2001 RESEARCH and CROPPING RESULTS
Area IV SCD/ARS Research Farm

Eighteenth Annual Progress Report
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TABLE OF CONTENTS

INTRODUCTION
AREA IV SCD/ARS RESEARCH FARM

The Area IV SCD/ARS Research Farm is the result of a specific cooperative agreement between USDA-ARS and the twelve Soil Conservation Districts (SCDs) that make up Area IV. This agreement was put in place in 1984. Through this agreement, the Area IV SCDs lease cropland from the Nelson estate for the Northern Great Plains Research Lab, USDA-ARS, to conduct cooperative research projects with the Area IV SCDs. Total cropland leased by AREA IV SCDs is 382 acres. In addition, USDA-ARS has leased 55 acres in sec. 17 and sec. 18 for soil and water conservation research for many years and another 26 acres in sec. 8 for tree plantings since 1989. Total acreage leased for research purposes is 463 acres. The Area IV Research Farm is located southwest of the USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND (Figure 1). The general 2001 cropping plans are outlined on maps for the four field areas designated as F, G, H, and I (Figure 2). The precipitation pattern for the 2001 growing season and the total precipitation history (1984-2001) for the duration of the Area IV cooperative agreement is shown in Figure 3 and Figure 4.

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

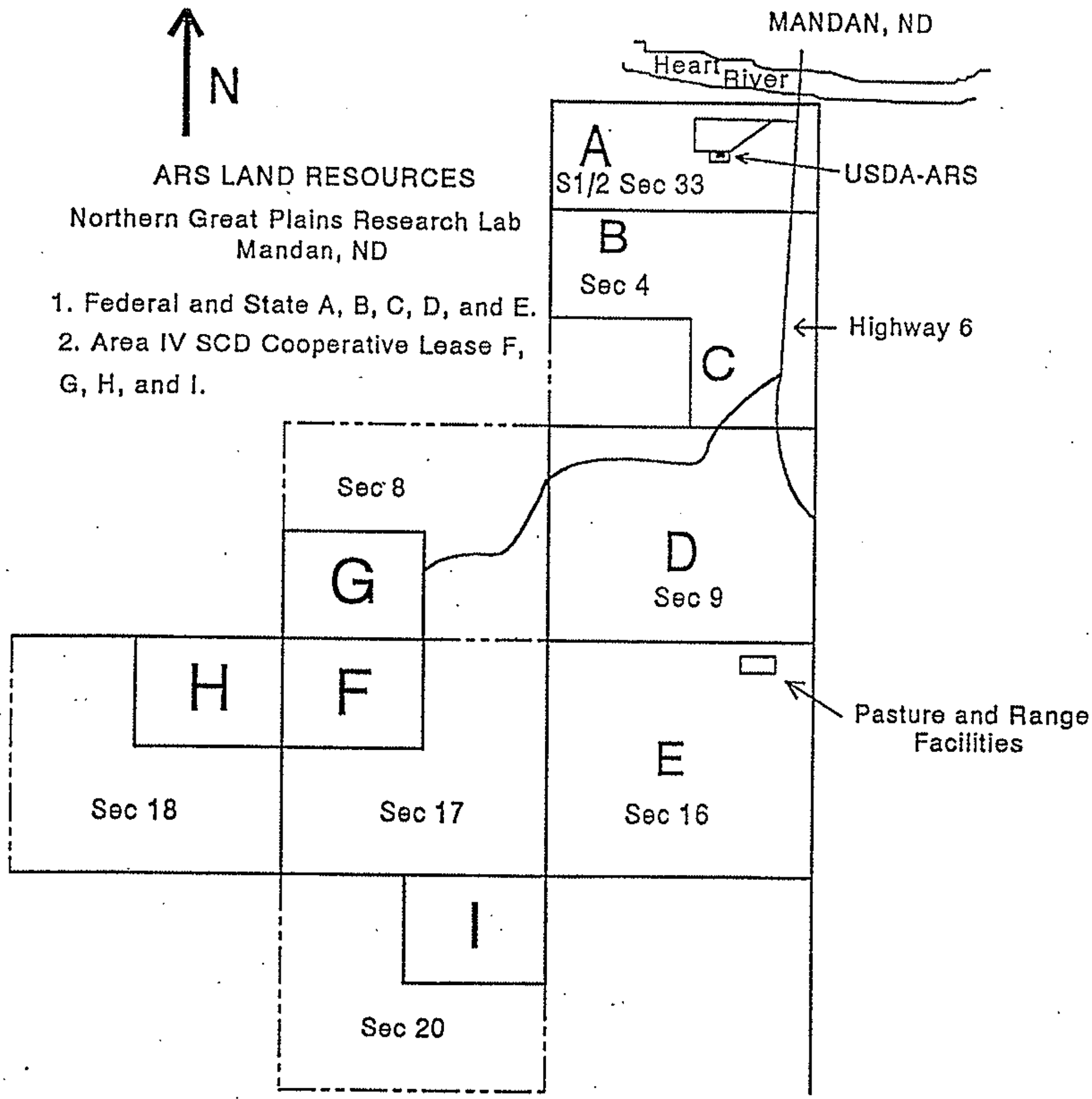
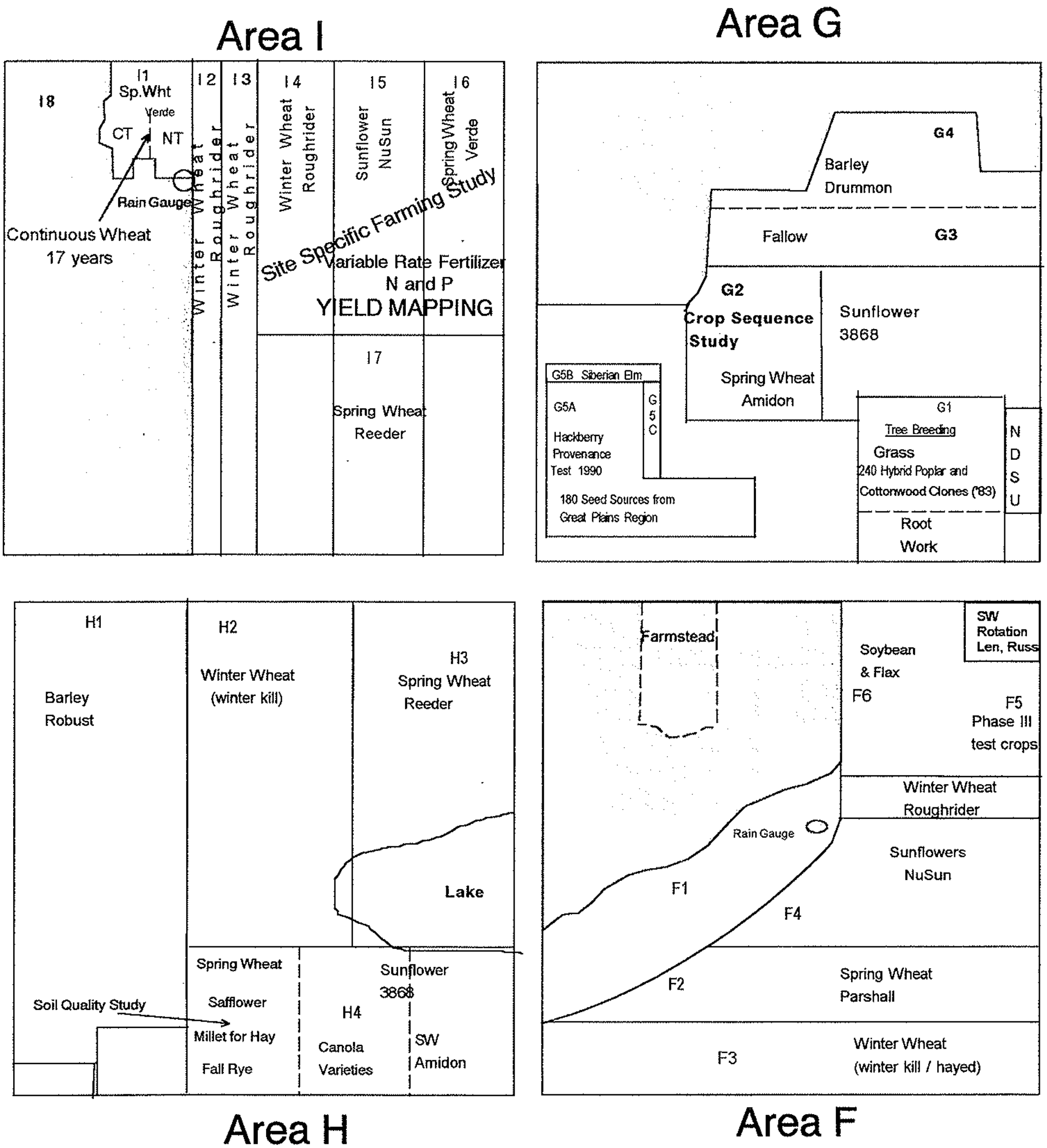


FIG. 2.

Area IV Research Farm Crop Plan - 2001.



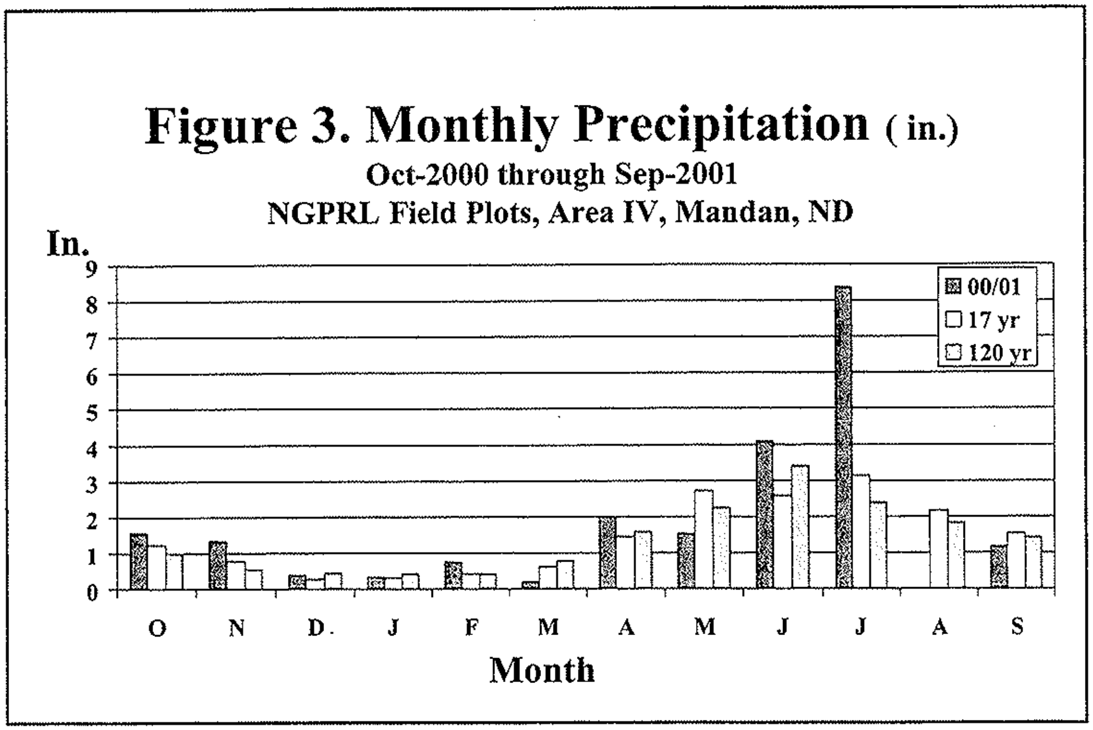


Figure 3. Monthly Precipitation (in.)
Oct-2000 through Sep-2001
NGPRL Field Plots, Area IV, Mandan, ND
In.
9
8
7
6
5
4
3
2
1
0
00/01
17 yr
120 yr
O N D J F M A M J J A S
Month

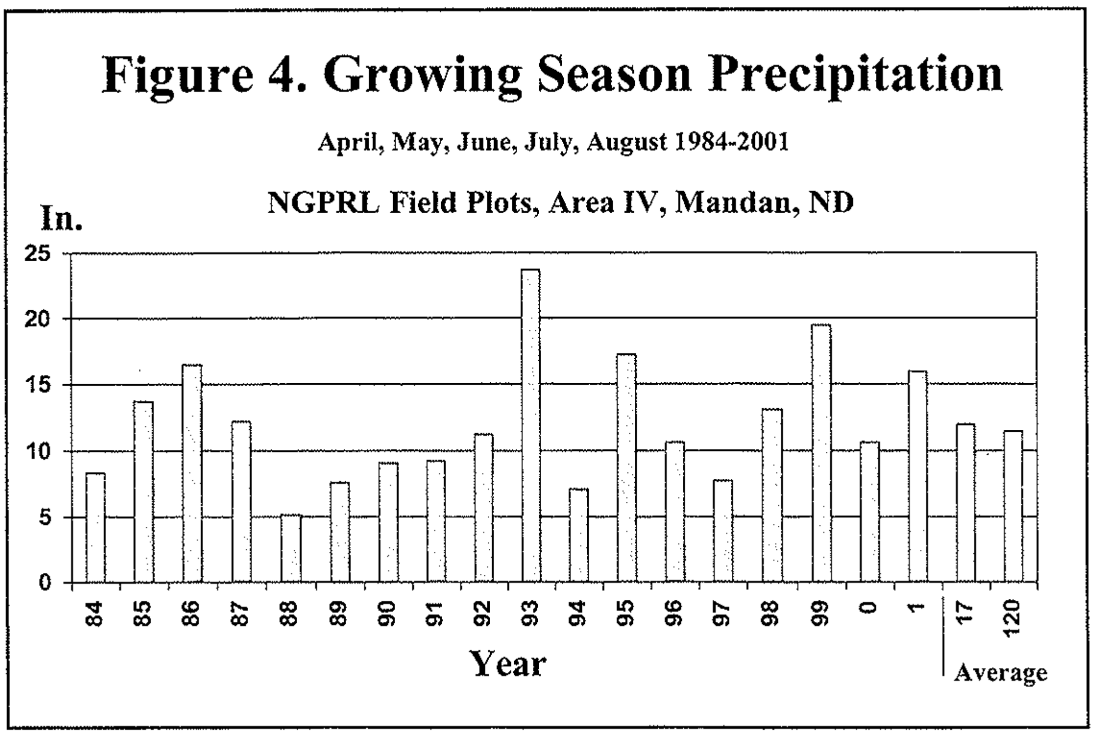


Figure 4. Growing Season Precipitation
April, May, June, July, August 1984-2001
NGPRL Field Plots, Area IV, Mandan, ND
In.
25
20
15
10
5
0
84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 0 1 17 120
Year
Average

Figure 5. A crop by crop residue matrix used to evaluate the influence of crop sequence on crops. During the first year ten crops (numbered 1 through 10) are seeded into a uniform crop residue. During the second year the same crops are no-till seeded perpendicular over the residue of the previous year's crop. Individual plot numbers are assigned for each replication.

