

**PROJECT TITLE:** Evaluation of Continuous Spring Wheat Cropping

**PROJECT LEADERS:** Jerald W. Bergman, Superintendent, MSU Eastern Agricultural Research Center, Sidney, Montana / Director, NDSU Williston Research Extension Center, Williston, North Dakota

Joyce L. A. Eckhoff, Research Agronomist, MSU Eastern Agricultural Research Center, Sidney, Montana

**OBJECTIVES:** To determine the feasibility of continuous spring wheat cropping of small grains on dryland when the best-known methods of weed control, fertilizer practices, and other management practices are applied in conjunction with tall wheatgrass barriers. In evaluating tall wheatgrass barriers for continuous spring wheat cropping, the following factors will be documented each year:

1. Crop yield
2. Disease problems associated with continuous cropping
3. Insect problems associated with continuous cropping
4. Tillage problems associated with continuous cropping
5. Weed problems associated with continuous cropping

**MATERIALS AND METHODS:**

The tall wheatgrass barriers eliminated from this study in 1998 were first established in the summer of 1965 as part of another experiment. As originally planned, the experiment contained 2-row grass barriers with a distance of 42 inches between the grass rows. Four of the barrier strips had inside crop dimensions of 30' by 265'. Three other barriers were of 60' by 265' inside dimensions. For check purposes, an exterior area without grass barriers was provided for in the experiment.

During the 1966-71 crop years, the grass barrier system was cropped each year to either spring or winter wheat. Data was collected on the efficiency of the barriers in trapping snow, preventing soil erosion, and affecting temperature relations over the crop. No fertilizer treatments were applied to the site and no program of controlling annual weeds was instituted. By 1971, the fertility status of the soil had declined to a low level and such annual weeds as wild oats, green foxtail, and yellow foxtail infested the land to a moderately serious degree. Beginning in 1971, an attempt to control these weed populations with herbicides was initiated. Safflower was grown in the barrier system in 1972, but thereafter spring wheat was continuously cropped in the barrier system utilizing effective herbicides and fertilizer. The 30 ft. barriers were eliminated in the fall of 1979 to provide two additional 60 ft. barriers for further continuously cropped studies under no-till and till-and plant conditions. The decision to eliminate the 30 ft. barriers was based on our research results indicating the 30 ft. barriers were too narrow to compensate for yield loss due to land removed from crop production. In 1998, the 60 ft. tall wheatgrass barriers were eliminated.

The decision to eliminate the 60 ft. barriers was based on previous results indicating the barriers only compensated for yield loss due to land removed from crop production on dry years when the yield was less than 20 bushels per acre and because of volunteer tall wheatgrass problems in the wheat associated with the tall wheatgrass of the barrier strips. Three of the barrier strips removed were tilled and three of the barrier strips were killed with Roundup herbicide without any tillage.

## **MATERIALS AND METHODS FOR THE 2003 SEASON:**

No tillage was performed on the plots in the fall of 2002 and the stubble was allowed to stand over winter to collect snow. All the plots were sprayed with Roundup herbicide at the rate of 2 quarts per acre on April 11, 2003 to control volunteer tall wheatgrass and emerging weeds.

Sixty pounds nitrogen in the form of 28-0-0 liquid nitrogen per acre was applied on April 11, 2003 on all continuous crop plots. On April 15, 2003, the plots scheduled for tillage were worked twice with a tandem disc, except the summer fallow plot, which was triple K'd twice just prior to planting.

On April 15<sup>th</sup>, the plots were seeded to Reeder spring wheat using a Versatile Noble No. 2000 no-till double disc drill with leading coulters and 9-inch row spacing. For both tilled and no-till plots, Reeder spring wheat was seeded at the rate of 78 pounds/acre and 80 pounds of 18-46-0 was applied through the drill on all plots including summer fallow.

