Project FY22-SP-006: Determining FHB Susceptibility in Wheat Cultivars in the Western US

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1. What are the major goals and objectives of the research project?

FHB damage in spring grain continues to increase in southern and eastern Idaho. Several years in a row, fields of spring wheat showed signs of the disease, and many spring wheat fields tested at >5 ppm DON, even after appropriate treatments with fungicides. Growers now regularly incorporate fungicide treatments for FHB suppression as standard practices for susceptible varieties, especially for hard white spring wheats, one of the two very susceptible classes (hard white spring and durum). The majority of the wheat varieties that are available to growers in the area are susceptible to FHB. Growers need information on FHB susceptibility of the varieties that currently are being grown and those newly released. Breeders need information on advanced lines and breeding material to release selections with reduced vulnerability to FHB damage and DON accumulation. Management practices need to be tested under the unique conditions in the irrigated production regions of the Intermountain West to develop appropriate management practices to reduce FHB and DON in susceptible cultivars. Project goals: Our specific objectives for this proposal were to: 1) determine the degree of susceptibility that exists in currently grown varieties and advanced lines to local *Fusarium graminearum* isolates, 2) provide DON data to local breeders and growers to increase the ability to select the best varieties for breeding and production. Awareness of variety reaction to FHB determines need for potential fungicide applications. Specific objectives - The specific objectives were to screen currently grown varieties to determine degree of susceptibility and assess risk of DON under intermountain west irrigated production conditions, and to select for increased resistance in breeding lines of wheat and barley to improve FHB resistance and reduce DON in newly released varieties.

2. What was accomplished under these goals or objectives? *(For each major goal/objective, address these three items below.)*

What were the major activities?

An assessment of released wheat cultivars and advanced lines from entries in the University of Idaho Extension Variety trials was conducted in on-station FHB nurseries at the Aberdeen Research and Extension Center. A second location at the USDA-ARS research facility at Kimberly, Idaho was added to add winter wheat testing, increase the number of environments and to include an environment more conducive to infection. Additional breeder material from Montana State University and a private breeding company (a division of Nutrien Ag) were included for testing. Winter wheat classes of soft white winter, hard white winter, and hard red winter where tested in Kimberly in conjunction with the USDA-ARS sites in Aberdeen and Kimberly. Spring wheat classes of soft white, hard white and hard red spring wheat were tested of existing varieties and advanced cultivars. Resistant and susceptible checks were: (for spring wheat) Jefferson hard red spring (susceptible check), and Rollag hard red spring (resistant check). Experimental units consisted of two-row plots with two replications using a randomized complete block design. Plots were 5-foot-long rows planted with a Hege 1000 headrow planter. Special irrigation systems were designed and installed to provide an environment conducive for FHB infection while simultaneously meeting the irrigation needs of the crop.

Autoclaved corn was inoculated with *F. graminearum* and allowed to grow for three weeks before drying. Corn spawn was spread in the field approximately three weeks prior to anthesis of the earliest lines at 60 grams per plot. During and after anthesis, plots were irrigated every other day for two hours. An irrigation system with sprinkler nozzles every 20 feet is used both for irrigation and increasing humidity in the plant canopy. A misting system provided additional moisture to increase likelihood of infection every day Monday through Sunday (run intermittently for 5 hours in the evening 5pm-10pm and three hours in the morning 6am-9am).

FHB was assessed in each plot at about soft dough (Feekes 11.2). Scab readings were done 21 days after flowering (24 days post-heading). Thirty spikes per plot were rated for percent disease severity. Percent incidence was determined by calculating the proportion of infected and the total number of assessed heads. FHB index is calculated using the formula: FHB Index = (% severity x % incidence) /100. On-site weather stations were used to collect temperature and humidity data. Plots were harvested using Wintersteiger Classic small plot combine and weighed for yield and test weight. Harvested samples were assessed for VSK prior to testing for DON. Samples were ground and submitted to the USWBSI-funded DON testing laboratories in St. Paul, MN for DON analysis.

