1989 Research and Cropping Results

Sixth Annual Progress Report

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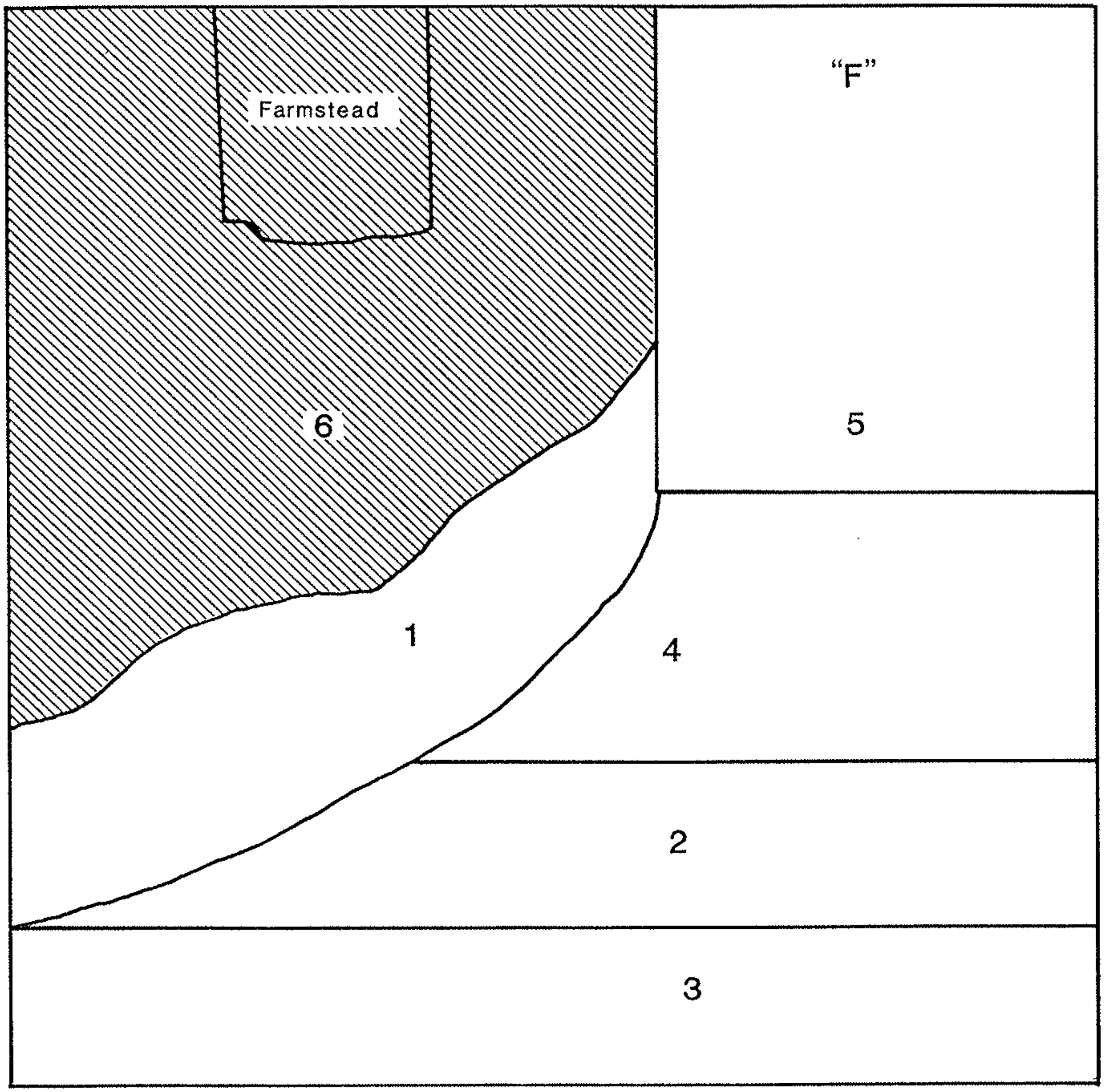
Contents Relate to Cooperative Agreement between USDA-ARS and Area IV Soil Conservation Districts represented by the Area IV SCD Research Advisory Committee.

NOTICE

Acknowledgment

USDA-ARS and Area IV SCD recognize the contributions made to this research program by the following cooperators: Elanco Products Co.; Monsanto Agr. Products Co.; Dahlgren and Co.; AgriPro, Inc.; Hoechst-Roussel Agri-Vet Co.; NDSU-Agricultural Experiment Station, and NDSU-Cooperative Extension Service.

NW$\frac{1}{4}$ Sec 17 T138 R81



F. NW-1/4 Sec 17 - Research Activities

F1. Conservation Bench Area - This area was dropped from the total acreage leased by AREA IV SCD beginning in 1987. Total cropland now leased is 382 acres.

F2. The previous crop in 1988 was sunflower. This field received a broadcast application of 40 lbs N/ac on May 3, 1989 and the field was divided into 6-blocks and seeded; 2 blocks each, to Butte 86 and Waldron spring wheat and 2-blocks to Bowman spring barley on May 6-8, 1989. These spring wheat and barley varieties provided a stubble source for Dr. Krupinsky to study disease cycles in a cropping sequence with disease-susceptible and disease-resistant winter wheat and spring cereal crops in a no-till system. The spring grains were sprayed with a mixture of 2,4-D (8 oz.) and Buctril (16 oz.) June 6, 1989. The barley was combine harvested July 27, 1989 and the spring wheat varieties on August 4, 1989. The spring wheat (both varieties) yielded about 8 bu/ac and the spring barley about 16 bu/ac. The barley and spring wheat stubble was sprayed to control weeds and volunteer grain with Roundup + 2,4-D August 29, 1989. Winter wheat varieties Roughrider, Norstar and Winalta were no-till planted into the 6-stubble source blocks, 2-blocks each of Bowman barley, Butte 86 and Waldron spring wheat stubble on Sept. 19, 1989. Continuing study of previous crop stubble effect on leaf spot diseases (Joe Krupinsky and Black)

F3. The previous crop in 1988 was spring wheat which was sprayed July 21, 1988 with Landmaster because the grain yield potential was near zero. Winter wheat was then no-till planted into the standing spring wheat residue Sept. 26, 1988. Because of the early-season decision to spray the spring wheat, sufficient soil water was gained to establish a good stand of winter wheat. The winter wheat was sprayed to control broadleaf weeds with a mixture of 2,4-D (8 oz.) and Buctril (16 oz.), May 23, 1989. The winter wheat was combine harvested July 26, 1989 with yields of Norwin, Rocky, Agassiz averaging about 15, 13, and 10 bu/ac, respectively. Protein averaged 16.6% and the test weight averaged 58 lb/bu.

F4. This field was seeded to sunflower in 1989 following winter wheat in 1988. We used the Haybuster undercutter with granular applicator to establish a study for Treflan, TR-10 and Sonalan, G-10 granular applications at rates ranging from 0.6 to 1.2 ai/ac on May 3, 1989. The field was undercut again (second incorporation) May 15, 1989 and then planted with the IH-800-cyclo seeder May 25, 1989 with 50 lbs N/ac banded beside the row. Both granular herbicides provided good weed control at rates of 0.8 lb ai/ac, or higher. Two varieties of sunflower AgriPro 4200 and AgriPro 88-945 were used in this study. Plots were combine harvested Oct. 17, 1989 and both varieties yielded similarly at about 600 lbs/ac.

F5. ARS Land Lease (variety trials) - Variety comparison trials with spring wheat have been conducted at this site since 1979. Barley varieties have been included since 1983. The varieties are planted on summerfallow with a press drill in tandem with an offset disk. Row spacing is six inches and planting depth about 1.5 inches. Planting rate of all varieties is one million viable seeds per acre based on kernel weight, germination percentage, and kernel water concentration.

Data of various measurements made are shown in Table 1. Note that all weights are expressed on an oven-dry-basis. Grain yields on a field-run basis would be about 12% higher than shown.

Barley varieties Bowman, Gallatin, and Hector are the two-row type and the others are six-rowed. Note the difference in the number of heads (HEA) and kernels per head (KPH) between these two barley types.