The type of tillage and planting for the various plots were as follows:

### **OPEN FIELD STUBBLE - CONTINUOUS CROP**

- Plot A - no-till and no-till planting
- Plot B - spring till and seeding
- Plot C - no-till and no-till planting
- Plot D - no-till and no-till planting
- Plot E - spring till and seeding
- Plot F - spring till and seeding  
(40 ft. barrier for this plot only)
- Plot G - no-till and no-till planting
- Plot H - spring till and seeding

### **SUMMER FALLOW - (WHEAT-FALLOW) ROTATION**

- Plot I - summer fallow
- Plot J - spring till and seeding on fallow

On May 28<sup>th</sup>, the plots were sprayed with 2.5 pints Hoelon, 0.125 pints MCPA ester and 1.75 pints crop oil per acre for grassy weed control and on June 13<sup>th</sup> the plots were sprayed with 2 pints Buctril per acre for broadleaf weed control.

## **RESULTS AND DISCUSSION:**

Precipitation as rain or snow occurred at this site during the October 2002 through September 2003 period as follows:

<u>Month and Year</u>	<u>Inches of Moisture</u>
October 2002	0.41
November 2002	0.05
December 2002	0.40
January 2003	0.47
February 2003	0.16
March 2003	2.37
April 2003	0.55
May 2003	3.68
June 2003	3.23
July 2003	1.42
August 2003	1.56
September 2003	<u>0.27</u>
<b>Total</b>	<b>14.57</b>

All of the plots in the study were harvested for yield determinations on August 14, 2003. Grain samples were obtained for test weight and protein analyses.

### CONTINUOUS CROPPING RESULTS FROM 2003

	Method of Seeding	Plant Height Inches	Test Weight Lbs/Bu	Grain Protein %	Yield Bu/Acre
<b>1. Continuous Crop</b>					
Plot A	no-till	29.9	61.0	13.9	32.4
Plot B	till	28.5	61.0	15.0	36.2
Plot C	no-till	27.8	61.5	13.5	36.2
Plot D	no-till	28.7	61.0	13.7	36.7
Plot E	till	29.1	60.0	16.2	36.8
Plot F	till	28.0	60.0	16.0	38.2
Plot G	no-till	29.1	61.5	14.0	34.8
Plot H	till	28.9	60.5	15.3	39.0
<b>2. Summer Fallow</b>					
Plot I	till	30.3	59.5	15.4	45.6

On continuous wheat cropping in 2003, tilled and planted plots averaged 37.6 bushels per acre with 15.6 percent protein whereas no-till plots averaged 35.1 bushels per acre with 13.8 percent protein. Open field stubble continuous wheat produced an average yield of 36.3 bushels per acre with 14.7 percent protein, whereas the wheat on summer fallow produced a yield of 45.6 bushels per acre with 15.4 percent protein.

The lower yields on no-till plots compared to tilled plots have been attributed to wild oats, volunteer wheatgrass infestations from the tall wheatgrass barrier and its spread into the no-till plots, and a higher incidence of disease in the no-till plots. The applications of one quart of Roundup in the springs of 1993, 1994 and 1995 about two weeks prior to seeding failed to control the volunteer wheatgrass. Two quarts per acre of Roundup spring applied in 1996-1998 for volunteer wheatgrass control provided fair-good control. The barriers were eliminated in 1998 and Roundup spring applied each year since 1998 has now eliminated volunteer wheatgrass. In 2003, the incidence of *Pyrenophora trichostoma* (tan spot) and *Septoria* again was most pronounced in the continuous wheat no-till plots, moderate in the continuous wheat tilled plots with a light level of disease in the wheat on the fallow plot. The principal weed in 2003 was green foxtail.

Damage by rodents, sawflies, or other pests were not noted in 2003.

A 30-year summary of data obtained from the continuous spring wheat and wheat-fallow systems are reported below.

