A “Pan-American” Approach to Durable Crown Rust Resistance

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Abstract

The main focus of our crown rust resistance discovery efforts is to reduce the likelihood of gene defeat thereby achieving greater durability of resistance. Our strategy is multifaceted and includes a “pan-American” preliminary resistance evaluation of parental candidates, with sites in Parana Argentina, Ontario Canada, Aberdeen, Idaho, and Minnesota. A combined summary of representative data over years and locations will be presented. Another focus of our efforts includes selecting materials with enough resistance to protect the crop while avoiding the materials with infection types indicative of complete or major gene resistance. In addition, we are favoring adult plant resistance over seedling reactions, especially in the evaluation of progeny from selected parental pairs. Specifically, we are collaborating with the USDA-ARS at Aberdeen, Idaho where field screening with controlled inoculation of adult plants is used to screen progeny from crosses between selected parents. Parental pair selection is based on a co-variance analysis of parental candidate reactions when exposed to isolates of crown rust collected annually in the Upper Midwestern United States. Resulting progeny families should contain segregants with the broadest genetic base of crown rust resistance and thus be less vulnerable to gene defeat thereby providing maximum durability of their resistance.

Introduction

A large number of single major crown rust resistance genes have been defeated during the time since the inheritance of such genes was first reported about 100 years ago. Since the year 2000, several important resistance genes have been defeated, most notably Pc 68, which was a major source of oat crown rust resistance, especially in much of the Canadian germplasm. In Minnesota, two releases, Starter and Premier, were earlier victims of gene defeat. Starter was quite widely grown in the late 1980s before it succumbed, but Premier never really occupied much commercial acreage even though its kernel quality was truly outstanding.

Materials and Methods

Because of our gene defeat experiences, we began, in the mid 1990s, to intentionally avoid selecting progeny which appeared to have only single major gene crown rust resistance. More recently, we have begun an approach to combine genetically different sources of resistance including genotypes with incomplete resistance. We have also begun to focus on adult plant reaction in a further effort to reduce gene defeat.

In this poster, we illustrate several segments of our current approach, beginning with a Pan-American initial screening of parental candidates. Our primary sites for such evaluation are in Ontario Canada, Parana Argentina, and Minnesota. Genotypes doing well in at least two of these locations have promise of a broad genetic base for their resistance (Table 1).

These candidates are then exposed to isolates collected the previous growing season (this approach keeps a moving target) and scored individually for each candidate-isolate reaction (Table 2). A covariance analysis is then performed with negative values for parental pairs indicating dissimilar genetic basis for resistance for the two parental candidates and positive values indicating more closely related genotypes for crown rust resistance. Some such results are given in Table 3.

In January 2008, Adolar Freitag began his M.S. research to evaluate the progeny from a series of selected crosses which has a range of covariance from –.59 to +.76 to begin testing whether families with negatively “correlated” parents produce different kinds of progeny for crown rust reaction than do positively correlated parental pairs. His research area is shown in Figure 1. In conclusion, everyone on the Wednesday PM field tour is invited to visit his plots as the concluding stop on the tour.

References

Stuthman, D.D., K.J. Leonard, J. Miller-Garvin. 2007. Breeding Crops for Durable Resistances. In: Advances in Agronomy. D.L. Sparks (ed.) Advances in Agronomy 95:319-367, invited major review.

Table 1. 2006 Fall Greenhouse Crossing Block Parents.

