SECTION IV

MISCELLANEOUS COOPERATIVE

PROJECTS

TABLE OF CONTENTS

SECTION IV

Drought Stress and Wheat Development:
Crop Development Study 1985-89

by
D. Claypool, R.J. Goos, and B.E. Johnson

INTRODUCTION

The Dickinson Research Center has conducted crop rotation studies for all of its 84-year history. The Crop Development Study is a substudy of the current rotation trial. On the average, wheat recrop will yield 70% of wheat on fallow. In 1985, the Crop Development Study was initiated at Dickinson to identify the differences in the wheat plants themselves that cause this difference in yield. The study was conducted in in cooperation with Dr. R.J. Goos of the Soils Department.

The goals of this study are to:

1. Compare wheat grown after fallow and wheat grown after sunflowers with regard to initiation of yield components, abortion of yield components, soil water depletion to 4 feet, and leaf water stress.
2. To identify drought periods and relate specific heat and water stress events to specific yield components of wheat.

Yield components include the number of tillers, size of the heads, and number of seeds per head. The measurements that we are taking include: soil water content at weekly intervals, leaf water content twice weekly, periodic rating of the growth stage of the main stem and tillers, and harvest analysis. The variety used was Stoa hard red spring wheat.

The part of a wheat plant that will be most affected by a dry spell is that part which is growing the fastest. The most critical growth stages are:

1. Double ridge stage (4 leaves) during which the head size is determined and the T2 tiller is initiated. The T2 tiller emerges from the second leaf node and is the strongest and most important tiller.
2. Tiller initiation (3 to 5 leaves). Drought at this stage will reduce the number of tillers initiated. Drought later on in the season can cause abortion of tillers especially during the 5 to 7 leaf stages.
3. Heading, pollination, and seed fill. Drought during these periods will cause fewer seeds per head and light seed.

MATERIALS AND METHODS

Drought stress was measured by using the relative water content (RWC) of the upper leaves. This technique, developed in 1950, is simple and can be done on several samples at once. Samples of 20 leaves per plot were clipped at 11:00 A.M., weighed, and floated in distilled water for 4 hours. The weight of the turgid leaves was measured and then the samples were oven dried. The ratio of the water content of fresh leaves to the water content of turgid leaves is the RWC:

$$\text{RWC} = [(\text{fresh} - \text{dry}) / (\text{turgid} - \text{dry})] \times 100\%$$

By taking semi-weekly RWC measurements we could get a precise measure of when the recrop really runs out of water, and when the serious drought events occur.

Soil water was measured to 4 feet in 12-inch increments. In 1985 and 1986, samples were taken with a bucket auger. Since 1987, a neutron probe has been used with two access tubes installed in each plot.

RESULTS

1985

The first RWC sampling was May 20 at the 4-4.5 leaf stage – the growth stage when the head size is set (Fig. 1). This was during a hot period but the crop was not drought stressed. After June 6, at the 7-8 leaf stage, the fallow crop was tapping the moist soil in the 2- and 4-foot depth which carried it through to the next rain. The recrop, which didn't have this reserve moisture, became stressed. The recrop and fallow headed on June 20 and 24, respectively, during this dry period. One and fifty-three one-hundredths inch of rain was recorded June 25 to 29. Grain fill occurred June 30 to July 2 which was a hot, dry period. July 5 to 13 was extremely hot.

The summerfallow treatment began the season with 4 feet of moist soil (Fig. 2). It was calculated that 6 inches of total soil water were present in the profile when the entire 4 foot sampling depth was at the wilting point. In the spring, about 60% of the total soil water was available on fallow compared to 30% on recrop. Note the rapid decline in soil water on the fallow when the roots reached the moisture in the 2- to 4-foot depth of soil during a dry period. The recrop ground dried out to nearly the wilting point during the season.

The wheat on fallow yielded 38 bu./A and the recrop yielded 17 bu./A (Fig. 11). Tiller initiation was 1.2/plant on fallow and 1.6/plant on recrop. Tiller survival was 0.7/plant on fallow and 0.1/plant on recrop. The drought stress periods caused considerable tiller abortion on the recrop and tillers made up only about 10% of the yield. The fallow crop was able to maintain its tillers due to the stored soil water in the 2- to 4-foot depth and tillers contributed one-third of the yield. Additionally, 95% of the main stems on fallow had 8 main stem leaves at maturity, but on recrop, 80% of the plants had only 7 main stem leaves. Apparently, one of the hot periods advanced the maturity of the crop, reducing the number of leaves.

1986

RWC sampling began at the 6-leaf stage (Fig. 3). Frequent rains prevented drought stress much of the season. The greatest drought stress on the recrop occurred from boot stage (Haun 9) to the beginning of pollination. Only half of the tillers initiated survived. The fallow initiated 2.2/plant and recrop 1.8/plant, but only 1.0/plant survived on both treatments. Another stress period occurred as the heads started to fill and the crop was ripening.

The 1986 growing season began with a good supply of stored soil moisture (Fig. 4). After June 10 the stored moisture in the 2- to 4-foot depth became important. The first half of June was dry, but there were good rains at the end of June (after the 22nd) and early July.

The above-average rainfall fell frequently enough to prevent prolonged or severe drought stress events. The yields were above average and the recrop yield was equal to the 1985 fallow yield (Fig. 12). The tillers made up 1/3 of the yield for both treatments. In 1986, both treatments had 8 leaves on the main stem.

1987

The first RWC sampling was at the 6-leaf stage (Fig. 5). This was followed by hot, dry, and windy weather in June. The RWC of the recrop dropped because it had no moisture reserve in the lower half of the soil profile. The crop headed June 16 and was hailed on the same day. Apparently, the hail did enough damage that the RWC did not respond to the rain. Both treatments were stressed during pollination and grain fill.

The roots reached lower half of the soil profile after June 3 which is indicated by the reduction in total soil water (Fig. 6). About 2 inches less total soil moisture was stored at planting than the previous two years.

Because of the hail damage, it was not practical to differentiate between the yields of tillers and main stems. The dry weather and heat took its toll on both fallow and recrop. The majority of the plants in both treatments had 8 leaves on the main stem. So, the number of leaves on the main stem was not affected by the hot weather in June.

1988

RWC sampling started at the 6-leaf stage (Fig 7). The crop on fallow was under moderate stress. The wheat on recrop was severely stressed at this time and remained so for the entire season. Both treatments headed June 18.

The 1988 growing season began with ample moisture in the fallow and the least stored water in recrop to date in this study (Fig. 8). The high temperatures in June advanced the crops maturity so much that it was not able to take advantage of all the stored soil water and roots did not reach the fourth foot of soil moisture on fallow.

There was not a harvestable yield on the recrop (Fig. 14). The fallow had few tillers survive. In addition, the heads were very small. Eighty-three percent of the fallow plants only 50% of the recrop plants had 8 main stem leaves.

1989

RWC sampling began at the 6-leaf stage (Fig. 9). The drought stress in June was not as severe as in 1988 due to cool temperatures. Both treatments headed June 28, 10 days later than 1988. By mid-June, the upper soil profile was dried out and the recrop went into a permanent decline. Over half the days in July were above 90°F. A stress period during grain fill reduced the test weights.

The 1989 growing season began with the least stored soil moisture for any year of this study (Fig. 10). Above-average precipitation in April got the crop off to a good start. Soil moisture increased 1.5 inches by early June.

Twenty-five percent of the fallow yield and 6% of the recrop yield came from tillers (Fig. 15). Yields were about the same as in 1987. The majority of plants had only 7 main stem leaves on both treatments.

SUMMARY

In this study, we were able to identify and quantify drought stress events in spring wheat using a very simple technique.

The yield component of spring wheat most affected by drought was the tillers. With adequate moisture they produced 1/3 of the yield. An unexpected result was that the average number of leaves on the main stem was reduced from 8 to 7, apparently in response to heat stress at the 4 to 5 leaf stage. We knew that tillers would be dropped during stressful times, but we were surprised that drought would affect the number of leaves.

The old rule of thumb for soil moisture still holds: for every foot of moist soil you improve your chances of getting an average crop by 25%. Assuming near average growing season rainfall, for one foot of moist soil you have a 25% chance, 2 feet gives you a 50% chance, 3 feet gives you a 75% chance, and 4 feet gives you nearly 100% chance of getting a crop, assuming weather conditions that are reasonably normal.

Figure 1. Total soil water, 1986.

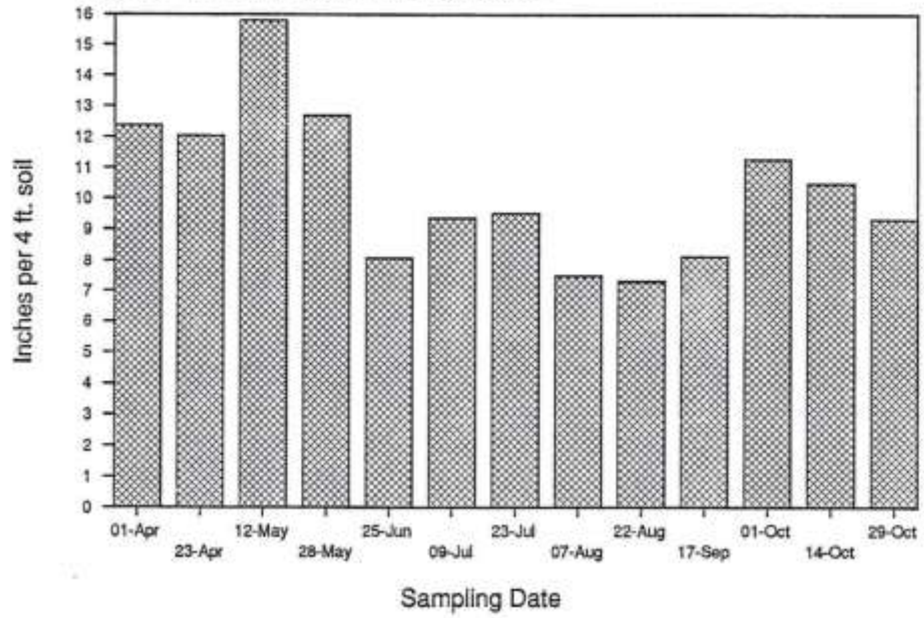


Figure 2. Total precipitation per sampling period, 1986.

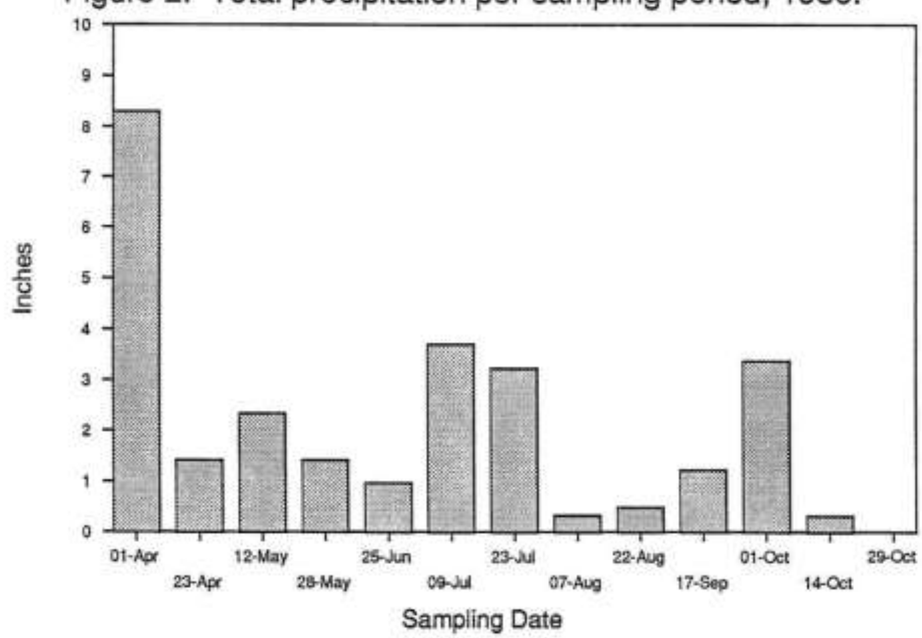


Figure 3. Total soil water, 1987.

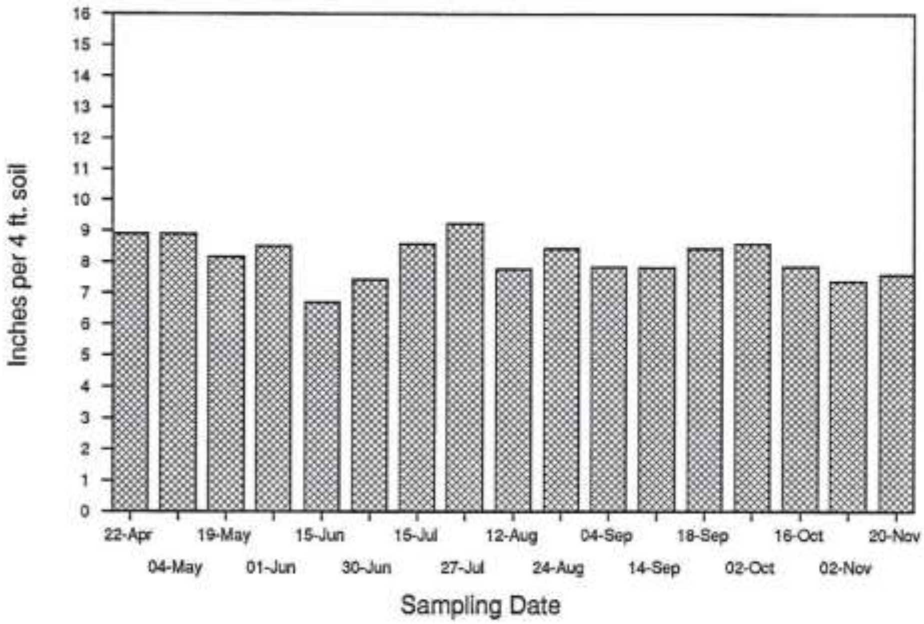


Figure 4. Total precipitation per sampling period, 1987.

