A STUDY OF GREENBUG RESISTANCE IN SORGHUM,

Sorghum bicolor (L.) Moench

By

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CHAPTER I

INTRODUCTION

The greenbug, *Schizaphis graminum* (Rondani), was reported as damaging to small grains in the United States in 1863, and became recognized as a major pest of sorghum in 1968. Grain yields of sorghum in some states, e.g., Kansas, Texas, and Oklahoma were reduced from 2 to 45%. Several insecticides can be used on sorghum for greenbug control. However, some are dangerous to use, and some are toxic to the plants. Also, insecticidal control of greenbugs may not be an economically feasible practice in some areas.

Although resistant sources of sorghum to greenbugs have been reported, additional sources were studied in the present investigation. The purposes of this study were to determine the inheritance of greenbug resistance in these new sources, and to compare the different sources of resistance.

CHAPTER II

LITERATURE REVIEW

The greenbug, *Schizaphis graminum* (Rond), was first reported on sorghum, *Sorghum bicolor* (L.) Moench, by Webster and Phillips (18) in the early part of 1863, but evidently it could not survive more than one generation. Kelly (14) raised the question in 1917 whether or not sorghum could be considered a host plant. The question was affirmatively answered in 1968 when Harvey and Hackerott (12) reported severe damage to sorghum in the Midwest and Southwest United States by a previously unreported biotype of greenbug. Small plants were killed and larger ones sometimes had in excess of 40,000 aphids per plant.

The study of greenbug biotypes was initiated by Wood (20). He found that a new greenbug biotype which originated in the greenhouse had the capability of destroying wheat lines Dickinson Sel. 28 A and CI 9058. These lines were resistant to the original biotype collected from the field. He designated the new biotype as Biotype B, and the original one as Biotype A. Later by differential reaction of certain small grain and sorghum varieties to greenbug infestation, by morphological differences, and by difference in feeding sites in leaves, Wood *et al*. (23) classified greenbugs into three major groups; Biotype A, Biotype B, and Biotype C.

Biotype A - This was original biotype to which Dickinson Sel. 28 A wheat, Omugi barley, and other selections of wheat, barley, and oats were resistant.

Biotype B - This biotype is not morphologically or ecologically different from Biotype A, but differs in respect to its feeding site and host plant reaction. Biotype B feeds in the parenchyma palisade cells whereas Biotype A feeds in the phloem seive tubes of the leaf. Biotype B can destroy Dickinson Sel. 28 A.

Biotype C - All wheats and wheat hybrids are susceptible to this biotype. It is morphologically and ecologically different from Biotypes A and B. It is much paler green in body color. The cornicles are yellowish-green with no blackening (1/3 of distal end black in Biotypes A and B); tips of cornicles not expanded, and wrinkles are present throughout their entire length (wrinkles on basal portion only in Biotypes A and B). About 10% of the young are males whereas no males occur in Biotypes A and B (21). Feeding is in the phloem similar to Biotype A. Biotype C can develop at temperatures as high as 110^{o}F while Biotypes A and B cannot.

Wood et al. (22) found a selection of sorghum, Shallu Grain SA 7536-1, to be resistant to Biotype C of greenbugs. Aphids reared on this resistant source were much smaller than those reared on susceptible varieties. Fecundity and longevity were decreased, also.

Harvey and Hackerott (13) reported that losses in grain production of sorghum varied from 2 to 45% depending on time and intensity of greenbug infestations. Greenbugs also caused damage to leaves, decreased test weight, decreased germination of seeds, and increased lodging in plants. However, greenbugs reduced grain yields more than they reduced grain quality.

Greenbug control on sorghum at present can best be achieved with insecticides or with the use of resistant varieties rather than natural parasites and predators. Daniels (6, 7, 8, 9) studied insecticides for control of greenbugs for several years. He stated that effective insecticides for the control of greenbugs were ethyl parathion, methyl parathion, phosphomidon, dimethoate, and disulfoton. Treated with these insecticides, grain sorghum yields were significantly increased. Cate and Bottrell (3) found that grain sorghum treated with insecticide at the 65% head emergence stage and during full bloom produced grain at harvest that was about equal in yield and test weight to untreated plants. Bottrell and Cate (2) reported an experiment which involved 11 systemic insecticide treatments of monocrotophos, disulfoton, and aldicarb on seed or soil. None of these insecticides was phytotoxic to the plants, but in their previous report (1) a foliar application of monocrotophos was phytotoxic to the plants. Pate (16) also confirmed that monocrotophos was toxic at 0.25 pound per acre on grain sorghum in the pre-boot stage.

On the basis of resistance to insects of crop plants, Painter (15) proposed three mechanisms of resistance: (a) preference and nonpreference, (b) antibiosis, and (c) tolerance. Curtis *et al*. (5) stated that in wheat, greenbug resistance was controlled by a single recessive gene designated as gl gl. In sorghum, Hackerott *et al*. (11) found that resistance was controlled by completely dominant genes at more than one locus. And on the basis of seedling survival, they grouped the plants into three major groups: resistant, intermediate resistant, and susceptible. They also found that the F_1 of resistant x susceptible crosses and the resistant parent survived 100% while the susceptible parent was killed. The F_2 population from a different source segregated in a ratio of 9 to 7 while the F_2 population from two resistant sources did not segregate. Weibel et al. (19) reported that F_1 plants gave an intermediate score between resistant and susceptible parents. Also, scores from F_2 populations indicated inheritance of resistance was probably controlled by a single incompletely dominant factor. They concluded that breeders should have little difficulty transferring this resistance to the adapted lines.

On the basis of partitioning method of genetic analysis for characters differentiated by one major effective factor pair, and by using a chi-square test, Powers (17) stated that the theoretical mean and distribution frequency of the backcross would be equal to the average of the F_1 and the parent to which backcrossing was done: $P_1 \times F_1(P_1 \times P_2) = \frac{1}{2} P_1 + \frac{1}{2}F_1(P_1 \times P_2)$, and the theoretical mean and distribution frequency of the F_2 would be equal to one half of the average of two parents plus one half of the F_1: $F_2(P_1 \times P_2) = \frac{1}{4}(P_1 + P_2) + \frac{1}{2} F_1(P_1 \times P_2)$. Likewise, if the effective factor pairs from the different parents were identical, the theoretical mean and distribution frequency of the F_1 would equal to the average of the two parents: $F_1(P_1 \times P_2) = \frac{1}{2}(P_1 + P_2)$.

CHAPTER III

MATERIALS AND METHODS

The sorghum material for this study consisted of 60 entires, comprising 9 parental lines, 21 F_1's, 12 F_2's, and 18 backcrosses.

The parental lines selected for the study and their reactions to greenbugs (19) were as follows:

Parent	Source	Reaction
PI 264453	Plant Introduction Center Experiment, Georgia	Resistant
IS 809	Sorghum Improvement Program New Delhi, India	Resistant
PI 308442	Plant Introduction Center Experiment, Georgia	Susceptible
Shallu Grain SA 7536-1	Texas	Resistant
Wheatland	Oklahoma	Susceptible
Redlan	Oklahoma	Susceptible
BOK 8	Oklahoma	Susceptible
BOKY 55	Oklahoma	Susceptible
Marum Kafir	Oklahoma	Susceptible

Six of the parental lines, PI 264453, PI 308442, Marum Kafir, Shallu Grain, Wheatland, and Redlan were crossed in all possible combinations in the greenhouse in the winter of 1969-70. The following winter IS 809 was grown and crossed with the previously mentioned six parental lines. At the same time F_1 plants from selected crosses were grown for F_2 seeds, and additional F_1 plants were grown for use in producing backcrosses. Cytoplasmic male-sterile forms of Wheatland and Redlan were utilized to facilitate producing crosses. This resulted in some sterile F_1 plants which facilitated making some of the backcrosses, but at the same time resulted in no selfed seed for F_2 populations. Hot water emasculation (47°C for 10 minutes) was used to produce the remaining crosses. Two additional lines, BOK 8 and BOKY 55, were included as susceptible checks. All of the sorghum entries and crosses used in this study are shown in Table I.