2005 Field and 2006 E Can Nurs		Crown Rust Reactions							
		2005 RSMT 1	2005 RSMT 2	2006 BT	2006 BT	E Can Nurs Palmerston	Bold=2007 E Can Nurs Lindsay 0-5	Bold=2007 E Can Nurs Navan 0-5	Argentina score
1	OA98Z-6/Leonard	MN02225	5 ms-s	8 ms-s	SR-S	3MS-S	2	2	3	R
2	MN98145/MN98468	MN02231	tr s-mr	5 ms-s	TMR	5MS-S	1	3	2	MR
3	Sask01T-504-02-153/MN01117	MN05145	10 ms-mr	tr mr	5MS-S	10MR-MS	3	2	0	MS
4	MN84185S/MN00206	MN05106	5 ms-mr	tr mr	3MR-S	SR-S	3	3	0	R
5	Sask01T-408-02-013/MN01117	MN05147	>20	tr mr	10MS-S	5MS-S	1	3	0	
6	Morton/IL99-912	MN05123	tr mr-r	tr r-mr	TR-MR	3MR-MS	2	2	0	
7	Sesqui/Sask01T-602-05-06	MN05222	tr r-mr	tr r-mr	10MR-S	5MS-S	3	2	1	
8	Morton/IL99-8803	MN06120	0		0	TMR-MS	2	3	0	
9	Sesqui*2/Belmeg	MN06135	tr r		TR-MR	TMR	1	2	2	
10	OA98Z-6/MN97203	MN03205	15 mr-s	5 mr-s	5 mr-s	3MR-MS	1SMS-S	1	3	1	R
11	IL99-8803/MN01135	MN05134	tr mr-ms	tr mr-r	N/A	N/A					
12	SA01511/IL95-1241	MN05155	5 mr-ms	5 r-mr	N/A	N/A					
13	Sask01T-505-01-145/Sesqui	MN05223	tr mr-r	15 ms-s	15MR-MS	5MR-MS					
14	QR179/Sesqui	04AR4134	N/A		N/A	N/A					
15	MN98133/SD/X11653	MN06101	0		3MR-S	5MS-S					
16	SD98600/ND981502	MN06107	tr mr		5MR-S	TR-MR					
17	Morton/IL99-8803	MN06120	0		0	TMR-MS	2	3	0		
18	IL95-1241/MN01117	MN06123	8 mr-r		5MR-MS	30MS-S		**5**	**4**		
19	Sask01T-602-05-06/MN01117	MN06130	5 ms-s		3MR-MS	5MR-S					
20	SA01511/IL95-1241	MN06131	tr ms-s		10MR-S	5MR-S					
21	Armagdon/Ogle/Joe/Shabasha	MN06147	tr mr		TR-MS	TMR		**4**	**2**		
22	Sask01T-602-05-06/Wabasha	MN05236	tr mr-r	15 ms-mr	20MR-S	5MS-S	2	3	0		
23	ND98150/SD/X12500	MN06206	tr r		3RM-R	TR-MR		**5**	**1**		
24	SD98600/ND981502	MN06207	tr mr-ms		5RM-R	5M-R		**5**	**1**		
25	S09915/CI/1082	MN06208	tr r		5MR-S	5RM-S					
26	Sesqui/W9757/1-1	MN06210	tr ms-mr		10MR-MS	15MR-S		**5**	**1**		
27	Sesqui/LA97BGB-22	MN06211	tr mr		0-W	W					
28	Morton/IL99-8803	MN06213	0		TM-RS	0					
29	MN01139/LA97BGB-22	MN06219	tr mr		TS-W	0-W					
30	W/X7571-1/Wabasha	MN06220	tr ms-s		15MR-S	20MR-MS		5	3		
31	IL99-3903/Sask01T-608-02-02-3	MN06231	18 ms-mr		10MR-MS	10MR-MS		**3**	**2**		
32	SA01508/IL99-8803	MN06232	tr mr-ms		3MS-S	5MS-S		**4**	**3**		
33	Morton/IL99-3903	MN06234	tr ms		3MS-S	10MR-S		**3**	**1**		
34	Sask01T-504-06-244/Wabasha	MN06241	tr ms-mr		5MS-S	TR-MS					
35	NO191-1/MN/00206	MN06243	0		5MR-S	5MR-MS		5	2		
36	MN84185S / MN00227	MN06246	tr ms-mr		10RM-S	10R-S					
37	ND9508252-9	HiFi Reselect	N/A		3MS-S	5MR-MS					
38	MN01117/IL99-912	MN05131	5 mr-ms	5 mr-r	30MR	20MR-MS	4	3	0		
39	Sask01T-505-01-145/IL99-912	MN05237	tr r-mr	tr ms-mr	5RM-R	20MR-S	1	3	3		
40	ND98150/SD/X12500	MN06106	tr r		TR-MR	10RM-R	1	4	3		

Rosemount = Rosemount, MN, planted next to wild buckthorn bushes; E Can Nursery = 3 locations in Ontario, Canada; BT = MN Buckthorn plot at St. Paul, MN; AR = Parana, Argentina

Table 2. Covariance matrix of rust reactions of parental candidates and CR isolates collected in Upper Midwest in summer 2005.

