Proceedings of the Iowa Academy of Science

Volume 91 | Number — Article 4

1984

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Proc. Iowa Acad. Sci. 91(4):128-131, 1984

Performance of Sorghum Hybrids in Relation to Sources of Resistance to Biotype C of the Greenbug[1]

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This paper presents results of research on the agronomic performance of sorghum [*Sorghum bicolor* (L.) Moench.] hybrids derived from several germplasm sources that possess resistance to biotype C of the greenbug [*Schizaphis graminum* (Rondani)]. Significant differences among hybrids with resistance from different sources were evident for grain yield, seeds/head, heads/plant, days to midbloom, and plant height. SA7536-1 seemed superior to KS30, IS809, and PI264453 resistance sources in potential for producing high-yielding hybrids with resistance to biotype C. Greater numbers of seeds/head was the component largely responsible for the yield advantage of the SA7536-1 hybrids.
INDEX DESCRIPTORS: *Sorghum bicolor* (L.) Moench., *Schizaphis graminum* (Rondani), sorghum, insect, resistance, greenbug.

The greenbug [*Schizphis graminum* (Rondani)], a longtime pest of small grains, became a major pest of sorghum [*Sorghum bicolor* (L.) Moench.] in the United States in 1968. Since then, control of the greenbug through biological or chemical methods has been a prime objective of many sorghum improvement programs. Plant breeders identified four primary sources of resistance among the many genotypes surveyed (Wood et al., 1969; Wood, 1971). These sources were the lines SA7536-1, IS809, and PI264453, plus *Sorghum virgatum* (Hack) Stapf that was released as a germplasm line, KS30, and as a random-mating population, KP6BR.

With use of these sources of resistance, lines and populations were developed that possessed adequate protection from the greenbug, as well as improved agronomic characteristics. Sorghum hybrids resistant to biotype C of the greenbug soon were available from commercial seed companies. Sorghum producers, however, often expressed concern, as summarized by Higdon (1976), that the introgression of greenbug resistance reduced grain yields of the hybrids. Several studies since 1976 indicated that greenbug resistance did not reduce sorghum yields (Kofoid et al., 1976; Walter, 1977; Daniels, 1978; Teetes, 1980), but none of the reports examined the performance of hybrids in relation to specific sources of resistance. The objective of our research was to evaluate the performance of a group of experimental hybrids in relation to different sources of resistance to biotype C of the greenbug for grain yield and other agronomic characters.

MATERIALS AND METHODS

The 111 greenbug-resistant sorghum hybrids evaluated in our experiments were produced by crossing 37 greenbug-resistant lines, used as male parents, onto three greenbug-susceptible, male-sterile seed parents (A-lines). The female parents, A Combine Kafir-60 (SA3197), A Martin (SA398), and A Wheatland (SA399) are widely used as seed parents for hybrid sorghums. The male parents represented five sources of greenbug resistance: SA7536-1, IS809, PI264453, KS30L (line), and KS30P (population, KP6BR). In addition, five greenbug-resistant and five susceptible commercial hybrid checks were included in the test.

The 111 experimental hybrids were grown in observation rows in the year after seed production, and bagged heads were checked for fertility restoration. Hybrids of the 37 male parents included in the experiment showed full restoration of fertility on each female parent, and the hybrids were acceptable in plant height and maturity for use as combine grain sorghums.

Our experiments were grown at the Iowa State University Agronomy Research Center near Ames, Iowa, in 1980 and 1981. Planting dates were May 20 and May 26, respectively. The entries were grown each year in an 11 x 11 triple-lattice field design with three replicates.

The experimental site was fertilized each year with 90 kg/ha of P_2O_5 and K_2O the preceding fall and with 112 kg/ha of N in the spring before planting. Weeds were controlled by preplanting applications of Bexton (Propachlor), plus field cultivations. Greenbugs were controlled by using 1.63 liters/ha of Defend (Cygon) applied as a foliar spray on July 10, 1980, and July 13, 1981.

