2002 RESEARCH and CROPPING RESULTS
Area IV SCD/ARS Research Farm

Nineteenth Annual Progress Report
January 21, 2003

Jon Hanson, Lab Director, Rangeland Scientist
Joe Krupinsky, Research Plant Pathologist
Donald Tanaka, Soil Scientist
Steve Merrill, Soil Scientist
Mark Liebig, Soil Scientist
Scott Kronberg, Animal Scientist
John Hendrickson, Rangeland Scientist
Jim Karn, Research Animal Scientist
John Berdahl, Research Geneticist
Al Frank, Plant Physiologist
Holly Johnson, Rangeland Scientist
Jason Gross, Soil Scientist
Eric Eriksmoen, Agronomist, NDSU Hettinger Experiment Station
Vern Hofman, NDSU Extension Agricultural Engineer

Field Support Staff
Bruce Boehm, John Bullinger, Chuck Flakker, Justin Hartel, Marv Hatzenbuhler, Gordon Jensen, Curt Klein, Faye Kroh, Larry Renner, Delmer Schlenker, Mary Kay Tokach, and Dawn Wetch.

NOTICE

ACKNOWLEDGMENTS

USDA-ARS and the Area IV Soil Conservation Districts recognize the contributions made by the following cooperators: Dow AgroSciences; Monsanto Ag Products; National Sunflower Association; Northern Canola Grower's Association; USDA Natural Resources Conservation Service; USDA-ARS Red River Valley Research Center; Pioneer Hi-Bred International; DeKalb; Dupont Ag Products; BASF Corporation; Gustafson; Legume Logic; NDSU Agricultural Experiment Stations; Circle Diamond Ranch Supply; Minn-Dak Growers, LTD; Knox Brothers Farms; Agricore United; North Dakota Dry Pea and Lentil Association; Micro Bio RhizoGen Corporation; Encore Technologies, LLC; NDSU-Cooperative Extension Service; Farm and Ranch Guide; Northern Plains Equipment Company; Farm Credit Services of Mandan; Interstate/Payco Seeds; Top Farm Hybrids; Gartner Seed Farm; RDO Equipment; Twin City Implement; Mandan Supply & Equipment; Legend Seeds; Bayer Crop Science; Frontier Agriculture; Agriliance; Croplan Genetics; Bis-Man Ford; Extreme Sales

USDA-ARS
Northern Great Plains Research Laboratory
PO Box 459 • Mandan, ND 58554-0459
Phone: 701/667-3001 • FAX: 701/667-3054
Home Page: www.mandan.ars.usda.gov

"DROUGHT SURVIVAL"
RESEARCH RESULTS & TECHNOLOGY CONFERENCE

January 21, 2003
Seven Seas Inn and Conference Center
Mandan, ND

Sponsored By
USDA-ARS Northern Great Plains Research Laboratory
Area IV Soil Conservation Districts
National Sunflower Association*
In cooperation with NDSU Experiment Stations

8:30 AM	**REGISTRATION** – coffee & cookies	Sponsored by Stutsman County SCD
9:00	**INTRODUCTION/COMMENTS**	
	Jon Hanson, Laboratory Director	USDA-ARS NGPRL
	Marvin Halverson, President	Area IV Advisory Committee
	Lloyd Klein, Board Chairperson	National Sunflower Association
9:20	**Crop Production Under Drought Conditions**	
	Don Tanaka, Soil Scientist	USDA-ARS NGPRL
	Soil Water Use by Diverse Crops	
	Steve Merrill, Soil Scientist	USDA-ARS NGPRL
	Beef Cow Wintering Strategies to Control Feed Costs	
	Jim Karn, Animal Scientist	USDA-ARS NGPRL
10:20	**BREAK** – coffee & cookies	Sponsored by Stutsman County SCD
10:45	**Drought Effects on Grassland Processes**	
	John Hendrickson, Rangeland Scientist	USDA-ARS NGPRL
	Non-Traditional Forages and Drought	
	Scott Kronberg, Animal Nutritionist	USDA-ARS NGPRL
11:30	**Balancing Cattle Rations with On-Farm Feeds**	
	Vern Anderson, Animal Scientist	NDSU - Carrington Research Extension Ctr.
Noon	**LUNCH COMPLIMENTS OF NSA**	
1:00 PM	**PANEL - How We Survived the Drought 2002!**	
	Steve Pfeifer, McLaughlin, SD	
	Byron Richards, Belfield, ND	
	Tim DeKray, Steele, ND	
	Lloyd Krein, Elgin, ND	
2.15	**EMERGING MARKETS/ISSUES**	
	Max Dietrich	*Production Coordinator National Sunflower Association*
3:00	**DOOR PRIZE DRAWINGS**	Sponsored by Area IV SCD Advisory Committee/Exhibitors
3:30	**AREA IV SCD MEETING**	

Table of Contents

Dr. Jim Karn — Research Animal Scientist, Range animal nutrition and forage quality karnj@mandan.ars.usda.gov
(701) 667-3009

Dr. Scott Kronberg — Animal Nutritionist, Plant-Animal Interactions/Nutrition/ Behavior/Rangeland Ecology/Rangeland Management
kronberg@mandan.ars.usda.gov
(701) 667-3013

Dr. Joe Krupinsky — Research Plant Pathologist, Tan spot, Septoria, and common root rot diseases of wheat and forage grasses; effect of conservation tillage systems, crop rotation, fertility, and cultivars on diseases of wheat; selection of disease resistant forage grasses; and aggressiveness of fungi
krupinsj@mandan.ars.usda.gov
(701) 667-3011

Dr. Mark Liebig — Soil Scientist, Alternative cropping, forage, and tillage systems; Soil quality liebigm@mandan.ars.usda.gov
(701) 667-3079

Dr. Steve Merrill — Soil Scientist, Soil erosion, crop root growth studies, and soil hydrology in conservation tillage systems
merrills@mandan.ars.usda.gov
(701) 667-3016

Dr. Don Tanaka — Soil Scientist, High residue management, dryland crop production systems, soil quality, conversion of CRP to crop production tanakad@mandan.ars.usda.gov
(701) 667-3063

Cooperators

Mr. Eric Eriksmoen — Research Agronomist, NDSU Hettinger Experiment Station
eericksmo@ndsuext.nodak.edu (701) 567-4325

Mr. Vern Hoffman — Extension Agricultural Engineer, NDSU-Fargo
vhofman@ndsuext.nodak.edu (701) 231-7240

Dr. Thomas Gulya, Jr. — USDA-ARS Northern Crop Science Laboratory 1307 N 18th Fargo, ND 58105-5677 (701) 239-1316

Dr. F. Zheng — Institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources, 26 Xinong Rd., Yangling, Shaanxi 712100, Peoples Republic of China;

Dr. C. Huang — USDA-ARS National Soil Erosion Research Laboratory, 1196 SOIL Bldg., Purdue University, West Lafayette, IN 47907

Dr. F. Darboux — INRA Orléans - Science du Sol, Avenue de la Pomme de Pin, BP 20619, F-45166 Olivet Cedex, France

Figure 1

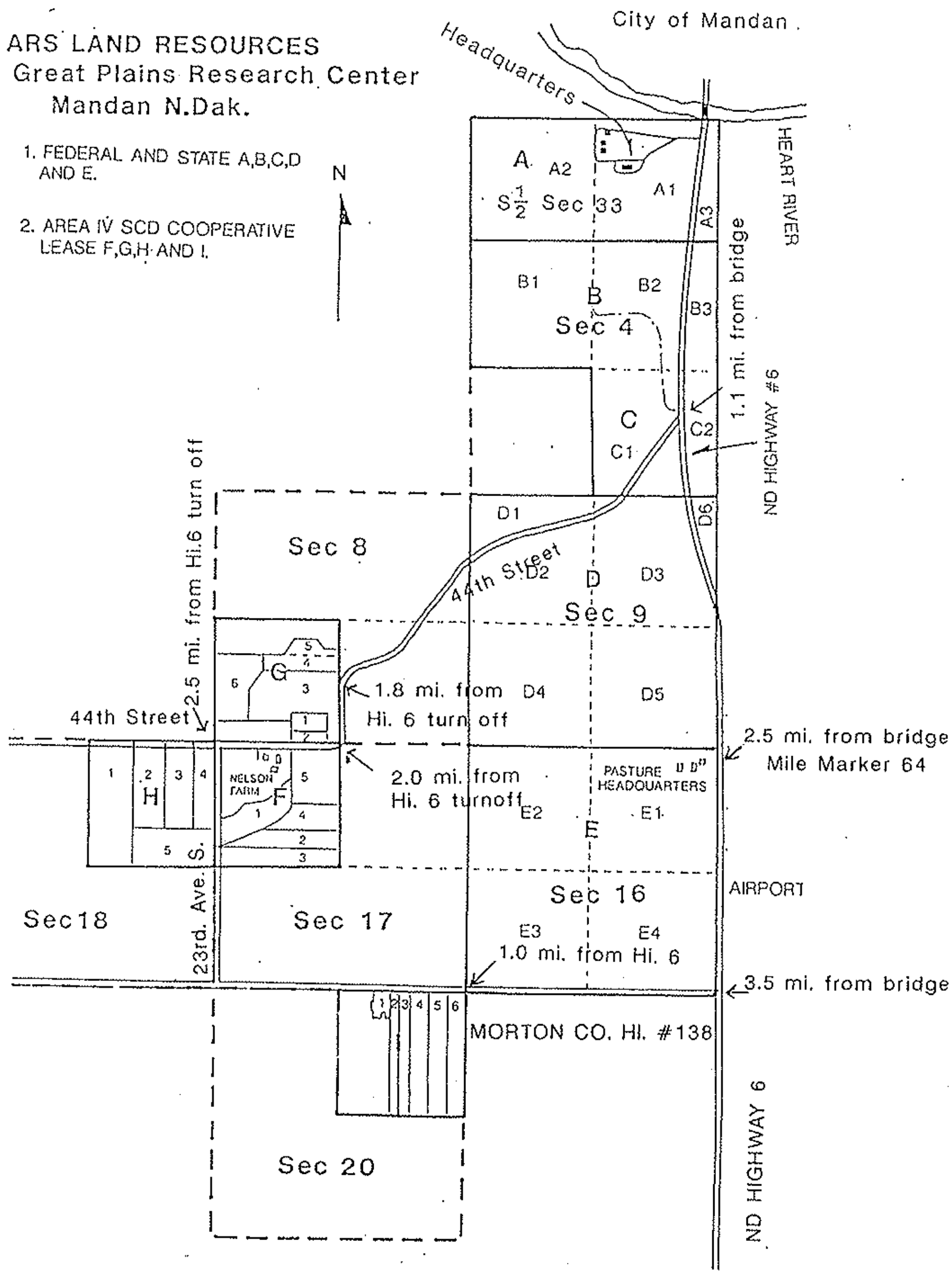

ARS LAND RESOURCES
Great Plains Research Center
Mandan N.Dak.
1. FEDERAL AND STATE A,B,C,D AND E.
2. AREA IV SCD COOPERATIVE LEASE F,G,H AND I.
N
City of Mandan
Headquarters
HEART RIVER
A A2
S 1/2 Sec 33
A1
A3
B1 B2
B
Sec 4
B3
1.1 mi. from bridge
C
C1
C2
ND HIGHWAY #6
D1
D6
Sec 8
44th Street
D2 D D3
Sec 9
2.5 mi. from Hi.6 turn off
G
1.8 mi. from Hi. 6 turn off
D4
D5
44th Street
2.5 mi. from bridge
Mile Marker 64
NELSON FARM
F
H
2.0 mi. from Hi. 6 turnoff
PASTURE HEADQUARTERS
E2
E
E1
23rd. Ave. S.
Sec18
Sec 17
Sec 16
AIRPORT
E3 E4
1.0 mi. from Hi. 6
3.5 mi. from bridge
MORTON CO. HI. #138
Sec 20
ND HIGHWAY 6

Figure 2

Area IV Research Farm Crop Plan - 2002.