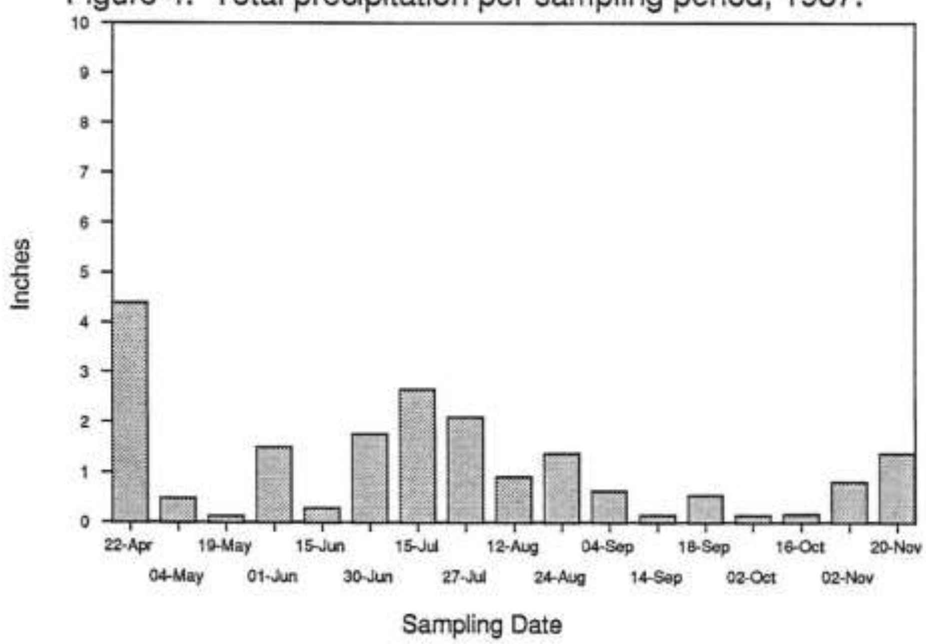


Figure 5. Total soil water, 1988.

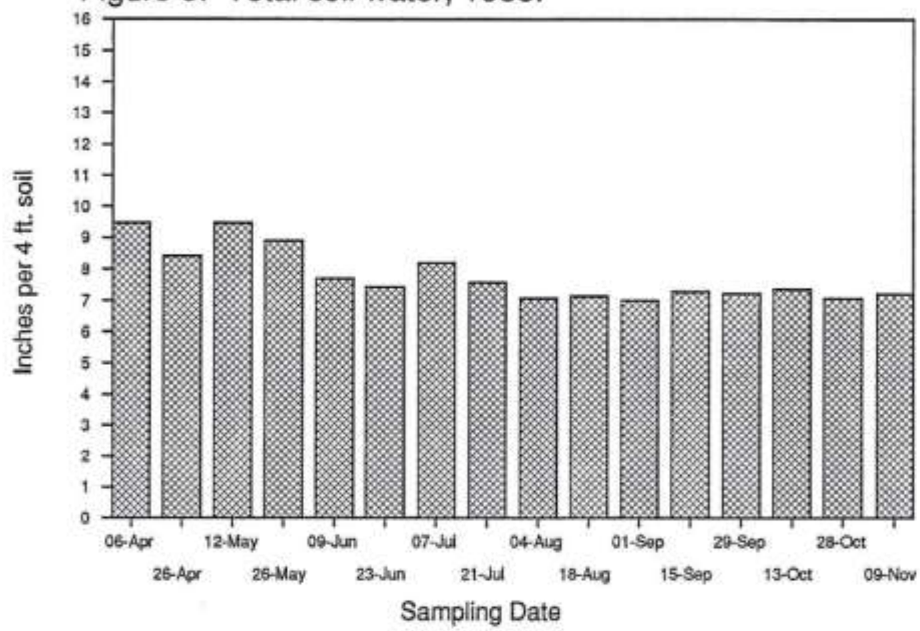


Figure 6. Total precipitation per sampling period, 1988.

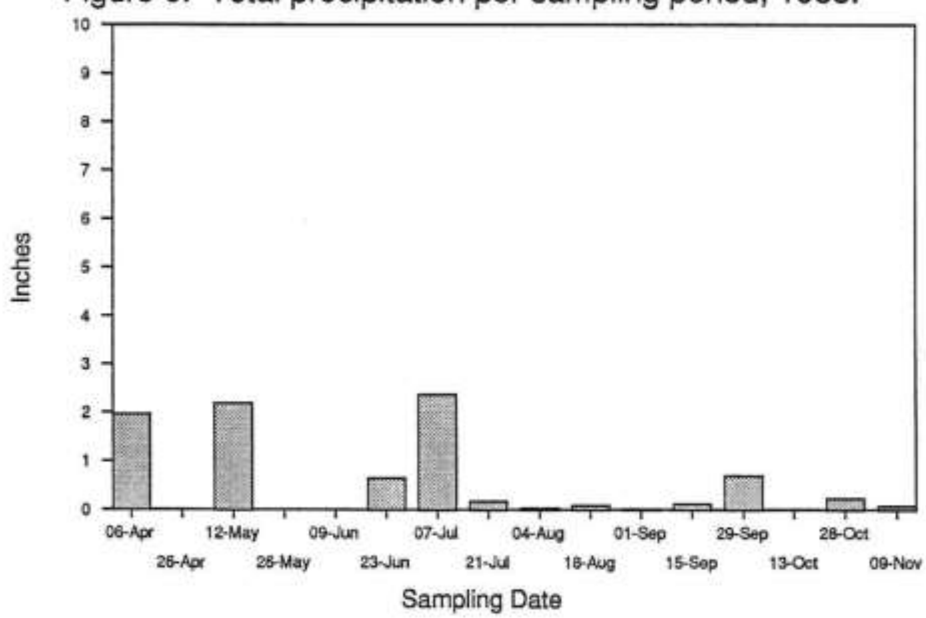


Figure 7. Total soil water, 1989.

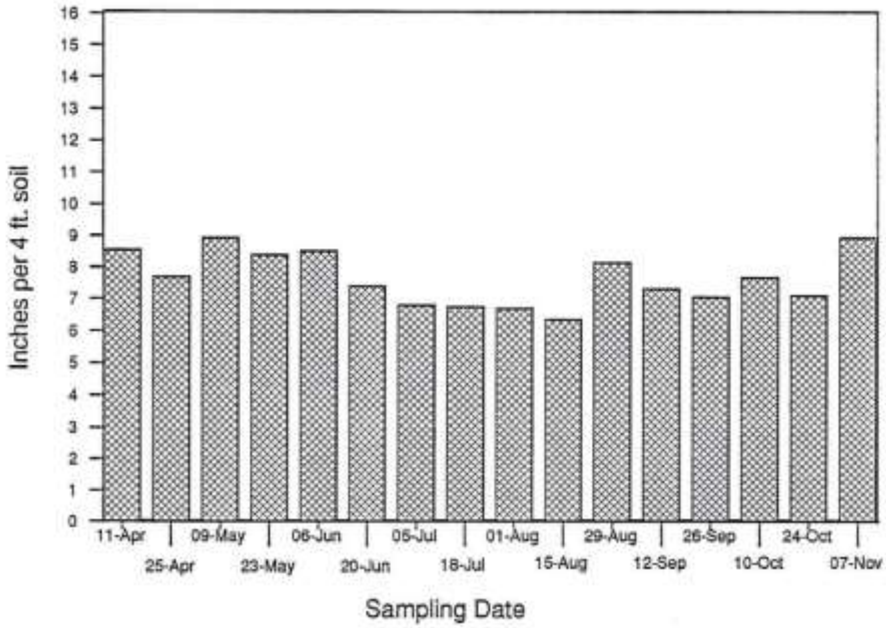
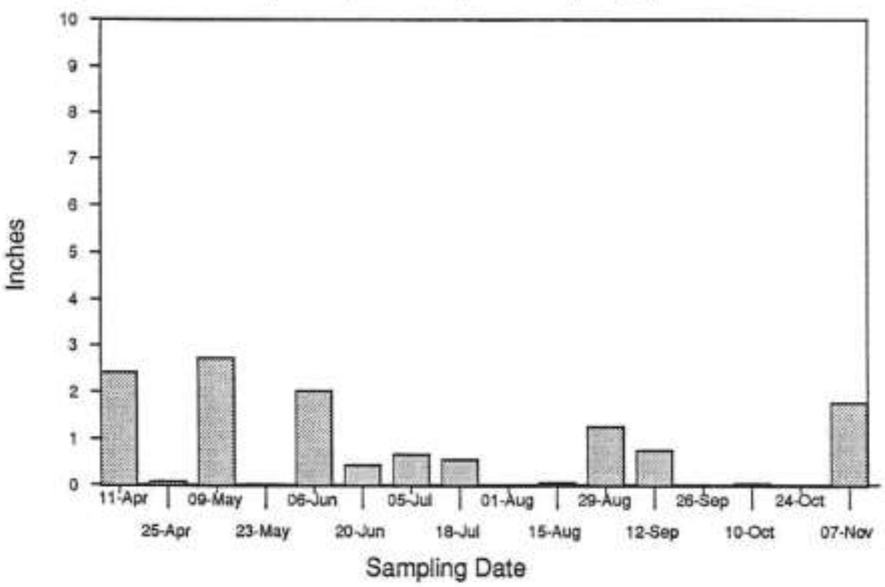


Figure 8. Total precipitation per sampling period, 1989.



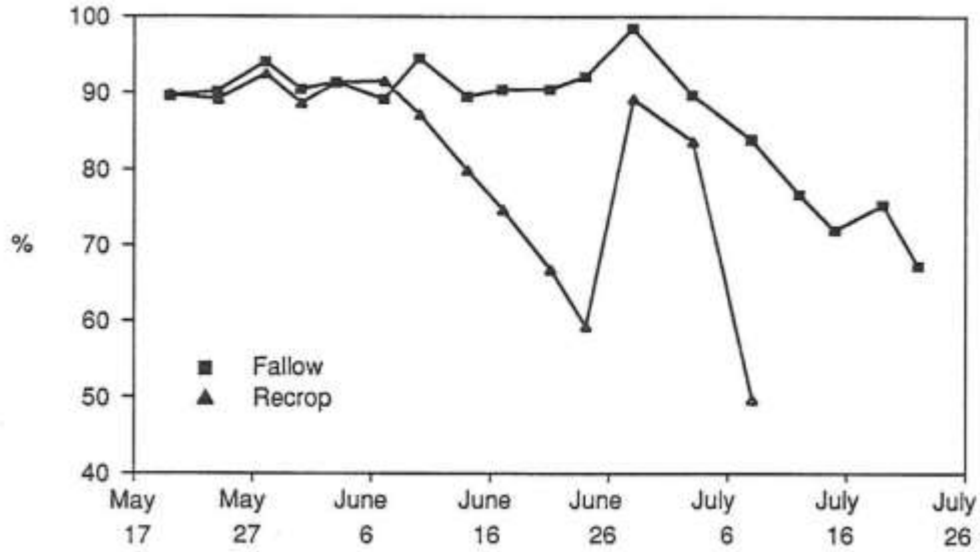


Figure 1. Relative water content index of drought stress in spring wheat, 1985.

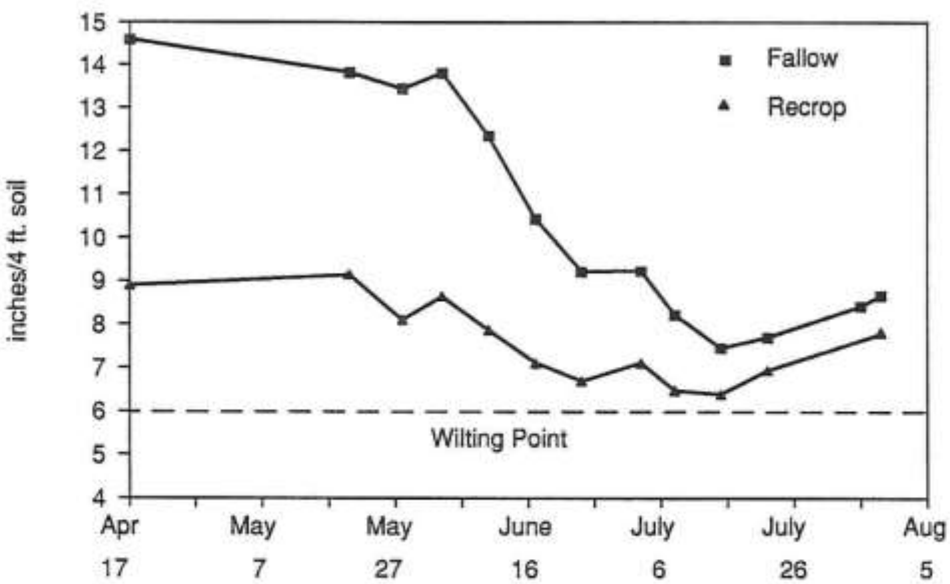


Figure 2. Total soil water at 0-4 feet, 1985.

