Crop Rotation, Prosaro Fungicide, Seed Treatment and Cultivar as Management Tools to Control Disease on Six-Row Barley, Langdon, 2010

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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 negative effects 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 foliar fungicide treatment, a seed treatment and cultivars with different levels of resistance or tolerance to FHB. Seed treatment was added to this study with support from the North Dakota Barley Council. The study utilized a common regional crop rotation, six-row barley after canola, as a comparison to a small grain rotation, six-row barley after hard red spring wheat. The theory behind this is that the quantity of inoculum would be reduced when the previous crop was not a crop susceptible to FHB. The second strategy researched was an application of Prosaro fungicide to headed barley 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 BASF seed treatment with untreated seed.

MATERIALS AND METHODS

These studies were initiated in 2008 and 2009 by planting six randomized replicated strips of hard red spring wheat and canola on the North Dakota State University Langdon Research Extension Center. The 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. The seed treatment factor was included by reducing the six replicates to three and adding the broad spectrum BASF seed treatment to three of the six replicates and leaving the other three replicates untreated. In 2009 six six-row barley type cultivars; Excel, Legacy, ND20448 (an experimental out the North Dakota six-row barley breeding program), Quest, Robust and Tradition were treated with seed treatment. The cultivar Quest would have slightly greater tolerance to FHB, followed closely ND20448, compared to the other tested cultivars. The cultivars were selected because they were planted on significant acreages of grower's fields 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 six-row barley with a Hege Model 11 liquid seed treater (Wintersteiger Inc., Salt Lake City, Utah). Seed was planted at 1.25 million pure live seeds per acre, determined by blotter paper germination in vitro.

The planted plots were seven rows six-inch row spacing and measured 20 feet long. An Almaco double disk drill was used to seed the plots on 27 Apr. Nitrogen liquid fertilizer, 28-0-0, was spring applied by broadcast method to achieve a target yield goal of 100 bushel /acre. After the seed had emerged, the established plants in two 36 inch lengths of row were counted and an initial plant stand determined. 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 head extended growth stage (GS), Feekes 10.5, on six-row barley. Prosaro fungicide (421 SC 3.57 lb. /gal. formulation of prothioconazole/tebuconazole, 19% +19% w/w, manufactured by Bayer CropScience) 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 GS, Feekes 11.2) 20 heads were removed and evaluated to determine FHB incidence (number of spikes infected) and head severity of the infected heads (number of FHB infected kernels per head divided by total kernels). FHB index is the summation of the individual head incidence times the head severity. The plots were harvested with a Hege plot combine and the sample processed to determine yield, test weight, seed weight and plump. After the plots were harvested, 16 Aug, roots were dug from a 36-inch section of the middle row and oven dried. The sub crown internode was removed and washed. The plants and sub crowns were counted. Twenty sub crown internodes were scored for disease severity using a 1-4 scale (1 = clean, 2 = slight, 3 = moderate, and 4 = severe disease) (Vol. 53, Can. Plant Dis. Surv. Sept. 1973) and reported as an index (0-1). Plants that did not have an intact sub crown internode were assumed to be severely infected and given a score of 4. A sub sample of the grain was ground and sent to North Dakota State University Barley Quality Lab to determine the presence of the toxin deoxynivalenol (DON). North Dakota State University Extension recommended production practices for barley 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 and 2).

RESULTS

Data was initially analyzed as a four factor experiment; factorial design and three replicates. The significant effects that included the seed treatment factor are reported in Tables 1, 3, 4, 5 and 6. The seed treatment factor was removed from the data set and the trial was re-analyzed as a three factor experiment with split split plot arrangement and six replicates, original design. The data is partitioned into three data pools to increase the degrees of freedom and the likelihood of measuring statistical differences between the three remaining factors. These results are reported in Tables 2, 3 and 7.

Seed Treatment. No significant affects were measured for seed treatment for any of the main effects, yield, test weight, plump, initial stand, seed weight, Fusarium head blight, incidence, index and head severity, deoxynivalenol, root severity and harvest stand, Table 1 and 3. A significant interaction (previous crop residue*seed treatment) was measured for harvest stand, Table 4. Applying seed treatment increased harvest stand when previous crop residue was HRSW. When previous crop residue was canola application of seed treatment did not increase harvest stand. A significant interaction (seed treatment*cultivar) was measured for root severity index, Table 5. The seed treatment was effective in reducing root severity index on Quest and Robust compared to ND20448. Tradition had lower root severity index compared to Robust and Legacy when no seed treatment was applied. Tradition without seed treatment was not different from any of the cultivars treated with seed treatment. A significant interaction (previous crop residue*fungicide treatment*seed treatment) was measured for both yield and plump, Table 6. Yield was much greater regardless of fungicide treatment or seed treatment when planted on previous crop canola versus previous crop HRSW, range 110.5-117.6 versus 66.6-76.6 bu. /acre. The fungicide treatment with seed treatment on previous crop HRSW and the no fungicide treatment and no seed treatment produced less yield than the Prosaro fungicide treatment and no seed treatment. Plump on previous crop canola were not different regardless of fungicide treatment or seed treatment but were much greater than all treatments planted into previous crop residue HRSW. Among the treatments planted into previous crop HRSW, plump was not different when Prosaro fungicide was applied regardless of seed treatment but was much greater than when no fungicide treatment was applied. The seed treatment had no effect on plump when no Prosaro fungicide treatment was applied to barley planted into HRSW previous crop residue.

