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WHEAT PRODUCTION SYSTEMS FOR SOUTHWESTERN NORTH DAKOTA

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SUMMARY

The wheat-black fallow rotation has been used extensively as a production strategy for spring wheat in western North Dakota and throughout the Great Plains. There are several benefits the black fallow period provides: organic nitrogen can be mineralized, weeds can be mechanically controlled, soil water recharge can occur, and crop loss risk can be reduced and farm income stabilized (Smika, 1970). Along with these benefits have come costs, including the formation of saline seeps, uncontrolled wind and water erosion, and reduced soil nutrient levels over time (Haas et al., 1957; Halvorson and Black, 1974). Moreover, the idling of productive land in a wheat-black fallow rotation has raised economic efficiency questions (Ali and Johnson, 1981). Soil conservation mandates, as exemplified by the Conservation Compliance Provision of the 1985 Farm Bill, suggest that alternatives to the wheat-black fallow rotation must be developed for the long-term viability of wheat production in North Dakota.

OBJECTIVES

1. Determine how cultivar selection and seeding rate affect spring wheat performance across wheat-black fallow, wheat-ecofallow, and wheat-chemical fallow systems.
2. Evaluate N fertilizer and N fertilizer by fungicide interactions for tan spot suppression, grain yield and

phenotypic response in continuously cropped environments.

3. Compare the agronomic performance of several spring wheat cultivars across wheat-black fallow, wheat-wheat, and wheat-corn rotations

INTRODUCTION

Objective 1

Most hard red spring wheat is sown on black-, eco-, and chemical-fallow in the Southwest Crop Reporting District (Beard and Hamlin, 1996). Generally several cultivars are sown each year, depending on seed costs, seed availability, and other factors (Solemaas, ASCS, per. comm.). A cultivar (C) by tillage system (TS) interaction has not been considered across fallow environments even though a C by TS interaction has been reported across recropped environments (Ciha, 1982). Knowledge of a C by TS interaction across different fallow environments would aid producers in selecting cultivars best suited to their fallow management strategies. Also needed is information on whether seeding rates (SR) should be adjusted according to the cultivar and tillage system used. Knowledge about C by TS and C by TS by SR interactions might result in more efficient spring wheat production in reduced- and no-till systems.

Objective 2

An alternative to a spring wheat-black fallow rotation is to grow wheat continuously. A benefit of continuous wheat compared to alternating wheat and fallow is that productive land is not idled. However, Tan Spot (incited by *Pyrenophora tritici-repentis* [Died.] Drechs.) can be a major pest in continuous wheat systems because this fungus overwinters in crop stubble. Tan spot and other fungal infestations can be accentuated in reduced-till and no-till systems. These fungi must be controlled for profitable wheat production.

Nitrogen (N) fertilizer applications have sometimes reduced outbreaks of tan spot in winter wheat (Huber et al., 1987), but the ability of N applications to suppress tan spot in spring wheat has not been demonstrated. Similarly, N fertilizer by tillage system interactions have not been identified regarding tan spot. Knowledge about these interactions would support profitable production in fields where wheat is grown during two or more continuous years.

Objective 3

Spring wheat cultivars respond differently in contrasting environments. It is unclear how wheat grain yield and quality, and other phenotypic characteristics, are influenced by cropping sequence. North Dakota producers need this information as they explore alternatives to black fallow in a wheat-black fallow rotation. Understanding the cultivar by crop rotation interaction is needed to explain why crop yields vary in regions of the state where rotations differ.

MATERIALS AND METHODS

Objective 1

A field experiment was conducted under dryland conditions at Dickinson in 1995 and 1996. Plots were arranged in a modified randomized complete block design in a split split-plot arrangement. Tillage system comprised main plots, seeding rate comprised subplots, and spring wheat cultivar comprised sub-subplots. Tillage systems included: (1) conventional-till (spring disking and leveling with a cultivator and culti-harrow until less than 5% of residue remains at the soil surface at planting); (2) reduced-till (leveling with a cultivator and culti-harrow in attempts to maintain between 30%-60% of residue at planting); and (3) no-till (direct sowing into standing stubble). Subplots consisted of seeding rates of 500,000, 1,000,000, and 1,500,000 PLS per acre. Sub-subplots consisted of 2 conventional height (AC Minto, Amidon) and 3 semidwarf (Bergen, Grandin, Norm) spring wheat cultivars representing a range of genotypes and phenotypes presently grown in the northern Great Plains Region.