Individual plots were single rows 4.27 m long with 102 cm between rows. Plots were thinned to four plants per 30 cm in 1980 (@129,000 plants/ha) and three plants per 30 cm in 1981 (@ 97,000 plants/ha). After thinning, a 3-m section of each plot was marked for use in obtaining character measurements. When 3 m of competitive plants were not available, a shorter plot was marked, and the data were adjusted accordingly. Data were recorded in accordance with established procedures for grain yield, seeds/head, 100-seed weight, heads/plant, days to midbloom, and plant height.

The seedbed for the 1981 experiment was variable for tilth and soil moisture, resulting in uneven emergence of seedlings. Plant stands in some plots were not satisfactory; thus, data were either missing or incomplete for 11 entries in that year. For the combined analysis of variance of the 1980 and 1981 results, data for these 11 entries were deleted, and weighted analyses were computed for the remaining entries after data sets were combined. These data were analyzed by using the PROC GLM and PROC MEANS options of SAS (Statistical Analysis System, The SAS Institute Inc., Cary, North Carolina).

Years and male parents within sources of greenbug resistance were considered random variables. Sources of greenbug resistance and female parent effects were considered fixed. Sums of squares ascribable to the different sources of resistance were subdivided into four nonorthogonal, single-degree-of-freedom contrasts. These were:

C1 = KS30L + KS30P + SA7536-1 + IS809 vs PI264453
C2 = KS30L + KS30P + SA7536-1 vs IS809
C3 = KS30L + KS30P vs SA7536-1
C4 = KS30L vs KS30P

Contrast 1 is between four sources of resistance derived from grassy-type sorghums and resistance from a combine-grain type (PI264453). Contrast 2 involves three sources developed in the United States versus a resistant line from India (IS809). The two sources most often used to transfer greenbug resistance to public agency and private company hybrids are the components of contrast 3. Finally, contrast 4 is between hybrids with resistance that traces to the same source (KS30), but derived by different breeding methods.

Two additional contrasts, involving resistant and susceptible commercial hybrids, were partitioned in the analysis of variance. Results from that aspect of the experiment are not presented in this paper, but

[1]Journal Paper No. J-11208 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project 2573.

Table 1. Mean squares for sources of resistance and four single-degree-of-freedom contrasts partitioned from the sources for six characters from combined 1980 and 1981 sorghum experiments.

Sources of variation	df	Grain yield	Seeds/ head	100-seed weight	Heads/ plant	Days to midbloom	Plant height
Sources of resistance	4	847.0**	528002*	.249	.31*	123.4**	328.2*
Sources x years	4	34.0	67632	.056	.02	3.3	45.4
Contrast 1	1	84.8	135320	.015	.04	30.9	0.8
Contrast 2	1	14.5	239284	.601*	.03	137.5**	81.0
Contrast 3	1	2944.9**	1547353**	.018	.01	8.8	393.7*
Contrast 4	1	273.6	41527	.328*	1.21**	304.2**	849.3**
Contrasts x years	6	50.8	48894	.045	.03	2.8	31.7

*, ** Significant at the .05 and .01 probability levels, respectively.

the contrasts x years mean squares with six degrees of freedom (Table 1) include that component.

RESULTS AND DISCUSSION

Environmental conditions during 1980 and 1981 at Ames generally were favorable for plant growth and development. Soil moisture levels after emergence in 1981 were plentiful, and plants were fully mature before the first frost in both years. Despite the slow emergence and poor stands of some entries in 1981, the mean yield for all entries exceeded the 1980 mean (78.2 vs 70.5 quintals/hectare).

Mean squares for sources of resistance and the four contrasts are shown in Table 1. Sources of resistance differed significantly ($P < 0.01$ or $P < 0.05$) for all characters except 100-seed weight. The single-degree-of-freedom contrasts in Table 1 were partitioned to elucidate the response among sources of resistance. For grain yield, contrast 3 (KS30L + KS30P vs SA7536-1) was significant ($P < 0.01$), but the other contrasts were not. The mean yield of SA7536-1 hybrids (78.6 q/ha, Table 2) was appreciably larger than the mean for the KS30L + KS30P hybrids (70.2 q/ha, Table 3). More seeds/head for the SA7536-1 hybrids (1862, Table 2) seems largely responsible for the yield advantage over the KS30 (L + P) hybrids (1662, Table 3). The mean square for contrast 3 for seeds/head exceeded $P < 0.01$ and it was decidedly larger than those for the other contrasts.