Isolate	1 04AR4134	2 MN06101	3 MN06107	4 MN06120	5 MN06123	6 MN06130	7 MN06131	8 MN06147	9 MN05236	10 MN06206	11 MN06207	12 MN06208	13 MN06210	14 MN06211	15 MN06213	16 MN06219	17 MN06220
05MN2Bulk	1 S	R	HR	HR	HR	2S,HR	HR	MS	HR	HR	HR	R	1S,HR	HR	HR	HR	HR
	2 2S,R	HR	HR	HR	S	HR	HR	MS	1S,HR	MS	1S,R	3S,HR	MR	HR	HR	HR	R
	3 R	HR	HR	HR	S	HR	HR	S	2S,HR	R	HR	HR	R	HR	HR	HR	R
	4 S	HR	HR	HR	R	HR	HR	MS	HR	HR	HR	HR	HR	HR	HR	HR	HR
	5 4S,R	HR	HR	HR	S	1S,R	HR	MS	HR	R	R	R	R	HR	HR	HR	R
	6 1MR,R	HR	HR	HR	HR	HR	HR	R	HR	HR	HR	HR	HR	HR	HR	HR	HR
	7 S	HR	HR	HR	S	HR	HR	MS	2S,HR	MR	HR	R	S	MS	HR	HR	S
	8 R	HR	HR	HR	HR	HR	HR	MR	2S,HR	HR	1S,HR	1S,HR	1S,R	HR	HR	HR	HR
	9 2MS,R	HR	HR	HR	HR	HR	HR	MR	HR	HR	HR	HR	R	HR	HR	HR	HR
	10 MS	MS	HR	HR	S	HR	HR	MS	S	R	S	S	MS	HR	HR	HR	R
	11 S	HR	HR	HR	MS	HR	HR	R	HR	HR	HR	HR	R	HR	HR	HR	R
	12 S	HR	HR	HR	MS	HR	HR	MR	HR	HR	HR	HR	R	HR	HR	HR	HR
	13 MS	HR	HR	HR	MS	HR	HR	MS	3SMHR	R	HR	3S,HR	HR	HR	HR	HR	R
	14 MS	HR	HR	HR	MS	HR	HR	R	1S,HR	HR	HR	HR	MR	HR	HR	HR	HR
	16 S	R	HR	HR	R	HR	HR	MR	HR	R	HR	HR	R	HR	HR	HR	R
	17 HR	HR	HR	HR	S	HR	HR	MS	2S,HR	MR	HR	HR	R	HR	HR	HR	R
	18 S	HR	HR	HR	HR	HR	1S,HR	MS	HR	HR	HR	HR	R	HR	HR	HR	HR
	19 2S,HR	HR	HR	HR	HR	HR	HR	MR	HR	HR	HR	R	HR	HR	HR	HR	HR
	20 MR	HR	R	HR	MR	2MR,HR	HR	MR	3S,R	MR	HR	R	R	HR	HR	HR	R
	21 MS	HR	HR	HR	HR	HR	HR	MR	2S,HR	HR	MR	R	HR	HR	HR	HR	HR
	22 R	HR	HR	HR	MR	HR	HR	MS	HR	HR	HR	HR	R	HR	HR	HR	HR