Available soil water by date and plant development stage in foot increments to six feet are shown in Table 2 and Table 3 for wheat and barley, respectively, and as well the rainfall quantity between soil water measurement dates. Note that more water was extracted from the soil to five feet during the growing season than was received in rainfall during the growing season. (Dr. Armand Bauer)

Table 1. Variety characteristic comparisons of spring wheat and spring barley, Mandan 1989.

Crop	Variety	POP no/m^2	HEA no/m^2	HGT inches	YIE bu/ac	TWT lbs/bu	TKW mg	YIM bu/ac	STR lbs/ac	TDM lbs/ac	KPH no.	HES no.	NEG %	PRO %
Wheat	Amidon	162	359	34	26.9	55.0	19.29	25.6	3307	4846	25.0	2.2	3.75	18.8
	Butte 86	176	464	34	28.8	55.6	20.97	29.4	3351	5114	20.2	2.7	3.56	17.9
	Cutlass	146	410	31	25.0	57.6	19.99	24.6	2767	4241	20.1	2.9	3.36	16.9
	Grandin	153	384	33	29.0	53.9	20.98	29.9	3318	5111	25.0	2.5	3.77	18.9
	Gus	144	425	32	29.0	54.2	19.11	29.3	3110	4873	24.3	3.0	3.71	18.6
	Leif	150	388	33	29.0	56.0	20.81	29.8	3417	5208	24.9	2.6	3.54	17.8
	Len	145	389	30	26.1	56.1	19.73	26.7	3144	4743	23.4	2.8	3.77	18.9
	Marshall	163	421	28	27.8	53.0	16.70	25.8	2940	4486	24.8	2.6	3.66	18.4
	Nordic	147	386	32	33.0	56.6	22.12	36.3	3635	5812	28.5	2.6	3.34	16.8
	Stoa	139	421	35	30.3	55.5	19.71	32.1	3504	5431	26.2	3.1	3.71	18.6
	LSD	NS	10	0.4	2.3	1.6	1.13	3.5	282	424	2.9	0.4	0.13	0.7
Barley	Azure	153	318	35	34.9	39.6	19.16	43.4	3738	6518	38.2	2.1	3.02	16.6
	Bowman	174	566	32	43.4	48.3	29.07	52.0	3312	6506	17.0	3.3	2.93	16.1
	Gallatin	151	555	33	38.4	42.7	19.72	47.3	3624	6600	23.5	3.7	3.23	17.8
	Hector	162	563	33	39.4	42.7	22.76	43.2	3707	6478	17.3	3.5	3.14	17.3
	Morex	152	291	33	35.5	40.9	20.08	38.7	2793	5210	35.5	2.0	3.16	17.4
	Robust	158	263	33	31.4	40.9	18.37	33.3	3080	5238	36.9	1.7	3.16	17.4
	LSD	NS	18	NS	4.6	1.7	2.01	7.2	379	679	3.8	0.4	0.17	0.9

Measurement columns: POP through PRO.

LEGEND

POP = Plant population, pre-3 leaf stage; no/m^2 * 0.836 = no/yd^2
HEA = Number heads at harvest
HGT = Height at harvest
YIE = Grain yield, combine
TWT = Test weight
TKW = Kernel weight
YIM = Grain yield, square meter sample
STR = Straw yield
TDM = Total dry matter at harvest
KPH = Kernels per head
HES = HEA/POP
NEG = Nitrogen concentration in grain
PRO = Protein in grain at 12% of water concentration

ALL WEIGHTS EXPRESSED ON OVEN-DRY BASIS

Table 2 . Available soil water by foot-increments to six feet and rainfall applied between dates of soil water measurement on spring wheat, 1989.

Planted	April 24
Emerge	May 8
Harvest (m^2)	July 26
(Combine)	July 27-31

Date	DS[1/]	Soil depth (feet) 0-1	1-2	2-3	3-4	4-5	5-6	Rain inches
		- - - - - - - - -	- inches	- - - -	- - - -	- - - -	- -	
4/25		1.63	1.94	2.56	2.04	1.80	1.66	
								1.71
5/02		2.16	2.30	2.67	2.29	1.85	1.70	
								0.04
5/09	0.6	2.03	2.20	2.63	2.42	1.95	1.72	
								0.12
5/16	2.8	1.84	2.10	2.57	2.36	2.06	1.87	
								0.12
5/23	3.1	1.59	1.98	2.51	2.33	2.07	1.91	
								1.54
6/01	5.4	2.04	1.94	2.45	2.27	2.02	1.89	
								0.00
6/06	6.4	1.36	1.88	2.51	2.36	2.09	1.97	
								0.16
6/15	6.9	0.60	1.08	2.32	2.23	2.04	1.91	
								0.24
6/22	8.1	0.23	0.36	1.76	2.07	1.97	1.88	
								0.08
6/28	9.0	0.11	0.22	1.23	1.87	1.93	1.85	
								0.00
7/06	10.8	-0.25	-0.02	0.59	1.53	1.96	1.92	
								0.28
7/12	12.1	-0.22	-0.11	0.42	1.29	1.90	1.79	
								0.24
7/19	13.4	-0.22	-0.14	0.37	1.19	1.89	1.85	
								0.00
7/26	15.0	-0.31	-0.14	0.33	1.11	1.87	1.80	
"Used"		1.94	2.08	2.23	0.93	-0.07	-	4.53

1/ Development stage, Haun scale, of Amidon wheat. (Estimated from growing degree days).

Rain = 4.53 inches
(7/26 - 4/25) Soil water use (5 ft) = 7.11
11.64 inches

Table 3 . Available soil water by foot-increments to six feet and rainfall applied between dates of soil water measurement on spring barley, 1989.

Planted	April 24
Emerge	May 7
Harvest (m^2)	July 21
(Combine)	July 24

Date	DS 1/	Soil depth (feet) 0-1	1-2	2-3	3-4	4-5	5-6	Rain inches
		- - - - - - - - - - inches - - - - - - - - - -						
4/25		1.79	1.97	2.25	1.86	1.40	1.56	
								1.71
5/02		2.32	2.28	2.48	1.99	1.45	1.60	
								0.04
5/09	0.8	2.19	2.22	2.36	2.16	1.51	1.60	
								0.12
5/16	3.2	2.00	2.12	2.25	2.09	1.74	1.75	
								0.12
5/23	3.5	1.77	1.99	2.10	1.95	1.73	1.85	
								1.54
6/01	5.7	2.00	1.98	2.07	1.96	1.74	1.82	
								0.00
6/06	6.8	1.29	1.99	2.14	2.05	1.81	1.93	
								0.16
6/15	7.3	0.61	1.51	1.91	1.91	1.77	1.84	
								0.24
6/22	9.8	0.27	0.63	1.51	1.77	1.69	1.82	
								0.08
6/28	11.1	0.13	0.38	1.01	1.61	1.65	1.80	
								0.00
7/06	12.0	-0.27	0.04	0.30	1.29	1.59	1.79	
								0.28
7/12	13.0	-0.24	-0.05	0.14	1.10	1.52	1.73	
								0.24
7/19	14.7	-0.28	-0.03	0.12	1.03	1.52	1.71	
								0.00
7/26	15.0	-0.40	-0.04	0.11	1.02	1.49	1.71	
	"Used"	2.19	2.01	2.14	0.84	-0.09	-	4.53