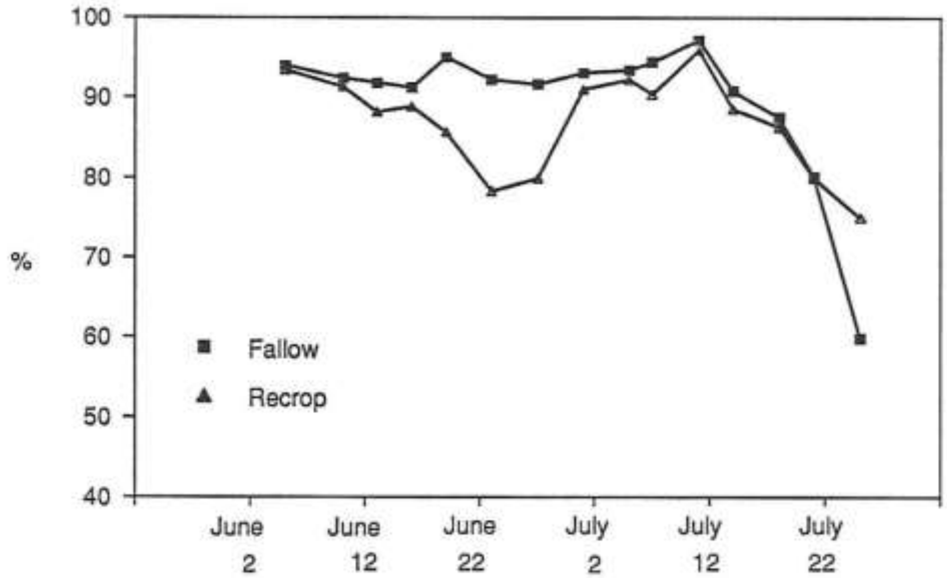


Figure 3. Relative water content index of drought stress in spring wheat, 1986.

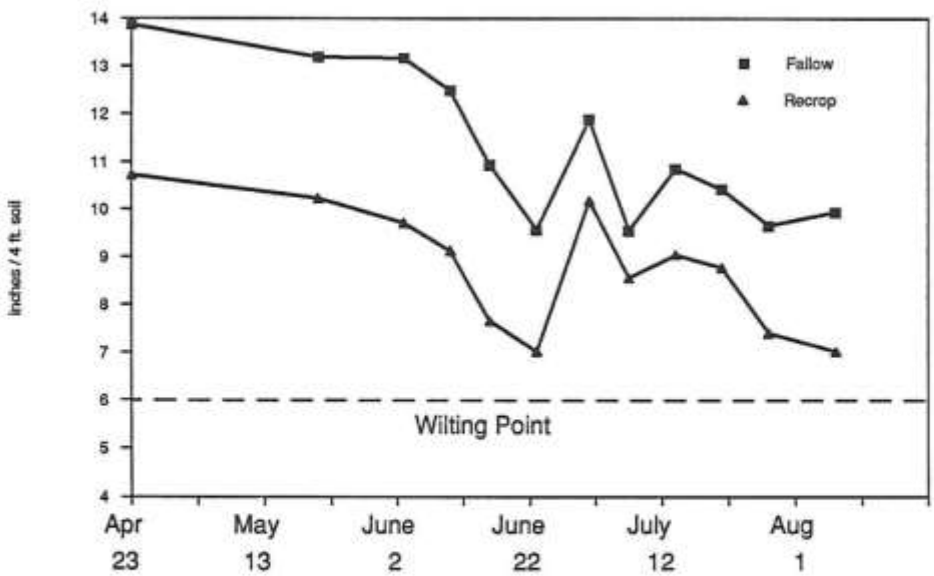


Figure 4. Total soil water at 0-4 feet, 1986.

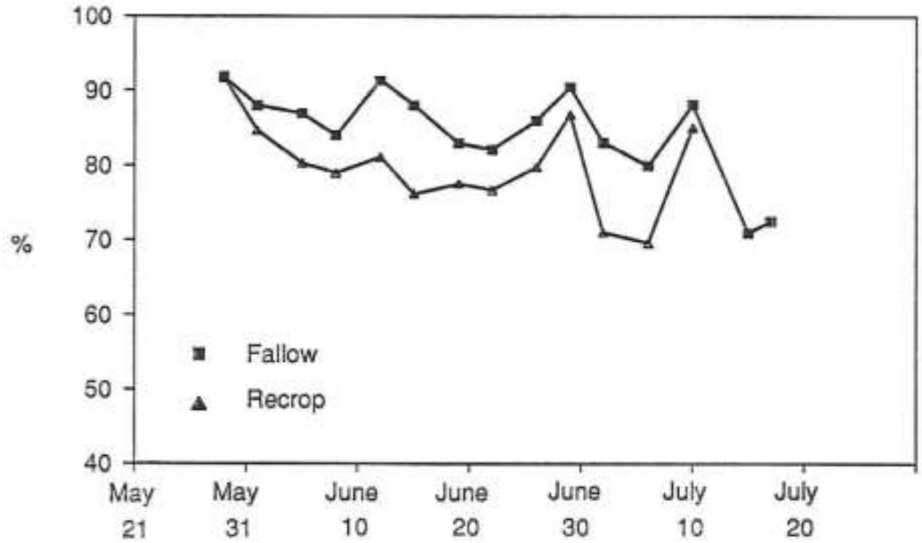


Figure 5. Relative water content index of drought stress in spring wheat, 1987.

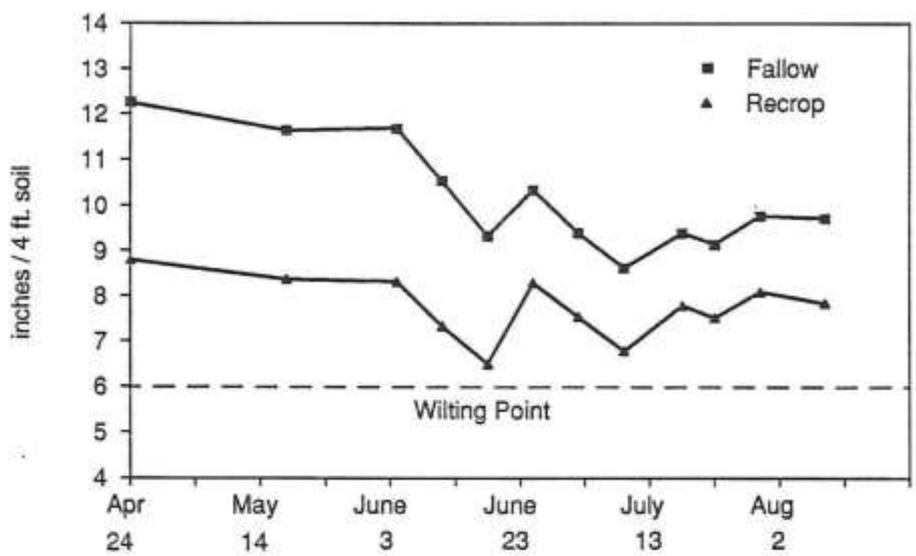


Figure 6. Total soil water at 0-4 feet, 1987.

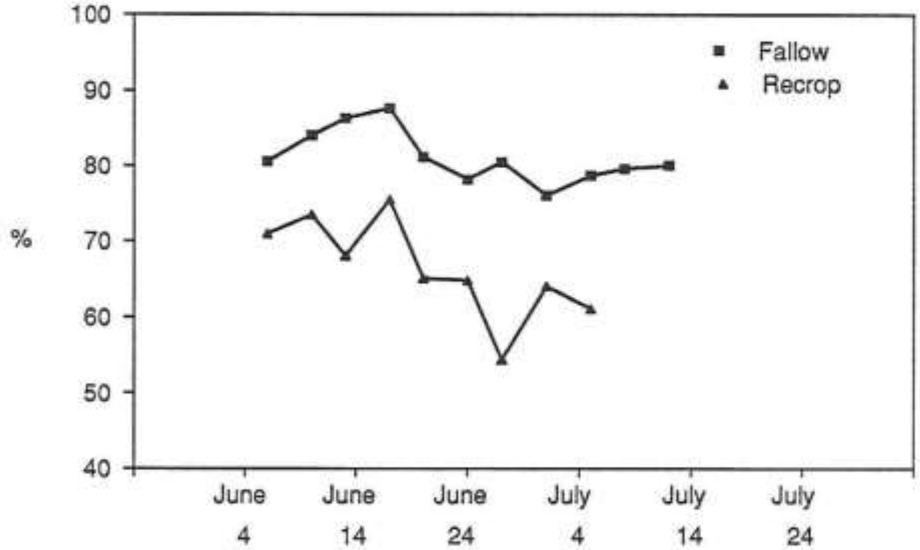


Figure 7. Relative water content index of drought stress in spring wheat, 1988.

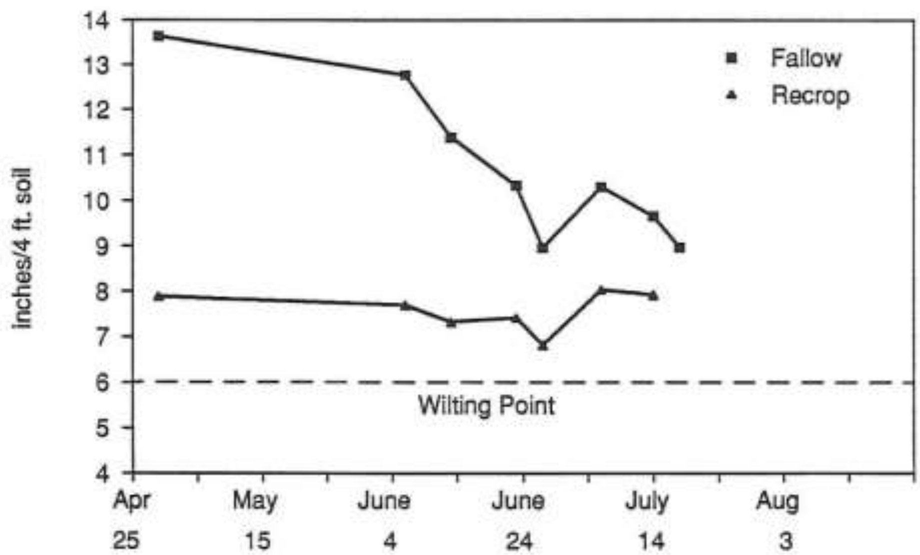


Figure 8. Total soil water at 0-4 feet, 1988.

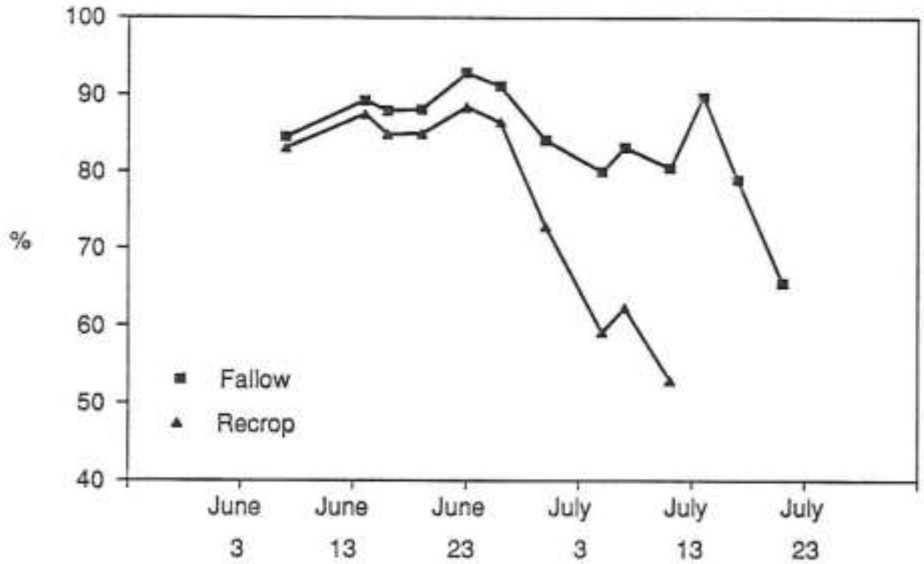


Figure 9. Relative water content index of drought stress in spring wheat, 1989.

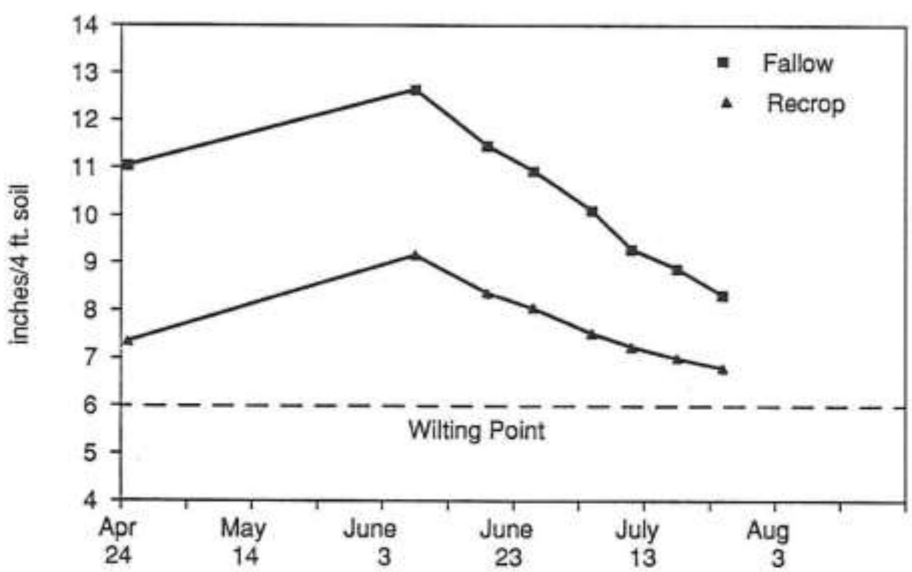


Figure 10. Total soil water at 0-4 feet, 1989.