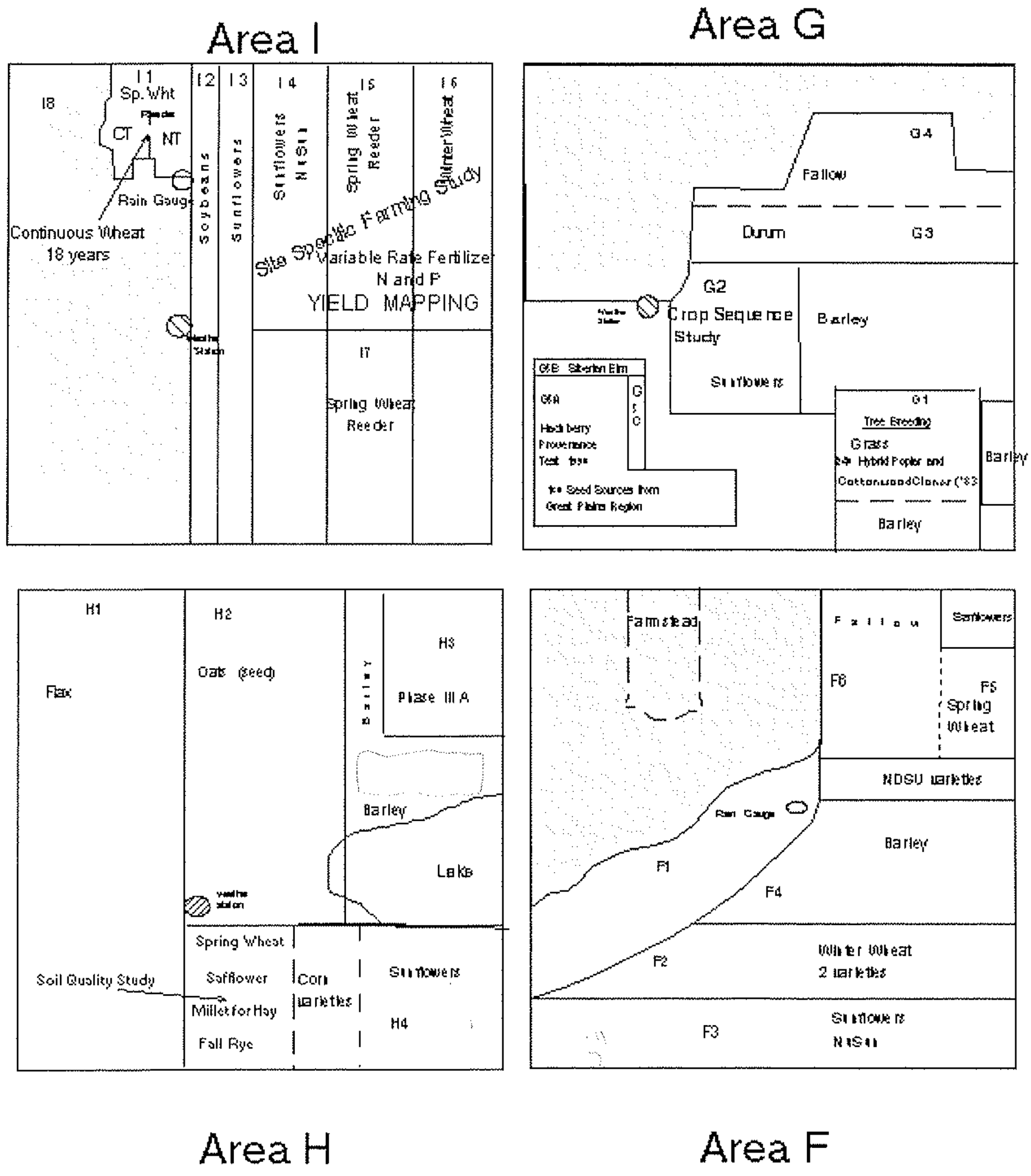


Figure 3

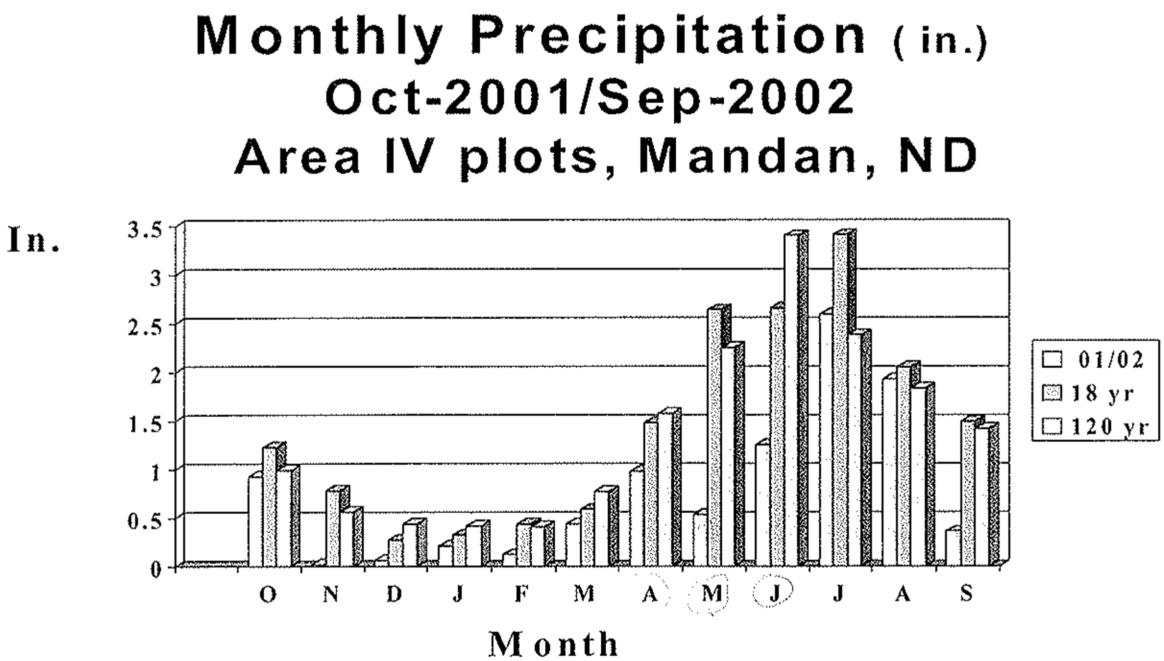
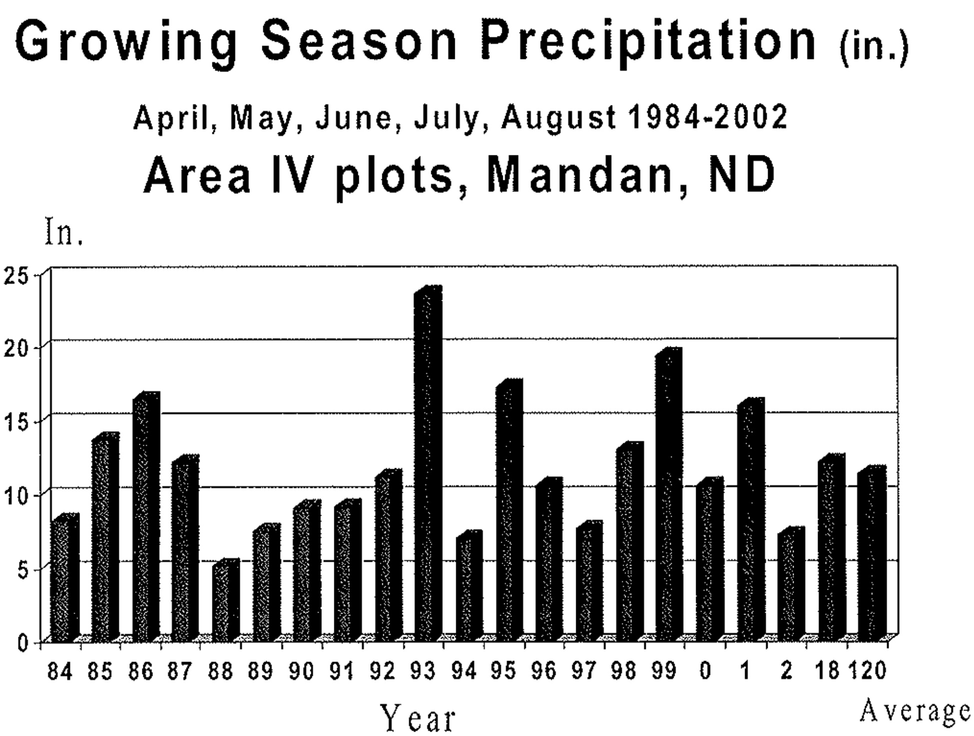


Figure 4



MANAGEMENT PRACTICES, 2002
AREA IV SCD/ARS RESEARCH FARM

AREA-F Field Operations, NW ¼ Section 17

Field F1

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

Field F2, Jerry and Roughrider winter wheat

9/19/01 The north half of the field consisting of 2.36 acres was seeded to Jerry winter wheat with the Haybuster 8000 hoe drill (10-inch row space) 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 using the Haybuster 8000 hoe drill. Fertilizer at 50 lb/a of 11-52-00 was banded at seeding.
4/5/02 Contractor spread urea at a rate of 70 lbs N/a.
5/22/02 Field was sprayed with Bronate at a rate of 1.5 pt/a.
7/31/02 Jerry winter wheat was combined and had a yield of 15.5 bu/a (combine yield). This Jerry winter wheat was kept for seed and used to seed field F4 on 9/18/02. The Roughrider winter wheat was combined and yielded 17.8 bu/a. The Roughrider winter wheat had protein of 16.8% and was sold for $3.55/bu.
8/22/02 Field was sprayed with Glyphomax (20 oz/a) plus LV4 (1 pt/a) and ammonium sulfate.
9/11/02 Sprayed with Glyphomax (16 oz/a) plus LV4 (1 pt/a) plus ammonium sulfate.

Field F3, NuSun sunflowers

4/5/02 Contractor applied 70 lbs N/a in the form of urea.
5/15/02 Sonalan was applied and incorporated at a rate of 1.1 lbs ai/a with a Gandy air applicator mounted to a Haybuster undercutter.
6/4/02 Field was tilled using a MulchMaster.
6/4/02 Seeded south side of field to Interstate Hysun 521 sunflowers and north side to DeKalb NuSun 31-01 sunflowers. Both varieties were seeded at a rate of 24,000 seeds/a using a JD Maxemerge II planter in 30 inch rows.
7/11/02 Applied Poast (1.5 pt/a) and crop oil (1 qt/a).
7/11/02 Assert (0.8 pt/a) and Preference (1 qt/100gal H_2O) was applied to field.
8/17/02 Asana XL was applied at 5.0 oz/a by contractor.
10/30/02 Sunflowers were combined. Dekalb 31-01 sunflowers yielded 1374 lbs/a (combine yield) and Interstate 521 sunflowers yielded 1994 lbs/a (combine yield).

Field F4, Conlon barley

5/2/02 Contractor sprayed field with Glyphomax Plus (24 oz/a) plus ammonium sulfate.
5/16/02 Seeded Conlon barley with the Bourgault air seeder (10-inch row space) at a rate of 95.3 lbs/a. Fertilizer was applied at seeding time as a blend of urea (70 lbs N/a) and 11-52-00 (50 lbs/a).
6/14/02 Puma (0.5 pt/a) plus Bison (1.5 pt/a) plus crop oil (1 pt/100gal H_2O) was applied for weed control.
8/9/02 Barley was swathed using a Versatile 4400.

8/26/02 Barley was combined and yielded 9.6 bu/a (combine yield). Barley was sold for $1.90/bu.
9/5/02 Sprayed Glyphomax (20 oz/a) plus LV4 (1.5 pt/a) plus ammonium sulfate.
9/11/02 Sprayed Glyphomax (16 oz/a) plus LV4 (1 pt/a) plus ammonium sulfate.
9/18/02 Seeded Jerry winter wheat with the Haybuster 8000 hoe drill (10-inch row spacing) at a rate of 1.3 million viable seeds/a. Fertilizer in the form of 11-52-00 was applied at seeding at a rate of 50 lbs material/a.

Field F5, Montola 2000 safflower

5/3/02 Applied and incorporated Sonalan (1.1 lbs ai/a) with the Gandy air applicator mounted to the Haybuster undercutter.
5/3/02 Seeded Montola 2000 safflower into spring wheat stubble at a rate of 200,000 seeds/a. 60 lbs N/a of 3D750 (34-00) and 10 lbs P/a of 0-44-0 were applied at the time of seeding.
6/20/02 Sprayed field with Harmony GT (1/12 oz/a) and then applied Poast (1 pt/a) and Crop Oil (1 qt/a).
7/19/02 Sprayed field with Quadris (6.2 oz/a).
9/24/02 Combined field with an estimated yield of 1200 lbs/a (combine yield). Sold for $13.00/cwt.

Field F5, Spring wheat varieties

See spring wheat varieties information on page 17.

Field F5, NDSU variety trials

See NDSU Variety trials information by Eric Eriksmoen on page 16.

Field F6, Chemical Fallow, Roughrider winter wheat

7/24/02 Tilled field with Haybuster undercutter.
8/2/02 Sprayed with Glyphomax (24 oz/a), LV4 (1 pt/a), and ammonium sulfate.
9/5/02 Sprayed with Glyphomax (20 oz/a), LV4 (1 pt/a), and ammonium sulfate.
9/18/02 Seeded Roughrider winter wheat with Bourgault air seeder (10-inch row space) at a rate of 1.3 million seeds/a. Fertilized at time of seeding with 70 lbs/a of 11-52-00.

<u>AREA-G Field Operations,</u> SW ¼ Section 8

Field G1 &G2 East, Conlon barley

4/30/02 Contractor sprayed field with Glyphomax (24 oz/a) and ammonium sulfate.
5/17/02 Seeded Conlon Barley with Bourgault air seeder (10-inch row space) at a seeding rate of 95.3lbs/a. Fertilized at time of seeding with a blend of Urea (70 lbs N/a) and 11-52-00 (50 lbs/a).
6/14/02 Sprayed with Puma (0.5 pt/a), Bison (1.5 pt/a), and Crop Oil (1 pt/100galH_2O).
8/9/02 Field was swathed with the Versatile 4400.
8/20/02 Barley was combined and yielded 16.4 bu/a (combine yield). Sold as feed ($1.90).
8/26/02 Sprayed with Glyphomax (20 oz/a), LV4 (1 pt/a), and ammonium sulfate.
9/11/02 Sprayed with Glyphomax (16 oz/a), LV4 (1 pt/a), and ammonium sulfate.

FIELD F5, NDSU VARIETY TRIALS

Eric Eriksmoen, NDSU Hettinger Experiment Station Agronomist

2002 Field Pea Variety Trial	Mandan

Variety	Seed Type	Plant Ht. at Harvest	Lodging	Test Weight	1000 Kernel Weight	Grain Yield
		inches	0-9*	lbs/bu	grams	bu/A
SW Salute	Yellow	17	1.0	62.3	222	19.6
SWA 5122	Yellow	19	1.2	61.2	201	19.4
Crusier	Green	16	2.2	62.0	210	16.5
SWA 5099	Yellow	17	1.5	61.7	234	15.4
Circus	Yellow	18	1.2	62.6	223	14.8
Toledo	Green	17	2.2	60.8	253	14.0
SWA 5111	Yellow	18	1.5	58.8	199	11.7
SWA 5097	Yellow	18	1.5	60.8	240	11.2
Integra	Yellow	19	2.5	60.4	253	11.0
SWA 5095	Yellow	17	2.2	62.5	250	10.9
Majoret	Green	17	1.2	64.0	242	10.7
Carneval	Yellow	19	1.2	55.1	228	10.4
SW 995877	Yellow	16	3.0	62.9	221	9.8
Trial Mean		17	1.8	61.2	229	13.5
C.V. %		8.1	36.0	3.9	6.0	27.6
LSD .05		2	0.9	ns	20	5.3
LSD .01		ns	1.2	ns	26	7.2

*Lodging: 0 = none, 9 = lying flat on ground.
Planting Date: April 25
Harvest Date: July 31
Seeding Rate: 250,000 live seeds/acre
Previous Crop: HRSW
Notes: The trial sustained severe heat and moisture stress during flowering resulting in poor seed set. Small grain varieties were abandoned.

Field F5. Spring Wheat (Len, Norpro, Russ, and Verde). The previous crops (2001) were corn, lentil, chickpea, buckwheat, proso millet, and grain sorghum. All spring wheat cultivars were no-till seeded on May 14 using the JD 750 at a rate of 1.3 million viable seeds per acre. Nitrogen at 60 lb N/a was banded and 10 lb P/a was applied with the seed. On May 24, Roundup Ultra (20 oz/a) plus ammonium sulfate was applied to control weeds. Puma (0.5 pt/a) plus Bison (1.5 pt/a) was used for post emergence weed control. Wheat yields were determined using a small plot combine. Area was broken down into legumes (previous crop chickpea and lentils), corn as previous crop, and late season crops (previous crop buckwheat, grain sorghum, and proso millet). Spring wheat yields ranged from 20 to 44 bu/a (Figure 1).

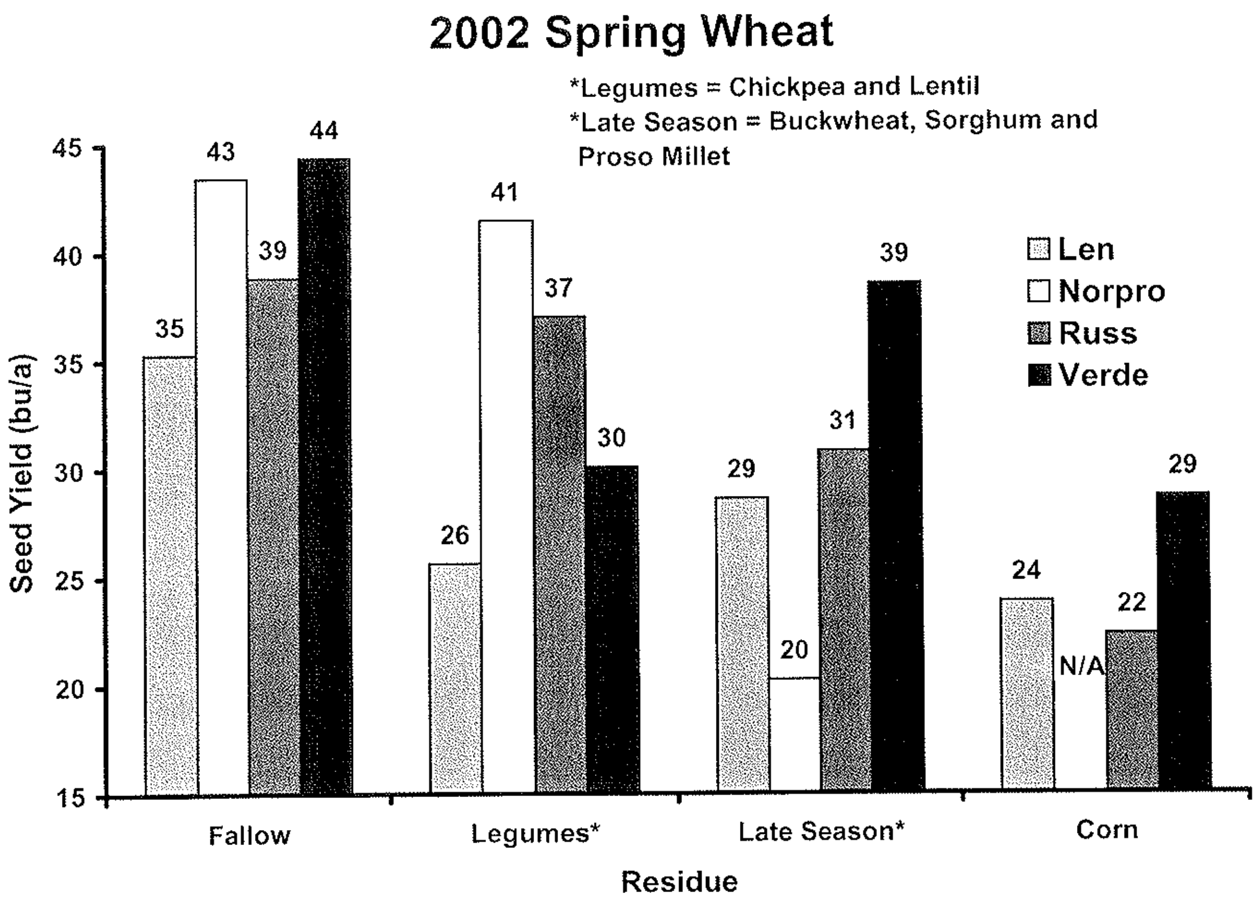


Figure 1. Spring wheat grain yields as influenced by cultivar and previous crop and crop residue.