What were the significant results?

Good disease formed in the winter and spring nurseries. DON levels were also obtained with the collaboration of Dr. Yanhong Dong, University of Minnesota. Consistent levels of disease have been achieved for several years.

In spring wheat for the hard red and white group, LCS Ascent, HRS3419 and Rollag had the lowest FHB Index at 8.2, 10.3, and 13.2, and 1.6, 3.7 and 3.2 ppm DON (Table 1), respectively. DON levels ranged from a low of 1.5 ppm to 16.6 ppm in the hard red spring wheat WB8148 (durum). In the soft white spring wheat, the most susceptible lines was the club wheat Roger, and the most resistant was Seahawk (Table 2). Rollag and Seahawk had the lowest FHB Index at 13.2 and 16.5, with 1.6 and 4.9 ppm DON (Table 2), respectively. DON levels ranged from a low of 4.9 ppm (Seahawk) to 18.4 ppm in the hard red spring wheat WB8148 (durum).

Winter wheat and winter barley was not planted in Aberdeen due to cooler conditions at heading that generally result in poor infection. At Kimberly, DON varied from not detected to 6.9 ppm (NuMont). WB4401 and Keldin had low DON and the lowest FHB Indexes were from WB4510CLP (0.6) and HSG108 (0.8). Of the soft white winter, advanced lines UIL17-995133B and WA8404 had the lowest FHB Indices, with LCS Blackjack, Otto, and Piranha CL+ not significantly different from the lowest lines. AP Olympia, PiranhaCL+, Perrine (WA8415) had the lowest DON, and Stephens and Norwest Tandem had the highest.

Most winter wheat varieties are highly susceptible, resulting in high levels of deoxynivalenol (DON) when diseased. A five-year (2020-2024) screening summary from the trials conducted at Kimberly, Idaho was presented at the USWBSI meeting in 2024. Widely grown varieties and advanced lines of soft white winter (SWW) and hard winter wheat (HWW) from public and private breeding programs were tested in two-row, 5-foot plots with two replications in a randomized complete block design. Plots were planted with a Hege 1000 head row planter. Secondary mist irrigation systems fostered conditions for FHB infection, with corn spawn applied at 30 g/m² three weeks before anthesis. FHB incidence, severity, and index were assessed at the soft dough (Feekes 11.2). FDK and DON concentrations were measured from harvested samples. Data were analyzed using PROC GLM in SAS 9.4, with LSD ($\alpha = 0.05$) for mean comparisons. Disease pressure varied across years, with no varieties showing resistance to FHB. After multiple years of testing, four cultivars 'WB4510CLP' and 'WB4623CLP' (Hard

Winter Wheat or Hww) and 'Sockeye CL+' and 'Perrine' (Soft White Winter or SWW) showed moderate susceptibility. Overall, 82.7% of cultivars were rated as susceptible (S) or very susceptible (VS). In HWW, FHB index ranged from 5.1 in Brundage (check) to 54.7 in UI Bronze Jade, with DON content from 4.4 ppm in WB4510CLP to 58.7 ppm in MT1642. In SWW, FHB index values ranged from 11.2 in ORI2190025CL+ to 58.0 in WA8334, while DON levels across entries varied from 5.1 to 56.1 ppm. Eighteen entries in multi-year trials exhibited varied reactions (MS to VS), with mixed reactions observed in approximately 24.3% of cases. 70 entries were evaluated only in a single year, with 36 rated S or VS. In 2024, DON and FDK data for the other 34 single-year entries are pending. A weighted equation that includes DON, Incidence, Severity and FDK was developed (DISK value) as [(0.3 * DON) + (0.2 * Incidence) + (0.2 * Severity) + (0.3 * FDK)] for assessing FHB reaction. Significant positive correlations were observed between FHB index and DISK in both HWW ($r = 0.733$) and SWW ($r = 0.798$), with $p < 0.0001$. This study offers insights for selecting less susceptible winter varieties to reduce DON contamination in grain and to serve as a source for increasing levels of resistance in the winter grain (see Tables 3 and 4).

