Crop Rotation, Prosaro Fungicide, Seed Treatment and Cultivar as Management Tools to Control Disease on Durum Wheat, Langdon, 2009

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Efforts have been initiated and funded by the U.S. Wheat and Barley Scab Initiative to communicate some of the research progress made in developing and identifying strategies that will reduce or minimize the effect on small grains from the disease Fusarium head blight (FHB) or scab. One of these efforts is reported here that compares using crop rotation, a fungicide treatment, a seed treatment and some of the different levels of cultivar resistance or tolerance to FHB. The study utilized a common regional crop rotation, durum after canola, as a comparison to a small grain rotation, durum after hard red spring wheat. The theory behind this is that the quantity of inoculum would be reduced when the previous crop was not susceptible to FHB. The second strategy researched was an application of Prosaro fungicide to minimize the effects of FHB. The third strategy researched would be the selection of a cultivar with less susceptibility to FHB. An additional strategy was also tested comparing a broad spectrum seed treatment with untreated seed.

MATERIALS AND METHODS

These studies were initiated in 2008 by planting randomized strips of hard red spring wheat and canola in six replicates on the North Dakota State University Langdon Research Extension Center. The original study plan was a randomized complete block design with a split split plot arrangement. Whole plot factor was previous crop, split plot factor was Prosaro fungicide and split split plot factor was cultivar. An additional factor was added by reducing the 6 replicates to three and adding a broad spectrum seed treatment to three of the six replicates. In 2009 four durum cultivars, Divide, Grenora, Lebsock and Monroe, were treated with seed treatment. Durum is extremely susceptible to FHB. The cultivar Divide would have slightly greater tolerance than the other cultivars. The cultivars were selected because they were planted on significant acreages of growers in North Dakota or fit a range of susceptibility to FHB. The seed treatments included BASF fungicides Charter F2 (triticonazole/metalaxyl) applied at rate of 5.4 fl oz/cwt, Stamina (pyraclostrobin) applied at rate of 0.4 fl oz/cwt and the BASF insecticide Axcess (imidicloprid) applied at a rate of 0.2 fl oz/cwt. The seed treatments were individually applied with a syringe to 2 lb lots of durum with a Hege Model 11 liquid seed treater (Wintersteiger Inc, Salt Lake City, Utah). Seed was planted at 1.5 million pure live seed per acre, determined by blotter paper germination in vitro.

The plots were seven rows wide six-inch row spacing and measured 20 feet long. An Almaco double disk drill was used to seed the plots on 18 May. Liquid fertilizer was spring applied by broadcast method. A solution of Prosaro fungicide and Induce adjuvant (Helena Chemical Co.) was applied at 6.5 fl oz /acre and 0.125%v/v at early anthesis growth stage on durum. Prosaro fungicide (421 SC 3.57 lb/gal. formulation of prothioconazole/tebuconazole, 19% +19% w/w, manufactured by Bayer CropScience), applied at Feekes growth stage 10.51, is recommended to reduce the effects of FHB in small grains. Fungicide treatments were applied with a CO_2-pressurized backpack sprayer. The boom was equipped with two Spraying Systems Co. XR8001 nozzles mounted on a double swivel. The swivels were spaced on 20-inch centers and oriented to spray 30 degrees downward from horizontal and forward and backward. The spray volume was 18.4 GPA obtained by pressurizing the boom at 40 psi. Twenty days after the fungicide application (soft dough growth stage, Feekes 11.2) 20 heads were removed and evaluated to determine FHB incidence (number of spikes infected) and severity of the infected heads(number of FHB infected kernels per head divided by total kernels). FHB index is the summation of the incidence times the severity. The plots were harvested with a Hege plot combine and the sample processed to determine yield and test weight on all crops and plump on the barley. A sub sample of the grain was ground and sent to North Dakota State University NDSU Veterinary Diagnostic lab to determine the presence of the toxin deoxynivalenol (DON). North Dakota State University Extension recommended production practices for durum wheat for Northeast North Dakota were followed. Data was analyzed with the general linear model (GLM) in SAS. Fischer's protected least significant differences (LSD) were used to compare means at the 5% probability level (Table 1).