Crop by Crop Residue Matrix, 1 Replicate, 100 Plots										
1	2	3	4	5	6	7	8	9	10	1
11	12	13	14	15	16	17	18	19	20	2
21	22	23	24	25	26	27	28	29	30	5
31	32	33	34	35	36	37	38	39	40	9
41	42	43	44	45	46	47	48	49	50	7
51	52	53	54	55	56	57	58	59	60	10
61	62	63	64	65	66	67	68	69	70	6
71	72	73	74	75	76	77	78	79	80	3
81	82	83	84	85	86	87	88	89	90	4
91	92	93	94	95	96	97	98	99	100	8
5	2	7	1	8	4	6	9	3	10	

1st year, ten crops seeded in strips

2nd year, ten crops seeded perpendicular over crop residue

Crops seeded in Crop Sequence Project, Phase II, 1998-2000.

1. Canola
2. Crambe
3. Dry Bean
4. Dry Pea
5. Flax
6. Safflower
7. Soybean
8. Sunflower
9. Wheat
10. Barley

Crop Sequence Calculator, Version 2

A Revised Computer Program to Assist Producers

USDA-ARS, NGPRL
Mandan, ND 58554-0459

The Crop Sequence Calculator (version 2) is a user-friendly program that runs directly from a CD-ROM eliminating the need for additional disk space or installation procedures. The program provides an introduction to the crop sequence research project and dynamic agricultural systems and contains information on crop production, economics, plant diseases, weeds, insects, water use, and surface soil properties to aid producers in their evaluation of management risks associated with different crop sequences. Once the previous crop (residue producing crop) and the expected crop are entered with a click of the mouse, summary statements appear regarding crop production, economics, plant diseases, weeds, insects, water use, and surface soil properties. The program can show the yield effect of ten crops (barley, canola, crambe, dry pea, dry bean, flax, safflower, soybean, sunflower, and spring wheat) grown in any two-year combination. Expected crop prices and expected loan deficiency payments and/or crop premiums can be entered to provide rapid calculations of potential returns. By selecting the "More Info" buttons adjacent to each summary statement, graphs, photos, internet resources and additional information is easily accessed. For example, additional information concerning plant diseases includes an introduction to plant diseases, research data, internet resources, and photographs of plant diseases to aid in their identification. The program also includes numerous photographs of weeds and insects to aid in identification.

Copies of the Crop Sequence Calculator can be obtained from:
from the **ARS website: www.mandan.ars.usda.gov**
or from: Crop Sequence Calculator
Northern Great Plains Research Laboratory
Agricultural Research Service-USDA
Box 459, Mandan, North Dakota 58554-0459

A postcard is supplied with the CD-ROM to register your copy. When a new version of the program is produced registered users will receive an upgraded copy. The underlying program and data were generated with the supplemental support of the Area IV Soil Conservation District, National Sunflower Association, North Dakota Oilseed Council, Northern Canola Growers Association, and North Dakota Dry Pea and Lentil Association. No material in this CD may be copied and distributed in part or whole without permission of the research scientists involved.

EARLY SEASON CROP SEQUENCE PROJECT

Phase II of the Diverse Cropping Systems Project

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

INTRODUCTION

The Early Season Crop Sequence Project, Phase II of the Diverse Cropping Systems Project, was initiated in 1998 to determine the sequence crops should follow to take advantage of the previous crop and crop residues. Field plots were located on the Area IV ARS/SCD Research Farm located near the Northern Great Plains Research Laboratory, southwest of Mandan, North Dakota. A field was divided into an east and west side in order to provide two site years. On the east side in 1998, ten crops (barley [*Hordeum vulgare*], dry bean [*Phaseolus vulgaris*], canola [*Brassica napus*], crambe [*Crambe abyssinica*], flax [*Linum usitatissimum*], dry pea [*Pisum sativum*], safflower [*Carthamus tinctorius*], soybean [*Glycine max*], oil seed sunflower [*Helianthus annuus*], and wheat [*Triticum aestivum*]) were seeded in an east-west direction with a JD 750 no-till drill in 9.1 m [30 ft] strips into wheat stubble in each of four replications and 60 lb N/a and 10 lb P/a were applied at seeding. Roundup® was applied after seeding early season crops (canola, crambe, dry pea, flax, safflower, barley, and spring wheat) and before seeding late season crops (dry bean, sunflower, and soybean). The cultivars for each crop were: Montola 2000 safflower, Stander barley, Dynamite canola, Meyer crambe, Shadow Black Turtle dry bean, Profi dry pea, Omega flax, Jim soybean, Cenex 803 oilseed sunflower, and Amidon spring wheat. In 1999 all crops were again randomized and seeded into stubble from the previous crops on the east side in a north-south direction, perpendicular to the 1998 crop, with a JD 750 no-till drill (Figure 5). This allowed every crop to be seeded on the residue of all the other crops (100 treatments per replication). Seeding perpendicular to previous crops established a minimum plot size of 9.1 m by 9.1 m (30 X 30 ft). In 1998, barley was uniformly seeded on the west side. The west side was treated similarly to the east side. All crops were seeded in an east-west direction in 1999 and in a north-south direction in 2000, again allowing every crop to be seeded on the residue of the ten previous crops (Figure 5). Following the crop by crop-residue matrix, a uniform wheat crop was grown on the east side in 2000 and on the west side in 2001 to determine how wheat performs after all crop sequences.

The Crop Sequence Calculator (version 2) includes an introduction to the cropping system project and dynamic agricultural systems. It also contains information on crop production, economics, plant diseases, weeds, insects, water use, and surface soil properties to aid producers in their evaluation of management risks associated with different crop sequences. (See Crop Sequence Calculator on page 7.)

Note: Phase III of the Diverse Cropping Systems Project will be initiated in 2002.

Crop Production and Crop Sequences
Dr. Donald Tanaka

Research was initiated in 1998 to determine the sequence crops needed to follow to take advantage of the synergism that occurs among crops. Ten crops (canola, crambe, dry bean, dry pea, flax, safflower, soybean, sunflower, wheat, and barley) were seeded on the residue of each of the crops in 1999 and 2000. Dry pea, flax, and barley residues (preferred) had the largest number of crop options (Table 1). Crop residues with the least number of options were canola and safflower (non-preferred). In general, crop seed and residue yields most influenced by previous crop and crop residues were flax and safflower followed by canola, sunflower, wheat, and barley. Crop seed and residue yields least influenced by previous crop and crop residues were crambe, dry bean, and dry pea. Seed yield for seven out of the ten crops was the lowest when the crop was grown on its own residue.

Spring wheat was no-till seeded over all plots where the ten crops were grown in 1999 and 2000. Average spring wheat seed yields 2 years after alternative crops (AC-W-W) produced 4% greater yields than continuous wheat (W-W-W). Seeding wheat after one year of alternative crop (W-AC-W) resulted in a 14% yield increase while wheat seeded after two years of alternative crops (AC-AC-W) resulted in a 20% yield increase when compared to continuous wheat (Figure 1A). By choosing specific crop sequences, wheat yields can be increased up to 20% (W-DP-W) by planting an alternative crop one out of three years and up to 32% (SB-DB-W) when alternative crops are planted in two out of three years (Figure 1B). All crop sequences were compared to continuous wheat.

Table 1. A summary of preferred and non-preferred crops (based on seed yield) for each of the ten crop residues from data collected in 1999 and 2000 on the Crop Sequence Project.

Crop Residue	Preferred Crops					Non-Preferred Crops					
Canola	Wheat					Canola	Crambe	Dry Bean	Dry Pea	Flax	Safflower
Crambe	Wheat	Barley				Dry Bean	Soybean	Sunflower			
Dry Bean	Canola	Sunflower				Crambe	Safflower	Soybean			
Dry Pea	Canola	Crambe	Dry Bean	Safflower	Sunflower	Dry Pea	Flax				
Flax	Dry Bean	Safflower	Sunflower	Wheat	Barley	Flax					
Safflower	Dry Pea					Crambe	Dry Bean	Safflower	Soybean	Sunflower	
Soybean	Dry Pea	Flax	Soybean			Canola	Wheat	Barley			
Sunflower	Crambe	Dry Bean	Flax	Soybean		Canola	Dry Pea	Sunflower	Wheat	Barley	
Wheat	Dry Pea	Barley				Wheat					
Barley	Canola	Crambe	Flax	Safflower	Soybean	Barley					

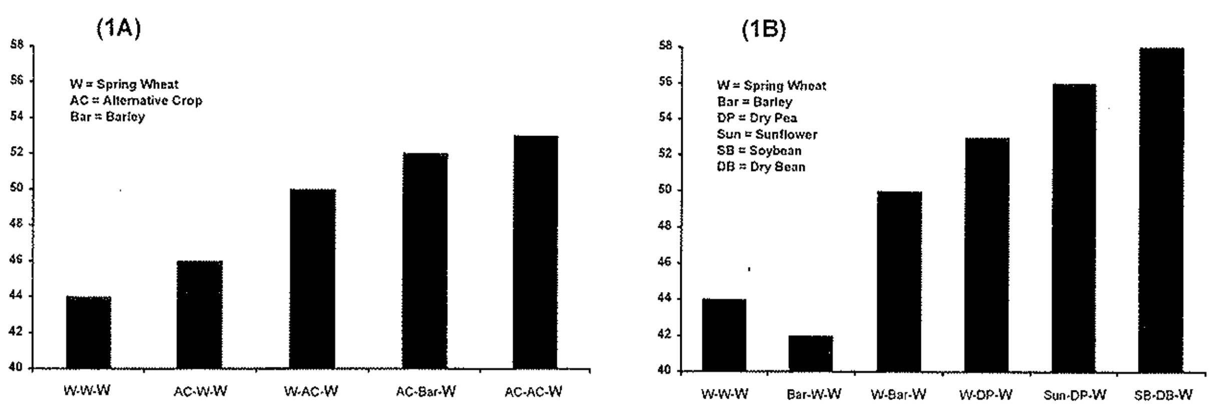


Figure 1. Spring wheat seed yield, indicated by bold letters, as influenced by crop sequence.

ECONOMICS AND CROP SEQUENCES

Dr. Dave Archer, USDA-ARS, Morris, MN

Economic returns in cropping systems are greatly affected not only by what crops are grown, but also the sequence in which they are grown. Economic returns for alternative crop sequences were estimated by multiplying observed yields in the cropping sequences study by the crop price and subtracting estimated production costs. Crop prices were estimated by the higher of a three-year average (1998-2000) of North Dakota season average prices and the 2001 commodity loan rate. Crop prices and estimated production costs for each crop are listed in Table 1. Production costs included herbicides and herbicide application costs, fertilizer costs, seed costs, and planting and harvesting costs. Herbicide costs were estimated based on the quantities of herbicides actually applied and using prices from the 2001 North Dakota Weed Control Guide. Seed costs were estimated from the planned seeding rates and using prices from Projected 2001 Crop Budgets South Central North Dakota. Planting, harvesting and herbicide application costs were estimated from Minnesota Farm Machinery Economic Cost Estimates for 2000.

An additional cost of $43.05 per acre was subtracted from the net returns for dry beans to reflect lost government support payments under the current farm program for planting a vegetable crop. This reduction reflects the loss in payments that would have occurred in 2000 if a producer lost one acre of wheat base payments with a proven yield of 35 bushels per acre for every acre of dry beans planted.

Crop production practices (and hence, crop production costs) were <u>not</u> adjusted for individual crops based on previous crop residues. As a result, effects of crop sequence on net returns through changes in herbicide and fertilizer use were not considered in this analysis.

Table 1. Crop Prices and Production Costs.

Crop	Crop Price ($/lb)	1999 Herbicide and Application Costs ($/ac)	2000 Herbicide and Application Costs ($/ac)	Seed Costs ($/ac)	Fertilizer, Planting, and Harvest Costs ($/ac)	Base Loss Cost ($/ac)*
Canola	$0.095	$22.01	$32.43	$13.75	$48.45	$0.00
Crambe	$0.090	$22.01	$22.58	$5.40	$48.45	$0.00
Dry Bean	$0.140	$43.32	$48.52	$25.00	$48.45	$43.05
Field Pea	$0.049	$22.01	$25.11	$24.00	$48.45	$0.00
Flax	$0.093	$30.49	$29.46	$5.25	$48.45	$0.00
Safflower	$0.122	$27.49	$28.37	$8.75	$48.45	$0.00
Soybean	$0.078	$48.80	$66.19	$16.80	$48.45	$0.00
Sunflower	$0.092	$39.82	$40.34	$13.20	$48.45	$0.00
Wheat	$0.049	$24.81	$30.95	$7.80	$48.45	$0.00
Barley	$0.035	$24.81	$30.95	$5.63	$48.45	$0.00

* Government payments that would have been lost in 2000 if an acre planted to dry beans resulted in a loss of one acre of wheat base with a proven yield of 35 bu/ac.