	23 S	HR	HR	HR	MR	HR	HR	R	3S,HR	R	1MR,HR	HR	MR	1S,HR	HR	HR	HR
	24 R	HR	HR	HR	HR	HR	HR	MR	HR	HR	HR	HR	R	HR	HR	HR	HR
	25 MS	R	HR	HR	S	HR	HR	S	2S,HR	R	HR	HR	R	HR	HR	HR	R
	26 1S,R	MS	HR	HR	MS	HR	HR	MR	MS	R	HR	R	MR	HR	HR	HR	R
	27 R	R	HR	HR	MS	HR	HR	MR	3S,HR	R	HR	HR	MS	HR	HR	HR	MR
	28 MR	R	1S,HR	HR	MR	MR	HR	R	MS	3S,R	HR	R	R	HR	HR	HR	HR
	29 R	HR	HR	HR	MS	HR	HR	MS	3S,HR	MR	HR	HR	R	HR	HR	HR	R
	30 R	HR	HR	HR	MR	HR	HR	MS	5S,HR	HR	HR	R	HR	HR	HR	HR	HR
	31 R	HR	HR	HR	R	HR	HR	R	4MR,HR	HR	HR	HR	HR	HR	HR	HR	HR
	32 4S,R	HR	HR	HR	2MS,HR	HR	HR	R	R	HR	R	R	R	HR	HR	HR	HR
	33 R	HR	HR	1S, HR	HR	HR	HR	R	HR	HR	HR	HR	HR	HR	HR	HR	HR
	34 R	HR	HR	HR	HR	HR	HR	MS	R	HR	HR	R	HR	HR	HR	HR	HR
	36 HR	HR	HR	HR	HR	HR	HR	R	HR	HR	HR	HR	HR	HR	HR	HR	HR
	37 3S,HR	HR	HR	HR	HR	HR	HR	R	3S,HR	R	HR	HR	HR	HR	R	HR	HR
	38 R	HR	HR	HR	HR	HR	HR	R	2MR,HR	HR	HR	HR	R	HR	HR	HR	HR
	39 R	HR	HR	HR	1S,HR	HR	HR	MR	3S,HR	HR	HR	HR	HR	HR	HR	HR	HR
	41 3S,HR	HR	HR	HR	HR	HR	HR	R	HR	HR	HR	R	R	HR	HR	HR	HR
	42 R	1S,HR	HR	HR	R	HR	HR	R	R	HR	HR	HR	R	HR	HR	HR	R
	43 MS	HR	HR	HR	MS	HR	HR	MS	3S,HR	HR	HR	HR	HR	HR	HR	HR	HR
	45 3S,R	1S,HR	HR	HR	MR	HR	HR	R	1S,HR	HR	R	R	R	HR	HR	HR	R
	46 MR	R	HR	HR	MS	HR	1S,HR	MR	HR	R	HR	HR	MR	HR	HR	HR	R
	47 R	HR	HR	HR	HR	2S,HR	1S,HR	R	2S,HR	HR	HR	HR	HR	HR	HR	HR	HR
	48 S	HR	MR	HR	S	HR	HR	MR	S	MR	MR	MR	MS	1S,HR	HR	HR	MS
	49 R	HR	HR	HR	MS	HR	HR	MS	3S,HR	MS	HR	HR	R	R	HR	HR	R

