Dickinson Research Extension Center
1089 State Avenue
Dickinson, ND 58601

2000 Diagnosis and Management of Root Disease in Wheat and Barley in Southwest North Dakota

R.O. Ashley*, M.P. McMullen, E.D. Eriksmoen,
B. Schmidt, M. Whitney, R. Schmidt, and W. Markegarrd

Summary

Western North Dakota producers of spring wheat (*Triticum aestivum* L.), durum (*Triticum turgidum* L. Durum Group), and barley (*Hordeum vulgare* L.) commonly plant into ground previously planted to wheat, durum, or barley. The objective of this project was to demonstrate the extent that root disease affects yield and quality of wheat in continuous wheat sequences and the effect that crop rotations have on reducing root disease. Field demonstrations were initiated at five locations in western North Dakota in 2000. Methyl bromide fumigant was used in plots to control fungal root diseases. Root disease ratings were consistently lower in fumigated plots than in natural (non-fumigated) soil plots. Fumigated plots in a continuous wheat field yielded 30% more grain than natural soil plots. Fumigated plots in an irrigated continuous barley field yielded 30% more grain than natural soil plots. In a hard red spring wheat field where non-host crops were grown for two years between wheat crops, no significant differences in yield or root rot ratings were found between fumigated and natural soils. *Fusarium* spp. and *Pythium* spp. soil propagule counts tended to decrease with time between wheat or barley crops. CDC Teal, a Canadian hard red spring wheat variety, and Oxen, a South Dakota hard red spring wheat variety, were found to be sensitive to methyl bromide.

Introduction

The flexibility allowed producers by the Federal Agriculture Improvement and Reform (FAIR) Act of 1996 and favorable prices for hard red spring wheat, durum, and barley in 1995 and 1996 prompted many western North Dakota producers to abandon summer fallow and initiate continuous cropping of these cereal grains. Statewide, North Dakota producers in 1997 seeded nearly 62% of their wheat acres on fields that were either in wheat or barley the previous year (McMullen, 1998). In western North Dakota, of the known previous crops reported in this study, 75% of the wheat grown had been in fields where wheat or barley was grown the previous year. In 1998, 1999 and 2000 crop prices fell, prompting some producers to either go back to the wheat-fallow system or consider abandoning the use of non-host crops in rotation with wheat.

Research conducted by North Dakota State University (NDSU) (Stack and McMullen, 1995) and Canadian scientists (Ledingham, et. al., 1973; Mathieson, 1943; Butler, 1961) suggests that root and crown diseases reduce yields an average of from five to ten percent. In continuous cereal and cereal fallow rotations, yields are commonly lower than expected based on available soil moisture and growing season precipitation. Cook (1990) over a 15-year period found that when root and crown diseases were controlled with fumigation in continuous winter wheat rotations, an average 70% yield increase could be expected. A one-year break and two-year break between wheat crops produced a 22% and 7% yield increase, respectively, for fumigated compared to non-fumigated plots. Producers are encouraged to incorporate crop rotations into their farming practices. Crop rotations have been shown to reduce pest problems while improving yields and quality of subsequent crops (Black and Siddoway, 1975). Many producers do not fully realize the extent of yield and quality losses that result from root and crown disease problems. This demonstration provided producers the opportunity to see the impact of root diseases on dryland wheat and durum wheat in western North Dakota and the role that crop rotation can play in disease control.

Materials and Methods

Five locations with a history (Table 1) of either continuous cereal grain, a non-host crop between wheat crops, or two years of non-host crops between wheat crops were selected. Agronomic practices and estimated stored soil water and precipitation were recorded (Table 2). Stored soil water was estimated at the time of fumigation with the use of a Paul Brown Soil Moisture Probe (Brown and Carlson, 1990). Precipitation from planting date to 15 days prior to harvest was obtained from the nearest North Dakota Agricultural Weather network (NDAWN) or from National Oceanic and Atmospheric Administration stations nearest to demonstration locations.