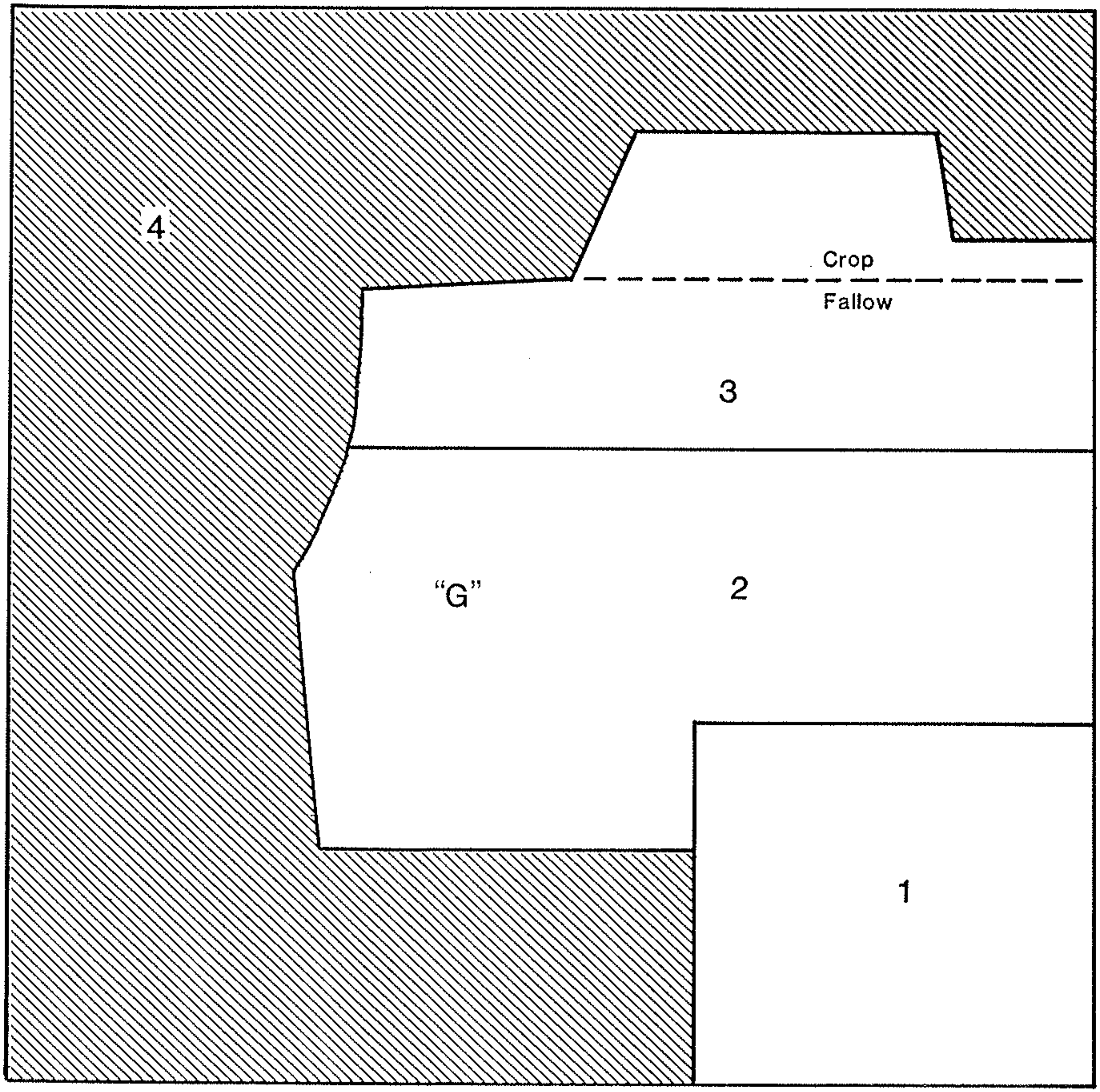
1/ Development stage, Haun scale, of Azure barley

Rain = 4.53 inches

(7/26 - 4/25) Soil water use (5 ft) = 7.09

11.62 inches

SW$\frac{1}{4}$ Sec 8 T138 R81



G. SW 1/4 Section 8 - Research Activities

G1. Populus Clonal Testing - Dr. Richard Cunningham
Dr. Joe Krupinsky

During the period 1983 to 1988, 240 hybrid poplar and cottonwood clones were planted in this area to compare their survival, growth rate, cold hardiness, and pest resistance. Similar field tests have been established on eight other sites in North Dakota and one site in Minnesota. Survival of all clones is scored annually, while total height, crown width, crown density, crown form, and stem diameter are measured every 5 years at a minimum. In the spring of 1989, our survival scoring revealed that many clones were dead or dying. The prolonged drought likely had stressed the trees severely and predisposed them to invasion by several stem canker causing diseases. The continuation of the drought this past fall and winter will intensify the stresses on these trees and I expect to see mortality occurring among many more of the clones this coming spring. In some respects we are fortunate that a drought of this magnitude has occurred as it presents the opportunity to accurately evaluate the drought hardiness of all the clones. We hope of course, that at least a few of the clones will survive and perform well. If they do, we can be fairly confident that they possess high levels of drought resistance.

A 26 acre plot immediately west and slightly north of the poplar test site, and not part of the Area IV Research Farm, has been leased from the Nelson estate. This area will serve as the site for a Cooperative Hackberry Provenance Test. About 13,5 acres will be planted to hackberry trees grown from seed collected at 180 different sites located throughout the Great Plains. Seed collections were made all the way from Manitoba to Oklahoma and Minnesota to Arkansas. The planting stock was grown at Oakes Nursery in cooperation with the Lincoln-Oakes Nurseries. The trees were lifted this past fall and have been graded, sorted and prepared for shipping to 14 cooperators who will test them in most of the states represented in the seed collections. The Mandan test planting will include all 180 seed sources for a total of about 3900 trees. The trees will be planted in May of 1990. Data on survival, height, insect and disease resistance, and crown characteristics will be collected for a minimum of 20 years. The goal of the project is to identify the best adapted, fastest growing, cold and drought hardy, pest resistant hackberry seed sources for each state in the Great Plains.

G2. USDA-ARS Forage Grass Breeding Activities Performed in 1989

Two western wheatgrass populations are currently being evaluated on land made available for a cooperative project of USDA-ARS and the North Dakota Area IV Soil Conservation District. Each population consists of 2,000 plants spaced on 6-foot centers. The populations constitute the cycle 1 and cycle 2 generations of a recurrent selection program. The initial population from which cycles 1 and 2 were derived consisted of 10,000 plants of which 30 unique accessions were selected in 1989 for inclusion in the National Plant Germplasm System. In Vitro Digestible Organic Matter data (a predictor of animal performance) of forage samples collected from individual cycle 1 plants indicate that sufficient variability exists in these populations to permit selection for improved digestibility. Cycles 1 and 2 were characterized during the summer and fall for overall plot appearance including: forage density, summer growth, desiccation tolerance, leafiness, and fall regrowth. Although two years of severe drought have applied natural selection to these two nurseries, many vigorous plants were identified. Of these, 300 plants were dug from the field and transplanted into the greenhouse. Three hundred plants from a cycle 3 crested wheatgrass population (derived from a nursery that was previously located on Area IV land) were also dug and transplanted into the greenhouse. Seed will be produced on these plants (winter 1989-1990) so that solid seeded experimental line performance nurseries can be established in 1990 as the initial step towards identifying elite parents for crested and western wheatgrass variety development. The western wheatgrass nurseries will continue to be evaluated for several traits including: spike emergence date, spike number, length, and fertility; seed maturity date, seed quality and dormancy; rate of leaf senescence; and insect and disease problems. (Dr. John Berdahl and Dr. Ian Ray)

G3. The previous crop in this field was winter wheat in 1988. The winter wheat stubble was left standing overwinter to trap snow. This field was undercut May 6, 1989, while simultaneously applying 0.8 lb ai/ac, Treflan TR-10 granules. The second undercutting for further incorporation of the herbicide occurred May 15, 1989. Sunflower varieties (Dahlgren 827, Dahlgren 725 and AgriPro 4200 were seeded May 26, 1989 with a no-till unit-row planter with 50 lb N/ac side-banded beside the row. The sunflowers were combine harvested October 18, 1989. Seed yields averaged 840, 1030 and 1080 lb/ac for the varieties AgriPro 4200, Dahlgren 726 and Dahlgren 827, respectively.

G4. This field was in spring wheat in 1988 and summerfallow in 1989. Because of low yield level of 10 bu/ac in 1988 the initial stubble level remaining after harvest was about 1200 lb/ac. Therefore, we no-till fallowed this field in order to save more than 30% cover after summer fallowing. The summer fallow operations included; spray June 2, 1989 with Landmaster 43 oz/ac) with 2% ammonium sulfate, spray June 23 and August 7, 1989 with Roundup (35 oz.) + 2% ammonium sulfate.