List key outcomes or other achievements.

The results of the previous FHB experiments and this study was/will be presented numerous times at the local, national and international level. Consultants and breeding companies in the area have used this data to improve variety recommendations, and growers now regularly spray to reduce FHB and DON in susceptible and moderately susceptible spring wheat cultivars. Growers are now aware of the varieties that are less likely to get FHB and suffer high DON, and to spray those varieties they know are vulnerable, especially when following corn in their crop rotations.

3. What opportunities for training and professional development has the project provided? New staff have joined the Cereals breeding program and have been trained in assessment of FHB disease.

4. How have the results been disseminated to communities of interest?

The results of all the trials are published in our Annual Small Grains Report, disseminated to collaborating breeders, presented at various grower seminar and field events, and reported annually at the Scab Forum and in the biennual Scabinar.

5. What do you plan to do during the next reporting period to accomplish the goals and objectives? There are no proposed changes in the 2025 experiments to continue the trials.

Table 1. Hard Spring Wheat Summary sorted by FHB Index over two locations, Kimberly and Aberdeen.

		Severity	Incidence	Index	FDK	DON
Variety/Line	Class	Estimate	Estimate	Estimate	Estimate	Estimate
LCS Ascent	hrs	16.3	43.3	8.2	7.5	1.6
HRS3419	hrs	19.9	56.9	10.3	8.2	3.7
Rollag	hrs	24.3	55.3	13.2	8.1	3.2
CP3055	hrs	21.0	52.5	10.6	10.4	5.7
LCS Buster	hrs	24.8	51.3	11.9	6.2	3.0
CP3201AX	hrs	28.0	56.3	12.1	17.4	7.6
HRS3419	hrs	22.8	55.8	12.2	8.1	3.4
CP3119A	hrs	19.2	73.8	14.3	15.2	14.0

Choteau	hrs	26.4	58.8	14.5	11.0	7.2
Duclair	hrs	26.2	55.0	15.2	6.1	3.9
LCS Boom	hrs	28.5	55.0	15.3	8.2	1.5
LCS Hammer AX	hrs	31.8	63.8	15.7	12.6	3.9
WB9724CLP	hrs	26.7	65.0	16.6	11.1	5.0
Rocker	hrs	22.4	75.0	17.3	13.9	8.5
MT Ubet	hrs	23.9	73.8	17.9	7.2	5.1
CP3322	hrs	26.4	66.3	18.2	12.7	10.3
Dayn (W)	hws	29.8	60.0	18.6	10.4	4.4
WA8393	hrs	29.9	65.0	18.7	13.8	5.7
Expresso	hrs	34.9	60.0	19.3	21.0	16.6
WA8407	hrs	31.3	70.0	19.5	16.8	8.2
Jefferson HF	hrs	34.3	60.0	19.9	11.6	4.0
WB7313 (W)	hws	28.1	80.0	21.3	7.0	5.3
Holmes	hrs	40.5	48.3	22.3	20.1	9.2
Glee	hrs	29.3	76.3	22.6	8.8	4.9
MT Carlson	hrs	33.8	66.3	22.7	12.2	8.8
IDO2202CL2	hrs	41.0	57.5	23.4	7.0	2.5
WB9749	hrs	38.2	66.3	24.5	12.7	3.9
WB9879CLP	hrs	37.3	67.5	25.1	11.1	5.5
WA8406	hrs	31.9	78.8	25.7	10.9	5.3
Dagmar	hrs	33.4	77.5	26.3	8.4	5.4
WB9929	hrs	30.4	86.3	26.7	22.9	13.5
Hale	hrs	32.9	81.3	26.8	15.2	10.6
SY-Teton (W)	hws	31.1	86.3	27.2	20.7	15.6
UI Gold (W)	hws	37.6	73.8	27.7	18.6	9.8
WB8148	hrs	45.4	68.8	28.2	21.2	17.6
Alum	hrs	31.6	85.0	28.6	21.9	9.7
WB7747	hws	36.2	78.8	29.0	12.4	6.9
WB7589 (W)	hws	42.6	72.5	30.5	20.0	14.8
WB7202CLP (W)	hws	48.9	66.3	30.9	13.1	12.3
IDO2105S	hrs	39.4	81.3	32.6	15.1	6.6
MT21074	hrs	43.2	66.3	32.8	28.5	16.6
UI Platinum (W)	hws	40.2	81.3	33.5	10.2	7.9
Alzada	hrs	46.9	71.3	33.5	23.3	16.2
IDO2104HF (W)	hws	39.3	90.0	35.3	16.9	16.5
BZ920-142W	hws	46.8	71.3	35.4	11.7	9.7
WB7696 (W)	hws	47.9	73.8	35.5	8.5	6.9
WB9668	hrs	46.5	81.3	38.9	18.2	7.0
WB9707	hrs	54.4	76.3	43.6	14.8	6.5
BZ920-136	hrs	58.5	83.8	49.5	21.7	10.0
P=0.05			**<0.0001**	**0.01**	**<0.0001**	**<0.0001**