Rows are isolates; columns are parental candidates; reaction types are converted to numerical scores: HR = 5, R = 3, MR = 1, MS = -1; S = -3

Figure 1. Field layout of Freitag thesis.

Table 3. Abbreviated listing of ranking of covariance values for rust reactions of parental-isolate matrix; neg. values indicate parents that are dissimilar and pos. values indicate parents that are similar for rust resistance.

JL RK	Neg CoVar	Cross	Cross (# 2)	Ped	2007 Ab CR F-1 Score	SR Par 1	SR Par 2	07 F-2	F-3 #P in NZ	Adolar Pop #
1	-1.6284	10-2a x 14-1b	10-11b x 14-10b	MN03205/04AR4134	SR	5		6		
2	-1.244	10-3b x 18-2a		MN03205/MN06123	0	5	4	3		
4	-1.096	18-10a x 4-8a		MN06123/MN05106	10R	4	3	1		
5	-1.0944	5-2a x 26-3a		MN05147/MN06210	0		3	1	17	
6	-1.0648	2-3a x 14-2a		MN02231/04AR4134	0	3		1		
7	-0.9856	1-2b x 14-5a		MN02225/04AR4134	0			1		
10	-0.848	4-3a x 30-2a		MN05106/MN06220	2R	3		3		
11	-0.8616	23-2a x 4-2b		MN06206/MN05106	0		3	2		
12	-0.7632	23-12b x 5-7a		MN06206/MN05147	0			2	19	
14	-0.7392	1-3b x 26-1b		MN02225/MN06210	0		3	3		
15	-0.6848	26-2b x 2-3a	3-1b x 26-3b	MN06210/MN05145	MSSING	3		5		
16	-0.656	30-4a x 5-1a	30-7b x 5-6a	MN06220/MN05147	SR		4	25		
18	-0.6224	21-8b x 10-1b		MN06147/MN03205	2R		5	2		
19	-0.6144	3-2b x 23-3a		MN05145/MN06206	10R			2		
21	-0.5864	23-6b x 10-1a		MN06206/MN03205	10R		5	2	9	12
23	-0.5824	37-6b x 4-6a		HiFi Reselect/MN05106	5MR	2	3	3		
24	-0.552	10-10a x 30-4b		MN03205/MN06220	15R	5		3		
25	-0.5488	10-9a x 26-4b	10-12a x 26-8b	MN03205/MN06210	0	5	3	5	32	11
28	-0.4736	26-1a x 2-3a	26-4a x 2-6a	MN06210/MN02231	5R	3	3	3		
29	-0.448	6-11b x 4-8b		MN05123/MN05106	5R	3		1		
30	-0.4352	39-6a x 23-3b	23-7a x 39-7a	MN05237/MN06206	0	3		3	38	7
31	-0.432	3-11b x 30-7b	3-12b x 30-11a	MN05145/MN06220	5MR			6		
32	-0.4256	21-5a x 4-1a		MN06147/MN05106	0		3	2		
40	-0.3584	39-4b x 26-5a		MN02537/MN06210	0	3	3	1	13	
43	-0.3224	10-3a x 22-2a		MN03205/MN05236	15MR	5		2		
47	-0.3136	15-9a x 1-1a		MN05106/MN02225	25R	2		1		
51	-0.304	3-4b x 18-4a		MN05145/MN06123	SR	4		3		
57	-0.2816	3-2b x 37-1a		MN05145/HiFi Reselect	5MR			2		
59	-0.2752	10-5b x 33-4b		MN03205/MN06234	0	5		1		
64	-0.264	9-5b x 4-1a		MN06135/MN05106	0	4	3	2		
65	-0.264	22-2b x 9-8a	9-12a x 22-7a	MN05236/MN06135	20R		4	5	38.59	8.1
69	-0.2528	2-12b x 21-12b		MN02231/MN06147	MSSING	3		3		
70	-0.248	30-6a x 1-2a		MN06220/MN02225	0			3		
73	-0.236	1-9a x 18-12a		MN02225/MN06123	5R		4	3		
88	-0.196	9-3b x 10-2a		MN05135/MN03205	15R	4	5	3		
93	-0.1792	3-7a x 33-9b		MN05145/MN06234	5R			2		
100	-0.1632	22-6b x 16-4a	22-7a x 16-9a	MN05236/MN06107	0		5	5	61.48	4.6
116	-0.1344	4-8b x 16-9a		MN05106/MN06107	0	3	5	2		
134	-0.1088	2-6b x 15-8b		MN02231/MN06135	2MR	3	3	2		
141	-0.096	3-10b x 9-12a		MN05145/MN06135	0		4	3		
147	-0.0912	38-3b x 31-1b	31-10b x 38-10a	MN05131/MN06231	0	3	3	5	35.40	10.8
150	-0.0896	16-7b x 3-4a		MN06107/MN05145	MSSING	5		2		
161	-0.0784	25-3b x 4-5a		MN06206/MN05106	0			2		
170	-0.0704	35-7a x 37-7b		MN06243/HiFi Reselect	5MR		2	1	11	3.9
192	-0.064	14-4a x 3-2b		04AR4134/MN05145	15MR-R			1	22	7.7
198	-0.0536	24-6a x 1-1a		MN06207/MN02225				1		
297	0.232	2-3b x 18-2a		MN02231/MN06123	0	3	4	2		
307	0.4128	4-1a x 26-4b		MN05106/MN06131	0	3	7	3		
311	0.5304	22-6a x 14-3b	22-1b x 14-4b	MN05236/04AR4134	15R			6	56.49	7.9
312	0.7532	36-8b x 2-7a		MN06246/MN02231	30R		3	2		
313	0.8704	36-8a x 4-8a		MN06246/MN05106	25R		3	2		

[1]2007 Ab rust reaction on remnant F_1 plants grown in Aberdeen, ID, inoculated in field as adult plants
[2]Stem rust reaction of parents taken in April 2007 in Baton Rouge, LA
[3]Populations sent to NZ for off-season increase (those not included in thesis because of bad stem rust in NZ)
[4]Populations included in Freitag thesis boxed