RESULTS

Data was initially analyzed as a four factor experiment. The significant effects that included seed treatment are reported in Tables 1, 2, 3 and 4. The trial was re-analyzed as a three factor experiment with split split plot arrangement and six replicated to increase the degrees of freedom and the likelihood of measuring differences between treatments. These results are reported in Tables 1, 2, 5 and 6.

Seed Treatment. Applying seed treatment increased the established stand, Table 2. Yield was positively affected, 65 bu/ acre vs. <50 bu/ acre, when both Prosaro and seed treatment were applied regardless of cultivar or previous crop, Table 3. Fusarium head blight severity, incidence and index were affected by previous crop, fungicide and seed treatment, Table 4. Prosaro fungicide and seed treatment reduced FHB severity on canola residue. Seed treatment increased FHB severity when Prosaro was not applied on canola residue. Prosaro was effective in reducing severity on HRSW residue but the addition of seed treatment did not affect FHB severity. Prosaro fungicide reduced disease incidence on both previous crop residues. Seed treatment, in combination with Prosaro fungicide, further reduced FHB incidence on both crop residues but seed treatment alone did not affect FHB incidence. Fusarium head blight disease index was affected in the same manner as severity. Deoxynivalenol concentration (DON) was reduced by Prosaro fungicide regardless of previous crop residue. Seed treatment had no affect on DON when used on canola residue but increased DON when used on HRSW residue. Test weight was increased on canola residue by the combination of Prosaro and seed treatment over other treatments and increased over no fungicide treatments on HRSW residue. Test weight for seed treatment without Prosaro fungicide on canola residue was less than both Prosaro and seed treatment on canola residue. No differences in any treatments were measured on HRSW residue. Seed treatment increased established stand except on HRSW residue with Prosaro fungicide. Seed treatment with Prosaro fungicide increased seed weight on canola residue but decreased seed weight when no Prosaro was applied. Prosaro and seed treatment increase seed weight on HRSW residue compared to no Prosaro and seed treatment. The application of seed treatment to the seed had no measurable effect on disease levels of the sub crown internode region of the root, Table 7.

Previous Crop Residue. Prosaro fungicide only affected yield on canola residue and seed weight when Prosaro fungicide was applied to both residues, Table 5. Deoxynivalenol accumulations were affected by cultivar, Table 6. Prosaro fungicide increased yield by 19.3 bu/ acre on canola residue over the untreated. Seed weight was also increased by 4.6 grams/ 1000 on canola residue over the untreated and 2 grams/ 1000 on HRSW residue over the untreated. Deoxynivalenol concentration was greatest on canola residue on cultivar Monroe, followed by Grenora, and Divide and Lebsock, which were the same, Table 6. No differences in DON were measured by cultivars grown on previous crop residue HRSW. Previous crop residue had no measurable effect on disease levels of the sub crown internode region of the root, Table 7. Relatively large numerical differences for severity and index were recorded that would have been statistically significant at 90% level of significance, Table 8.

Prosaro Fungicide. The application of Prosaro fungicide positively affected all parameters except yield and stand decreasing FHB severity, incidence and index, DON and increasing test weight and 1000 seed weight, Table 2. Yield would have been increased at the 0.10 confidence level, Table 1. The application of Prosaro fungicide had no measurable effect on disease levels of the sub crown internode region of the root, Table 7.

Cultivar. No differences in cultivar were measured for any of the disease assessment parameters. Yield was greatest on Lebsock and Monroe, followed by Divide which was greater than Grenora, Table 2. Grenora and Monroe had the greatest test weights. Lebsock's test weight was less than Monroe but greater than Divide. Thousand seed weight was greatest on Monroe followed by Lebsock which was the same as Divide. Both were greater than Grenora. Cultivar had no measurable effect on disease levels of the sub crown internode region of the root, Table 7.