Table 2. Soft White Spring Wheat Summary sorted by FHB Index over two locations, Kimberly and Aberdeen.

Variety/Line	Class	Severity Estimate	Incidence Estimate	Index Estimate	FDK Estimate	DON Estimate
Rollag	hrs	24.3	55.3	13.2	8.1	3.2
Seahawk	sws	31.9	58.8	16.5	6.8	4.9
UI Cookie	sws	31.0	61.3	18.5	10.7	6.8
WB6430	sws	37.3	57.5	21.1	12.9	7.7
Tekoa	sws	25.1	83.8	21.6	11.2	8.0
WA8384	sws	36.4	63.8	22.1	8.6	7.1
Alturas	sws	37.7	63.8	23.3	13.1	4.1
Butch CL+	sws	34.9	67.5	23.8	13.4	7.9
Melba (club)	sws	43.0	67.5	25.1	15.0	18.4
WA8327	sws	38.5	73.8	27.4	13.2	10.1
IDO1902S	sws	39.0	71.3	28.5	13.5	8.3
UI Stone	sws	36.3	88.8	32.6	6.0	6.6
Louise	sws	40.5	83.8	34.2	15.7	12.2
WB6211CLP	sws	55.8	66.3	36.1	22.9	17.1
Ryan	sws	54.1	78.8	42.5	9.7	8.4
Roger	sws	52.1	77.5	42.6	20.2	13.0
P=0.05			**<0.0001**	**0.01**	**<0.0001**	**<0.0001**

Table 3. Average FHB reaction, incidence, severity, index, and FDK and DON of Hard Winter Wheat genotypes from multiple years (2020-24) data in southeast Idaho.