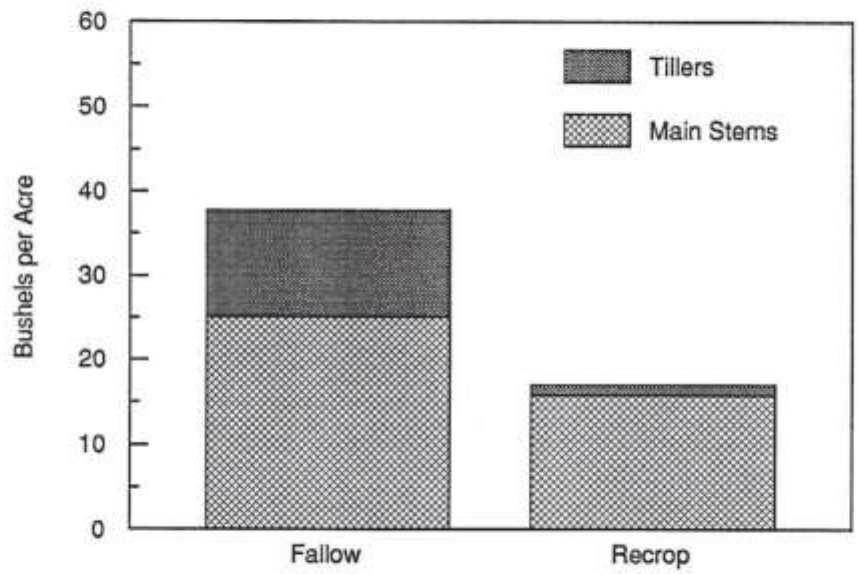


Figure 11. Major components of spring wheat yield, 1985.

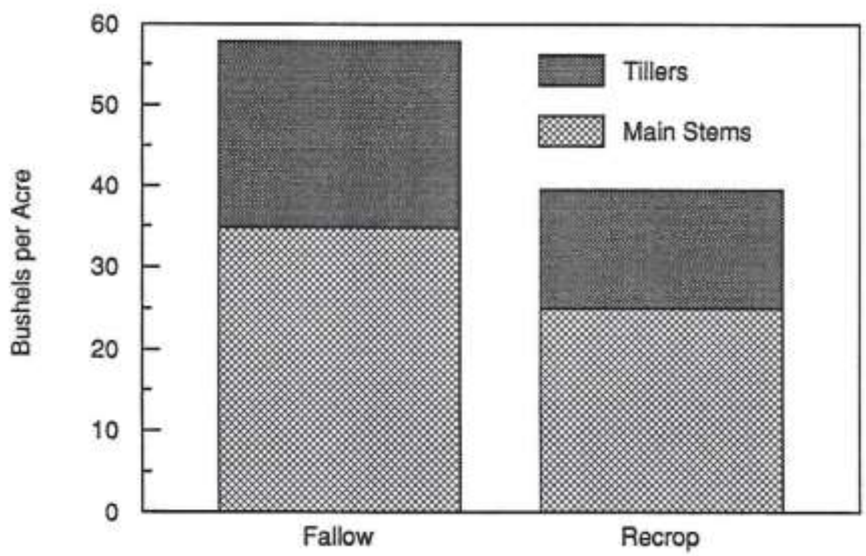


Figure 12. Major components of spring wheat yield, 1986.

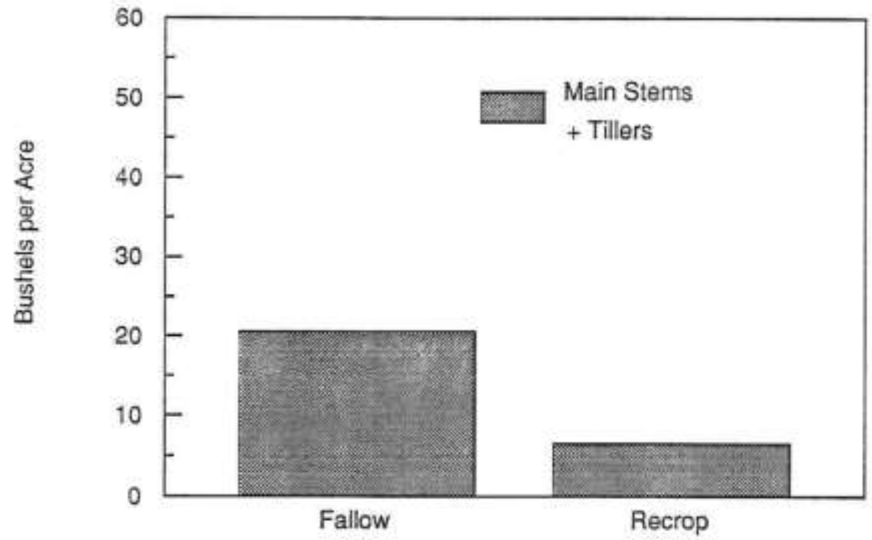


Figure 13. Major components of spring wheat yield, 1987.

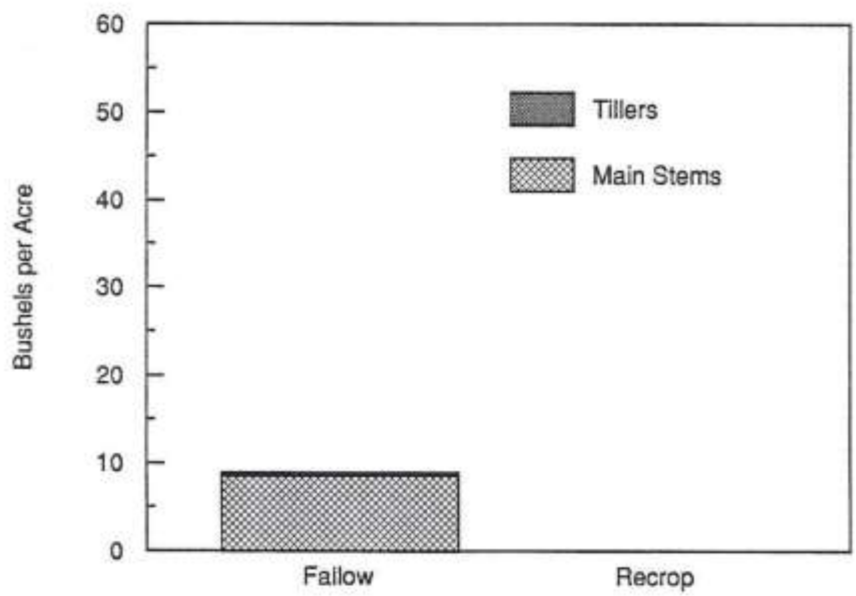


Figure 14. Major components of spring wheat yields, 1988.

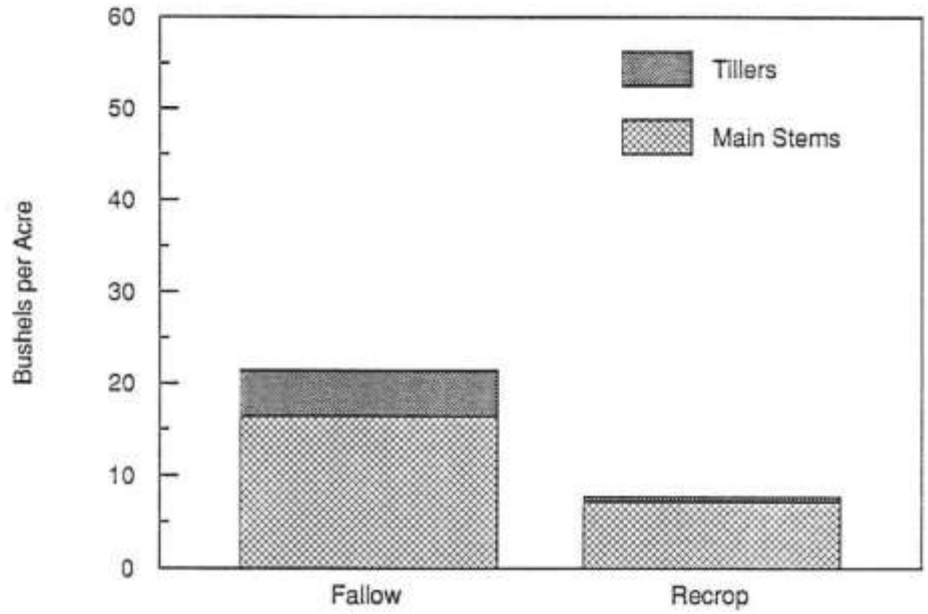


Figure 15. Major components of spring wheat yield, 1989.

Climatology of Soil Water

In cooperation with Dr. John Enz, Department of Soil Science, NDSU, under project ND 2520, a long term study was initiated in August, 1985 to determine the climatology of soil water on continuous spring wheat. A second objective was to develop a fall soil water recharge model. The study is being conducted at the Carrington, Dickinson, Hettinger, Langdon Research Centers at the Fargo Station.

Water content of 8 layers to a 48 inch depth was measured at 3 sites on biweekly intervals from spring thaw until fall freezeup in 1989 by station personnel. Precipitation was measured nearby. The soils were sampled in 1986 to determine bulk density, particle size, field capacity, and wilting point, which are used in the calculation of available soil water.

Soil water recharge during 1985, 1986, and 1987, was assessed for each station by analyzing precipitation variables and the change in total soil water at various depths (see Chris Brenk's M.S. thesis). Precipitation variables used were cumulative between sampling, cumulative but scaled, limited in quantity, and weighted by time before sampling. In general, cumulative precipitation was the better prediction variable, but all variables were useful. Differences between them depend on the characteristics of precipitation, especially the number of events. Unfortunately, much of the data are from very wet periods when little recharge is evident. Fall recharge models were developed for Carrington, Dickinson, Minot, and Streeter, but more data are needed to improve the correlations. It is important to note that none of the variables work well when time between samplings is greater than about 14 days. In addition, they do not work well during the grand consumption stage of soil water in June and July.

Given the wide range of conditions during past years this will be a very important long term data set.

See the 1988 Annual Report for data from 1986-1988. Data for 1989 are summarized in Figures 7, 8, 9 and 10 and Tables 1 and 2.

Figure 7. Total soil water, 1989.

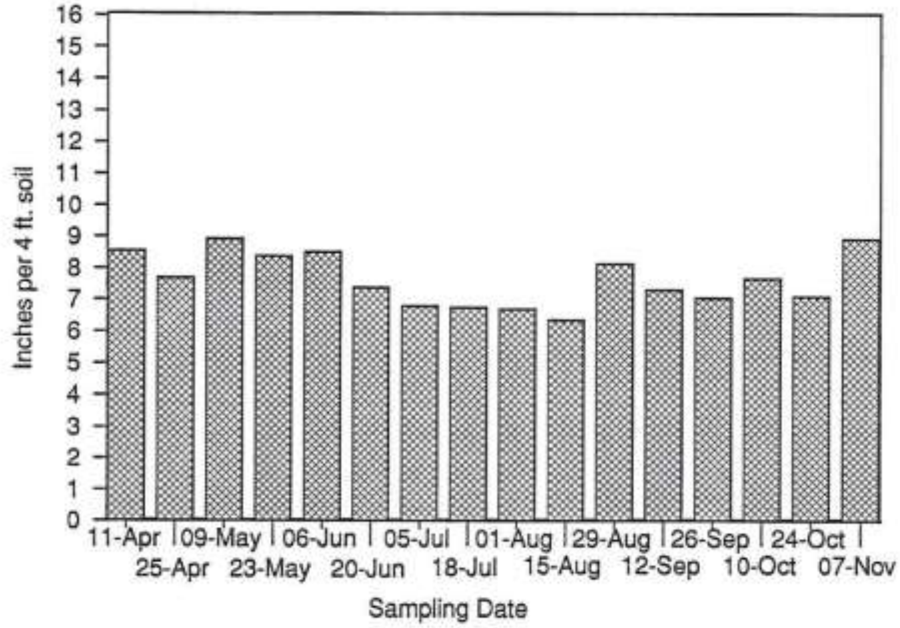


Figure 8. Total precipitation per sampling period, 1989.

