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WHEAT PRODUCTION SYSTEMS FOR SOUTHWESTERN NORTH DAKOTA

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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.

4. Determine the agronomic potential of crops as a substitute for fallow in southwestern North Dakota.

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, including the mineralization of organic matter (Haas et al., 1974), the recharge of soil water (Black and Power, 1965), and the stabilization of farm income (Smika, 1970). With these benefits come costs, including the formation of saline seeps

(Halvorson and Black, 1974), uncontrolled wind and water erosion (Haas and Black, 1974), and reduced soil nutrient levels over time (Haas et al., 1957). The idling of productive land in a wheat-black fallow rotation has also raised economic efficiency questions (Ali and Johnson, 1981). Soil conservation mandates, as exemplified by the Conservation Compliance Provision of the 1985 Farm Bill, indicate that alternatives to the wheat-black fallow rotation must be developed for the long-term viability of wheat production in North Dakota.

INTRODUCTION

A cultivar by tillage (C by TS) system interaction exists for several crops (Cox and Shelton, 1992; Elmore, 1987; Hallauer and Calvin, 1985; Hwu and Allan, 1986). However, C by TS interactions with spring wheat seldom have been evaluated. Thompson and Hoag (1987) compared grain yield, test weight, and other agronomic characteristics of 10 spring wheat cultivars across conventionally-tilled fallow and recrop experiments, and in a recrop no-till trial. They concluded that the cultivars responded similarly across different tillage systems. Because comparisons were made between separate field experiments each year, it was difficult to separate tillage effects from those of other factors.

A significant C by TS interaction for grain yield and seed weight existed among 18 spring wheat cultivars grown across conventionally-tilled and reduced-till systems in South Dakota (Hall and Cholick, 1989). These data support earlier work indicating that spring wheat cultivars respond differently in contrasting tillage systems (Chevalier and Ciha, 1986). However, Chevalier and Ciha limited evaluations of C by TS interactions to systems where wheat was sown following wheat, even though most of the spring wheat in western North Dakota is produced on previously fallowed land (Wiyatt and Hamlin, 1992). Soil moisture status and other factors can differ dramatically between fallow and recrop land, regardless of the tillage system used.

Several studies indicate that spring wheat yield tends to be reduced in no-till compared to conventionally-tilled systems (Chevalier and Ciha, 1986; Ciha, 1982; Thompson and Hoag, 1987). The reduced yield may result from an allelopathic effect of the crop residue on the seeded crop (Elliott et al., 1978). Allelopathy could account for the poor plant stands sometimes established in no-till compared to conventionally-tilled wheat fields. Increasing the seeding rate in no-till compared to conventionally-tilled systems may improve stand establishment and, ultimately, grain yield in a no-till system. It is unknown how seeding rate influences grain yield and quality in reduced- and no-till compared to conventionally-tilled systems, or if a cultivar by tillage by seeding rate interaction exists. This project is directed is quantifying how the seeding rate used and the cultivar selected affect hard red spring wheat performance in conventionally-, reduced-, and no-till environments.

Tan spot and other leaf-spotting diseases affect spring and winter wheats in North Dakota. Of the leaf spotting diseases, tan spot generally is the most prominent (McMullen and Nelson, 1992). Severe tan spot infestations can drastically reduce both grain yield and quality of spring wheat (Hosford and Busch, 1974). Even mild infestations can adversely impact yield (McMullen, per. comm.).

Tan spot incidence increases as tillage is reduced in wheat production systems (Rees and Platz, 1992). This negative relationship suggests tan spot control measures are needed to maintain profitable wheat production in reduced- and no-till systems.

Rotating wheat with nonsusceptible crops is an effective tan spot control measure in reduced-till systems. Fungicides can also be used, but they are rarely economical in western North Dakota. Thus, other controls may be needed in reduced- and no-till systems in the west for wheat yield and quality to be maintained or enhanced.

Nitrogen fertilizer applications have reduced tan spot infection severity in winter wheat. For example, tan spot infection was reduced by anhydrous ammonia applications in Indiana (Huber et al., 1987). It is unknown what, if any, effect N applications have on tan spot infection in spring wheat. If N applications could reduce tan spot severity, then tan spot might be controlled in reduced- and no-till systems by implementing an aggressive N fertilizer program. Applying N would have many benefits besides suppressing tan spot in western North Dakota, where insufficient amounts of N generally are applied (Goos, per. comm.). This project will explore what, if any, effects applications of ammonium nitrate have on incidence of leaf spotting in spring wheat.

Crop rotation is a management practice well known for its yield benefits. Several explanations have been suggested for the "rotation effect" including reduced pest problems, improved soil fertility, and reduced allelopathic or phytotoxic effects (Ball, 1987).

Past work indicates that a crop rotation incorporating both food and feed crops is best suited to farm operations in southwestern North Dakota (Conlon et al., 1953). Among the most productive crop rotations was a corn-spring wheat-oat sequence. Subsequent work indicated that a corn-wheat rotation compared favorably with cropping sequences commonly used in the region (Conlon, 1992, per. comm.).

It is unknown if contrasting cropping systems influence agronomic performance of spring wheat cultivars differently. Because varying the cropping sequence can dramatically influence soil moisture and other factors (Badaruddin and Meyer, 1990; Black et al., 1981), and spring wheat cultivar by environment interactions are known to exist (Carr et al., 1992; Peterson et al., 1986), a spring wheat cultivar by cropping sequence interaction is likely. Evidence of a cultivar by cropping sequence interaction would indicate that rotations should be considered when making cultivar recommendations for spring wheat. This project will compare the agronomic performance of several spring wheat cultivars across wheat-wheat, wheat-corn, and wheat-black fallow cropping sequences.