Snow Moisture Collection System	Plant Height Inches	Grain Protein Percent	Grain Test Weight Lbs/Bushel	Grain Yield Bushel/Acre
<i>Open Field Stubble</i>				
1974	20.0	15.2	60.0	26.0
1975	25.0	16.1	59.5	30.4
1976	28.0	--	62.5	40.3
1977	15.3	16.4	60.3	4.2
1978	30.7	14.0	61.0	37.6
1979	22.3	15.3	60.3	19.6
1980	10.8	16.7	57.8	3.9
1981	--	14.9	58.0	19.8
1982	26.0	14.9	57.5	27.6
1983	26.5	16.9	60.5	24.3
1984	21.0	16.4	58.4	10.0
1985	11.0	16.4	56.4	10.9
1986	25.5	12.4	61.3	24.7
1987	20.5	16.7	59.8	26.0
1988	--	--	--	0.0
1989	21.0	17.5	56.3	20.3
1990	18.0	16.5	59.0	10.3
1991	33.0	14.4	61.5	33.3
1992	36.5	13.1	62.3	45.6
1993	33.5	14.4	57.0	25.6
1994	33.9	10.8	62.8	36.8
1995	28.0	12.4	62.5	20.3
1996	19.7	11.7	55.8	27.1
1997	24.0	13.6	54.5	29.7
1998	29.3	11.4	58.5	28.2
1999	27.9	10.6	60.9	30.5
2000	--	13.2	63.4	30.5
2001	25.3	12.9	61.3	37.2
2002	22.3	12.8	59.7	22.5
2003	28.8	14.7	60.8	36.3
<b>Average</b>	<b>24.3</b>	<b>14.4</b>	<b>59.6</b>	<b>24.8</b>

<b>Snow Moisture Collection System</b>	<b>Plant Height Inches</b>	<b>Grain Protein Percent</b>	<b>Grain Test Weight Lbs/Bushel</b>	<b>Grain Yield Bushel/Acre</b>
<b><i>Summer Fallow</i></b>				
1974	21.0	16.9	58.5	45.4
1975	28.0	16.4	59.0	35.3
1976	32.0	--	61.0	62.5
1977	19.5	16.2	59.5	18.5
1978	32.5	14.5	60.5	54.7
1979	23.4	16.7	61.0	24.9
1980	12.0	15.6	59.0	23.0
1981	--	17.1	59.5	23.4
1982	26.0	15.6	57.0	32.9
1983	28.0	16.6	60.0	26.0
1984	21.0	17.3	58.1	22.9
1985	18.0	16.9	56.2	12.0
1986	28.0	13.2	60.9	38.9
1987	23.0	15.0	59.5	36.0
1988	13.0	18.4	57.5	3.7
1989	23.0	16.3	57.5	27.0
1990	23.0	16.5	58.3	21.9
1991	32.0	14.8	61.5	38.4
1992	37.5	13.8	62.0	67.4
1993	32.5	12.8	57.0	40.4
1994	38.4	12.2	62.5	49.9
1995	30.7	14.1	62.0	27.4
1996	21.3	12.4	56.0	39.6
1997	26.1	14.4	53.5	38.6
1998	30.7	14.2	56.5	41.2
1999	33.1	12.6	59.0	53.8
2000	--	15.0	63.0	47.0
2001	28.7	14.6	61.5	48.1
2002	23.2	15.0	58.0	30.5
2003	30.3	15.4	59.5	45.6
<b>Average</b>	<b>26.3</b>	<b>15.2</b>	<b>59.2</b>	<b>35.9</b>

During the past 30-year period of this continuous cropped spring wheat study, grain test weights have averaged 0.4 lbs. per bushel higher under continuous cropping. Conversely, grain protein content of wheat on fallow has averaged 0.8% higher than wheat on open field continuous cropping. Average yields for continuous crop spring wheat is 24.8 bushels per acre for open field continuous cropped spring wheat and 35.9 bushels per acre for summer fallow.

In this long-term study the continuous wheat cropping yields in the barrier system yielded 3.0 bushels per acre less than continuous wheat cropping in open field stubble. One bushel per acre of the yield difference is due to the land removed from wheat production by the presence of the barriers as this land area is included in the plot size for yield determination. The competitive effect of the tall wheatgrass in the barriers nearby wheat plants also causes some yield reduction. However, tall wheatgrass barriers do provide some benefits such as reduced wind erosion and favorable climatic effects within the barriers, which should be considered for soil and water conservation of the land. These factors become more critical in years of below normal rainfall and on soils with lower soil moisture carrying capacity.

