechanics of swath grazing, such as workable portable electric fencing, proper fence placement to minimize feed wastage, how much swath should be opened for grazing at one time, will animals eat from swaths when the weather is cold and swaths are snow covered, can adequate crude protein and digestibility levels be maintained in swathed forage, and can appropriate animal productivity be maintained with swath grazing. We are currently evaluating this preliminary research and planning more comprehensive winter grazing studies for the future.

USE OF FOLIAR APPLIED NITROGEN TO INCREASE KERNEL NUMBERS AND PROTEIN IN SPRING WHEAT

Drs. Al Frank, Brian Wienhold (USDA-ARS, Lincoln, NE),
and Ardell Halvorson (USDA-ARS, Ft. Collins, CO)

The purpose of this study is to determine the effects of foliar applications of nitrogen that coincide with specific stages of plant-apex development on kernel numbers, size, and protein Nitrogen is the nutrient applied to fields in the greatest quantities by producers. Accurate N application rates require a yield goal and knowledge of residual soil N. In the Northern Great Plains annual variation in temperature and growing season moisture make it difficult to establish a yield goal. In 1997, a study was initiated utilizing a chlorophyll meter to improve N use efficiency in spring wheat. Although there has been research done on effects of post-emergence nitrogen applications on wheat production, there is an absence of research on timing of nitrogen application to coincide with the wheat plant apex double ridge and terminal spikelet stages of development. In theory, these apex stages should hold most promise for increasing kernels and protein with increasing nitrogen. Average protein spreads for spring wheat over winter wheat are often as great as 3-4%, and could result in a good premium for HRS wheat.

The treatments consisted of foliar applications of 30 lb N/acre (28% UAN) in water at 21 GPA. The crop was sprayed at Haun growth stages 3-3.5 (vegetative), Haun 4 (apex double ridge), Haun 5.5 (apex terminal spikelet), Haun 9.5 (boot), and Haun 12.1 (watery ripe). Measurements taken included leaf tissue for N analyzer prior to N application and at 7-day intervals after spraying, plant growth stage, tiller numbers, spike development, and visual color of the crop. In 1997 when foliar N was applied at Haun 4, the apex double ridge stage, the trend was for higher grain yield, kernel weight, and kernels per head than for the check and all other foliar applications: grain yields were 36 bu/acre at Haun 4 vs. 34 for the check, kernel weight was 29.9 vs. 28.8, and kernels per head were 27.6 vs. 25.7. In 1998 foliar N applied at the vegetative, apex double ridge, and apex terminal spikelet stages all had greater yields and kernel/head (44 bu/acre and 27 kernels/head) than the check (41 bu/acre and 26 kernels/head).

CHLOROPHYLL METER AS A N MANAGEMENT TOOL FOR MALTING BARLEY

Dr. Brian Wienhold (USDA-ARS, Lincoln, NE)

A two year study was initiated in 1997 to assess the potential for using a commercially available chlorophyll meter as a N management tool. The barley variety Stander was used both years and is a high protein 6-row barley. A low protein 6-row barley, Foster, was included in 1998. In 1997 barley was grown under the following N treatments:

1. 100% N needed to meet the yield goal applied preplant
2. 50% N needed to meet the yield goal applied preplant
3. 0% N needed to meet the yield goal applied preplant
4. 50% N needed to meet the yield goal applied preplant and 25% N applied at the Haun 4 to 5 growth stage
5. 50% N needed to meet the yield applied preplant and 50% N applied at the Haun 4 to 5 growth stage

In 1998 N was applied preplant at 0, 50, 75, and 100% the rate needed to meet the yield goal and at 50% preplant and either 25 or 50% at the Haun 4 to 5 growth stage. At the Haun 4 to 5 growth stage chlorophyll meter readings and leaf tissue N concentrations were determined in all plots. Relative chlorophyll meter readings were correlated with relative grain yields and less so with relative grain protein. Plots having relative chlorophyll meter readings below 95% responded to N topdressed at the Haun 4 to 5 growth stage with yields similar to those of plots receiving 100% N preplant and with grain protein concentrations acceptable for malting. In 1998 conditions during the growing season resulted in low yields and unacceptably high grain protein concentrations in Stander plots receiving 50% or more N preplant.

