COMPONENTS OF GENERATION MEANS FOR RESISTANCE TO GRAIN MOLD-CAUSING FUNGI CURVULARIA AND FUSARIUM IN SORGHUM

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SUMMARY

A generation mean analysis of resistance to two sorghum (Sorghum bicolor L. Moench) grain molds, namely, C. lunata and F. moniliforme, was carried out. Parental, F_1, F_2 and backcross generations of eight crosses, representing high susceptible x low susceptible, high susceptible x high susceptible and low susceptible x low susceptible combinations were studied after evaluating grain mold susceptibility by inoculations in the field. The results indicated large dominance effects and significant epistatic effects for resistance to both C. lunata and F. moniliforme. In a majority of the crosses duplicate type of interactions governed resistance to F. moniliforme. Although additive and additive x additive effects were present, they were only next in importance to the dominance effects.

Additional index Words: Sorghum bicolor (Moench) Curvularia lunata (Wakker) Fusarium moniliforme (Sheld), Percent infection, Inheritance, Gene effects, Genic interaction, Duplicate epistasis.

INTRODUCTION

Grain molds are recognized as a major limiting factor for increased production of sorghum (Sorghum bicolor L. Moench) since they reduce the yield and quality of grain (Williams and Rao, 1980). Early maturing improved cultivars which frequently mature during wet weather are particularly vulnerable to grain molds. Curvularia spp. and Fusarium spp. have been identified as the most important parasitic fungi that cause sorghum grain molds in the tropical as well as temperate countries (Castor and Frederiksen, 1980; Williams and Rao, 1980). Exploitation of host plant resistance is an economic and reliable solution to the problem of sorghum grain molds and some progress has been made towards this end (Murty et al. 1980). Preliminary studies by Murty et al. (1980) indicated that resistance of sorghum grains to Curvularia lunata (Wakker) Boedijn and Fusarium moniliforme Sheld. is polygenic. Further studies on generation means of resistance to these two fungi were taken up to make an assessment of the nature and magnitude of various types of gene action controlling resistance to these two fungi and the results are reported in this paper.

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MATERIALS AND METHODS

In 1977, a set of eight genetically homozygous cultivars, comprising four low mold susceptible and four high susceptible, were chosen for this study, on the basis of preliminary screening carried out at ICRISAT Center on a wide range of germplasm and breeding material under artificially inoculated mold conditions (Rao and Williams, 1980). The high susceptible cultivars were SC-120, SPV-104, 370 (CSV-3) and H-112 while IS-9327, IS-9530, E35-1 and CS-3541 (CSV-4) were the low susceptible parents. Pericarp color of all the parents except IS-9530 was white. These eight parents were used to make eight crosses representing low susceptible x high susceptible, low susceptible x low susceptible and high susceptible x high susceptible combinations. The parents and the cross combinations were so chosen as to minimize wide segregation for plant and seed color and days to 50% flowering, since grain mold assessments on widely segregating material could be biased due to variation in maturity and color of the grains. The eight F_1 crosses were advanced to the F_2 generation and also backcrossed to their respective parents. The parents, F_1, F_2 and backcross generations of the crosses were planted on 27 June 1979 at the ICRISAT Center, Patancheru for an assessment of infection caused to the grains by C. lunata and F. moniliforme.

Test plants were sprayed separately with inoculum of either C. lunata or F. moniliforme following the methods described by Rao and Williams (1980). The inoculum was an aqueous mycelial/conidial suspension (20,000 conidia /ml) of either Curvularia lunata or Fusarium moniliforme. The inoculum was sprayed on the panicles two days after anthesis and the panicles were covered with paper bags. The bags were removed from the panicles 25 days after flowering. Days to 50% flower of individual panicles inoculated ranged from 62 to 79. General experience of sorghum workers is that wet weather following flowering is necessary for grain mold development. The rainfall during the month of September and the first week of October 1979 recorded at the ICRISAT Center totalled 362mm while the maximum and minimum temperature and relative humidity averaged 32 °C to 21 °C and 95 to 52 percent respectively. Climatic conditions were conducive for the development of grain molds. This was also evidenced by the fact that susceptible parents showed profuse mold development. Grain mold damage due to Curvularia and Fusarium were rated on the basis of percent grain infection per panicle. The number of plants inoculated with each of the two fungi separately in the parental and F_1 generation was around 50 while in the backcross generation it ranged from 144 to 222 and in the F_2 generation from 351 to 486. Approximately ten percent of the panicles inoculated with either Curvularia lunata or Fusarium moniliforme showed some natural infection with other fungi also. However, such panicles were scored only for infection by the fungus inoculated.

An examination of the individual mold ratings among the segregating and non-segregating populations showed that their distribution was not normal as approximately 25% of the values were outside the 20 to 80% infection range. Since also the correlation between the means and the variances was non-significant the original percentages were transformed to arcsins (Sokal and Rohlf, 1969) to compute means and variances for the A, B and C scaling tests of Mather and Jinks (1971). As the scaling tests indicated significant deviations from a simple additive dominance gene action model, generation means of the transformed data were analysed following the two gene interaction models and formulae of Mather and Jinks (1971). The computations of [m], [d],[h], [i], [j] and [l] effects was done considering the low mold susceptible parent as P_1.