A randomized complete block design with four replications was used at all locations. At all locations except Reeder the fumigant was applied in the spring of 2000. At Reeder fumigation was completed in the fall of 1999. Each plot was 300 ft^2 (28 m^2). Plots to be fumigated were covered with a six mil plastic sheet, edges buried in trenches four to six inches deep to seal the covered area, and methyl bromide was metered through plastic hoses at the rate of one pound per 100 ft^2 (50 g m^{-2}). Fumigated plots remained covered from 48 to 120 hours after which time the plastic was removed. Non-fumigated or natural soil plots served as checks. After the plastic was removed, producers farmed through the fumigated and natural soil plots with their normal management practices.

Root samples were collected from plots between Haun stage 6 and 7.5 at all locations except Reeder and then again at Haun stage 14.5 (soft dough stage) from all locations. Samples were carefully washed by hand. An evaluation of the first and second group of samples was completed at the Dickinson Research Extension Center. Plant length, plant development, root counts, and evaluation of the subcrown internode were recorded during the first evaluation. The second group of root samples was evaluated for root mass, root color, and extent of root rot lesions on the subcrown internode. Selected root and crown samples from the soft dough stage were sent to the NDSU Plant Diagnostic Clinic for agar plate culture evaluation.

Soil samples collected at Haun stage 14.5 from the two to four inch depth in the natural soil plots at all locations except Amidon were submitted to Ribeiro Plant Lab Inc., Bainbridge Island, WA for a biological soil assay for *Pythium* spp. and *Fusarium* spp. Pythium presence and levels were determined using a modification of the PARPH medium published by Jeffers and Martin (1986) and Erwin and Riberiro (1996); and *Fusarium* presence and levels were determined using Komada's medium (Komada, 1975).

Head density, mature plant height, and total above ground biomass were measured at harvest. At all locations, yield samples were harvested from each plot by hand from an area four rows wide by 8 ft (2.4 m) long, bagged, hung up to dry, threshed, and yield and quality factors measured. Protein was analyzed with an NIR analyzer at Southwest Grain Inc., Dickinson, ND.

All data was statistically analyzed using SAS Statistical software version 6.12 (SAS Institute Inc., 1996).

Results and Discussion

Sensitivity to Methyl Bromide

CDC Teal, a Canadian variety, and Oxen, a South Dakota variety, exhibited severe sensitivity to the methyl bromide treated soil throughout the growing season. The symptoms were similar to those described by Cook (1998). Grain yield and total biomass was lower in fumigated plots than natural soil plots (Table 3). Other crop growth characteristics observed at these two sites was probably affected by the soil fumigant. The remaining portion of this paper will address the three locations and conditions where varieties grown were not sensitive to methyl bromide.

Yield and Quality

Significant differences in grain yield and total biomass were detected between fumigated and natural soil plots where winter wheat was grown in a continuous wheat rotation near Reeder and in an irrigated barley crop grown in a continuous barley-wheat rotation near Zap (Table 3). Yield differences were about 30 percent at these locations rather than average of 40 percent for hard red spring wheat found the previous three years (Ashley et. al. 1999, 1998, 1997). However the values observed for winter wheat and barley are within the range that was observed in spring wheat for continuous wheat rotations. Where corn and oat separated wheat crops at Amdion, no significant differences in grain yield or total biomass was detected. No significant differences were detected in protein or test weight at any of the locations, although test weight of grain from the fumigated plots on continuous wheat or barley tended to be higher than grain from the natural soil plots. Cook (1990) and Rovira and Ridge (1979) noted similar patterns in grain yield and crop rotations.

Plant Length, Mature Plant Height, and Head Density

No significant differences in plant length (Table 4) or mature plant height (Table 3) occurred at either Amidon or Zap. However, head density was significantly greater from fumigated plots for winter wheat grown at Reeder and barley at Zap than from the natural soil plots where there was no rotation break between wheat or barley. At Amidon where a two-year break occurred between wheat crops there was no significant difference in head density. Head density found in this demonstration is consistent with the finding of Cook et. al. (1987).

Root Assessments

Initial root evaluation (Table 4) indicated that plants grown at Zap on fumigated plots had greater crown and seminal root numbers than plants grown on natural soil plots. No significant differences in either seminal or crown root counts were detected for the Amidon location. Tiller counts tended to be higher for fumigated plots at Zap while little difference in tiller counts could be found at Amidon.