Based on these results the following N management strategy is proposed. For malting barley, 40 to 50% of the N calculated for the yield goal is applied at planting and a fully fertilized reference strip is included for each variety or soil type. At the Haun 4 to 5 growth stage, chlorophyll meter readings are taken in the reference strip and in the field. Normalized chlorophyll meter readings below 95% of the reference strip indicate a need for additional N fertilizer. This strategy will provide producers with additional time (up to a month) to evaluate growing season conditions before investing in additional crop inputs and will improve the likelihood that a barley crop acceptable for malting will be produced.

SITE-SPECIFIC RESEARCH, 1995-1998

D.W. Franzen, Ext. Soils Specialist, NDSU, Fargo, ND
V.L. Hofman, Ext. Ag. Engineer, NDSU, Fargo, ND

INTRODUCTION

In 1995, a site-specific sampling project was underway in eastern North Dakota. Following a meeting at the 1st North Dakota Site-Specific Workshop in February, Dr. A.D. Halvorson suggested that the project be expanded to include a site at the Area IV farm near the Northern Great Plains Research Laboratory. A grant was secured from USEPA 319 Water Quality Funds for soil testing expenses, and equipment was purchased using a combination of funding from both NDSU grants, Area IV, and USDA-ARS funds. Larry Renner and Marv Hatzenbuhler have been instrumental in equipment operation and computer analysis of data since the onset of the project. In 1997 when Dr. Halvorson moved to Colorado, Dr. Krupinsky supported the work. Dr. Jon Hanson, present Laboratory director has also provided his support for the project.

The project objectives were to serve as a demonstration of site-specific techniques, but also to gather data to support soil sampling techniques, profitability and changes in soil test levels through a rotation and time.

METHODS

The 'I' fields (I4-I6) were selected for the study. The I-6 field (east) was sampled in a 110 foot grid, and the other two fields (center and west) were sampled in a 150 foot grid. Samples were divided into a 0-6 inch core, and a 6-24 inch core. Nitrate-N, sulfate-S and chloride were analyzed to both depths, and P, K, pH, EC, Zn, Cu and organic matter were analyzed at only the 0-6 inch depth. In 1997, soil pH was analyzed on the 6-24 inch depth in addition to the 0-6 inch depth. Yields were measured using a yield monitor, and variable-rate fertilizer applications were made with a modified Concord air-seeder with two compartments for application of two different products with independent rates for each. Topography was measured using a laser-surveying device and recording measurements in a 110 foot grid.

To compare less dense gridding with the original 110 foot grid, those points not represented by the less dense grid locations were deleted from the data base. A map was generated using inverse distance squared interpolation, and the estimates for each of the deleted 110 foot grid points were correlated with the sampled and analyzed values. To compare topography strategies, the fields were separated into fourteen sampling zones based on topography. Within each zone, the zone was given a value based on a single sampling point (point sampled) or based on the mean of six grid points within that zone. Each 110 foot grid point location within a zone was given the point or average value, then correlated with the original 110 foot sampled/analyzed value. Mapping was conducted using Surfer for windows.

RESULTS

Sampling study

Various grid density and topography sampling strategies were compared from 1995 through 1998. In 1996 through 1998, different variable-rate/conventional N and P treatments were imposed on the fields which may have impacted correlation analysis in some years. The correlation factors are presented in Table 1.

Table 1. Comparison of topography-based, 220 foot/300 foot, 330 foot/300 foot, and 440 foot/450 foot grids with the 110 foot sampling grid, 1995-1998.