Significance ($P < 0.05$) was indicated for contrast 2 (KS30L + KS30P + SA7536-1 vs IS809) for 100-seed weight. The mean for the group of hybrids was 2.66 g per 100-seed (Table 3) vs 2.84 g for IS809 hybrids (Table 2). Contrast 4 (KS30L vs KS30P) was significant ($P > 0.05$) for 100-seed weight, and also for heads/plant ($P > 0.01$).

The mean squares in Table 1 also indicate that the sources of resistance differed significantly for days to midbloom and plant height. In contrast 2, the hybrids of KS30L + KS30P + SA7536-1 required 71 days to midbloom (Table 3) vs 68 days for IS809 hybrids (Table 2). In contrast 4, KS30L hybrids required 69 days to midbloom vs 73 days for the KS30P hybrids (Table 2). Contrast 1, which compared hybrids with the PI264453 source of resistance with those from all other sources was not significant for any of the characters measured (Table 1).

Mean grain yields (Table 2) ranged from 78.6 q/ha for hybrids with the SA7536-1 resistance to 67.7 q/ha for hybrids with KS30P resistance. 100-seed weights did not differ greatly, ranging from 2.61 g to 2.84 g among the different groups. KS30P hybrids (2.72 g) and IS809 hybrids (2.84 g) had the heaviest 100-seed weight, but they also had the lowest mean yields. Heads/plant showed little difference among the sources, ranging from 1.4 to 1.6.

Seeds/head (Table 2) ranged from 1586 for hybrids with the IS809 resistance to 1862 for hybrids with SA7536-1 resistance. The higher-yielding hybrid groups seemed to have many seeds/head and relatively low 100-seed weights. Average days to midbloom ranged from 68 days for the IS809 hybrids to 73 days for KS30P hybrids. The range for plant height was not great, with a mean of 125 cm for the IS809 and SA7536-1 hybrids and 131 cm for hybrids with KS30L resistance.

Means for hybrids grouped by male parents and resistance sources are presented in Table 4. Grain yields ranged from 58.5 q/ha for male 20 to 88.7 q/ha for male 27. Most of the higher yields were exhibited by hybrids with the SA7536-1 resistance. All hybrids with that source via the Texas lines yielded 80 q/ha or more, with the exception of hybrids with Tx2741 as the male parent. Only three hybrids with resistance from sources other than the Texas male parents yielded more than 80 q/ha. These were hybrids with male 7 (via OK GP-4) and males 23 and 34 (via the KS30L source).

The low grain-yield potential of the KS30P source is noteworthy. The highest-yielding hybrid with this resistance had a mean of 70.6 q/ha and the lowest yielder averaged 62.8 q/ha. Yields among hybrids with the KS30L resistance displayed the greatest variability, ranging from 58.5 to 81.2 q/ha.

Table 2. Means and standard errors for hybrids grouped by source of resistance for six agronomic characters from combined 1980 and 1981 sorghum experiments.

Resistance source	Grain yield (q/ha)	Seeds/ head	100-seed weight (g)	Heads/ plant	Days to midbloom	Plant height (cm)
SA7536-1	78.6 ± .40	1862 ± 12	2.65 ± .011	1.5 ± .010	72 ± .12	125 ± .41
PI264453	74.3 ± .95	1750 ± 29	2.68 ± .026	1.5 ± .024	71 ± .27	127 ± .96
KS30L	72.1 ± .44	1655 ± 13	2.61 ± .012	1.6 ± .011	69 ± .13	131 ± .44
IS809	71.3 ± .70	1586 ± 21	2.84 ± .019	1.6 ± .017	68 ± .20	125 ± .71
KS30P	67.7 ± .51	1671 ± 15	2.72 ± .014	1.4 ± .013	73 ± .15	126 ± .52

Table 3. Means and standard errors for entries grouped by hybrid combinations for six agronomic characters from combined 1980 and 1981 sorghum experiments.