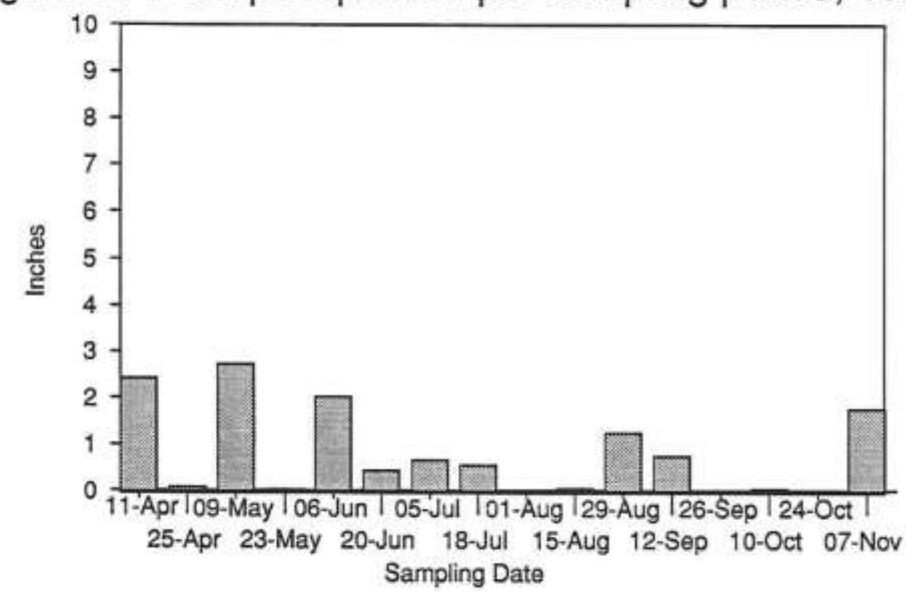
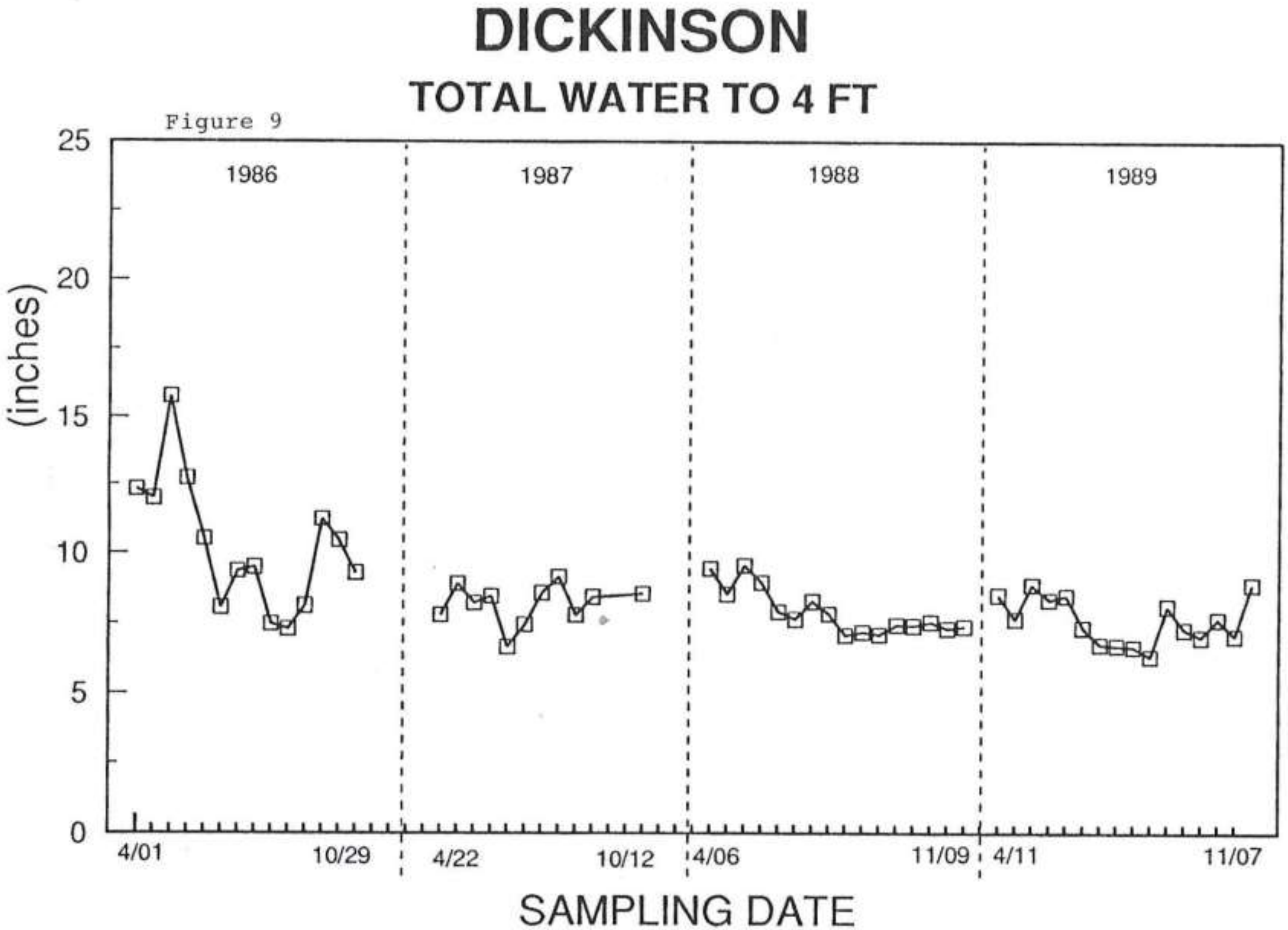
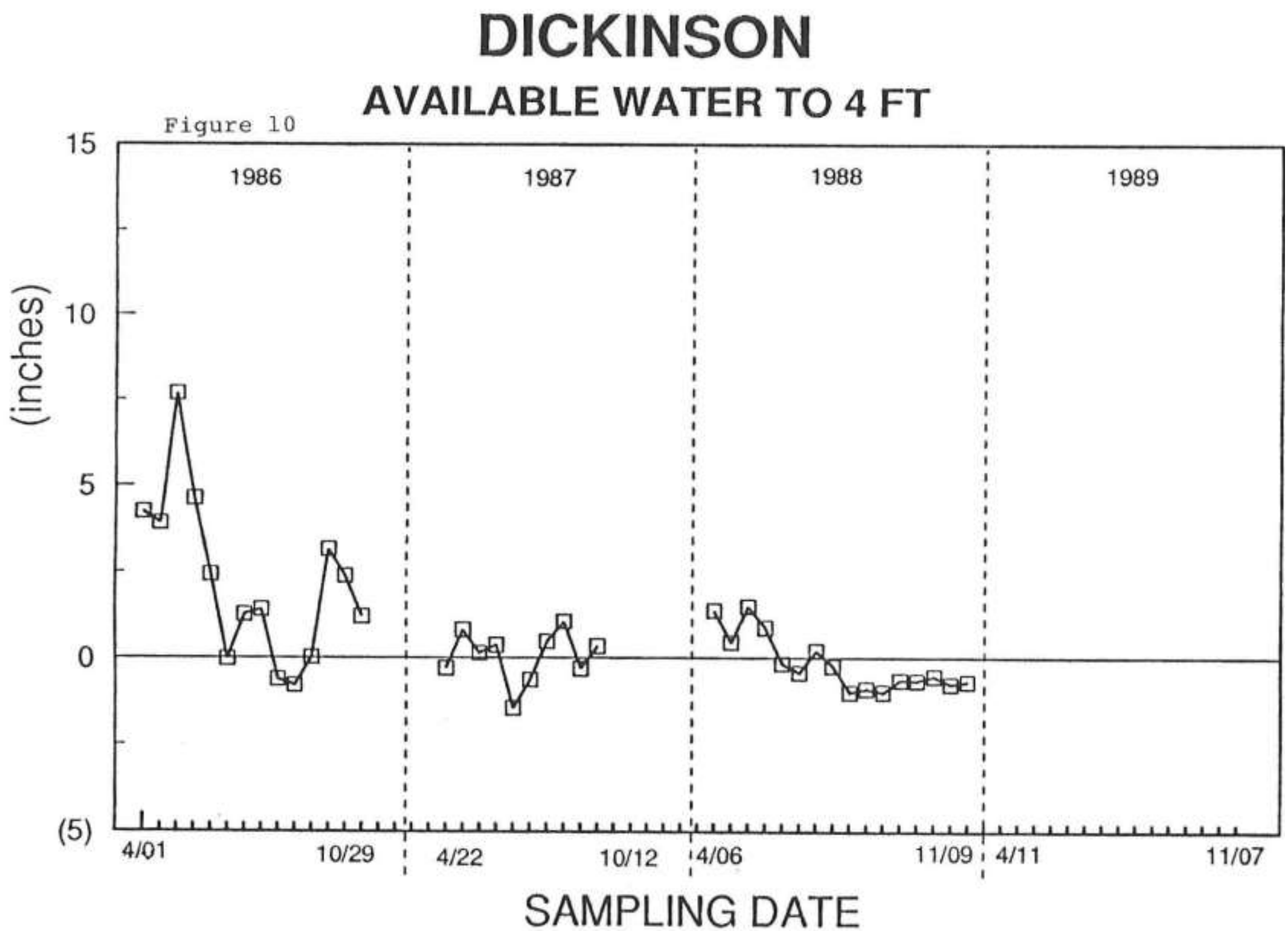


Figure 9


DICKINSON
TOTAL WATER TO 4 FT
25
20
15
10
5
0
(inches)
1986
1987
1988
1989
4/01
10/29
4/22
10/12
4/06
11/09
4/11
11/07
SAMPLING DATE



DICKINSON
AVAILABLE WATER TO 4 FT
Figure 10
15
10
5
0
(5)
(inches)
1986
1987
1988
1989
4/01
10/29
4/22
10/12
4/06
11/09
4/11
11/07
SAMPLING DATE

DICKINSON RESEARCH CENTER

Table 1. 1989 Average Available Water (Inch) for Three Reps for Each Layer Ending at Indicated Depth

DATE SAMPLED	DEPTH IN INCHES								PROFILE TOTAL
	3	6	9	12	18	24	36	48	
04/11/89	0.25	0.24	0.10	0.04	-0.31	-0.32	0.42	0.01	0.43
04/25/89	0.03	0.13	0.02	0.08	-0.34	-0.39	0.31	-0.26	-0.42
05/09/89	0.25	0.28	0.28	0.34	-0.13	-0.34	0.34	-0.22	0.80
05/23/89	0.04	0.15	0.17	0.23	-0.14	-0.31	0.33	-0.21	0.26
06/06/89	0.16	0.21	0.20	0.22	-0.20	-0.31	0.33	-0.21	0.40
06/20/89	-0.14	-0.08	-0.08	0.02	-0.26	-0.34	0.34	-0.18	-0.72
07/05/89	-0.28	-0.16	-0.15	-0.09	-0.40	-0.39	0.34	-0.21	-1.32
07/18/89	-0.22	-0.16	-0.16	-0.12	-0.45	-0.40	0.38	-0.23	-1.36
08/01/89	-0.30	-0.19	-0.16	-0.11	-0.47	-0.38	0.39	-0.20	-1.41
08/15/89	-0.36	-0.27	-0.22	-0.16	-0.47	-0.41	0.34	-0.21	-1.75
08/29/89	0.17	0.04	0.17	0.23	-0.32	-0.38	0.34	-0.21	0.03
09/12/89	-0.04	-0.14	-0.09	0.03	-0.30	-0.38	0.34	-0.23	-0.79
09/26/89	-0.20	-0.12	-0.11	-0.01	-0.31	-0.38	0.30	-0.24	-1.06
10/10/89	-0.06	0.07	0.07	0.14	-0.33	-0.38	0.31	-0.24	-0.43
10/24/89	-0.20	-0.09	-0.07	-0.00	-0.33	-0.38	0.31	-0.24	-1.01
11/07/89	0.38	0.27	0.23	0.31	-0.07	-0.37	0.31	-0.24	0.82

1989 Average Total Water (Inch) for Three Reps for Each Layer Ending at Indicated Depth

DATE SAMPLED	DEPTH IN INCHES								PROFILE TOTAL
	3	6	9	12	18	24	36	48	
04/11/89	0.71	0.69	0.59	0.52	1.23	1.10	1.91	1.77	8.52
04/25/89	0.49	0.58	0.51	0.56	1.20	1.03	1.80	1.50	7.67
05/09/89	0.70	0.73	0.76	0.83	1.41	1.08	1.83	1.54	8.89
05/23/89	0.50	0.61	0.66	0.72	1.40	1.11	1.81	1.55	8.36
06/06/89	0.61	0.67	0.69	0.70	1.34	1.11	1.81	1.55	8.49
06/20/89	0.32	0.38	0.41	0.51	1.28	1.08	1.83	1.58	7.37
07/05/89	0.18	0.30	0.34	0.40	1.14	1.03	1.83	1.55	6.77
07/18/89	0.24	0.29	0.33	0.36	1.10	1.02	1.87	1.53	6.73
08/01/89	0.16	0.26	0.32	0.38	1.08	1.05	1.88	1.56	6.68
08/15/89	0.10	0.19	0.27	0.33	1.07	1.01	1.82	1.55	6.34
08/29/89	0.63	0.50	0.65	0.72	1.22	1.04	1.83	1.54	8.12
09/12/89	0.42	0.32	0.40	0.51	1.25	1.04	1.83	1.53	7.30
09/26/89	0.26	0.34	0.38	0.47	1.23	1.04	1.79	1.52	7.03
10/10/89	0.40	0.53	0.55	0.63	1.21	1.04	1.79	1.51	7.66
10/24/89	0.26	0.37	0.41	0.48	1.21	1.04	1.79	1.51	7.08
11/07/89	0.84	0.73	0.72	0.80	1.47	1.05	1.79	1.51	8.91

Table 2. **Summary of Soil Water Data**

SAMPLING DATE	DEPTH (in)	AVE. T.W. (in)	AVE. A.W. (in)	SAMPLING DATE	DEPTH (in)	AVE. T.W. (in)	AVE. A.W. (in)
08/22/85	48	4.60	1.90	04/06/88	48	9.46	1.37
10/25/85	48	12.18	4.10	04/26/88	48	8.54	0.45
				05/12/88	48	9.57	1.48
04/01/86	48	12.33	4.25	05/26/88	48	8.96	0.87
04/23/86	48	12.00	3.92	06/09/88	48	7.92	-0.17
05/12/86	48	15.77	7.69	06/23/88	48	7.66	-0.43
05/28/86	48	12.73	4.64	07/07/88	48	8.29	0.20
06/10/86	48	10.51	2.43	07/21/88	48	7.85	-0.24
06/25/86	48	8.05	-0.03	08/04/88	48	7.10	-0.99
07/09/86	48	9.35	1.27	08/18/88	48	7.20	-0.89
07/23/86	48	9.49	1.41	09/01/88	48	7.11	-0.98
08/07/86	48	7.47	-0.61	09/15/88	48	7.45	-0.64
08/22/86	48	7.29	-0.79	09/29/88	48	7.43	-0.66
09/17/86	48	8.11	0.02	10/13/88	48	7.56	-0.53
10/01/86	48	11.24	3.16	10/28/88	48	7.33	-0.76
10/14/86	48	10.46	2.38	11/09/88	48	7.40	-0.69
10/29/86	48	9.29	1.21	04/11/89	48	8.52	0.43
04/22/87	48	7.80	-0.30	04/25/89	48	7.67	-0.42
05/04/87	48	8.90	0.81	05/09/89	48	8.89	0.80
05/19/87	48	8.23	0.14	05/23/89	48	8.36	0.26
06/01/87	48	8.46	0.37	06/06/89	48	8.49	0.40
06/15/87	48	6.66	-1.44	06/20/89	48	7.37	-0.72
06/30/87	48	7.46	-0.63	07/05/89	48	6.77	-1.32
07/15/87	48	8.57	0.48	07/18/89	48	6.73	-1.36
07/27/87	48	9.15	1.05	08/01/89	48	6.68	-1.41
08/12/87	48	7.79	-0.31	08/15/89	48	6.34	-1.75
08/24/87	48	8.43	0.34	08/29/89	48	8.12	0.03
10/12/87	48	8.55		09/12/89	48	7.30	-0.79
				09/26/89	48	7.03	-1.06
				10/10/89	48	7.66	-0.43
				10/24/89	48	7.08	-1.01
				11/07/89	48	8.91	0.82
				04/26/89	48	7.68	-0.42

United States Department of Agriculture

Agricultural Research Service

Northern Plains Area
Northern Great Plains Research Laboratory

Highway 6 South
P.O. Box 459
Mandan, North Dakota
58554

January 16, 1990

Supt. Tom Conlon
Dickinson Experiment Station
P.O. Box 1117
Dickinson, ND 58601

Dear Tom:

Enclosed are results of the variety trials we conducted at the Northern Great Plains Research Laboratory in 1988 and 1989. I had sent results of the 1988 trials to you about a year ago but I did not include the grain protein information (our auto analyzer was down for almost a year) nor water use data.