Field H4. Corn Production. The previous crop (2001) was canola cultivars with seed yields ranging from 420 to 1110 lb/a. Corn cultivars were no-till seeded with a Maxemerge planter equipped with residue managers. Each cultivar was 12 rows with 30 inches between rows, except for Legend RR90484RB, which was 24 rows. Grain yield was determined by harvesting all 12 or 24 rows of each cultivar and using a weigh wagon.

Table 1. Corn maturity, seeding date, harvest date, seeding rate, and fertilizer rate.

Cultivar	Maturity in Days	Seeding Date	Harvest Date	Seeding Rate (seeds/a)	Fertilizer Rates	
					*N (lbs/a)	P (lbs/a)
Legend RR9084RB	84	May 22	Nov. 12	28,000	70	0
Dekalb 3259RR	82	May 22	Nov. 12	28,000	70	0
TFSX 8183RR	85	May 22	Nov. 12	28,000	70	0
TFSX 2183	84	May 22	Nov. 12	28,000	70	0
Chesak Minn 13	90	May 22	Nov. 12	28,000	70	0
Chesak Rainbow	>100	May 22	Nov. 12	28,000	70	0
Pioneer 39D81	84	May 22	Nov. 12	28,000	70	0

*Urea was bulk spread on 4-5-02

Spray Date	Chemical/a
6/20/02	Option (1.5oz/a) + UAN (1.5qt/a) + Banvel (4oz/a) + MSO 28% (1.5pt/a)

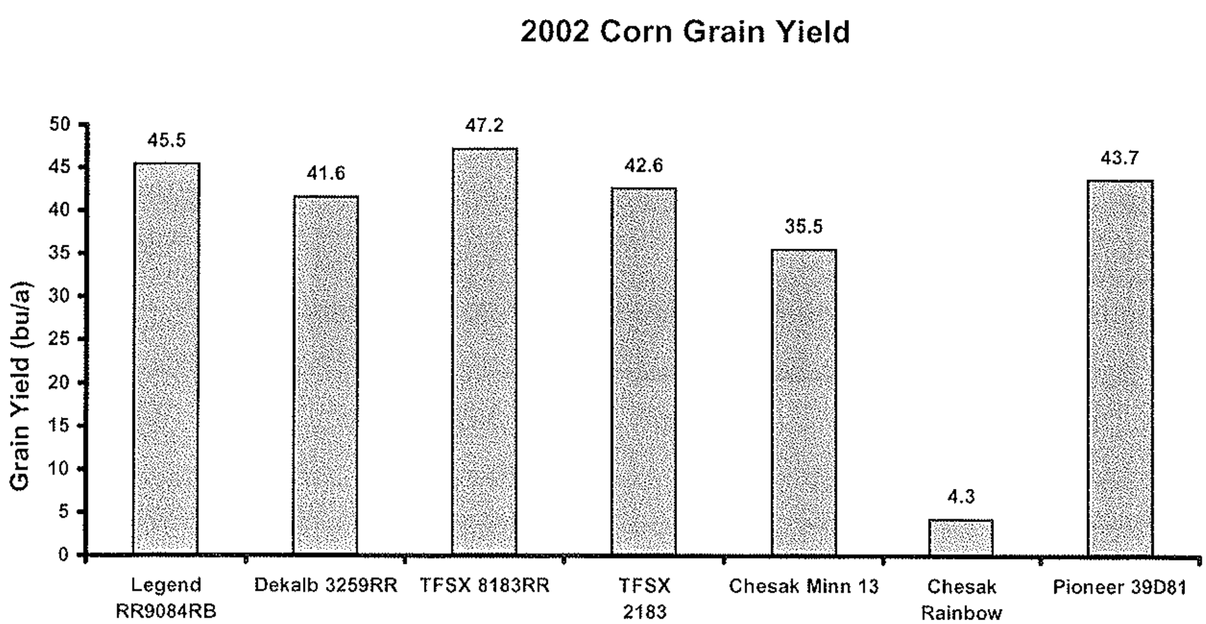


Figure 1. Corn grain yield as influenced by cultivar.

DIVERSE CROPPING SYSTEMS
CROP SEQUENCE PROJECT

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

INTRODUCTION

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

Phase II of the Crop Sequence Project, Early Season Crops

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. Ten crops were included (barley, dry bean, canola, crambe, flax, dry pea, safflower, soybean, oil seed sunflower, and hard red spring wheat). A crop by crop residue matrix was evaluated in 1999 and 2000. Following the crop by crop-residue matrix, a uniform wheat crop was grown in 2000 and 2001 over the crop matrix to determine how wheat performs after all crop sequences. A sunflower crop followed the wheat crop in 2001 and 2002. The Crop Sequence Calculator (version 2) provides an introduction to Phase II of the cropping system project and 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.

Phase III of the Crop Sequence Project, Late Season Crops

Phase III of the Diverse Cropping Systems Project, was initiated in 2002 to continue determining the sequence crops should follow to take advantage of the previous crop and crop residues. Field plots were located on the Area IV ARS/SCD Research Farm located near the Northern Great Plains Research Laboratory, southwest of Mandan, North Dakota. In 2002, ten crops (canola, dry pea, oil seed sunflower, hard spring wheat, proso millet, grain sorghum, chickpea, lentils, corn, buckwheat) 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. Four of these crops (canola, dry pea, oil seed sunflower, hard spring wheat) were also included in Phase II. In 2003 all ten crops will be again randomized and seeded into stubble from the previous crops in a north-south direction, perpendicular to the 2002 crop, with a JD 750 no-till drill. This allowed every crop to be seeded on the residue of all the other crops (100 treatments per replication). In another field, the ten crops will be seeded in an east-west direction in 2003 and in a north-south direction in 2004, again allowing every crop to be seeded on the residue of the ten previous crops.

LATE SEASON CROP SEQUENCE PROJECT

(Phase III of the Diverse Cropping System)

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

The warm season crop sequence project (Phase III) was initiated in the spring of 2002 to determine the sequence crops should follow to take advantage of the synergism that occurs among crops. Precipitation for the growing season (May through September) was 60% of the long-term average (Figure 1). Crops, crop variety, seeding date, harvest date, plant population, and fertilizer rates are shown in Table 1. All crops were no-till seeded into an area that was previously spring wheat for two years. The dry early part of the growing season (May and June) provided an opportunity to evaluate crops under moisture stress. Seed yield (Figure 3) and relative yield (Figure 2) for 2002 was the best for grain sorghum, chickpea, and sunflower. Corn, grain sorghum, and proso millet produced the most seed for each inch of water used (Table 2). Canola produced the least seed for each inch of water used.

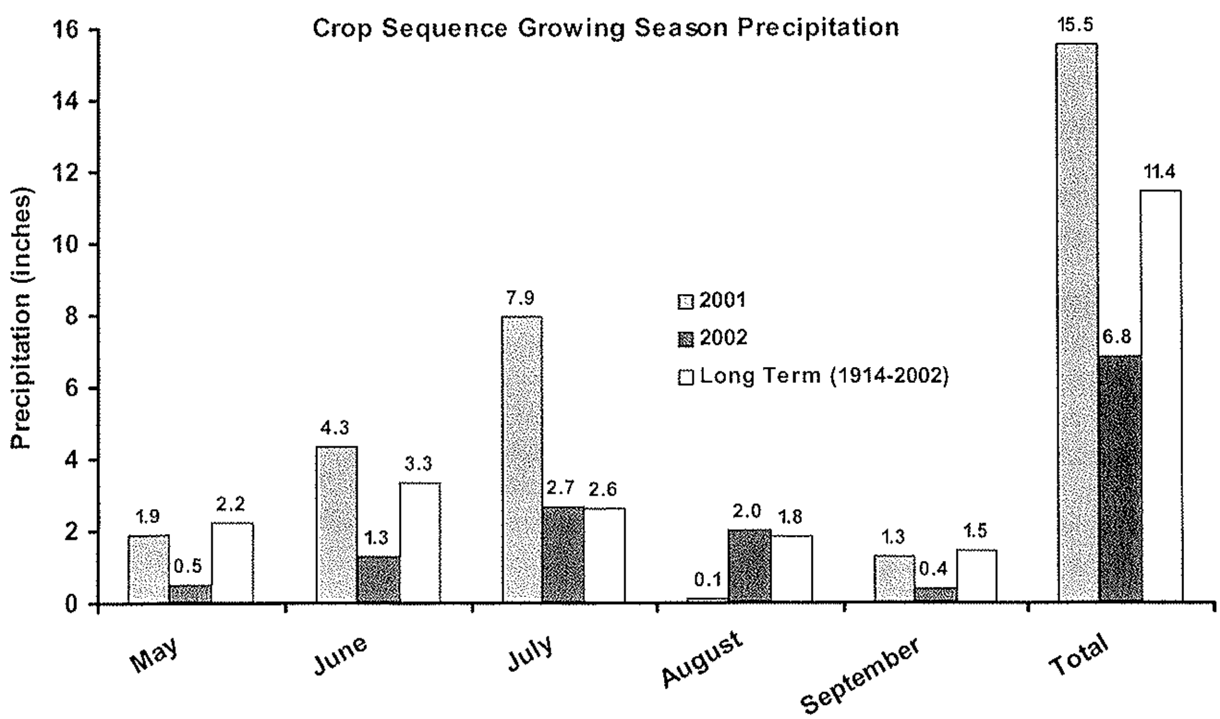


Figure 1. Monthly growing season precipitation for 2001, 2002, and long-term at Mandan, ND.

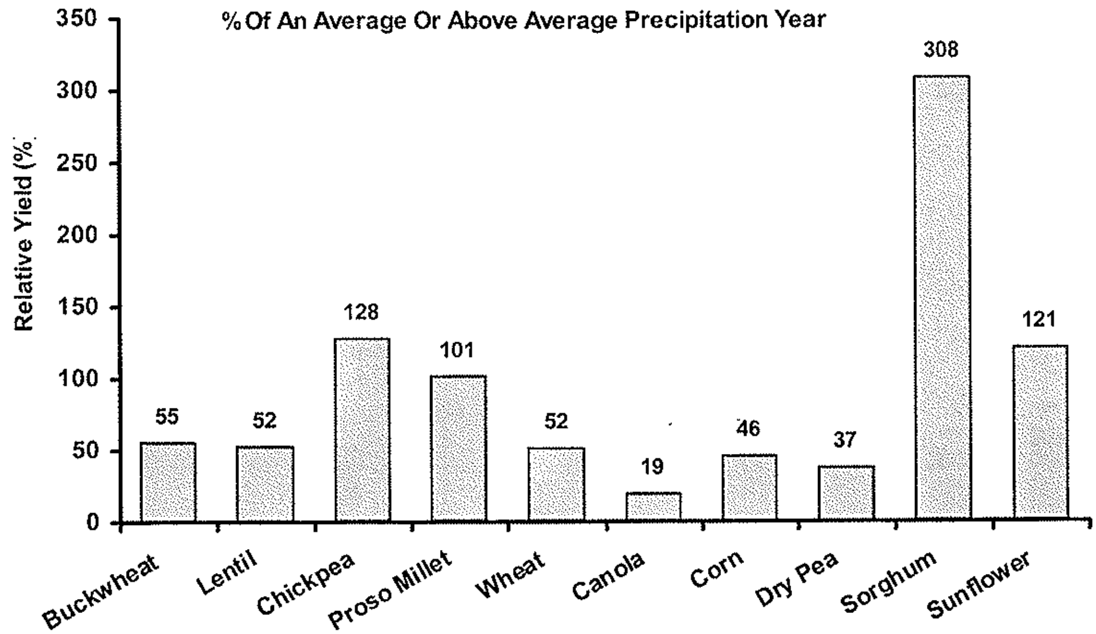


Figure 2. Relative yield for 2002 expressed as a percent of the crop yields from 2001 on average yield from 1999 and 2000 at Mandan, ND.

Table 1. Crop, seeding date, harvest date, plant population, and fertilizer rate for the initiation of the warm season crop sequence research project.

Crop (Cultivar)	Seeding Date	Harvest Date	Target Population (Seeds/acre)	Fertilizer Rate		
				N (lb/a)	P (lb/a)	S (lb/a)
Buckwheat (Koto)	6/5/2002	8/23/2002	910,000	70	10	0
Canola (357RR)	4/26/2002*	8/12/2002	540,000	70	10	10
Chickpea (B-90)	5/13/2002	8/15/2002	180,000	0	10	0
Corn (TF8183RR)	5/22/2002	10/4/2002	28,000	70	10	0
Dry Pea (Profi)	4/26/2002	7/17/2002	350,000	0	10	0
Grain Sorghum (DK28E)	6/5/2002	10/4/2002	200,000	70	10	0
Lentil (Milestone)	5/13/2002	8/15/2002	700,000	0	10	0
Proso Millet (Earlybird)	6/5/2002	9/6/2002	1.3 Million	70	10	0
Sunflower (63M91)	5/30/2002	10/11/2002	28,000	70	10	0
Wheat (Amidon)	4/26/2002	8/8/2002	1.3 Million	70	10	0

* Reseeded on 5/23/2002 because of frost

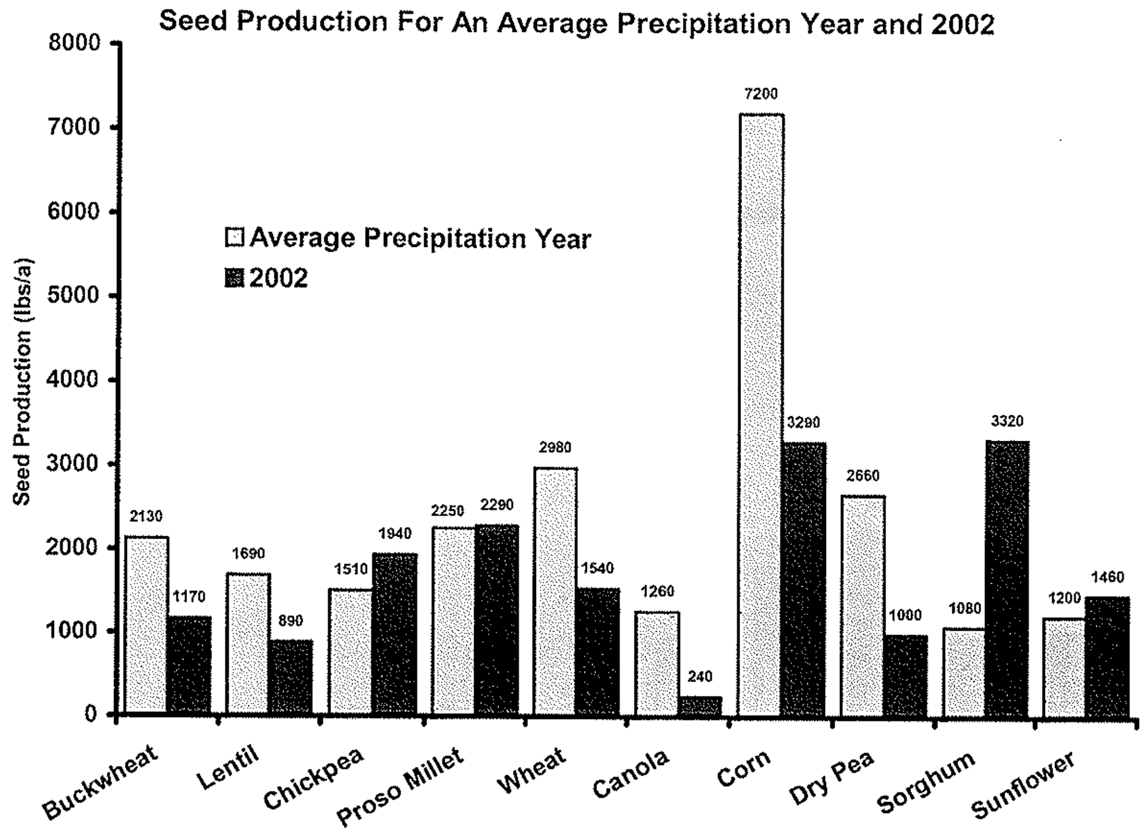


Figure 3. Seed yield for 2001 or an average of 1999 and 2000 (average precipitation year) and 2002 for the ten crops inthe crop sequence project.

