Crop Rotation, Prosaro Fungicide, Seed Treatment and Cultivar as Management Tools to Control Disease on 2-Row Barley, Langdon, 2010

Halley, S.*, Crop Protection Scientist and Arens, A., Research Technician.
Corresponding author* North Dakota State University-Langdon Research Extension Center Langdon, ND 58249. PH: (701) 256-2582, E-mail: Scott.Halley@ndsu.edu.

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 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, 2-row barley after canola, as a comparison to a small grain rotation, 2-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 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 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 a broad spectrum BASF seed treatment to three of the six replicates and leaving the other three replicates untreated. In 2009 six 2-row barley cultivars, AC-Metcalfe, Conlon, Merit, Pinnacle, Rawson and Scarlet were treated with seed treatment. The cultivar Conlon would have slightly greater tolerance to FHB than 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 2-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 wide 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. 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 on 2-row barley. 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 10.5, is recommended to reduce the effects of FHB in small grains. Fungicide treatments were applied with a CO_2-pressurzed 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 individual head incidence times the severity. The plots were harvested with a Hege plot combine and the sample processed to determine yield, test weight and plump on the barley. 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 the plants and sub crowns washed and 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. 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. Differences were measured for DON accumulation by fungicide application and seed treatment, Table 4. Deoxynivalenol accumulation was greater when no fungicide and no seed treatment were applied compare to when fungicide was applied. A difference in DON accumulation was measured for seed treatment by cultivar with greater DON on Rawson when no seed treatment was applied compared to Rawson where the BASF seed treatment was applied, Table 5. Differences were also measured for previous crop residue by fungicide application by seed treatment for seed weight, FHB incidence and index, Table 6. The seed treatment and fungicide application improved test weight much more when barley was planted on canola residue than HRSW residue. Fusarium head blight incidence was greater on canola residue when seed treatment but no fungicide was applied. Fusarium head blight index was affected differently on canola residue decreasing when fungicide application was applied and seed treatment used but increasing when fungicide was applied and seed treatment used on HRSW residue.

Previous Crop Residue. Barley yield was increased when planted into canola crop residue compared to HRSW residue by 35.7 bu. /acre Table 2. Test weight, plump and seed weight were also all increased when planted into canola crop residue by 3.3 lb./bu., 8.5% and 5 g. /1000 respectively. Initial stand was not affected by previous crop residue. Only the FHB head severity was increased slightly by planting into canola crop residue, P = 0.1. FHB incidence, index and DON were not affected by previous crop residue. Root severity index on the sub crown internode of barley was less when planted into canola residue, P = 0.1. The harvest stand, P= 0.1 was nearly 200,000 plants per acre greater where barley was planted into canola residue compared to HRSW residue. Interactions were also measured for previous crop residue by cultivar for test weight, plump, initial stand and FHB incidence, Table 7. Test weight differences were mostly a magnitude effect, being much greater on canola residue. Conlon and AC Metcalfe had the greatest benefit from planting into canola residue. Plump was much greater on AC Metcalfe followed by Rawson on canola residue compared to the other cultivars. Initial stand of the cultivar Scarlet was not affected by previous crop residue. Conlon and Rawson had lower FHB incidence on HRSW residue compared to canola residue.

Prosaro Fungicide. Yield, test weight, plump and seed weight were not affected by the application of Prosaro fungicide, Table 2. Fungicide application did reduce FHB incidence but had no effect on index and head severity. The accumulation of DON in the seed was reduced by the application of Prosaro fungicide by about one-third. Root severity was slightly greater, P = 0.1, when planted into canola residue. No differences in harvest stand were measured.

Cultivar. No differences in yield, test weight and harvest stand were measured, Table 2. Plump was greater on Rawson followed by Conlon and Pinnacle. The initial stand of Merit was the smallest. Stand of Scarlet was greater than Pinnacle and Rawson. Rawson had the greatest seed weight and AC Metcalfe and Scarlet had the smallest seed weight. Pinnacle had the lowest FHB incidence followed by Conlon and Rawson which were nearly equal. Merit was the most affected cultivar by FHB by all visual parameters. However Rawson had the greatest DON accumulation. Conlon was the most affected by root severity and Merit the least affected.

Discussion. Soil was ready for planting early in 2009 and seed emerged quickly for the early plant date. The site was in small grain rotation before 2009 for several years and the effects of the lack of rotation were quite severe when planted to barley. Seed treatment alone was not effective as a single management strategy for negating the effects of excessive levels of root disease. The small effect of seed treatment on DON levels is attributed to general overall plant health and it is suggested that further evaluations be conducted. The same conclusion can be attributed to seed weight. Fusarium head blight disease levels were moderately low in this study in 2010 and it is suggested that the seed treatment effect on FHB incidence and index may be difficult to repeat.