The average of the 1999 and 2000 net returns for each crop sequence are shown in Table 2. For 6 out of the 10 crops the lowest net returns occurred for crops grown on their own residue. For 3 of the 10 crops lowest net returns occurred on canola residue, mainly due to problems with volunteer canola in 2000 that could not be controlled. There was wide variation in net returns for each crop depending on crop sequence. The difference between the highest and lowest net returns for each crop indicates the potential cost of making cropping decision without considering the effect of crop sequence (Figure 1). For dry beans, net returns differed by as much as $105 per acre depending whether they were planted on wheat residue or crambe residue. Wheat had the highest average net returns on each of the crop residues except field peas and wheat. Crambe had the highest net returns on field pea residue. Dry beans had the highest net returns on wheat residue.

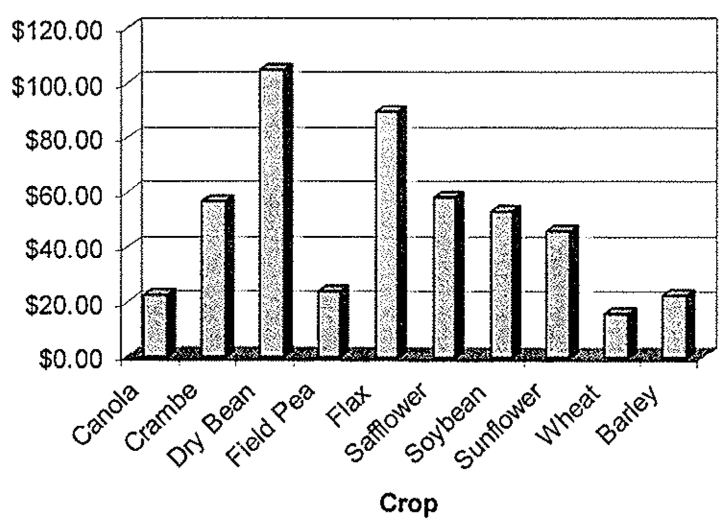
Crop

Crop Residue	Canola	Crambe	Dry Bean	Field Pea	Flax	Safflower	Soybean	Sunflower	Wheat	Barley
Canola	***$26.96***	***$9.96***	($21.89)	***$28.38***	$38.27	$10.07	$33.93	$18.26	$75.74	$51.91
Crambe	$34.19	$46.65	***($40.54)***	$35.40	$41.64	$18.32	$10.25	$13.78	$73.52	**$65.61**
Dry Bean	**$49.17**	$32.44	$15.86	$43.01	$48.67	$17.45	$25.19	$36.21	$73.59	$50.18
Field Pea	$47.04	**$66.79**	$32.39	$31.59	$38.19	$43.46	$30.86	**$42.41**	$66.33	$57.27
Flax	$45.51	$56.80	$28.24	$42.22	***($24.90)***	$44.60	$35.08	$34.20	**$77.71**	$60.33
Safflower	$37.93	$30.50	$50.34	$44.40	$51.29	***($10.95)***	***$7.84***	($2.98)	$71.22	$54.83
Soybean	$27.25	$44.12	$34.60	$45.41	**$64.78**	$20.93	**$60.81**	$16.70	$65.98	$49.04
Sunflower	$37.51	$65.26	$54.76	$33.39	$57.49	$26.68	$50.37	***($3.39)***	$68.94	$53.21
Wheat	$37.59	$54.23	**$64.04**	**$52.24**	$49.96	$42.70	$23.76	$21.87	***$61.82***	$60.01
Barley	$47.64	$66.03	($3.06)	$40.61	$56.66	**$47.53**	$41.80	$28.20	$70.08	***$42.85***

Table 2. Net Returns to Land and Management ($/acre) for Alternative Crop Sequences.

Bold, Underline = Highest average net returns for each crop
Bold, Italics = Lowest average net returns for each crop

Figure 1. Potential Cost of Ignoring Crop Sequence Effects ($/acre).



PLANT DISEASES AND CROP SEQUENCES

Dr. Joe Krupinsky

With the adoption of reduced tillage practices annual cropping becomes a viable option for producers. Diversification of cereal cropping systems with oilseeds, pulses, and forages presents the producer with a range of options. Crop diversification also improves management of plant diseases through crop selection and interruption of disease cycles through crop rotation. The influence of the previous crop and crop residues on plant diseases needs to be more fully understood in order to develop effective crop sequences for cropping systems that minimize risk for plant diseases. The objective of this study was to determine the effect of previous crops on Sclerotinia diseases (white mold) on canola, crambe, safflower and sunflower, and leaf spot diseases on spring wheat and barley.

A crop X crop residue matrix (Figure 5, page 6) formed with ten crops (barley, canola, crambe, dry bean, dry pea, flax, safflower, soybean, oil seed sunflower, and wheat) was evaluated for plant diseases for two consecutive years, 1999 and 2000. Safflower was rated for Sclerotinia head blight incidence using the presence of sclerotia under the necrotic head to confirm the disease. Canola and crambe plants with bleached (white) stems, were rated positive for Sclerotinia. Wheat and barley were evaluated for leaf spot diseases. The total percentage of necrosis and chlorosis was visually assessed for individual leaves and used as an indicator of the severity of leaf spot diseases. Twenty leaves of the same leaf type (e.g., flagleaf) from plants at the same stage of plant development were collected from each plot for each evaluation. The wheat crop was evaluated 14 times in 1999 and 8 times in 2000. The barley crop was evaluated 11 times in 1999 and 4 times in 2000.

A crop X crop residue matrix is a good tool for evaluating the effect of crop sequences on crop diseases. A good example of high disease severity when a crop is seeded for two consecutive years was flax seeded after flax (Figure 2). Sclerotinia head blight on safflower ranged from 0% to 3% in 1999 and from 0% to 2% in 2000, with the highest level following crambe. With canola, sclerotinia stem rot ranged from 0% to 6% in 1999 and from 1% to 5% in 2000. With crambe, sclerotinia stem rot ranged from 2% to 15% in 1999 and from 10% to 60% in 2000. The higher levels of sclerotinia on canola and crambe followed safflower (Data in last year's report and Crop Sequence Calculator, v.2). No Sclerotinia infected sunflower plants were identified in 1999 and very few (0.01%) in 2000.

With early evaluations (FL-2 & FL-3), leaf spot diseases on wheat and barley were more severe following a wheat and barley crop, respectively, compared with the other nine crops (Figure 3) but not later in the season (Crop Sequence Calculator, v. 2). Crop sequences need to be considered when minimizing disease risk.

Producers should not rely exclusively on a single management practice to minimize disease risk but rather integrate a combination of practices to develop a consistent long-term strategy for disease management that is suited to their production system and location. For example, plant disease risks can be lowered through crop and cultivar selection, crop sequence/crop rotation, fungicide application, seeding rate and seeding date, balanced fertility, control of weeds and volunteer crop plants, and modification of the micro-environment within the crop canopy using tillage practices and stand density (Krupinsky, J.M., Bailey, K.L., McMullen, M.P., Gossen, B.D., and Turkington, T.K. 2002. Managing plant disease risk with diversified cropping systems. Agron. J. March/April 2002)

Figure 2. High disease with flax on flax.

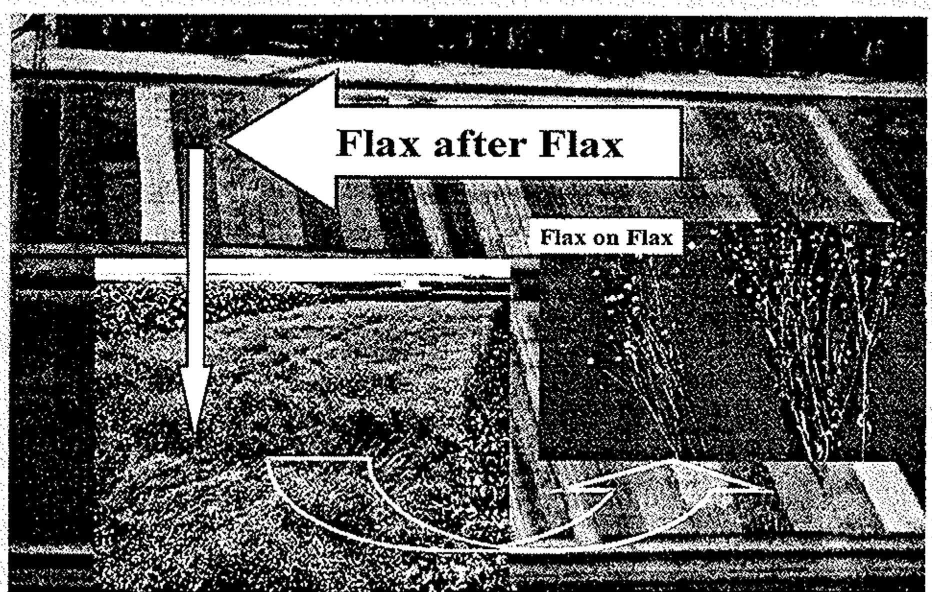
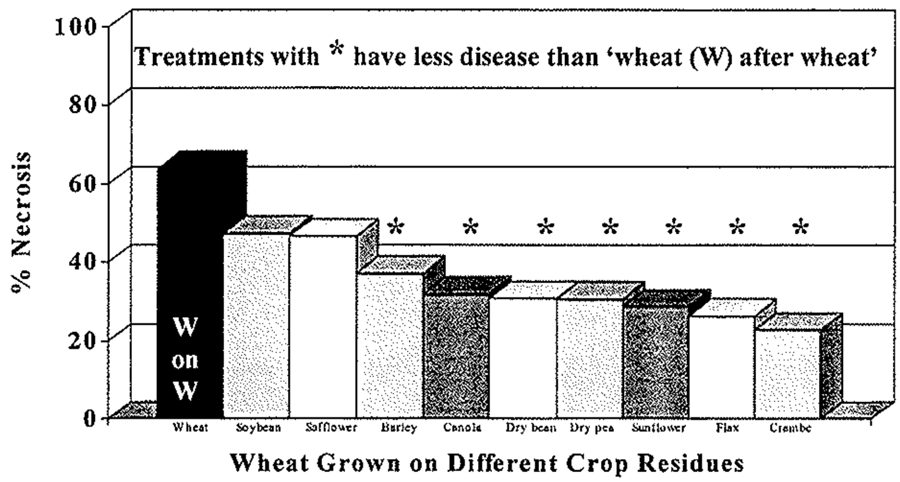


Figure 3. Leaf spot disease on Wheat (FL-2).
July 6, 2000 rating



Crop Sequence Calculator, v.2, Cropping Systems, NGPRL-ARS-USDA, Mandan, ND

ACKNOWLEDGMENTS

We thank D. Wetch, J. Hartel, C. Flakker, M. Hatzenbuhler, D. Schlenker, C. Klein, J. Bullinger, M. Tokach, and L. Renner for technical assistance.

SHORT-TERM EFFECTS OF CROP SEQUENCES ON SOIL PROPERTIES

Dr. Mark Liebig

Decreasing commodity prices for cereal-base crops have resulted in greater crop diversification in the Northern Great Plains. Understanding crop effects on the soil resource is essential to develop sustainable cropping systems. Crop effects on near-surface properties, in particular, are vitally important given the impact the soil surface has on erosion control, water infiltration, and nutrient conservation.

A short-term crop sequence experiment was established near Mandan, ND in 1998 on a Wilton silt loam (fine-silty, mixed, superactive frigid Pachic Haplustoll). The experiment consisted of 10 crops (barley, wheat, crambe, canola, sunflower, safflower, flax, dry pea, dry bean, and soybean) seeded into the residue of the same 10 crops under no-till management. To investigate short-term effects of individual crops on soil properties, soil samples were collected in the spring of 2000 and 2001 from plots where the same crop was previously planted in consecutive years (e.g., canola-canola, crambe-crambe, etc.). Samples were analyzed for physical, chemical, and biological properties considered sensitive to short-term changes in management.

Soil properties influenced by crop in a short-term crop sequence experiment under no-till management near Mandan, ND. Data is for the 0-7.5 cm depth and specific to plots where the same crop was planted in consecutive years.

				----- 1-2 mm fraction -----	
Crop	Soil NO_3-N ($kg\ ha^{-1}$)	Soil pH	Microbial biomass C ($kg\ ha^{-1}$)	Total glomalin ($mg\ g^{-1}$)	Easily extractable glomalin ($mg\ g^{-1}$)
Spring wheat	6.4	6.18	514	3.41	0.57
Barley	5.6	6.00	472	4.22	0.75
Canola	5.9	6.13	619	3.38	0.64
Crambe	7.8	6.40	518	3.98	0.69
Flax	6.6	6.12	561	4.26	0.69
Sunflower	5.7	6.22	730	4.16	0.65
Safflower	5.1	6.10	439	4.12	0.69
Dry pea	10.1	5.88	396	3.63	0.61
Dry bean	6.5	6.04	486	3.35	0.63
Soybean	5.6	6.08	604	3.42	0.63
LSD (0.1)†	2.3	0.24	177	0.62	0.05

† LSD = Least significant difference. Numbers in a column differing by more than the LSD value are considered significantly different at P<0.1.