Table 2. Water use, seed yield, and seed water use efficiency for the ten crops in the crop sequence project. Water use was soil water at seeding minus soil water at harvest plus precipitation for that period.

Crop Water Use			
Crop Name	**Water Use (in)**	**Seed Yield (lb/a)**	**Seed WUE (lb/a/in)**
Buckwheat	9.25	1172	**126.65**
Canola	10.17	242	**23.77**
Chickpea	10.99	1937	**176.26**
Corn	13.13	3289	**250.41**
Dry Pea	5.74	996	**173.62**
Grain Sorghum	11.53	3317	**287.76**
Lentil	9.42	886	**94.03**
Proso Millet	9.37	2288	**244.25**
Sunflower	14.28	1461	**102.30**
Wheat	8.86	1540	**173.76**

SOIL WATER DEPLETION BY CROPS IN THE LATE SEASON

SOIL WATER DEPLETION BY CROPS IN THE LATE SEASON CROP SEQUENCE EXPERIMENT

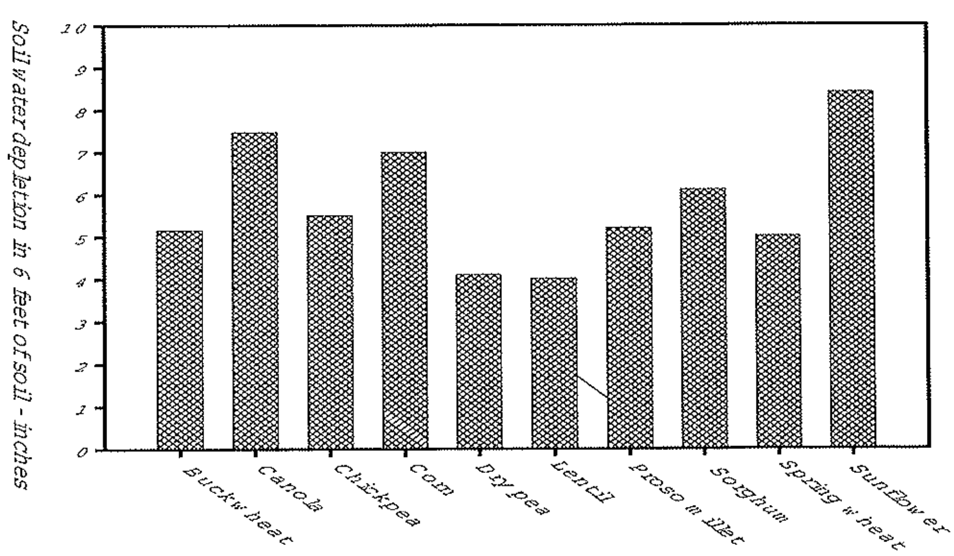
(Phase III of the Diverse Cropping System)

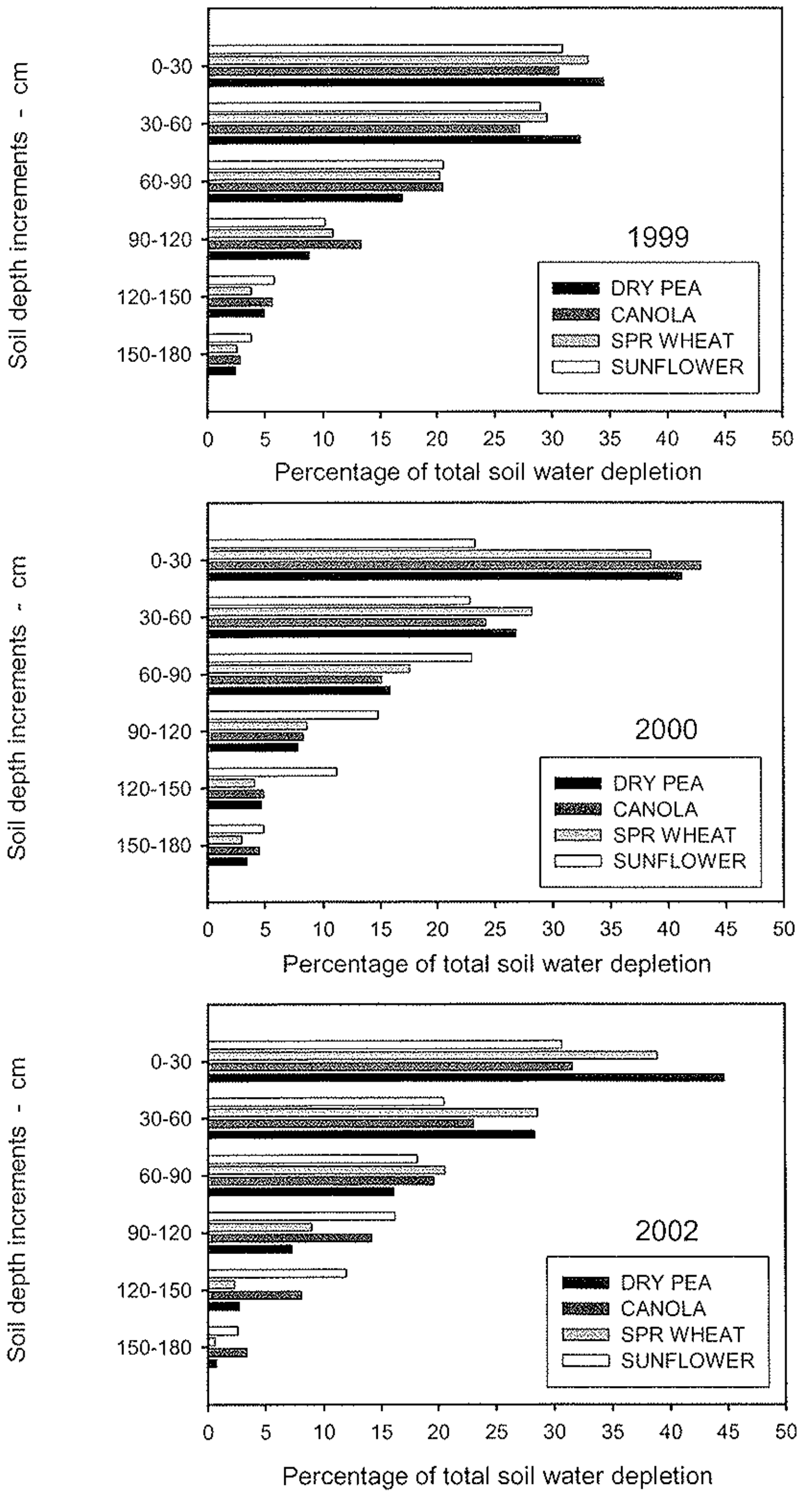
Drs. Steve Merrill, Donald Tanaka, and Joe Krupinsky

Soil water use is the combination of growing season precipitation and water extracted from the soil profile by evaporation and plant transpiration. When comparing dryland crops in the same experiment, differences in water use may be observed as differences in soil water depletion. The 2002 cropping season was the first year that 10 predominantly warmer-season crops were grown on our new Phase III Crop Sequence Experiment at the ARS – SCD's Cooperative Research Farm. Non-destructive soil water measurements were made with neutron moisture meters. Soil water depletion from May to September to a depth of 6 feet are shown in Fig. A. May through August precipitation in 2002 was about 50% less than long-term average, and crops were forced to make up a higher percentage of water use as soil water extraction than observed for crops in our Phase II Crop Sequence Experiment. Sunflower depleted the largest amount of soil water, and dry pea and lentil the least amount in 2002. Both dry pea and lentil are early-season crops. Data from the Phase II experiment taken in 1999 and 2000 showed sunflower to deplete greatest and dry pea the least or nearly the least amounts of soil water. Canola, corn, and sorghum depleted relatively larger amounts of water in 2002. Canola was green when harvested in 2002, and this undoubtedly contributed to its relatively higher water depletion. Earlier measurements with another variety of canola have shown lower relative water depletion and use.

Fig. B shows the distribution of water extraction over soil depth for four of the crops grown in 2002. Both dry pea and spring wheat depleted a relatively greater portion of total water depleted from the upper 2 feet of soil, and a lesser portion from below 2 feet depth compared to sunflower and canola, which both showed deeper relative water depletion. In 2000, canola depletion and use was more similar to that of spring wheat, and its depth distribution of water depletion was also similar to those of dry pea and spring wheat.

Fig. A. Soil water depletions in Phase III Crop Sequence Experiment - 2002. Measured from 13 May to 24 Sept.





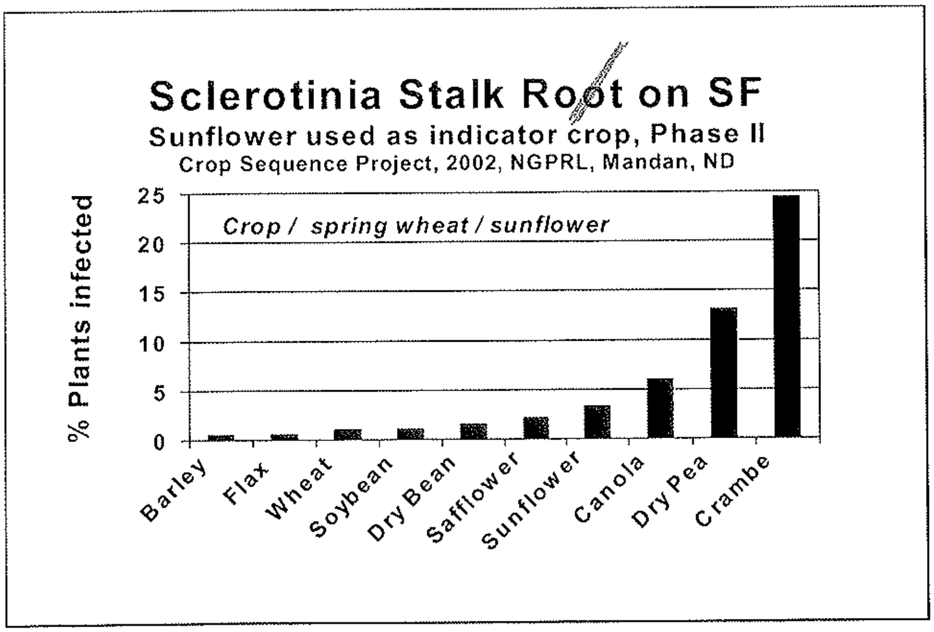
ACKNOWLEDGMENTS
We thank J. Hartel, M. Hatzenbuhler, D. Schlenker, and L. Renner for technical assistance.

MANAGEMENT PRACTICES AND SCLEROTINIA (WHITE MOLD)

Drs. Donald Tanaka, Joe Krupinsky, Steve Merrill, Mark Liebig, Jon Hanson and Thomas Gulya, Jr., USDA-ARS Northern Crop Science Laboratory

The effect of management practices, crop sequence and biological control, on Sclerotinia white mold (*Sclerotinia sclerotiorum*) were evaluated in 2002. Sunflower was used as an indicator crop to detect Sclerotinia in several studies. Sunflower was used as an indicator crop because of its ability to become readily infected through the roots by contact with *S. sclerotiorum* in the soil. Thus, the rating of sunflower for Sclerotinia basal stalk rot will avoid the inter-plot inference possible with the movement of ascospores between plots.

The efficiency of *Coniothyrium minitans* (Intercept WG®) was evaluated for reducing the risk to Sclerotinia disease. Treatments included tillage, the use of a non-host crop (spring wheat) for one season, followed with a susceptible indicator crop to determine the presence of Sclerotinia disease in 2002. Sclerotinia basal stalk rot tended to be less with the *C. minitans* treatment compared to no treatment, and with the no-till treatment compared to the other tillage treatments.



Phase II of the Crop Sequence Project includes a crop by crop residue matrix (grown in 2000) to evaluate the impact of previous crops (safflower, canola, crambe, dry pea, dry bean, flax, soybean, sunflower, spring wheat, and barley) and crop residue on Sclerotinia diseases. A uniform spring wheat crop was seeded over this matrix in 2001 and a sunflower crop was seeded in 2002 to evaluate Sclerotinia disease. The numbers of sunflower plants infected with Sclerotinia basal stalk rot were related to the crops grown in 2000. The highest level of Sclerotinia basal stalk rot was associated with plots where crambe was grown in 2000.

Phase III of the Crop Sequence Project, similar in design to Phase II, was started in 2002. Ten crops (buckwheat, chickpea, corn, lentils, proso millet, grain sorghum, canola, dry pea, sunflower, and wheat) were seeded in strips. Probably, because of the dry conditions in 2002, no Sclerotinia was detected on buckwheat, chickpea, canola, dry pea, or lentil. Sclerotinia basal stalk rot was present on sunflower. Crop residues are now in place for next year's crop matrix. The same crops will be evaluated in 2003.

Contact Information – J.M. Krupinsky, 701-667-3011; krupinsj@mandan.ars.usda.gov

MANAGEMENT STRATEGIES FOR SOIL QUALITY

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

A long-term study was initiated in the spring of 1993 to evaluate the influences of residue management and crop rotations on soil quality. Tillage, crops, and crop residue were all in the appropriate places in 1994. Treatments for the 2002 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 on May 3 at 1.3 million viable seeds per acre. Safflower (cv. Montola 2000) was seeded on May 3 at 200,000 viable seeds per acre. Millet for hay was seeded at 4 million viable seeds per acre on June 6. Residue from previous crops was uniformly distributed for no-till on minimum-till seeding. All no-till plots were sprayed with Roundup (0.375 lb ai/a) prior to seeding while minimum-till plots were tilled with an undercutter about 3 inches deep prior to seeding. Spring wheat, safflower, and millet were seeded with a JD750 no-till drill with N fertilizer banded at seeding and P applied with the seed at seeding. Recrop plots received 60 lb N/a and 10 lb P/a while fallow or partial fallow plots received 30 lb N/a and 10 lb P/a at seeding. Rye was seeded on September 26, 2001 at 1.3 million viable seeds per acre with a Haybuster 8000.

Precipitation for April through June was 37% of the long-term average of 7.0 inches. The low spring precipitation reduced rye total dry matter production as well as spring wheat and safflower seed yield (Figures 1,2, and 3). It is interesting to note that spring wheat grown after millet for hay produced the highest yield (1640 lb/a), even greater than spring wheat on fallow (1580 lb/a). Continuous spring wheat with or without residue produced the lowest yield. Millet hay production for 2002 (3910 lb/a) was close to hay production for the above-average precipitation year of 2000 (5080 lb/a).

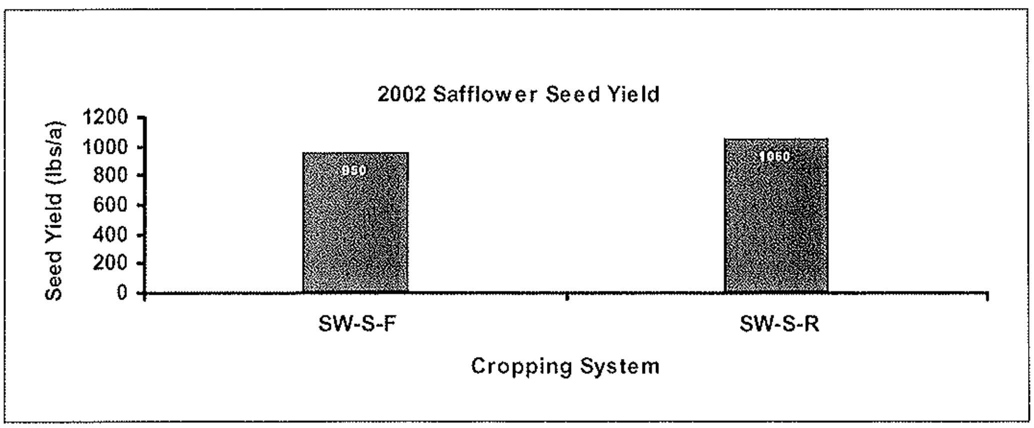


Figure 1. Safflower seed yield as influenced by cropping system. Yields are the average of minimum and no-till.