G5. This field was minimum-till fallow in 1988. Spring wheat 'Butte 86' was planted May 9, 1989 at a seeding rate equivalent to 80 lb/ac. This field was sprayed with Tiller alone at a rate of 16 oz. of material per acre. On August 8, 1989 this field was combine harvested and the spring wheat averaged 19 bu/ac, 15.6% protein and 59 lb/bu.

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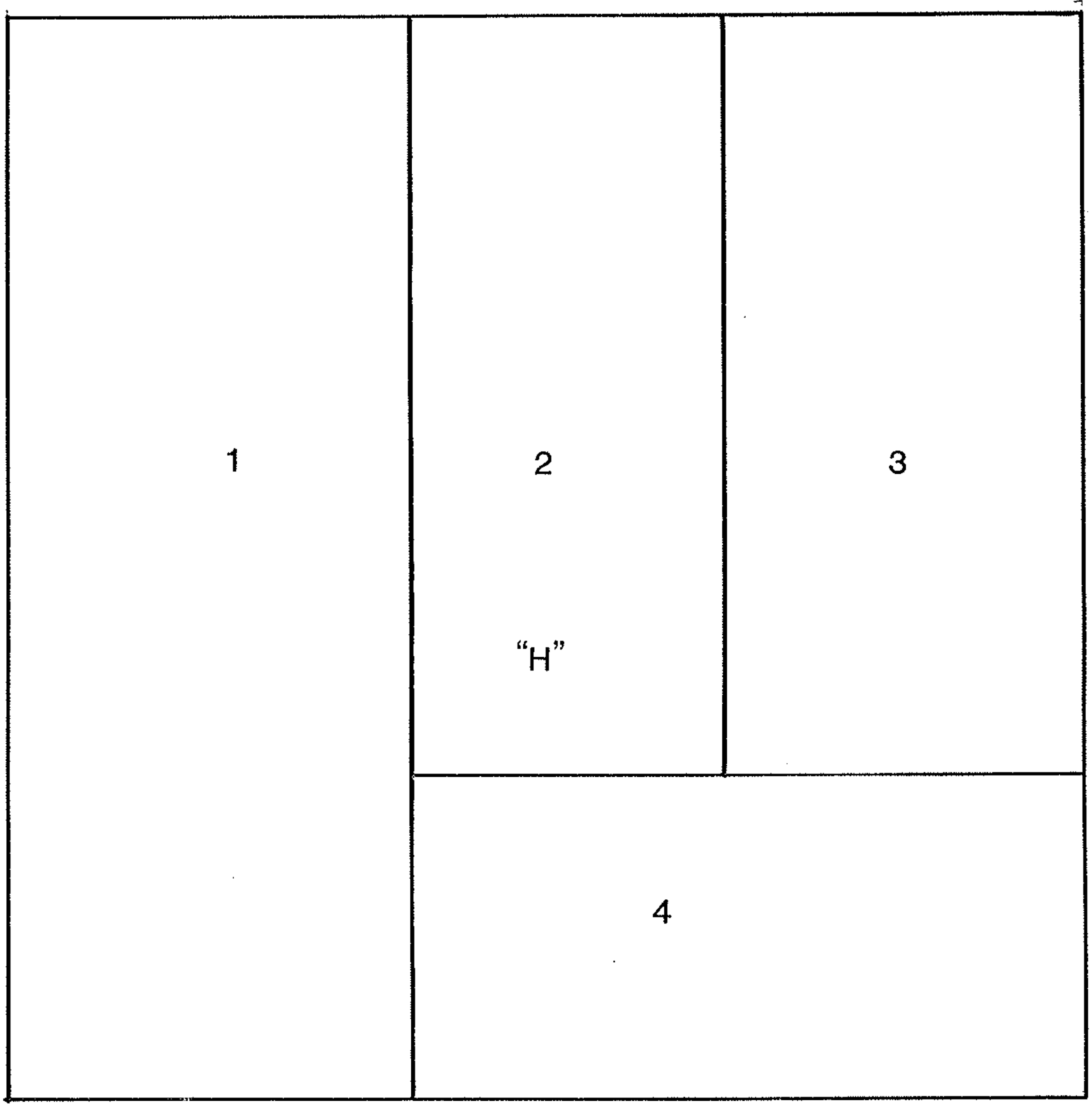

H. NE 1/4 Section 18 - Research Activities

H1-A. Cropping Systems - Conservation Tillage Research Project (65 Acre-Study)

(A1) Spring wheat-fallow (1989 spring wheat crop plots)

Spring wheat crop plots - Schedule of operations for each tillage system.

Date mo/day	Conventional-till No-residue	to <30% Cover	Minimum-till 30 to 60% cover	No-till >60% cover
5/1	Applied 0,20,40 lb N/ac	Broadcast as 34-0-0 to all tillage plots		
5/3	---	---	Undercut	---
5/4	Disked	Disked	---	---
5/5	Planted Butte 86 and Stoa Spring Wheat in all tillage systems			
6/8	- - - - - - Sprayed Tiller (16oz) plus Buctril (16oz) - - - - - - - -			
8/1	- - - - - - Hand harvest samples obtained from all plots - - - - - -			
8/24	- - - - - - - - Combine harvested all plots - - - - - - - - - - - -			

(A2) Grain yields of spring wheat in the spring wheat-fallow rotation as affected by tillage system, N-rates, and cultivar grown.

Spring Wheat Grain Yield Data (1989)

Cultivar	Rate of N	Conventional-till No Residue	Conventional-till <30% Cover	Minimum-till 30-60% Cover	No-till >60% Cover	Avg
	lbs N/ac	- - - - - - - - -	bu/ac	- - - - - - - - -		
Butte 86	0	19.8	28.3	29.7	25.7	25.9
	20	20.7	27.8	25.0	25.8	24.8
	40	17.1	28.2	28.8	26.3	25.1
	Avg.	19.2	28.1	27.8	25.9	22.3
Stoa	0	20.3	28.9	30.3	29.0	27.1
	20	20.7	25.5	26.8	27.7	25.2
	40	18.0	25.7	26.4	25.8	24.0
	Avg.	19.7	26.7	27.8	27.5	25.4
Avg. (Tillages)		19.4	27.4	27.8	26.7	

(A3) Spring wheat-summerfallow with the schedule of operations performed for fallow series plots in 1989 as follows:

Date	Conventional till		Minimum-till	No-till
mo/day	No Residue	<30% Cover	30 to 60% Cover	>60% Cover
5/15	----	----	----	Roundup
5/18	Offset Disk	T. Disked	Undercut	----
6/15	Undercut	Undercut	Roundup	----
6/23	----	----	----	Roundup+2,4-D
7/10	Roundup	Roundup	Roundup	----
8/3	----	Roundup	Roundup	Roundup
8/24	Roundup	----	----	----

H1-B, Spring wheat-winter wheat-sunflower cropping system

B1. Spring wheat crop plots-schedule of operations for each tillage system.

Date mo/day	Conventional-till	Minimum-till	No-till
5/1	Applied 30,60,90 lbs N/ac Broadcast as 34-0-0 to all plots		
5/3	----	Undercut	----
5/4	T. Disked	----	----
5/5	Seeded Butte 86 and Stoa with HB-1000 no-till drill (7-in.spacing)		
6/18	Sprayed with mixture of Tiller (14 oz/ac) and Buctril (14 oz/ac)		
7/31	- - - - Hand Harvest samples obtained from all plots - - - - -		
8/7	- - - - - - Combine harvested all plots - - - - - - - - - - - -		
8/23	Roundup+2,4-D	Roundup+2,4D	Roundup+2,4D
9/15	Disked	Undercut	----

B1. Spring wheat grain yields in the spring wheat-winter wheat-sunflower rotation as influenced by tillage system, N-rates, and cultivar grown.