RESULTS AND DISCUSSION

The mean reaction of the parents, F_1, F_2 and backcross generations to grain mold inoculation with Curvularia lunata and Fusarium moniliforme on the original scale are presented in Tables 1 and 2. A cursory examination of the parental and F_1 generation means computed from the original as well as transformed data revealed that in most of the crosses studied, the F_1 hybrids were less susceptible to C. lunata and F. moniliforme than the mid-parent, indicating that resistance exhibited dominance effects. There were significant heterotic effects for low susceptibility in the cross SC-120 x SPV-104. The results of the individual A, B and C scaling tests of Mather and Jinks (1971) carried out on the transformed data showed highly significant deviations from a simple additive dominance model, for all the eight crosses.

Estimates of the additive, dominance and interaction components obtained by applying the six parameter model of Mather and Jinks (1971) are given in Tables 3 and 4. In the case of reaction to C. lunata, the [d] values representing additive effects were significant in all the crosses except IS 9327 x IS 9530 and were generally smaller than the dominance effects. The dominance or [h] effects were significant in five crosses and were of large magnitude, particularly in the crosses SC 120x SPV 104 and E35-1xCS 3541. Significant additive x dominance or [j] effects were present in most of the crosses and were large particularly in the cross SC 120xIS 9327. The [l] effects representing dominance x dominance interactions were significant only in two crosses, namely, SC 120x SPV 104 and E35-1 x CS 3541. These two crosses were heterotic and the signs of the [h] and [l] effects were in opposite directions, indicating "duplicate" type of interaction.

The components of generation means for reaction to F. moniliforme indicated (Table 4) that the dominance and dominance x dominance interaction effects were larger in magnitude than any of the other parameters. They consistently showed opposite signs indicating that "duplicate" type of interactions were of major importance in the genetic control of resistance to F. moniliforme. The additive x dominance types of interaction were significant and large in the crosses SC 120xIS 9327, 370xIS 9327 and CS 3541 x 370. The additive x additive interaction effects were significant and were of substantial magnitude in crosses 370 x IS 9327 and CS 3541 x 370. Although the interpretations establish the significance of gene interactions in the inheritance of resistance to Fusarium and Curvularia, they suffer from limitations arising from the assumptions of the genetic models applied. These models do not account for linkage and higher order interaction effects as these were assumed to be absent. Dabholkar and Baghel (2) reported significant general combining ability and specific combining ability effects for resistance to C. lunata on the

Table 1. Generation means of reaction of sorghum grains to *Curvularia lunata**

Cross ♀ ♂	$\bar{P}_1$	$\bar{P}_2$	$\bar{F}_1$	$\bar{F}_2$	$\bar{B}_1$	$\bar{B}_2$
SC-120xSPV-104	84.2 ± 2.2	61.4 ± 2.9	49.0 ± 2.3	45.6 ± 1.2	46.0 ± 0.6	44.0 ± 0.8
SC-120xIS 9327	84.2 ± 2.2	31.2 ± 1.8	34.6 ± 2.1	47.4 ± 1.4	46.0 ± 0.7	51.0 ± 1.2
IS 9327xIS 9530	31.2 ± 1.8	30.8 ± 1.4	28.3 ± 1.9	43.0 ± 1.1	34.0 ± 1.6	38.0 ± 2.3
370 x IS 9327	91.0 ± 1.7	31.2 ± 1.8	36.0 ± 1.5	56.2 ± 1.3	60.0 ± 1.9	39.0 ± 1.3
E35-1xCS 3541	33.4 ± 2.1	43.0 ± 2.8	32.0 ± 1.5	57.9 ± 1.5	47.0 ± 1.9	39.0 ± 1.3
CS 3541x 370	43.0 ± 2.8	91.0 ± 1.7	40.0 ± 1.8	58.1 ± 1.1	49.0 ± 1.8	61.0 ± 1.2
SPV 104xCS 3541	61.4 ± 2.9	43.0 ± 2.8	34.0 ± 1.4	56.3 ± 1.2	56.0 ± 0.9	50.0 ± 1.9
IS 9327xH 112	31.2 ± 1.8	80.0 ± 2.7	44.0 ± 2.2	57.0 ± 1.3	44.0 ± 1.4	65.0 ± 1.1

* Means and standard errors presented are on the original scale of evaluation

Table 2. Generation means of reaction of sorghum grains to *Fusarium moniliforme**

