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COMBINING ABILITY ANALYSIS OF RESISTANCE OF SORGHUM TO SHOOTFLY

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ABSTRACT

Seven genotypes of sorghum, viz., PS 14413, PS 14454, E 503, E 602, SPV 346, Gwalior 304 and 2219 B, were crossed in half-diallel fashion in the rainy season of 1984 at Indore. The first four genotypes are known for their resistance to *Atherigona soccata* Rond. Observations were recorded on number of eggs laid by shootfly and dead hearts 14, 21 and 28 days after crop emergence. Combining ability analysis pooled over three dates revealed that, in addition to the significance of mean squares for gca and sca, the mean squares for gca × dates were also significant for both characters. PS 14413 and PS 14454 emerged as desirable combiners. Cross PS 14413 × E 602 was considered as desirable by virtue of its per se performance and sca effect.

Key words: Combining ability, shootfly, sorghum.

Sorghum shootfly (*Atherigona soccata* Rondani) is a serious pest of sorghum not only in India but also in West Africa, Israel and East Africa. High yielding hybrids and varieties of sorghum released earlier in India were highly susceptible to this pest. Consequently, breeding programmes were initiated to incorporate resistance against this pest in the varieties/hybrids to be released. Initially the sources of resistance against shootfly were local cultivars like IS 5490, IS 5604, M 35–1, etc., which were undesirable for most of the agronomic traits. Several shootfly resistant genotypes have now been developed which possess some desirable agronomic attributes related to plant height, maturity and grain yield. However, their shootfly resistance and other desirable traits in the progeny needs to be assessed before accepting them as sources of resistance.

MATERIALS AND METHODS

Genotypes PS 14413 (IS 1082 × SC 108–3), PS 14454 (IS 5622 × CS 3541), bred at the International Crops Research Institute for Semi-Arid Tropics, Hyderabad; and E 503, E 602 (IS 84 × BP 53), evolved at the Indian Agricultural Research Institute, New Delhi, exhibit resistant reaction to shootfly. Gwalior 304 is an indigenous cultivar grown in the northern districts of Madhya Pradesh. 2219 B is a maintainer of cytoplasmic genetic male sterile line 2219 A, employed as female parent of hybrid CSH 6. SPV 346 (SB 1066 × CS 3541) is a high yielding variety released for general cultivation.

These seven genotypes were crossed in a half-diallel fashion in the rainy season of 1984 at Indore. Twenty one F_1 and seven parents were planted on 23 July 1985 at the JNKVV Research Farm, College of Agriculture, Indore. The planting was deliberately delayed so that shootfly multiplies on other sorghum material planted with the onset of monsoon. The experimental material was planted in randomized block design with 3 replications in plots of single rows, 3 m long, spaced 45 cm apart, with the plant-to-plant distance of 15 cm.

Observations were recorded on number of eggs per plant and dead hearts 14, 21 and 28 days after crop emergence. Dead heart percentages were transformed to angles as $0° = \text{Arcsin} \sqrt{\text{percentage}}$.

The data were analysed following Griffing's Model I, Method 2 [1]. Pooled combining ability analysis was carried out according to Singh [2, 3].

RESULTS AND DISCUSSION

Nonpreference for oviposition has been postulated as one of the predominant mechanisms responsible for resistance of sorghum cultivars to shootfly, *Atherigona soccata* [4, 5]. However, seedling resistance due to inability of the larvae to penetrate through the leaf sheaths and survival of the new tillers formed when the growing apex is destroyed (recovery resistance) has also been suggested as another mechanism of resistance [4]. The degree of resistance of sorghum genotypes to shootfly is, therefore, measured in terms of number of eggs per plant and percentage of dead hearts. Blum [6] pointed out that the reaction of sorghum plants to shootfly is influenced by the size of insect population. Therefore, it is essential that desirable combiners for shootfly resistance should be screened under high pest population. The experimental material in this study was; therefore, planted late in kharif season. Combining ability analysis of pooled observations recorded on three different dates (which are usually recommended for recording observations in shootfly studies) would enable identification of a desirable combiner with respect to shootfly resistance.

Table 1. ANOVA for combining ability for number of eggs/plant (upper figures) and per cent dead hearts (figures in parentheses)

Source	d.f.	Mean squares on different days		
		14	21	28
gca	6	0.07** (3.85**)	0.23** (3.13**)	0.98** (1.75**)
sca	21	0.04 (0.53**)	0.03** (0.35**)	0.16* (0.27)
Error	27	0.01 (0.10)	0.01 (0.08)	0.06 (0.16)

* P= 0.05, **P = 0.01.

The analysis revealed significant differences among the 28 genotypes for number of eggs/plant and dead heart percentage recorded 14, 21 and 28 days after germination. Mean sums of squares for gca were highly significant for all three dates for both the attributes (Table 1). On the other hand, mean sums of squares for sca were significant for the second (21 days) and third (28 days) observations for number of eggs/plant, and first (14 days) and second (21 days) observation for per cent dead hearts. The information obtained from pooled analysis is also very interesting (Table 2). Significant differences were observed among the observation days not only for eggs/plant but also for dead heart percentage. Mean sum of squares for gca and sca were highly significant for both characters, suggesting the importance of additive and nonadditive components of heritable variation for both the traits. These results are in agreement with earlier reports [7, 8]. Mean sums of squares for gca × dates

Table 2. Pooled ANOVA for combining ability of sorghum (mean squares)

Source	d.f.	Eggs/plant	Per cent dead hearts (transformed values)
Dates	2	5.23*	9.27*
gca	6	0.95**	8.00**
sca	21	0.13**	0.77**
gca × dates	12	0.17**	0.36*
sca × dates	42	0.04	0.20
Pooled error	81	0.03	0.14

*P = 0.05, **P = 0.01.

were also significant for both the characters, which suggested interaction of gca effects with observation time. The shootfly population increases with the advancement of crop season. The susceptibility/resistance reaction of sorghum genotypes tends to change with change in shootfly population. Borikar and Chopde [9] observed that susceptibility was recessive in nature when insect population was low but exhibited dominance under high shootfly population. Interaction of sca effects with dates of observation was not observed in this study, which implied that the sca effects of crosses exhibited relatively similar changes in response to change in days of observation. Selection of crosses on the basis of sca effects calculated from pooled analysis would, therefore, be satisfactory.

