Crop Breeding and Applied Biotechnology 5:294-301, 2005
Brazilian Society of Plant Breeding. Printed in Brazil

Potential of soybean genotypes as insect resistance sources

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Received 2 February 2005

Accepted 24 July 2005

ABSTRACT - *Partial diallel crosses between insect-attack susceptible and resistant soybean genotypes were realized in order to check the possibility of joining favorable alleles of insect resistance and high grain yield in the same genotype. F_2 progeny was evaluated in three distinct locations, each one with a different priority: grain yield and responses to sucking and chewing insects. The experimental design was of randomized blocks with six replicates to evaluate F_2 generation from 16 crosses and eight parent lines, amounting to 24 treatments. The experimental plot was represented by 12 individual plants with a row/plant spacing of 0.5 x 0.6 m. The best general combining ability was detected in parent IAC-100 for insect resistance and grain yield. Cross Davis x IAC-100 showed a higher potential for specific combining ability to grain yield and resistance to sucking and chewing insects.*

Key words: *Glycine max*, *Piezodorus guildinii*, *Nezara viridula*, *Cerotoma arcuata*, *Diabrotica speciosa*, *Anticarsia gemmatalis*

INTRODUCTION

The introduction of soybean in Brazilian agriculture has caused a revolution in the sector. Then, soybean rapidly became one of the most important agricultural and economic commodities of national economy. Soybean crops are traditional in the Southern and Southeastern regions of Brazil and, more recently, in the Central West and Northeastern regions. This shift demanded the development of novel cultivars in order to increase the yield in traditional areas and to adapt soybean crops to new areas. The expansion of the crop has been responsible for a gradual increase in losses caused by leaf - feeding insects.

Modern agriculture is characterized by monoculture, frequently covering large areas. This practice results in agrossystems that expose the crops permanently to the risk of pathogen and insect attacks (Boerma and Walker 2004). In spite of the use of more than 2.5 million tons of pesticides applied annually at a cost of US$30 billions, leaf-feeding insects, plant pathogens and invasive plants are responsible for the destruction of over 40% of the potential food production in the world (Pimentel 1997). An estimate of the financial loss caused by insects in Brazil

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for the harvest season of 1996/1997 was presented by Bento (2000). Multiplying the average price of an unit of the product by the annual production of each crop, the author obtained a figure corresponding to the lost percentage due to insect attack. Losses in soybean amount to 5% (US$ 281 million), corresponding to the third-highest value among the most insect-injured crops.

Soybean is attacked by several insect species; noteworthy are stink bugs that suck the pods (*Piezodorus guildinii, Nezara viridula* and *Euschistus heros*) (Rossetto et al. 1981a) and leaf-chewing insects (caterpillar, *Anticarsia gemmatalis*; and small-sized beetles, *Cerotoma arcuata, Diabrotica speciosa, Colaspis sp., Diphaulaca viridipennis* and *Gynandrobrotica cavipes adumbrata*) (Rossetto et al. 1981b, Massariol et al. 1979, Rossetto and Nagai 1980, Lourenção and Miranda 1986, Pinheiro and Vello 1997).

Historically, insect infestations in crops were suppressed by chemical products. An alternative or at least complementary strategy would be the use of soybean plants genetically resistant to leaf-feeding insects. The use of resistant plants is a factor that stabilizes the yield and has significant advantages over the use of insecticides: it is ecologically safe, does not increase production costs, does not involve the transfer of new technologies and is compatible with other control methods used in insect management. This study evaluated the potential of biparent crosses of insect- resistant soybean genotypes with high-yield but insect- susceptible genotypes. Thus, the estimation of genetic parameters has allowed to evaluate the possibility of introducing favorable alleles to leaf-feeding insect resistance as well as high grain yield in a single genotype.

MATERIAL AND METHODS

The experimental material consisted of eight soybean genotypes, four of them resistant and four of them susceptible to insects. The resistant parent cultivars were Crockett, with resistance derived from PI 171451, Lamar with resistance derived from PI 229358, the experimental line D72-9601-1 with resistance derived from PI 229358; and as adapted resistant parent cultivar IAC 100 with resistance derived from PI229358 and PI 274454. The cultivars BR-6 (Nova Bragg), IAS- 5, Davis and OCEPAR-4 (Iguaçu) were used as susceptible and adapted parents.