Spring wheat generally is grown in fields previously fallowed in western North Dakota. Recent work suggests that buckwheat and other crops might be economically grown in place of a fallow period without adversely affecting spring wheat yield in the subsequent year. This project will evaluate the potential of buckwheat in continuously-cropped, low-fertility environments.

MATERIALS AND METHODS

Objective 1

HRSW Cultivar by Seeding Rate by Tillage System Trial. A field experiment was conducted under dryland conditions. Plots were arranged in a modified randomized complete block design in a split split-plot arrangement. Tillage system com-prised 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 are being maintained through-out the trial's duration. As a result, 50% of the space allocated for plots was not planted in 1995 (i.e., fallow plots); weeds in these plots were either mechanically controlled (conventional-till), control-led 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 dimen-sions 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.

Postemergent 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 conven-tional-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 seed weight, grain volume weight, and grain protein content. Number of tillers at the six-leaf stage and at maturity were counted.

Data were analyzed using a computer-driven statistical program.

Amidon Spring Wheat by Seeding Rate Trial. Amidon spring wheat was sown in a no-till environ-ment at Beach, a conventionally-tilled, fallowed environment at Beulah and Glen Ullin, and a conventionally-tilled, continuously-cropped environment at Hannover in southwestern North Dakota. Amidon spring wheat was sown at five rates at each location: 500,000 Pure Live Seed (PLS) per acre; 750,000 PLS per acre; 1,000,000 PLS per acre; 1,250,000 PLS per acre; and 1,500,000 PLS per acre.

Plots were arranged in a randomized complete block design with four replicates at each location. Vari-ables measured on each plot included: grain yield, test weight, kernel weight, and grain protein content.

Data were analyzed using a computer-driven statistical program.

Objective 2

Nitrogen Rate by Fungicide by Tillage System Trial. The experiment was arranged in a randomized complete block design in a split split-plot arrange-ment. Tillage system comprised main plots, fungi-cide treatment comprised subplots, and N applica-tions comprised sub-subplots. Tillage systems were established as described for the HRSW Cultivar by Seeding Rate by Tillage System Trial under Objective 1.

A single application of mancozeb at 1.0 lb a.i per acre made at the 5 leaf stage (Haun 6.0) 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.

Nitrogen Rate by Spring Wheat Cultivar Trial. Amidon, Grandin, Gus, Kulm, Norm, and 2375 wheat cultivars were each sown in plots where soil- plus applied-N was 50, 75, 100, and 125 pounds of N per acre. Plots were arranged in a randomized complete block design in a split-plot arrangement; N level comprised main plots and wheat cultivar comprised subplots. Plot dimensions were 10 by 28 feet.

Variables measured on each plot included: foliar leaf spotting, plant height, grain yield, test weight, kernel weight and grain protein content. 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 (AC Minto, Amidon, Butte 86, Sharp, and Stoa) and five semidwarf (Bergen, Grandin, HiLine, Norm, and 2371) spring wheat cultivars comprised subplots treatments.

Both phases of wheat-black fallow and wheat-corn rotations were established 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, 1000 seed weight, grain volume weight, and grain protein content.

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

Objective 4

Buckwheat Cultivar Adaptation Trial. Six buckwheat cutlivars were sown in a low-fertility, continuously-cropped environment in a field following barley. Plots were arranged in a randomized complete block design with four replicates. Individual plot dimensions were 6 by 28 ft.

Variables measured on each plot included: days to flower, plant height, seed yield, test weight, and seed weight. The data were analyzed using a computer-driven statistical program.

Buckwheat/Wheat Nitrogen by Sulfur Trial. Butte 86 spring wheat and Manor buckwheat were each sown in plots receiving 0, 10, and 20 pounds of nitrogen per acre as either ammonium nitrate (34-0-0) or ammonium sulfate (21-0-0-24). Elemental sulfur (ES) was applied at 10 and 20 pounds per acre with selected ammonium nitrate (AN) treatments. Crop (wheat or buckwheat) constituted main plots and fertilizer treatment constituted subplots. There were 7 subplot treatments per main plot: 29 lbs AN per acre; 29 lbs AN plus 10 lbs ES per acre; 60 lbs AN plus 20 lbs ES per acre; 40 lbs ammonium sulfate (AS) per acre; 80 lbs AS per acre; and a check (no fertilizer applied).

Subplot dimensions were 6 by 28 feet. Variables measured on each plot included: plant height, grain yield, test weight, and kernel or seed weight. The data were analyzed using a computer-driven statistical program.

RESULTS

Objective 1

Hard Red Spring Wheat Cultivar by Seeding Rate by Tillage System

No differences in success at establishing wheat in no-till compared to reduced- and conventional-till environments were detected in 1994 or 1995. More plants generally were counted in a conventional-till environment than a no-till environment in 1994, whereas more plants were counted in a no-till environment in 1995.