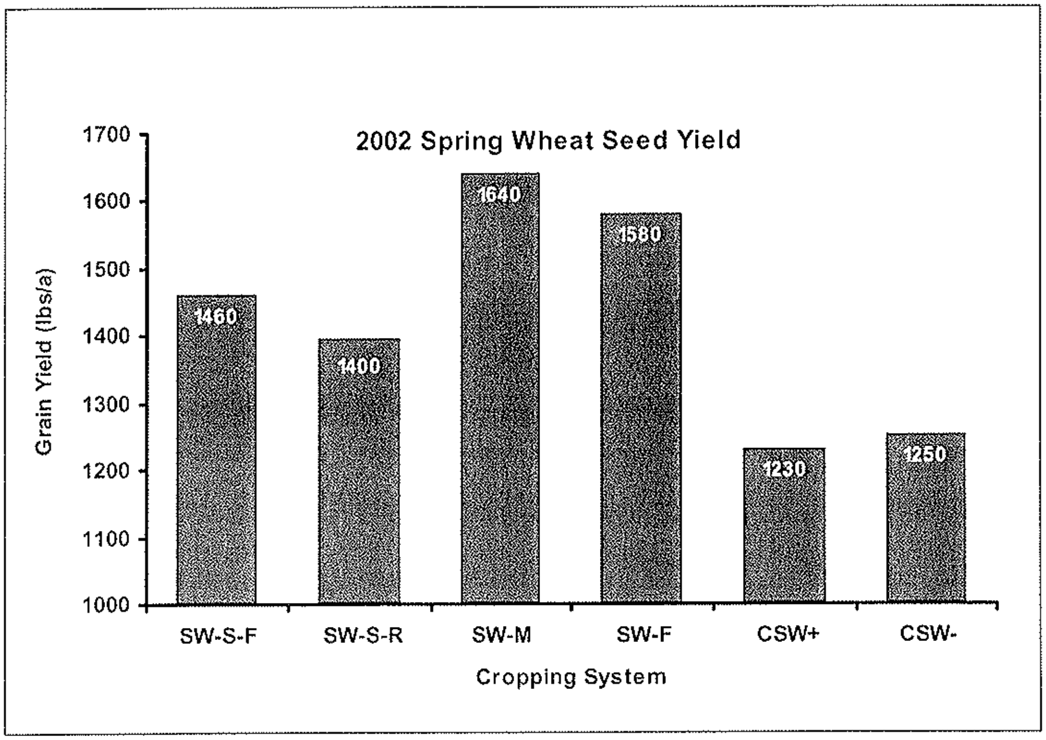


Figure 2. Spring wheat grain yield as influenced by cropping system. Yields are the average of minimum and no-till.

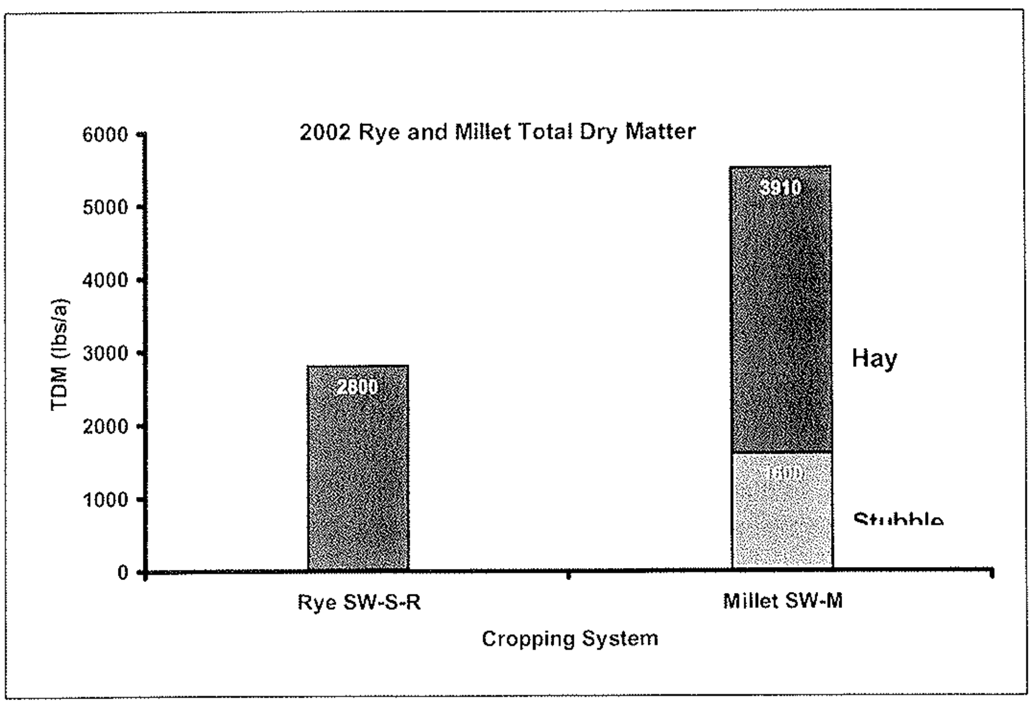


Figure 3. Total dry matter production for rye used as a partial fallow and siberian millet used for hay.

MANAGEMENT EFFECTS ON SOIL QUALITY INDICATORS AFTER EIGHT YEARS IN A LONG-TERM CROPPING SYSTEMS EXPERIMENT

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

Background

The extreme climate of the northern Great Plains of North America requires cropping systems to possess a resilient soil resource in order to be sustainable. While advances in management have been made in the northern Great Plains to enhance cropping system performance, research is needed to better understand the interactions of tillage, crop sequence, and cropping intensity on the broad spectrum of physical, chemical, and biological soil properties considered to be indicators of soil quality. Understanding management effects on near-surface properties, in particular, is vitally important given the impact the soil surface has on erosion control, water infiltration, and nutrient conservation.

In 1993, a long-term cropping systems experiment was established on the Area IV SCD/ARS Research Farm to evaluate the effects of residue management and crop sequence on soil quality. Crop sequences included in the study were as follows:

I. Continuous spring wheat with crop residue left on the soil surface (CSW+)
II. Continuous spring wheat with crop residue removed (CSW-)
III. Spring wheat-millet (SW-M)
IV. Spring wheat-safflower-fallow (SW-S-F)
V. Spring wheat-safflower-rye (SW-S-R)
VI. Spring wheat-fallow (SW-F)

Each crop sequence was split into two tillage treatments: minimum tillage (representing 30-60% soil cover by residue after planting) and no-till (representing >60% soil cover by residue after planting). Each phase of all crop sequences was present every year and treatment combinations were replicated three times.

This research summary reviews the effects of the above treatments on soil physical, chemical, and biological properties considered as indicators of soil quality. Evaluations were conducted in spring 2001 in plots previously cropped to spring wheat. Samples were collected at depths of 0 to 7.5, 7.5 to 15, and 15 to 30 cm and were processed and analyzed following standard methods.

Results

Tillage effects on soil quality indicators were limited to soil bulk density, particulate organic matter (POM), potential mineralizable nitrogen (PMN), and microbial biomass C (Table 1). Trends in soil bulk density are generally considered a rough approximation of soil structural changes. In light of this, no-till (NT) resulted in greater soil consolidation at 0 to 7.5, while minimum till (MT) resulted in tillage-induced compaction at 7.5 to 15 cm. Absolute differences in soil bulk density between treatments at both depths, however, were quite small (0.02 to 0.03 Mg m^{-3}). Furthermore, none of the bulk densities measured were high enough to affect crop root growth.No significant differences were observed between tillage treatments among soil chemical properties, although soil pH values for both treatments fell within the moderately acid range (Table 1).

Table 1. Mean values of soil properties as affected by minimum tillage and no-till.

	MINIMUM TILLAGE	NO-TILL
0 to 7.5 cm[†]		
Soil bulk density ($Mg\ m^{-3}$)	1.26 a[‡]	1.29 b
EC ($dS\ m^{-1}$)[§]	0.18	0.17
Soil pH ($-\log[H^+]$)	5.87	5.89
Soil NO_3-N ($kg\ ha^{-1}$)	5.5	5.6
SOC ($Mg\ ha^{-1}$)	20.36	19.79
TN ($Mg\ ha^{-1}$)	2.17	2.14
POM ($Mg\ ha^{-1}$):		
0.053 to 0.5 mm	5.85 a	5.44 b
0.5 to 2.0 mm	1.39 a	1.18 b
0.053 to 2.0 mm	7.24 a	6.62 b
% as SOM	11.9 a	10.8 b
PMN ($kg\ ha^{-1}$)	19.2 a	15.8 b
Microbial biomass C ($kg\ ha^{-1}$)	705 a	620 b
Microbial biomass N ($kg\ ha^{-1}$)	43	39
7.5 to 15 cm		
Soil bulk density ($Mg\ m^{-3}$)	1.41 a	1.39 b

[†] Data for all properties are presented for 0 to 7.5 cm. Below 7.5 cm, only properties affected by tillage are shown.

[‡] Values within a row followed by a different letter are significantly different at $P<0.1$.

[§] EC = Electrical conductivity; SOC = Soil organic carbon; TN = Total nitrogen; POM = Particulate organic matter; PMN = Potentially mineralizable N.

Particulate organic matter (POM) was greater under MT than NT (Table 1). This trend was consistent for both POM fractions (0.053 to 0.5 and 0.5 to 2.0 mm) as well as the percentage of POM present as soil organic matter. This somewhat surprising result was apparently caused by greater production of crop residue in MT (Table 2). While NT systems under annual cropping typically enhance biomass production relative to other forms of tillage in semi-arid environments, the wetter than normal growing conditions since 1993 may have resulted in greater biomass production in systems where the soil was able to dry out and warm up earlier in the growing season. Such a microclimatic effect may have occurred in MT relative to NT, thereby resulting in a greater return of residue to soil in the form of stover and roots. The trend of higher soil organic carbon (SOC) and total nitrogen (TN) in MT as compared to NT strengthened this possible explanation, along with the significantly higher levels of PMN and microbial biomass C in MT (Table 1).

Table 2. Mean values of stover yield over 8 yr as affected by tillage and crop sequence.

Treatment	Crop residue (Mg ha^{-1})
Tillage	
Minimum tillage	26.6
No-tillage	26.0
LSD (0.1)	NS
Crop sequence	
CSW+	31.4
CSW-	29.3
SW-M	30.3
SW-S-F	19.9
SW-S-R	27.2
SW-F	19.6
LSD (0.1)	2.1

Continuous cropping tended to enhance near-surface soil condition relative to crop sequences that included fallow (Table 3). Soil quality indicators affected by crop sequence included soil pH, electrical conductivity (EC), POM, PMN, and microbial biomass C. Crop sequence effects on soil pH were driven by the acidifying effect of N fertilization. The sequence receiving the least fertilizer N (SW-F) possessed the highest soil pH (6.05), while the sequences receiving the most fertilizer N and having the highest average stover production (CSW+, SW-M) possessed the lowest soil pH (5.77). Soils throughout the Northern Great Plains possess a buffer against acidification because they are often rich in $CaCO_3$, resulting in soil pH levels near neutral or slightly alkaline in the surface horizons. Given the trend in soil pH among crop sequences within the first 8 yr of the experiment, however, it is apparent lime application will eventually be necessary on this soil for crops to reach their full physiological potential.

Particulate organic matter, the fraction of soil organic matter composed mainly of plant residue, was greatest in continuous spring wheat (CSW+ and CSW-) and lowest in sequences with fallow (SW-S-F and SW-F) (Table 3). This general trend among crop sequences was similar for the 0.053 to 0.5 mm POM fraction, which made up an average of 82% of total POM. The larger POM fraction (0.5 to 2.0 mm), was significantly greater in CSW+ as compared with the other sequences; likely a reflection of the effect of stover production and its retention on the soil surface for this less-degraded soil organic matter fraction. The percentage of POM present as soil organic matter was different among crop sequences with CSW+ possessing the most (13.3%), CSW-, SW-M, and SW-S-R intermediate (Avg. = 11.7%), and SW-S-F and SW-F the least (Avg. = 9.8%).

Potentially mineralizable N was greater in CSW- (22.5 kg ha^{-1}) than all other crop sequences (Avg. = 16.5 kg ha^{-1}), indicating greater N mineralization potential over the growing season for that crop sequence (Table 3). The same sequence possessed significantly greater microbial biomass C (792 kg ha^{-1}) as compared with sequences with fallow (SW-S-F and SW-F; Avg. = 577 kg ha^{-1}). Microbial biomass is an important indicator of soil quality, functioning as an agent for the transformation of organic matter and the cycling of plant nutrients.

Table 3. Mean values of soil properties as affected by crop sequence.

SOIL PROPERTY	CSW+	CSW-	SW-M	SW-S-F	SW-S-R	SW-F
0 to 7.5 cm†						
Soil bulk density (Mg m^{-3})	1.26	1.31	1.26	1.27	1.26	1.28
EC (dS m^{-1})‡	0.18	0.17	0.17	0.18	0.18	0.17
Soil pH (-log[H^+])	5.77 c§	5.87 bc	5.77 c	5.95 b	5.89 b	6.05 a
Soil NO_3-N (kg ha^{-1})	6.6	5.6	6.0	5.3	5.8	4.3
SOC (Mg ha^{-1})	20.66	22.31	20.93	19.31	18.28	18.76
TN (Mg ha^{-1})	2.19	2.33	2.20	2.05	2.08	2.08
POM (Mg ha^{-1}):						
0.053 to 0.5 mm	6.35 ab	6.68 a	5.92 bc	4.83 d	5.34 cd	4.76 d
0.5 to 2.0 mm	1.98 a	1.27 b	1.46 b	0.93 c	1.16 bc	0.93 c
0.053 to 2.0 mm	8.33 a	7.95 ab	7.38 b	5.76 c	6.50 c	5.69 c
% as SOM	13.3 a	12.0 b	11.9 b	9.7 c	11.1 b	9.9 c
PMN (kg ha^{-1})	16.0 b	22.5 a	17.4 b	14.8 b	17.4 b	17.0 b
Microbial biomass C (kg ha^{-1})	673 ab	792 a	695 ab	591 b	663 ab	562 b
Microbial biomass N (kg ha^{-1})	40	52	43	40	42	28
7.5 to 15 cm						
EC (dS m^{-1})	0.15 ab	0.16 a	0.14 b	0.15ab	0.14 b	0.14 b

† Data for all properties are presented for 0 to 7.5 cm. Below 7.5 cm, only properties affected by crop sequence are shown.

‡ EC = Electrical conductivity; SOC = Soil organic carbon; TN = Total nitrogen; POM = Particulate organic matter; PMN = Potentially mineralizable N.

§ Values within a row not followed by the same letter are significantly different at $P<0.1$.

Conclusions

Trends in soil organic matter related properties indicated continuous cropping and minimum tillage were creating a more favorable plant growth environment relative to crop sequences with fallow or no-till. Differences in soil properties between tillage treatments, however, may have resulted from abnormally wet soil conditions atypical to the Great Plains region. Results from the first eight years of the experiment confirm that farmers in the northern Great Plains can improve soil quality by adopting production systems that employ intensive cropping practices with reduced tillage management.

Summary adapted from: Liebig, M.A., D.L. Tanaka, and B.J. Wienhold. Tillage and cropping effects on soil quality indicators in the northern Great Plains. *Soil and Tillage Research* (Accepted for publication, 7/31/02).