As in previous years, the trials were conducted on summerfallow, planted with a press drill equipped with disk openers, at six-inch spacing between rows. Planting rate for both wheat and barley cultivars was a million viable seeds per acre in 1988 and 1.2 million viable seeds per acre in 1989, based on kernel weight, germination percentage, and kernel water concentration. Planting and harvest dates are shown on the enclosed information

This is the first time I have sent the soil water depletion and rainfall information to you. We have identical data for almost all of the years these trials have been conducted at Mandan since 1979. The data prior to 1987 are included in Experiment Station Bulletin 519, January 1989 "Soil water use by plant development stage of spring and winter wheat".

Call if you have any questions.

Thank you for your cooperation in providing the seed.

Sincerely,

ARMAND BAUER
Soil Scientist

cc:
Jack Stewart
Elroy Haadem

Northern Great Plains Research Laboratory, Mandan, ND
1988 VARIETY TRIAL

						Measurement						
Cultivar	**POP** no/m²	**HEA** no/m²	**HGT** inches	**YIE** bu./ac	**TWT** lbs./bu.	**TKW** mg	**YIM** bu./ac	**STR** lbs./ac	**TDM** lbs./ac	**KPH** no.	**HES** no.	**NEG** 1/ %
Azure	185	458	19	15.0	47.4	29.78	38.7	3304	5162	15.9	2.5	2.68
Bowman	222	927	18	38.1	49.1	34.66	54.1	3482	6078	9.1	4.2	2.62
Gallatin	197	769	21	27.5	48.3	28.89	51.8	3572	6058	12.6	3.9	2.60
Morex	189	380	19	21.5	46.7	28.44	45.0	2720	4882	22.5	2.0	2.70
Robust	200	426	17	18.2	46.4	28.35	47.4	3255	5529	21.1	2.1	2.73
Arra 1/	173	500	16	13.8	41.4	27.85	30.2	3183	4632	11.7	2.1	3.22
Datal 1/	197	695	19	14.8	40.2	21.60	38.7	3037	4895	13.8	3.5	3.19
Otal 1/	87	367	20	13.3	42.4	23.19	27.5	2177	3498	17.5	4.2	3.58
LSD 2/	26	29	1	6.9	3.1	3.22	7.1	312	580	2.6	0.5	0.15
Alex	158	327	23	16.1	57.9	24.26	22.9	2190	3565	19.5	2.1	3.82
Amidon	180	275	22	19.0	57.9	24.25	22.1	2162	3486	22.2	1.5	3.60
Challenger	185	247	16	14.3	56.5	22.49	18.5	1515	2625	22.5	1.3	3.53
Cutlass	169	301	18	13.7	56.5	20.94	16.8	1757	2766	17.9	1.8	3.71
Keif	151	266	19	16.5	56.9	23.41	16.8	1739	2748	18.3	1.8	3.55
Len	171	283	18	12.3	57.8	23.15	15.0	1889	2787	15.4	1.7	3.71
Nordic	144	252	18	17.5	58.7	27.27	19.0	1890	3031	18.6	1.8	3.29
Wheaton	174	229	16	14.9	55.7	23.10	16.1	1466	2431	20.5	1.3	3.45
LSD 2/	19	20	2	2.3	1.1	1.43	2.1	205	321	2.3	0.2	0.13

1/ These are from Alaska.

2/ The difference between any two values in the column above must be at least this large to be significant at the 95% confidence level.

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. (Saved all seeds irrespective of size)
STR = Straw yield
TDM = Total dry matter at harvest
KPH = Kernels per head
HES = HEA/POP
NEG = Nitrogen concentration in grain

ALL WEIGHTS ARE EXPRESSED ON AN OVEN-DRY BASIS

1/ For wheat, multiply by 5.016 to convert to % protein at 12% water concentration; for barley, multiply by 5.5.

Northern Great Plains Research Laboratory, Mandan, ND
1989 VARIETY TRIAL

Measurement

Crop	Variety	POP no/m	HEA no/m	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

LEGEND

ALL WEIGHTS EXPRESSED ON OVEN-DRY BASIS

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

Table 2. Available Soil Water by Foot-Increments to Six Feet and Rainfall/ Irrigation Applied between Dates of Soil Water Measurement on Spring Barley, Mandan, ND, 1988

Planted 4/25/88
Emerge 5/06/88

Date mo/day	DS[1/]	Soil depth – feet 0-1	1-2	2-3	3-4	4-5	5-6	Rain inches
		inches available water						
5/06	0.5	1.37	1.88	2.08	1.78	1.80	1.90	0.52[2/]
								0.04
5/10	1.6	1.33	1.86	2.02	1.80	1.77	1.87	
								0.12
5/19	3.8	1.18	1.88	2.06	1.80	1.84	1.93	
								0.00
5/25	5.4	0.70	1.87	2.07	1.84	1.87	2.02	
								0.16
6/01	7.0	0.28	1.65	1.96	1.80	1.84	1.95	
								0.00
6/07	8.4	-0.11	1.00	1.78	1.78	1.87	1.95	
								2.01[3/]
6/15	9.8	0.59	0.48	1.29	1.70	1.84	1.99	
								2.55[4/]
6/21	11.9	0.11	0.42	0.97	1.44	1.74	1.91	
								1.61[4/]
6/28	13.5	0.94	0.40	0.74	1.34	1.80	1.99	
								2.05
7/05	14.0	1.31	0.86	0.66	1.28	1.72	1.96	
								0.00
7/12	14.6	0.17	0.68	0.65	1.16	1.74	1.94	
								0.00
7/20	15.0	-0.09	0.56	0.35	1.06	1.66	1.93	
	"Used"	1.46	1.32	1.73	0.72	0.14	----	9.06

1/ Development stage, Haun scale, average 5 barley varieties. Stages on 5/10 and 5/19 estimated from regression.
2/ Planting to 5/06.
3/ Rain was 0.40 inches; the remainder is from irrigation.
4/ All from irrigation.
5/ Received 0.08 inches rain on 7/20.

Total water = 14.43 inches
(5) Average yield = 24.1 bu./ac

.

Table 3. Available Soil Water by Foot-Increments to Six Feet and Rainfall Amounts between Dates of Soil Water Measurement on Spring Wheat, Mandan, ND, 1988

Planted 4/25/88
Emerge 5/07/88

Date mo/day	DS[1]	Soil depth - feet 0-1	1-2	2-3	3-4	4-5	5-6	Rain inches
		---------- inches available water						
								0.52[2]
5/06		1.18	1.77	2.01	1.81	1.72	1.64	
								0.04
5/10		1.18	1.72	2.00	1.80	1.74	1.63	
								0.12
5/19		1.09	1.78	2.01	1.81	1.76	1.67	
								0.00
5/25		1.02	1.77	2.03	1.86	1.79	1.71	
								0.16
6/01		0.52	1.60	1.96	1.84	1.77	1.68	
								0.00
6/07		0.00	1.05	1.83	1.80	1.81	1.70	
								0.40
6/15		0.30	0.45	1.40	1.76	1.75	1.73	
								0.00
6/21		-0.07	0.32	0.93	1.54	1.68	1.62	
								0.00
6/28		-0.06	0.24	0.59	1.26	1.74	1.70	
								2.05
7/05		1.09	0.24	0.47	1.14	1.61	1.65	
								0.00
7/12		0.16	0.24	0.45	0.99	1.59	1.66	
								0.00[3]
7/20		-0.10	0.21	0.43	0.85	1.49	1.62	
	"Used"	1.28	1.56	1.58	0.96	0.23	0.02	3.29

1/ Development stage.
2/ Planting to 5/06.
3/ 0.08 inches recorded on 7/20.

Total water = 8.92 inches
Average Yield = 15.5 bu./ac

Table 4. 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. 5 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

JANSSEN
PHARMACEUTICA

40 KINGSBRIDGE ROAD
PISCATAWAY, NEW JERSEY 08854

March 16, 1989

Mr. T. J. Conlon
Dickinson Experiment Station
P.O. Box 1117
Dickinson, North Dakota 58601

Dear Mr. Conlon:

As we recently discussed, Janssen Pharmaceutica is interested in evaluating our imazalil seed treatment fungicide on a wheat, barley and durum variety in replicated trials at your research facility. Since growers in your area typically apply Vitavax to their small grain seed we propose to compare the Vitavax treatment to treatment with Vitavax plus imazalil.

In previous trials of a similar nature we have found that if a relatively susceptible variety is grown on ground previously planted to wheat or barley, the response to root rot control with imazalil is usually more pronounced. Although varietal susceptibility is important, we do not want to test a variety not typically grown in your area.

Our primary interest in these trials is to determine yield response. Information about stand establishment is also useful. Frequently we observe increased tillering from imazalil treatment and if this is noticed in these plots we would like it quantified (ie. number of heads per 4 foot of row).

Janssen can provide $500.00 in support of these trials on our behalf. Your interest is greatly appreciated. Please call to let me know if these arrangements are agreeable to you.

Sincerely,

David Helmer

David B. Helmer
Technical Manager
Plant Protection Division
(201) 524-9012

DBH/lm
Enclosure
WRG/DH
/1670Z

North Dakota State University

OF AGRICULTURE AND APPLIED SCIENCE
NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

DICKINSON EXPERIMENT STATION
P.O. BOX 1117
DICKINSON, NORTH DAKOTA
58602 1117

Oct. 30, 1989

Mr. David B. Helmer
Technical Manager
Plant Protection Division
Janssen Pharmacentica
40 Kingsbridge Road
Piscataway, NJ 08854

Dear Dave,

Enclosed for your information is a summary report of the 1989 fungicide trial, and a summary of growing conditions prevailing this year. Yields reflect the stress of two consecutive years of extreme drought.

A copy of this report has been sent to Dr. Marcia McMullen, Plant Pathologist, North Dakota State University. Dr. McMullen inspected the trial during the growing season. Contact her directly, or let me know if you want her comments on the trial.

Sincerely,

Thomas J. Conlon, Supt.
Dickinson Research Center

TJC:ab
encl:

1989 Dickinson Fungicide Trial

Variety	Treatment	Bu/A Avg.	Test Wt. lbs.
---------- Spring Wheat ----------			
Amidon	Control	12.8	58.0
Amidon	Vitavax	15.3	58.0
Amidon	Vit. + Imazalil	13.8	57.5
Stoa	Control	16.2	57.0
Stoa	Vitavax	14.3	57.5
Stoa	Vit. + Imazalil	15.5	57.5
L.S.D. 5% = 3.9 Bu/A C.V. = 14.7 %			
---------- Barley ----------			
Azure	Control	16.6	46.0
Azure	Vitavax	12.2	40.5
Azure	Vit. + Imazalil	11.4	43.0
Bowman	Control	15.1	45.5
Bowman	Vitavax	16.6	43.5
Bowman	Vit. + Imazalil	16.4	44.5
L.S.D. 5% = 5.8 Bu/A C.V. = 22.8 %			
---------- Durum ----------			
Vic	Control	10.7	53.5
Vic	Vitavax	11.6	58.0
Vic	Vit. + Imazalil	10.3	56.0
Ward	Control	10.8	56.5
Ward	Vitavax	10.9	58.0
Ward	Vit. + Imazalil	10.0	58.0
L.S.D. 5% = 2.1 Bu/A C.V. = 13.1 %			

Seeding Date: May 8

Harvest Date: Aug. 2

Fertilizer Applied: 60 lbs./A 18-46-0 + 100 lbs./A 46-0-0, broadcast

Imazalil Flo Pro 30% applied at 0.5 fl. oz. per cwt.

1989 COOPERATIVE WOODY PLANT TESTING REPORT

Larry J. Chaput, Dale E. Herman, and Gerald A. Tuskan

1989 marked the third year of the cooperative program to test woody tree and shrub taxa at selected locations throughout North Dakota. Current test sites include Bismarck (loc 1), Carrington (2), Dickinson (3), Fargo (4), Grand Forks (5), Langdon (6), and Minot (7).

The following four species were incorporated into the program in 1989:

1. Two clonal accessions of Euonymus bungeana (Winterberry euonymus): the first propagated by cuttings from a specimen tree in Shenandoah, IA; the second produced vegetatively from a second generation open pollinated seedling population of E. bungeana 'Pendula' growing at the Horticulture Research Farm near Absaraka, ND.