Previous Crop Residue. Significant effects by previous crop residue were measured for yield, test weight, plump, seed weight, Fusarium head blight index and head severity, deoxynivalenol accumulation, and root severity, Table 3. Planting barley into previous crop residue canola increased yield by 43 bu. /acre, test weight by 3.1 lbs. /bushel, plump by 14% and seed weight by 3.9 g. /1000. Fusarium head blight index, head severity and DON were negatively increased when previous crop residue was canola. Root severity index was decreased by 14.7 % when previous crop residue was canola.

Prosaro Fungicide. Applying fungicide treatment at heading had no effect on yield, initial and harvest stand, FHB incidence, index and head severity, Table 3. However, fungicide treatment increased test weight by 0.7 lb. /bushel, plump by 4.8%, test weight by 1.4 g. /1000 and reduced the level of DON accumulation by almost 55%,

Cultivar. Yield and root severity were not different among cultivars, Table 3. Test weight was greatest on Robust, less on ND20448 and Tradition and smallest on Excel, Legacy and Quest. Plump was 90.8% on ND20448, less on Robust and Tradition and much less on Legacy, Excel and Quest. Seed weight was also greatest on ND20448, equal on Robust but less on Tradition and Excel and much less on Quest and Legacy. FHB incidence was greatest on ND20448, slightly less on Tradition and 5.6% less on Legacy. FHB index and head severity followed similar patterns. Robust and Tradition FHB index and head severity were less than ND20448, about equal to Excel and not as small as Quest and Legacy. Deoxynivalenol accumulation was greatest on Excel which was not different from Robust and Legacy but much higher than Tradition and ND20448, which were both greater than Quest. The harvest stand of ND20448 was smallest at 946,220 plants /acre. All other cultivars were equal. An interaction was measured for previous crop residue*cultivar for plump, Table 7. All plumps regardless of cultivar were much less when planted into previous crop residue HRSW. Quest plump was ranked 4th smallest of six barley cultivars when planted on previous crop HRSW residue and smallest overall when planted into previous crop canola residue.

Discussion. Root severity levels were very high in this year's studies. The high levels of root disease are likely a result of sequential years of small grains in rotation prior to the initiation of this study. This inoculum overload likely had impact on the effect of seed treatment. Nevertheless, seed treatment had a small but positive effect on harvest stand when barley was planted into previous crop HRSW. The durum study data reported in separate venue had even greater overall root disease severity than two and six row barley; fewer intact sub crown internodes and a study comparing the different crops would be interesting. Root disease severity was very severe on ND20448 and was reduced by the application of seed treatment to cultivars Quest and Robust. This severity to root disease on ND20448 was conveyed by Stephen Neate, (personal communication) and was likely a factor in not releasing ND20448 by the NDSU barley breeding program despite very high overall plump and lower DON accumulation than many current grown varieties. The fact that seed treatment had negative effect on yield when fungicide treatment was applied on Canola residue is difficult to explain and further investigation is needed. A positive effect was seen with the application fungicide treatment on previous crop HRSW and seed treatment without Prosaro fungicide treatment.

The crop rotation effect was substantial in this study with major increases in agronomic traits that can have major effect on profitability. The rotation had no effect on stand but a substantial effect on root severity index levels. Different results for stand effect may be determined when the root disease intensity is less and the environment causes extended delays in spring emergence as was seen in 2009. One negative impact of crop rotation is increase in DON accumulation. This has been measured previously in other trials conducted at Langdon. The density of the canopy increases dramatically in canola residue, probably as a result of a healthier root system. The canopy modification changed the microclimate increasing the likelihood of DON accumulation. A fungicide treatment will likely increase benefit in this rotation system. Low DON levels in this study precluded that from occurring.

Fungicide application did not affect yield on barley but had positive effects on test weight and seed weight, major components that often have positive correlations with yield. Major yield effects on barley occur when foliar disease is present early and at significant levels. Neither early disease nor significant levels were present in 2010, data not shown. Plump was increased by fungicide which could be predicted. Fungicide application did not affect any FHB parameter. FHB levels for head severity were very low in 2010. Although the Prosaro treatment reduced DON, levels were very low also.