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). Plots were hayed on October 11, 1994 and tillage and spray operations were done on October 14, 1994.

The 2001 spring wheat crop (cv. Amidon) was no-till seeded on May 4 with a JD 750 drill at 1.3 million viable seeds per acre. All plots received 30 lb N/a banded at seeding with 10 lb P/a applied with the seed. The previous crop was dry pea. A pre-emergence burn down of Roundup (20 oz/a) was applied on May 10 to all plots. Spring wheat was harvested on August 14. The addition of 60 lb N/a over the past 6 years did not result in increased spring wheat yields on CT, but the fertilizer did increase yield on MT and NT when compared to no fertilizer addition (Figure 1). NT and MT may have the potential to sustain the positive crop production benefits of the CRP perennial vegetation longer than CT.

On August 29, Roundup Ultra Max (16 oz/a) plus 24-D (LV4, 16 oz/a) was used to control post harvest weeds. As agreed on in the contract, intermediate wheatgrass and alfalfa were seeded in the research area on September 5. Evaluations of grass and alfalfa stands in the spring of 2003 will determine if grass and/or alfalfa needs to be reseeded.

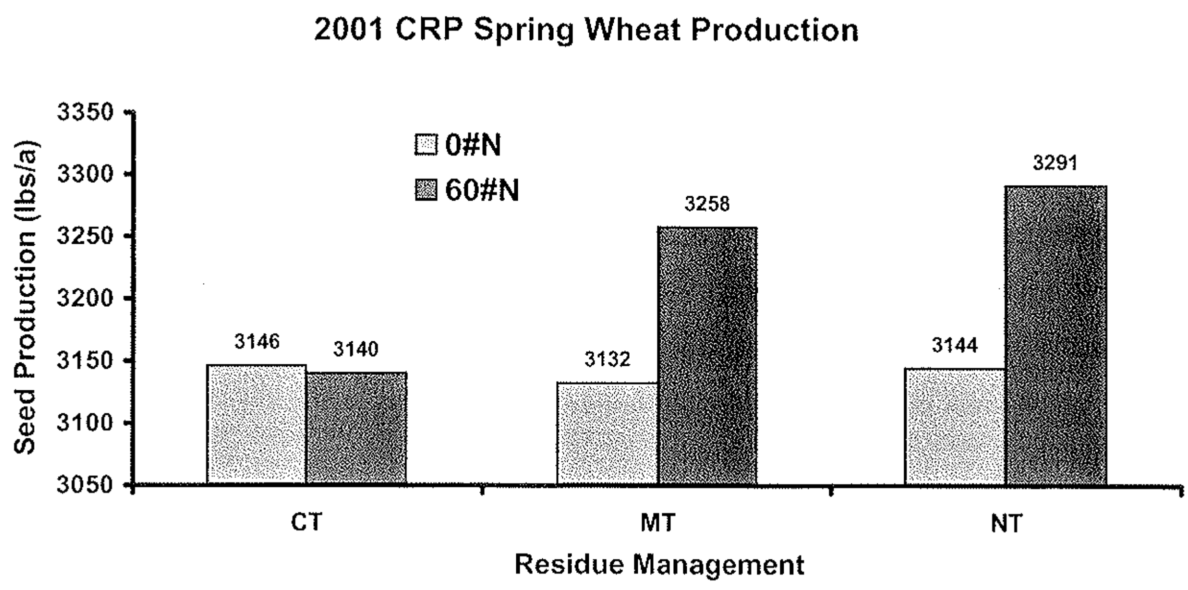


Figure 1. Spring wheat grain yields as influenced by previous residue management and fertilizer application (0 or 60 lb N/a) in 2001. Conventional-till (CT), <30% surface cover; minimum-till (MT), 30 to 60% surface cover; and no-till (NT), >60% surface cover, residue managements.

WATER EROSION ON POST-CRP LAND CONVERTED TO CROP AND HAY PRODUCTION

Drs. Steve Merrill, Donald Tanaka, and Mark Liebig, ARS, Mandan, and Drs. Chi-hua Huang, ARS, West Lafayette, IN, Fen-li Zheng, CAS, Yangling, Shaanxi, China, and Fréderic Darboux, INRA, Orléans, France.

There is concern about how to establish soil conserving management on lands converted from CRP to crop production. In August and September 2000, a team of scientists from both our lab and the ARS West Lafayette IN location conducted a rainfall simulation study on CRP land that was the site of a crop and hay production experiment. Starting with the 1995 cropping season, we established a study on CRP land with loam-textured surface soil near the Research Farm that included three tillage treatments (conventional-, minimal-, and no-till) in a spring wheat – winter wheat – dry pea rotation, annual hayed plots, and CRP undisturbed. Conventional-till consisted of pre-plant tandem disk tillage. Weed control was with glyphosate and other compounds. After dry pea harvest, a rainfall simulator was set over bordered runoff plots (5 ft. wide, 16 ft. long) on land with 4% slope. The hayed plots were closely mowed before runoff/erosion measurements. To simulate natural rainfall, we used purified water manufactured for us by the U. S. Army Reserves. For each setup, a series of simulated rainfalls at different rates were carried to approximately steady runoff flow. Soil erodibility is a durable measure of vulnerability of soil and land to water erosion. Soil erodibility values were calculated as the rate of soil erosion loss divided by rate of runoff flow at near steady state.

The conventional-till treatment (which often had greater than 30% soil coverage by residue) showed approximately 6 times greater soil erodibility than the no-till treatment (see Fig. 1). Probably our most important result is that, on average, the cropped no-till treatment had the same low soil erodibility value (about 0.3 erodibility units) as that of the CRP land put into annual hay production. This indicates the value of longer-term, established no-till management for conversion of set-aside lands to crop producton. It is probable that our particular results are based on conditions of the study, which included a relatively moderate, 4% slope, a higher-residue producing, wheat-dominated rotation, and the fact that in the 6 cropping years prior to our measurements, precipitation was either near average or above average. It is believed that more droughted conditions, lower residue-producing crop rotations, steeper slopes, and more fragile soils would prove to be a greater soil erosion challenge to no-till management than was the case with our study. Soil erodibility of plots that had been subjected to thorough tillage (multiple passes with an offset disk) soon before measurement was from about 3 times to over 10 times greater than that of undisturbed plots. Erodibility of tilled treatments was greatest on conventional-till, intermediate on no-till, and least on the hayland treatment.

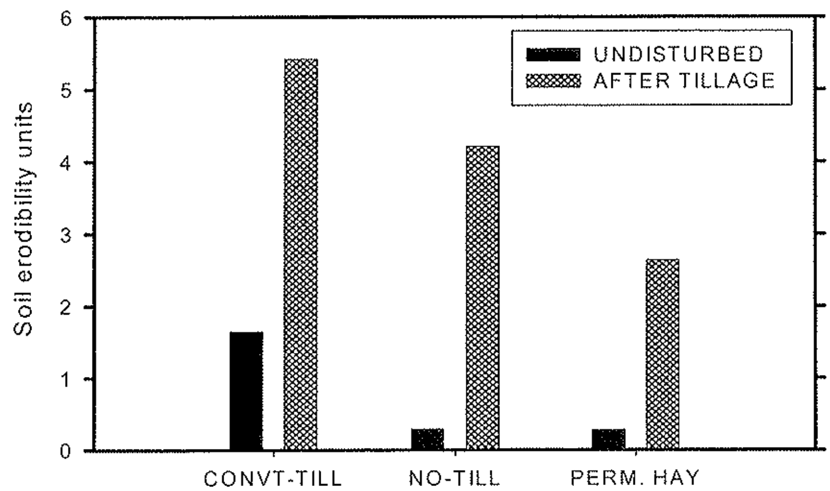


Figure 1. Soil erodibility measured in land use treatments using rainfall simulation. Measurements were conducted in Aug. and Sept. 2000 at end of 6th cropping season after conversion of land from CRP.

SITE-SPECIFIC FARMING IN WESTERN ND- 2002

Vern Hofman, Ext. Ag. Engineer, NDSU Extension Service

Introduction: The site-specific farming project in cooperation with Area IV SCD and USDA-ARS was continued on fields I 4, 5 & 6 at Mandan. Intensive soil sampling, variable fertilizer application, aerial photography, yield monitoring and cropping cost analysis have been the emphasis areas.

In previous years, this demonstration has shown.

1. Soil sampling based on topographic zones provides residual fertilizer information with accuracy similar to grid soil sampling at a cheaper cost.
2. Variable rate fertilizer application is good for the environment as only enough fertilizer to produce a crop is applied. This reduces the amount of N available that may move through the soil profile and contaminate underground water supplies.
3. Sunflower is an excellent crop with a tap root that can reach to the 3 to 5 ft. depths and retrieve crop nutrients. This is sometimes needed when the previous crop left fertilizer in the soil.
4. Yield monitoring of a field is an excellent way to determine variability across a field. This can also be helpful along with soil test information to determine the amount of fertilizer to apply to the next year's crop.

Year 2002

This production year produced a much below normal wheat crop. This was due to below normal rainfall during the previous year. The winter wheat produced an average of 14.8 bu/acre while the spring wheat produced only 6.7 bu/acre. Sunflower produced a crop that averaged over 2100 lbs. per acre which was very good in a dry year. Fields I 4 and I 6 yield contour maps are shown in Fig. 1. Field I 4 produced a fairly uniform yield at over 2100 lbs./acre with two areas well over 2300 lbs/acre. This field is relatively uniform in soil type which produced a uniform crop. Field I 6 was in winter wheat. A large part of the field had yields under 14 bu/acre (the white area), while the north end of the field produced well over 20 bu/acre. This is indicated by the gray area near the dark streak across the field. The dark streak is a drain across the field that flattens out near the right side of the field. The lower area in the field contained good soil with good moisture holding capability. As can be seen from the I 6 field, this was the only part of the field that produced a reasonably good crop. Table 1 is an estimate of the crop returns, costs and net returns. The wheat crops lost money while the sunflower crop produced a good net return.

Table 1: I 4, 5, & 6 Crops Returns, Costs and Net Returns.

Field	Crop	Average Yield/Acre	Average Income/Acre	Estimated Cost/Acre	Average Return/Acre
I 4	Sunflower	2,112 lbs./ac	$232.32	$130/ac	$ 102.32/ac
I 5	Spring Wheat	6.7 bu/ac	$ 23.85	$100/ac	$-76.15/ac
I 6	Winter Wheat	14.8 bu/ac	$ 52.54	$100/ac	$-47.46/ac

Figure 2 indicates the residual nitrogen remaining in the three I fields down to the 4 ft. soil depth. All three fields soil tests are shown combined together. Te left side (I 4 field) shows a large (white) area of low N. This was where sunflower was grown in 2002. A good crop was produced and little N is remaining in the soil. The center section (I 5field) produced a very low yielding spring wheat crop and shows a very high amount of N in the soil. The right side (I 6 field) had a slightly better crop yield which used more N than the spring wheat but left some N remaining in the soil. Winter wheat was planted on the I 6 field last fall and will have more fertilizer added next spring by variable application to better utilize the residual N remaining. The center field, I 5 will be planted to sunflower to utilize the N that moved to the 3 to 5 ft. level. Fertilizer will be applied variable rate to utilize the residual N more accurately based on soil type and soil tests.

Remote Sensing:

The past two years, a remote-controlled airplane has been used to photograph the three I fields. The method is being studied to obtain aerial photos of fields at an economical cost. The airplane shown in Figure 3 has an 8 ft. wingspan and is about 5 ft. long. A digital camera is mounted inside which is controlled by a switch on the RC control panel. The plane will operate for about 20-25 minutes allowing us to take about 30 pictures of a field. After landing the pictures are downloaded to a computer to check for quality. If more pictures are needed, the plane can be flown again. One of the main problems encountered is wind. Out in the field, the plane needs to take off from roads. Often, the wind is blowing at an angle to the road making for a difficult takeoff. Also, wind makes it difficult to get the plane high enough to get a large portion of the field. Our latest plane (Fig. 3) has automatic leveling which helps keep the camera stable and directed down.

Some good pictures have been obtained and look to be an excellent way for crop producers to get pictures at an economical cost. This method will be investigated further as aerial photography can be another good way to look at a crop during the growing season. We are also looking at taking infra-red pictures so plant vigor or poor plant growth might be identified.

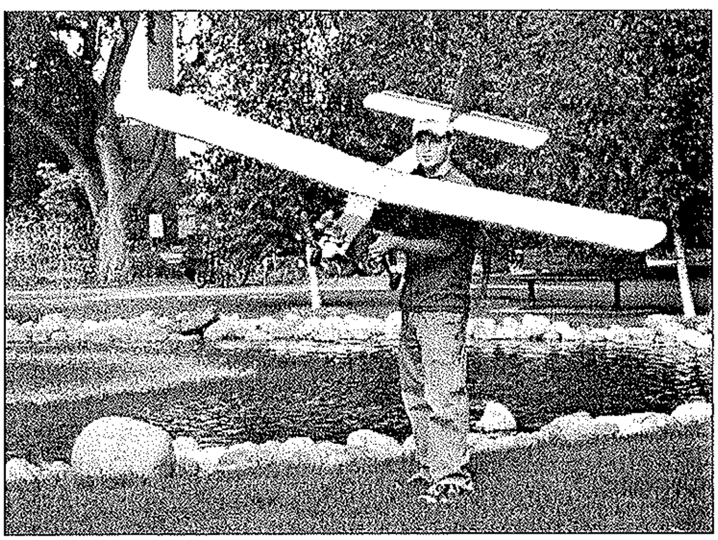


Figure 3.