The experiment was conducted in a greenhouse from October 1971 to January 1972. The seeds were planted in metal flats containing 5 parts of soil and 1 part of peat. The kernels were covered with sand, and watered as needed. Each flat had 10 rows spaced about 4 cm apart, and in each row 30 seeds were planted. An average of 20 plants for each entry in each replication was used for measurements. Randomized into each flat with six experimental entries were four standard check varieties. The four standard checks consisted of two resistant varieties, IS 809 and Shallu Grain, and two susceptible varieties, BOK 8 and BOKY 55.

Greenbug Biotype C was cultured on sorghum and barley in the greenhouse. Experimental plants were infested 3 or 4 days after emergence with aphids brushed from culture pots onto the flats. Certain flats were reinfested three or four times in order to obtain a uniform infestation from flat to flat. Watering also helped to distribute the aphids within the experiment. At the time of infestation the average height of the above ground portion of the plants per row was recorded. Individual plant ratings to greenbug damage on a scale of one to six were taken 9 to 12 days after first infestation depending on when the susceptible standards, BOK 8 or BOKY 55, were killed. At the same time another average plant height per row was recorded.

With regard to the damage score ratings, rating 1 referred to no injury, rating 2 was very slightly damaged, rating 3 was moderately damaged, rating 4 was severely damaged, rating 5 was badly damaged, and rating 6 was dead or dying. Practically, ratings one and two were considered as resistant, ratings three and four as intermediate and ratings five and six as susceptible.

The experimental design used in this study was a randomized complete block design with six replications. The six replications were divided into three sets of two replications each for sowing, infesting, and rating.

Statistical analyses were done on plant heights at infesting time, plant heights at rating time, and height difference from infesting time to rating time. Frequency distributions of F_2 individual plants in the damage classes were tested for goodness of fit to an expected ratio by chi-square. Correlations of damage score with plant height at infesting time, and damage score with height difference from infesting time to rating time were computed.

TABLE I

THE SORGHUM ENTRIES USED IN THE EXPERIMENT

Entry Number	Generation	Pedigree	Source	Coleoptyl Color*
14	P	PI 264453	70 $F_1$82-1	R
33	P	PI 308442	70 $F_1$85-1	G
59	P	Marum Kafir	70 Wd. V. N.	G
56	P	Shallu Grain SA 7536-1	70 $F_2$67-2	G
39	P	B Wheatland	69 $F_2$94-1	R
10	P	B Redlan	70 Fld 142	G
16	P	IS 809	70 $F_1$60-1, 4	G
1	P	BOKY 55	70 DN 2 S	G
29	P	BOK 8	70 Fld 122	R
52	F_1	PI 308442 x Sh. Gr.	70 GHD-9, 10	LR
41	F_1	PI 308442 x PI 264453	70 GHD-23, 24	R
12	F_1	PI 264453 x Sh. Gr.	70 GHD-1-4	LR
38	F_1	Marum Kafir x Sh. Gr.	70 GHD-35-38	LR
20	F_1	Marum Kafir x PI 264453	70 GHD-54-56	R
57	F_1	Marum Kafir x PI 308442	70 GHD-48	G
42	F_1	A Redlan x Sh. Gr.	70 GHD-G	LR
35	F_1	A Redlan x PI 264453	70 GHD-H	R
7	F_1	A Redlan x PI 308442	70 GHD-1	G
50	F_1	A Redlan x Marum Kafir	70 GHD-J	G
13	F_1	A Redlan x B Wheatland	70 GHD-K	LR
43	F_1	A Wheatland x Sh. Gr.	70 GHD-L	LR
48	F_1	A Wheatland x PI 264453	70 GHD-M	R
11	F_1	A Wheatland x PI 308442	70 GHD-N	LR
6	F_1	A Wheatland x Marum Kafir	70 GHD-0	R
36	F_1	PI 308442 x IS 809	71 GH482	LR
5	F_1	PI 264453 x IS 809	71 GH 489	LR
51	F_1	Sh. Gr. x IS 809	71 GH 502	G
30	F_1	Marum Kafir x IS 809	71 GH 469	LR
4	F_1	A Redlan x IS 809	71 GH 446	LR
40	F_1	A Wheatland x IS 809	71 GH 463	R
28	F_2	PI 308442 x Sh. Gr.	71 GH 729	LR
17	F_2	PI 308442 x PI 264453	71 GH 734	Seg.
18	F_2	PI 264453 x Sh. Gr.	71 GH 735	Seg.
9	F_2	Marum Kafir x Sh. Gr.	71 GH 739	Seg.
55	F_2	Marum Kafir x PI 264453	71 GH 743	Seg.
49	F_2	Marum Kafir x PI 308442	71 GH 748	G

TABLE I (Continued)

Entry Number	Generation	Pedigree	Source	Coleoptyl Color*
23	F_2	A Redlan x Sh. Gr.	71 GH 751	Seg.
19	F_2	A Redlan x PI 264453	71 GH 756	Seg.
53	F_2	A Wheatland x Sh. Gr.	71 GH 773	Seg.
25	F_2	A Wheatland x PI 264453	71 GH 777	R
27	F_2	A Redlan x IS 809	70 F_1 65-2	Seg.
22	F_2	AOKY 55 x IS 809	70 F_1 62-6	Seg.
46	BC	PI 308442 x F_1(PI 308442 x Sh.Gr.)	71 GH 820	Seg.
54	BC	PI 308442 x F_1(PI 308442 x PI 264453)	71 GH 818	Seg.
32	BC	PI 264453 x F_1(PI 308442 x PI 264453)	71 GH-A	R
47	BC	PI 264453 x F_1(PI 264453 x Sh. Gr.)	71 GH 492	R
3	BC	Sh. Gr. x F_1(PI 264453 x Sh. Gr.)	71 GH 497	Seg.
58	BC	Marum K. X F_1(Marum K. x PI 264453)	71GH 811-813	Seg.
60	BC	Marum K. x F_1(Marum K. x PI 264453)	71GH 474	Seg.
26	BC	PI 264453 x F_1(Marum K. x PI 264453)	71GH-B	R
15	BC	F_1(A Red. X B Wheat.) x B Wheat.	71GH-C	LR
34	BC	PI 308442 x F_1(Marum K. x PI 308442)	71GH 821	G
31	BC	A Red. x F_1(A Red. x Sh. Gr.)	71GH-D	Seg.
37	BC	A Red. x F_1(A Red. x PI 264453)	71GH-E	Seg.
21	BC	A Wheat. x F_1(A Wheat x Sh. Gr.)	71GH 802	Seg.
44	BC	A Wheat. x F_1(A Wheat. x PI 264453)	71GH 801	R
2	BC	F_1(A Red. x Marum K.) x Marum K.	71GH 766	G
45	BC	F_1(A Red. x PI 308442) x PI 308442	71GH 762	G
8	BC	F_1(A Wheat. x Marum K.) x Marum K.	71GH 783	Seg.