Spring wheat grain yields (1989) for continuous cropping

Cultivar	Rate of Nitrogen	Conv-till	Min-till	No-till	Avg.
	lbs N/ac	- - - - - - - - - -	bu/ac	- - - - - - - -	
Butte 86	30	9.4	8.5	9.5	9.1
	60	10.1	8.3	8.2	8.9
	90	10.9	8.4	9.5	9.6
Avg.		10.1	8.4	9.1	9.2
Stoa	30	6.3	8.0	10.8	8.4
	60	6.9	9.5	10.3	8.9
	90	6.6	9.2	11.8	9.2
Avg.		6.6	8.9	11.0	8.8
Avg (Tillages)		8.4	8.7	10.0	

B2. Winter wheat plots - schedule of operations for each tillage system following spring wheat-continuous cropping.

Date mo/day	Conventional-till	Minimum-till	No-till
8/9 (88)	Roundup	Roundup	Roundup
9/20 (88)	T-Disked	----	---
9/20 (88)	Seeded W. wheat (Roughrider and Norstar) with HB-8000 Drill		
5/1	Applied 30,60,90 lbs N/ac Broadcast as 34-0-0 (All plots)		
5/3	*Spray Landmaster	*Spray Landmaster	----
5/4	Seeded Butte 86+Stoa	Seeded 86+Stoa	----
5/22	----	----	Buctril+2,4-D
6/8	Tiller+Buctril	Tiller+Buctril	----
7/24	----	----	Hand Harvest Samples
	----	----	Combine Harvest
7/31	Hand Harvested Samples	Hand Harvested Samples	----
8/7	Combine Harvested	Combine Harvested	----
8/24	Roundup 2,4-D	Roundup 2,4-D	Roundup 2,4-D
10/12	----	----	Surflan

* Near total winterkill occurred in conventional- and minimum-till systems so we used Landmaster as a burndown treatment to control weeds and the few surviving winter wheat plants before no-till seeding the substitute spring wheat cultivars.

B2. Winter wheat grain yields (1989) in the spring wheat-winter wheat-sunflower rotation as affected by tillage system, N-rates and cultivar grown.

Cultivar	Rate of Nitrogen	Conv-till	Min-till	No-till	Avg.
	lbs N/ac	- - - - - - - - - - bu/ac	- - - - - - - -		
Roughrider	30	(13.4)[1/]	(11.3)[1/]	16.2	13.6
	60	(11.2)	(12.7)	16.3	13.4
	90	(10.2)	(13.3)	19.5	14.3
Avg.		(11.6)	(12.4)	17.3	13.8
Norstar	30	(11.6)[2/]	(10.6)[2/]	17.4	13.2
	60	(10.8)	(11.0)	16.3	12.7
	90	(11.5)	(12.4)	15.8	13.2
Avg.		(11.3)	(11.3)	16.5	13.0
Avg (Tillages)		11.4	11.9	16.9	

1/ Butte 86 Spring wheat substituted for Roughrider due to winterkill.
2/ Stoa spring wheat substituted for Norstar due to winterkill.

B3. Sunflower plots - schedule of operations for each tillage system following winter wheat-continuous cropping.

Date mo/day	Conventional-till	Minimum-till	No-till
7/16/88	Roundup	Roundup	Roundup
9/9/88	----	----	Surflan 1.25 lb ai/ac
5/6/89	Undercut + Treflan	Undercut + Treflan	----
5/18	T. Disked	Undercut	----
5/19	Planted AgriPro 2036 & 2057 Cultivars with IH800 planter		
6/14	Sprayed Poast (1pt/ac) + crop oil (1qt/ac) to all plots		
8/3	Sprayed Scout Extra (3oz/ac) + Bond & Li 700 - insect control		
10/3-4	- - - - - - - - - - Hand Harvest (Samples) - - - - - - - - - -		
10/18	- - - - - - - - - - - Combine Harvest - - - - - - - - - - - - -		

B3. Sunflower seed yield data (1989) in the spring wheat-winter wheat-sunflower rotation as affected by tillage, N-rates and cultivar grown.

Cultivar	Rate of Nitrogen	Conv-till	Min-till	No-till	Avg.
	lbs N/ac	- - - - - - - - - -	lb/ac - - - - - - - -		
AgP 2057	30	390	780	660	610
	60	360	840	600	600
	90	210	450	750	470
Avg.		320	690	670	560
AgP 2036	30	330	620	720	560
	60	410	740	700	620
	90	300	430	720	480
Avg.		340	600	710	550
Avg. (Tillages)		330	650	690	

C1. Because of the continued drought, disease symptoms were confounded with drought stress symptoms. Plants were stunted and the leaves were yellowing. Although plants could not be accurately rated for diseases, leaves were collected and processed in the lab to identify the disease organisms present. Surprisingly, 75% of the 240 samples processed were infected with the fungi that cause tan spot and septoria leaf spot. This indicates that the fungi which cause these two major foliar diseases were present even under drought conditions. (Dr. Joe Krupinsky)

Environmental data collected will document the drought conditions for future comparisons. Very low numbers of fungal spores were collected with the fungal spore traps. With such low numbers of spores differences among plots were not evident. (Dr. Joe Krupinsky)

D1. Study of spring wheat root growth and function, begun in the severely droughted 1988 season, was continued through the moderately droughted 1989 season. This study is being conducted in the continuous cropping rotation of the 65-acre Cropping Systems Experiment. Observation of winter wheat was attempted, but winterkill has limited our results to no-till only. Biomass and seed yields of spring wheat were approximately equivalent over tillage treatments in 1989. Data shown in Table 1 indicated, however, a definite propensity for spring wheat under no-till to proliferate greater root length than plants under minimal- or conventional-till. Depth of root penetration appeared to be either the same for tillage treatments or very slightly greater under no-till in 1989. Root growth of all spring wheat treatments under continuous cropping was largely confined to the uppermost 2 feet of the soil, as indicated by Fig. 1. Subsoil had been dried by the previous sunflower crop, and the water not replenished in 1988/89. Wheat roots are evidently not capable of proliferating in soil drier than some limit. Depth of winter wheat root growth was considerably greater in our system than depths of spring wheat rooting, as shown in Fig. 1. Marginally greater amounts of soil water were available to winter wheat, in both the topsoil zone and in subsoil below 2 feet, that were not available to spring wheat. Much of the proliferation of winter wheat roots below the 2-ft depth occurred during and after heading; spring wheat, growing at a later and considerably harsher time in the season, did not show any significant root growth after heading. (Dr. Steve Merrill)

Figure 1.