Figure 1 Yield Maps

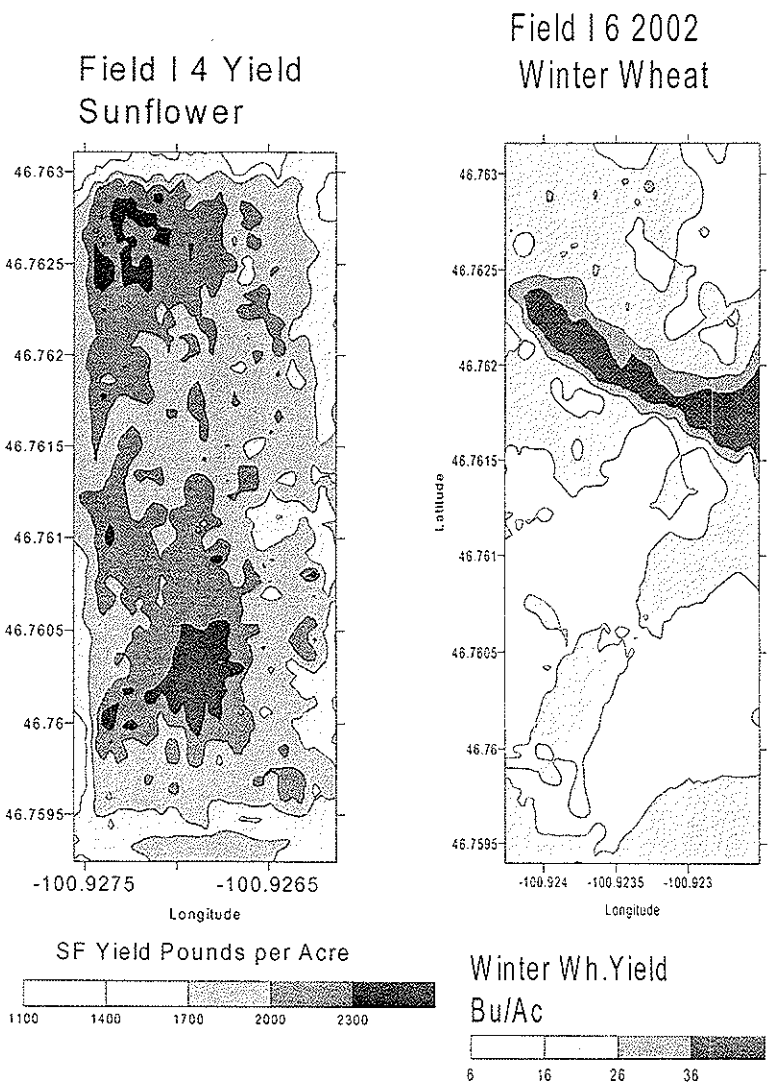


Figure 2 Residual Nitrogen

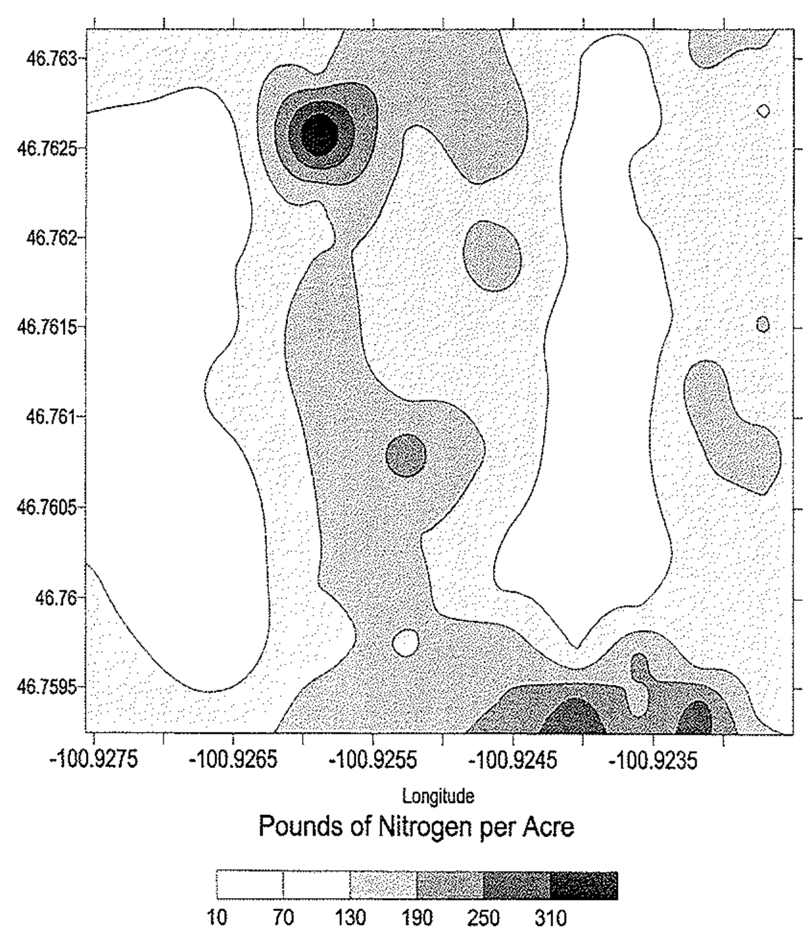


Table 4. Composition of feeds used during the winter of 2001-2002.

	CP[1]	IVDMD[1]	NDF[1]	ADF[1]	P[1]
Feedstuff	% of DM	%	% of DM	% of DM	% of DM
Hay, baled and fed in drylot	9.7	61.1	67.2	44.8	0.13
Western wheatgrass, swathed	6.3	58.5	70.5	46.6	0.09
Corn, drilled and swathed	6.2	72.0	64.7	33.7	0.15
Triticale straw, swathed	5.2	53.0	81.3	57.8	0.11
Oat/pea straw, swathed	6.1	52.3	77.7	56.4	0.12
Grain supplement	20.6	91.9	26.9	6.6	0.46

[1]CP=crude protein, IVDMD=in vitro dry matter digestibility, NDF=neutral detergent fiber, ADF=acid detergent fiber and P=phosphorus.

Some forages that could be used for winter feeding are shown in Table 2. Notice that some of the feeds provide more nutrients than required and some provide less.

Table 5. Some forages that might be used to winter cows.

	TDN % DM	ME, Mcal/lb	CP % DM	Ca % DM	P % DM
Alfalfa hay	66.0	1.08	22.2	1.71	0.30
Brome hay, early	74.0	1.22	21.3	0.55	0.45
Brome hay, late	53.0	0.87	6.0	0.26	0.22
Barley Straw	40.0	0.65	4.4	0.30	0.07
Corn stalks	50.0	0.82	6.6	0.57	0.10
Oat hay	53.0	0.87	9.5	0.32	0.25

Nutrient Requirement of Beef Cattle, National Research Council 1996.

ALFALFA BREEDING RESEARCH

Dr. John Berdahl

Experimental populations of alfalfa, developed by crossing purple-and yellow-flowering selections, have approximately two-thirds yellow-flowering parentage. These 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, which improve long-term survival but reduce regrowth after cutting or grazing.

NON-TRADITIONAL FORAGES TO HELP WITH DROUGHT SURVIVAL

Dr. Scott Kronberg

Our climate appears to be warming and may become dryer and/or more erratic. Cattle producers would be wise to develop a production system that will allow them to tolerate two dry years in a row without major destocking. Making a production system more drought tolerant will probably require adjusting the whole system in a variety of ways not just tweaking the old system. Production systems that are barely profitable in years with higher cattle prices are ripe for disaster when drought and low prices occur together as they often do. In contrast, a production system that is very profitable when cattle prices are higher and slightly profitable when prices are lower is probably more drought tolerant. Most producers can't imagine having a highly profitable cattle production system, yet studies show that there are a small percentage of cattle producers who have highly profitable systems. Marginally profitable producers who have little drought tolerance probably need to be open to major changes if they wish to be more profitable and drought tolerant, and change comes hard to most of us. There are many changes a producer might make to become more profitable and drought tolerant and the best changes vary with the unique conditions of each producer. One example of a relatively simple but difficult change that might make a cattle producer in the western Dakotas more profitable and less susceptible to drought could be to sell or lease out all or part of their ranch in the western Dakotas at rates more associated with recreation than agriculture then buy or lease land in the eastern Dakotas that has higher average precipitation and a better ratio of price to productivity. Another relatively simple change that could help a western Dakota producer adjust to long-term dryer and/or more erratic rainfall could be to reduce their cow numbers and graze yearlings (perhaps for someone else) whose numbers can be adjusted easier depending on forage availability. The following information might lead to useful additions to a whole set of changes toward a more drought tolerant system that might even turn out to be more profitability in dry and wetter years.

With careful and conservative grazing management on the northern Great Plains, a considerable amount of old cool-season grass from the previous year should be available for grazing during a dry year. If this old grass is from cool-season species like the wheatgrasses and smooth bromegrass, it will be about 50 % digestible and provide a tolerable source of energy for cattle and sheep as long as additional crude protein is supplied to the animals to meet the nitrogen needs of their rumen microbes. Unfortunately, warm season grasses like switchgrass and the bluestems do not work well for this purpose because of their lower digestibility when mature, so producers need to be aware of the species composition of their forage base. In dry years and during winter crude protein is in short supply on the grasslands of the Dakotas because these rangelands currently have few palatable shrubs and trees.

One important benefit of palatable shrubs and trees is that some produce lots of leaves with higher levels of protein all year even in dry years. The three native shrub species discussed below all occur in the western half of the Dakotas, but are more common in the dryer western states (they tolerate aridity well).

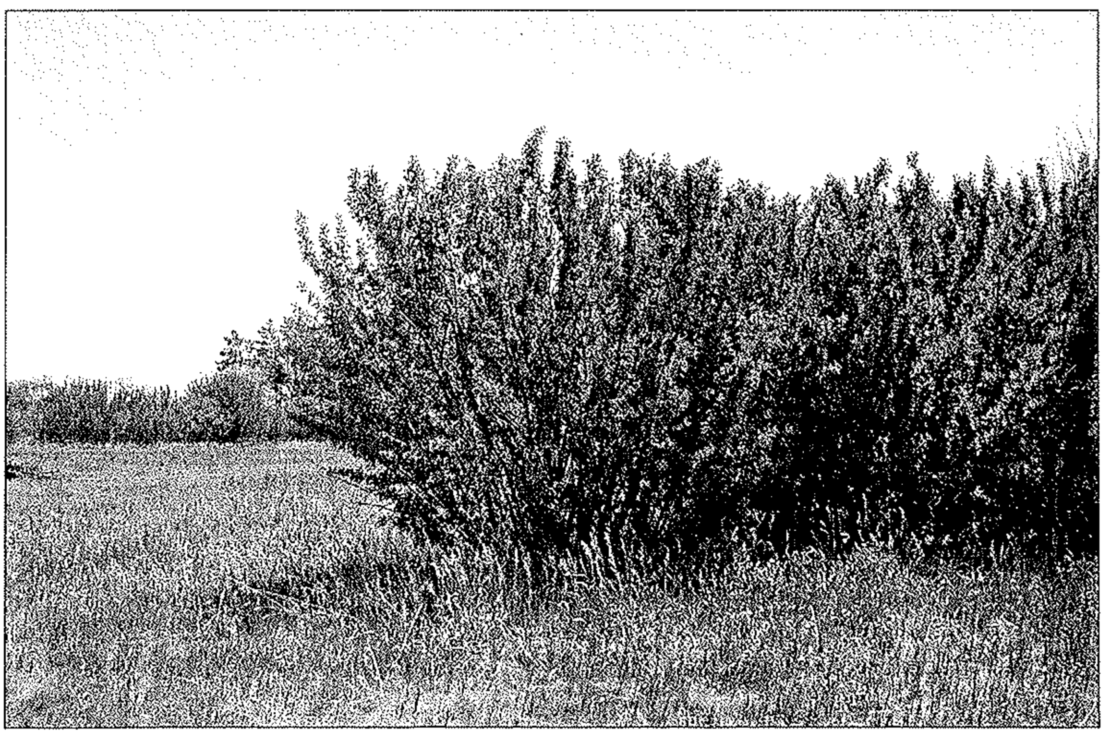
Winterfat is a shrub that grows on hillsides, uplands and plains. The shrub four-wing saltbush grows in many different types of soil. Both of these shrubs grow in colder weather than will grasses and will retain some or most of their leaves through winter. Both shrubs are fairly easy to establish from seed.

Winterfat on the left and four-wing saltbush on the right. Photograph taken at the Bismarck Plant Materials Center in late fall of 2002.

Silver sagebrush is another useful shrub. Silver sagebrush is less palatable to cattle than winterfat and four-wing saltbush, but cattle will browse silver sagebrush in winter especially when they are deficient in crude protein. Silver sage grows in river valleys, on terraces and uplands in moist to moderately dry soils. It tends to be more abundant in deep loamy to sandy soils, and can be challenging to establish from seed.

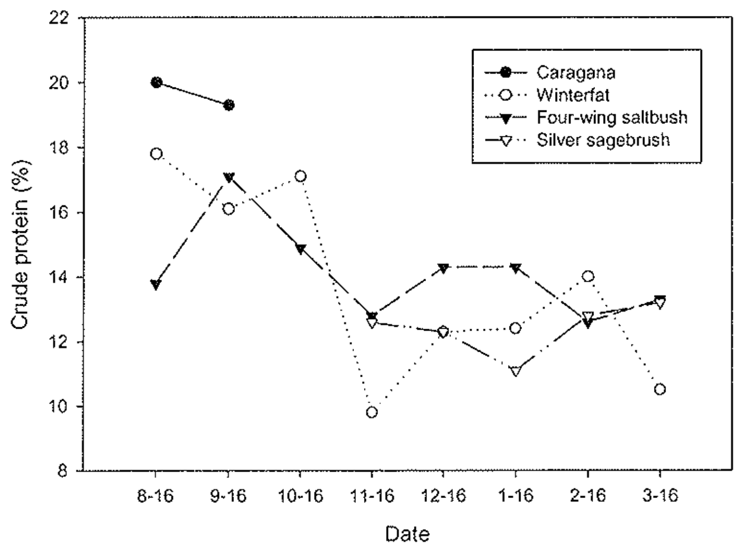
Caragana, a small leguminous tree, is another species that can improve the diet quality of cattle in summer. This tree is often used in Dakota shelterbelts and must be protected from cattle for that use. Since it is deciduous, it leaves can only be useful forage for cattle during the growing season. It is considered drought tolerant, and its leaves have very high levels of crude protein.

Young silver sagebrush at the Northern Great Plains Research Lab in the summer of 2002.

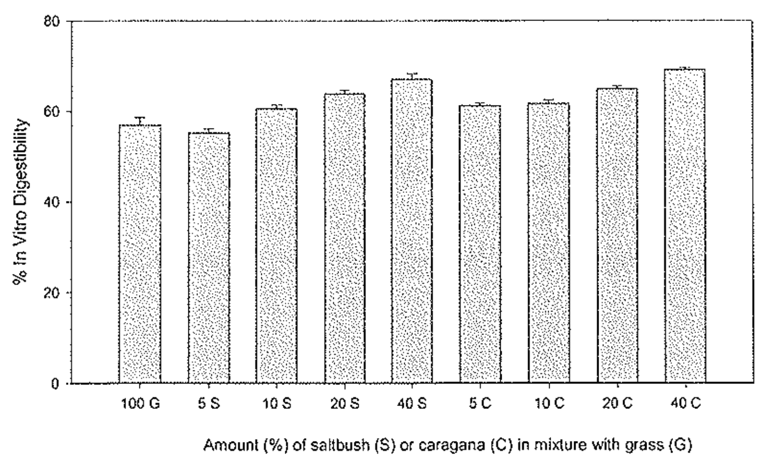


Mature caragana at the Northern Great Plains Research Lab in summer 2002.

Crude protein levels for caragana in late summer, for winterfat and four-wing from late summer through winter, and for silver sagebrush in winter.



Digestibility of mature grass or mature grass mixed with varying amounts of four-wing saltbush or caragana. Small improvements in digestibility lead to larger increases in digestible energy intake.



Finally, one should ask: Why bother establishing palatable shrubs and trees instead of just feeding protein supplements to animals grazing old grass? In answering this question remember that trees can moderate the environment and reduce stress on animals (shade on hot summer days and winter wind and blizzard protection), which can improve animal productivity. Also, shrubs and trees have the potential to store considerable amounts of carbon that producers may soon be paid to capture.

DROUGHT EFFECTS ON GRASSLAND PROCESSES

Dr. John Hendrickson, Rangeland Scientist

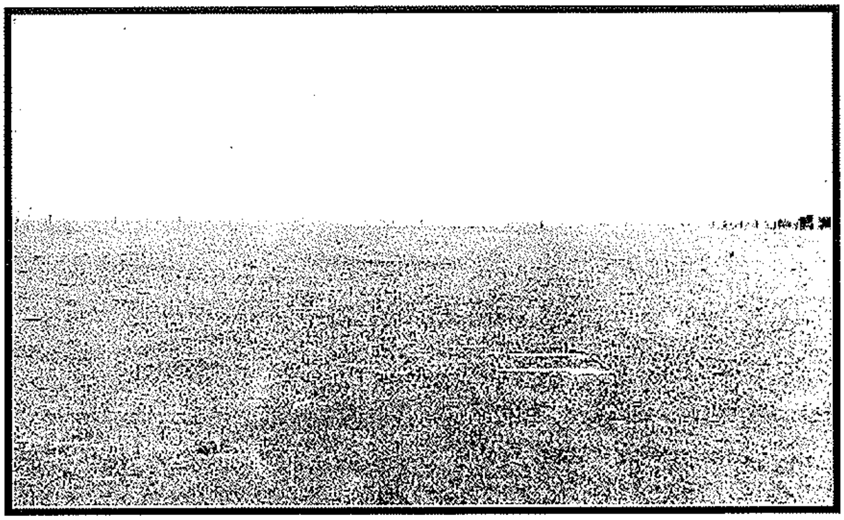
Drought is a word that has different meanings for different people but there is not a clear concise definition. The Society of Range Management defines drought as a period of "prolonged dry-weather, generally when precipitation is less than ¾ of the annual amount". Using this definition to examine the weather records at the Northern Great Plains Research Laboratory in Mandan from 1914 to 2000 reveals that 12 of the 87 years or about 14% were drought years. This means, as many people have pointed out, drought is a normal but unpredictable part of the climatic fluctuations in the Northern Great Plains. Therefore, it is necessary to include the potential for drought in all range management planning.