Discussion. The planting season was cool and later than previous years at Langdon. In this study there were stand reductions by replicate which have not been previously experienced by this research team. Seed treatment was generally very positive except on HRSW residue where it negatively affected some of the FHB disease parameters. Further research is warranted before recommendation to change management strategies for seed treatment on HRSW residue would be recommended. Overall the magnitude of the seed treatment was considerably different between replicates and some of this seed treatment effect could be explained by this magnitude difference which could have been affected by the established stand variation between replicates. Substantial evidence is shown that the combination of crop rotation, seed treatment and fungicide are effective management strategies. The Prosaro fungicide and previous crop canola residue was effective in increasing yield and a producers bottom line at current input and crop prices. Durum cultivar selection can have some benefit on accumulation of the toxin DON when planted into previous crop residue although differences in resistance to DON accumulation are small. From the high numbers of sub crown internodes receiving scores of four, it would appear that durum was very susceptible to root disease in 2010. Although there was not a statistical difference measured by previous crop residue, the differences between canola residue and HRSW residue were numerically quite high. An additional year of study is warranted under less intense disease pressure. A third observation was that the levels of resistance to infection of the sub crown internode among the cultivars are relatively close.

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Table 1. Source of variation for seed treatment, previous crop residue, fungicide and cultivar and confidence intervals for Fusarium head blight disease severity, incidence and index, deoxynivalenol concentration (DON), yield, test weight stand and 1000 seed weight on durum, Langdon 2009.

Source of Variation	Severity	Incidence	Index	DON	Yield	Test Weight	Stand	1000 Seed weight
Replicate (3) [z]	0.6407	0.0007	0.2382	0.2091	<0.0001	0.0005	<0.0001	0.0002
Seed treatment	0.2984	0.1708	0.0567	0.1671	0.0708	0.2401	0.0100	0.9126
Res.*Seedtrt	0.2315	0.0288	0.5628	0.0759	0.5318	0.2924	0.8855	0.2470
Fung*Seedtrt	<0.0001	0.5003	<0.0001	0.0727	0.0452	0.0184	0.1891	0.0026
Cultivar*Seedtrt	0.1515	0.5507	0.2752	0.7946	0.3885	0.5810	0.5838	0.9377
Res*Fung*Seedtrt	0.0073	0.0028	0.0016	0.0130	0.0614	0.0156	0.0394	0.0025
Replicate (6) [z]	<0.0001	<0.0001	<0.0001	0.1468	<0.0001	<0.0001	<0.0001	<0.0001
Residue	0.8328	0.1927	0.8482	0.6950	0.4966	0.1650	0.4693	0.9669
Rep*Res	<0.0001	0.0020	<0.0001	0.0058	<0.0001	0.0030	0.0148	<0.0001
Fungicide	<0.0001	0.0001	<0.0001	<0.0001	0.0679	0.0004	0.8258	<0.0001
Res*Fung	0.4586	0.3625	0.5879	0.4789	0.0224	0.0605	0.0874	0.0191
Rep*Fung(Res)	0.1901	<0.0001	0.1126	0.1545	0.0069	0.1647	0.1319	0.5631
Cultivar	0.0879	0.1085	0.1462	0.5212	0.0004	0.0003	0.0752	<0.0001
Res*Cult	0.4266	0.6793	0.3890	0.0075	0.6421	0.2727	0.3160	0.5465
Fung*Cult	0.4989	0.2148	0.1224	0.0914	0.5033	0.0771	0.5645	0.0577
Res* Fung*Cult	0.9113	0.1894	0.6191	0.0604	0.3675	0.8528	0.2693	0.8841
% C.V.	36.2	12.8	45.6	42.5	22.6	2.1	22.2	5.6

[z] Seed treatment was analyzed with ANOVA in a factorial arrangement with three replicates due to limited degrees of freedom. Seed treatment was dropped for second ANOVA analysis in split split plot arrangement with six replicates to increase the degrees of freedom for the analysis.

Table 2. Fusarium head blight severity, incidence and index, DON, yield, test weight, stand and 1000 seed weight for seed treatment averaged across previous crop residues, fungicide treatments and cultivars, residue average across fungicide treatments and cultivars, fungicide averaged across previous crop residues and cultivars, and cultivar averaged across residues and fungicide treatments on durum, Langdon 2009.