More plants were counted as the seeding rate was increased across the tillage systems, but fewer tillers and heads on plants were counted. More heads than tillers were sometimes counted per plant; this anomaly can be explained by the method in which tillers were counted. Only well developed tillers were counted at the 6-leaf stage (Haun 7.0); head counts were made prior to harvest, suggesting that some of the less developed tillers not counted at earlier did develop heads. Cultivars differed in the tillers and heads which formed on a plant, but a consistent trend among cultivars was not observed.

The seeding rate by cultivar interaction was generally significant for plant, tiller, and head count, but the tillage system by cultivar and tillage system by seeding rate by cultivar interactions were not significant for these parameters in 1994 and 1995.

Both kernel weight and test weight differed across tillage system. A consistent trend in kernel weight was not observed, but a heavier test weight occurred when wheat was sown in a conventional- than a no-till environment. A heavier test weight also resulted as the seeding rate was increased. Bergen generally produced the heaviest kernels with the heaviest test weight.

Grain yield, grain protein content, and economic returns did not vary across the tillage systems. More grain and, consequently, greater returns were generated as the seeding rate was increased. The cultivars varied in grain yield, grain protein content, and returns; Bergen was the highest yielding cultivar and generated the greatest returns. AC Minto produced grain containing the most crude protein.

Amidon Spring Wheat by Seeding Rate

Seeding rate generally influenced grain yield; more grain was produced as the seeding rate was increased from 500,000 to 1,250,000 Pure Live Seed (PLS) per acre. Grain yield was sometimes increased as the seeding rate was increased from 1,250,000 PLS per acre to 1,500,000 PLS per acre, depending on the location.

Grain protein content, test weight, and kernel weight generally were not affected by seeding rate when each location was analyzed separately. While these data have not been analyzed across locations and years, some general trends were observed: (1) grain yield and test weight tended to increase as the seeding rate was increased from 500,000 PLS per acre to 1,500,000 PLS per acre; (2) a slight decrease in grain protein content resulted as the seeding rate was increased; and (3) kernel weight was not affected by the seeding rate.

Objective 2

Nitrogen Rate by Fungicide by Tillage System

Amount of leaf spotting did not vary across tillage systems in either 1994 or 1995, and grain yield did not differ among tillage systems in 1994. Less grain was produced in a no-till than a conventional-till environment in 1995.

Grain contained more crude protein when produced in a no-till than a conventional-till environment in 1995, and kernels weighed less in no-till plots. Test weight varied among tillage systems in both 1994 and 1995, although a consistent trend was not observed.

Applications of mancozeb reduced leaf spotting ($P<0.10$) in 1995; this did not have a significant impact on grain yield, grain protein content, kernel weight, or test weight. In general, an application of mancozeb at the 6-leaf stage failed to significantly impact any grain parameter.

Leaf spotting was not affected by the amount of N available to wheat plants, but more grain was produced as greater amounts of N fertilizer was available. Grain protein content was also increased in 1995 as more N was available. Tillage system by N rate, fungicide treatment by N rate, and tillage system by fungicide treatment by N rate interactions generally have not been significant for any parameter.

N Rate by Spring Wheat Cultivar

Amount of leaf spotting was not affected by the amount of N that was available to wheat plants. However, leaf spotting did vary among the spring wheat cultivars. Least amount of leaf spotting occurred with Amidon, Grandin, and Gus in 1994 and 1995. Very little leaf spotting was observed with Norm in 1994, whereas more leaf spotting occurred with Norm than Amidon in 1995. Greatest amount of leaf spotting occurred with 2375 in 1995.

Grain yield and grain protein content were increased as more N was available in 1994 and 1995, whereas kernel weight and test weight generally increased. Grain yield varied among the cultivars in 1995 but not in 1994. Kernel weight and test weight varied among the cultivars in both years. Kernels produced by Norm and 2375 were among the heaviest in both years, whereas those produced by Gus were among the lightest. Kulm produced kernels with the heaviest weight in both years.

Objective 3

Cropping systems generally have not varied for any parameter, whereas differences have been detected among cultivars. Among the conventional height wheats, AC Minto has been the latest maturing and lowest yielding cultivar. Amidon has been among the highest yielding conventional height cultivars, but grain protein content of Amidon has been lower than AC Minto and Butte 86. Among the semidwarf cultivars, 2371 has been the latest maturing and lowest yielding cultivar. Bergen has been the earliest maturing and highest yielding cultivar.

The cropping system by cultivar interaction generally has not been significant for any parameter, except in 1994 for grain yield, test weight, and gross returns. In that year, greatest amount of grain was produced when semidwarf cultivars followed corn in a sequence, and when conventional-height cultivars followed fallow. This same trend was not observed in 1995.

Objective 4

Buckwheat Cultivar Adaptation

Seed yield among the six entries averaged over 1000 pounds per acre in a low-N, continuously-cropped environment in 1995. Common buckwheat and 85624 were the highest yielding entries, whereas germplasm from Japan was the lowest yielding.

Buckwheat/Wheat Nitrogen by Sulfur

Spring wheat was shorter, but produced more grain with a heavier test weight, and produced a heavier kernel than buckwheat. Wheat produced more grain as more N and S were applied, but a response to fertilizer application was not observed for grain protein content, test weight, or kernel weight. Buckwheat failed to respond to applications of N and S for any grain parameter.