Cross ♀ ♂	$\bar{P}_1$	$\bar{P}_2$	$\bar{F}_1$	$\bar{F}_2$	$\bar{B}_1$	$\bar{B}_2$
SC 120xSPV 104	83.0 ± 1.8	69.0 ± 2.3	47.0 ± 2.3	47.3 ± 1.2	47.0 ± 0.4	45.0 ± 1.1
SC 120xIS 9327	83.0 ± 1.8	34.6 ± 1.8	32.0 ± 2.2	42.8 ± 1.2	51.0 ± 0.9	53.0 ± 1.3
IS 9327 x IS 9530	34.6 ± 1.8	30.4 ± 1.7	29.0 ± 1.9	39.4 ± 1.0	32.0 ± 1.4	37.0 ± 1.9
370 x IS 9327	83.8 ± 2.2	34.6 ± 1.8	37.0 ± 1.6	47.3 ± 1.2	58.0 ± 1.7	50.0 ± 1.8
E35-1xCS 3541	33.4 ± 1.7	35.6 ± 2.3	32.0 ± 1.3	49.6 ± 1.8	44.0 ± 1.8	50.0 ± 2.1
CS 3541 x 370	35.6 ± 2.3	83.8 ± 2.2	37.0 ± 1.5	48.6 ± 1.1	53.0 ± 1.5	57.0 ± 1.1
SPV 104xCS 3541	69.0 ± 2.3	35.6 ± 2.3	34.0 ± 1.3	56.4 ± 1.3	60.0 ± 1.5	53.0 ± 2.1
IS 9327 x H 112	34.6 ± 1.8	72.4 ± 2.8	45.0 ± 1.3	42.3 ± 1.3	50.0 ± 2.1	62.0 ± 1.8

* Means and standard errors presented are on the original scale of evaluation

Table 3. Genetic effects for reaction of sroghum grains to <u>Curvularia lunata</u>†

Cross ♀ × ♂	[m]	[d]	[h]	[i]	[j]	[l]
SC 120 x SPV 104	65.5 ± 8.4**	-9.5 ± 1.4**	-88.5 ± 19.5**	- 4 ± 8.3	19 ± 3.7**	87 ± 17.9**
SC 120 x IS 9327	33.5 ± 4.8**	-18.5 ± 1.2**	-27.5 ± 10.7**	- 6 ± 4.6	43 ± 2.9**	5 ± 6.5
IS 9327 x IS 9530	53.5 ± 5.0**	- 0.5 ± 0.7	-24.5 ± 13.5	-20 ± 5.0**	9 ± 4.1*	3 ± 8.8
370 x IS 9327	74.0 ± 5.6**	-22.0 ± 1.1**	-53.0 ± 14.2**	-18 ± 5.5**	14 ± 4.3**	14 ± 9.5
E35-1 x CS 3541	82.0 ± 5.7**	- 3.0 ± 1.3*	-68.0 ± 13.8**	-44 ± 5.6**	18 ± 3.9**	20 ± 8.5**
CS 3541 x 370	65.5 ± 5.3**	-18.5 ± 1.1**	-30.5 ± 13.5*	- 6 ± 5.2	27 ± 4.2**	3 ± 8.9
SPV 104 xxCS 3541	62.5 ± 4.8**	- 5.5 ± 1.4**	-19.5 ± 11.8	-16 ± 4.6**	3 ± 3.7	-7 ± 7.3
IS 9327 x R 112	61.0 ± 5.1**	-17.0 ± 1.2**	-21.0 ± 12.4	-10 ± 4.9*	8 ± 3.8*	2 ± 7.9

†Based on transformed data

*Significant at 5% probability

**Significant at 1% probability

Table 4. Genetic effects for reaction of sorghum grains to *Fusarium moniliforme*†

Cross ♀ ♂	[m]	[d]	[h]	[i]	[j]	[l]
SC 120 x SPV 104	72.5 ± 4.2**	- 5.5 ± 1.2**	-81.5 ± 6.4**	-10 ± 4.0**	9 ± 2.9**	53 ± 6.1**
SC 120 x IS 9327	34.0 ± 4.1**	-16.0 ± 0.8**	32.0 ± 7.4**	18 ± 4.0**	34 ± 3.0**	-32 ± 7.1**
IS 9327xIS 9530	46.5 ± 4.5**	- 1.5 ± 1.1	-15.5 ±10.1	-12 ± 4.4**	11 ± 3.6**	1 ± 7.7
370 x IS 9327	29.0 ± 5.2**	-17.0 ± 0.9**	56.0 ±11.4**	24 ± 5.1**	34 ± 4.3**	-48 ± 8.3**
E35-1xCS 3541	41.5 ± 5.8**	- 0.5 ± 1.3	29.5 ±12.4*	- 6 ± 5.7	-9 ± 4.4*	-37 ± 9.5**
CS 3541 x 370	33.0 ± 4.9**	-17.0 ± 1.1**	43.0 ±11.5**	20 ± 4.8**	34 ± 4.4**	-38 ± 8.5**
SPV 104 x CS 3541	50.5 ± 5.3**	-10.5 ± 1.3**	16.5 ±10.3	-4 ± 5.2	9 ± 3.9*	-31 ± 0.1**
IS 9327 x H 112	43.0 ± 5.7**	-13.0 ± 0.9**	33.0 ±12.5**	10 ± 5.5	8 ± 4.7	-30 ± 9.5**

†Based on transformed data

*Significant at 5% probability

**Significant at 1% probability

basis of and F_1 diallel cross study and our results confirm their observation, as specific combining ability is attributed to dominance and epistasis Griffing(1956). These results also suggest that intercrossing early segregating material followed by selective inbreeding could be adopted to improve the level of resistance to Curvularia lunata and Fusarium moniliforme.

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