Both phases of each tillage system (crop and fallow) were established and will be maintained throughout the trial's duration. As a result, 50% of the space allocated for plots is not planted in any year (i.e., fallow plots); weeds in these plots are either mechanically controlled (conventional-till), controlled both mechanically and with herbicides (reduced-till), or controlled solely using herbicides (no-till).

Main plots were 4500 square feet (90 by 50 ft). There were 6 main plots per replicate and four replicates in the experiment. Sub-subplot dimensions were 50 by 6 ft.

Plant nutrients were supplied as needed for a grain yield goal of 60 bu per acre, based on soil test results.

Post-emergent herbicides were used during the crop phase in conventional- and reduced-till systems to control weeds. In the fallow plots, mechanical cultivation was used to control weeds in the conventional-till system. Two herbicide applications and a light disking were used in the reduced-till system. Non-incorporated herbicides were used in the no-till system.

Variables measured on each cropped plot included: number of plants at emergence, plant height, grain yield, 100 kernel weight, grain volume weight, and grain protein content. Number of tillers at the six-leaf stage were counted, as were the number of heads that had developed on wheat plants at physiological maturity.

Data were analyzed using a computer-driven statistical program.

Objective 2

The experiment was arranged in a randomized complete block design in a split split-plot arrange-ment. Tillage system comprised main plots, fungicide treatment comprised subplots, and N applications comprised sub-subplots. Tillage sys-tems were established as described for Objective 1.

A single application of mancozeb at 1.0 lb a.i per acre along with a control (no fungicide) constituted subplot treatments. Applications of mancozeb at this rate may be economical in western North Dakota if severe tan spot infestations exist. The fungicide treatment was also used to assess if applications of N fertilizer were effective in suppressing tan spot.

Nitrogen as ammonium nitrate was applied, based on soil test results, at high and low rates. The high rate corresponded to a fertilizer plus soil N amount of 100 lbs N per acre and the low rate to 50 lbs N per acre.

Main plots were 2200 square ft. Sub-subplot dimensions were 55 by 10 ft. There were four replicates.

The following variables were measured on each plot: foliar leaf spotting at anthesis, plant height, grain yield, 1000 seed weight, and grain volume weight. Data were analyzed using a computer-driven statistical program.

Objective 3

The experiment was arranged in a modified randomized complete block design in a split-plot arrangement. Cropping sequence comprised main plots and consisted of wheat-black fallow, wheat-wheat, and wheat-corn rotations. Five conventional-height cultivars (AC Minto, Amidon, Butte 86, Sharp, Stoa) and five semidwarf spring wheat cultivars (2371, Bergen, Grandin, Hi Line, Norm) comprised subplots treatments.

Both phases of wheat-black fallow and wheat-corn rotations were established in 1994 and will be maintained throughout the trial's duration. Hence, two main plots will be maintained each year for both rotations. By having both phases represented each year, wheat grain yield and quality data will be generated annually by each rotation. These data can then be compared with that produced by the wheat-wheat rotation each year the experiment is conducted.

Main plots were 1680 square feet. There were five main plots per replicate (two each for both wheat-black fallow and wheat-corn rotations and one for the wheat-wheat rotation). There were four replicates. Subplot dimensions were 6 by 28 ft.

Variables measured on each plot included: plant height, grain yield, 100 kernel weight, grain volume weight, and grain protein content.

The data were analyzed using a computer-driven statistical program.

RESULTS

Objective 1

Seeding wheat at 500,000 PLS per acre resulted in a lower grain yield than seeding wheat at either 1,000,000 or 1,500,000 PLS per acre in each year across the three tillage systems. Seeding wheat at 1,500,000 PLS per acre produced more grain with heavier test weight than seeding wheat at 1,000,000 PLS per acre in 1995, but not in 1996.