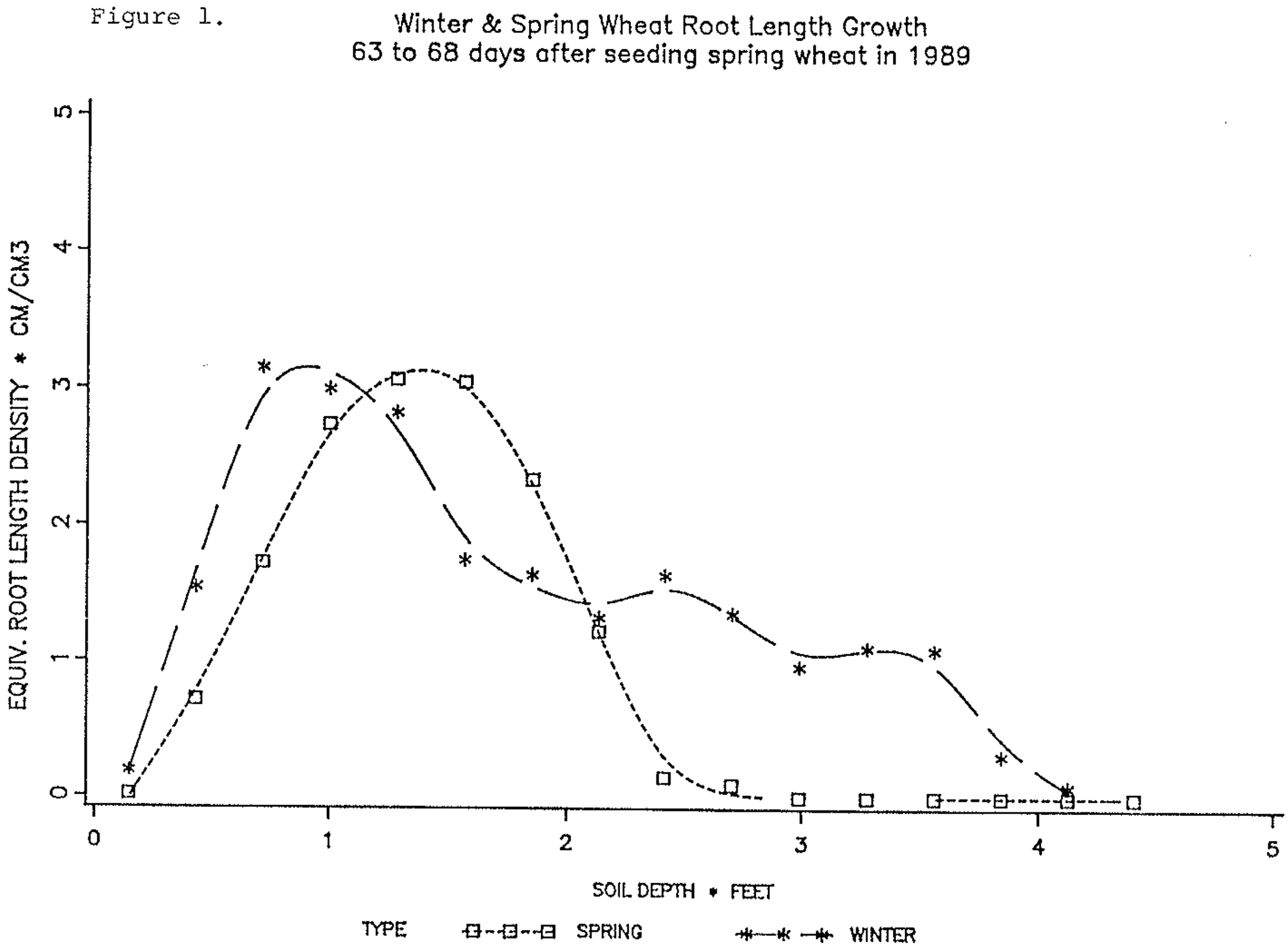

Table 1. Total root lengths of spring and winter wheat crops growing under various conservation tillage treatments as measured by minirhizotron-video techniques in 1989. Units are in cm/cm^2. Spring and winter wheat crops were grown as part of the Cropping Systems Experiment, and were part of the continuous cropping rotation of that experiment.

Calendar Dates	Spring Wheat Conventional-till	Spring Wheat Minimal-till	Spring Wheat No-till	Winter Wheat No-till
MAY 26	2.6	2.3	7.1	
JUN 2-4	4.9	3.8	10.7	87.5
JUN 8	5.7	5.3	14.5	
JUN 14	16.2	23.4	31.9	90.3
JUN 19-20	43.0	56.5	56.4	136.8
JUN 28-30	87.7	104.9	132.3	157.5
JUL 7-12	104.8	131.2	156.5	190.2
JUL 19-23	107.4	152.9	130.3	
JUL 25-27	114.3	147.0	162.4	186.5

D2. The study of soil wind erodibility properties begun in April, 1988 has been carried out through 1989 and is expected to continue through 1990. Measurements are being conducted on the fallow phase of the spring wheat-summerfallow component of the 65-acre Cropping Systems Experiment. Of particular interest are the Surface Components Analysis results from 1989, shown in Table 2. The four conservation tillage treatments show progressively greater percentages of soil surfaces being protected from wind erosion by plant residues. Dangerously wind-erodible loose material is shown to be ephemerally present as result of tillages of the Low-Residue and Conventional-Till treatments. Although aggregate stability analysis for 1989 material had not been completed at the time of this report, results for 1988 are shown in Table 3. The results, of considerable apparent scientific value and interest, indicate that the high surface residue of No-Till tends to shield surface aggregates in the 1/2- to 3/4-inch size class from environmental forces responsible for building soil strength. (Dr. Steve Merrill)

Table 2. Percentages of soil surface occupied by various surface entities in fallow phase of spring wheat-summerfallow system under various types of conservation tillage during 1989. The surface component category not shown is "crusted soil", which completes each group for a total of 100%.

Calendar Dates	Surface Component	Low-residue	Conventional-till	Minimal-till	No-till
18-MAY-89		offset-disk	disked	undercut	
02-JUN-89	Plant material	14.2	45.8	47.5	69.2
	Clods	5.8	7.5	12.0	0
	Loose material	0	0.8	0	0
15-JUN-89		undercut	undercut		
26-JUN-89	Plant material	5.0	36.7	57.5	70.8
	Clods	28.3	25.0	8.3	2.5
	Loose material	66.7	33.3	0	0
26-JUL-89	Plant material	12.5	42.5	53.3	75.8
	Clods	17.5	11.7	0	0
	Loose material	0	0	0	0
29-AUG-89	Plant material	12.5	42.4	48.3	75.0
	Clods	9.2	6.8	0.9	1.7
	Loose material	0	0	0	0

Table 3. Aggregate stability values measured on soil surface samples form the fallow phase of a spring wheat-summerfallow cropping system under various conservation tillages. Measurements listed are median crushing energy values, in J/kg, made with a Surface Aggregate Crushing Energy Meter (SACEM). Values represent composites of 3 replications with 8 to 15 aggregates in each replication.

Calendar Dates	Low-residue	Conventional-till	Minimal-till	No-till
26-MAY-88	8.14	6.26	2.57	1.40
08-JUN-88	9.54	7.83	10.86	3.71
29-JUN-88	10.81	10.28	7.12	4.48
06-JUL-88	9.27	3.93	4.01	2.60
28-JUL-88	10.67	5.92	6.41	2.74
05-AUG-88	9.10	7.30	6.01	5.12
28-AUG-88	9.65	6.09	6.10	2.77
20-SEP-88	7.62	6.96	4.40	3.58
18-OCT-88	8.81	4.71	4.47	2.40

H2. The previous 1988 crop in this field was sunflower, yielding about 1000 lb/ac. In 1989, this field received a bulk-broadcast application of 40 lb N/ac May 3, 1989 and spring barley (Bowman) was seeded without tillage with the Haybuster 1000 no-till drill with 45 lb/ac of 18-46-0 (8 lb N/ac + 9 lb P/ac). The spring barley was sprayed with a mixture of 2,4-D (8 oz. mtl/ac) + Buctril (16 oz. mtl/ac) June 5, 1989. The barley was combine harvested July 27, 1989 yielding 15 bu/ac with 44 lb/bu test weight. We were able to leave a stubble height of about 8-10 inches and the stubble was sprayed with Roundup + 2,4-D August 23, 1989 to control weeds and volunteer barley. Sufficient soil water was conserved to obtain an adequate stand of winter wheat (variety study) seeded September 22, 1989. This is a continuing study of winter wheat variety by N-fertilizer rate interaction on leaf spot diseases conducted by Krupinsky and Black.

H3. The previous crop in 1988 was barley. Winter wheat varieties were no-till seeded in the west-half of this field and Roughrider winter wheat was no-till seeded on the east-half September 23, 1988. Winter wheat stands in the spring of 1989 were less than 50% (about 80 plants/m^2) for the variety trials (west-half). The decision was made to spray the west half on May 3, 1989 with Landmaster (40 oz/ac) to kill surviving winter wheat plants and weeds. We no-till seeded spring wheat 'Marshall' in the west-half. The Roughrider winter wheat in the east-half had a plant population of about 60% (100 plants/m^2), so we did not destroy this portion of the field to have a comparison. The winter wheat was sprayed for broadleaf weeds May 23, 1989 with a mixture of Buctril (15 oz/ac) and 2,4-D (7oz/ac). The reseeded spring wheat (west-half) was sprayed June 9, 1989 with a mixture of Tiller (16 oz/ac) and Brominol (8 oz/ac). The winter wheat yielded 15 bu/ac with 16.6% protein and a test weight of 58 lb/bu. The reseeded spring wheat yielded 8 bu/ac with 15.5% protein and a test weight of 58 lb/bu.