	Correlation (r)							
Year	Topography (point)				Topography (area)			
	N	P	S	Cl	N	P	S	Cl
1995	0.76*	0.58*	0.12	0.22*	0.83*	0.70*	0.13	0.22*
1996	0.29*	0.62*	0.36*	0.39*	0.47*	0.64*	0.39*	0.34*
1997	0.86*	0.35*	0.63*	0.82*	0.87*	0.44*	0.72*	0.83*
1998	0.35*	0.19*	0.10	0.05	0.46*	0.31*	0.25*	0.21*
	220/300 foot grid				330/300 foot grid			
	N	P	S	Cl	N	P	S	Cl
1995	0.29*	0.58*	0.48*	0.56*	0.44*	0.22*	0.24*	0.17
1996	0.20	0.72*	0.04	0.17	0.28*	0.53*	0.11	0.15
1997	0.81*	0.39*	0.59*	0.69*	0.77*	0.24*	0.57*	0.67*
1998	0.20*	0.21*	0.10	0.50*	0.19*	0.13	0.09	0.42*
	440/450 foot grid							
	N	P	S	Cl				
1995	0.23*	0.58*	0.08	0.14				
1996	0.14	0.51*	0.11	0.15				
1997	0.67*	0.27*	0.43*	0.43*				
1998	0.35*	0.22*	0.02	0.30*				

*denotes significantly correlated at the 95% probability level.

The grid and topography sampling study at Mandan agreed with the findings of the other four sites in eastern North Dakota. Topography based sampling, particularly the area based topography sampling provides as good or better soil nutrient information as dense grid sampling at a fraction of the samples needed to determine field levels. For example, the 220 foot/300 foot grid would require 51 samples, while the topography-based samplings only used 14. The zone sampling approach will enable growers of wheat, barley, sunflowers and other commodity-type crops to gather high quality plant nutrient information at relatively low cost. The information gathered from the Mandan location, along with the information gathered at other sites, has served as a basis for revision of NDSU soil sampling guidelines. This new information is published in NDSU Extension Circular SF-990 (revised, 1998).

Profitability

Profitability studies with conventional uniform applications of N and P compared to variable-rate based on topography sampling or grids was conducted from 1996 through 1998.

In 1996, N and P rates were varied on both sunflower and spring wheat, but the spring wheat was hailed out just before harvest, so the data could not be used for profitability evaluation. The sunflower data showed a net increase of topography-directed N and P of $11.57/acre over the uniform treatment, and a 440/450 foot grid had a net increase of $4.97/acre over the uniform treatment. The study considered the cost of fertilizers and sampling/analysis costs, but not the cost of application equipment.

In 1997, the variability of N within fields was low compared to 1996, and there were no differences between variable-rate N/P and a uniform application based on the mean.

In 1998, variable-rate studies were conducted on the winter wheat (west field) and the sunflower (center field). Both the winter wheat and sunflower yields were relatively low, with sunflower only yielding about 850 lb/acre and the winter wheat about 25 bu/acre. There were no differences in yields due to treatments. In the east field, spring wheat was treated with a normal rate of fertilizer derived from soil testing alone (98 lb/acre N as urea to supplement the 15 lb/acre NO_3-N in the 0-24 inch depth) compared to a 30 lb/acre reduction in N based on a contribution of N from sunflower residues the previous year (68 lb/acre N). There were no significant differences in yield due to either treatment, which might suggest the reduction was justified. However, yields achieved by the spring wheat averaged 33 bu/acre and the plots were fertilized for 45 bu/acre. The rate of 68 lb/acre, together with the 15 lb/acre already in the soil was sufficient for a 33 bu crop without the supplemental N from sunflower residue. Although the reduction in N did not reduce yields, it cannot be said that sunflower residue sustained higher yields than the crop was fertilized for.

Variable-rate studies have also been conducted at other sites in North Dakota. From this limited data base, the following guidelines are suggested to guide profitable application.

1. Nutrients impacting yield must be sufficiently variable for profitable returns from variable-rate application. If N levels are below 30 lb/acre in the upper 0-24 inches, then it is unlikely that sufficient variability is present to warrant variable-rate application. P levels medium or higher would not likely be candidates for short-term variable P benefits.