Hybrid combination	Grain yield (q/ha)	Seeds/ head	100-seed weight (g)	Heads/ plant	Days to midbloom	Plant height (cm)
All hybrids	73.5 ± .23	1739 ± 7	2.67 ± .006	1.5 ± .006	71 ± .07	127 ± .23
KS30L + KS30P + SA7536-1 + IS809	73.3 ± .24	1726 ± 7	2.68 ± .007	1.5 ± .006	71 ± .07	127 ± .24
KS30L + KS30P + SA7336-1	73.6 ± .26	1745 ± 8	2.66 ± .007	1.5 ± .006	71 ± .07	127 ± .26
KS30L + KS30P	70.2 ± .33	1662 ± 10	2.66 ± .009	1.5 ± .008	71 ± .10	129 ± .34

Table 4. Means for hybrids grouped by resistance source and male parent for six agronomic characters from combined 1980 and 1981 sorghum experiments.

Resistance source	Male parent no.	Male parent designation	Grain yield (q/ha)	Seeds/ head	100-seed weight (g)	Heads/ plant	Days to mid-bloom	Plant height (cm)
SA7356-1	1	TAM Bk41	74.0	1627	2.74	1.6	77	123
	2	TAM Bk41	71.2	1470	2.96	1.6	66	121
	3	TAM Bk41	68.1	1388	2.83	1.7	66	122
	6	OK GP-4	77.2	1653	2.75	1.7	72	122
	7	OK GP-4	83.0	1904	2.45	1.7	73	126
	24	Tx 2734	81.3	1918	2.64	1.6	75	129
	25	Tx 2735	86.1	1987	2.82	1.5	75	134
	26	Tx 2736	82.6	1847	2.91	1.5	74	141
	27	Tx 2737	88.7	1888	2.72	1.6	75	137
	29	Tx 2741	75.9	2046	2.47	1.4	72	121
	30	Tx 2742	80.2	2342	2.34	1.4	73	126
	31	Tx 2743	82.1	2080	2.46	1.5	73	122
	32	Tx 2744	80.0	2196	2.42	1.4	73	116
KS30L	18	N-6	67.2	1498	2.26	1.9	66	136
	19	N-8	67.2	1541	2.36	1.8	67	123
	20	N-14	58.5	1447	2.30	1.7	63	127
	21	N-16	72.0	1430	2.46	2.0	65	134
	22	N-20	68.5	1792	2.23	1.6	70	122
	33	N-22	74.1	1991	2.81	1.3	72	124
	34	N-24	80.7	1869	2.38	1.8	71	131
	35	N-25	78.6	1783	2.60	1.6	71	143
	23	N-27	81.2	1488	3.49	1.5	73	141
	36	N-28	73.3	1825	2.89	1.3	75	123
	37	N-29	77.3	1725	3.06	1.4	74	133
KS30P	11	KP6BR	64.9	1531	2.81	1.5	73	122
	12	KP6BR	69.6	1830	2.66	1.4	73	129
	13	KP6BR	68.1	1646	2.57	1.5	71	126
	14	KP6BR	69.6	1663	2.84	1.4	73	120
	15	KP6BR	68.1	1713	2.77	1.4	73	138
	16	KP6BR	62.8	1746	2.47	1.4	75	112
	17	KP6BR	70.6	1570	2.91	1.5	73	131
IS809	8	OK GP-6	76.1	1672	2.87	1.7	69	133
	9	OK GP-6	66.3	1256	2.93	1.8	65	125
	10	OK GP-6	72.9	1592	2.98	1.5	67	126
	28	Tx 2738	69.3	1940	2.44	1.4	73	115
PI264453	4	TAM Bk42	76.2	1758	2.66	1.6	71	130
	5	TAM Bk42	72.5	1732	2.69	1.5	72	123
LSD (0.05)			12.9	407	0.34	0.28	4	13

The range in 100-seed weights (Table 4) was from 2.45 to 2.90 g for a large segment of the hybrids. A few entries, however, transcended that range appreciably. Hybrids with male 23 had the heaviest 100-seed weight (3.49 g), and the lowest weight (2.23 g) was recorded for hybrids with male 22. Both of these hybrids possessed the KS30L resistance. A distinct association of either large or small seed with a specific source of resistance was not evident.

Number of heads/plant for the different male parent sources ranged from 1.3 to 2.0, with both the highest and lowest means recorded for hybrids with the KS30L source of resistance. Seeds/head exhibited a large range, from 1256 for hybrids with male 9 (IS809 source) to 2342 for hybrids with male 30 (SA7536-1 source). The high-yielding hybrids with Texas-line male parents that possessed the SA7536-1 resistance also had large numbers of seeds/head.