Agronomic traits test weight, plump and seed weights were different among cultivars suggesting genetic differences. The stands for ND20448 indicates that perhaps the blotter paper test that was used to calculate pure live seed and planting rate was ineffective for this line in this season. Some differences in visual FHB parameters were measured but at these levels of FHB head severity the difference may be somewhat different in repeat examination and different levels of disease severity for both FHB symptoms and DON accumulation

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Table 1. Confidence levels for six-row barley yield, test weight, plump, stand, seed weight, Fusarium head blight incidence, index and head severity and deoxynivalenol (DON), root severity index and harvest stand by source of variation, Langdon 2010.

Source of Variation	Yield	Test Weight	Plump	Stand	Seed Weight	Fusarium Head Blight: Incidence	Fusarium Head Blight: Index	Fusarium Head Blight: Head Severity	DON	Root Severity	Harvest Stand
Replicate (3) [z]	0.9589	0.7136	0.1991	0.0004	0.0871	0.2517	0.0914	0.0747	0.0040	0.0086	0.8100
Seed treatment	0.7995	0.6382	0.6441	0.7868	0.5333	0.5573	0.9032	0.9558	0.9730	0.2122	0.8507
Res*Seedtrt	0.2446	0.6797	0.8906	0.3814	0.2955	0.7267	0.8572	0.8311	0.8292	0.0895	0.0067
Fung*Seedtrt	0.4269	0.2390	0.0591	0.4865	0.2637	0.7267	0.9857	0.9873	0.9701	0.5847	0.8198
Cultivar*Seedtrt	0.8286	0.8613	0.8739	0.8007	0.9905	0.9670	0.2851	0.1856	0.5199	0.0501	0.9412
Res*Fung*Seedtrt	0.0280	0.9956	0.0282	0.1681	0.1618	0.1905	0.2632	0.4061	0.8599	0.7111	0.1768
% C.V.	13.1	2.4	6.2	13.1	5.6	3.6	22.9	20.9	59.9	6.6	22.1

[z] Seed treatment was analyzed with ANOVA in a factorial arrangement with three replicates due to limited degrees of freedom.

Table 2. Confidence levels for six-row barley yield, test weight, plump, stand, seed weight, Fusarium head blight incidence, index and head severity and deoxynivalenol (DON), root severity index and harvest stand by source of variation, Langdon 2010.

Source of Variation	Yield	Test Weight	Plump	Stand	Seed Weight	Fusarium Head Blight: Incidence	Fusarium Head Blight: Index	Fusarium Head Blight: Head Severity	DON	Root Severity	Harvest Stand
Previous Crop (WP)	<0.0001	<0.0001	<0.0001	0.6947	<0.0001	0.8540	0.0318	0.0295	0.0328	0.0002	0.5243
Rep*WP	0.0737	0.5996	0.1289	0.7792	0.5220	0.8371	0.6486	0.6607	0.0879	<0.0001	0.2631
Prosaro (SP)	0.2062	0.0388	0.0057	0.1998	0.0250	0.6191	0.3101	0.3454	<0.0001	0.6801	0.8760
WP*SP	0.9571	0.1191	0.1244	0.8733	0.7251	0.4905	0.7984	0.9198	0.4718	0.3230	0.0962
Rep*SP (WP)	0.0021	0.0167	0.0022	0.0013	0.0008	0.2147	0.0340	0.0253	0.9836	0.1996	0.3596
Cultivar (SSP)	0.0665	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0072	0.3396	0.0071
WP*SSP	0.0532	0.0916	0.0068	0.4768	0.0979	0.0975	0.0631	0.0889	0.1838	0.9943	0.4809
SP*SSP	0.8691	0.9200	0.6129	0.9579	0.9805	0.4690	0.4858	0.4757	0.8903	0.8852	0.1924
WP*SP*SSSP	0.6052	0.9938	0.9888	0.7427	0.6240	0.8627	0.8363	0.7806	0.5619	0.1283	0.6252
%C.V.	11.3	2.3	5.5	12.2	4.8	3.6	22.3	20.4	62.1	6.8	22.1

Seed treatment was dropped for the second ANOVA analysis, split split plot arrangement with six replicates, to increase the degrees of freedom for the analysis.

Table 3. Yield, test weight, plump, stand, seed weight, Fusarium head blight incidence, index and head severity and deoxynivalenol accumulation in the seed (DON), root severity and harvest stand by source of variation, previous crop, fungicide treatment, seed treatment and six-row barley cultivar, Langdon 2010.

