Accelerated Breeding for Resistance to Fusarium Head Blight

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Research Questions

Complete resistance to Fusarium Head Blight (FHB) is unknown, yet genetic variability for resistance is well documented. Steady progress toward increasing resistance levels has been demonstrated by breeding programs through the implementation of largely repeatable FHB screening procedures. Breeding programs must sustain efforts to simultaneously select resistant materials with desirable agronomic characteristics. The objective of this program is to use traditional plant breeding and selection techniques to develop hard spring wheat germplasm and cultivars that possess agronomic characteristics worthy of release in addition to acceptable levels of FHB resistance.

Results

Entries retained in the advanced yield trial (AYT) are thought to be at least moderately resistant to FHB. Those that do not perform adequately are generally discarded after the first year of AYT observation. 2014 AYT results are presented in the appendix. Thirty-six experimental breeding lines were tested along with twelve check cultivars during the 2014 growing season. Of the thirty-six experimental lines, seventeen had FHB disease index (DIS) values that were less than the test average. Ten of these seventeen entries also had Fusarium damaged kernel (FDK) values that were below average. Among these ten, seven produced more grain than average and the test weight of six was also heavier than average. One of these six (SD4362)) is presently under consideration for release as a new cultivar. Specifically, SD4362 will likely be released this fall and be made available to Certified seed producers in spring 2015.

Application/Use

With the progression of time, increases in FHB resistance levels should help to prevent devastating loses to growers caused by severe FHB outbreaks.

Material and Methods

Focused efforts to increase resistance began within this program after the 1993 FHB epidemic in the spring wheat production region. Both mist-irrigated greenhouse and field screening nurseries were established and disease evaluation methods were developed. Breeding materials are evaluated for FHB resistance using three generations per year: two in the greenhouse and one in the field. We have the capacity to screen 4,500 individual hills in the greenhouse. We also have 4 acres in the field under mist-irrigation. Both the field and greenhouse nurseries are inoculated with grain spawn (corn that is infested with the causal fungus) and spore suspensions. Mist-irrigation is used to provide a favorable environment for infection. Approximately 25 percent of the experimental populations possess *Fhb1* as a source of resistance. Most of what remains are crosses with various "field resistant" advanced breeding lines. Experimental materials are advanced through the program in the following fashion;

Year 1	Field	Space planted F_2 populations
Year 1	Fall greenhouse	$F_{2:3}$ hills
Year 1	Spring greenhouse	$F_{3:4}$ hills
Year 2	Field	$F_{4:5}$ progeny rows
Year 2	Off-season Nursery	$F_{5:6}$ progeny rows
Year 3	Field	$F_{5:7}$ Yield Trials (1 replication, 2 locations)
Year 4	Field	$F_{5:8}$ Yield Trials (2 replications, 5 locations)
Year 5	Field	Advanced Yield Trials (3 reps, 8 locations)

F_2 populations are planted in the field and individual plants are selected. These are advanced to the fall greenhouse where seed from each plant is sown as individual $F_{2:3}$ hills and evaluated for FHB resistance. Four plants from each of the top 25% of the hills are advanced to the spring greenhouse. They are sown as individual $F_{3:4}$ hills and evaluated for FHB resistance. Those with FHB resistance nearly equal to or better than 'Brick' are advanced to the mist-irrigated field nursery as $F_{4:5}$ progeny rows. They are evaluated again for resistance and general agronomic performance. Plants are selected within the superior rows and sent to New Zealand as $F_{5:6}$ progeny rows for seed increase. A portion of seed from each selected plant is also grown in the fall greenhouse to confirm its resistance. If the FHB resistance of an $F_{5:6}$ line is confirmed, then the respective progeny row is harvested in New Zealand. In the following South Dakota field season, the selected lines are tested in a two replication, multi-location yield trial. Those that have agronomic performance and yield similar to current cultivars are included in more advanced, multi-location, replicated yield trials the following year. In year 5, lines advanced through this portion of the program are included in the AYT along with entries from the traditional portion of the program. Performance data with respect to DIS and FDK, along with agronomic potential from the 2014 AYT are presented in Table 1 of the appendix.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

The presence of FHB inoculum within fields and favorable weather conditions are just two factors that heavily influence whether this disease will become problematic. Immediate economic benefits are therefore difficult to assess. When conditions become favorable for disease presence, however, cultivars with elevated FHB resistance levels can help to reduce potentially serious losses for growers.