Results from this experiment show:

- Few properties were affected by crop over a two-year period. Properties not affected included aggregate stability, potentially mineralizable nitrogen, identifiable plant material, and particulate organic matter.
- Dry pea tended to enhance soil NO_3-N levels in comparison to other crops, but resulted in the lowest soil pH.
- Microbial biomass C was greatest in sunflower, and lowest in dry pea.
- Total glomalin – a glycoprotein produced by arbuscular mycorrhizal fungi that holds soil particles together, thereby increasing aggregate stability (Wright and Upadhyaha, 1996) – was greatest in flax, barley, sunflower, and safflower, and lowest in dry bean, spring wheat, and soybean. Easily extractable glomalin, representative of recently deposited glomalin, was greatest in barley and lowest in spring wheat.
- When crops were grouped by crop type (grass, mustard, taproot, linum, and legume), total glomalin was 23% higher in linum (flax) than legume (dry pea, dry bean, soybean). No other differences in soil properties were observed among crop types (data not shown).

Given the short-time frame of the experiment, few of the measured soil properties were affected by crop. This result underscores the importance of evaluating crops in long-term experiments to ensure trends in soil properties are constant and not ephemeral. Continuous cropping of some crops can lead to disease build-up in soil and significant weed pressure resulting in reduced crop yields. Consequently, crop effects on soil condition may be better evaluated in rotation.

While trends in a few soil properties were observed in this study, caution should be exercised when projecting crop effects over the long-term. This is especially true for properties affected by crop but not related to parameters known to affect agroecosystem functions (e.g., glomalin was affected by crop, but not correlated with aggregate stability).

SOIL WATER AND CROP SEQUENCE – SNOW CAPTURE AND SPRING SOIL WATER

Dr. Steve Merrill

In last year's Annual Progress Report, it was reported that full season soil water depletion values in 1999 and 2000 were greatest for the oilseed crops safflower and sunflower. Dry pea was reported to have depleted the least amount of water, and barley and crambe were the next lowest depleters of water on average. The relative pattern of soil water depletions observed in 1999 and 2000 was similar to the results with crop water use. Crop water use is defined as soil water depletion plus growing season precipitation.

During the growing season there is a net depletion of soil water by crops in our semiarid/ subhumid region. During the fall and winter, and early spring, there is a net recharge of soil water. Snow capture by crop residues and subsequent snowmelt is an important process. The amount of snow held varies considerably from year to year and among crop types, with no-tillage greatly enhancing snow capture. When snow depths were measured in Feb. 2001, residues of legume pulse crops soybean, dry bean, and dry pea were observed to hold less snow than the other crops because of relative lack of standing crop residue (see Fig. A). When soil water in the profile was measured after snowmelt in April 2001, the amounts of water were greater than amounts measured in fall 2000 (see Fig. B). Differences caused by different water usages by the crops over the 2000 season persisted in the spring-measured amounts. The oilseed crops sunflower and safflower had the lowest amounts of soil water. The greatest amount of soil water was measured in dry pea, which had 3.5 inches more water than sunflower. Residual effects of seasonal soil water use cannot be overcome by snow capture, especially for the more heavy water-using crops such as sunflower.

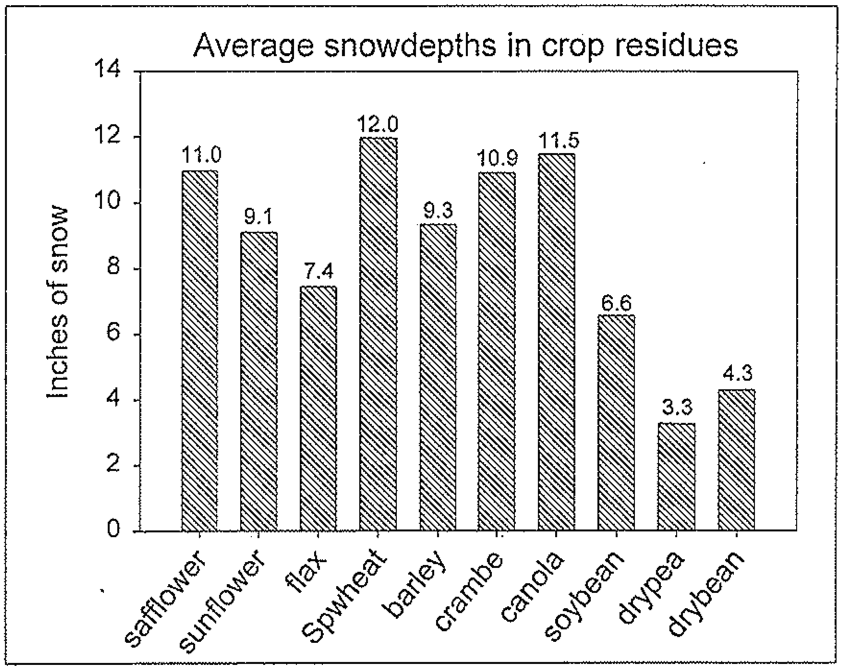


Fig. A. Average depths of snow measured in crop residues in Feb. 2001 in plots of the Crop Sequence Experiment.

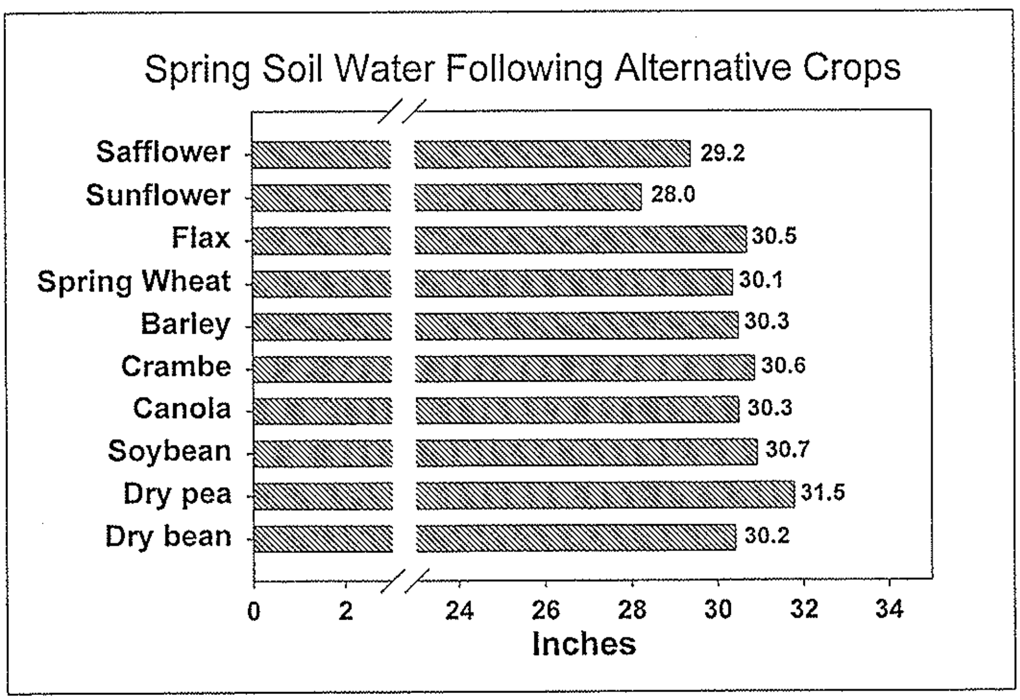


Fig. B. Soil water measured in April 2001 in stubble of alternative crops that had followed spring wheat. A neutron moisture meter was used for measurements to a depth of 8 feet.

CROP SEQUENCES - SOIL AREA COVERED BY CROP RESIDUES

Dr. Steve Merrill

Soil surface area covered by crop residues is important for conserving soil water from evaporative loses and for protecting the soil from wind and water erosion hazards. Soil area coverage values were measured immediately after spring seeding following two previous seasons of spring wheat – alternative crop sequences (Figs. A and B). Percent of soil coverage values were over 50%, reflecting the generally good residue conservation achieved in no-till systems. The lowest values on average were measured when the spring wheat was followed by legume pulse crops or sunflower.

One of the most important soil sustainability problems in diverse cropping systems occurs when lower residue crops are grown back-to-back (see Fig. C). The somewhat higher soil area coverage levels of spring wheat followed by lower residue-covering crops were compared to the lower soil area coverage levels generated by back-to-back sequences of lower residue-covering crops. The lowest value shown in Fig. C for the sunflower/sunflower sequence was over 30%, which was a somewhat marginal level of soil protection. However, these results were observed under conditions of average to above average precipitation levels. Drought conditions coupled with back-to-back sequences of lower residue-covering crops will generate unacceptably low levels of soil surface area protected by residue. Crop growth is attenuated under drought and significant wind erosion hazard can and will occur, even under the type of strict no-till management such as was used in our crop sequence study.

Soil Cover by Crop Residue
Spring 2000 after alternative crop in 1999 and spring wheat in 1998

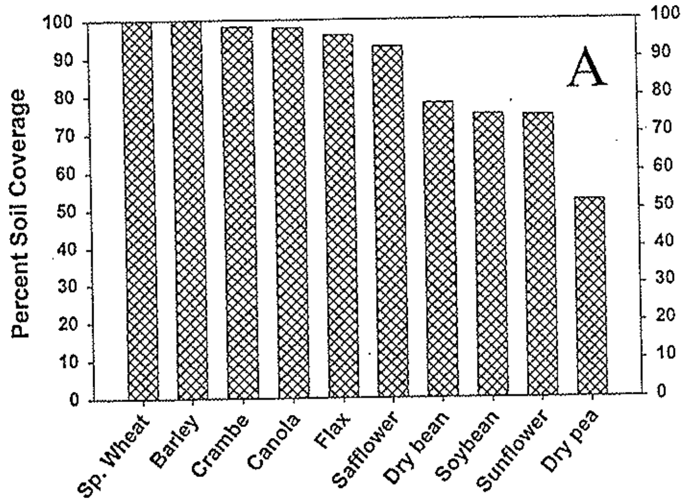
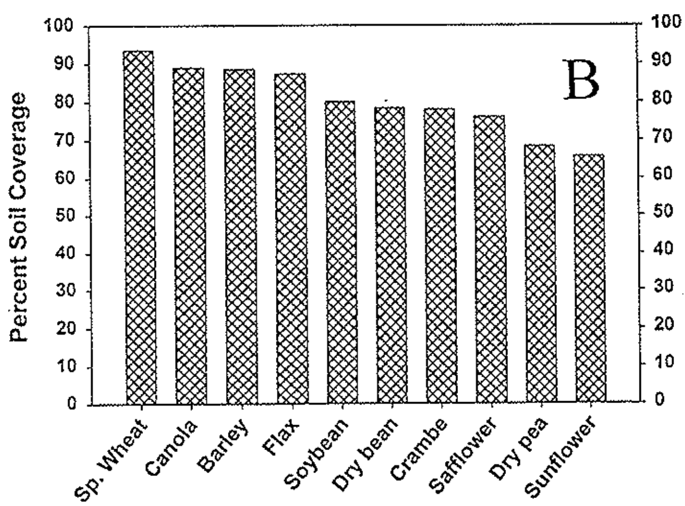


Fig. A. Percentage of soil area covered by crop residues measured in May, 2000 by transect method in residues of the indicated crops following sequences of spring wheat – alternative crops. Measurements were done after seeding spring wheat.

Fig. B. As in Fig. A but with measurements being taken in May 2001.

Fig. C. As in Fig. A but with measurements taken in spring 2001 after spring wheat seeding. Crop sequences included both spring wheat – alternative crop and alternative crop – alternative crop sequences.

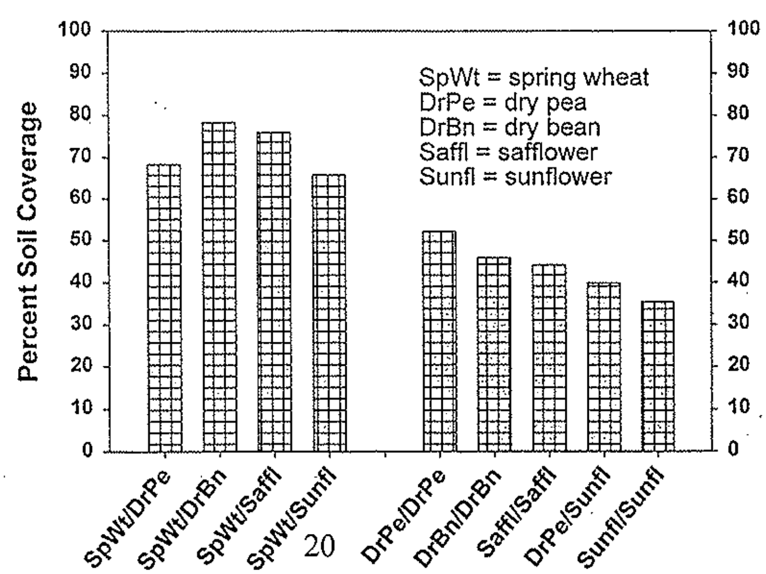
Soil Cover by Crop Residue:
Spring 2001 after alternative crop in 2000 and spring wheat in 1999



Soil cover by crop residue measured in spring 2001:
crops on left were spring wheat - alternative crop in 1999 - 2000,
crops on right were alternative crop - alternative crop in 1999 - 2000.

C

Crops that generate more fragile and less covering residues can result in relatively low levels of soil cover if such crops are grown back-to-back. Drought can and will make this worse.



