Accelerated Breeding for Resistance to Fusarium Head Blight

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Research Questions

Complete resistance to Fusarium Head Blight (FHB) is unavailable, 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 project is to use traditional plant breeding and selection techniques to develop hard red 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 generally at least moderately resistant to FHB. Those that do not perform adequately are discarded after the first year of AYT observation. 2017 AYT results are presented in the appendix. Thirty-four experimental breeding lines were tested along with fourteen check cultivars during the 2017 growing season. Of the thirty-four experimental lines, eighteen had FHB disease index (DIS) values that were less than the test average. Among these entries, eight produced more grain than average. Among these eight, test weight of four entries was higher than average, and protein content of one (SD4711) was also better than average. Although not among the most highly resistant to FHB, SD4539, is presently being increased for the second year and may be considered for release as a new cultivar in fall 2018. Likewise, SD4625 is also being increased for potential release in 2019, and is among those that are more resistant than average to FHB, although it is slightly below average in protein concentration.

Application and Use

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

Materials 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 as many as 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, along with agronomic potential from the 2017 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 becomes 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 grower losses.

Appendix:

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 trials conducted at seven test environments in 2017.

ENTRY	DIS INDEX	YIELD (BU/AC)	TW (LB/BU)	PROTEIN (%)	HEADING (D>6/1)	HEIGHT (INCHES)
BRICK	11.5	46.3	61.5	15.2	15	27
FOCUS	11.7	42.6	61.5	15.8	15.3	28
FOREFRONT	12.3	50.9	60.8	15	15.9	30.4
SD4742	12.5	42.1	59.4	15	17.9	26.4
SD4546	13.2	45.1	60.8	15.3	15.9	27
SURPASS	13.4	45	59.5	15.1	16.5	23.7
SD4752	13.4	45.4	60.8	15.4	18.6	27.7
SD4748	13.7	46.3	59.9	15	15.9	25.1
SELECT	13.8	46.6	61.4	14.8	15.3	26.2
SD4465	13.9	45.1	60	14.9	17.6	25.4
PREVAIL	14	50.5	59.7	14.7	17	27.2
SD4738	14.2	42.5	61.7	15.7	16.3	25.9
SD4711	14.5	47.9	61	15.4	15.4	26.6
SD4747	14.8	44.8	59.9	15.3	15.5	27.1
SD4708	14.8	47.8	60.6	15.2	16.8	26.4
SD4706	14.9	49.2	59.6	15	15.4	27.7
FALLER	15.1	40.3	58	14.7	20.2	30.5
SD4720	15.3	43.3	58.9	16.6	18.9	27.6
SD4721	15.5	47.3	59.2	15.7	17.7	25.4
BRIGGS	15.7	46.5	59.6	15.3	16.3	27.8
SD4689	15.7	43.6	60.9	15.8	17.1	28.4
SD4719	15.9	47.9	59.8	15.3	19.4	28.1
SD4693	16	43.9	58.9	15.5	17.5	29
SD4745	16.1	45.2	60	16.1	17.8	28.1
SD4740	16.3	46.4	60.8	14.9	16.5	26.2
SD4625	16.4	51.5	60.1	15.2	19.5	29.1
SD4732	16.5	42.4	59.9	15.6	15.6	24.1
SD4539	16.7	46.6	60	15.3	18.9	28.9
SD4735	16.7	47.2	60.3	14.9	18.5	28.4
SD4729	16.8	45.1	58.1	14.9	18.6	26.8
SD4702	17.1	47	59.9	14.9	16.3	26.8
ADVANCE	17.7	45.5	60.4	14.7	17.8	27.7
BOOST	17.7	44.8	59.2	15.9	20.3	30.2
TRAVERSE	17.8	48.3	57.2	14.6	17.6	27.6
SD4595	18	44.3	61.2	15.8	17.6	29.2
SD4579	18.2	43.4	60.5	15.5	17.8	27.1
SD4681	18.3	46.6	61.4	15.4	17	30.1
SD4676	18.9	46	59.8	15.4	19.7	28.3
SD4692	19	44.4	58.7	15.5	18.7	24.3
STEELE-ND	19.1	46.2	59.5	15.4	19.2	31
SD4707	19.5	44.3	57.4	15.3	17	25.7

Table 1. continued

ENTRY	DIS INDEX	YIELD (BU/AC)	TW (LB/BU)	PROTEIN (%)	HEADING (D>6/1)	HEIGHT (INCHES)
SD4529	19.5	43.8	60.4	15.6	17.8	29.3
SD4746	19.5	44.3	61.8	15.3	16.8	26.5
SD4744	20.4	42.9	59.5	15.4	18	26
OXEN	20.5	47.5	58.7	15	17.4	27.6
SD4650	20.5	50.8	59.6	15.2	18.9	29.6
SD4703	21.1	48.5	59.8	13.8	17.8	25.7
LCS-TRIGGER	25.3	50.4	58.9	14.6	23.1	30.3
MEAN	16.44	45.92	59.93	15.25	17.53	27.48
LSD (0.05)	3.88	1.94	0.46	0.2	0.46	0.65
cv	16.86	5.43	1.76	2.98	9.08	6.30