Since gca effects of PS 14413, PS 14454, E 602 and E 503 were significant and negative for number of eggs/plant (Table 3), these genotypes could be considered as desirable parents for hybridization. Among these genotypes, the gca effects of PS 14413, PS 14454 and E 602 were statistically at par, hence they can be treated as equally desirable combiners. On the other hand, 2219 B could be characterized as the most undesirable combiner for eggs/plant as it registered significant positive gca effect.

PS 14413, PS 14454, E 602 and E 503 showed significant negative effects for dead heart formation (Table 3). However, since gca effects of PS 14413, PS 14454 and E 602 were statistically at par, these genotypes are equally desirable combiners for this attribute. 2219 B, SPV 346 and Gwalior 304 emerged as poor combiners.

Table 3. Estimates of gca (in bold) and sca effects for number of eggs per plant (upper values) and percent dead hearts (lower values)

Strain	PS 14413	PS 14454	E 602	E 503	SPV 346	2219 B	Gwalior 304
PS 14413	**−0.19****	−0.01	−0.13	−0.08	−0.04	0.28**	0.16
	−0.61**	0.12	−0.69**	−0.29	0.46*	1.14**	0.05
PS 14454		**−0.19****	0.07	0.18	0.08	0.15	−0.07
		−0.50**	0.23	0.60**	0.34	0.25	−0.22
E 602			**−0.11****	0.09	−0.01	0.12	−0.16
			−0.40**	0.06	−0.05	−0.47*	0.08
E 503				**−0.07****	0.10	−0.10	−0.05
				−0.17*	0.36	−0.11	−0.05
SPV 346					**0.16****	−0.31**	−0.12
					0.54**	−0.78**	0.41
2219 B						**0.30****	0.55**
						0.72**	0.36
Gwalior 304							**0.09***
							0.42**

*P = 0.05, **P = 0.01

SE_{gi} ± 0.03 SE_{gi-gj} ± 0.05 SE_{sij} ± 0.09 SE_{sij} ± 0.13 $SE_{sij-skl}$ ± 0.13
± 0.07 ± 0.10 ± 0.19 ± 0.29 ± 0.27

The rank of gca effects changed for both the characters on the dates of observation. E 503 was not found to be a desirable combiner consistently on all the three dates. On the other hand, PS 14413 and PS 14454 had significant negative gca effects for both characters on all dates. These genotypes were, therefore, considered as desirable. The gca effects of E 503 and E 602 were nonsignificant for eggs/plant recorded on 28-day-old crop, hence these genotypes should be regarded as undesirable.

Among other things, the choice of an efficient breeding procedure is determined by the predominant component of genetic variation or gene action. Superior crosses are usually selected on the basis of their sca effects. However, this may not always be the most appropriate criterion. The present investigation indicated crosses SPV 346 × 2219 B, PS 14413 × E 602, and E 602 × 2219 B to be the best by virtue of their sca effects for dead heart. The estimates of sca effects were statistically at par among these crosses. Only two of these crosses involved one genotype identified as a desirable combiner for this character. For eggs/plant, only cross SPV 346 × 2219 B was identified as desirable. Surprisingly, the estimates of sca effects of most crosses involving both parents identified as desirable combiners, either for eggs/plant or dead heart percentage, were nonsignificant, and when significant (e.g. cross PS 14413 × E 602 for dead heart percentage) not in desirable direction. There is no reason to believe that the undesirable combiners, such as, SPV 346 and 2219 B, would transmit relatively more genes for shootfly resistance (measured in terms of nonpreference for oviposition and less dead heart formation) than the parents identified as superior combiners for these characters. Similar results were reported from combining ability analysis [10] and synchrony traits of wheat [11]. Crosses selected on the basis of gca effects of parents or per se performance were not identical with those selected on the basis of their sca effects. Jatasra and Paroda [11] rightly pointed out that sca effect is merely an indication of deviation of F_1 performance, therefore, the sca effect for a given F_1 may or may not have high value, desirable direction, and significance depending on the performance of parental lines. The high sca effect need not necessarily mean high performance by the hybrid as well. Jatasra and Paroda [11] suggested that the best cross could be selected on the basis of performance (and heterosis over check). On the basis of per se performance, cross PS 14413 × E 602 was significantly superior to the remaining crosses for dead heart formation. However, it was statistically comparable with the crosses PS 14413 × PS 14454, PS 14454 × E 602, PS 14413 × E 503, E 602 × Gwalior 304 and PS 14454 × Gwalior 304 for number of eggs/plant. Cross PS 14413 × E 602 could be regarded as the most desirable combination for resistance to shootfly, being superior on the basis of per se performance for both the characters combined with significant negative sca effect.

Since additive as well as nonadditive components of genetic variability determined the inheritance of both the traits under investigation, an efficient breeding plan would be the one which can exploit both these components.

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