Grain yield did not vary across the three tillage systems in either 1995 or 1996. The hard spring wheat cultivars varied for each factor considered in both years, except for the number of tillers formed at the six-leaf stage in 1996.

A cultivar (C) by tillage system (TS) interaction generally did not occur for any factor considered.

A C by seeding rate (SR) interaction occurred for grain yield in both years the experiment was conducted. A C by SR interaction also existed for returns ($/acre) in each of the two years. A C by SR by TS interaction generally did not exist for any factor in both years in which the experiment was conducted.

Objective 2

Applications of mancozeb failed to reduce leaf spotting in two of the three years in this trial when leaf spotting was determined. Similarly, tillage environment failed to affect grain yield in most years. Application of N fertilizer increased grain yield in 1994 and 1995, but not in 1993 or 1996. Nitrogen fertilizer did not affect leaf spotting in the years when fertilizer was applied and leaf spotting was determined.

Suppression of leaf spotting from applications of N fertilizer on hard red spring wheat was not demonstrated in this experiment.

Objective 3

Grain yield has not varied whether wheat follows corn, fallow, or wheat in 1994, 1995, or 1996. However, a wheat cultivar (C) by cropping sequence (CS) interaction existed in both 1994 and 1996 for grain yield and returns. Returns were higher when the semidwarf cultivars were grown following corn than when the conventional-height cultivars were sown following corn in 1994. In this same year, returns were higher when the conventional-height cultivars were sown after fallow than when the semidwarf cultivars were planted. Comparable returns were generated by both cultivar groups in a wheat-wheat system.

Returns were higher when the semidwarf cultivars were seeded after fallow than when conventional-height cultivars were seeded after fallow in 1996. Returns were similar among both cultivar groups when seeded after corn or wheat in 1996.

HRSW Cultivar by Seeding Rate by Tillage System Trial Dickinson					

Treatment	Protein		TW		Yield		Average		-Returns	
	1995	1996	1995	1996	1995	1996	2 year	3 year	1995	1996
	%		lbs/bu		bu/acre				$/acre	
Tillage system										
No-tillage	14.1	14.8	54.5	60.3	37.1	51.5	44.3	----	158.0	214.0
Reduced-tillage	14.3	15.2	55.1	59.8	41.9	44.3	43.1	----	181.0	190.0
Conventional-tillage	14.5	15.2	55.3	60.6	40.9	45.9	43.4	----	179.0	198.0
LSD .05	NS	NS	NS	NS	NS	NS	----	----	NS	NS
Seeding rate (pls/acre)										
500 000	14.4	15.0	54.0	60.0	37.1	45.7	41.4	----	158.0	193.0
1 000 000	14.3	15.1	55.2	60.6	40.6	48.0	44.3	----	175.0	204.0
1 500 000	14.3	15.2	55.7	60.3	42.1	48.0	45.1	----	184.0	205.0
LSD .05	0.1	NS	0.2	NS	1.0	1.5	----	----	4.3	NS
Variety										
AC Minto	15.1	15.7	53.6	59.2	33.2	41.6	37.4	----	146.0	186.0
Amidon	14.1	15.1	55.5	60.4	42.3	46.0	44.2	----	183.0	200.0
Bergen	13.9	14.4	55.5	60.3	44.0	51.6	47.8	----	189.0	207.0
Grandin	14.5	15.7	55.2	61.3	38.8	47.2	43.0	----	170.0	211.0

Norm	14.1	14.5	54.9	60.0	41.4	49.6	45.5	----	175.0	200.0
Mean	14.3	15.1	55.0	60.3	39.9	47.2	----	----	173.0	201.0
C.V. %	1.9	1.6	1.2	1.5	6.9	8.6	----	----	7.0	8.4
LSD .05	0.1	0.1	0.3	0.4	1.2	1.9	----	----	5.7	7.8

Planted: April 22
Herbicides (HRSW): 0.75 pt glyphosate plus 1 pt Class Act plus 0.25 pt 2,4-D ester per acre to no-till plots on April 23 (as a burn down); 0.33 oz Harmony Extra plus 0.75 pt MCP ester per acre on June 12; 2 pt Diclofop on June 12; (no-till and reduced-till fallow) 1 pt glyphosate plus 0.5 pt dicamba plus 1 pt Class Act on June 3; 1.2 pt paraquat on July 7; 1 pt glyphosate plus 0.5 pt banvel plus 1 qt Class Act on July 15; 1 qt glyphosate plus 1.5 pt banvel plus 1 qt Class Act on August 22
Harvested: August 14