Variety/Line	Rating	INC (%)		Sev (%)		IND		FDK(%)		DON		DISK
IDO1806 (W)	VS	79	ab	66	ab	53.0	ab	54.5	b-d	48.8	ab	59.9
WA8309	VS	73	a-e	61	a-d	45.7	a-e	60.4	ab	49.6	ab	59.9
WB4792	VS	77	abc	63	abc	49.3	abc	48.5	b-f	46.0	b-c	56.1
UI Bronze Jade (W)	VS	76	abc	67	a	54.7	a	44.6	b-h	45.8	b-c	55.8
MT1642	VS	49	i-l	49	a-h	26.3	g-m	56.0	bc	58.7	a	53.9
OR2150168H (W)	VS	61	c-k	58	a-e	37.9	b-j	50.5	b-e	34.5	ed	49.3
LCS Rocket	VS	73	a-e	59	a-e	45.9	a-e	41.8	c-i	26.5	d-i	46.8
Yellowstone	VS	56	f-l	62	abc	34.6	c-k	39.3	d-j	33.0	d-f	45.3
Flathead	VS	76	abc	60	a-e	44.6	a-e	33.4	f-m	24.4	e-j	44.5
IDO1906 (W)	VS	71	a-g	63	abc	45.0	a-e	35.5	e-l	22.0	g-k	44.0
OR2160065H (W)	VS	51	h-l	41	b-h	22.8	j-m	54.0	b-d	28.9	d-g	43.2
Scorpio	VS	55	f-l	43	a-h	28.5	f-m	46.1	b-g	27.7	d-h	41.8
MT1745	VS	54	g-l	58	a-e	33.8	c-k	37.5	e-k	26.5	d-i	41.7
Irv (W)	VS	59	d-k	54	a-f	36.7	c-k	32.1	g-m	23.7	f-j	39.2
FourOsix	VS	61	c-k	61	a-d	35.1	c-k	24.7	j-p	18.9	g-l	37.5
UI Silver	VS	67	a-h	62	a-d	41.8	a-g	18.1	m-s	19.9	g-l	37.2
OR2190064R	VS	48	jkl	63	abc	30.0	e-m	26.4	j-p	20.0	g-l	36.2
Juniper	VS	82	a	55	a-e	46.8	a-d	14.3	n-s	14.8	j-o	36.1
Kairos	VS	61	c-k	47	a-h	26.1	g-m	32.7	f-m	15.0	j-o	36.0
Milestone	VS	57	e-l	51	a-f	31.9	d-m	31.6	g-m	15.6	j-o	35.7
Utah 100	VS	58	d-k	39	c-h	21.8	k-n	27.6	j-o	26.7	d-i	35.6
Caledonia (Check)	VS	65	c-j	57	a-e	38.1	b-j	23.2	k-q	14.4	j-p	35.5
Balance	VS	74	a-d	52	a-f	37.5	b-k	24.8	j-p	10.1	l-q	35.5
IDO2006 (W)	VS	66	a-i	36	d-h	24.5	h-m	28.9	h-n	18.5	h-m	34.5
WB4303	VS	74	a-d	63	abc	40.3	a-i	13.3	n-s	7.6	o-q	33.6
UI SRG	VS	46	kl	53	a-f	26.8	f-m	24.3	j-q	15.1	j-o	31.7

Golden Spike (W)	VS	58	d-l	58	a-e	37.2	b-k	13.5	n-s	11.9	k-q	30.6			
Sequoia	VS	56	f-l	42	a-h	27.0	f-m	23.9	j-q	11.9	k-q	30.3			
Keldin	S	58	d-k	41	b-h	27.9	f-m	14.4	n-s	17.3	i-o	29.2			
WB4422	S	51	i-l	61	a-d	42.7	a-f	7.2	rs	10.2	l-q	27.8			
LCS Jet	S	49	i-l	55	a-e	24.2	i-m	13.3	n-s	8.5	n-q	27.3			
Promontory	S	47	kl	50	a-g	25.2	h-m	10.8	p-s	14.8	j-o	27.1			
Millie (W)	S	41	l	35	e-h	17.4	mno	21.2	l-r	14.2	j-p	25.8			
Apst-52	S	46	kl	38	c-h	24.1	j-m	13.8	n-s	8.7	m-q	23.7			
WB4401	S	47	kl	23	h	16.1	mno	21.0	l-r	7.9	o-q	22.8			
HSG108	S	46	kl	28	fgh	18.9	l-o	18.6	m-s	5.9	pq	22.3			
Brundage (Check)	S	40	o-t	38	i-n	15.6	p-t	7.3	pqr	13.9	s-z	22.0			
WB4510CLP	MS	45	kl	24	gh	16.7	mno	8.7	q-s	4.4	q	17.8			
WB4623CLP	MS	21	m	36	d-h	7.4	no	4.2	s	7.9	o-q	15.0			
SE		13.3		20.5		12.7		12.0		7.7					
Variety		<0.0001		<0.05		<0.0001		<0.0001		<0.0001					
Year		<0.0001		<0.01		<0.0001		<0.0001		<0.0001					
Variety *Year		0.0612	ns	0.9409	ns	<0.05		<0.0001		<0.0001					

(W) = White

Table 4. Average FHB reaction, incidence, severity, index, and FDK and DON of Soft White Winter Wheat genotypes from multiple years (2020-24) data in southeast Idaho.