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HRSW CULTIVAR X SEEDING RATE X TILLAGE SYSTEM TRIAL --- DICKINSON						
	Plants		Tillers		Spikes	
Treatment	1994	1995	1994	1995	1994	1995
	acre		plant		plant	
Tillage system (TS)						
No-tillage	542,269	675,205	3.6	1.7	3.9	3.3
Reduced-tillage	559,521	637,327	3.7	2.3	3.6	3.4
Conventional-tillage	587,004	591,612	2.9	2.2	3.4	3.3
Seeding Rate (SR)						
500,000 PLS/acre	264,005	337,058	4.7	3.1	5.2	4.7
1,000,000 PLS/acre	582,650	654,380	3.1	1.9	3.2	2.9
1,500,000 PLS/acre	842,138	912,706	2.5	1.2	2.5	2.3
Cultivar (C)						

AC Minto	783,507	726,847	3.6	2.2	3.3	3.2
Amidon	551,031	641,221	3.9	2.1	3.6	3.2
Bergen	591,848	664,805	3.0	1.6	3.4	3.0
Grandin	506,858	483,637	3.1	2.6	3.7	4.4
Norm	381,413	657,064	3.4	1.8	4.1	2.8
TS	NS	NS	NS	NS	NS	NS
SR	***	***	***	***	***	***
TS x SR	NS	NS	NS	NS	NS	NS
C	***	***	**	***		***
TS x C	NS	NS	NS	NS	NS	NS
SR x C	***	*	*		*	NS
TS x SR x C	NS	NS	NS	NS	NS	NS

=P<0.10 level of significance

Previous crop: fallow; Soil test results: varied by treatment; Planting date: May 11; Applied Dakota TP (0.5 pt Fenoxyprop + 1 pt MCPA) + 2 oz Banvel per acre on June 6; Harvested on September 5.

HRSW CULTIVAR X SEEDING RATE X TILLAGE SYSTEM TRIAL ---DICKINSON						
	Plant height		Kernel weight -		Test weight	

Treatment	1994	1995	1994	1995	1994	1995
	inches		kernels/lb		lbs/bu	
Tillage system (TS)						
No-tillage	32	30	12,910	15,592	59.3	54.5
Reduced-tillage	31	31	13,320	14,918	58.7	55.1
Conventional-tillage	31	30	12,248	14,262	60.3	55.3
Seeding Rate (SR)						
500,000 PLS/acre	30	30	12,828	15,282	58.9	54.0
1,000,000 PLS/acre	31	30	12,841	14,797	59.7	55.3
1,500,000 PLS/acre	32	31	12,810	14,693	59.7	55.7
Cultivar (C)						
AC Minto	35	34	13,458	15,860	59.2	53.6
Amidon	33	34	13,121	15,987	59.8	55.5
Bergen	28	27	12,173	13,655	59.6	55.5
Grandin	30	29	13,078	14,768	59.8	55.2
Norm	29	28	12,300	14,351	58.9	54.9

TS	NS	NS		*	*	*
SR	***	NS	NS	NS	***	**
TS x SR	NS	NS	NS	NS	NS	*
C	***	***	***	***	***	***
TS x C		NS	NS	*	NS	NS
SR x C	NS		NS	NS	NS	NS
TS x SR x C	NS	*	NS	NS	NS	NS

=P<0.10 level of significance

Previous crop: fallow; Soil test results: varied by treatment; Planting date: May 11; Applied Dakota TP (0.5 pt Fenoxyprop + 1 pt MCPA) + 2 oz Banvel per acre on June 6; Harvested on September 5.

HRSW CULTIVAR X SEEDING RATE X TILLAGE SYSTEM TRIAL --- DICKINSON

	Protein		Grain yield		Returns	
Treatment	1994	1995	1994	1995	1994	1995
	%		bu/ac		$/acre	
Tillage system (TS)						
No-tillage	15.9	14.1	48.9	37.1	245.56	158.24
Reduced-tillage	15.4	14.3	43.9	41.9	215.87	181.10
Conventional-tillage	15.6	14.5	49.1	40.9	246.11	178.81

Seeding Rate (SR)						
500,000 PLS/acre	15.6	14.4	41.6	37.1	205.78	158.76
1,000,000 PLS/acre	15.6	14.3	48.6	40.6	242.75	175.41
1,500,000 PLS/acre	15.7	14.3	51.7	42.1	258.91	183.98
Cultivar (C)						
AC Minto	16.2	15.1	46.1	33.2	233.19	145.78
Amidon	15.8	14.1	48.8	42.3	245.96	183.13
Bergen	15.0	13.9	51.3	44.0	251.12	188.52
Grandin	15.7	14.5	44.7	38.8	223.71	170.36
Norm	15.4	14.1	45.6	41.4	225.10	175.81
TS	NS	NS	NS	NS	NS	NS
SR	NS	NS	*	**	***	***
TS x SR	NS	NS	NS	NS	NS	NS
C	***	***	***	***	***	***
TS x C	NS	NS	NS	NS	NS	*
SR x C	NS	NS	NS		NS	

TS x SR x C		NS	NS	NS	NS	NS
=P<0.10 level of significance Previous crop: fallow; Soil test results: varied by treatment; Planting date: May 11; Applied Dakota TP (0.5 pt Fenoxyprop + 1 pt MCPA) + 2 oz Banvel per acre on June 6; Harvested on September 5.						