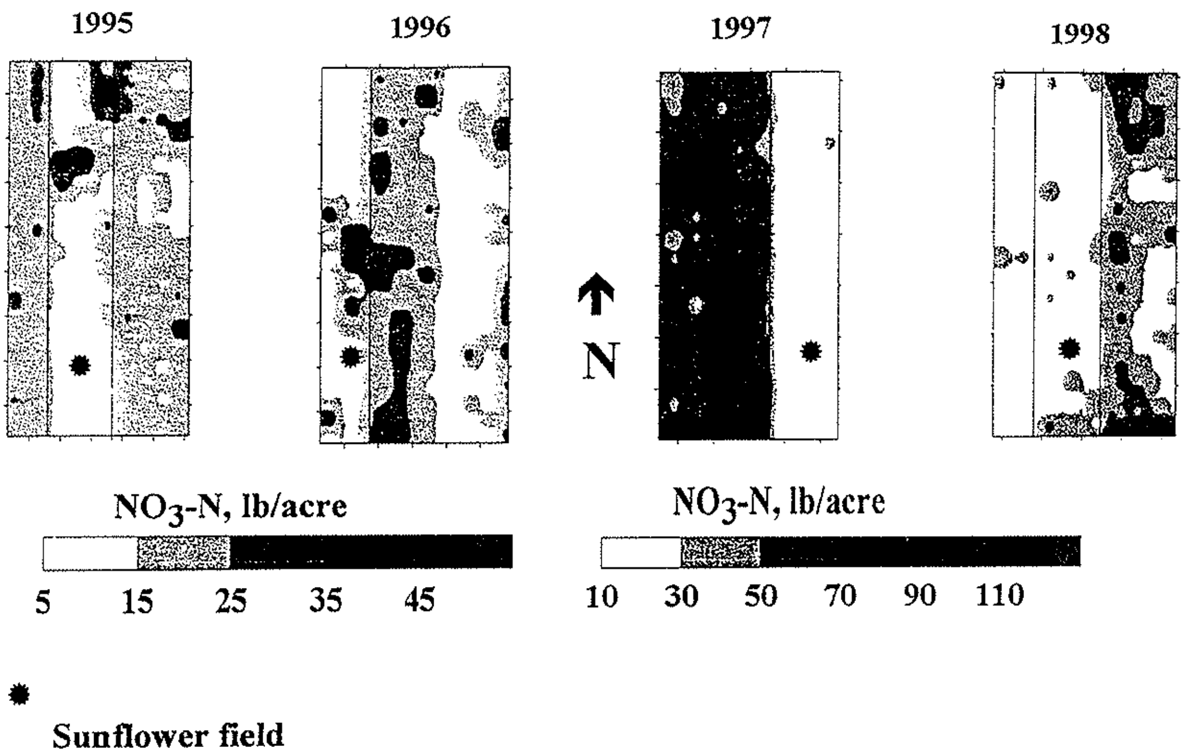
2. If resulting yields are low due to environmental conditions, it is unlikely that variable-rate fertilizer application will be most effective.

3. Variable-rate application will be most effective when high variability of a nutrient is present, the nutrient is variable within the zone where adjustment impacts crop yield, and environmental conditions allow yields to achieve those considered in yield goal based nutrient requirement predictions.

Variability over a rotation

Variability of N was not the same every year (Figure 1). Although similar patterns were detected, soil N levels were drastically reduced after sunflower, and increased more than predicted the year after sunflower. This phenomena suggests that sunflower may accumulate N in plant tissues, lower soil N levels at deep depths, and then make a portion of that N available to the subsequent crop in future years.

Figure 1. Soil NO_3-N levels, 1995-1998.