Only initial stand and FHB parameters were not affected by previous crop. Fusarium head blight is caused by ascospores which are quite mobile in the wind so the lack of affect is expected. Head severity was slightly elevated in canola residue which was likely caused by the visually denser canopy of the barley. Root severity was excessively severe across the trial and minimally less on canola residue. An increased harvest stand likely accounted for a portion of the increased yield. Yield and other agronomic parameters were increased as much as observed in several site years of evaluations of small grains planted into canola and HRSW residues. The differences by cultivar and previous crop residue would be expected and should weigh in annually on the cultivar selection process.

Fungicide application at heading would be expected to affect FHB parameters even when disease levels were at these moderately low levels. Percent reductions fit ranges that would be expected with single fungicide applications on two-row barley.

The severity of the root disease in this year's study negated some of the benefits of cultivar selection making the cultivar agronomic trait more equal than under lower root disease severity. Root disease reduces the capacity of the variety to transfer nutrients to the plant and negates genetic trait advantage. Genetic advantage for plump, seed weight and FHB resistance were still evident on a smaller scale for some cultivars. A reduction in root severity for Scarlet provided only small benefit and did not offset overall genetic differences among cultivars in this trial.

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

						Fusarium Head Blight					
Source of Variation	Yield	Test Weight	Plump	Stand	Seed Weight	Incidence	Index	Head Severity	DON	Root Severity	Harvest Stand
Replicate (3) [z]	0.0543	0.0475	0.3134	0.0007	0.3893	0.5740	0.0988	0.0631	0.0494	0.0099	0.4765
Seed treatment	0.2965	0.3129	0.5685	0.4453	0.3711	0.1594	0.0759	0.3091	0.7279	0.9382	0.5297
Res*Seedtrt	0.4952	0.4039	0.2184	0.8484	0.9840	0.8214	0.5504	0.3165	0.8467	0.2264	0.3825
Fung*Seedtrt	0.2799	0.7789	0.7830	0.8186	0.3611	0.4692	0.3572	0.8762	0.0071	0.5877	0.5017
Cultivar*Seedtrt	0.9990	0.9770	0.9098	0.5434	0.7301	0.8564	0.8924	0.7448	0.0225	0.3655	0.8344
Res*Fung*Seedtrt	0.2177	0.0925	0.0580	0.4840	0.0021	0.0150	0.0069	0.4564	0.0902	0.6237	0.9596
% C.V.	28.6	4.9	8.5	23.1	9.6	25.7	63.7	28.5	86.3	8.9	29.1

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

						Fusarium Head Blight					
Source of Variation	Yield	Test Weight	Plump	Stand	Seed Weight	Incidence	Index	Head Severity	DON	Root Severity	Harvest Stand
Previous Crop (WP)	0.0066	0.0061	0.0116	0.2404	0.0069	0.1285	0.2394	0.0988	0.1415	0.0999	0.0964
Rep*WP	0.0001	0.0003	0.0011	<0.0001	0.0050	0.5386	0.8550	0.6904	0.0058	0.0268	0.0015
Prosaro (SP)	0.8713	0.6070	0.5793	0.7805	0.4035	0.0281	0.2540	0.7452	0.0294	0.0678	0.1325
WP*SP	0.2993	0.2452	0.0697	0.6321	0.1147	0.0686	0.1848	0.3936	0.6314	0.6279	0.6535
Rep*SP (WP)	<0.0001	0..0006	0.0692	0.1387	0.0043	0.8763	0.2382	0.3570	0.0239	0.0003	0.0012
Cultivar (SSP)	0.1107	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0037	<0.0001	0.2216
WP*SSP	0.4067	0.0185	0.0020	0.0063	0.4367	0.0238	0.2582	0.8519	0.3129	0.3857	0.1363
SP*SSP	0.7613	0.7826	0.8173	0.8964	0.9599	0.7781	0.8514	0.6233	0.2003	0.6616	0.2559
WP*SP*SSSP	0.6846	0.4631	0.6441	0.2115	0.6353	0.6349	0.8430	0.7023	0.3351	0.4784	0.7361
%C.V.	21.7	82.3	7.0	15.6	8.2	26.4	65.6	28.2	78.9	7.4	24.1