Means for days to midbloom (Table 4) spanned a 2-week period from 63 to 77 days. Hybrids with most male parents reached midbloom in 70 to 74 days. Hybrids with IS809 resistance most often were early, as were several hybrids with KS30L and SA7536-1 male parents. Plant heights varied from 112 cm for hybrids with male 16 to a mean of 143 cm for hybrids with male 35. There did not seem to be a trend for a preponderance of short or tall hybrids within any of the resistance sources.

Our results showed distinct differences among hybrids that utilized different sources of greenbug resistance for grain yield, seeds/head, heads/plant, days to midbloom, and plant height. Variability in performance among entries within each of the sources seemed adequate for selecting resistant hybrids with a diversity of agronomic traits.

SA7536-1 resistance seemed superior to the other sources in potential for producing high-yielding, greenbug-resistant hybrids. Greater numbers of seeds/head was the component largely responsible for the yield advantage of the SA7536-1 hybrids.

The KS30L source of resistance produced hybrids that displayed marked variability for grain yield and most other characteristics. Our results suggest that this source should prove useful in providing lines for sorghum breeding programs.

Lines derived from KS30P produced hybrids with the lowest average yield. Poor performance by these hybrids may reflect the derivation of the lines from early cycles of an unselected random-mating population. The use of random-mating populations as a means for generating new parental lines has merit, however, because this approach seems more likely to lead to new gene combinations that may protect sorghum more effectively from the greenbug. Lines selected after additional cycles of random mating, with some selection for desirable height, maturity, and other traits, might serve more effectively in producing hybrids with greenbug resistance and acceptable grain yields.

The other two sources of resistance seemed less promising in breeding potential. Hybrids with the IS809 resistance displayed heavy 100-seed weight, but they had the fewest seeds/head. The PI264453 source produced hybrids that had averages for all characters that were near the experimental mean.

Our study dealt with resistance to biotype C of the greenbug, and the results are applicable only in relation to that biotype. Two additional biotypes, D and E, have appeared in recent years. Biotype D is an organophosphate-resistant strain of biotype C that has been controlled successfully by using chemicals of nonorganophosphate derivation. Biotype E, however, has been able to infest sorghum genotypes representing all the sources of resistance used in our study except the PI264453 source.

Significant differences in grain yield and other agronomic traits were expressed in our experiments by hybrids that possessed different sources of greenbug resistance. The test materials were limited to five sources of resistance to biotype C. It seems reasonable to expect, however, that differences in performance also will be identified among different resistance sources for biotype E.

LITERATURE CITED

DANIELS, N. E. 1978. Greenbug control in grain sorghum. Texas Agric. Exp. Stn. Prog. Rep. PR-3527.

HIGDON, J. M. 1976. Total performance of grain sorghum hybrids classified as greenbug resistant. Proc. Annu. Corn and Sorghum Res. Conf., Am. Seed Trade Assoc. Chicago, Ill., 31:1-11.

KOFOID, K. D., W. M. ROSS, H. L. HACKEROTT, T. L. HARVEY, and S. D. KINDLER. 1976. Evaluation of greenbug resistance in S_2 progenies of grain sorghum. Crop Sci. 16:265-267.

TEETES, G. L. 1980. Proceedings of plant breeding workshop. Texas Agric. Exp. Stn. Tech. Rep. 80-1:3-4.

WALTER, T. L. 1977. 1976 Kansas tests with greenbug resistant grain sorghums. p. 38 *In* Proc. 10th Biennial Grain Sorghum Res. and Utilization Conf. Grain Sorghum Producers Assoc., Wichita, Kansas.

WOOD, E. A. 1971. Designation and reaction of three biotypes of the greenbug cultured on resistant and susceptible species of sorghum. J. Econ. Entomol. 64:183-185.

WOOD, E. A., H. L. CHADA, D. E. WEIBEL, and F. F. DAVIES. 1969. A sorghum variety highly tolerant to the greenbug, *Schizaphis graminum* (Rond.). Oklahoma Agric. Exp. Stn. Prog. Rep. P-614.