ADDITIONAL RESEARCH ON AREA IV SCD/ARS FARM

Evaluation of Warm Season Crops for Crop Sequence Project, Phase III
Dr. Donald Tanaka

Corn was seeded on 15 May at 23,500 viable seeds/acre using no-till techniques. Nitrogen at 70 lb/a was broadcast on 25 March. Seed yield ranged from 129 bu/a to 76 bu/a (Figure 1). In general, seed yield and seed water concentration increased with longer maturity varieties. Chickpea and lentil were no-till seeded on 16 May at 230,000 viable seeds/a for chickpea and 1.0 million viable seeds/a for lentil. At seeding, 30 lb N/a and 10 lb P/a were banded. On 2 July and again on 17 July, Quadris was applied to chickpea and lentil to control disease. Chickpea seed yield ranged from 1620 to 1360 lb/a and test weight ranged from 57.1 to 56.2 lb/bu. Lentil seed yield was similar for both varieties but test weight ranged from 63.8 to 62.0 lb/bu. Buckwheat and millet were no-till seeded on 21 June at 60 lb/a for buckwheat and 1.3 million viable seeds/a for millet. Buckwheat seed yield ranged from 2120 to 1370 lb/a and test weight ranged from 50.3 to 47.2 lb/bu. Millet seed yield ranged from 2250 to 1750 lb/a with no difference in test weight.

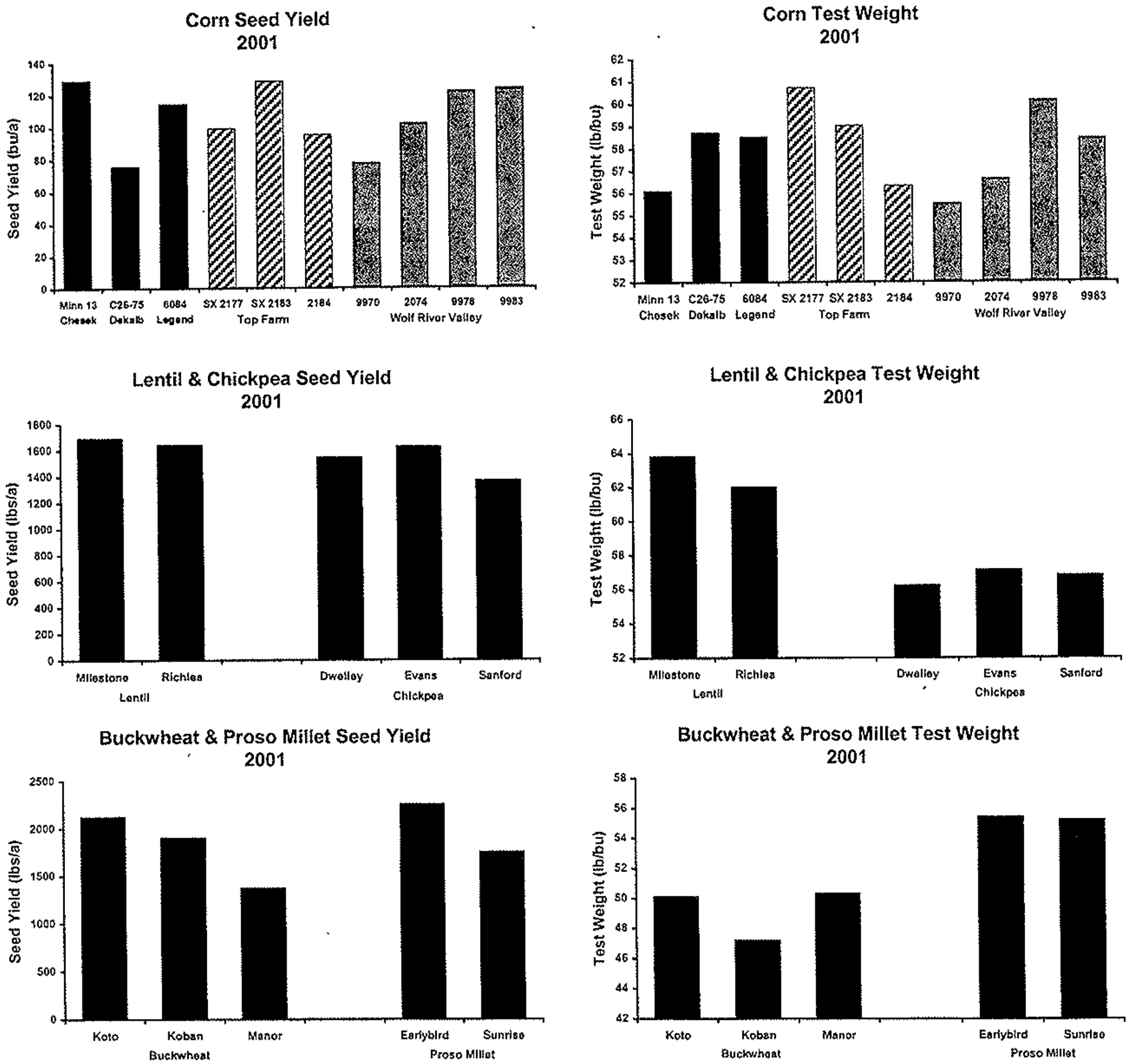


Figure 1. Seed yield and test weight for corn, lentil, chickpea, buckwheat, and proso millet.

CROP SEQUENCE, TILLAGE, AND NITROGEN FERTILIZATION EFFECTS ON SOIL pH OVER 16-YEARS

Drs. Mark Liebig and Donald Tanaka

Decreases in soil pH in agricultural soils can affect plant nutrient availability and crop yield. For soils possessing high levels of calcareous minerals, such as those found throughout much of the Northern Great Plains, decreases in soil pH could also enhance C loss to the atmosphere due to acidification of $CaCO_3$. We evaluated changes in soil pH over a 16 yr period for a long-term cropping systems experiment established on calcareous parent material near Mandan, ND. Management variables included in the experiment were crop sequence [spring wheat-fallow (SW-F) and spring wheat-winter wheat-sunflower (SW-WW-SF)], tillage (conventional, minimum, no-till), and N fertilization (0, 22, and 45 kg N ha^{-1} for SW-F and 34, 67, and 101 kg N ha^{-1} for SW-WW-SF). Management effects on soil pH were modest over the 16 yr period. Nitrogen fertilization resulted in acidification, with decreases in soil pH greatest in the HIGH N treatment (-0.67), followed by the MED (-0.33) and LOW (-0.15) N treatments. While acidification did occur, it was limited to the surface 7.6 cm where pH values were less than 7.2. Consequently, C loss by acidification of $CaCO_3$ was highly unlikely in this long-term cropping systems experiment. Below 15.2 cm, soil pH increased over the 16 yr period. The exact mechanism for the increase is unknown, though may be the result cations leaching from the acidified 0-7.6 cm depth to lower depths. Evaluation of exchangeable cations levels is necessary to better understand the observed trends in soil pH over depths.

MANAGEMENT STRATEGIES FOR SOIL QUALITY

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

Influences of residue management and crop rotations on soil quality are being evaluated in a long-term study. Treatments for the 2001 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)

Samples from the 2001 growing season are being processed.

MINIMUM-TILL CANOLA PRODUCTION, 2001

Drs. Donald Tanaka and Joe Krupinsky

Minimum-till canola was seeded on 3 May and 4 May 2001 to evaluate agronomic traits of each cultivar. Cultivars Dynamite, Hudson, Croplan 601, Invigor 2573, and Invigor 2663 were seeded at 1.0 million seeds per acre to achieve at least 500,000 plants at harvest. Cultivars Gladiator, Hyola 357, and Hyola 401 were seeded at 5 lb/a. Sonalan at 1.1 lb a.i./a was applied two weeks prior to seeding and incorporated with an undercutter. Seed yield ranged from 1113 to 419 lb/a (Figure 1) with test weights ranging from 53.7 to 50.4 lb/bu (Figure 2). All cultivars had good plant stands and vegetative growth, but environmental conditions must not have been conducive for seed production.

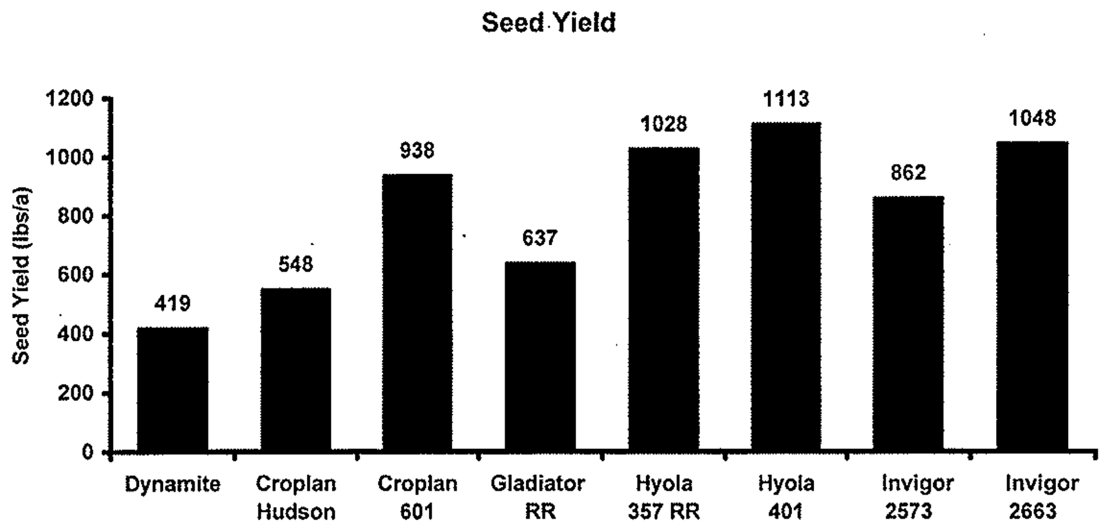


Figure 1. Average seed yield for canola grown in 2001.

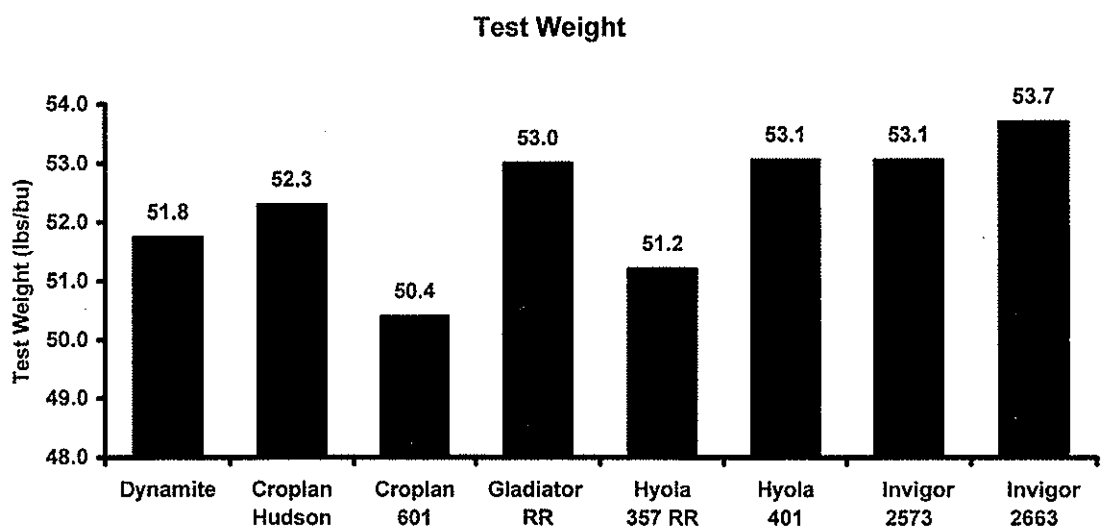


Figure 2. Average test weight for canola grown in 2001.

CROP SEQUENCING TO IMPROVE WEED MANAGEMENT

Drs. John Hendrickson and Randy Anderson

Research at ARS locations in Akron Colorado and Mandan, North Dakota suggest that a crop's season of growth as well as other biological traits may be valuable in improving weed management. Using crops with alternative life cycles may provide the biggest impact in controlling weeds. Research in Colorado shows that rotating winter wheat with summer crops such as corn can help in controlling weeds. Many weeds are associated with certain crops and sequencing crops with different planting dates such as peas and sunflowers may aid in controlling these weeds. Selecting cultivars with denser canopies can shade out weeds, whereas sequencing crops with different row spacings can either establish a canopy quicker or allow cultivation to control weeds. Finally, if possible, delaying planting may allow weeds a chance to emerge and be controlled. Future research at the Northern Great Plains Research Lab will evaluate these cultural practices and possibly incorporate them into a decision aid to assist producers in designing crop sequences.

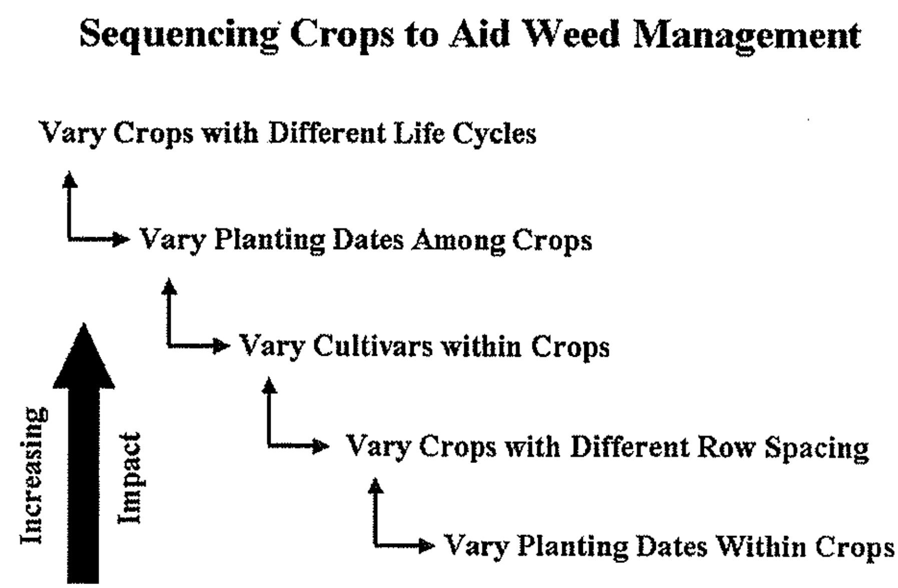


Diagram illustrating the potential impact of several suggested cultural techniques on weed control.