H4. (1) One block in this field (previously spring wheat) was used for an exploratory study involving the use of a legumenous cover crop for soil protection and N-fixation during summerfallow. This spring wheat stubble field was undercut with Treflan granules applied (0.8 lb ai/ac) on May 3, 1989. We established three summerfallow cover crop treatments: no cover crop (normal summerfallow maintenance), Simu S1 peas, and Tinga flatpea. The pea cover crops were sprayed to stop growth at early-bloom and early pod-formation growth stages and one plot was allowed to grow to maturity. Soil water use and soil water gains were measured to 5-feet periodically in all summerfallow and cover-crop growth stage treatments. This area will be cropped to spring wheat in 1990 to measure cover-crop treatment affects on yield, available N, and soil water levels. (Black and Bauer)

(2) Corn Trial - This was the third year of this trial. The corn was planted in 36-inch rows with the International cyclo air planter; final plant population established was 16,200 plants per acre. The lowest nitrogen (N) level in 1989 was about twice as much N as in the lowest level in previous two years because of the carry over from the drought of 1988.

Water use was essentially the same among the residue and nitrogen treatments (Table 1). Some water was removed from the 30-42 inch depth in 1989, whereas no water was extracted from that depth in 1988.

Silage yield data are shown in Table 2. No ears were formed in 1989. This result was a repeat of 1988. (Dr. Armand Bauer)

Table 1. Corn, 1989. Change in soil water content from planting on May 18 to harvest on August 25.

Treatment[1/]	Soil Depth (inches)						
	0-6	6-12	12-18	18-30	30-42	42-54	54-66
	inches water						
R1 N1	0.80	0.71	0.43	0.31	0.42	0.16	0.16
N2	0.81	0.71	0.48	0.27	0.47	0.17	0.17
N3	0.75	0.69	0.43	0.41	0.24	0.11	0.11
Avg	0.79	0.70	0.45	0.33	0.38	0.15	0.15
R2 N1	0.81	0.71	0.47	0.60	0.38	0.06	0.06
N2	0.85	0.68	0.52	0.24	0.39	0.12	0.12
N3	0.87	0.74	0.49	0.31	0.15	0.02	0.02
Avg	0.84	0.71	0.49	0.38	0.31	0.07	0.07
R3 N1	0.85	0.71	0.47	0.30	0.10	0.02	0.02
N2	0.88	0.72	0.52	0.34	0.14	0.04	0.04
N3	0.78	0.72	0.51	0.45	0.29	0.04	0.04
Avg	0.84	0.72	0.50	0.36	0.18	0.03	0.03

[1/] R1 = disk (<30% residue). Growing season rain = 4.14 inches.
R2 = undercut (30-60% residue).
R3 = no-till (>60% residue).

N1 = 120 lbs N/ac to four feet.
N2 = 140 lbs N/ac to four feet.
N3 = 195 lbs N/ac to four feet.

Table 2. Corn, 1989. Silage yield and stover water concentration as affected by residue and available nitrogen level.

Residue	Nitrogen Level 1	2	3	Avg.[2]	Nitrogen Level 1	2	3	Avg.[2]
	tons/ac[1]				% water			
R1	2.11	2.23	2.07	2.13	23.9	23.6	22.9	23.5
R2	2.12	2.21	2.43	2.25	23.6	23.7	22.9	23.4
R3	1.74	1.68	1.81	1.74	22.9	23.3	22.9	23.0
Avg.[2]	1.99	2.04	2.10		23.5	23.5	22.9	

[1]/At 70% water content.

[2]/The odds are less than 95 out or 100 that differences are due to treatment rather than chance.

Because of the dry conditions, no ears were formed.

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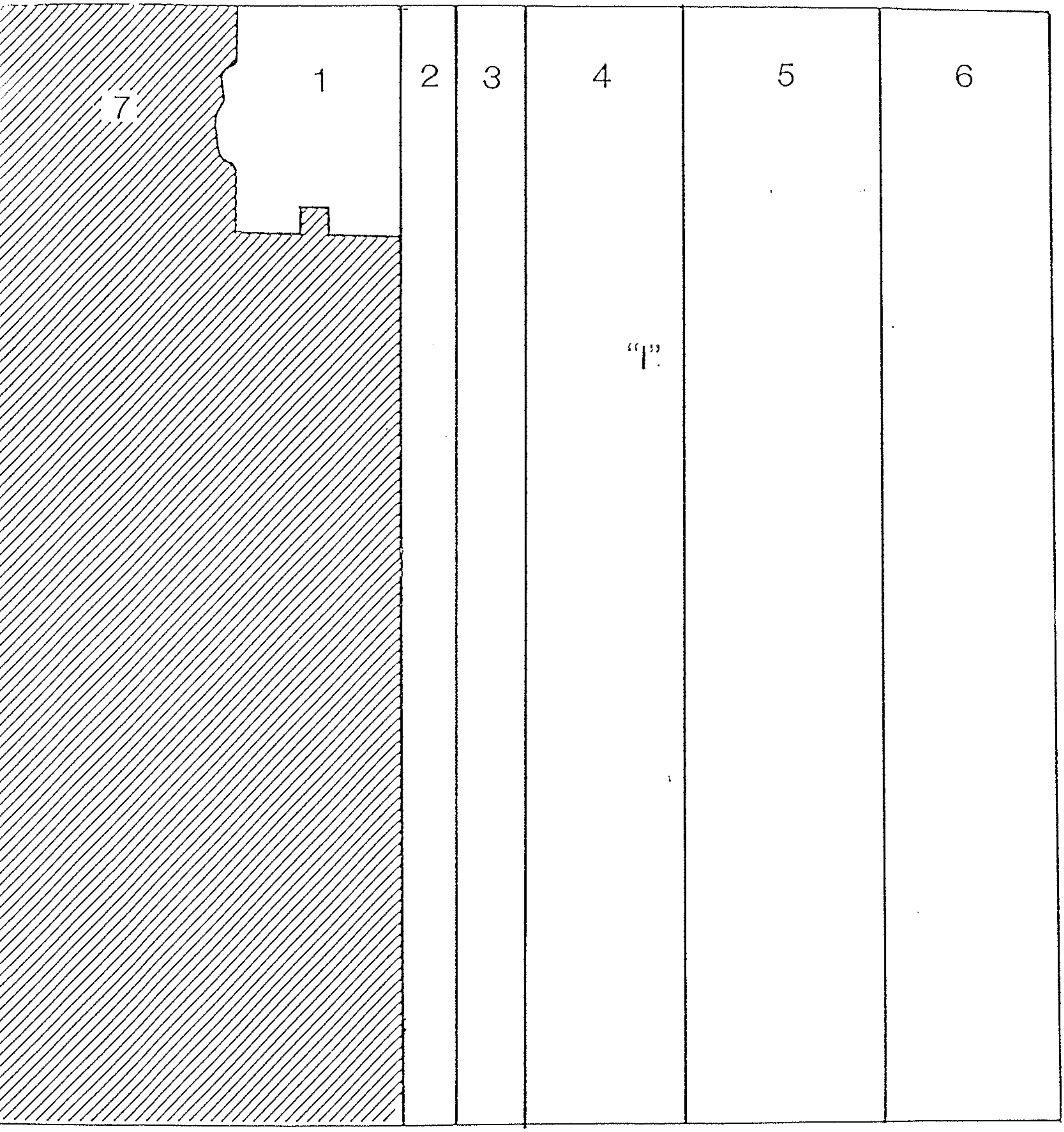

I. NE 1/4 Section 20 - Research Activities

I1. 1899 NAPP - This was the third year of this trial, and it was conducted as reported in previous years.

Splitting the application of fertilizer nitrogen had essentially no effect on grain yield (Table 1). However, protein concentration was increased by fertilizer nitrogen applied after planting at water level 2 (applied supplemental water).

A foliar application of 30 pounds nitrogen per acre from Ni-Sul at the kernel water-ripe stage increased the grain protein concentration at both water levels and essentially all fertilizer nitrogen treatments (Table 2). This may be a good management decision in years when the grain protein concentration of winter wheat grown in the central and southern plains states is low.