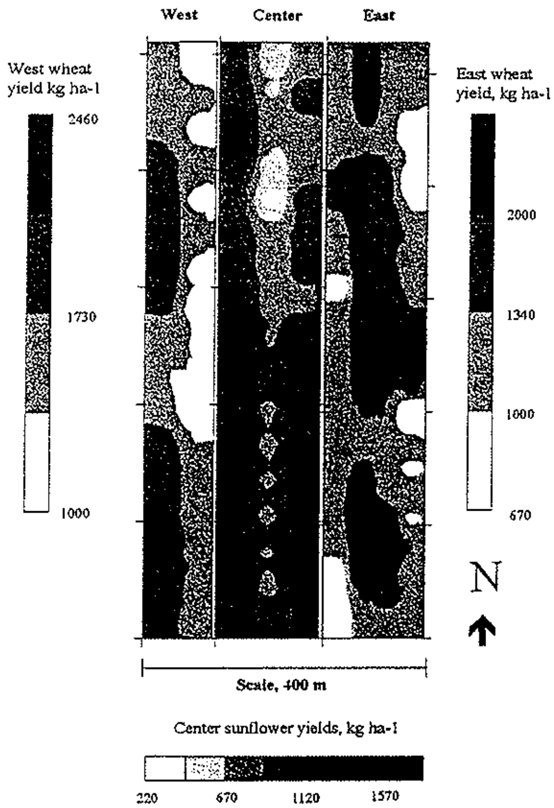


In 1998, soil samples were taken on a topography-based pattern in the sunflower field from 24-48 inches. At all locations, except where sunflower yields were extremely low, soil N was below 20 lb/acre. In the area of exceptionally low sunflower growth, levels were about 50 lb/acre, suggesting that sunflower does accumulate N from deep depths.

Yields

Yields have been helpful in profitability studies, and also have shown some similarity between years. Some areas have consistent high yields, while others vary between years. The following figures provide yield maps from 1995 through 1998. Yield maps in 1995 were both of amidon spring wheat and confectionary sunflower. Fertilizer was not variably applied as we only began the site-specific project in the summer. Spring wheat was planted in the spring on the two wheat strips and oil type sunflower was planted on the remaining strip. Yields in the 1996 wheat are unadjusted for hail. The sunflower yield map (center field) in 1998 shows a high streak through the center of the field. This is a yield monitor problem, as the calibration factor in the yield monitor was changed and does not show a true statement of yield. The remainder of the field is relatively accurate. Yield of sunflower in 1998 was very poor producing 833 lb/ac. Because of planting earlier by 1 to 2 weeks, the field was heavily infected with stem weevils. The stem weevils apparently helped increase the spread and severity of Phoma black stem in the plots. The winter wheat yielded 24 bu/ac and the spring wheat yielded 33 bu/ac.

Figure 2. Yields, 1995-1996.