No differences were found in subcrown internode ratings during the initial evaluation. However the infection ratings at the soft dough stage of the subcrown internodes from the natural soil plots at Zap and Reeder were significantly higher than the fumigated plots (Table 5). Roots were a darker color and smaller root mass in the natural soil plots compared to natural soil plots at Reeder and Zap. At Amidon where a two-year break occurred between wheat crops no significant differences were detected between fumigated and natural soil plots in any of the parameters evaluated during the evaluation at soft dough.

Root and crown samples from selected plants indicated that *Fusarium* and *Pythium* were present. Also symptoms from *Fusarium*, *Pythium*, and Common root rot (*Bipolaris sorokiniana*) were noted during subcrown internode examinations.

Soils were sampled at Glen Ullin, Hannover, Reeder, and Zap at the soft dough stage. Soil biological assays were conducted for *Pythium* spp. and *Fusarium* spp. *Pythium* propagule counts were 230, 890, 225, and 300 propagules per gram (ppg) of soil at Glen Ullin, Hannover, Reeder, and Zap respectively. *Fusarium* propagule counts were 1120, 1160, 1640, and 1680 ppg of soil at Glen Ullin, Hannover, Reeder, and Zap respectively. Not all *Fusarium* detected in this analysis are species pathogenic to wheat or barley, and no attempt was made to separate counts of pathogenic Fusaria from non-pathogenic specias. *Fusarium* propagule counts tended to be high where either the immediate past crop or the crop prior to the immediate past crop was a non-host crop for wheat root disease pathogens. *Fusarium* propagule counts tended to be very high when wheat or barley was the immediate past crop. *Pythium* propagule counts tended to be medium when the immediate past crop was something other than wheat but were high to very high when following wheat. Moisture may have also been a factor particularly at Hannover where growing season precipitation was greater than normal (Table 2). Soil environment has been shown to affect development and severity of root disease (Cook and Veseth, 1991).

Implications of Demonstration

Root disease ratings were consistently lower in fumigated plots than in natural soil plots with a field history of continuous wheat or continuous barley. In previous demonstrations (Ashley et. al. 1999,1998, and 1997) root disease ratings were consistently lower in fumigated plots than in natural soil plots with a field history of continuous wheat but were the same when crop rotations included crops that were poor hosts to wheat root disease. Plants with healthier root systems can extract more water from the soil and are more efficient in utilizing the moisture and nutrients absorbed in the production of grain. When a two-year break in the crop rotation utilizes non-host crops, there was no difference in root disease ratings between fumigated and natural soil plots. Soil fumigation reduces soil-borne pathogens and may modify nutrient availability in soil, both of which affects yield. Fumigation is not an economical means for wheat producers to control root disease but crop rotation can provide control of soil-borne pathogens nearly as well as fumigation. Fumigation used in this demonstration was used to measure the effectiveness of crop rotations in the control of root pathogens. In this demonstration, propagule counts for *Pythium* and *Fusarium* decreased with time between wheat crops.

Cooperating Producers

The authors wish to thank the following producers for cooperating in conducting this emonstration. These cooperators shared their time, equipment, and knowledge in making this demonstration a success. Producers are: Larry Lamborne, Amidon, ND; Gene Engref, Reeder, ND; Ron Gunsch, Zap, ND; Richard Schrado, Glen Ullin, ND; and Kelly and Murray Hintz, Hannover, ND. In addition we would like to thank Southwest Grain for use of their NIR analyzer in determining grain protein.

Links of Interest

The following links are to studies that author, Roger Ashley was involved in in the past year that may serve as good cross reference.

http://www.ag.ndsu.nodak.edu/minot/pestsum/rr0400.htm - 2000 Aventis Root Rot Seed Treatment Study Barley–Minot, ND

http://www.ag.ndsu.nodak.edu/minot/pestsum/rr0300.htm - 2000 Aventis Root Rot Seed Treatment Study Durum – Minot, ND

http://www.ag.ndsu.nodak.edu/minot/pestsum/rr0200.htm - 2000 Aventis Root Rot Seed Treatment Study Durum – Williston, ND

http://www.ag.ndsu.nodak.edu/minot/pestsum/rr0100.htm - 2000 Aventis Root Rot Seed Treatment Study Hard Red Spring Wheat–Minot, ND

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* R.O. Ashley, Area Extension Specialist/Cropping Systems, Dickinson Research Extension Center, Dickinson, ND; M.P. McMullen, Extension Plant Pathologist, NDSU, Fargo, ND; E.D. Eriksmoen, Agronomist, Hettinger Research Extension Center, Hettinger, ND; B. Schmidt, County Agent, Beulah, ND; M. Whitney, County Agent, Amidon, ND; R. Schmidt, County Agent, Cetner, ND; and W. Markegarrd, County Agent, Ft. Yates, ND.