SEEDING RATE TRIAL - AMIDON HRSW DICKINSON				
Seeding Rate	Kernel weight	Protein	Test Weight	Grain Yield
	kernels/lb	- % -	lbs/bu	bu/acre
500,000	16,149	14.9	56.5	34.9
750,000	15,911	14.8	57.0	39.4
1,000,000	16,220	14.8	57.6	41.7
1,250,000	15,752	14.8	57.0	43.2
1,500,000	16,163	14.7	57.5	44.2
Previous crop: Green fallow (Beach), Corn (Hannover), Fallow (Beulah and Glen Ullin); Soil test results (varied with location - refer to off-station variety trial data tables); Planted on May 18 (Beach) and 19 (other locations); Did not apply herbicides at Beach - applied 2.7 pt Hoelon + 0.33 oz Harmony Extra + 0.75 pt MCPA Ester per acre in two passes on June 13 at other sites; Harvested on September 8 (Beach), 11 (Beulah), 12 (Glen Ullin), and 13 (Hannover).				

SEEDING RATE TRIAL - AMIDON HRSW --- DICKINSON									
Location	Seeding Rate	Seeds		Protein		Test Weight		Grain Yield	
		1994	1995	1994	1995	1994	1995	1994	1995
		lbs		%		lbs/bu		bu/acre	
Beach	500,000	16,029	20,427	14.2	14.1	59.0	53.5	26.5	26.7
	750,000	16,307	20,660	13.9	14.0	59.6	54.1	30.6	26.6
	1,000,000	16,670	20,929	14.1	13.9	60.2	55.6	29.6	26.9
	1,250,000	16,267	19,994	14.0	13.9	60.1	55.2	31.2	28.8
	1,500,000	17,028	21,559	14.0	13.9	60.1	55.5	32.1	28.7
Mean		16,460	20,714	14.0	13.9	59.8	54.8	30.0	27.5
CV(%)		2.7	7.6	1.8	0.9	1.0	2.2	6.1	5.3
LSD.05		NS	NS	NS	NS	NS	NS	2.8	NS
Beulah	500,000	13,628	16,981	16.3	14.6	60.2	53.0	57.9	30.1
	750,000	14,007	16,129	16.3	14.4	60.6	53.5	62.6	33.3
	1,000,000	13,881	17,278	16.3	14.4	61.4	54.1	67.3	35.7
	1,250,000	14,414	16,541	16.1	14.2	61.9	54.4	69.9	36.9
	1,500,000	14,382	16,926	16.1	14.2	61.5	54.4	68.4	37.8

Mean		14,063	16,771	16.2	14.4	61.1	53.9	65.2	34.8
CV(%)		2.6	4.2	1.3	2.1	0.8	1.3	3.1	5.4
LSD.05		555	NS	NS	NS	0.7	NS	3.1	2.9
Glen Ullin	500,000	13,815	16,659	14.5	14.5	57.5	56.2	47.0	40.1
	750,000	13,799	16,127	13.9	14.3	58.0	57.0	50.8	52.8
	1,000,000	13,334	15,865	14.2	14.2	58.1	57.5	52.2	56.34
	1,250,000	12,321	15,653	14.2	14.2	57.9	57.7	57.4	56.5
	1,500,000	13,233	15,328	13.9	14.2	57.0	57.0	57.0	59.2
Mean		13,300	15,927	14.2	14.3	57.8	57.2	52.9	53.0
CV(%)		8.4	7.4	1.7	1.0	0.8	1.2	6.7	5.9
LSD.05		NS	NS	0.4	0.2	NS	NS	5.5	4.8
Hannover	500,000	14,388	17,264	16.6	14.8	59.6	52.6	29.1	21.9
	750,000	14,113	16,143	16.8	14.7	59.9	53.1	32.7	26.0
	1,000,000	14,027	17,777	16.6	14.7	60.6	53.5	37.2	28.5
	1,250,000	14,078	16,747	16.8	14.7	60.5	53.5	35.9	29.4
	1,500,000	14,393	16,454	16.8	14.6	60.9	53.7	37.1	33.0
Mean		14,200	16,877	16.7	14.7	60.3	53.3	34.4	27.8
CV(%)		3.2	12.6	1.4	1.0	0.9	1.1	9.9	6.5

LSD.05		NS	NS	NS	NS	0.8	NS	5.3	2.8

NITROGEN BY FUNGICIDE BY TILLAGE SYSTEM TRIAL --- DICKINSON						
	Leaf					
	Spotting			Grain Yield		
Treatment	1993	1994	1995	1993	1994	1995
	% of flag leaf			bu/ac		
Tillage system						
No-tillage (NT)	26	36	22	31.9	43.2	27.7
Reduced-tillage (RT)	37	31	32	34.6	45.4	30.5
Conventional-tillage (CT)	34	47	26	38.3	40.6	32.2
Fungicide Treatment						
No Fungicide (NF)	32	42	29	35.1	43.7	30.5
Fungicide (F)	33	34	24	34.7	42.4	29.7
N Fertilizer Rate						
Low Rate (LR)	----	38	27	----	40.6	28.3