Data in Table 3 show the soil depths of water extraction, the rainfall during the growing season, and water-use-efficiency. These data are typical of these collected in the past in North Dakota. (Dr. Bauer)

I2. Fields I1, I2, I4, and I6 were cropped to spring wheat in 1989 with 50 lbs/ac of 18-46-0 applied with the seed following minimum-till summerfallow in 1988 (Landmaster, Undercut, Landmaster, Landmaster sequence during summerfallow).

Seeded I2 field after disking to Amidon spring wheat May 8, 1989 at a seeding rate of 1-million viable seeds per acre. We sprayed this field June 8, 1989 with Tiller (0.25 lb ai/ac) plus Buctril (0.25 lb ai/ac) and obtained 100% weed control of all weeds including green foxtail. This field was combine harvested August 9, 1989 and a grain yield of 34 bu/ac was obtained with protein at 15.4% and a test weight of 60 lb/bu.

We seeded the I4 field to Butte 86 after disking on May 9, 1989 and the field was sprayed for weed control June 8, 1989 with Tiller plus Buctril each at 0.25 lb ai/ac. Combine harvested this field on August 19, 1989 and the grain yield was about 22 bu/ac with 14.7% protein and 59 lb/bu test weight. This field had about 4 acres out of 21 that were recropping after wheat in 1989.

Field I6 was no-till seeded to Marshall spring wheat with the 1000 HB drill on May 10, 1989 with 50 lb/ac of 18-46-0 applied with the seed. Four different rates of N were applied between every-other pair of 7-inch rows; 0, 20, 40, and 60 N/ac using ammonium nitrate as the source of N. This field was sprayed for weed control June 8, 1989 with Buctril and Tiller, each at 0.25 lb ai/ac. Grain yields for N-rates of 0, 20, 40, and 60 lb/ac were 26.0, 26.0, 28.0 and 29.0 bu/ac, respectively. Protein averaged 16.0% an the test weight averaged 58 lb/bu across N-rates.

Field I1 has been continuously cropped to spring wheat with 40 lb N/ac added each year since 1984. This field was seeded to Marshall spring wheat in 1989 at the same time the other I-fields were seeded with 50 lb/ac of 18-46-0 with the seed. This field yielded 12 bu/ac in 1989.

Table 1. Effect of timing of nitrogen application to Amidon wheat on crop characters, 1989 NAPP.

Water level[1]	N treatments[2] P	5	7	H	POP no/m²	HEA no/m²	YIE bu/ac	TWT lbs/bu	IKW mg	PRO %
	lbs N/ac									
1	65				181	305	25.9	59.9	20.59	14.2
	65	35			130	288	29.3	59.6	20.96	14.6
	65		35		151	302	29.6	59.1	20.48	15.4
	65			35	154	290	28.3	60.0	19.95	14.6
1	110				158	300	21.2	57.9	18.03	16.5
	110	35			154	330	26.5	57.8	18.62	16.3
	110		35		143	306	29.2	58.2	18.63	16.1
	110			35	138	307	27.6	58.5	19.01	15.6
1	145				138	326	25.3	57.2	17.51	17.7
	145	35			120	303	27.8	58.1	19.24	17.2
	145		35		141	267	25.2	57.9	18.36	17.2
	145			35	141	252	23.2	58.6	20.42	16.7
2	65				181	428	45.0	61.5	24.15	12.3
	65	35			179	474	46.9	61.0	24.58	13.7
	65		35		164	478	31.1	60.0	22.71	15.0
	65			35	170	452	46.8	61.3	24.87	14.4
2	110				135	453	45.7	60.4	23.74	14.0
	110	35			128	461	45.4	59.4	21.04	16.2
	110		35		139	531	49.1	59.4	23.08	16.5
	110			35	140	483	45.8	59.7	22.80	16.2
2	145				130	397	41.4	58.8	20.98	15.6
	145	35			109	448	38.0	57.4	19.89	16.8
	145		35		124	504	42.7	58.0	20.37	16.7
	145			35	118	477	41.9	58.3	21.31	17.2

Columns POP through PRO are grouped under "Characters".

1/See Table 3 for water level data.

2/Amount of N as nitrate present to four feet at P = planting and added at, 5 = 4-5 leaf stage, 7 = 6-7 leaf stage, H = heading.

3/POP = seedling population before 3-leaf stage
HEA = head population near harvest
YIE = grain yield at 12% water concentration
TWT = test weight, oven-dry basis
TKW = kernel weight, oven-dry basis
PRO = protein at 12% water concentration

Table 2. Effect of foliar application of 30 pounds N per acre from Ni-Sul at kernel watery-ripe stage on grain protein, NAPP 1989.

Water[1/] level	N treatment P	5	7	H	Foliar No	Yes
	lbs N/ac				% protein	
1	65				14.2	15.1
	65	35			14.6	16.3
	65		35		15.4	16.3
	65			35	14.6	15.4
1	110				16.5	17.0
	110	35			16.3	17.5
	110		35		16.1	17.0
	110			35	15.6	17.2
1	145				17.7	17.8
	145	35			17.2	18.1
	145		35		17.2	18.4
	145			35	16.7	18.4
2	65				12.3	13.2
	65	35			13.7	15.3
	65		35		15.0	17.3
	65			35	14.4	16.1
2	110				14.0	14.5
	110	35			16.2	16.6
	110		35		16.5	16.9
	110			35	16.2	18.3
2	145				15.6	17.3
	145	35			16.8	17.2
	145		35		16.7	17.4
	145			35	17.2	17.8

[1/] See Table 3 for description of water levels.
[2/] See Table 1 for description of treatment.
[3/] Protein at 12% water concentration.

Table 3. Water "used" by Amidon spring wheat from planting to harvest as affected by nitrogen level, 1989.

Water level	N level	Soil depth, inches 0-6	6-12	12-18	18-30	30-42	42-54	54-66	Rain
		inches water							inches
1[2/]	65	1.05	0.99	0.86	1.14	0.83	0.10	0.02	3.40
	110	1.00	0.48	0.79	1.36	0.21	0.00	-0.03	3.40
	145	1.00	1.00	0.02	1.79	0.56	0.04	0.04	3.40
2[2/]	65	1.03	1.00	0.92	1.54	1.06	0.10	0.04	9.40
	110	1.11	1.02	0.95	1.32	1.19	0.24	-0.01	9.40
	145	1.02	0.97	0.79	1.07	0.61	0.09	0.01	9.40

[1/]Present at planting to four feet.
[2/]Water level 1 received only rain; water level 2 received 3.40 inches rain and 6.00 inches irrigation water.

Water use efficiency (WUE)

Water level	N level	Yield	Water Source: Soil	Rain/Irrigation	Water "used"	WUE
		bu/ac	inches			bu/ac/in
1	65	25.9	4.97	3.40	8.37	3.1
	110	21.2	4.34	3.40	7.74	2.7
	145	25.3	5.31	3.40	8.71	2.9
2	65	45.0	5.65	9.40	15.05	3.0
	110	45.7	5.83	9.40	15.23	3.0
	145	41.4	4.55	9.40	13.95	3.0

[1/]At 12% water concentration.
[2/]To 54-inch soil depth.

I3. Fields I3 and I5 were no-till summerfallowed in 1989. Field I3 was sprayed with Landmaster (43 oz/a) plus 2% NH_4SO_4 on June 2, 1989; with Roundup (0.4 lb ai/ac) plus 2, 4-D (0.25 lb ai/ac) plus 2% NH_4SO_4 plus surfactant on June 23, 1989; and with Roundup (24 oz/ac; 0.57 lb ai/ac) plus NH_4SO_4 and Surfactant on August 8, 1989. Because of the relatively low level of straw produced in 1988 (about 1200 lb/ac), we elected to summerfallow without tillage to assure more than 30% cover at the end of the summerfallow period using only three spray operations. Field I5 was sprayed the same as the I3 field on June 2 and June 23, 1989 but the final spraying on August 10, 1989 was with Fieldmaster (32 oz/ac) consisting of Roundup (0.28 lb ai/ac plus Diacamba (0.15 ai/ac) plus 2% NH_4SO_4 with excellent results.