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) by source of variation, previous crop, fungicide treatment, seed treatment and two-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.	%		%	Ppm	Index	Plants/a
Canola	101.1	49.0	93.5	1,136,674	46.2	53.5	2.7	7.8	0.212	0.88	1,244,283
HRSW	65.4	45.7	85.0	1,024,071	41.2	49.7	2.5	7.2	0.137	0.92	1,050,280
LSD	***	***	**	NS	***	NS	NS	*	NS	*	*
Fungicide Treatment											
Prosaro	82.7	47.4	89.7	1,068,261	44.1	49.5	2.4	7.5	0.131	0.91	1,112,393
Untreated	83.8	47.3	88.9	1,092,485	43.3	53.7	2.8	7.4	0.218	0.89	1,185,170
LSD	NS	NS	NS	NS	NS	**	NS	NS	**	*	NS
Seed Treatment											
Seed Treatment	81.2	47.1	88.9	1,064,401	43.4	53.2	2.8	7.7	0.170	0.90	1,164,827
Untreated	85.3	47.5	89.6	1,096,345	44.0	50.0	2.3	7.3	0.179	0.90	1,129,737
LSD	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS
Cultivar											
AC Metcalfe	74.6	46.9	82.4	1,108,856	38.5	50.6	2.1	7.4	0.160	0.91	1,097,470
Conlon	81.9	49.0	92.5	1,112,051	45.7	45.8	1.9	7.6	0.185	0.94	1,218,470
Merit	85.5	46.3	85.4	986,670	41.5	81.3	6.9	10.2	0.148	0.89	1,079,320
Pinnacle	89.5	47.1	91.5	1,058,944	45.5	35.7	1.2	6.8	0.172	0.92	1,096,260
Rawson	82.6	47.6	95.7	1,045,367	52.4	45.6	1.6	6.9	0.272	0.91	1,235,410
Scarlet	85.3	47.3	88.1	1,170,348	38.5	50.7	1.3	6.0	0.109	0.84	1,156,760
LSD	NS	NS	3.6	96,229	2.1	7.8	1.0	1.2	0.079	0.04	NS

Table 4. Deoxynivalenol accumulation in the seed by fungicide treatment and seed treatment averaged across all previous crop residues and cultivars, Langdon 2010.

Fungicide Application (Heading G.S.)	Seed Treatment	Deoxynivalenol (Ppm)
Prosaro	No seed treatment	0.10
	BASF seed treatment	0.16
No fungicide	No seed treatment	0.26
	BASF seed treatment	0.18
LSD $_{(0.05)}$		0.12

G.S. = growth stage.

Table 5. Deoxynivalenol accumulation in the seed by seed treatment and cultivar averaged across all previous crop residues and fungicide treatments, Langdon 2010.

Seed Treatment	Cultivar	Deoxynivalenol (Ppm)
No seed treatment	AC Metcalfe	0.14
	Conlon	0.18
	Merit	0.13
	Pinnacle	0.15
	Rawson	0.38
	Scarlet	0.09
BASF seed treatment	AC Metcalfe	0.18
	Conlon	0.19
	Merit	0.16
	Pinnacle	0.20
	Rawson	0.16
	Scarlet	0.13
LSD $_{(0.05)}$		0.12

Table 6. Seed weight, FHB incidence and index by previous crop residue, fungicide treatment and seed treatment averaged over all cultivars, Langdon 2010.

Previous Crop Residue	Fungicide Application (Heading G.S.)	Seed Treatment	Test Weight (lb. /bu.)	FHB Incidence (%)	Index
Canola	Prosaro	No seed treatment	46.4	51.9	2.6
		BASF seed treatment	48.7	47.5	1.9
	Untreated	No seed treatment	46.6	52.4	2.4
		BASF seed treatment	43.1	62.1	3.8
HRSW	Prosaro	No seed treatment	41.8	45.6	1.9
		BASF seed treatment	39.7	53.1	3.0
	Untreated	No seed treatment	41.1	50.3	2.3
		BASF seed treatment	42.1	50.0	2.5
LSD $_{(0.05)}$			2.8	8.8	1.1

Table 7. Test weight, plump, initial stand and Fusarium head blight (FHB) incidence averaged across all fungicide treatments by previous crops and two-row barley cultivars, Langdon 2010.

Previous Crop Residue	Cultivar	Test Weight Lb./bu.	Plump %	Stand %	FHB Incidence %
Canola	AC Metcalfe	49.5	91.6	1,167,553	45.8
	Conlon	51.1	96.5	1,172,345	52.4
	Merit	47.7	89.2	1,074,916	80.4
	Pinnacle	48.8	95.3	1,133,213	39.2
	Rawson	48.3	97.3	1,092,485	52.4
	Scarlet	48.4	91.3	1,179,532	50.6
HRSW	AC Metcalfe	44.3	73.1	1,050,159	55.4
	Conlon	46.9	88.5	1,051,756	39.2
	Merit	44.8	81.7	898,425	82.1
	Pinnacle	45.5	87.6	984,674	32.2
	Rawson	46.8	84.2	998,250	38.8
	Scarlet	46.1	85.0	1,161,164	50.8
		2.3	7.3	67,855	11.3