TABLE I (Continued)

Entry Number	Generation	Pedigree	Source	Coleoptyl Color*
24	BC	F_1(A Wheat. x PI 308442) x PI 308442	71GH-F	Seg.

* R-Red, G-Green, LR-Light Red, Seg.-Segregating

CHAPTER IV

RESULTS AND DISCUSSION

Frequency distributions of the parental lines, the F_1's, the F_2's, and the backcrosses into six damage classes are given in Table II. Classes 1 and 2 were considered to be resistant, classes 3 and 4 were intermediate, and classes 5 and 6 were susceptible to greenbugs. After grouping the classes in this manner as shown in Table III, the parental lines, PI 264453, Shallu Grain, and IS 809 were resistant to greenbugs, while PI 308442, Marum Kafir, Wheatland, Redlan, BOK 8, and BOKY 55 were susceptible to greenbugs. However, the resistant parental lines did have some plants in the intermediate class, and the susceptible parental lines except BOKY 55 had a number of plants in the intermediate class. It appeared that possibly PI 308442, Marum Kafir, Wheatland, and Redlan could have minor genes for resistance. The F_1 plants of resistant x resistant crosses were resistant. The resistant x susceptible crosses involving PI 264453 as the resistant parent had only a few plants in the intermediate group indicating complete or nearly complete dominance of resistance. The resistant x susceptible crosses involving Shallu Grain as the resistant parent had numerous or even a predominance of plants in the intermediate group indicating incomplete or partial dominance of resistance. The resistant x susceptible crosses involving IS 809 had both of the above types of reaction, showing complete dominance with PI 308442 but less than complete dominance of resistance

TABLE II

FREQUENCY DISTRIBUTIONS OF PLANTS IN GREENBUG DAMAGE CLASSES

Entry Number	Generation	Pedigree	Damage Classes 1	2	3	4	5	6
14	P	PI 264453	25	83	5	7	0	0
33	P	PI 308442	0	0	11	21	25	63
59	P	Marum Kafir	0	0	23	20	61	16
56	P	Shallu Grain SA 7536-1	23	72	25	0	0	0
39	P	Wheatland	0	0	6	17	34	63
10	P	Redlan	0	0	14	15	51	40
16	P	IS 809	7	86	18	9	0	0
1	P	BOKY 55	0	0	0	5	101	14
29	P	BOK 8	0	6	7	25	21	61
52	F_1	PI 308442 x Shallu Grain	3	42	20	51	4	0
41	F_1	PI 308442 x PI 264453	14	91	13	1	1	0
12	F_1	PI 264453 x Shallu Grain	43	75	2	0	0	0
38	F_1	Marum K. x Shallu Grain	20	47	35	18	0	0
20	F_1	Marum K. x PI 264453	28	71	16	1	3	1
57	F_1	Marum K. x PI 308442	0	0	7	12	67	34
42	F_1	Redlan x Shallu Grain	13	42	26	13	2	24
35	F_1	Redlan x PI 264453	34	62	19	5	0	0
7	F_1	Redlan x PI 308442	1	19	15	23	39	23
50	F_1	Redlan x Marum K.	0	0	37	24	43	16
13	F_1	Redlan x Wheatland	0	0	36	11	39	34
43	F_1	Wheatland x Shallu Grain	1	33	44	29	6	7
48	F_1	Wheatland x PI 264453	25	68	9	5	13	0
11	F_1	Wheatland x PI 308442	0	18	12	26	50	14
6	F_1	Wheatland x Marum K.	0	14	8	25	32	41
36	F_1	PI 308442 x IS 809	15	95	6	4	0	0
5	F_1	PI 264453 x IS 809	31	76	6	7	0	0
51	F_1	Shallu Grain x IS 809	35	59	23	3	0	0
30	F_1	Marum K. x IS 809	27	44	18	17	13	1
4	F_1	Redlan x IS 809	6	54	40	10	8	2
40	F_1	Wheatland x IS 809	28	35	10	9	36	1

TABLE II (Continued)

Entry Number	Generation	Pedigree	Damage Classes 1	2	3	4	5	6
28	F_2	PI 308442 x Shallu Grain	10	44	28	20	16	2
17	F_2	PI 308442 x PI 264453	15	25	21	25	26	8
18	F_2	PI 264453 x Shallu Grain	41	59	16	4	0	0
9	F_2	Marum K. x Shallu Grain	13	51	33	20	3	0
55	F_2	Marum K. x PI 264453	17	54	15	19	10	5
49	F_2	Marum K. x PI 308442	0	0	38	34	35	13
23	F_2	Redlan x Shallu Grain	6	55	30	12	8	9
19	F_2	Redlan x PI 264453	1	39	21	19	27	13
53	F_2	Wheatland x Shallu Grain	5	27	24	25	28	11
25	F_2	Wheatland x PI 264453	18	28	20	21	13	20
27	F_2	Redlan x IS 809	2	51	12	16	24	15
22	F_2	AOKY 55 x IS 809	4	19	12	29	32	24
46	BC	PI 442 x (PI 442 x Sh. Gr.)	11	28	22	22	31	16
54	BC	PI 442 x(PI 442 x PI 453)	0	36	7	24	34	19
32	BC	PI 453 x (PI 442 x PI 453)	37	46	17	14	4	2
47	BC	PI 453 x (PI 453 x x Sh. Gr.)	27	93	0	0	0	0
3	BC	Sh. Gr. x (PI 453 x Sh. Gr.)	34	66	10	10	0	0
58	BC	Marum K. x (Marum K. x Sh. Gr.)	5	24	22	27	15	27
60	BC	Marum K. x (Marum K. x PI 453)	5	42	17	23	27	6
26	BC	PI 453 x (Marum K. x PI 453)	45	58	11	3	3	0
15	BC	(Red. x Wheat.) x Wheat.	0	0	6	22	47	45
34	BC	PI 442 x (Marum K. x PI 442)	0	0	0	24	79	17
31	BC	Red. x (Red. x Sh. Gr.)	3	37	34	13	19	14
37	BC	Red. x (Red. x PI 453)	12	30	15	16	22	25
21	BC	Wheat. x (Wheat. x Sh. Gr.)	1	12	16	16	31	44

TABLE II (Continued)

Entry Number	Generation	Pedigree	Damage Classes 1	2	3	4	5	6
44	BC	Wheat. x (Wheat. x PI 453)	0	25	11	14	19	51
2	BC	(Red. x Marum K.) x Marum K.	0	0	27	32	45	16
45	BC	(Red. x PI 442) x PI 442	0	0	41	29	42	8
8	BC	(Wheat. x Marum K.) x Marum K.	0	24	17	29	43	7
24	BC	(Wheat. x PI 442) x PI 442	0	0	33	45	24	18