Variety/Line	FHB Rating	INC (%)*		Sev (%)		IND		FDK(%)		DON		DISK
WB1783	VS	65	c-k	61	a-d	38.6	b-j	42.9	ab	55.8	a	54.7
UIL 176268 CL+	VS	69	b-h	69	a	47.2	a-f	30.3	b-h	56.1	a	53.3
WB1529	VS	79	a-d	68	a-b	53.1	ab	33.3	a-e	43.5	c-e	52.4
M-Press	VS	78	a-e	52	a-j	40.6	b-h	36.6	a-d	51.1	abc	52.3
Midas	VS	79	a-d	51	a-j	40.8	a-g	25.3	c-n	54.4	ab	49.9
WA8334	VS	90	a	64	a-c	58.0	a	33.3	a-e	25.3	h-q	48.4
OR2160264R	VS	87	ab	57	a-f	50.4	abc	31.8	b-f	27.0	h-n	46.5
LCS Drive	VS	40	p-t	35	j-o	27.9	g-t	49.5	a	52.1	abc	45.5
AP Illiad	VS	69	b-h	49	c-j	34.7	c-m	30.6	b-g	34.3	e-h	43.0
ORI2190027CL+	VS	73	a-f	56	a-g	47.4	a-e	32.6	a-e	24.5	h-r	42.9
OR2160243	VS	69	b-h	57	a-f	39.6	b-h	29.6	b-j	27.0	h-n	42.3
SY Ovation	VS	66	c-j	50	b-j	34.4	c-m	22.0	c-q	38.2	d-f	41.3
LCS Artdeco	VS	54	f-q	38	i-n	21.2	k-t	38.3	abc	38.2	d-f	41.2
UIL1572223	VS	62	d-m	58	a-f	35.0	c-m	21.3	c-r	33.4	f-i	40.3
Devote	VS	67	c-h	47	c-l	38.9	b-h	27.7	b-k	30.2	f-k	40.2
IDO1708	VS	62	d-m	51	b-j	33.6	c-m	27.9	b-k	31.1	f-j	40.2
Stephens	VS	58	f-o	39	h-m	22.8	i-t	25.0	c-o	37.1	d-g	37.9
SY Raptor	VS	56	f-o	44	d-m	27.9	g-t	13.5	g-r	44.9	b-d	37.5
Otto	VS	66	c-j	48	c-k	37.4	b-k	20.8	d-r	28.1	g-k	37.4
Nixon	VS	55	f-o	45	d-m	25.3	g-t	13.0	h-r	45.1	b-d	37.4
Nimbus	VS	62	d-m	45	d-l	32.6	d-o	29.2	b-k	20.8	k-v	36.4
Norwest Duet	VS	60	d-m	54	a-i	29.9	g-r	18.0	e-r	26.4	h-o	36.0
YSC 268	VS	82	abc	59	a-e	47.7	a-d	5.3	pqr	21.1	k-v	35.9
SY Assure	VS	65	c-k	44	d-m	32.6	d-o	17.7	e-r	28.8	f-k	35.7
LCS Blackjack	VS	51	h-q	40	g-m	24.8	g-t	26.9	b-m	30.4	f-k	35.4
UIL 16-478001	VS	51	h-q	60	a-d	32.6	d-o	24.9	c-o	17.1	o-w	34.8
UIL15-028024	VS	61	d-m	51	b-j	30.4	e-r	19.9	d-r	20.9	k-v	34.7
Norwest Tandem	VS	60	e-l	44	d-m	30.2	f-r	19.3	d-r	26.1	h-p	34.6
UI Sparrow	VS	56	f-o	58	a-f	32.6	d-o	17.0	e-r	21.5	j-t	34.5
OR2170559	VS	62	d-m	56	a-h	35.8	c-m	21.5	c-r	13.6	t-z	34.0
VI Voodoo CL+	VS	73	a-f	49	c-j	35.6	c-m	16.4	e-r	15.6	q-w	33.9