High Rate (HR)	----	38	26	----	45.5	31.9
NT + NF + LR	--	36.5	33.5	--	40.9	27.6
NT + F + LR	--	40.7	22.0	--	42.5	23.1
NT + NF + HR	25.6	32.2	18.7	29.8	42.8	29.6
NT + F + HR	26.4	35.3	14.2	33.9	46.6	30.4
RT + NF + LR	--	34.0	27.2	--	46.6	28.3
RT + F + LR	--	24.5	32.0	--	39.6	29.1
RT + NF + HR	33.1	40.3	34.1	37.4	50.7	33.9
RT + F + HR	41.2	24.8	33.4	33.6	44.6	30.6
CT + NF + LR	--	56.2	27.3	--	38.2	30.5
CT + F + LR	--	33.0	22.8	--	35.7	31.4
CT + NF + HR	35.9	50.4	33.1	38.1	42.6	33.3
CT + F + HR	31.6	47.1	20.3	38.4	45.7	33.4
Tillage System (TS)	*	NS	NS	NS	NS	
Fungicide Treatment (FT)	NS	NS		NS	NS	NS
TS x FT	NS	NS	NS	*	NS	NS

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

=P<0.10 level of significance

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 April 26; Applied Dakota TP (0.5 pt Fenoxyprop + 1 pt MCPA) + 2 oz Banvel per acre on May 31; Applied 1 lb Mancozeb on June 14 when wheat plants at the 5-leaf stage (Haun 6.0); Harvested on September 1.

NITROGEN BY FUNGICIDE BY TILLAGE SYSTEM TRIAL --- DICKINSON

	Protein		Kernel Weight			Test Weight		
Treatment	1994	1995	1993	1994	1995	1993	1994	1995
	%		kernels/lb			lbs/bu		
Tillage system								
No-tillage (NT)	15.0	14.8	15,521	14,225	18,573	57.7	60.6	54.4
Reduced-tillage (RT)	14.6	14.4	15,300	14,589	13,224	57.4	60.2	54.4
Conventional - tillage (CT)	14.6	14.0	15,337	14,965	16,358	57.6	59.7	56.2

Fungicide Treatment								
No Fungicide (NF)	14.8	14.4	15,595	14,560	17,831	57.5	60.2	55.2
Fungicide (F)	14.7	14.3	15,166	14,626	17,605	57.6	60.2	54.8
N Fertilizer Rate								
Low Rate (LR)	14.6	14.2	--	14,282	17,765	----	60.5	55.1
High Rate (HR)	14.9	14.6	--	14,904	17,671	----	59.8	54.9
NT + NF + LR	14.8	13.8	--	14,081	18,846	--	60.9	54.7
NT + F + LR	14.4	13.6	--	13,998	18,336	--	60.7	53.6
NT + NF + HR	14.8	14.1	15,447	14,449	18,926	57.6	60.2	54.7
NT + F + HR	14.6	14.5	15,226	14,371	18,183	57.8	60.5	54.5
RT + NF + LR	14.6	14.4	--	13,971	18,641	--	60.5	54.7
RT + F + LR	14.0	13.9	--	14,252	17,720	--	60.6	55.0
RT + NF + HR	15.0	14.7	15,573	15,120	17,748	57.5	59.9	54.5
RT + F + HR	15.0	14.6	14,937	15,015	18,785	57.2	60.0	53.4

CT + NF + LR	14.5	14.7	--	14,071	16,676	--	60.4	56.4
CT + F + LR	15.4	14.5	--	14,322	16,372	--	60.0	55.9
CT + NF + HR	15.2	14.9	15,764	14,668	16,149	57.5	59.1	56.1
CT + F + HR	14.9	14.8	15,277	15,799	16,235	57.6	59.4	56.2
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
Nitrogen Fertilizer Rate (NFR)	NS	***	--		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

=P<0.10 level of significance

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 April 26; Applied Dakota TP (0.5 pt Fenoxyprop + 1 pt MCPA) + 2 oz Banvel per acre on May 31; Applied 1 lb Mancozeb on June 14 when wheat plants at the 5-leaf stage (Haun 6.0); Harvested on September 1.

HRSW CULTIVAR X N FERTILITY TRIAL --- DICKINSON						
			Days to Heading		Leaf Spotting	
Treatment	Type		1994	1995	1994	1995
	acre		days		%	
N rate (N)						
50 lbs N	--		53	--	13	45
75 lbs N	--		54	--	13	30
100 lbs N	--		54	--	15	28
125 lbs N	--		54	--	15	21
Cultivar (C)						
Amidon	Medium		54	--	10	13
Grandin	Semidwarf		55	--	10	23
Gus	Semidwarf		54	--	10	19
Kulm	Medium		52	--	26	36
Norm	Semidwarf		55	--	9	29
2375	Semidwarf		53	--	19	66
Mean			53.7	--	14	31
CV(%)			2.2	--	57.4	48.0

LSD.05			0.8	--	5.7	15.5
N			NS	--	NS	NS
C			***	--	***	***
N x C			NS	--	NS	NS

	Grain Yield		Kernel Weight		Test Weight	
Treatment	1994	1995	1994	1995	1994	1995
	bu/acre		kernels/lb		lbs/bu	
N rate (N)						
50 lbs N	44.9	42.4	12,896	14,213	62.5	57.7
75 lbs N	46.4	46.5	13,092	14,977	62.4	57.0
100 lbs N	43.7	47.2	13,638	15,095	62.3	56.9
125 lbs N	52.4	57.0	13,880	14,522	61.7	56.8
Cultivar (C)						
Amidon	47.4	54.6	13,976	14,673	61.9	57.2
Grandin	46.7	47.1	13,120	14,128	62.2	57.2