The results of this long term study have also shown that the barrier system continuous cropping wheat generally out yields open field stubble continuous cropping wheat when yields are less

than 20 bushels per acre (1977, 1980, 1984, 1985, 1989 and 1990) but that open field stubble continuous cropping wheat generally had a yield advantage over the barrier system when wheat yields exceed this level (1974, 1975, 1976, 1978, 1983, 1987, 1993, 1994, 1995, 1996, 1997, and 1998). Open field stubble continuous cropping wheat had a very definite yield advantage over the barrier system continuous cropped wheat when yields exceed 30 bushels per acre (1975, 1976, 1978, 1991, and 1992).

In 1977, no-till treatments were added to this long-term continuous cropping system for comparison with conventional till plant plots. The no-till plots have produced yield similar to conventional till and plant plots except for in 1978, 1986, and 1992 – 2003. In 1978 the no-till plots had a larger population of wild oats than conventional till and plant plots. In 1986 when the no-till plots were seeded with a no-till versatile Noble No. 2000 drill deep seed placement contributed to the lower yields in the no-till plots. In 1992 – 2003, the lower no-till yields were attributed in part to volunteer wheatgrass in the no-till plots and a higher incidence of disease in the no-till plots. Also in 1993, poor seed to soil contact in the no-till plots resulted in delayed emergence and reduced yields and in 1997 wild oats were a problem. Test weights have been slightly higher in no-till plots whereas protein has averaged 0.8% lower in no-till plots than tilled plots despite the no-till plots' lower yield of 3.1 bushels per acre.

The incidence of the disease *Pyrenophora trichostoma* (tan spot) and *Septoria* has been highest in the no-till plots. Conversely, the incidence of annual weeds such as wild oats, green foxtail, and yellow foxtail has been usually greater in the till and plant plots with the exception of 1978, 1997, 1998, 1999 and 2000 when wild oats occurred in the no-till plots. Volunteer tall wheatgrass has been an annual problem in all the barrier plots each spring, necessitating an application of Roundup herbicide to destroy the volunteer wheatgrass prior to seeding. This treatment has been effective in controlling annual weeds that have emerged in the no-till plots prior to seeding time. Over the thirty year period, continuous spring wheat cropping has produced 6.8 bushels per acre per year more than the spring wheat-fallow rotation.

Snow Moisture Collection System	Plant Height Inches		Grain Protein Percent		Grain Test Wt. Lbs/Bu		Grain Yield Bu/Acre	
	<u>No-Till</u>	<u>Till</u>	<u>No-Till</u>	<u>Till</u>	<u>No-Till</u>	<u>Till</u>	<u>No-Till</u>	<u>Till</u>
<b><u>60 Ft. Barriers *</u></b>								
1978	30.9	31.3	13.6	14.3	61.5	60.5	30.0	35.6
1979	21.7	21.5	14.6	16.2	61.0	61.0	15.6	15.3
1980	11.0	10.7	14.7	14.4	56.8	57.8	12.7	9.8
1982	26.0	26.0	13.9	14.6	58.2	58.0	28.1	29.3
1983	25.0	25.8	16.5	16.8	61.2	60.0	20.3	21.5
1984	21.3	21.3	15.8	15.0	59.5	59.8	12.0	11.2
1985	12.3	11.0	16.1	16.9	57.1	56.1	11.1	11.7
1986	27.0	26.7	11.9	12.4	61.7	61.9	9.1**	27.0
1987	21.5	20.3	14.9	15.4	60.5	60.4	22.2	22.7
1988	--	--	--	--	--	--	0.0	0.0
1989	25.0	23.3	15.8	16.0	57.3	56.8	23.5	25.6
1990	19.0	18.7	16.4	17.3	60.0	59.0	12.2	12.2
1991	33.0	33.0	13.0	13.9	61.8	61.7	30.8	29.9
1992	34.8	36.5	12.8	13.1	62.5	62.3	32.4	50.9
1993	32.5	32.4	14.0	14.1	56.5	56.2	19.6	28.4
1994	30.4	34.4	10.5	10.9	61.8	63.0	20.0	32.0
1995	29.6	28.6	12.0	13.2	62.5	62.2	13.7	20.5
1996	20.1	19.4	11.9	12.1	57.2	57.0	18.7	23.5
1997	25.0	24.6	13.4	13.7	53.2	52.8	20.6	31.5
1998	29.9	28.2	10.6	11.2	59.0	58.0	22.7	29.4
<b>Average</b>	<b>25.0</b>	<b>25.2</b>	<b>13.8</b>	<b>14.2</b>	<b>59.4</b>	<b>59.2</b>	<b>19.3</b>	<b>23.4</b>

\* Data in 1981 were omitted as different varieties were planted in no-till and till and plant plots.