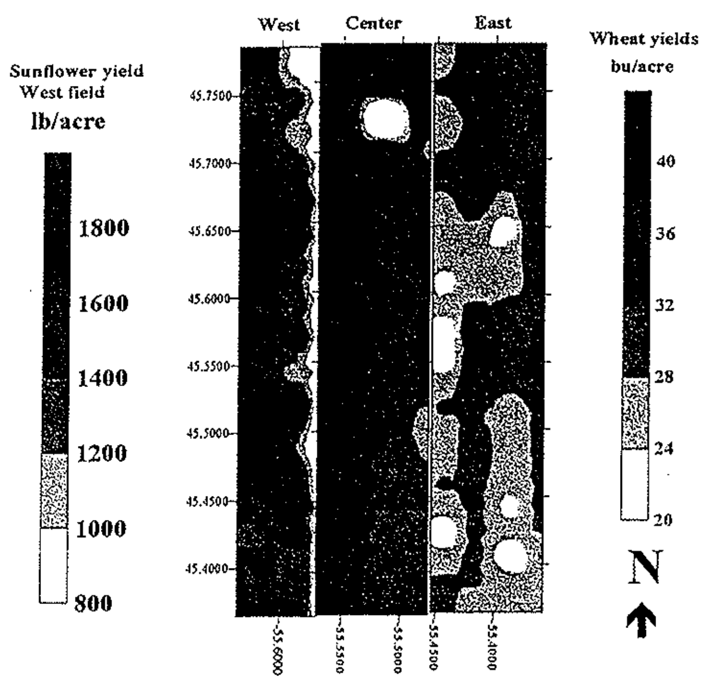
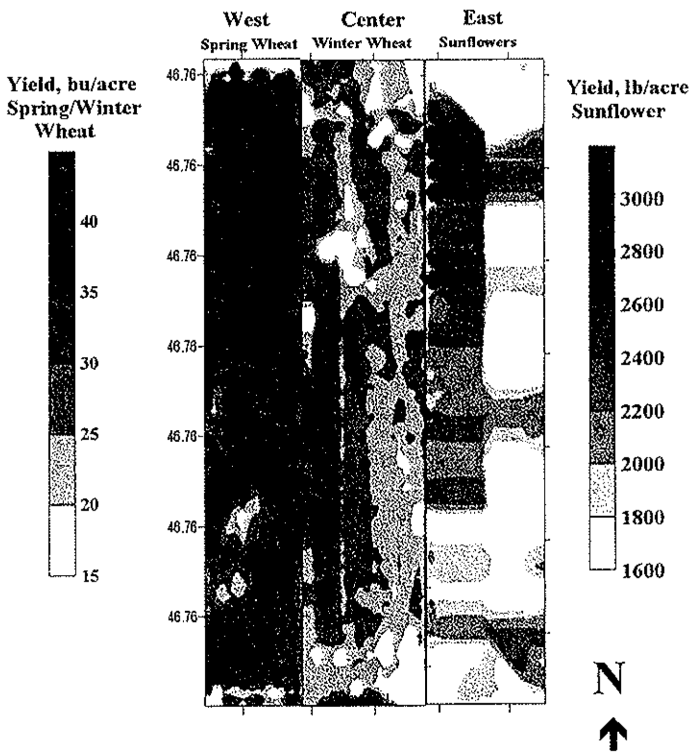
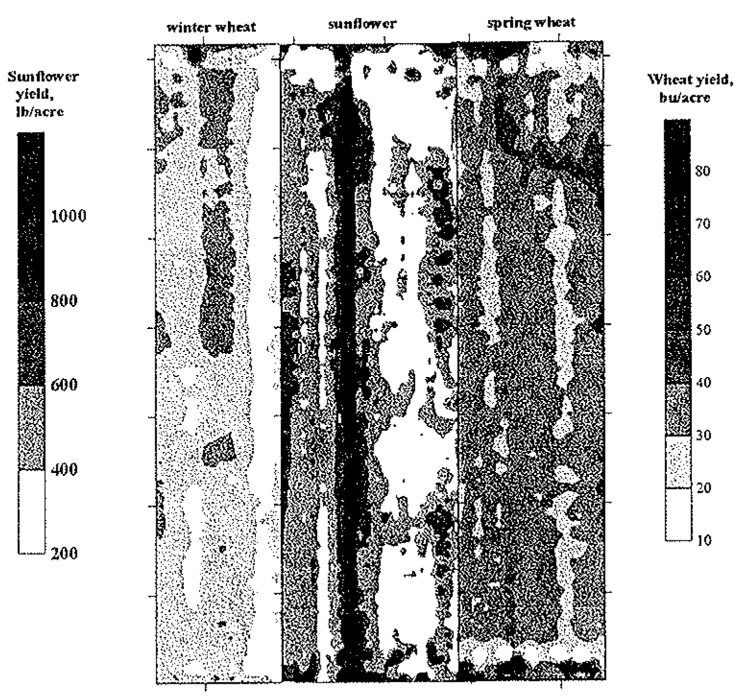


Figure 3. Yields, 1997-1998.

1997



1998



SUMMARY

Four years of site-specific research has provided considerable information regarding the variability and measurement of variability within North Dakota fields. Initial profitability early in the study was promising, but subsequent results have been affected by resulting decrease in variability due to previous treatments. The research has indicated that spatial variability may change due to cropping, and that sunflower may cycle N from deep depths to shallow depths, providing subsequent crops with N similar to a legume. Continuing work at the station will allow further study of rotational effects on variability and the N cycling nature of sunflower in a wheat/sunflower rotation.