Gus	44.8	48.5	13,542	16,198	61.9	55.9
Kulm	47.0	47.4	14,671	14,524	63.2	59.1
Norm	47.9	46.9	12,300	14,096	62.1	56.2
2375	47.1	45.1	12,652	14,591	62.2	57.1
Mean	46.9	48.3	13,377	14,702	62.2	57.1
CV(%)	7.8	7.9	4.8	6.2	0.9	1.0
LSD.05	NS	2.7	455	645	0.4	0.4
N	*	***	*	NS	**	*
C	NS	***	***	***	***	***
N x C	NS	NS	NS	NS	NS	NS

HRSW CULTIVAR X N FERTILITY TRIAL --- DICKINSON				
	Protein		Returns	
Treatment	1994	1995	1994	1995
	- %		$/acre	
N rate (N)				

50 lbs N	14.4	12.2	--	185.77
75 lbs N	14.5	13.1	--	202.21
100 lbs N	15.0	13.5	--	207.40
125 lbs N	15.6	13.8	--	252.98
Cultivar (C)				
Amidon	14.6	12.7	--	238.13
Grandin	14.6	13.3	--	209.65
Gus	15.2	13.8	--	210.27
Kulm	15.0	13.5	--	220.10
Norm	14.7	12.9	--	198.33
2375	15.0	12.6	--	196.04
Mean	14.9	13.1	--	212.09
CV(%)	7.8	3.7	--	8.4
LSD.05	NS	0.3	--	12.59
N	***	***	--	NS
C	NS	***	--	***
N x C	NS	NS	--	NS

Previous crop: oat: Soil test results: 13 lbs N, 4 ppm P; applied 77 lbs 0-45-0 per acre, sufficient N as 34-0-0 to achieve 20, 30, 40, and 50 bu/acre HRSW at a grain protein content of 14%; Seeded at 1.2 million Pure Live Seed per acre on May 15; Applied 2 pt Hoelon + 1 pt Buctril per acre on June 5; Harvested on August 31.

HRSW CULTIVAR X CROPPING SEQUENCE TRIAL --- DICKINSON					
		Days to Heading		Plant Height	
Treatment	Type	1994	1995	1994	1995
	acre	----- days -----		----- inches -----	
Cropping Sequence (CS)					
Wheat-corn	--	47	52	32	32
Wheat-fallow	--	48	52	33	31
Wheat-wheat	--	49	53	32	31
Cultivar (C)					
Conventional					
AC Minto	Medium	50	56	39	34
Amidon	Medium	49	53	35	35
Butte 86	Medium	47	50	32	31
Sharp	Medium	47	50	32	32
Stoa	Medium	48	53	34	34

Mean		48	52	34	33
Semidwarf					
Bergen	Semidwarf	47	52	28	27
Grandin	Semidwarf	48	53	31	29
HiLine	Semidwarf	47	52	30	27
Norm	Semidwarf	48	53	29	28
2371	Semidwarf	50	55	36	36
Mean		48	53	31	29
CS		***	NS	NS	NS
C		***	***	***	***
CS x C		NS	NS	NS	NS

HRSW CULTIVAR X CROPPING SEQUENCE TRIAL --- DICKINSON						
	Grain yield					
	Grain yield		Percent of fallow		Test weight	
Treatment	1994	1995	1994	1995	1994	1995
	bu/acre		%		lbs/bu	

Cropping Sequence (CS)						
Wheat-corn	50.7	56.0	101	103	60.8	56.7
Wheat-fallow	50.2	54.3	100	100	61.2	56.8
Wheat-wheat	47.8	54.1	95	100	60.4	56.7
Cultivar (C)						
Conventional						
AC Minto	46.2	47.5	--	--	60.0	55.7
Amidon	51.1	60.2	--	--	61.3	57.1
Butte 86	47.3	57.4	--	--	61.3	57.4
Sharp	50.2	55.9	--	--	62.7	58.6
Stoa	51.6	54.3	--	--	60.6	56.0
Mean	49.3	55.1	--	--	61.2	57.0
Semidwarf						
Bergen	54.4	61.3	--	--	61.2	56.1
Grandin	47.4	54.5	--	--	60.7	56.8
HiLine	51.4	50.6	--	--	60.5	57.2
Norm	50.8	56.2	--	--	61.0	56.0

2371	44.9	50.1	--	--	59.0	56.1
Mean	49.8	54.5	--	--	60.5	56.4
CS	NS	NS	--	--	*	NS
C	***	***	--	--	***	***
CS x C	**	NS	--	--	**	NS

HRSW CULTIVAR X CROPPING SEQUENCE TRIAL --- DICKINSON						
	-- Grain protein --		-- Kernel weight --		--- Returns --	
Treatment	1994	1995	1994	1995	1994	1995
	- % -		- kernels/lb -		- $/acre -	
Cropping Sequence (CS)						
Wheat-corn	16.2	14.8	13,289	14,807	259.12	256.00
Wheat-fallow	16.2	14.7	12,953	14,811	256.68	249.49
Wheat-wheat	15.5	14.7	13,155	15,008	239.16	247.08
Cultivar (C)						
Conventional height						
AC Minto	16.6	15.4	13,337	15,167	238.51	217.40