SCLEROTINIA DISEASE AND BIOLOGICAL CONTROL

Drs. Joe Krupinsky and Donald Tanaka

The fungus, *Sclerotinia sclerotiorum*, has a wide host range causing wilt and rot Sclerotinia disease on broadleaf crops and weeds. Sclerotinia disease is reported worldwide and can cause serious yield and quality losses on broadleaf crops. Sclerotinia has the ability to produce sclerotia, which are hard fungal bodies that may survive for at least 3-5 years in the soil. Thus, the fungus can pose a disease risk for a number of years. This project will evaluate the efficiency of a fungus, *Coniothyrium minitans*, to act as a biological control agent to reduce the impact of sclerotinia disease under field conditions in the Northern Great Plains area. *Coniothyrium minitans* reduces the carryover of sclerotinia disease by attacking and destroying sclerotia of *S. sclerotiorum*. If effective, the use of this biological control agent will provide producers with a management practice that can be used to reduce disease risks.

CROP PRODUCTION ON POST-CRP LAND

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

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). Data is being analyzed for publication.

2001 Barley	Mandan

Variety	Plant Height	Test Weight	Protein	Grain Yield
	inches	lbs/bu	%	bu/ac
Conlon	32	50.3	12.3	104.9
Robust	37	47.9	12.4	85.8
Stark	31	51.2	12.5	72.2
Trial Mean	33	49.8	12.4	87.6
C.V. %	4.6	0.7	--	5.9
LSD .05	3	0.8	--	11.8
LSD .01	NS	1.3	--	19.6

Planting Date: April 24, 2001
Harvest Date: August 9, 2001
Seeding rate: 750,000 live seeds/A (approx. 1.4 bu/A).
Previous Crop: Barley.
NS = no statistical difference between varieties.

2001 Durum Wheat - Continuously Cropped No-till	Mandan

				-------- Grain Yield --------			Average Yield	
Variety	Plant Height	Test Weight	Protein	1999	2000	2001	2 year	3 year
	inches	lbs/bu	%	----------bu/ac----------				
Mountrail	36	58.1	13.8	60.5	66.1	50.3	58.2	59.0
Ben	38	59.0	14.5	59.0	62.0	43.8	52.9	54.9
Lebsock	36	59.7	14.0	55.0	66.4	43.1	54.8	54.8
Maier	33	55.7	15.4	51.9	63.5	37.3	50.4	50.9
Plaza	28	56.0	14.0	45.3	42.2	42.4	42.3	43.3
Pierce	37	59.1	13.7			43.4		
Trial Mean	35	57.9	14.2	54.4	61.3	43.4	--	--
C.V. %	3.5	1.4	--	8.9	14.4	6.9	--	--
LSD .05	2	1.5	--	8.6	13.2	5.4	--	--
LSD .01	3	2.1	--	NS	18.1	7.7	--	--

Planting Date: April 24, 2001
Harvest Date: August 9, 2001
Seeding rate: 1.25 million live seeds/A (approx. 2.2 bu/A).
Previous Crop: 1999 = HRSW, 2000 = rye, 2001 = barley.
NS = no statistical difference between varieties.

2001 Hard Red Spring Wheat - Continuously Cropped No-till	Mandan

Variety	Plant Height	Test Weight	Protein	-------- Grain Yield -------- 1999	2000	2001	Average Yield 2 year	3 year
	inches	lbs/bu	%	---------------------bu/ac---------------------				
Reeder	33	59.4	14.6	46.9	60.3	48.6	54.4	51.9
Parshall	38	61.3	14.2	42.9	54.1	45.6	49.8	47.5
Oxen	31	57.8	14.1	36.0	59.1	45.0	52.0	46.7
Keene	39	59.5	14.8	39.8	48.6	40.6	44.6	43.0
Norpro	31	58.2	14.0		57.4	49.6	53.5	
Ivan	30	59.5	13.8		59.7	46.7	53.2	
Ingot	36	63.0	14.7		48.9	45.6	47.2	
Ember	31	60.6	13.5		50.9	43.2	47.0	
Alsen	32	60.2	15.1		50.2	42.9	46.6	
Mercury	29	59.3	13.3			52.3		
Walworth	34	58.4	15.0			47.2		
Trial Mean	34	59.8	14.4	39.3	52.7	45.9	--	--
C.V. %	3.3	1.0	--	12.5	9.5	8.3	--	--
LSD .05	2	1.0	--	8.3	7.2	6.4	--	--
LSD .01	3	1.4	--	11.3	9.6	8.7	--	--

Planting Date: April 24, 2001
Harvest Date: August 9, 2001
Seeding rate: 1.1 million live seeds/A (approx. 1.6 bu/A).
Previous Crop: 1999 = HRSW, 2000 = rye, 2001 = barley.

2001 Oats - Continuously Cropped No-till **Mandan**

Variety	Plant Height	Test Weight	Grain Yield 1999	Grain Yield 2000	Grain Yield 2001	Average Yield 2 year	Average Yield 3 year
	inches	lbs/bu	bu/ac				
Ebeltoft	40	36.1	99.2	110.2	84.1	97.2	97.8
Youngs	40	34.5	84.1	110.0	97.8	103.9	97.3
Jud	38	35.1	91.0	97.0	81.3	89.2	89.8
Jerry	39	33.6	58.7	89.4	90.9	90.2	79.7
Killdeer	42	35.5		121.1	89.2	105.2	
HiFi	35	33.3			98.9		
Morton	39	35.3			82.2		
Trial Mean	39	34.8	76.3	98.8	89.2	--	--
C.V. %	7.9	2.7	5.9	10.4	20.8	--	--
LSD .05	NS	1.6	8.3	15.2	NS	--	--

Planting Date: April 24, 2001
Harvest Date: August 9, 2001
Seeding rate: 750,000 live seeds/A (approx. 1.7 bu/A).
Previous Crop: 1999 = HRSW, 2000 = rye, 2001 = barley.
NS = no statistical difference between varieties.

Site-Specific Farming in Western North Dakota – 2001

Vern Hofman, Extension Agricultural Engineer
Dr. Dave Franzen, Extension Soil Scientist
Lowell Disrud, Agricultural Engineer
NDSU

<u>Introduction</u>. The site-specific farming project has continued on the I 4, 5 and 6 fields for the past several years. This has been a cooperative demonstration project between NDSU, Area IV SCD, and USDA-ARS at Mandan. Intensive soil sampling, variable fertilizer application, yield monitoring and crop cost analysis have been the main emphasis areas up to the present time. Some important findings over the years are as follows.

a. Soil sampling based on topographic zones provides soil fertility levels similar to intensive grid sampling. Zone sampling requires fewer samples, which is more economical and identifies variability.

b. Profitability of variable fertilizer application has been erratic. Some years variable fertilizer application has shown a profitable return while in other years, it has not. For profitable fertilizer application, residual N fertilizer needs to vary by more than 30 lbs/ac. This needs to occur on a large area or you won't be able to make it pay.

c. Variable fertilizer application is excellent for the environment. This study has found less residual soil N from variable application as compared to uniform application. Less N in the soil will reduce the potential for polluting above and below ground water supplies. Variable application allows a producer to apply fertilizer based on the crop production capabilities of the soil.

d. This demonstration has shown that sunflower does an excellent job of removing soil N from the two to four foot soil depths. The sunflower tap root is able to pull soil N from lower depths to reduce the potential of N moving down to underground water supplies. This study has found that sunflower will have 15-20 lbs/ac less N in the soil than after a wheat crop is grown. A rotation with a tap root crop is excellent for retrieving N from the 2 to 4 ft. soil depths.

e. Yield monitoring is an excellent means of determining crop variability. It gives the producer a chance to see how production practices affect crop yield. Yield monitoring with a GPS receiver is probably the first thing a producer should do when starting site-specific farming.

<u>Year 2001</u>. This year produced a variation in crop yields. Winter wheat yields were 16.5 bu/ac, while the spring wheat yields were about 50 bu/ac, and the sunflower yielded 1,816 lbs/ac. Winter wheat yields were low due to significant winter kill. Yield income, costs and returns/acre are:

Table 1. Crop Production and Costs.

		Average Yield/Acre	Average Income/Acre	Estimated Cost/Acre	Average Return/Acre
I4	Winter Wheat	16.5 bu/ac	$46.36/ac	$100/ac	-$53.64/ac
I5	Sunflower	1,816 lb/ac	$219.37/ac	$130/ac	$89.37/ac
I6	Spring Wheat	50 bu/ac	$146.50/ac	$100/ac	$46.50/ac

Two of the three crops are showing good yields Figure 1. The winter wheat (I4) yields varied from zero to over 40 bu/ac. Large areas were near zero due to winter kill. Fertilizer was applied to the winter wheat at 125 lbs/ac of N spread uniformly across the field. Soil tests after harvest show a good portion of the field contains over 100 lbs/ac of N with the majority of that at the 24 to 48 inch level Figure 2. The crop used an average of about 40 lbs/ac. Sunflower is planned for this field in 2002, which should be able to reach the N and use it for crop production. Fertilizer expense for the 2002 season should be small, but starter fertilizer will be applied at planting time. If wheat were planted on this field in 2002, the N would not be retrieved due to the shallow root system.

The I5 field (sunflower) had fertilizer variably applied in the spring of 2001. An average rate of about 60 lbs/ac of N was applied, with some areas receiving over 100 lbs/ac and other areas receiving less than 50 lbs/ac. The soil tests taken after harvest found the majority of the field had an average amount of N less than 30 lbs/ac Figure 2. The variable application and the taproot of the sunflower did an excellent job of removing the N to a uniform low level.

The I6 field (spring wheat) had 125 lbs/ac of N applied in the spring of 2001. The soil tests completed after harvest show a uniform low level of N at less than 30 lbs/ac Figure 2. The 50 bu/ac wheat crop removed about 125 lbs/ac or all of the applied N.

Dave Franzen measured the electroconductivity of the soil with the use of a Varius EC meter. This gives an indication of the dissolved salt content of the soil. This was done on the I fields of the site-specific project. EC analysis is in the beginning stages as study is needed to determine the relationship of this information to other data collected.

Another new aspect of this project is remote sensing or aerial photography. About two years ago, a commercial pilot was hired to take photos of the I fields during the growing season. Excellent pictures were obtained, but were expensive. This past year, a remote-controlled (RC) airplane was obtained and equipped with a camera so we could take more pictures during the growing season at less cost. A digital camera was installed in the airplane, so as soon as the plane landed the pictures could be downloaded to a computer for viewing. The first pictures were taken with a 1.3 megapixel camera, which was found to be too low in resolution. Next, a 2.1 megapixel camera was used, which did much better. The next problem we found was matching up the pictures so a complete composite of the field could be made. This is being studied and improved for the next growing season. We plan to install a GPS receiver in the airplane, and with special software we can match up the time a picture is taken with the camera to the time recorded in the GPS tracking system. With coordinates, we should be able to align the pictures in a computer to produce a complete image of the field.

We also are looking at installing a video camera with a remote-monitor so we can see what the digital camera is taking a picture of when in the air. This will help determine if the picture taken is inside the field, eliminating the pictures that may be on the edge of the field. We also plan to place some large markers on the edges of the field, which will help identify where the pictures are obtained.

Also, this year ARS staff took pictures out the window of an airplane. These pictures are excellent, but are distorted due to the angle the picture was taken. A much better picture can be taken through the bottom of the airplane. This is usually more expensive and time consuming. The remote-controlled airplane may be an economical alternative and more pictures can be taken by a producer and help keep the cost low. It is planned to study these pictures and correlate the images to the yield maps. This may help us monitor the crop during the growing season so changes can be made quickly and improve production.