UIL 17-7706 CL+	VS	72	b-g	44	d-m	35.4	c-m	19.9	d-r	15.7	q-w	33.8
UIL 14-211120A	VS	55	f-o	45	d-l	33.2	d-o	22.4	c-p	21.5	j-t	33.1
WB1376CLP	VS	67	c-i	50	c-j	36.7	b-l	12.5	j-r	20.0	m-w	33.1
VI Shock	VS	54	f-q	61	a-d	31.0	d-r	22.5	c-p	9.4	yz	32.4
UIL13-046145A	VS	64	c-l	44	d-m	32.0	d-q	17.3	e-r	16.3	p-w	31.8
WB1621	VS	59	f-m	54	a-i	35.9	c-m	19.5	d-r	10.3	w-z	31.4
Caledonia (Check)	VS	52	h-q	54	a-i	28.9	g-r	9.7	m-r	21.6	j-t	30.7
YSC 201	VS	46	l-r	37	i-n	20.1	l-t	30.0	b-i	16.4	p-w	30.6
UI Magic CL+	VS	54	f-q	36	j-o	21.1	k-t	14.0	g-r	27.3	h-m	30.3
WA8305 CL+	S	51	h-r	36	j-o	21.6	j-t	12.0	k-r	27.8	g-k	29.2
LCS Hulk	S	57	f-o	46	d-l	28.0	g-t	12.6	i-r	15.4	r-y	29.0
YSC 215	S	47	k-r	40	g-m	24.6	g-t	15.1	f-r	23.6	i-s	29.0
Eltan	S	54	f-q	35	j-o	28.9	g-r	13.7	g-r	19.4	m-w	27.8
WA8306 CL+	S	44	m-s	42	e-m	19.4	m-t	5.5	pqr	28.6	f-k	27.3
WB 456	S	48	j-r	42	e-m	21.4	j-t	8.9	n-r	17.5	m-w	26.0
ORI2190025CL+	S	23	t	49	c-j	11.2	t	22.5	c-p	16.1	q-w	25.9
VI Encore CL+	S	58	f-o	30	l-o	23.6	g-t	12.4	j-r	14.3	s-z	25.7
AP Exceed	S	62	d-m	38	i-n	25.0	g-t	8.3	n-r	6.5	yz	24.3
Stingray CL+	S	53	h-q	30	k-o	19.0	m-t	9.7	m-r	15.0	r-y	24.2
Appleby CL+	S	48	j-r	41	f-m	19.1	m-t	7.1	pqr	13.7	t-z	24.1
IDO2008	S	45	m-s	30	l-o	12.8	st	11.6	m-r	15.7	q-w	23.1
Nimbus	S	28	st	59	a-e	16.3	o-t	7.6	o-r	11.1	v-z	22.9
Brundage (Check)	S	40	o-t	38	i-n	15.6	p-t	7.3	pqr	13.9	s-z	22.0
OR2X2CL+	S	33	r-t	45	d-l	14.1	r-t	4.2	r	17.5	n-w	22.0
VI Presto CL+	S	52	h-q	37	i-n	16.5	n-t	4.9	qr	5.1	z	20.8
Piranha CL+	S	49	j-r	23	n-o	16.3	o-t	10.0	m-r	8.5	yz	20.0
Perrine	MS	36	q-u	27	m-o	15.1	q-t	10.3	m-r	13.6	t-z	19.9
Sockeye CL+	MS	41	n-s	19	o	16.2	o-t	11.3	m-r	7.9	yz	17.9
SE		13.3		12.7		12.4		13.2		7.5		
Variety		<0.0001		<0.0001		<0.0001		<0.0001		<0.0001		
Year		<0.0001		<0.0001		<0.0001		<0.0001		<0.0001		
Variety *Year		0.146	ns	<0.0001		0.15	ns	0.83	ns	<0.0001		