TABLE III

OBSERVED AND EXPECTED FREQUENCY DISTRIBUTIONS AND REACTIONS OF PLANTS IN GREENBUG DAMAGE CLASSES

Entry Number	Generation	Pedigree	Observed			Expected*			P
			Res.	Int.	Susc.	Res.	Int.	Susc.	
14	P	PI 264453	108	12	0	Resistant			
16	P	IS 809	93	27	0	Resistant			
56	P	Shallu Grain SA 7536-1	95	25	0	Resistant			
33	P	PI 308442	0	32	88	Susceptible			
59	P	Marum Kafir	0	43	77	Susceptible			
39	P	Wheatland	0	23	97	Susceptible			
10	P	Redlan	0	29	91	Susceptible			
5	F_1	PI 453 x IS 809	107	13	0	101	19	0	.25
12	F_1	PI 453 x Sh. Gr.	118	2	0	102	18	0	$<$.005
51	F_1	Sh. Gr. x IS 809	94	26	0	94	26	0	.99
41	F_1	PI 442 x PI 453	105	14	1	Intermediate			
20	F_1	Marum K. x PI 453	99	17	4	Intermediate			
48	F_1	Wheat. x PI 453	93	14	13	Intermediate			
35	F_1	Red. x PI 453	96	24	0	Intermediate			
36	F_1	PI 442 x IS 809	110	10	0	Intermediate			
30	F_1	Marum K. x IS 809	71	35	14	Intermediate			
40	F_1	Wheat. x IS 809	63	20	37	Intermediate			
4	F_1	Red. x IS 809	60	50	10	Intermediate			
52	F_1	PI 442 x Sh. Gr.	45	71	4	Intermediate			
38	F_1	Marum K. x Sh. Gr.	67	53	0	Intermediate			
43	F_1	Wheat. x Sh. Gr.	34	73	13	Intermediate			
42	F_1	Red. x Sh. Gr.	55	39	26	Intermediate			
57	F_1	Marum K. x PI 442	0	19	101	0	37	83	$<$.005

TABLE III (Continued)

Entry Number	Generation	Pedigree	Observed Res.	Observed Int.	Observed Susc.	Expected Res.	Expected Int.	Expected Susc.	P
11	F_1	Wheat. x PI 442	18	38	64	0	28	92	
7	F_1	Red. x PI 442	20	38	62	0	31	89	
6	F_1	Wheat. x Marum K.	14	33	73	0	33	87	
50	F_1	Red. x Marum K.	0	61	59	0	36	84	$<.005$
13	F_1	Red. x Wheat.	0	47	73	0	26	94	$<.005$
18	F_2	PI 453 x Sh. Gr.	100	20	0	110	10	0	$<.005$
17	F_2	PI 442 x PI 453	40	46	22	53	23	44	$<.005$
55	F_2	Marum K. x PI 453	71	34	15	77	22	21	$<.05$
25	F_2	Wheat. x PI 453	46	41	33	73	16	31	$<.05$
19	F_2	Red. x PI 453	40	40	40	75	37	23	$<.005$
27	F_2	Red. x IS 809	53	28	39	53	39	28	.02
28	F_2	PI 442 x Sh. Gr.	46	50	24	39	44	37	.25
9	F_2	Marum K. x Sh. Gr.	64	53	3	57	44	19	$<.005$
53	F_2	Wheat. x Sh. Gr.	32	49	39	40	49	31	.20
23	F_2	Red. x Sh. Gr.	61	42	17	51	33	36	$<.005$
42	F_2	Marum K. x PI 442	0	72	48	0	28	92	$<.005$
47	BC	PI 453 x (PI 453 x Sh.Gr.)	120	0	0	113	7	0	.01
3	BC	Sh. Gr. x (PI 453 x Sh. Gr.)	100	20	0	106	14	0	.10
54	BC	PI 442 x (PI 442 x PI 453)	36	31	53	53	23	44	.01
32	BC	PI 453 x (PI 442 x PI 453)	83	31	6	106	13	1	$<.005$
60	BC	Marum x (Marum x PI 453)	47	40	33	50	30	40	.10
26	BC	PI 453 x (Marum x PI 453)	103	14	3	103	15	2	.90
44	BC	Wht. x (Wht. x PI 453)	25	25	70	46	19	55	$<.005$
37	BC	Red. x (Red. x PI 453)	42	31	47	48	27	45	.50
46	BC	PI 442 x (PI 442 x Sh. Gr.)	39	44	37	23	51	46	$<.005$

TABLE III (Continued)

Entry Number	Generation	Pedigree	Observed Res.	Observed Int.	Observed Susc.	Expected Res.	Expected Int.	Expected Susc.	P
58	BC	Marum x (Marum x Sh. Gr.)	29	49	42	33	48	39	.75
21	BC	Wht. x (Wht. x Sh. Gr.)	13	32	75	17	48	55	< .005
31	BC	Red. x (Red. x Sh. Gr.)	40	47	33	28	34	58	< .005
24	BC	PI 442 x (Wht. x PI 442)	0	24	96	0	26	94	.95
45	BC	PI 442 x (Red. x PI 442)	0	78	42	0	48	72	<.005
34	BC	PI 442 x (Marum x PI 442)	0	70	50	0	45	75	<.005
8	BC	Marum x (Wht. x Marum)	24	46	50	7	38	75	<.005
2	BC	Marum x (Red. x Marum)	0	59	61	0	52	68	.25
15	BC	Wht. x (Red. x Wht.)	0	28	92	0	35	85	.25
1	P	BOKY 55	0	5	115	Susceptible			
29	P	BOK 8	6	32	82	Susceptible			
22	F_2	AOKY 55 x IS 809	53	28	39	Segregating			

*Expected ratio based on segregation of single gene pair.

with Marum Kafir, Wheatland, and Redlan. Only one susceptible x susceptible cross, Marum Kafir x PI 308442, had predominantly susceptible plants. All other susceptible x susceptible crosses had numerous plants in the intermediate group and even some plants in the resistant group, indicating some resistance.

The F_2 population of resistant x resistant cross (PI 264453 x Shallu Grain) showed no segregation, while the F_2 population of the susceptible x susceptible cross (Marum Kafir x PI 308442) had about three-fifths of the plants in the intermediate group. The F_2 populations of resistant x susceptible crosses segregated for reaction to greenbugs. A ratio of 1 : 2 : 1 of resistant : intermediate : susceptible was proposed and tested for goodness of fit by chi-square. Only two of nine populations, PI 308442 x Shallu Grain and Wheatland x Shallu Grain, appeared to fit the hypothesis. Apparently, the F_2's involving PI 264453 expressed lower resistance than expected, while the F_2's involving Shallu Grain expressed higher resistance than expected, except for the F_2 of Wheatland x Shallu Grain. These departures could have resulted from: (a) chance segregation, (b) environmental effects at the time of the experiment, e.g., insect activities and climatic conditions, (c) hybrid vigor which was the specific property of certain crosses, (d) the effect of minor genes, and (e) variation in the rating system.

The backcross populations of resistant x F_1 (resistant x resistant) did not segregate. The backcross populations of susceptible x F_1 (susceptible x susceptible) were not expected to segregate, but two of four, PI 308442 x F_1 (Marum Kafir x PI 308442) and Marum Kafir x F_1 (Wheatland x Marum Kafir) had numerous plants in the intermediate group and even some plants in the resistant group. These were possibly a result of a low level of resistance in the susceptible parents. The backcross populations of resistant x F_1 (resistant x susceptible) and susceptible x F_1 (resistant x susceptible) showed segregation, and by using the chi-square test they were fitted to 1 : 1 ratios of resistant : intermediate and intermediate : susceptible, respectively. However, the segregation ratios tended to show lower resistance than expected in backcrosses involving PI 264453, but higher resistance than expected in some backcrosses involving Shallu Grain. This might have been due to some of the same reasons given above for departure from the expected ratios.

Considering the resistance and the intermediate resistance of some of the F_1 populations from resistant x susceptible crosses, the 1 : 1 ratios of the susceptible x F_1 (resistant x susceptible) and resistant x F_1 (resistant x susceptible) backcrosses, it was proposed that resistance was conferred by genes at one locus. The gene action may be additive, partially, or completely dominant depending on the parents involved, e.g., PI 308442 x IS 809 was completely dominant, Redlan x PI 264453 was partially dominant, and PI 308442 x Shallu Grain was additive.