	Fusarium Head Blight							1000
Main Effects	Severity	Incidence	Index	DON	Yield	Test Weight	Stand	Seed weight
Seed Treatment	(%)	(%)		(ppm)	(bu/a)	(lb/bu)	(plt/a)	(g)
Untreated	24.0	78.9	18.1	3.0	49.3	58.8	956,505	45.0
Treated	26.4	82.0	22.7	3.4	56.7	59.1	1,106,545	44.9
LSD $_{(P=0.05)}$	NS	NS	NS	NS	NS	NS	112,928	NS
Residue								
Canola	25.8	77.1	20.9	3.1	56.1	58.5	999,309	45.0
HRSW	24.6	83.7	19.9	3.3	49.9	59.4	1,063741	44.9
LSD $_{(P=0.05)}$	NS	NS	NS	NS	NS	NS	NS	NS
Fungicide								
Untreated	33.7	93.8	30.9	4.8	48.8	58.2	1,024,870	43.3
Prosaro	16.8	67.0	9.8	1.7	57.2	59.7	1,038,180	46.6
LSD $_{(P=0.05)}$	5.0	10.0	5.4	0.8	NS	0.7	NS	1.1
Cultivar								
Divide	29.4	84.7	24.2	3.6	51.0	58.1	998,855	44.7
Grenora	24.6	78.3	19.0	3.0	44.7	59.7	1,052,700	42.9
Lebsock	23.6	78.1	18.8	3.1	58.2	58.8	1,121,670	45.3
Monroe	23.4	80.6	19.4	3.2	58.1	59.2	952,875	46.9
LSD $_{(P=0.05)}$	NS	NS	NS	NS	6.9	0.7	NS	1.5

Table 3. Fusarium head blight (FHB) incidence by previous crop residue and seed treatment averaged across fungicide treatments and cultivars and Fusarium head blight severity and index, yield, test weight and seed weight by fungicide and seed treatment averaged across cultivars on durum, Langdon 2009.

Residue	Seed treatment	FHB Incidence (%)
Canola	None	79.1
	Treated	75.2
HRSW	None	78.7
	Treated	88.7
LSD $_{(P=0.05)}$		8.8

		Fusarium head blight				
Fungicide	Seed treatment	Severity (%)	Index	Yield (bu/a)	Weight (lb/bu)	Seed Weight (g)
Prosaro	None	20.9	12.5	49.4	59.2	45.6
	Treated	12.7	7.2	65.0	60.3	47.6
None	None	27.2	23.7	49.2	58.3	44.4
	Treated	40.1	38.2	48.4	58.0	42.2
LSD $_{(P=0.05)}$		6.4	6.6	11.4	0.9	2.0

Table 4. Fusarium head blight severity, incidence and index and deoxynivalenol concentration, test weight, stand and seed weight by previous crop residue, fungicide and seed treatment on durum Langdon 2009.

			Fusarium head blight						
			Severity	Incidence	Index	DON	Test Weight	Stand	Seed Weight
Residue	Fungicide	Seed Treatment	(%)	(%)		(ppm)	(lb/bu)	(plt/a)	(g)
Canola	Prosaro	None	22.4	69.4	15.2	1.4	58.5	960,740	44.8
		Treated	10.7	53.8	4.1	1.5	60.8	1,162,810	49.9
	Untreated	None	24.1	88.8	19.9	5.0	57.8	879,670	44.4
		Treated	46.1	96.7	44.3	4.6	57.0	994,015	40.9
HRSW	Prosaro	None	19.3	63.7	9.9	2.1	59.8	1,040,600	46.5
		Treated	14.8	81.3	10.2	1.7	59.8	988,570	45.3
	Untreated	None	30.3	93.8	27.4	3.6	58.9	945,010	44.3
		Treated	34.1	96.2	32.1	5.9	58.9	1,280,785	43.6
LSD $_{(P=0.05)}$			9.1	12.4	9.4	0.8	1.3	71,494	2.9

Table 5. Yield and seed weight by residue and fungicide treatment averaged across cultivars in durum, Langdon 2009.

Residue	Fungicide	Yield (bu/a)	1000 Seed Weight (g)
Canola	Untreated	46.4	42.7
	Prosaro	65.7	47.3
HRSW	Untreated	51.2	43.9
	Prosaro	48.6	45.9

Yield LSD=23.5 for a_0b_0 vs. a_1b_0 and LSD=12.8 for a_0b_0 vs. a_0b_1.

Seed weight LSD=3.51 for a_0b_0 vs. a_1b_0 and 1.51 for a_0b_0 vs. a_0b_1.