Figure 1.
2001 Crop Yield Maps

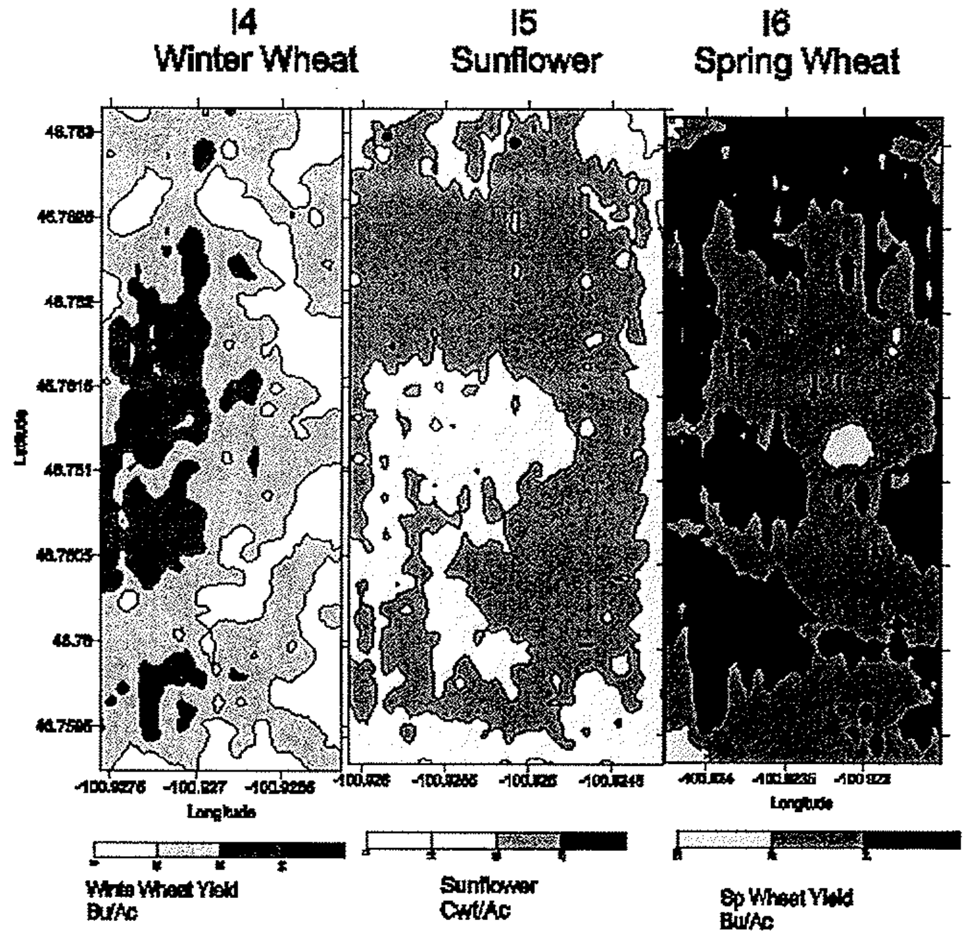
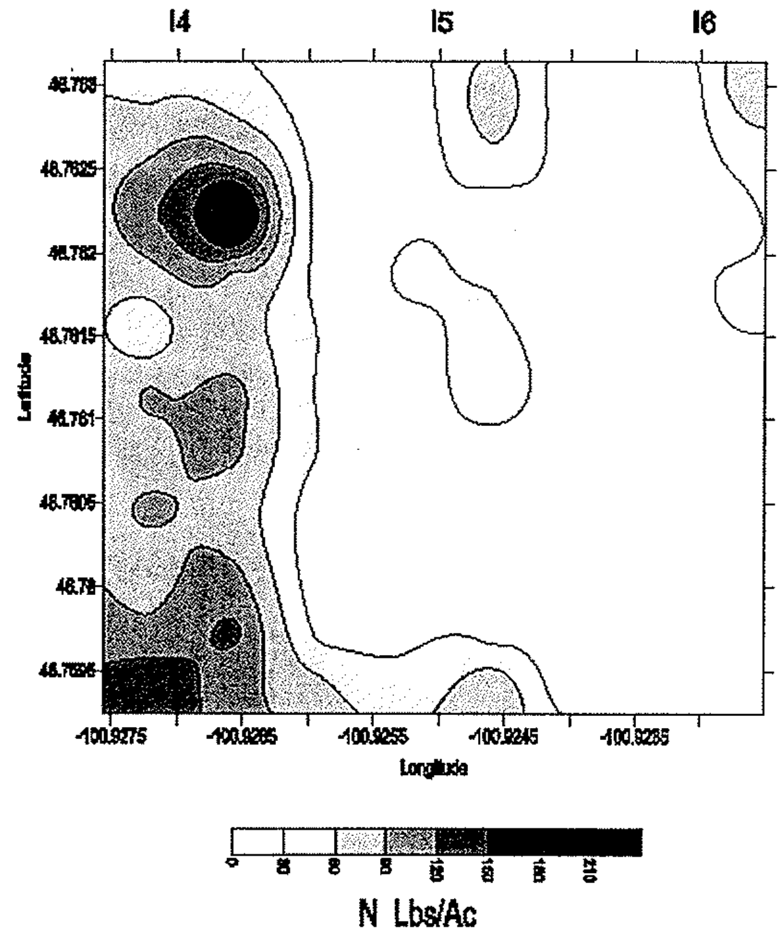


Figure 2.
Residual Soil Nitrogen
Fall 2001



MANAGEMENT PRACTICES, 2001
AREA IV SCD/ARS RESEARCH FARM

Field F-2, Parshall spring wheat, (Figure 2, page 4)

5/2/01 The JD MulchMaster was used to breakdown the sunflower stalks from 2000.

5/3/01 Parshall spring wheat was seeded with the Haybuster 107 disk drill (7-inch row spacing) at a rate of 1.3 million seeds/a. 70 lb N/a (urea) and 50 lb/a of 11-52-00 were applied at seeding.

6/13/01 Contract sprayed the field with Puma (0.4 pt/a), Bronate (1.0 pt/a), and Harmony GT (0.3 oz/a).

8/13/01 Spring Wheat was combined and produced a yield of 50.2 bu/a (combine yield). Protein was 13.4%.

9/12/01 A burndown of Roundup at 20 oz/a, LV4 at 16 oz/a, and ammonium sulfate was applied.

9/19/01 The north half of the field consisting of 2.36 acres was seeded with the Haybuster 8000 hoe drill (10-inch row space) to Jerry winter wheat at a seed rate of 1.3 million seeds/a. The same seed rate was used on the south half of the field were Roughrider winter wheat was seeded also using the Haybuster 8000 hoe drill. 50 lb/a of 11-52-00 was banded at seeding.

Field F3, Nekota winter wheat – hayed (Figure 2, page 4).

9/26/00 Seeded the south half of the field to Nekota winter wheat, a variety from South Dakota, with the Haybuster 8000 hoe drill (10-inch row space) along with 50 lb/a of 11-52-00 fertilizer. Seed rate was 1.3 million seeds/a.

9/27/00 The north half of the field was seeded using the Haybuster 8000 hoe drill to Roughrider winter wheat. 11-52-00 was applied at this time at a rate of 50 lb/a. Seeding rate was 1.3 million seeds/a.

10/2/00 Field was sprayed with Roundup Ultra at a rate of 24 oz/a.

3/30/01 Urea at a rate of 80 lb N/a was applied by contractor.

6/2/01 Field was sprayed with Buctril (1 pt/a) and LV6 Ester (1pt/a) by contractor with plane.

***** Winter wheat was hayed because of winterkill.

Field F4, NuSun sunflowers (Figure 2, page 4).

9/27/00 Field was sprayed with Roundup Ultra (24 oz/a).

3/30/01 Urea was bulk spread at a rate of 70 lb N/a.

5/3/01 Roundup at 20 oz/a and ammonium sulfate was applied.

5/25/01 Glyphomax (24 oz/a) plus ammonium sulfate and Pendimax (3.25 pt/a) was applied.

6/4/01 Three varieties (Cenex Croplan CL-345, Dekalb DK 29-99, and Dekalb DK 31-01) of NuSun sunflowers were planted using the JD Maxemerge II planter at a seed rate of 25,000 seeds/a in 30-inch rows.

7/3/01 Poast at 1.5 pt/a, and Prime Oil at 1 qt/a was applied.

10/18/01 Sunflowers were combined yielding 1,653 lb/a (combine yield).

Field F5, Corn, Lentil, Chickpea, Buckwheat, and Proso Millet varieties

See 'Evaluation of warm season crops for crop sequence project, Phase III' on page 21.

Field F6, Soybean varieties.
Soybean data in process.

Field G1, Root growth study and NDSU variety trials.
See 'Small grain variety evaluations, 2001' on pages 26-28.

Field G2, Crop Sequence Project, Phase II (Figure 2, page 4).
See 'Early Season Crop Sequence Project, Phase II of the Diverse Cropping Systems Project on pages 8 through 20.

Field G3, Fallow
5/29/01 Sprayed with Glyphomax (24 oz/a) + ammonium sulfate
6/8/01 Glyphomax Plus (32 oz/a) + ammonium sulfate and Banvel (8 oz/a) was applied.
7/5/01 Roundup Ultra at 18 oz/a, Banvel at 0.5 pt/a and ammonium sulfate was applied.
8/13/01 Sprayed with Roundup (32 oz/a) + ammonium sulfate.

Field G4, Drummon barley (Figure 2, page 4).
5/1/01 Field was seeded to Drummon barley at a rate of 90 lbs/a with the JD 750 no-till drill (7.5-inch row spacing). Urea was banded at time of seeding at a rate of 60 lbs N/a and 11-52-00 at 50 lbs/a was put down with the seed.
6/13/01 Puma (0.4 pt/a), Bronate (1 pt/a), and Harmony GT (0.3 oz/a) was sprayed on the field by plane.
7/26/01 Barley was swathed.
8/3,6/01 Barley was combined producing a yield of 83.9 bu/a (combine yield).
9/12/01 Sprayed with Roundup at 20 oz/a, LV4 at 16 oz/a and ammonium sulfate.

Field H1, Robust barley (Figure 2, page 4).
5/10/01 Field was sprayed with Glyphomax plus (20 oz/a) + ammonium sulfate.
5/17/01 Field was worked with the JD MulchMaster.
5/22-24/01 Seeded Robust barley with the Bougault air seeder (10-inch row space) at a seed rate of 95.3 lbs/a. 60 lb N/a (urea) and 50 lb/a 11-52-00 was banded at the time of seeding.
6/25/01 Puma at 0.4 pt/a, Bronate at 1 pt/a, and Harmony GT at 0.3 oz/a was sprayed on field.
8/20/01 Field was combined and had a yield of 61.1 bu/a (combine yield).
9/28/01 Field was harrowed with 60-foot harrow.

Field H2, Winter kill.
9/28/00 Field was seeded to Roughrider winter wheat with the Haybuster 8000 hoe drill (10-inch row space). The seeding rate was 1.3 million seeds/a and 11-52-00 was applied at the time of seeding at a rate of 50 lb/a.
3/30/01 80 lb N/a in the form of urea was bulk spread by a contractor.
7/9/01 A complete burndown to fallow was done using Roundup Ultra (18 oz/a), Banvel (0.5 pt/a) + ammonium sulfate because of winterkill to the winter wheat.
***** No harvest due to winterkill.

Field H3, Reeder spring wheat (Figure 2, page 4).
8/18/00 Sprayed with Roundup Ultra (24 oz/a).

9/27/00 Sprayed with Roundup Ultra (24 oz/a).
5/2/01 Field was seeded to Reeder spring wheat at a rate of 1.3 million seeds/a with the Bourgault air seeder (10-inch row space). At the time of seeding 70 lbs N/a (urea) and 50 lbs/a 11-52-00 was applied.
6/13/01 Field was sprayed by plane with Puma (0.4 pt/a), Bronate (1 pt/a), and Harmony GT (0.3 oz/a).
8/6/01 Sprayed with Roundup at rate of 16 oz/a by plane as a pre-harvest kill.
8/14/01 Combined spring wheat with a yield of 46.4 bu/a (combine yield). Protein was 14.7%.

Field H4, Soil Quality Management (Figure 2, page 4).
See 'Management Strategies for Soil Quality' on page 22.

Field H4, Canola Varieties (Figure 2, page 4).
See 'Minimum-Till Canola Production' on page 23.

Field H4, Sclerotinia Biological Control Studies.
See 'Sclerotinia Disease and Biological Control' see page 25.

Field I1, Verde spring wheat (Figure 2, page 4).
9/20/00 Sprayed with Roundup Ultra (24 oz/a) by contractor.
5/9/01 Seeded Verde spring wheat at rate of 1.3 million seeds/a with the Concord air seeder with hoe openers and a 10-inch row spacing. 50 lbs/a 11-52-00 and 128 lbs N/a (urea) was put down at the time of seeding.
6/21/01 Sprayed with Puma (0.4 pt/a), Bronate (1 pt/a), and Harmony GT (0.3 oz/a).
8/15/01 Field was swathed.
8/20/01 Field was combined producing a yield of 25.4 bu/a (combine yield). Protein was at 15.1%.
8/27/01 Sprayed with Roundup (20 oz/a) and LV4 (16 oz/a).

Field I2 & I3, Roughrider winter wheat (Figure 2, page 4).
9/20/00 Sprayed with Roundup Ultra at rate of 24 oz/a by contractor.
9/27/00 Seeded field to Roughrider winter wheat using the Concord air seeder with hoe openers and a 10-inch row spacing. Seeding rate was 1.3 million seeds/a. 11-52-00 was applied at 50 lbs/a between the split seed row.
3/30/01 Contractor bulk spread urea at 80 lbs N/a.
6/2/01 Field was sprayed by plane with 2,4-D Ester (1 pt/a) and Buctril (1 pt/a).
8/7,8/01 Field was combined and had a yield of 30.8 bu/a (combine yield). Protein ranged from 13.5% to 14.1%.
8/27/01 Field was spot sprayed with Roundup (20 oz/a) and LV4 (16 oz/a).

Field I4, Roughrider winter wheat (Figure 2, page 4).
9/20/00 Sprayed with Roundup Ultra at 24 oz/a by contractor.
9/26/00 Field was seeded to Roughrider winter wheat using the Concord air seeder with hoe openers and a 10-inch row spacing. Seeding rate was 1.3 million seeds/a. 50 lbs/a of 11-52-00 and urea at 180 lbs N/a was applied between the split seed row.
6/2/01 Sprayed with 2,4-D Ester at rate of 1 pt/a and Buctril at 1 pt/a with plane.

8/9/01 Winter wheat was combined producing a yield of 16.5 bu/a (combine yield). Protein ranged from 13.5% to 14.1%.

8/27/01 Sprayed field with Roundup (20 oz/a) and LV4 (16 oz/a).
See 'Site-Specific Farming in Western North Dakota – 2001' on pages 29-31.