Not only does the severity of drought influence grassland processes but the timing of drought may also have an impact. In the Northern Great Plains, many grasslands are dominated by cool-season grasses. A lack of rainfall early in the growing season may reduce their forage productivity even if adequate rainfall falls later.

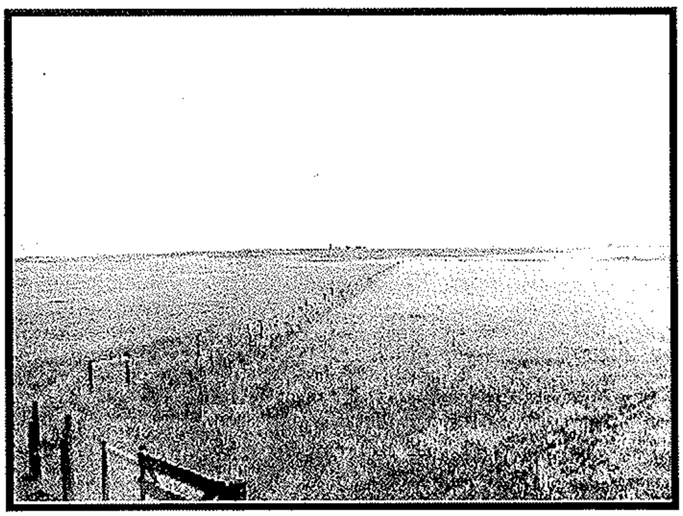
Because droughts occur periodically in the Great Plains, many rangeland plants have developed methods of adapting to drought. Plants generally deal with drought in three ways. Some plants are <u>drought escapers</u>. These are often short-lived annual or perennial plants that complete their life cycle before the effects of drought become limiting. Other plants <u>postpone dehydration</u>. These plants reduce water loss through mechanisms such as leaf rolling or senescence or maintain water uptake by the use of fibrous root systems or by getting water from deeper in the soil. Many cool-season grasses use mechanisms that postpone dehydration. The final method that many plants use is <u>dehydration tolerance</u>. These plants are primarily warm-season grasses and can tolerate low tissue water potentials by stabilizing the cell membrane structure through increased cell sugars.

The good news for producers is that grasses in the Great Plains are relatively persistent. That means that if managed correctly, they can withstand periods of drought and still recover. Good management during non-drought periods may be as important as management during the drought periods.

Livestock grazing before, during or after a drought can affect the ability of plants to respond to drought. Livestock grazing isn't a uniform controlled clipping like haying and therefore management is often more challenging. Livestock grazing can affect root growth, which impacts plant's ability to withstand drought as well as recover from it. In addition, livestock grazing can affect the number of tillers or shoots in grasses. Production of tiller or shoots is a key method that grasses persist over time. By grazing before grasses have adequate time to recover, desirable grasses can be replaced by non-desirable grasses. This can result in lower productivity even in times of above average precipitation.



Photos showing the effects of drought on a heavily grazed pasture, on preceding page, and a moderately grazed pasture, on the below, in 1936 at the Northern Great Plains Research Laboratory. The time of year the photos were taken is not known.



RUSSIAN WILDRYE BREEDING RESEARCH

Dr. John Berdahl

Forage breeding research at Mandan is currently 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 improved seedling vigor as well as increased water use efficiency.

ALFALFA VARIETIES FOR GRAZING

Drs. John Hendrickson and John Berdahl

Alfalfa can provide a valuable grazing resource for producers in the Northern Great Plains by increasing the quantity and quality of the forage resource. Alfalfa can be incorporated into existing grasslands or grazed as a monoculture. Recently, several new varieties have been released specifically for grazing. However, many of these varieties have not been developed to withstand the climatic conditions of the Northern Great Plains. The Northern Great Plains Research Lab has recently completed two experiments to evaluate the survival of alfalfa under grazing. One experiment looked at 16 varieties and strains of alfalfa that were planted into an existing grassland and heavily grazed from 1997 to 2000 and the other evaluated alfalfa survival both in monocultures and in a grass alfalfa mixture. This experiment was also heavily grazed from 1998 to 2000. In the first experiment, 10 of the 16 varieties and strains had survival rates over 50% (Figure 1). Generally, those varieties developed in colder areas such as SC MF 3713 developed in Swift Current, Saskatchewan, Alaska Syn A developed in Alaska and Anik had higher survival than did the other varieties. The survival of Mandan 3851 developed at the Northern Great Plains Research Lab and Travois also had over 70% survival. Mandan 3851 also had the highest vigor rating at the end of the experiment.

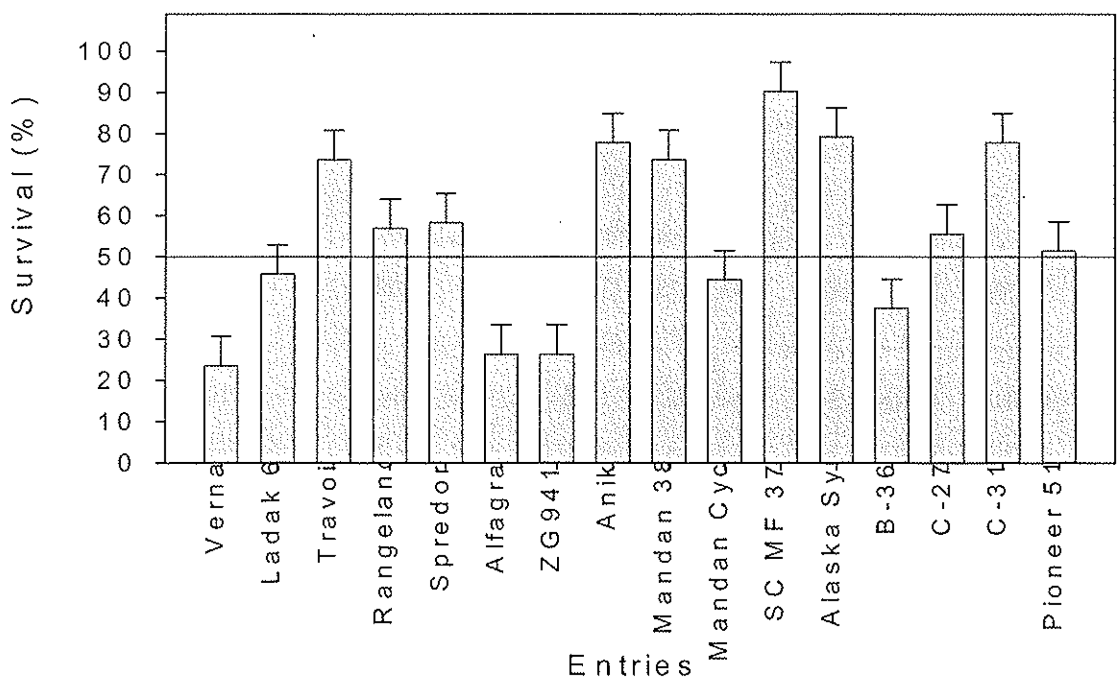


Figure 1. Survival in May 2001 of 16 varieties and strains of alfalfa that were planted into an existing grassland in July 1996.

SWITCHGRASS BREEDING RESEARCH

Dr. John Berdahl

Research sponsored by the U.S. Department of Energy has shown that switchgrass has good potential as a perennial crop for biofuel. As part of this research, eight switchgrass cultivars and experimental strains ranging in origin from North Dakota to Oklahoma were evaluated for biomass yield and persistence at Mandan and Dickinson. All sites were fertilized with 50 lb phosphorus/Acre in the establishment year. Nitrogen has been applied annually at 60 lb/A at the Mandan sites and 40 lb/A at the Dickinson site. Initial stands were excellent at the two Mandan sites, and the Dickinson site was fair. Dry matter yields are reported in Table 1 and plant stand counts in Table 2. Both 'Sunburst', developed at South Dakota, and 'Trailblazer', developed at Nebraska, were consistently high in stand establishment and dry matter yield. However, winter injury was evident for Trailblazer at the Mandan sites in the spring of 2001. The two entries of North Dakota origin, 'Dacotah' and ND3743, had high survival, but their dry matter yields averaged significantly lower ($P<0.01$) than Sunburst and Trailblazer. 'Summer' from South Dakota has poor seedling vigor. 'Shawnee', OK NU 2, and 'Cave-In-Rock' are of southern origin and are not well adapted to North Dakota. Dry matter yields at the two Mandan sites in 2002 averaged approximately one-third of the yields in the two previous years due to drought stress. Precipitation for April through August at Mandan totaled 7.0 inches in 2002, 60% of the long-term average for these months.Good establishment capability relative to other cultivars, good winter survival, an early-August heading date, and consistently high dry matter yields are traits that suit Sunburst for biofuel production in North Dakota.

Table 1. Dry matter yields of eight switchgrass cultivars and strains from a single annual harvest in mid-August of 2000, 2001, and 2002 at three sites in North Dakota.

	Mandan site 1[1/]			Mandan site 2[2/]			Dickinson		Overall percent of
Entry	2000	2001	2002	2000	2001	2002	2001	2002	Sunburst
	tons/acre								
Sunburst	4.10	4.42	1.34	4.68	5.01	1.54	3.13	3.43	100
Dacotah	2.35	3.64	1.17	3.52	4.01	1.07	1.91	2.77	74
ND3743	2.35	3.22	0.97	3.04	3.77	1.13	1.44	2.49	67
Summer	3.15	3.72	1.18	4.47	3.22	1.02	2.00	1.62	74
Trailblazer	3.59	4.00	1.46	4.92	4.38	1.10	3.12	3.20	93
Shawnee	3.40	3.18	1.15	4.77	3.26	0.94	2.55	2.63	79
OK NU 2	2.55	2.52	0.83	4.03	3.49	0.98	2.43	2.35	69
Cave-in-Rock	3.51	2.25	1.11	4.19	2.48	1.18	2.10	2.03	68
$LSD_{0.05}$	0.66	0.81	0.32	0.69	0.61	0.32	0.32	0.49	
CV (%)	14.5	16.4	19.2	12.6	11.1	19.3	9.0	13.1	

[1/] Mandan site 1 = sandy-loam soil
[2/] Mandan site 2 = silt-loam soil

Table 2. Stand counts of eight switchgrass cultivars and strains measured in September of 2000, 2001, and 2002 at three sites in North Dakota.

	Mandan site 1[1/]			Mandan site 2[2/]			Dickinson		Overall percent of
Entry	2000	2001	2002	2000	2001	2002	2001	2002	Sunburst
	plants/yd^2								
Sunburst	33	33	33	33	31	31	33	32	100
Dacotah	33	32	32	33	32	32	27	27	96
ND3743	32	32	32	32	31	31	27	27	94
Summer	26	23	23	24	22	22	11	11	63
Trailblazer	32	31	33	33	31	31	31	31	97
Shawnee	32	28	28	33	29	29	28	28	91
OK NU 2	30	26	26	31	27	27	22	22	81
Cave-in-Rock	32	23	23	33	28	28	24	24	83
$LSD_{0.05}$	2.8	3.5	3.4	2.8	2.7	3.3	4.6	2.2	
CV (%)	5.9	8.3	7.6	6.0	6.2	7.1	12.3	11.6	

[1/] Mandan site 1 = sandy-loam soil
[2/] Mandan site 2 = silt-loam soil
Maximum stand count = 33 plants/yd^2

IMPROVING THE PERSISTENCE OF INTERMEDIATE WHEATGRASS VARIETIES

Drs. John Hendrickson, John Berdahl, Jim Karn and Mark Liebig

Intermediate wheatgrass has the potential to be an important introduced grass in the Northern Great Plains. However, the lack of stand persistence under grazing has been a problem. A project was started to evaluate whether the time of grazing would influence stand persistence. Eight different varieties and strains of intermediate wheatgrass were established in 1997. The site was hayed in 1998 and 1999 and grazing was started in 2000. The area was divided into paddocks with some of the paddocks being grazed in the early vegetative stage, a different set of paddocks grazed when stems were elongating and the final set of paddocks were grazed in the boot stage. Tillers or shoots were monitored over time as well as biomass of intermediate wheatgrass and weeds. Soil samples were collected prior to the start of grazing and will be collected again at the project's end. Paddocks will be grazed the final time in 2003 and vegetation measurements will be completed. Tiller monitoring was completed in the fall of 2002. Very preliminary results suggest that the most appropriate time to graze intermediate wheatgrass may depend on the variety or strain used. Additional analysis using the full data set is needed to verify these results.

CARBON DIOXIDE SEQUESTRATION BY A GRAZED MIXED-GRASS PRAIRIE

Dr. Al Frank, Plant Physiologist

Agriculture is increasingly taking on the role of mitigating carbon dioxide emissions into the atmosphere. Grasslands may serve as a significant sink for atmosphere carbon dioxide because grasslands occupy a large area and also contain nearly 80 percent of their biomass below ground, which suggests that grasslands can play an important role in the global carbon cycle. The large below ground root biomass serves as storage for carbon dioxide taken from atmospheric by photosynthesis. The Bowen ratio/energy balance technique has been used to measure carbon dioxide fluxes over grazed mixed-grass prairie grasslands at the Northern Great Plains research Lab from 1995 to 2001. Net carbon sequestration varied greatly over years due to rainfall and ranged from 134 lbs carbon dioxide/acre in 1997 to 2197 lbs carbon dioxide/acre in 2001. The cumulative flux over the seven years totaled 7859 lbs carbon dioxide/acre (Fig. 1).

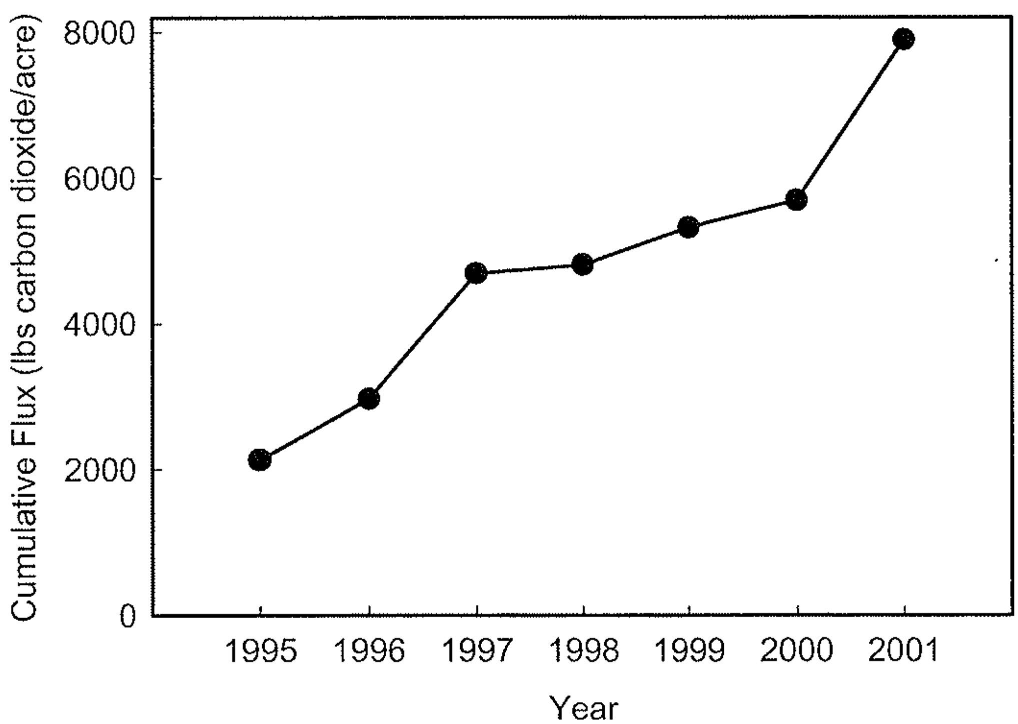


Fig. 1. Cumulative CO_2 flux over seven years for a grazed mixed-grass prairie at Mandan, ND.

These results from a long-term seven year study quantify the carbon storage potential for this grazed prairie site to be quite small, but considering that the site was grazed and still remains a sink for atmospheric carbon dioxide is significant.