2. One seedling accession of Ptelea trifoliata (Hoptree) produced from seed collected from a superior plant growing in the SCS field nursery near McKenzie, ND.

3. One clonal accession of Acer saccharum subsp. nigrum 'Green Column' (Green Column Black sugar maple) plus a control cultivar, Acer saccharum 'Green Mountain' (Green Mountain sugar maple), a standard sugar maple sold in the nursery trade.

4. One clonal accession of Pyrus ussuriensis (Ussurian pear) growing at the Carrington Research/Extension Center (original seed source - Plant Materials Center, Bismarck, ND) plus Ussurian pear seedlings used as the control.

Table 1 lists the locations and species or accessions planted at each site in 1989. Planting was done over a 17-day period beginning May 16 in Bismarck and ending June 2 at Fargo. All species were hand-planted and watered in to aid in establishment. Initial height measurements were recorded. Subsequent waterings were carried out throughout the growing season to combat persistent drought conditions. High mortality caused by the 1988 drought required the full replacement of jack pine and lodgepole pine in the 1988 plots at Bismarck, Carrington, Dickinson, and Langdon, as well as replacement of European alder at Bismarck.

In addition to the 1989 species list, the following species planted in 1987 and 1988 were included in the data analysis: (1) one seedling accession of Alnus glutinosa (European alder); (2) one clonal accession of Platanus occidentalis (American sycamore); (3) one seedling accession of Pinus banksiana (Jack pine); (4) one seedling accession of Pinus contorta var. latifolia (Lodgepole pine); (5) two seedling accessions of Juglans nigra (Black walnut); (6) three new cultivars of Fraxinus pennsylvanica (Green ash), plus 'Marshall's Seedless' ash used as a control; (7) one seedling accession of Maackia amurensis var. Buergeri (Buerger amur maackia); (8) one clonal accession of Euonymus bungeana 'Pink Lady' {seed strain} (Winterberry euonymus); (9) two seed propagated cultivars and one seedling accession of Acer ginnala (Amur maple) and (10) one native seedling accession of Viburnum lentago; (Nannyberry), bringing the total to 22.

DATA ANALYSIS FOR SPECIES PLANTED IN 1987

Data included survival (Table 2), seasonal growth (Table 3) and vigor ratings for all species. Data were analyzed to determine mean growth, percent growth and survival using the Student-Newman-Kuels test to separate location, source and/or treatment differences. Vigor ratings were compared using chi-square frequency tables.

Mean growth is the current season's average growth for all plants of a given species or cultivar at a given location. Percent (%) growth is a measure or ratio of mean growth divided by that plant's final height the previous season. Percent growth measures the amount of increase in size (in this case the height) of a plant compared to its previous size. For example, if a plant was three feet tall and it grew an additional three feet; its growth would be three feet but its percent growth would be 100% since the plant doubled in size. In the discussion that follows, % growth will represent the average increase in growth for all plants of a given species or cultivar at a given location.

Green Ash 'Dakota Centennial' (TS7240) 'Prairie Dome' (TS7263) 'Prairie Spire' (TS7265) 'Marshall's Seedless' (TS87458-CTP)

Analysis results indicated no significant differences in winter survival among sources or locations for the four cultivars of green ash tested. With the exception of Langdon, where a few ash have died from soil related problems, and the initial loss of one 'Prairie Dome' ash at Bismarck, survival has been essentially 100% (Table 2). There were significant location and source effects for the two growth variables. Mean growth of the four ash clones at Minot (38.4") was significantly greater than five of the six other locations, except Fargo (Table 3). Mean growth of ash at Grand Forks was significantly less than the other six locations. Mean growth of 'Dakota Centennial' (29.5" for all locations) was significantly greater than 'Prairie Spire' (25"), 'Prairie Dome' (24.3") or 'Marshall Seedless' (control) with a 17.3" growth rate. 'Prairie Dome' had the greatest percent (%) growth, followed by 'Prairie Spire' and 'Dakota Centennial'. All had significantly greater % growth than the control. Chi square frequency analysis indicated that the above average vigor of the three new ash clones was greater than expected at all locations, except Grand Forks.

Amur Maackia (TS81103-CTP)

There were no significant differences in survival between the three test sites. Mean growth at Minot (4.5") was significantly greater than mean growth at Carrington or Fargo. Percent growth was significantly greater at Minot compared to Fargo. Amur Maackia tends to be a rather slow growing tree which may influence its overall use in the landscape. Its interesting bark, leaf texture and small tree stature make it a potential candidate for use in North Dakota, once hardiness and adaptability studies are completed.

Winterberry Euonymus **'Pink Lady'** (TS84273-CTP)

This seed strain, named 'Pink Lady' and originally tested as PI62418, has been performing well over the last three years at Bismarck. Initial establishment at Grand Forks was slow but overall performance at the latter site was excellent in 1989. Survival at both sites has been 100% through two winters. Plant height at Bismarck was significantly greater than at Grand Forks though mean growth was not significantly different between locations. Percent growth at Grand Forks was greater though not significantly so. Vigor of plants at both locations was very good. Winterberry euonymus has not been widely tested in the state. Identification of hardy accessions of this species is important since this species could have landscape and/or shelterbelt value for planting in the Northern Plains.

Amur Maple 'Flame' (TS87457-CTP), ND access (TS87463-CTP), 'Redwing' (TS87459-CTP)

Survival data indicates no significant differences between locations, although all three clones at Langdon have exhibited higher survival percentages (Table 2). Mean growth for 'Flame', 'Redwing' and the ND selection was significantly greater at Carrington and Langdon vs. Dickinson. Two years of extreme heat and drought in western North Dakota have influenced the establishment and growth of the amur maple clones at the Dickinson site. Percent growth of the amur maple accessions at Carrington and Langdon was significantly greater than Dickinson.

Nannyberry (TS87467-CTP)

Establishment and survival of the nannyberry seedling population being tested has been disappointing. Although Viburnum lentago is native in the state, selection of a superior seed source is still needed. Three years of data suggests that the current seedling accession does not appear to be adaptable. Survival at Minot and Dickinson is approximately 50%. Mean growth of nannyberry at Minot was significantly greater than Dickinson but overall performance at both locations has been poor. This accession will probably be dropped from the program.

DATA ANALYSIS FOR SPECIES PLANTED IN 1988

Data included survival (Table 2), seasonal growth (Table 3) and vigor ratings. Data were analyzed using procedures outlined earlier.

European Alder (TS87464-CTP)

Survival at Fargo and Dickinson was significantly less than at Carrington, Langdon, Minot and Grand Forks (Table 2). Mean growth at Bismarck, Carrington, Grand Forks and Langdon was also significantly greater than mean growth at Fargo and Dickinson. Dieback on plants at the latter two sites produced a negative mean growth (Table 3). This species to date has performed best at Carrington. The low vigor and dieback at Dickinson, probably caused in part by the drought of 1988 and 1989, suggest that this species may not be adapted to western North Dakota.

American Sycamore (TS84278-CTP)

Survival data indicates no significant differences between locations (Table 2). Only 56% of the original number of sycamore trees at Bismarck and 50% of the trees at Minot are alive. Two years of drought stress may have contributed to these low survival percentages. Mean growth on the remaining trees at Bismarck and on the trees at Fargo was significantly greater than growth at Grand Forks or Minot where dieback, probably caused in part by the prevalent drought conditions during the previous two seasons, produced negative growth.

Black Walnut ND source (TS87465-CTP), SD source (TS87466-CTP)

Two seed accessions of Juglans nigra are currently being tested; one source from Hankinson, ND and another from Aberdeen, SD. Preliminary data suggests that the North Dakota source is better adapted than the South Dakota source. Plants of the latter source at Dickinson all died, either from lack of hardiness, drought conditions, or a combination of both. Only 42% of the plants from the South Dakota source at Langdon are still surviving. The North Dakota source at Minot has had 90% survival. Plants at Minot showed good vigor during 1989.

DATA ANALYSIS FOR SPECIES PLANTED IN 1989

Winterberry Euonymus Source 1 (TS88312-CTP), Source 2 (TS88125-CTP)

Tow clonal accessions of winterberry euonymus (Source 1 from NDSU and Source 2 from Mount Arbor Nurseries) were planted in 1989. Source 1 was planted at Carrington, Dickinson, Langdon, and Minot. Source 2 was only planted at Carrington and Langdon because of inadequate numbers for all four sites. Mean growth of Source 1 was significantly less at Dickinson vs. the other three sites. Differences in percent growth was not significant between locations for both sources. Hardiness of the eastern source will be of prime concern. The NDSU source has sufficient hardiness in the southeastern portion of North Dakota where preliminary testing has been done.

Hoptree (TS84238-CTP)

Plants at all sites produced minimal growth the first season. Mean growth ranged from a high of 8.8" at Bismarck to 2.5" at Dickinson (Table 3). The high winds and heat, coupled with the drought at the latter site, resulted in low vigor and subsequent poor growth. Growth at Bismarck was best though not significantly greater than at other sites. Percent growth at Bismarck was significantly greater than the other five locations.

Sugar-Black Maples 'Green Column' (TS89223-CTP), 'Green Mountain' (TS89222-CTP)

Data indicates minimal growth of both cultivars at all four sites (Table 3). Harsh environmental conditions at planting time and throughout the growing season may have resulted in poor performance of both Green Column and Green Mountain maples. Fifty percent of the 'Green Column' plants at Carrington failed to establish.

Jack Pine (TS89279-CTP)

Because of the high mortality rates at the end of the 1988 growing season, full replacement of jack pine and lodgepole pine was done in 1989. Mean growth of jack pine at Carrington was significantly greater than growth at Dickinson or Bismarck. The majority of the plants at both locations had average to above average vigor. Percent growth was not significantly different between locations.

Lodgepole Pine (TS89280-CTP)

Data indicates no significant differences in growth or percent growth between locations. The majority of the plants had average vigor. Lodgepole pine is one of several conifers which could show promise for shelterbelt use as well as adaptation to the urban landscape.

Ussurian Pear NDSU selec. (TS86189), control (TS89281-CTP)

A new clonal selection of Pyrus ussuriensis was planted at the seven test locations. Like most of the other species planted in 1989, the harsh environmental conditions contributed to the low vigor and minimal growth of the pear selection and the control. Despite low to average vigor, the NDSU pear selection maintained high quality foliage compared to the control, and plant losses at the end of the growing season were minimal.

FUTURE SPECIES TO BE TESTED

New species scheduled for inclusion in the program in 1990 include Fraxinus mandshurica 'Mancana' (Mancana Manchurian ash), two seed accessions of Quercus mongolica (Mongolian oak), a seedling population of Acer saccharum (Sugar Maple), and selected seed accessions of Pseudotsuga menziesii (Douglas-fir). Seedling populations of Ostrya virginiana (Ironwood), Gymnocladus dioica (Kentucky coffeetree), Cornus alternifolia (Pagoda dogwood) and Viburnum rafinesquianum (Downy-leaved arrowwood) are being grown in the greenhouse. Preliminary studies are being conducted with seven seed accessions of Platanus occidentalis (American sycamore) and five accessions of Cercis canadensis (Redbud) to identify hardier seedlings of these two species for possible inclusion in the cooperative testing program. Three clonal accessions of Salix pentandra (Laurel willow) and one cutting propagated accession of Salix purpurea 'Gracilis' (Slender purple osier willow) were lined out at the Horticulture Research Farm in 1989. These will be incorporated into the program when sufficient numbers have been produced. The latter cultivar is attractive as an ornamental and could have potential use in shelterbelt plantings.

Table 1. LOCATIONS AND WOODY PLANT ACCESSIONS PLANTED IN THE 1989 COOPERATIVE TESTING PROGRAM

LOCATION (#)	ACCESSIONS
Bismarck (1)	Hoptree, Green Column Maple, Green Mountain Maple, NDSU Pear Selection
Carrington (2)	Winterberry euonymus (Source 1 and Source 2), Hoptree, Green Column Maple, Green Mountain Maple, NDSU Pear Selection
Dickinson (3)	Winterberry euonymus (Source 1), Hoptree, NDSU Pear Selection
Fargo (4)	Hoptree, Green Column Maple, Green Mountain Maple, NDSU Pear Selection
Grand Forks (5)	Hoptree, Green Column Maple, Green Mountain Maple, NDSU Pear Selection
Langdon (6)	Winterberry euonymus (Source 1 and Source 2), NDSU Pear Selection
Minot (loc 7)	Winterberry euonymus (Source 1), Hoptree, NDSU Pear Selection

Table 2. Cooperative Testing Program 1989 Survival Data[1] by Location for Accessions Planted in 1987 and 1988

1987 SPECIES LIST	BISMARCK	CARRINGTON	DICKINSON	FARGO	GRAND FORKS	LANGDON	MINOT
Acer ginnala (Amur Maple) cvs.							
'Flame'	NTS[2]	86	43	NTS	NTS	93	NTS
ND Selection	NTS	70	77	NTS	NTS	100	NTS
'Redwing'	NTS	100	57	NTS	NTS	97	NTS
Euonymus bungeana 'Pink Lady'							
Winterberry Euonymus	100	NTS	NTS	NTS	100	NTS	NTS
Fraxinus pennsylvanica (green ash clones)							
'Dakota Centennial'	100	100	100	100	100	94	100
'Marshall's Seedless'	100	100	100	100	100	100	100
'Prairie Dome'	89	100	100	100	100	94	100
'Prairie Spire'	100	100	100	100	100	94	100
Maackia amurensis var. buergeri							
Buerger Amur Maackia	NTS	93	NTS	83	NTS	NTS	83
Viburnum lentago (Nannyberry)	NTS	NTS	55	NTS	NTS	NTS	52
1988 SPECIES LIST							
Alnus glutinosa (European Alder)	---[3]	100a[4]	57b	67b	100a	100a	100a
Juglans nigra (Black Walnut)							
ND Source	NTS	NTS	NTS	NTS	NTS	NTS	97
SD Source	NTS	NTS	NTS	NTS	NTS	42	NTS
Platanus occidentalis American Sycamore	56	NTS	NTS	89	89	NTS	50

1 Values listed for each location represent % mean survival for a particular species, cultivar or selection.

2 NTS = Non Test Site indicating a site where the species, cultivar or selection was not tested.

3 Dashes indicate sites where data analysis was not performed due to high mortality rates for species.

4 Means followed by different letters were significantly different at $P \leq 0.05$ based on Student-Newman-Kuels Test. Values without letters were not significantly different at $P \leq 0.05$ based on same test.