In 1988, continuous cropped wheat plots were a complete crop failure. **In 1998, the barriers were eliminated.**

\*\* Deep seed placement contributed to the lower yield of the no-till plots in 1986.

Snow Moisture Collection System	Plant Height Inches		Grain Protein Percent		Grain Test Wt. Lbs/Bu		Grain Yield Bu/Acre	
	<u>No-Till</u>	<u>Till</u>	<u>No-Till</u>	<u>Till</u>	<u>No-Till</u>	<u>Till</u>	<u>No-Till</u>	<u>Till</u>
<b><u>Open Field Stubble</u></b>								
1978	30.0	31.4	13.2	14.7	61.5	60.5	31.1	44.0
1979	21.6	22.9	14.5	16.1	61.0	59.5	19.5	19.7
1980	8.0	8.0	16.2	17.1	58.0	57.5	3.9	3.9
1982	26.0	26.0	14.3	15.5	57.5	57.5	24.9	27.6
1983	26.0	27.0	16.0	17.7	61.0	60.0	23.7	24.9
1984	22.0	20.0	16.7	16.0	58.2	58.5	10.8	9.2
1985	11.0	11.0	15.6	16.6	57.0	55.7	11.2	10.6
1986	25.0	26.0	12.1	12.7	61.3	61.2	18.6**	30.8
1987	22.0	19.0	16.6	16.7	60.5	59.0	27.3	24.6
1988	--	--	--	--	--	--	0.0	0.0
1989	22.0	20.0	17.1	17.8	56.5	56.0	20.0	20.6
1990	20.0	17.0	16.3	16.6	59.0	59.0	10.9	9.6
1991	33.0	33.0	14.0	14.7	61.5	61.5	34.7	31.9
1992	36.5	36.5	12.9	13.2	62.5	62.0	38.0	53.5
1993	33.9	33.1	14.2	14.6	57.0	57.0	28.2	22.9
1994	32.3	35.4	10.3	11.9	62.5	63.0	35.0	38.5
1995	29.1	26.8	11.3	13.6	62.5	62.5	17.9	22.7
1996	20.9	18.5	11.7	11.6	55.5	56.0	24.4	29.7
1997	24.0	23.9	13.2	13.9	55.0	54.0	26.0	33.4
1998	29.1	29.5	10.8	11.9	58.5	58.5	26.2	30.1
1999	27.8	27.9	10.3	10.8	60.8	61.0	25.7	35.4
2000	--	--	13.3	13.3	63.5	63.4	28.6	32.4
2001	24.5	26.2	12.8	13.1	61.3	61.4	34.7	39.8
2002	22.8	21.8	12.5	13.1	59.8	59.6	24.8	26.2
2003	28.9	28.6	13.8	15.6	61.3	60.4	35.1	37.6
<b>Average</b>	<b>25.1</b>	<b>24.8</b>	<b>13.7</b>	<b>14.5</b>	<b>59.6</b>	<b>59.4</b>	<b>23.2</b>	<b>26.3</b>

\* Data in 1981 were omitted as different varieties were planted in no-till and till and plant plots.

In 1988, continuous cropped wheat plots were a complete crop failure.

\*\*Deep seed placement contributed to the lower yield of the no-till plots in 1986.

**FUTURE PLANS:**

The long-term influences of no-till, conventional till, and continuous cropping on wheat growth, vigor, yield, quality and other crop performance characteristics is an objective that will continue. Continuation of this long-term study could include detailed soils analyses to determine the long-term influence of no-till, conventional till, and continuous cropping on soil health. It may also prove beneficial to assay the soils of the continuous cropping wheat plots for potential biocontrol agents for wheat diseases and / or other wheat pests.