Tillage system	**Returns ($/acre)**					
	1995			**1996**		
Variety	***NT***	***RT***	***CT***	***NT***	***RT***	***CT***
AC Minto	137.0	150.0	150.0	193.0	176.0	189.0
Amidon	166.0	192.0	191.0	207.0	186.0	207.0
Bergen	169.0	202.0	198.0	225.0	202.0	194.0
Grandin	152.0	185.0	174.0	231.0	199.0	204.0
Norm	167.0	177.0	181.0	215.0	189.0	197.0
Mean	158.2	181.2	178.8	214.2	190.4	198.2

NT = no tillage; *RT* = reduced tillage; *CT* = conventional-tillage

1995									
Factor	plants	tillers	heads	kernels	height	yield	protein	seeds	TW
	acre	-- plant^{-1} --			- in -	bu/acre	-- % --	- lb^{-1} -	lbs/bu
Tillage (T)	NS	NS	NS	NS	NS	NS	NS	**	NS
Seeding rate (SR)	**	**	**	**	NS	**	NS	*	**
T by SR	NS	NS	*	NS	NS	NS	NS	**	NS
Variety (V)	**	**	**	**	**	**	**	**	**
T by V	NS	NS	NS	NS	NS	NS	NS	**	NS
SR by V	**	NS	NS	NS	*	*	NS	NS	NS
T by SR by V	NS	NS	NS	NS	**	NS	NS	NS	NS

1996									
Factor	plants	tillers	heads	kernels	height	yield	protein	seeds	TW
	acre	-- plant^{-1} --			- in -	bu/acre	-- % --	- lb^{-1} -	lbs/bu
Tillage (T)	**	NS	NS	NS	**	*	NS	**	NS

Seeding rate (SR)	**	**	**	**	**	**	*	**	NS
T by SR	NS	NS	NS	NS	NS	*	NS	NS	NS
Variety (V)	**	NS	**	**	**	**	**	**	**
T by V	NS	NS	NS	NS	*	NS	NS	NS	*
SR by V	NS	NS	NS	NS	NS	**	NS	NS	NS
T by SR by V	NS	NS	NS	NS	NS	NS	NS	NS	NS
** = p < .05; * = p < 0.10; NS = not significant									

Nitrogen by Fungicide by Tillage System Dickinson								
Treatment	**Leaf Spotting**				**Grain Yield**			
	1993	**1994**	**1995**	**1996**	**1993**	**1994**	**1995**	**1996**
	% of flag leaf				**bu/ac**			
Tillage system								
No-tillage (NT)	26	36	22	----	31.9	43.2	27.7	33.6
Reduced-tillage (RT)	37	31	32	----	34.6	45.4	30.5	41.0
Conventional-tillage (CT)	34	47	26	----	38.3	40.6	32.2	38.4
Fungicide Treatment								
No Fungicide (NF)	32	42	29	----	35.1	43.7	30.5	39.1
Fungicide (F)	33	34	24	----	34.7	42.4	29.7	36.2

N Fertilizer Rate								
Low Rate (LR)	----	38	27	----	----	40.6	28.3	37.4
High Rate (HR)	----	38	26	----	----	45.5	31.9	37.9
NT + NF + LR	----	36.5	33.5	----	----	40.9	27.6	38.9
NT + F + LR	----	40.7	22.0	----	----	42.5	23.1	39.2
NT + NF + HR	25.6	32.2	18.7	----	29.8	42.8	29.6	39,1
NT + F + HR	26.4	35.3	14.2	----	33.9	46.6	30.4	36.6
RT + NF + LR	----	34.0	27.2	----	----	46.6	28.3	41.7
RT + F + LR	----	24.5	32.0	----	----	39.6	29.1	39.9
RT + NF + HR	33.1	40.3	34.1	----	37.4	50.7	33.9	47.5
RT + F + HR	41.2	24.8	33.4	----	33.6	44.6	30.6	34.7
CT + NF + LR	----	56.2	27.3	----	----	38.2	30.5	34.5
CT + F + LR	-----	33.0	22.8	----	----	35.7	31.4	30.2
CT + NF + HR	35.9	50.4	33.1	----	38.1	42.6	33.3	33.0
CT + F + HR	31.6	47.1	20.3	----	38.4	45.7	33.4	36.7
Tillage System (TS)	*	NS	NS	----	NS	NS		NS
Fungicide Treatment (FT)	NS	NS		----	NS	NS	NS	NS
TS x FT	NS	NS	NS	----	*	NS	NS	NS
Nitrogen Fertilizer Rate (NFR)	----	NS	NS	----	----	*	*	NS