Field I5, NuSun sunflower (Figure 2, page 4).

9/20/00 Field was sprayed by contractor with Roundup Ultra (24 oz/a).

5/17/01 Variable rate urea was applied using Concord air seeder.

5/24/01 Sonalan was applied with a Gandy air applicator mounted to a Haybuster undercutter at a rate of 1 lb ai/a.

6/1/01 Field was seeded to Dekalb DK 31-01 NuSun sunflowers at a rate of 25,000 seeds/a with the JD Maxemerge II planter. Row spacing was 30-inches.

10/17,18/01 Field was combined and had a yield of 1,768 lb/a (combine yield).
See 'Site-Specific Farming in Western North Dakota – 2001' on pages 29-31.

Field I6, Verde spring wheat (Figure 2, page 4)

5/8/01 Field was seeded to Verde spring wheat at a rate of 1.3 million seeds/a with the Concord air seeder hoe drill (10-inch row spacing). Fertilizer was applied at 128 lbs N/a (urea) and 50 lbs/a 11-52-00 at seeding time.

6/6/01 Sprayed Puma (0.4 pt/a) and Bronate (1 pt/a).

8/16/01 Combine yield was 50.5 bu/a (combine yield). Protein ranged from 14.6% to 15.2%.

9/12/01 Sprayed Roundup at 20 oz/a and LV4 at 16 oz/a.

9/19/01 Seeded Roughrider winter wheat with the Concord air seeder at rate of 1.3 million seeds/a along with 50 lbs/a of 11-52-00.
See 'Site-Specific Farming in Western North Dakota – 2001' on pages 29-31.

Field I7, Reeder spring wheat (Figure 2, page 4).

5/2/01 Seeded Reeder spring wheat at 1.3 million seeds/a with the Bourgault air seeder (10-inch row space) along with 70 lbs N/a (urea) and 50 lbs/a 11-52-00.

6/6/01 Sprayed Puma at 0.4 pt/a and Bronate at 1 pt/a.

8/6/01 Contractor sprayed Roundup at 16 oz/a as a pre-harvest kill.

8/13,14/01 Combined with a yield of 52.2 bu/a (combine yield). Protein was at 14.4%.

INTEGRATED CROP/LIVESTOCK SYSTEMS FOR 2000 AND 2001 (CROP PRODUCTION)

Drs. Donald Tanaka, Jim Karn, Ron Ries, and Jon Hanson

Oat/pea (50 lb/a Paul oat and 60 lb/a Arvika pea) and triticale (100 lb/a Trical 2700) plus sweet clover (8 lb/a) were seeded no-till on 3 May and 4 May of 2000 in a three-year rotation of oat/pea-triticale/clover-corn. Research was initiated in the spring of 1999. All areas received a pre-plant burn down of glyphosate at 24 oz material/a plus ammonium sulfate just prior to seeding. Grain and straw production, as well as total dry matter, were greater for triticale than oat/pea (Figure 1A, B, and C). Protein concentration for the grain was greater for oat/pea than triticale, but straw protein was about the same (Figure 1D). Corn produced the most total dry matter of all crops with a protein concentration that was slightly greater than oat/pea and triticale straw (Figure 1C and D).

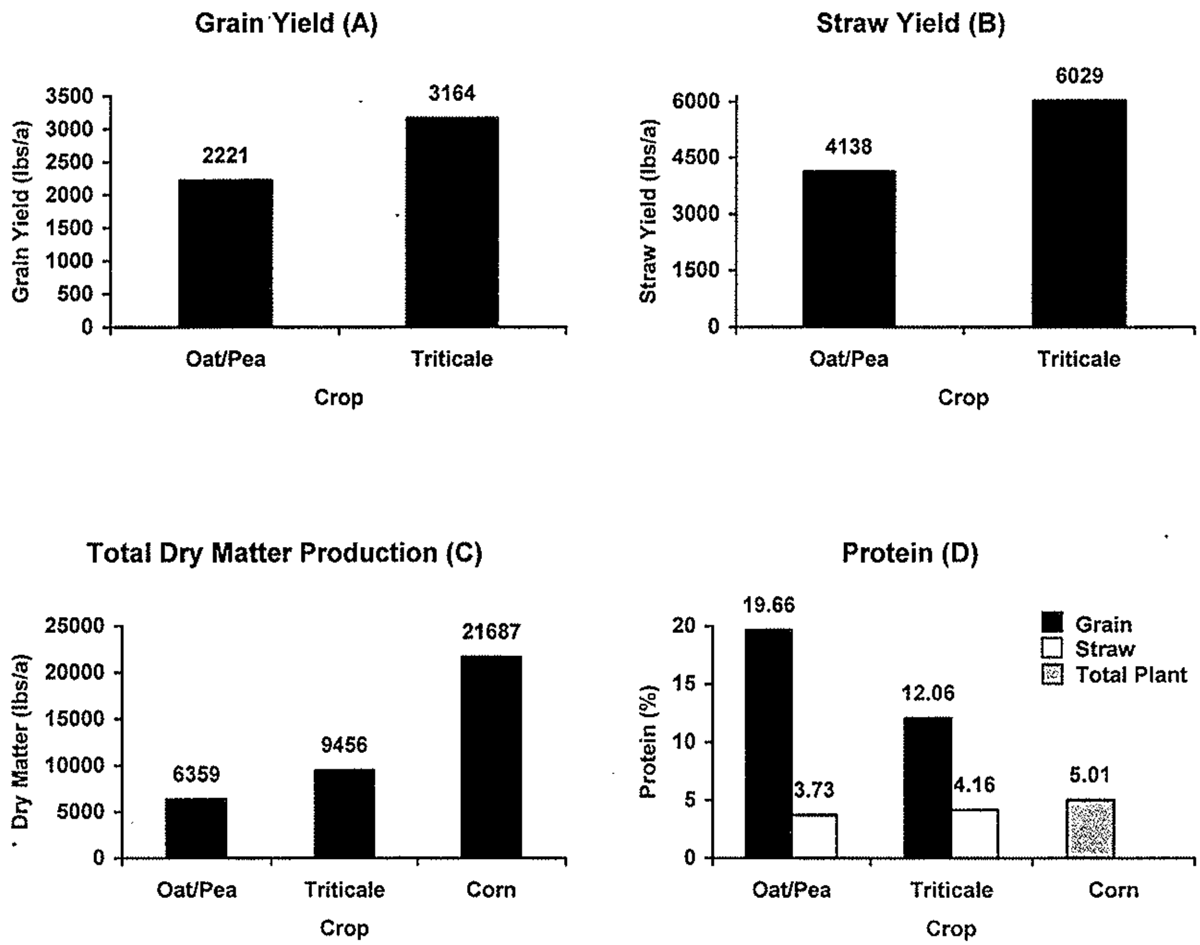


Figure 1. Grain and straw yield for oat/pea and triticale (A and B), total dry matter production (grain plus straw; C), and protein concentration for oat/pea, triticale, and corn for forage (D).

PERFORMANCE OF BEEF COWS WINTERED ON SWATHED FORAGES

Drs. Jim Karn, Donald Tanaka, Ron Ries, and Jon Hanson

Treatments, forages, methods and first year results (1999-2000) of wintering dry bred beef cows on swathed forages, were presented in the 2001 AREA IV report. Temperatures in 1999-2000 were generally above the 80 year average (Fig. 1), while temperatures in 2000-2001, especially in December, were below average (Fig. 2). Differences in snow fall, temperature, and wind between years will affect animal performance and determine whether swath grazing can be routinely used in the Northern Plains. In this regard, we felt that 2000-2001 gave us a more valid test of swath grazing than the first year. During the 83-day wintering period of 2000-2001, cows fed hay in a drylot gained 93 lbs, cows grazing crop residue and drilled corn lost 6 lbs, and cows grazing swathed perennial grass lost 9.0 lbs. Cow condition scores did not change between or within treatments over the 83 days. Cows grazing swathed crops and swathed grass were supplemented with an average of 4.5 and 3.5 lbs. per day, respectively, of a mixture of dry rolled oat/pea (75 %) and triticale (25 %). Crude protein, phosphorus, in vitro dry matter digestibility, and neutral detergent fiber (NDF) in feeds used during this study are shown in Table 1. Crude protein and phosphorus concentrations were not adequate for dry bred cows in the oat/pea and triticale straw, and phosphorus was also not adequate in swathed hay. We expect to collect calving and reproductive information on these cows, to determine if subsequent productivity is affected by wintering treatment. Over the first two years, even with some weight loss in 2000-2001, winter animal performance does not appear to be adversely affected by swath grazing when animals are appropriately supplemented, but longer term reproductive information is necessary to be sure that calving percentage or calving date are not affected.

Fig. 1. Mean Daily Temperatures during 1999-2000.

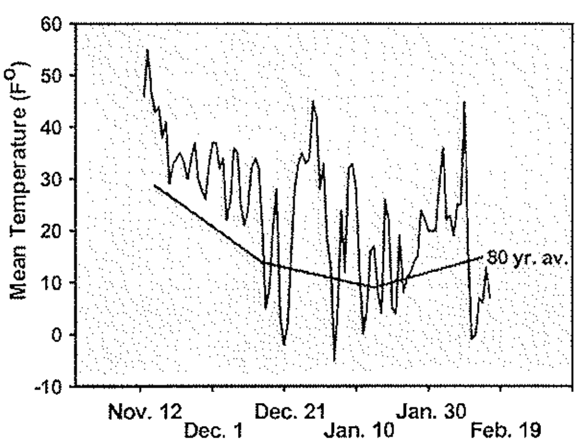


Fig. 2. Mean Daily Temperatures during 2000-2001.

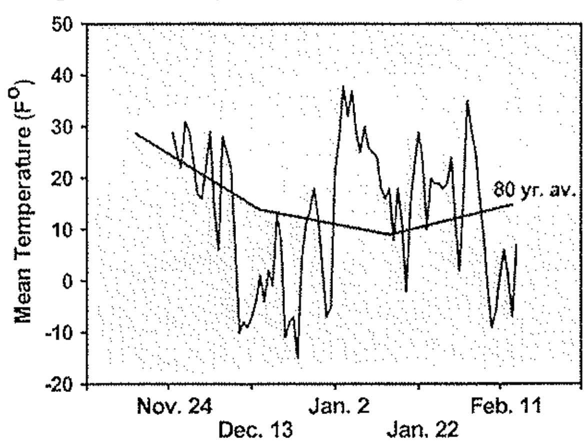


Table 1. Forage and grain quality in 2000-2001.

		Swathed				
	Hay	Grass	Corn	Triticale straw	Oat/pea straw	Supplement
Item	% of dry matter					
Crude protein	10.4	7.5	7.2	4.2	4.2	19.1
Phosphorus	0.17	0.10	0.16	0.06	0.08	0.44
IVDMD	65.4	52.3	66.4	55.1	54.5	93.0
NDF	65.8	74.1	71.8	82.8	78.8	49.0

FORAGE BREEDING RESEARCH

Dr. John Berdahl

The objective of our forage breeding research is to develop dependable perennial forage cultivars that will complement our native grasslands and provide additional management options for integrated forage-crop-livestock production systems. Our efforts are focused on development of Russian wildrye cultivars with improved seedling vigor and alfalfa cultivars that are adapted for use as dryland pasture and hay. We have doubled the normal chromosome number of Russian wildrye, and experimental populations have had greatly improved seedling vigor as well as increased dry matter production under drought stress. In regional tests, seedling establishment of this tetraploid Russian wildrye was equal to crested wheatgrass, and dry matter yield from the first production year averaged approximately 30% greater than Mankota and Bozoisky, two current Russian wildrye cultivars. Four experimental populations of alfalfa are being screened for resistance to bacterial wilt and will be entered into regional tests in 2003. These alfalfa populations have broad, deep-set crowns, fine stems, and high levels of drought resistance and winter survival. They have higher levels of drought- and cold-induced plant dormancy than current alfalfa cultivars. We believe that these grazing-type alfalfas will be useful in grass-alfalfa mixtures for pasture and hay in sub-humid to semi-arid environments of the Northern Great Plains.

THE ROLE OF GRASSLANDS IN THE GLOBAL CARBON CYCLE

Dr. Al Frank

It has become apparent to society that carbon dioxide concentration in the atmosphere is rapidly increasing. Most of this increase can be attributed to the burning of fossil fuels and other industrial activities. To counter this increase in carbon dioxide, governments are searching for economical ways to reduce the absolute atmospheric carbon dioxide concentration or at the least reduce the rate of increase. This is where agriculture can play a significant role. At the NGPRL we are conducting research to evaluate the role the vast grasslands areas of the USA and around the world have in controlling atmospheric carbon dioxide levels. This research is being conducted at the NGPRL and at ten other ARS rangeland location in the Great Plains and western states. This research requires the use of sophisticated instrumentation to measure changes in carbon dioxide concentration in the atmosphere at near canopy height as it is taken up by the plants or lost from the plants and soil through respiration. Our studies include evaluating both grazed and nongrazed grasslands to determined if grasslands can be used for grazing and also serve as a sink for atmospheric carbon dioxide. Initial results suggest that for grasslands to serve both purposes requires good management practices with moderate grazing intensities. Several years results suggest that both grazed native prairie, nongrazed native prairie, and seeded western wheatgrass pastures do sequester significant amount of atmospheric carbon dioxide during the April to November period. However, results also show that a significant amount of carbon dioxide is lost back to the atmosphere from the soil during the November to April time period. Overall, these results show that Northern Great Plains grasslands capture more carbon dioxide than is lost back into the atmosphere from soil respiration, and when scaled to the large acreage of grasslands, suggests a significant role for grasslands in reducing atmospheric carbon dioxide.