The evidence above leads to a consideration of whether the resistant genes and the susceptible genes contributed by the resistant parents and by the susceptible parents, respectively, are the same. The F_1 and F_2 of susceptible x susceptible and resistant x resistant crosses were tested for homogeneity of genes (Table III) by using the chi-square test. It was revealed that in crosses among the resistant parents, negligible segregation occurred. Thus resistance contributed by these parents appeared to be at the same locus. However, sufficient differences among F_1 populations was present to suggest that the resistant genes might be an allelic series. The susceptible genes also might be an allelic series. Furthermore, the homogeneity test revealed that among this proposed allelic series of resistant genes, the sequence of gene relationships should be PI 264453 - IS 809 - Shallu Grain, and also among the allelic susceptible genes, the sequence should be Marum Kafir - PI 308442 - Redlan - Wheatland.

A possible explanation of the genotypic and phenotypic constitution of the parents, PI 264453, Shallu Grain, IS 809, PI 308442, Marum Kafir, Wheatland, and Redlan, and possible F_1 combinations with gene actions follow:

F_1's	PI 453 A_1A_1	IS 809 A_2A_2	Sh.Gr. A_3A_3	M.K. a_1a_1	PI 442 a_2a_2	Red. a_3a_3	Wheat. a_4a_4
PI 453 A_1A_1		Res. A_1A_2	Res.* A_1A_3	Part.* A_1a_1	Part.* A_1a_2	Part.* A_1a_3	Part.* A_1a_4
IS 809 A_2A_2	---		Res. A_2A_3	Part. A_2a_1	Comp. A_2a_2	Part. A_2a_3	Part. A_2a_4
Sh.Gr. A_3A_3	---	---		Part. A_3a_1	Additive A_3a_2	Additive A_3a_3	Additive A_3a_4
M.K. a_1a_1	---	---	---		Susc. a_1a_2	Susc.* a_1a_3	Susc.* a_1a_4
PI 442 a_2a_2	---	---	---	---		Susc.* a_2a_3	Susc.* a_2a_4
Red. a_3a_3	---	---	---	---	---		Susc.* a_3a_4
Wheat. a_4a_4	---	---	---	---	---	---	

Res.*: higher resistance than both parents;

Res.: resistance; Comp.: complete dominance;

Part.*: nearly complete dominance; Part.: partial dominance;

Additive: additive gene action; Susc.: susceptible;

Susc.*: higher resistance than both parents

Applying the X^2 test (Table III) according to the model on the previous page, the F_2's and the backcrosses could be summarized as follows:

	PI 453 1 2 3	IS 809 1 2 3	Sh.Gr. 1 2 3	M.K. 1 2 3	PI 442 1 2 3	Red. 1 2 3	Wheat. 1 2 3
PI 453		o o o	* + *	+ + *	* * *	o + *	o * *
IS 809	---		o o o	o o o	o o o	o o o	o o +
Sh.Gr.	---	---		o + *	o * +	o * *	o * +
M.K.	---	---	---		o * *	+ o o	* o o
PI 442	---	---	---	---		* o o	+ o o
Red.	---	---	---	---	---		o + o
Wheat.	---	---	---	---	---	---	

1 = backcross to row-parent; 2 = backcross to column parent;

3 = the F_2 from the F_1 cross; * = significance of chi-square test;

+ = non significance of chi-square test; o = no data

The average scores of damaged plants, the average plant height at infesting time and at rating time, and the average height difference from infesting time to rating time of the 60 entires are given in Table IV. Also, these averages for the 9 parental lines, the 21 F_1's,

TABLE IV

DAMAGE SCORES AND OTHER DATA FROM GREENBUG TESTS ON SORGHUMS

Entry Number	Generation	Pedigree	Av. Damage Score	Av. Ht. at: Infest. (cm)	Av. Ht. at: Rating (cm)	Ht. Diff. (cm)
12	F_1	PI 453 x Shallu Grain	1.67	3.52	14.23	10.71
47	BC	PI 453 x (PI 453 x Sh. Gr.)	1.78	3.87	13.73	9.86
26	BC	PI 453 x (Marum K. x PI 453)	1.85	3.62	12.45	8.83
18	F_2	PI 453 x Sh. Gr.	1.88	2.73	9.73	7.00
5	F_1	PI 453 x IS 809	1.92	3.45	13.95	10.50
14	P	PI 264453	1.93	3.72	15.90	12.18
51	F_1	Sh. Gr. x IS 809	1.93	3.47	10.87	7.40
3	BC	Sh. Gr. x (PI 453 x Sh. Gr.)	1.98	3.12	11.42	8.30
56	P	Shallu Grain	2.00	1.78	8.93	7.15
36	F_1	PI 442 x IS 809	2.00	2.82	10.82	8.00
20	F_1	Marum K. x PI 453	2.03	3.72	12.50	8.78
35	F_1	Redlan x PI 453	2.05	3.72	12.32	8.60
41	F_1	PI 442 x PI 453	2.07	4.08	13.35	9.27
32	BC	PI 453 x (PI 442 x PI 453)	2.23	3.27	11.38	8.12
48	F_1	Wheat. x PI 453	2.25	4.42	16.05	11.63
16	P	IS 809	2.25	2.92	9.98	7.06
38	F_1	Marum K. x Sh. Gr.	2.40	2.58	8.92	6.34
30	F_1	Marum K. x IS 809	2.57	2.67	9.50	6.83
9	F_2	Marum K. x Sh. Gr.	2.60	1.98	9.18	7.20
4	F_1	Redlan x IS 809	2.72	2.60	9.58	6.98
55	F_2	Marum K. x PI 453	2.72	3.65	12.53	8.88
28	F_2	PI 442 x Sh. Gr.	2.93	1.62	7.28	5.67
40	F_1	Wheat. x IS 809	2.95	3.47	10.88	7.42
23	F_2	Redlan x Sh. Gr.	2.97	1.85	9.98	8.13
52	F_1	PI 442 x Sh. Gr.	3.08	2.42	9.57	7.15
42	F_1	Redlan x Sh. Gr.	3.17	2.72	10.45	7.73
43	F_1	Wheat. x Sh. Gr.	3.23	3.37	9.10	5.73
17	F_2	PI 442 x PI 453	3.32	2.98	10.80	7.82
60	BC	Marum K. x (Marum K. x PI 453)	3.35	2.33	9.30	6.97
25	F_2	Wheat. x PI 453	3.37	4.37	14.52	10.15
31	BC	Red. x (Red. x Sh.Gr.)	3.45	1.93	8.58	6.65
27	F_2	Redlan x IS 809	3.47	2.52	10.28	7.77
19	F_2	Redlan x PI 453	3.50	3.62	9.62	6.00
53	F_2	Wheat. x Sh. Gr.	3.60	2.02	6.55	4.53
46	BC	PI 442 x (PI 442 x Sh. Gr.)	3.60	2.27	8.95	6.63

TABLE IV (Continued)