Table 3. 1989 Average Growth Data[1] by Location for Accessions in the Woody Plant Cooperative Testing Program

SPECIES LIST	BISMARCK	CARRINGTON	DICKINSON	FARGO	GRAND FORKS	LANGDON	MINOT
Acer ginnala (Amur Maple) cvs.							
'Flame'	NTS[2]	16.8	5.4	NTS	NTS	15.0	NTS
ND Selection	NTS	16.0	6.1	NTS	NTS	15.3	NTS
'Redwing'	NTS	16.6	7.1	NTS	NTS	17.0	NTS
Acer saccharum (Sugar Maple) cvs.							
'Green Column'	0.9	0.9	NTS	1.3	2.0	NTS	NTS
'Green Mountain'	2.1	3.8	NTS	1.6	0.5	NTS	NTS
Alnus glutinosa							
European Alder	11.5x[3]	13.1x	-6.0y	-6.2y	5.2x	8.2x	3.0xy
Euonymus bungeana (1987 planting) 'Pink Lady'							
Winterberry euonymus	21.6	NTS	NTS	NTS	17.6	NTS	NTS
Euonymus bungeana (1989 planting)							
NDSU Source	NTS	13.0	6.9	NTS	NTS	11.5	10.5
Mt. Arbor Nursery Source	NTS	12.2	NTS	NTS	NTS	10.0	NTS
Fraxinus pennsylvanica (green ash clones)							
'Dakota Centennial'	30.0	34.8a[4]	19.6a	38.7a	12.0	26.8	41.6a
'Marshall's Seedless'	31.4	19.6c	11.8b	9.6c	3.4	15.9	28.3c
'Prairie Dome'	32.2	27.1b	19.4a	25.9b	6.5	21.3	39.4ab
'Prairie Spire'	31.6	25.6b	19.9a	38.5a	4.8	20.4	33.1b
Juglans nigra (Black Walnut)							
ND Source	NTS	NTS	NTS	NTS	NTS	NTS	10.2
SD Source	NTS	NTS	NTS	NTS	NTS	3.0	NTS

Table 3. 1989 Average Growth Data[1] by Location for Accessions in the Woody Plant Cooperative Testing Program (Cont'd):

SPECIES LIST	BISMARCK	CARRINGTON	DICKINSON	FARGO	GRAND FORKS	LANGDON	MINOT
Maackia amurensis var. buergeri							
Buerger Amur Maackia	NTS	2.0x	NTS	0.7x	NTS	NTS	4.5y
Pinus banksiana							
Jack pine	8.3x	10.7y	8.9x	NTS	NTS	9.5xy	NTS
Pinus contorta var. latifolia							
Lodgepole pine	4.1	6.0	4.8	NTS	NTS	5.5	NTS
Platanus occidentalis							
American Sycamore	21.7x	NTS	NTS	17.3x	-16.1y	NTS	-30.3y
Ptelea trifoliata							
Hoptree	8.8	4.8	2.6	3.7	4.4	NTS	4.8
Pyrus ussuriensis (Ussurian pear)							
NDSU selection	4.9	1.9	1.6a	1.6	1.7	2.7	2.2
Control Pear	7.2	6.4	7.4b	1.0	0.8	5.4	4.7
Viburnum lentago							
Nannyberry	NTS	NTS	3.7x	NTS	NTS	NTS	7.1y

1 Values listed for each location represent mean growth in inches for a particular species, cultivar or selection.

2 NTS = Non Test Site indicating a location where the corresponding species, cultivar or selection were not tested.

3 Row means followed by different letters of x or y were significantly different at P $\leq$ 0.05 based on Student-Newman-Kuels Test. Values without letters were not significantly different at P $\leq$ 0.05 based on same test.

4 Column means followed by different letters of a, b, or c were significantly different at P $\leq$ .05 based on Student-Newman-Kuels Test. Values without letters were not significantly different at P $\leq$ .05 based on same test.

DICKINSON RESEARCH CENTER

1988 PLOT PLAN

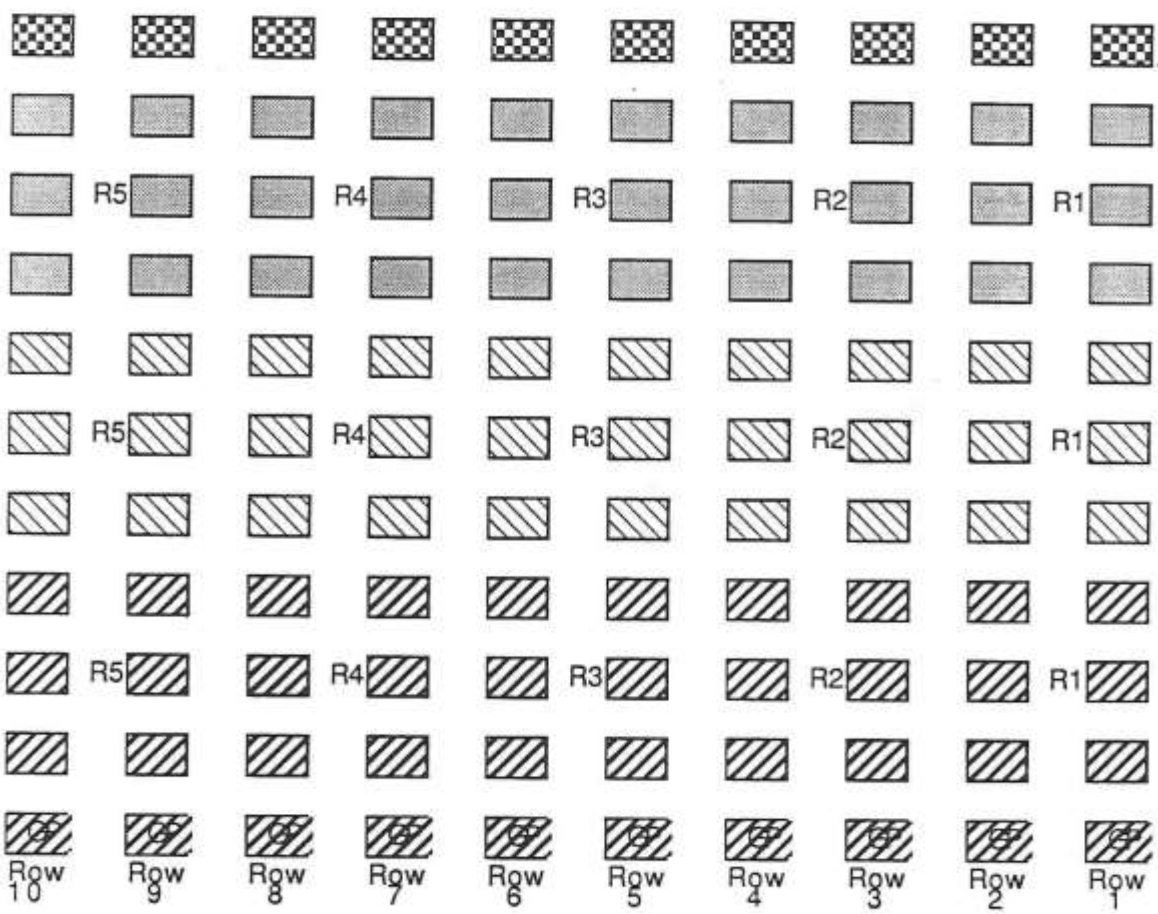
NORTH →

Planting Date________

Legend

- **Lodgepole Pine** (Species 4)
  5 reps of 6 plants
- **Jack Pine** (Species3)
  5 reps of 6 plants
- **European Black Alder** (Species 1)
  5 reps of 6 plants
- **Common Hoptree from 1989 Planting**

R1=REP 1



SPACING; 20' BETWEEN ROWS; 15' BETWEEN PLANTS WITHIN ROWS

PLOT SIZE: 200' east to west x 210' north to south

DICKINSON RESEARCH CENTER

1989 PLOT PLAN

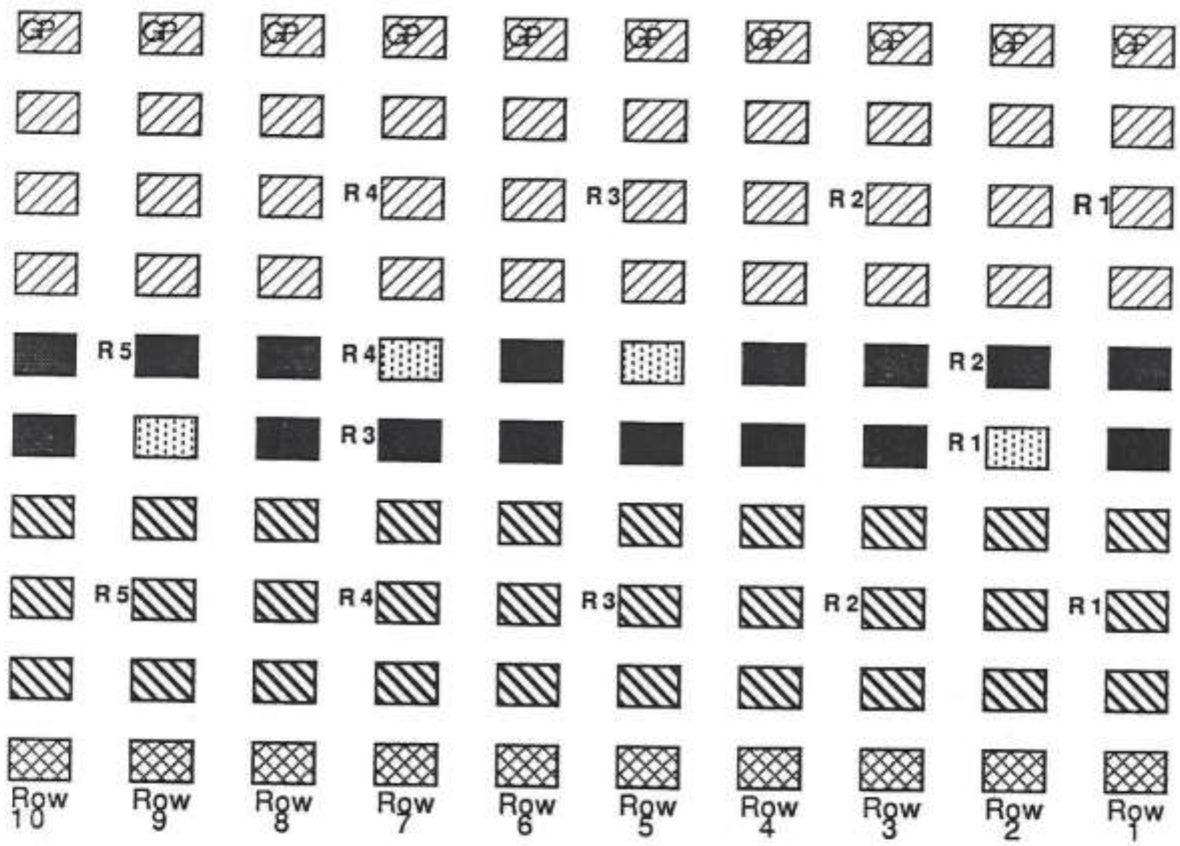
NORTH →

Legend

Planting Date ________

- **Common Hoptree (Species 2)**
  5 reps of 6 plants
- **NDSU Pear Sel. (Species 4)**
  4 reps of 4 plants **Sor 1**
- **Black Alder (west row of 1988 plot)**
- **Ussurian Pear Sdlg. (Species 4)** **Control**
  4 reps of 1 plant **Sor 2**
- **Winterberry Euonyumus (Species 1, Sor 1 - NDSU)**
  5 reps of 6 plants

R1=REP 1 GP = Guard Plant(Euonymus bungeana) Sor = Source



SPACING; 20' BETWEEN ROWS; 15' BETWEEN PLANTS WITHIN ROWS

PLOT SIZE: 145' east to west x 210' north to south

3118 Ida Drive
Concord, CA 94519-2135

February 1, 1990

Thomas J. Conlon
Dickinson Exp. Sta.
Box 1117
Dickinson, ND 58601

Dear Phenological Observer:

Thank you for cooperating in the renewed phenology network. It's time to prepare for collecting 1990 lilac and honeysuckle observations. As last year, I have included a survey-data form for you to record observations on and check information about your station, as well as a stamped envelope to return it after all phenological events are recorded. Research projects using the data continue to show progress. Results from one, studying changes in the nature of the lower atmosphere (temperature, humidity, etc.) after first leaf occurs, will soon be appearing in the journal Monthly Weather Review. I also hope to be adding a few new stations when plants become available this spring.

I have copied two maps for your information on the back of this letter. The first shows stations that reported data in 1989 (dark symbols are lilacs, hollow symbols are honeysuckles, and half-filled symbols are both plants). The second shows lilac first leaf in 1989 (values on isolines are days after January 1st). Thanks again for your help, and I hope you will be able to continue as a part of the phenology network.

Sincerely,

Mark D. Schwartz, Ph.D.
Climatologist

Enclosure

Reporting Stations 1989

Lilac First Leaf 1989