TS x NR	----	NS		----	----	NS	NS	NS
FT x NR	----	NS	NS	----	----	NS	NS	NS
TS x FT x NR	----	NS	NS	----	----	NS	NS	NS

* = p < 0.05; = p < 0.10; NS = not significant

Previous crop: HRSW; Soil test results: varied by treatment and plot; Fertilizer applied: Sufficient N and P to support a yield goal of 20 bu/acre (LR) or 40 bu/acre (HR) at a grain protein content of 14%; Planted with Stoa HRSW at 1,000,000 Pure Live Seed per acre on May 17; Herbicides: 0.75 pt glyphosate plus 1 pt Class Act plus 0.25 pt 2,4-D ester per acre to no-till plots on April 23 (as a burn down); 0.33 oz Harmony Extra plus 0.75 pt MCP ester per acre on June 12; 2 pt Diclofop on June 12; Applied 1 lb Mancozeb on June 20 when wheat plants at the 5-leaf stage (Haun 6.0); Harvested on August 26.

Nitrogen by Fungicide by Tillage System Dickinson

Treatment	Kernels				Test Weight			
	1993	1994	1995	1996	1993	1994	1995	1996
	lb				lbs/bu-			
Tillage system								
No-tillage (NT)	15,521	14,225	18,573	15,338	57.7	60.6	54.4	61.2
Reduced-tillage (RT)	15,300	14,589	13,224	15,160	57.4	60.2	54.4	61.8
Conventional -tillage (CT)	15,337	14,965	16,358	15,310	57.6	59.7	56.2	61.7
Fungicide Treatment								

No Fungicide (NF)	15,595	14,560	17,831	15,291	57.5	60.2	55.2	61.6
Fungicide (F)	15,166	14,626	17,605	15,247	57.6	60.2	54.8	61.5
N Fertilizer Rate								
Low Rate (LR)	----	14,282	17,765	15,051	----	60.5	55.1	61.9
High Rate (HR)	----	14,904	17,671	15,487	----	59.8	54.9	61.2
NT + NF + LR	----	14,081	18,846	15,341	----	60.9	54.7	61.6
NT + F + LR	----	13,998	18,336	14,642	----	60.7	53.6	61.6
NT + NF + HR	15,447	14,449	18,926	15,731	57.6	60.2	54.7	60.7
NT + F + HR	15,226	14,371	18,183	15,637	57.8	60.5	54.5	60.7
RT + NF + LR	----	13,971	18,641	15,389	----	60.5	54.7	62.2
RT + F + LR	----	14,252	17,720	14,937	----	60.6	55.0	62.0
RT + NF + HR	15,573	15,120	17,748	14,768	57.5	59.9	54.5	61.5
RT + F + HR	14,937	15,015	18,785	15,546	57.2	60.0	53.4	61.2
CT + NF + LR	----	14,071	16,676	14,900	----	60.4	56.4	62.0
CT + F + LR	----	14,322	16,372	15,097	----	60.0	55.9	61.7
CT + NF + HR	15,764	14,668	16,149	15,619	57.5	59.1	56.1	61.5
CT + F + HR	15,277	15,799	16,235	15,625	57.6	59.4	56.2	61.6
Tillage System (TS)	NS	NS	**	NS	NS	*	*	
Fungicide Treatment (FT)	*	NS	NS	NS	NS	NS	NS	NS
TS x FT	NS	NS	NS	NS	NS	NS	NS	NS