Table 1. Cropping history[1] of selected fields in western North Dakota.

Location	1999	1998	1997	1996	1995	1994
Amidon	corn	oat	hrsw	chem-fallow	hrsw	oat
Glen Ullin	sunflower	hrsw	NA	NA	NA	NA
Hannover	hrsw	oat	NA	NA	NA	NA
Reeder	durum	durum	durum	NA	NA	NA
Zap	barley	barley	hrsw	hrsw	hrsw	hrsw

[1] hrsw = hard red spring wheat, NA = Not Available.

Table 2. Agronomic practices and water availability, 2000.

Location	Cultivar	Tillage system	Weed severity rating	Seed treatment	Estimated stored soil water[1]	Growing season precipitation[2]	Total water
					inches	inches	inches
Amidon	Parshall hrsw	conventional	none	Vitavax Extra (carboxin + imazalil + thiabendazole	4.4	7.95	12.35
Glen Ullin	Oxen hrsw	minimum	none	none	6.2	9.91	16.11

Hannover	CDC Teal hrsw	conventional	none	none	6.3	12.23	18.53
Reeder	Clare hrww	no-till	none	none	4.6	8.76	13.36
Zap	Lagacy barley	conventional	none	none	6.3	14.8[3]	21.1

1 Stored soil water estimates were made using the Brown probe.
2 Growing season precipitation provided by nearest NDAWN or National Oceanic and Atmospheric Administration location.
3 Includes growing season precipitation plus irrigation water applied.

Table 3. Yield, test weight, protein, height, head density, and total biomass of wheat at selected locations in North Dakota, 2000.

Location	Treatment	Head density	Height	Total biomass	Protein	Test weight	Yield
		no./yd^2	inches	lb/acre	%	lb/bu	bu/a
Amidon	Fumigated	373.2	28.7	5960.0	16.2	62.8	41.7
	Natural	339.6	28.6	5896.9	16.0	62.7	39.1
	Mean	356.4	28.6	5928.5	16.1	62.7	40.4
	CV%	10.0	2.6	7.5	5.5	1.0	9.9
	LSD $_{.05}$	NS	NS	NS	NS	NS	NS
Glen Ullin[1]	Fumigated	482.2	28.5	6439.8	14.9	59.2	38.1
	Natural	588.7	30.6	8954.1	13.3	58.9	62.3
	Mean	535.5	29.5	7696.9	14.1	59.1	50.2
	CV%	15.9	3.0	8.6	2.0	3.7	12.1

	LSD .05	NS	2.0	1485.1	0.6	NS	13.7
Hannover[1]	Fumigated	285.7	35.0	5934.8	17.0	55.4	24.0
	Natural	264.7	33.5	6025.0	16.5	55.1	27.3
	Mean	275.2	34.3	5979.9	16.7	55.3	25.7
	CV%	5.4	9.0	14.9	2.8	4.9	3.1
	LSD .05	NS	NS	NS	NS	NS	1.8
Reeder[2]	Fumigated	618.7	29.9	6229.3	16.6	59.4	42.8
	Natural	414.3	28.4	5499.1	15.6	58.5	31.9
	Mean	516.5	29.1	5864.2	16.1	58.9	37.3
	CV%	16.6	2.8	3.9	3.7	0.8	4.5
	LSD .05	193.4	NS	520.4	NS	NS	3.8
Zap[3]	Fumigated	1389.3	34.8	10461.6	8.5	45.7	103.3
	Natural	876.2	32.6	8265.8	8.2	41.9	78.4
	Mean	1132.7	33.7	9363.7	8.3	43.8	90.8
	CV%	2.8	3.6	7.9	2.5	4.9	1.9
	LSD .05	71.5	NS	1668.5	NS	NS	4.0

[1] Crop grown at the Reeder location was hard red winter wheat.
[2] Crop grown at the Reeder location was hard red winter wheat.
[3] Crop grown at the Zap location was irrigated barley.