Entry Number	Generation	Pedigree	Av. Damage Score	Av. Ht. at: Infest. (cm)	Rating	Ht. Diff. (cm)
37	BC	Red. x (Red. x PI 453)	3.72	2.53	9.22	6.69
58	BC	Marum K. x (Marum K. x Sh. Gr.)	3.83	2.43	7.71	4.74
22	F_2	AOKY 55 x IS 809	3.95	2.58	6.97	4.38
54	BC	PI 442 x (PI 442 x PI 453)	3.95	3.20	9.50	6.30
8	BC	(Wheat. x Marum K.) x Marum K.	3.95	2.53	9.33	6.80
45	BC	(Red. x PI 442) x PI 442	4.17	2.12	9.13	7.02
11	F_1	Wheatland x PI 442	4.18	3.38	10.27	6.88
49	F_2	Marum K. x PI 442	4.22	1.55	6.77	5.22
24	BC	(Wheat. x PI 442) x PI 442	4.25	2.32	9.00	6.68
7	F_1	Redlan x PI 442	4.28	2.87	8.98	6.11
50	F_1	Redlan x Marum K.	4.35	2.80	8.05	5.25
2	BC	(Red. x Marum K.) x Marum K.	4.43	2.48	7.12	5.24
13	F_1	Redlan x Wheatland	4.48	2.85	9.35	6.50
21	BC	Wheat. x (Wheat. x Sh. Gr.)	4.48	2.67	8.87	6.20
44	BC	Wheat. x (Wheat x PI 453)	4.50	3.35	9.45	6.10
59	P	Marum Kafir	4.55	2.85	7.55	4.70
6	F_1	Wheatland x Marum K.	4.68	3.63	9.68	6.05
34	BC	PI 442 x (Marum K. x PI 442)	4.95	1.83	5.02	3.18
10	P	Redlan	5.00	2.70	7.32	4.62
57	F_1	Marum K. x PI 442	5.07	2.22	7.12	4.90
29	P	BOK 8	5.07	2.50	7.33	4.83
1	P	BOKY 55	5.08	2.40	5.52	3.12
33	P	PI 308442	5.15	2.77	7.27	4.50
15	BC	(Red. x Wheat.) x Wheat.	5.15	2.53	7.03	4.50
39	P	Wheatland	5.20	3.72	7.05	3.33
		Average	3.91	2.87	9.73	6.86
		L.S.D. .05	0.82	0.67	2.83	2.72
		L.S.D. .01	1.08	0.88	3.71	3.57

Correlation factor (r) between:

damage score and height at infesting = -0.364

damage score and height difference = -0.783

r(.05) = 0.255

r(.01) = 0.330

the 12 F_2's and the 18 backcrosses are given in Tables V, VI, VII, and VIII, respectively. Among the resistant parents, PI 264453 was most resistant, Shallu Grain was next, and IS 809 was least resistant. Nevertheless, the damage scores among them were not significantly different. Among the F_1 average damage scores, the crosses of resistant x resistant parents had the lowest damage scores. These were followed by crosses of resistant x susceptible parents. The crosses of susceptible x susceptible parents had the highest damage scores. In some cases the F_1's had more resistance than either parent and in other cases they were more resistant than the average of the parents. The F_1's of resistant x resistant crosses were more resistant than either parent, but not significantly. The F_1's of resistant x susceptible crosses were more resistant than the average of the parents, and a few crosses were significantly more resistant than the average of their parents, e.g., crosses of PI 308442 x PI 264453, and PI 308442 x IS 809.

Among the average damage scores of the F_1's, the crosses involving PI 264453 were most resistant, followed by crosses of IS 809, and finally by crosses of Shallu Grain. The crosses involving PI 264453 were significantly more resistant than the crosses involving Shallu Grain, but not significantly more than the crosses involving IS 809. The crosses involving IS 809 were not significantly more resistant than the crosses involving Shallu Grain. This evidence suggests in general that the degree of dominance of the resistant gene in the parent, PI 264453, was higher than Shallu Grain, but not higher than IS 809. PI 264453 expressed nearly complete dominance, whereas IS 809 expressed partial dominance, and Shallu Grain expressed additive gene action over the susceptible parents. However, in some specific crosses, IS 809

TABLE V

DAMAGE SCORES AND OTHER DATA FROM GREENBUG TESTS ON PARENTAL LINE SORGHUMS

Entry Number	Gener- ation	Pedigree		Av. Damage Score	Av. Ht. at: Infest. (cm)	Rating	Ht. Diff. (cm)
14	P	PI 264453		1.93	3.72	15.90	12.18
56	P	Shallu Grain		2.00	1.78	8.93	7.15
16	P	IS 809		2.25	2.92	9.98	7.06
59	P	Marum Kafir		4.55	2.85	7.55	4.70
10	P	Redlan		5.00	2.70	7.32	4.62
29	P	BOK 8		5.07	2.50	7.33	4.83
1	P	BOKY 55		5.08	2.40	5.52	3.12
33	P	PI 308442		5.15	2.77	7.27	4.50
39	P	Wheatland		5.20	3.72	7.05	3.33
		Average		4.26	2.82	8.54	5.72
		L.S.D.	.05	0.54	0.48	2.37	2.27
			.01	1.33	1.18	5.85	5.61
		C. V. (%)		13.89	17.69	28.86	41.24

Correlation coefficient (r) between:

damage score and height at infesting = +0.020

damage score and height difference = -0.848

r(.05) = ±0.666

r(.01) = ±0.798

TABLE VI

DAMAGE SCORES AND OTHER DATA FROM GREENBUG TESTS ON F_1 SORGHUMS

Entry Number	Generation	Pedigree	Av. Damage Score	Av. Ht. at: Infest. (cm)	Av. Ht. at: Rating (cm)	Ht. Diff. (cm)
12	F_1	PI 453 x Sh. Gr.	1.67	3.52	14.23	10.71
5	F_1	PI 453 x IS 809	1.92	3.45	13.95	10.50
51	F_1	Sh. Gr. x IS 809	1.93	3.47	10.87	7.40
36	F_1	PI 442 x IS 809	2.00	2.82	10.82	8.00
20	F_1	Marum K. x PI 453	2.03	3.72	12.50	8.78
35	F_1	Redlan x PI 453	2.05	3.72	12.32	8.60
41	F_1	PI 442 x PI 453	2.07	4.08	13.35	9.27
48	F_1	Wheat. x PI 453	2.25	4.42	16.05	11.63
38	F_1	Marum K. x Sh. Gr.	2.40	2.58	8.92	6.34
30	F_1	Marum K. x IS 809	2.57	2.67	9.50	6.83
4	F_1	Redlan x IS 809	2.72	2.60	9.58	6.98
40	F_1	Wheat. x IS 809	2.95	3.47	10.88	7.42
52	F_1	PI 442 x Sh. Gr.	3.08	2.42	9.57	7.15
42	F_1	Redlan x Sh. Gr.	3.17	2.72	10.45	7.73
43	F_1	Wheat. x Sh. Gr.	3.23	3.37	9.10	5.73
11	F_1	Wheat x PI 442	4.18	3.38	10.27	6.88
7	F_1	Redlan x PI 442	4.28	2.87	8.98	6.11
50	F_1	Redlan x Marum K.	4.35	2.80	8.05	5.25
13	F_1	Redlan x Wheat.	4.48	2.85	9.35	6.50
6	F_1	Wheat. x Marum K.	4.68	3.63	9.68	6.05
57	F_1	Marum K. x PI 442	5.07	2.22	7.12	4.90
		Average	3.00	3.18	10.74	7.56
		L.S.D. .05	0.91	0.70	2.73	2.72
		L.S.D. .01	1.20	0.92	3.62	3.60
		C. V. (%)	26.47	19.19	22.25	31.43