Nitrogen Fertilizer Rate (NFR)	--		NS	*	--	*	NS	**
TS x NFR	--	NS	NS	NS	--	NS	NS	*
FT x NFR	--	NS	NS	NS	--	NS	NS	NS
TS x FT x NFR	--	NS	NS	NS	--	NS	NS	NS

HRSW Cultivar by Cropping Sequence Trial Dickinson									
Treatment	**Grain Yield**			**Test Weight**			**Returns**		
	1994	**1995**	**1996**	**1994**	**1995**	**1996**	**1994**	**1995**	**1996**
	bu/acre			**lbs/bu**			**$/acre**		
Wheat following									
Corn	50.7	56.0	41.7	60.8	56.7	59.9	220.0	256.0	186.5
Fallow	50.2	54.3	48.7	61.2	56.8	60.1	217.8	249.5	215.2
Wheat	47.8	54.1	44.4	60.4	56.7	60.3	202.2	247.1	190.1
Mean	49.6	54.8	44.9	60.8	56.7	60.1	213.3	250.9	197.3
LSD .05	NS	NS	NS	0.3	NS	NS	NS	NS	NS
Variety									
Conventional									
AC Minto	46.2	47.5	41.4	60.0	55.7	58.6	203.0	217.4	186.5

Amidon	51.1	60.2	46.0	61.3	57.1	59.9	219.2	276.7	205.8
Butte 86	47.3	57.4	45.6	61.3	57.4	60.7	206.6	270.1	199.9
Sharp	50.2	55.9	41.7	62.7	58.6	61.9	214.7	265.0	183.5
Stoa	51.6	54.3	43.8	60.6	56.0	59.1	221.0	243.6	193.4
Mean	49.3	55.1	43.7	61.2	57.0	60.0	212.9	254.6	193.8
Semidwarf									
2371	44.9	50.1	43.8	59.0	56.1	59.5	198.5	232.9	199.4
Bergen	54.4	61.3	50.0	61.2	56.1	60.2	226.4	268.7	208.7
Grandin	47.4	54.5	46.7	60.7	56.8	60.7	207.3	256.7	209.9
Hi Line	51.4	50.6	43.9	60.5	57.2	60.2	219.3	230.4	193.1
Norm	50.8	56.2	46.2	61.0	56.0	60.1	217.6	246.9	192.6
Mean	49.8	54.5	46.1	60.5	56.4	60.1	213.8	247.1	200.7
C.V. %	6.5	4.8	6.0	1.0	0.9	1.1	6.5	5.9	6.7
LSD .05	2.6	2.1	2.2	0.5	0.4	0.6	11.3	12.1	10.7

Variety	**1994**			**1995**			**1996**		
	Wheat following -								
Conventional	**Corn**	**Fallow**	**Wheat**	**Corn**	**Fallow**	**Wheat**	**Corn**	**Fallow**	**Wheat**

	$/acre								
AC Minto	201	213	195	225	219	208	172	203	184
Amidon	218	237	202	283	279	268	205	222	191
Butte 86	204	220	196	280	260	269	197	212	191
Sharp	217	230	198	266	265	263	179	189	182
Stoa	217	233	213	252	244	235	192	207	181
Mean	211	227	201	261	253	249	189	207	186
Semidwarf									
2371	203	199	193	234	235	230	187	216	195
Bergen	245	213	221	288	263	255	195	229	202
Grandin	229	196	196	251	257	262	191	232	206
Hi Line	235	223	200	233	228	230	172	225	182
Norm	231	215	207	248	245	248	174	218	186
Mean	229	209	203	251	246	245	184	224	194
Planted at 1,200,000 Pure Live Seed per acre on April 22; Herbicides: (HRSW) 0.33 oz Harmony Extra plus 0.75 pt MCP ester per acre on June 12; 2 pt Diclofop on June 12; (Corn) 0.66 oz Accent plus 0.75 pt MCPA ester on June 3; 1.25 pt sethoxydim plus 1qt Scoil plus 1.5 qt AmmonSul on June 27; Harvested on August 13 (corn on September 13).									

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