Table 4. Initial root and plant evaluations at Huan stage 6-7.5 of wheat in various rotations in selected fields in North Dakota, 2000.

Location	Treatment	Development stage	Length[1]	Tillers	Subcrown rating[2]	Seminal root count	Crown root count
		Haun	inches	no./plant		no./plant	no./plant

Amidon	Fumigated	6.0	19.0	2.7	0.44	4.6	17.8
	Natural	6.0	18.6	2.8	0.72	4.3	17.0
	Mean	6.0	18.8	2.8	0.58	4.5	17.4
	CV%	4.3	5.5	14.8	25.2	8.6	16.2
	$LSD_{.05}$	NS	NS	NS	NS	NS	NS
Glen Ullin	Fumigated	7.0	18.6	1.9	0.23	3.8	18.1
	Natural	6.8	18.6	2.8	0.48	4.4	15.0
	Mean	6.9	18.6	2.3	0.35	4.1	16.6
	CV%	3.9	4.8	18.9	54.5	6.8	5.7
	$LSD_{.05}$	NS	NS	NS	NS	NS	2.1
Hannover	Fumigated	7.1	13.8	2.5	0.20	5.0	13.6
	Natural	6.8	11.5	1.9	0.97	4.4	10.5
	Mean	6.9	12.6	2.2	0.58	4.7	12.0
	CV%	1.1	10.3	11.1	40.3	8.6	10.1
	$LSD_{.05}$	0.2	NS	0.5	0.53	NS	2.8
Zap[3]	Fumigated	6.5	16.1	1.7	0.76	5.0	14.4
	Natural	6.3	14.4	1.2	0.67	4.8	12.1
	Mean	6.4	15.3	1.48	0.71	4.9	13.3
	CV%	1.6	10.5	18.6	32.4	1.4	6.1
	$LSD_{.05}$	NS	NS	NS	NS	0.1	1.8

[1] Length measured from the crown to the tip of the last fully extended leaf of the plant.

[2] Subcrown internode rating, 0-4: 0 = no infection, 1 = less than 25% of the internode infected; 2 = 25 - 50% of the internode infected; 3 = 51 - 75% of internode infected, multiple lesions; and 4 = 75 - 100% of internode infected, lesions coalesced.

[3] Crop grown at the Zap location was irrigated barley.

Table 5. Visual root scores for wheat at soft dough stage grown at selected locations in North Dakota, 2000.

Location	Treatment	Subcrown internode rating[1]	Color index[2]	Root mass[3]
Amidon	Fumigated	1.4	1.1	3.0
	Natural	1.4	1.4	2.6
	Mean	1.4	1.2	2.8
	CV%	5.4	25.0	8.6
	LSD $_{.05}$	NS	NS	NS
Glen Ullin	Fumigated	1.3	1.0	2.0
	Natural	1.6	2.5	2.6
	Mean	1.4	1.8	2.3
	CV%	24.0	39.3	15.1
	LSD $_{.05}$	NS	NS	NS
Hannover	Fumigated	1.3	1.0	2.3
	Natural	1.8	1.6	2.2
	Mean	1.5	1.3	2.3
	CV%	3.5	3.1	12.0
	LSD $_{.05}$	0.1	0.1	NS
Reeder[4]	Fumigated	1.8	1.2	2.4
	Natural	2.4	2.4	1.5
	Mean	2.1	1.6	2.0
	CV%	11.7	25.8	21.6
	LSD $_{.05}$	0.6	NS	NS
Zap[5]	Fumigated	1.5	1.2	2.7
	Natural	1.8	2.4	2.2

	Mean	1.6	1.2	2.5
	CV%	6.9	11.9	6.9
	LSD $_{.05}$	0.3	0.3	0.4

[1] Subcrown internode rating, 0 - 4: 0 = no infection; 1 = less than 25% internode infected; 2 = 25 - 50% internode infected; 3 = 51 - 75% of internode infected, multiple lesions; and 4 = 75 - 100% infected, lesions coalesced.

[2] Root color index, 1 - 4: 1 = white; 4 = dark brown to black.

[3] Root mass, 1 - 4.

[4] Crop grown at Reeder was hard red winter wheat.

[5] Crop grown at the Zap location was irrigated barley.