It is also planned to study aerial and satellite photographs during the next growing seasons. This will be done as cost of the images permit. Images during the growing season can be helpful to determine the change in the crop, pest infestation and to determine the correlation of crop growth to crop yield.

SMALL GRAIN VARIETY EVALUATIONS AT MANDAN

Eric Eriksmoen, Agronomist, NDSU, Hettinger, ND

Hard Red Spring Wheat - No-till Recrop **Mandan**

				--Grain Yield --		Average Yield
Variety	Plant Height	Test Weight	Protein	1997	1998	2 year
	in	lbs/bu	%	------------ bu/ac	------------	
Forge	34	61.6	11.7	37.8	56.3	47.0
2375	33	60.2	12.8	38.4	55.2	46.8
Oxen	31	56.2	11.6	37.3	52.6	45.0
2398	23	59.3	13.1	29.3	58.8	44.0
2371	31	57.1	13.0	38.8	45.3	42.0
Amidon	38	60.7	12.7	33.0	50.6	41.8
Keene	38	61.0	12.9	32.6	50.4	41.5
Trenton	39	60.6	13.5	27.8	52.0	39.9
Grandin	33	57.5	12.9	32.5	45.2	38.8
Kulm	36	61.2	13.3	30.3	46.3	38.3
Ernest	37	59.8	13.0	28.7	46.9	37.8
Argent HWSW	34	59.2	13.3		42.9	
Trial Mean	35	59.5	12.8	34.0	50.2	--
C.V. %	3.2	1.0	--	20.7	7.0	--
LSD .05	2	0.8	--	NS	6.0	--
LSD .01	2	1.1	--	NS	8.0	--

Planting Date: April 15, 1998
Seeding rate: 1.1 million live seeds/A (approx. 1.6 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.

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
2ND15403	26	50.3	10.7		64.8	
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.

Oats - No-till Recrop	Mandan

Variety	Plant Height	Test Weight	--Grain Yield -- 1997	1998	Average Yield 2 year
	in	lbs/bu	------------ bu/ac	------------	
Whitestone	38	39.0	73.7	130.9	102.3
Troy	38	40.5	50.4	119.2	84.8
Jud	42	39.8	53.4	112.9	83.2
Jerry	38	40.9	40.2	125.2	82.7
Paul*	42	45.4	33.8	93.3	63.6
AC Medallion	40	39.2		119.9	
Trial Mean	40	40.8	50.4	116.9	--
C.V. %	7.7	1.4	15.6	7.8	--
LSD .05	NS	0.9	11.6	13.6	--
LSD .01	NS	1.2	15.8	18.7	--

Planting Date: April 15, 1998
Seeding rate: 750,000 live seeds/A (approx. 1.7 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.
* = Naked (hulless) type.

Durum Wheat - No-till Recrop	**Mandan**

Variety	Plant Height	Test Weight	Protein	--Grain Yield -- 1997	1998	Average Yield 2 year
	in	lbs/bu	%	------------ bu/ac		------------
Ben	37	61.9	13.7	42.5	53.6	48.0
Renville	37	60.5	12.4	40.9	52.1	46.5
Munich	33	60.1	13.2	34.2	51.5	42.8
Belzer	35	58.6	12.6	31.8	45.0	38.4
Mountrail	34	60.9	12.6		57.0	
Maier	35	61.7	13.4		54.6	
Trial Mean	35	60.6	13.0	37.5	52.3	--
C.V. %	3.8	1.8	--	15.7	5.2	--
LSD .05	2	1.7	--	NS	4.0	--
LSD .01	3	2.3	--	NS	5.5	--

Planting Date: April 15, 1998
Seeding rate: 1.25 million live seeds/A (approx. 2.2 bu/A).
Harvest Date: August 10, 1998
Previous Crop: 1997 = corn
1998 = HRSW
Yields are adjusted to 12.5% moisture.
NS = no statistical difference between varieties.