Table 1. South Dakota State University advanced yield trial spring wheat entries ranked according to FHB disease index values (lowest to highest – collected at Brookings) presented along with agronomic data obtained from three replication tests conducted at eight test environments in 2014

ENTRY	FHB DIS INDEX	TOMB-STONE (%)	GRAIN YIELD (BU/AC)	TEST WEIGHT (LB/BU)	GRAIN PROTEIN (%)	HEAD DATE (D > 6/1)	PLANT HEIGHT (INCHES)
SD4511	15.56	23.67	55.54	61.38	14.90	30.17	46.83
SD4383	15.59	37.50	59.10	58.62	14.75	24.83	38.98
FOREFRONT	15.92	33.33	59.01	60.30	14.73	26.00	42.92
BRICK	16.36	28.00	56.84	60.85	14.90	23.06	40.26
SD4472	16.51	42.50	56.00	59.16	14.89	26.28	38.37
SD4362	17.99	28.33	58.13	60.64	14.87	23.33	42.18
SD4321	18.17	27.83	52.91	59.08	16.27	25.56	41.35
SD4393	18.61	37.50	57.84	59.65	15.00	27.22	37.69
SD4450	18.69	36.67	55.71	60.10	14.95	25.22	40.11
SD4330	18.70	35.33	55.24	60.98	15.30	27.00	42.69
SD4299	19.09	34.17	57.67	59.47	15.07	31.72	38.98
SD4501	19.09	40.83	50.96	59.90	16.04	26.61	40.14
SD4514	19.13	29.50	56.31	60.65	15.12	29.56	44.10
SD4471	19.50	34.50	57.70	59.23	14.42	26.22	39.94
SD4493	20.12	39.17	53.43	59.33	14.94	26.89	37.26
SD4451	20.25	50.00	56.69	59.94	15.05	25.89	39.43
PREVAIL	21.32	35.00	61.21	59.55	14.09	28.83	39.43
SD4416	21.65	30.83	54.84	59.87	15.09	28.00	39.51
SD4470	22.07	22.83	52.76	58.67	14.66	25.78	39.66
STEELE-ND	22.63	42.50	51.14	58.97	15.00	28.11	40.06
SD4517	22.67	40.83	50.50	57.82	15.23	27.06	38.65
SD4400	22.82	33.33	53.99	59.37	14.83	29.61	43.62
FALLER	22.92	36.17	60.30	59.91	13.90	30.39	40.11
SD4543	23.08	30.00	54.59	60.21	14.94	28.00	43.57
SD4496	23.11	27.00	54.96	59.51	15.24	25.72	42.56
SD4539	23.13	39.17	54.52	59.40	14.80	29.61	42.69
SD4506	23.91	40.83	51.84	60.02	15.18	28.33	43.90
SD4469	23.96	25.33	54.10	58.65	14.78	26.78	41.22
SD4492	24.05	37.00	53.68	60.19	14.70	24.44	41.02
SD4537	24.17	37.50	58.13	60.70	14.80	29.44	40.24
SD4403	24.23	28.33	55.45	59.95	15.14	29.72	40.52
ADVANCE	24.35	32.50	55.41	59.62	14.28	29.78	38.62
SD4520	24.35	30.33	50.80	59.98	14.77	31.44	43.70
SD4515	24.58	40.33	54.33	59.21	15.48	27.06	39.13
BRIGGS	24.65	44.17	51.13	58.28	15.10	26.56	40.14
SD4546	24.99	45.00	56.65	61.17	15.10	23.94	40.16
SD4477	25.02	37.50	57.59	59.32	15.08	28.50	37.29
SELECT	25.33	45.33	55.36	60.08	14.67	24.61	40.74
SD4532	25.53	49.17	53.26	60.10	14.55	27.44	41.98
SD4529	26.63	37.50	54.03	59.76	15.30	27.94	42.23
GRANGER	26.93	50.00	52.62	59.30	14.78	28.28	44.10
OXEN	27.30	51.67	51.72	56.54	14.78	27.44	36.98
TRAVERSE	27.31	47.50	57.99	56.71	14.43	26.89	41.78
SD4465	27.87	38.33	57.63	59.64	14.66	27.22	39.61
SD4548	28.00	44.17	46.62	60.66	16.10	29.22	40.42
SD4524	29.63	40.83	57.87	59.43	14.00	27.50	39.51
SD4518	30.45	51.67	48.18	59.40	15.13	29.00	41.10
KNUDSON	30.61	44.17	51.96	58.78	14.20	30.83	37.21
MEAN	22.68	37.41	54.88	59.58	14.92	27.48	40.68
lsd (0.05)	6.24	11.54	1.47	0.30	0.19	0.80	0.91
cv (%)	17.40	20.02	5.59	1.62	3.12	7.48	5.24