Table 6. Deoxynivalenol concentration by previous crop residue and cultivars averaged across fungicide treatments on durum, Langdon 2009

Residue	Cultivar	DON (ppm)
Canola	Divide	2.5
	Grenora	3.2
	Lebsock	2.6
	Monroe	4.3
HRSW	Divide	3.7
	Grenora	3.3
	Lebsock	3.5
	Monroe	2.9

DON LSD=1.1 for a_0c_0 vs. a_0c_1 and LSD=1.7 for a_0c_0 vs. a_1c_0 and a_0c_0 vs. a_1c_1.

Table 7. Source of variation and confidence intervals for disease from assessment of the sub crown internode (1-4) for roots scoring one, two, three, four, severity and index on durum, Langdon 2009.

Source of Variation	One	Two	Three	Four	Severity	Index
Replicate (3) [z]	0.1278	0.1587	0.3905	0.2123	0.1459	0.1419
Seed treatment	0.4052	04428	0.4742	0.7467	0.9830	0.9657
Res*Seedtrt	0.7207	0.6893	0.5004	0.5906	0.5667	0.5534
Fung*Seedtrt	0.4992	0.3419	0.4487	0.8929	0.6557	0.6345
Cultivar*Seedtrt	0.1939	0.5386	0.5970	0.8659	0.7435	0.7614
Res*Fung*Seedtrt	0.1247	0.0642	0.9663	0.3477	0.1579	0.1493
Replicate (6) [z]	0.0131	0.0007	0.5135	0.0120	0.0009	0.0008
Residue	0.2442	0.0593	0.2069	0.1127	0.0988	0.0991
Rep*Res	0.0148	0.0002	0.0015	<0.0001	<0.0001	<0.0001
Fungicide	0.1852	0.6605	0.1697	0.4690	0.6842	0.6896
Res*Fung	0.5556	0.9444	0.2638	0.5250	0.6089	0.5915
Rep*Fung(Res)	0.9582	0.0054	0.3674	0.0246	0.0138	0.0152
Cultivar	0.6348	0.8024	0.2865	0.4148	0.5248	0.5646
Res*Cult	0.9390	0.4312	0.4346	0.3259	0.3514	0.3322
Fung*Cult	0.0835	0.6308	0.9857	0.8603	0.6870	0.7024
Res* Fung*Cult	0.2993	0.4208	0.8262	0.8627	0.6236	0.6162
% C.V.	348.3	84.6	75.7	27.6	9.2	7.9

[z] Seed treatment was analyzed with ANOVA in a factorial arrangement with three replicates. Seed treatment was dropped for second ANOVA analysis in split split plot arrangement with six replicates to increase the degrees of freedom for the parameter pools for the analysis.

Table 8. Disease from assessment of the sub crown internode (1-4) for roots scoring one, two, three, four, severity and index for seed treatment averaged across previous crop residues, fungicide treatments and cultivars; residue averaged across fungicide treatments and cultivars; fungicide averaged across previous crop residues and cultivars; and cultivar averaged across residues and fungicide treatments on durum, Langdon 2009.

	Sub Crown Internode Scores					
Main Effects	One	Two	Three	Four	Severity	Index
Seed Treatment	(Count)	(Count)	(Count)	(Count)	(%)	
Untreated	0.156	1.36	3.2	10.3	77.0	3.6
Treated	0.083	1.63	2.8	10.5	77.1	3.6
LSD $_{(P=0.05)}$	NS	NS	NS	NS	NS	NS
Residue						
Canola	0.219	2.3	3.7	8.8	72.8	3.4
HRSW	0.021	0.7	2.3	12.0	81.3	3.7
LSD $_{(P=0.05)}$	NS	NS	NS	NS	NS	NS
Fungicide						
Untreated	0.156	1.4	3.4	10.1	76.6	3.6
Prosaro	0.083	1.6	2.7	10.7	77.5	3.6
LSD $_{(P=0.05)}$	NS	NS	NS	NS	NS	NS
Cultivar						
Divide	0.208	1.4	3.4	10.0	76.2	3.5
Grenora	0.125	1.4	2.9	10.6	77.7	3.6
Lebsock	0.063	1.7	3.4	9.9	75.8	3.5
Monroe	0.083	1.5	2.3	11.1	78.5	3.6
LSD $_{(P=0.05)}$	NS	NS	NS	NS	NS	NS