Correlation coefficient (r) between:

damage score and height at infesting = -0.419

damage score and height difference = -0.747

r(.05) = $\pm$0.433

r(.01) = $\pm$0.549

TABLE VII

DAMAGE SCORES AND OTHER DATA FROM GREENBUG TESTS ON F_2 SORGHUMS

Entry Number	Generation	Pedigree		Av. Damage Score	Av. Ht. at: Infest (cm)	Rating	Ht. Diff. (cm)
18	F_2	PI 453 x Sh. Gr.		1.88	2.73	9.73	7.00
9	F_2	Marum K. x Sh. Gr.		2.60	1.98	9.18	7.20
55	F_2	Marum K. x PI 453		2.72	3.65	12.53	8.88
28	F_2	PI 442 x Sh. Gr.		2.93	1.62	7.28	5.67
23	F_2	Redlan x Sh. Gr.		2.97	1.85	9.98	8.13
17	F_2	PI 442 x PI 453		3.32	2.98	10.80	7.82
25	F_2	Wheat. x PI 453		3.37	4.37	14.52	10.15
27	F_2	Redlan x IS 809		3.47	2.52	10.28	7.77
19	F_2	Redlan x PI 453		3.50	3.62	9.62	6.00
53	F_2	Wheat. x Sh. Gr.		3.60	2.02	6.55	4.53
22	F_2	AOKY 55 x IS 809		3.95	2.58	6.97	4.38
49	F_2	Marum K. x PI 442		4.22	1.55	6.77	5.22
		Average		3.21	2.62	9.52	6.90
		L.S.D.	.05	0.73	0.69	2.27	2.19
			.01	1.80	1.71	5.58	5.40
		C.V. (%)		23.72	27.61	25.44	33.14

Correlation coefficient (r) between:

damage score and height at infesting = -0.113

damage score and height difference = -0.417

r(.05) = ± 0.576

r(.01) = ± 0.708

TABLE VIII

DAMAGE SCORES AND OTHER DATA FROM GREENBUG TESTS ON SOME BACKCROSS SORGHUMS

Entry Number	Generation	Pedigree	Av. Damage Score	Av. Ht. at: Infest. (cm)	Rating (cm)	Ht. Diff. (cm)
47	BC	PI 453 x (PI 453 x Sh. Gr.)	1.78	3.87	13.73	9.86
26	BC	PI 453 x (Marum K. x PI 453)	1.85	3.62	12.45	8.83
3	BC	Sh. Gr. x (PI 453 x Sh. Gr.)	1.98	3.12	11.42	8.30
32	BC	PI 453 x (PI 442 x PI 453)	2.23	3.27	11.38	8.12
60	BC	Marum K. x (Marum K. x PI 453)	3.35	2.33	9.30	6.97
31	BC	Red. x (Red. x Sh. Gr.)	3.45	1.93	8.58	6.65
46	BC	PI 442 x (PI 442 x Sh. Gr.)	3.60	2.27	8.95	6.63
37	BC	Red. x (Red. x 453)	3.72	2.53	9.22	6.69
58	BC	Marum K. x (Marum K. Sh. Gr.)	3.83	2.43	7.17	4.74
54	BC	PI 442 x (PI 442 x PI 453)	3.95	3.20	9.50	6.30
8	BC	(Wheat x Marum K.) x Marum K.	3.95	2.53	9.33	6.80
45	BC	(Red. x PI 442) x PI 442	4.17	2.12	9.13	7.02
24	BC	(Wheat x PI 442) x PI 442	4.25	2.32	9.00	6.68
2	BC	(Red. x Marum K.) x Marum K.	4.43	2.48	7.12	5.24
21	BC	Wheat. x (Wheat. x Sh. Gr.)	4.48	2.67	8.87	6.20
44	BC	Wheat. x (Wheat. x PI 453)	4.50	3.35	9.45	6.10
34	BC	PI 442 x (Marum K. x Wheat.	4.95	1.83	5.02	3.18
15	BC	(Red. x Wheat.) x Wheat.	5.15	2.53	7.03	4.50
		Average	3.65	2.69	9.29	6.60
		L.S.D. .05	0.69	0.46	2.57	2.40
		L.S.D. .01	1.70	1.13	6.31	6.03
		C. V. (%)	19.83	17.90	28.93	38.93

TABLE VIII (Continued)

Entry Number	Generation	Pedigree	Av. Damage Score	Av. Ht. at: Infest. Rating (cm)	Ht. Diff. (cm)

Correlation coefficient (r) between:

damage score and height at infesting = -0.638

damage score and height difference = -0.877

r(.05) = ±0.468

r(.01) = ±0.590

expressed complete dominance, as over PI 308442, and Shallu Grain expressed partial dominance, as over Marum Kafir.

The average damage scores of the F_2 populations showed less resistance when compared to the average damage scores of the F_1 plants, except for Redlan x Shallu Grain and Marum Kafir x PI 308442 crosses. This might suggest hybrid vigor of the F_1 plants. Above it was pointed out that the F_1 damage scores were less than the average damage scores of the parents involved. Hybrid vigor might help explain the fact that the average damage scores of the F_1 plants were less than the average damage scores of the F_2 plants. Chance segregation of the F_2 plants would also have an effect if they showed more of the less resistant plants or more resistant plants than expected. Chance segregation might also explain why the F_2 plants of Marum Kafir x PI 308442 and Redlan x Shallu Grain had higher resistance than the F_1 plants.

The average height of plants at infesting time and at rating time, and also the height difference from infesting time to rating time were studied. The resistant parent, PI 264453, is a tall forage type, whereas Shallu Grain is a short grassy type and IS 809 is a short grain type. The susceptible parent, Marum Kafir, is tall forage type, whereas PI 308442, Wheatland, and Redlan are short grain types. This might indicate that the average height at infesting time would be unrelated to resistance. However, the average height at rating time of the resistant plants tended to be more than of the susceptible plants. Also, the height differences from infesting time to rating time of the resistant plants were more than of the susceptible plants. This suggested that under greenbug infestation, the resistant plants grew more than the susceptible plants.

To gain more information on the possible relationship of plant height to resistance, correlations were calculated between damage score and plant height at infesting time, and between damage score and height difference from infesting time to rating time. The simple correlation coefficients between damage score and height at infesting time of the parental lines, the F_1, and the F_2 populations were not significant, while the backcross and the overall populations were significant. The majority of the backcross populations involved the resistant parent, PI 264453, and the other susceptible parents. The crosses involving PI 264453 were generally taller than the crosses involving other parents. Thus, the simple correlation coefficient was significant in backcross populations. The backcross populations were one component of the overall populations, possibly explaining why the simple correlation coefficient was significant in the overall populations.

The simple correlation coefficients between damage score and height difference from infesting time to rating time were significant in all populations, except the F_2 populations. Ten of 12 of the F_2 populations were progenies of resistant x susceptible parents, while one came from resistant x resistant (PI 264453 x Shallu Grain), and one from susceptible x susceptible (Marum Kafir x PI 308442). This resulted in a similar distribution of resistance among the F_2 plants independent of height difference, and consequently a nonsignificant correlation coefficient.

The studies of correlations between damage score and height at infesting time, and correlations between damage score and height difference from infesting time to rating time, indicated that the height at infesting time was dependent on the characteristics of the individual plants, whereas height at rating time was dependent on the resistant capability of the individual plants, and probably on plant characteristics, also.

CHAPTER V

SUMMARY AND CONCLUSION

A study was conducted to determine the inheritance of greenbug resistance, and to compare three sources of resistance to greenbugs. Sixty entries of sorghum plants including 9 parental lines, 21 F_1's, 12 F_2's, and 18 backcrosses were planted in metal flats in the greenhouse. Three to 4 days after emergence, seedling plants were infested with Biotype C of greenbug. At the time of infestation the average height of the above ground portion of the plants in each row was recorded. To obtain uniform infestation, certain flats were reinfested three or four times. Nine to 12 days after first infestation, individual plant ratings to greenbugs on a damage scale of 1 to 6 were taken. At the same time the average plant height per row was recorded.