Amidon	15.7	14.7	13,490	15,056	258.30	276.73
Butte 86	16.1	14.9	12,730	13,857	241.93	270.07
Sharp	15.7	14.4	13,189	13,777	253.77	265.00
Stoa	15.6	14.8	13,886	16,336	260.77	243.65
Mean	15.9	14.8	13,326	14,839	250.66	254.57
Semidwarf						
Bergen	15.2	14.1	12,253	13,809	271.58	268.69
Grandin	16.3	15.1	13,142	14,515	243.16	256.72
HiLine	15.7	14.1	13,412	15,837	260.09	230.38
Norm	15.8	14.2	12,055	14,303	257.28	246.94
2371	17.0	15.5	13,830	16,096	231.15	232.95
Mean	16.0	14.6	12,938	14,912	252.65	247.14
CS	**	NS	NS	NS	NS	NS
C	***	***	***	***	***	***
CS x C	NS	NS	NS	NS	**	NS

HRSW CULTIVAR X CROPPING SEQUENCE TRIAL --- DICKINSON

	Grain yield					
	Wheat-corn		Wheat-fallow		Wheat-wheat	
Treatment	1994	1995	1994	1995	1994	1995
	bu/acre					
Cultivar (C)						
Conventional height						
AC Minto	45.6	48.7	48.2	47.6	44.8	46.0
Amidon	50.6	61.7	54.0	60.2	48.6	58.6
Butte 86	46.5	59.6	49.9	56.1	45.5	56.7
Sharp	50.3	56.1	53.1	55.9	47.2	55.7
Stoa	50.1	56.2	54.4	53.9	50.3	52.8
Mean	48.6	56.5	51.9	54.7	47.3	54.0
Semidwarf						
Bergen	57.8	66.1	51.0	59.2	54.3	58.7
Grandin	52.2	53.6	44.4	53.9	45.7	56.1
HiLine	54.3	50.9	51.7	50.1	48.3	50.9
Norm	53.4	56.4	50.2	55.4	48.8	56.8

2371	45.9	50.9	44.8	50.2	44.0	49.2
Mean	52.7	55.6	48.4	53.8	48.2	54.3

1995 BUCKWHEAT - RECROP --- DICKINSON									
					Grain Yield				
	Plant	Days to		Test				--- Averages ---	
Variety	Height	flower	Seeds	weight	1995	1994	1992	3-year	2-year
	inches	June	lbs	lbs/bu	lbs/ac				
85624	28	35	14,454	36.6	1158.8	1541.7	1260.0	1320.2	1350.3
Common	26	34	24,699	41.8	1176.2	1617.4	1650.0	1481.2	1396.8
G. American	30	37	18,628	37.3	944.3	1555.3	1178.0	1225.9	1249.8
Japanese 1	32	35	18,372	39.1	775.1	--	--	--	--
Mancan	29	35	18,604	40.4	1070.2	1618.6	1094.0	1260.9	1344.4
Manor	31	35	18,802	39.0	1064.2	1395.8	1137.0	1199.0	1230.0
Mean	29.4	35.1	18,927	39.0	1031.5				
CV(%)	3.0	1.3	8.5	1.9	11.7				
LSD.05	1.3	0.67	2430	1.1	182.3				

Previous crop: barley; Soil test results: 13 lbs N, 4 ppm P - no fertilizer applied; Sown at 670,000 Pure Live Seed per acre on April 15; Applied 1 pt Poast + 1 pt Scoil per acre on June 9; Harvested on August 29.

BUCKWHEAT/WHEAT N X FERTILITY TRIAL --- DICKINSON					
		Yield	Test	Seed	
Treatment	Height	1994	Weight	Weight	Protein
	inches	lbs/acre	lbs/bu	Seed/lb	%
Crop (C)					
Wheat	30	2,435.0	57.8	13,317	12.3
Buckwheat	33	999.3	40.1	16,385	--
Fertilizer Treatment (FT)					
Wheat (W)					
29 lbs 34-0-0	30	39.8	58.0	13,213	12.5
29 lbs 34-0-0 + 10 lbs S	30	41.3	57.6	13,200	12.6
60 lbs 34-0-0	30	43.1	57.6	13,211	11.8
60 lbs 34-0-0 + 20 lbs S	31	43.1	58.0	13,205	12.0
40 lbs 24-0-0-24	29	39.5	57.9	13,662	12.4
80 lbs 24-0-0-24	30	41.1	58.0	13,271	12.4
Check	30	36.2	57.8	13,453	12.3

Mean	30	40.6	57.8	13,317	12.3
CV(%)	3.0	5.6	0.9	3.3	4.0
LSD.05	NS	3.4	NS	NS	NS
Buckwheat					
29 lbs 34-0-0	33	20.8	39.9	16,015	--
29 lbs 34-0-0 + 10 lbs S	33	20.5	40.1	16,729	--
60 lbs 34-0-0	34	20.1	40.1	16,558	--
60 lbs 34-0-0 + 20 lbs S	33	20.2	40.1	16,836	--
40 lbs 24-0-0-24	32	21.1	40.2	16,337	--
80 lbs 24-0-0-24	34	22.1	39.9	16,176	--
Check	31	20.1	40.1	16,046	--
Mean	33	20.8	40.1	16,385	--
CV(%)	3.3	9.4	1.2	4.0	--
LSD.05	1.6	NS	NS	NS	--
C	*	*	***	**	

FT	*	*	NS	NS	
C x FT	NS	**	NS	NS	
Previous crop: barley; Soil test results: 13 lbs N, 4 ppm P - no fertilizer applied; Sown at 670,000 Pure Live Seed per acre on April 15; Applied 1 pt Poast + 1 pt Scoil per acre on June 9; Harvested on August 29.					

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