						Fusarium Head Blight					
	Yield	Test Weight	Plump	Stand	Seed Weight	Incidence	Index	Head Severity	DON	Root Severity	Harvest Stand
Previous Crop	Bu./ a.	Lb./bu.	%	Plants/a	G./1000	%		%	Ppm	Index	Plants/a
Canola	113.2	48.0	92.3	1,124,292	38.1	98.0	10.4	10.7	0.189	0.828	1,085,773
HRSW	70.2	44.9	78.3	1,117,637	34.0	97.9	9.5	9.8	0.122	0.950	1,117,637
LSD	***	***	***	NS	***	NS	**	**	**	***	NS
Fungicide Treatment											
Prosaro	93.7	46.8	87.7	1,093,033	36.7	98.1	10.2	10.5	0.122	0.891	1,098,277
Untreated	89.6	46.1	82.9	1,148,895	35.3	97.8	9.7	10.0	0.189	0.886	1,105,133
LSD $_{(0.05)}$	NS	**	***	NS	**	NS	NS	NS	***	NS	NS
Seed Treatment											
Seed Treatment	91.9	46.5	85.5	1,131,753	36.1	98.1	10.0	10.3	0.155	0.891	1,105,537
Untreated	91.4	46.4	85.1	1,110,175	35.9	97.8	9.9	10.3	0.156	0.886	1,097,873
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cultivar											
Robust	92.4	47.7	86.0	1,208,185	36.7	99.0	10.6	10.8	0.180	0.892	1,183,380
Excel	91.8	45.9	82.9	1,089,605	36.2	98.1	9.6	9.9	0.202	0.883	1,061,170
Legacy	90.1	45.6	83.6	1,174,305	34.5	94.4	7.4	8.1	0.170	0.906	1,179,750
ND20448	88.0	47.0	90.8	948,640	37.6	100.0	12.8	12.8	0.140	0.902	946,220
Quest (M122)	90.6	45.4	81.2	1,197,295	34.6	98.3	8.5	8.8	0.099	0.877	1,082950
Tradition	97.2	47.3	87.2	1,107,755	36.4	97.9	10.8	11.2	0.143	0.874	1,156,760
LSD $_{(0.05)}$	NS	0.6	2.7	78,132	1.0	2.0	1.3	1.2	0.055	NS	139,470

Table 4. Harvest stand by previous crop residue and seed treatment averaged across all fungicide treatments and six-row barley cultivars, Langdon, 2010.

Previous Crop Residue	Seed Treatment	Harvest Stand (Plants /acre)
Canola	BASF Seed Treatment	1,033,340
	Untreated	1,138,207
HRSW	BASF Seed Treatment	1,177,733
	Untreated	1,057,540
LSD $_{(0.05)}$		36,134

Table 5. Root severity index by six-row barley cultivar and seed treatment averaged over all previous crop residues and fungicide treatments, Langdon 2010.

Seed Treatment	Cultivar	Root Severity Index (0-1)
BASF Seed Treatment	Excel	0.884
	Legacy	0.891
	ND20448	0.913
	Quest (M122)	0.859
	Robust	0.854
	Tradition	0.881
Untreated	Excel	0.881
	Legacy	0.921
	ND20448	0.892
	Quest (M122)	0.894
	Robust	0.929
	Tradition	0.867
LSD $_{(0.05)}$		0.048

Table 6. Yield and plump by previous crop residue, fungicide treatment and seed treatment averaged over all six-row barley cultivars Langdon, 2010.

Previous Crop Residue	Fungicide Treatment	Seed Treatment	Yield (bu. /acre)	Plump (%)
Canola	Prosaro	BASF Seed Treatment	117.6	94.0
		Untreated	112.9	93.1
	Untreated	BASF Seed Treatment	110.5	91.2
		Untreated	111.6	90.9
HRSW	Prosaro	BASF Seed Treatment	67.7	80.1
		Untreated	76.6	83.5
	Untreated	BASF Seed Treatment	69.8	76.7
		Untreated	66.6	72.8
LSD $_{(0.05)}$			8.0	3.5

Table 7. Percent plump by previous crop residue and six-row barley cultivar averaged over all fungicide treatments on, Langdon 2010.

Previous Crop Residue	Cultivar	Plump (%)
Canola	Excel	91.8
	Legacy	92.6
	ND20448	96.3
	Quest (M122)	85.8
	Robust	93.5
	Tradition	93.9
HRSW	Excel	74.0
	Legacy	74.6
	ND20448	85.3
	Quest (M122)	76.6
	Robust	78.5
	Tradition	80.5
LSD $_{(0.05)}$		4.4 or 5.4*

*LSD for a_0c_0 vs. a_1c_0 or a_0c_0 vs. a_2c_1 = 4.35 and $a_0b_0c_0$ vs. $a_0b_0c_2$ = 5.4