On the basis of individual damage scores, resistance appeared to be conferred by genes at one locus. The resistant genes of the three parents seemed to be at the same locus, but they were differentiated within the locus (an allelic series). Gene actions appeared to be additive, partially, or completely dominant depending on the parents and crosses involved. The susceptible parents appeared to have some minor factors enhancing their resistant capabilities. Crosses involving PI 264453 produced the most resistance, followed by IS 809, and finally Shallu Grain.

Correlations between damage score and height at infesting time for individual populations were not significant, except for the back-cross and the overall populations. Correlations between damage score and height difference from infesting time to rating time were significant in all populations, except for the F_2 population. This indicated that plants which were damaged less grew more rapidly.

It appeared throughout the experiment that F_1 and F_2 hybrid plants tended to show a higher level of resistance than expected. Only one cross indicated complete dominance.

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A P P E N D I X

TABLE IX

COMPARISONS F_1 AND F_2 OF RESISTANT PARENTS CROSSED TO SUSCEPTIBLE PARENTS

		PI 453 (1.93)	Sh.Gr. (2.00)	IS 809 (2.25)
F_1:	PI 442 (5.15)	2.07	3.08	2.00
	M.K. (4.55)	2.03	2.40	2.57
	Wheat. (5.20)	2.25	3.23	2.95
	Red. (5.00)	2.05	3.17	2.72
	Mean	2.10	2.97	2.56
F_2:	PI 442	3.32	2.93	---
	M.K.	2.72	2.60	---
	Wheat.	3.37	3.60	---
	Red.	3.50	2.97	---
	Mean	3.23	3.03	---
	Mean (F_1+F_2)	2.66	3.00	---

t-values of F_1: PI 453 v.s. Sh.Gr. = 4.97
PI 453 v.s. IS 809 = 2.55
Sh.Gr. v.s. IS 809 = 1.58
t-table: .05 = 3.18
.01 = 5.84

t-value of F_2: PI 453 v.s. Sh.Gr. = 1.20
t(.05) = 3.18

t-value of (F_1+F_2): PI 453 v.s. Sh. Gr. = 1.44
t(.05) = 2.36

TABLE X

DAMAGE SCORES OF THE F_1'S

From the crosses of:	PI 453	IS 809	Sh.Gr.
(a) resistant x susceptible			
PI 442	2.07	2.00	3.08
M.K.	2.03	2.57	2.40
Wheat.	2.25	2.95	3.23
(b) resistant x resistant			
PI 453	---	1.92	1.67
IS 809	---	---	1.93
Sh.Gr.	---	---	---

(c) susceptible x susceptible	PI 442	M.K.	Wheat.	Red.
PI 442	---	5.07	4.18	4.28
M.K.	---	---	4.68	4.35
Wheat.	---	---	---	4.48
Red.	---	---	---	---

TABLE XI

ANALYSIS OF VARIANCE OF THE PARENTAL LINES DATA

Source of variation	d.f.	S.S.	M.S.
(a) Damage score			
Total (cor.)	53	125.3437	
Rep.	5	6.6015	1.3203
Entry	8	106.2237	13.2780
Residual	40	12.5185	0.3130
(b) Height at infesting time			
Total (cor.)	53	88.2750	
Rep.	5	60.4106	12.0821
Entry	8	17.9333	2.2417
Residual	40	9.9311	0.2483
(c) Height at rating time			
Total (cor.)	53	1399.6883	
Rep.	5	716.8239	143.3648
Entry	8	439.9333	54.9917
Residual	40	242.9311	6.0733
(d) Height difference			
Total (cor.)	53	976.8533	
Rep.	5	185.6626	37.1325
Entry	8	40.3105	2.0155
Residual	40	222.7689	5.5692

TABLE XII

ANALYSIS OF VARIANCE OF THE F_1 DATA

(a) Damage score

Source of variation	d.f.	S.S.	M.S.
Rep.	5	25.3080	5.0616
Entry	20	139.5230	6.9761
Residual	100	63.2370	0.6324
Corrected Total	125	228.0680	

(b) Height at infesting time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	185.6626	37.1325
Entry	20	40.3105	2.0155
Residual	100	37.2190	0.3722
Corrected Total	125	263.1921	

(c) Height at rating time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	1863.9987	372.7997
Entry	20	601.2916	30.0646
Residual	100	570.7713	5.7077
Corrected Total	125	3036.0616	

(d) Height difference

Source of variation	d.f.	S.S.	M.S.
Rep.	5	895.5414	179.1083
Entry	20	391.1244	19.5562
Residual	100	564.7737	5.6477
Corrected Total	125	1851.4394	

TABLE XIII

ANALYSIS OF VARIANCE OF THE F_2 DATA

(a) Damage score

Source of variation	d.f.	S.S.	M.S.
Rep.	5	10.2857	2.0571
Entry	11	26.4615	2.4056
Residual	55	31.8760	0.5796
Corrected Total	71	68.6232	

(b) Height at infesting time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	54.5844	10.9169
Entry	11	52.6544	4.7868
Residual	55	28.8256	0.5241
Corrected Total	71	136.0644	

(c) Height at rating time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	557.0490	111.4098
Entry	11	387.4482	35.2226
Residual	55	322.4093	5.8620
Corrected Total	71	1266.9065	

(d) Height difference

Source of variation	d.f.	S.S.	M.S.
Rep.	5	271.4029	54.2806
Entry	11	208.8471	18.9861
Residual	55	287.2988	5.2236
Corrected Total	71	767.5488	

TABLE XIV

ANALYSIS OF VARIANCE OF THE BACKCROSSES DATA

(a) Damage score

Source of variation	d.f.	S.S.	M.S.
Rep.	5	31.2318	6.2464
Entry	17	110.7419	6.5142
Residual	85	44.4548	0.5230
Corrected Total	107	186.4285	

(b) Height at infesting time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	110.3867	22.0773
Entry	17	34.3033	2.0178
Residual	85	19.6967	0.2317
Corrected Total	107	164.3867	

(c) Height at rating time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	1386.0542	277.2108
Entry	17	419.7075	24.6887
Residual	85	614.1208	7.2250
Corrected Total	107	2419.8825	

(d) Height difference

Source of variation	d.f.	S.S.	M.S.
Rep.	5	741.6531	148.3306
Entry	17	258.9375	15.2316
Residual	85	561.7186	6.6085
Corrected Total	107	1562.3092	

TABLE XV

ANALYSIS OF VARIANCE OF THE OVERALL DATA

(a) Damage score

Source of variation	d.f.	S.S.	M.S.
Rep.	5	68.3202	13.6640
Entry	59	432.9982	7.3390
Residual	295	157.1931	0.5329
Corrected Total	359	658.5116	

(b) Height at infesting time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	402.5379	80.5076
Entry	59	165.3099	2.8019
Residual	295	104.1788	0.3531
Corrected Total	359	672.0266	

(c) Height at rating time

Source of variation	d.f.	S.S.	M.S.
Rep.	5	4432.8664	886.5732
Entry	59	2077.4294	35.2107
Residual	295	1841.2933	6.2417
Corrected Total	359	8351.5875	

(d) Height difference

Source of variation	d.f.	S.S.	M.S.
Rep.	5	2220.8750	444.1750
Entry	59	1373.8136	23.2850
Residual	295	1702.5333	5.7713
Corrected Total	359	5297.2219	

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