In order to identify the parents of high yield potential to generate superior progenies, a partial diallel cross was performed between insect attack-resistant and susceptible genotypes, totalizing 16 biparental combinations. The F2 generation was evaluated in three experiments, each one with a specific target characteristic. Grain yield and traits associated to insect resistance (grain filling period, weight of 100 seeds and percentage of leaf retention) were evaluated in Piracicaba, SP, in the growth season of 11/28/1991 on the experimental area of the Genetics Department of ESALQ/USP and with chemical insect control ; the response to stink bug attack was evaluated in Mococa, SP, sown on 11/29/1991 at the Region Pole APTA and without insect control; the response to chewing insects was evaluated in the city of Campinas, SP, sown on 03/20/1992 at the Experimental Center of IAC, without insect control until flowering to allow the attack of chewing insects, and with severe insect control thereafter. The out-of-season sowing dates used in this experiment aimed to increase the natural insect infestation to facilitate the differentiation among genotypes. The sowing fields were chosen after a preliminary evaluation of the natural insect infestation.

Randomized blocks were used in the experimental design, with six replicates to evaluate F_2 generation of 16 crosses and the eight parental lines, summing up to 24 treatments (Table 1). The experimental plot consisted of three ranks of 2.0 x 0.6m, containing four plants spaced 0.5m between each plant, so each experimental plot consisted of 12 individual plants. Six to 12 seeds were placed in each sowing hill, and the method of SHDT (Single Hill Descent Thinned, Vello 1992a, b) was employed to leave a single plant per hill. This method consists of random thinning of the sowed plantlets at the trifoliate stage (stage V2) of themajority of the plants in the sowing hill. Thinning eliminates the competition between plants in the hill and thus avoids the competition between plants at different development stages. Moreover, it allows an easy examination and evaluation of the plants of individual sowing hills.

The traits evaluated in Piracicaba were grain filling period (GFP), 100 seeds weight (HSW), leaf retention percentage (LRP) and grain yield (GY); in Mococa, LRP, GY and the percentage of stained seeds (PSS) were evaluated; in Campinas LRP, GY and percentage of cut leaf area (CLA) were evaluated twice (22 and 43 days after sowing).

The plot mean was estimated based on individual data from each sowing hill for the six replicates.

Variance analysis was performed based on these means.

The criterion of Scott Knott (1974) was used for each trait; it evaluates the significance of the differences between the groups of treatment means to a balanced

Table 1. Identification of 24 treatments, eight parent soybean lines used in 16 partial F_2 diallel crosses.

Genotype	Description	Genotype	Description	Parent	Description
1	BR-6x Crockett	9	Davis x Crockett	17	BR-6
2	BR-6 x Lamar	10	Davis x Lamar	18	IAS-5
3	BR-6 x IAC-100	11	Davis x IAC-100	19	Davis
4	BR-6 x D72-9601-1	12	Davis x D72-9601-1	20	OCEPAR-4
5	IAS-5 x Crockett	13	OCEPAR-4 x Crockett	21	Crockett
6	IAS-5 x Lamar	14	OCEPAR-4 x Lamar	22	Lamar
7	IAS-5 x IAC-100	15	OCEPAR-4 x IAC-100	23	IAC-100
8	IAS-5 x D72-9601-1	16	OCEPAR-4 x D72-9601-1	24	D72-9601-1

design, especially when a great number of genotypes is being screened. The combinining ability (lines x testers) was approached according to the methodology of Kempthorne described by Singh and Chaudhary (1977), which is based on the performance mean of the cross between lines and testers. The heritability of the trait was also determined at the mean level and to show the evaluated criteria as percentage the arc sin transformation $\sqrt{x/100}$ was used.

RESULTS AND DISCUSSION

The presence of genetic variability in the generated populations was identified based on variance analysis (Table 2) and the clustering criterion (Table 3) in relation to the traits insect resistance and yield.

Cultivar IAC 100 has a high grain yield, superior to the remaining parents, resistant or not, in all three experiments (Table 3). The progenies generated from IAC 100 crosses were also superior for this trait at the three locations of the experiment.

In the trial in Piracicaba parent IAC 100 was superior to the components of stink bug resistance (GFP and HSW) and its progenies showed the highest performances. Even under chemical control, LRP was evaluated and it was verified that there were no significant differences by the Scott Knott test among the genotypes, but a trend to low frequency was observed for Crockett and IAC 100, as well as for their progenies. The smallest GFP and HSW were observed for parent IAC 100, that is, it was the quickest to go through the period of higher susceptibility to stink bugs and produce smaller seeds, which mitigates the damage, in agreement to the observations of Panizzi et al. (1986) and Rossetto et al. (1995).

The response to stink bug attack evaluated in the trial in Mococa produced an unclear discrimination of the genotypes due to the severe infestation of stink bugs.

However, a trend of superior performance concerning the evaluated traits was observed for the resistant parent IAC 100. The traits LRP and PSS were lower for the afore mentioned parent.

Besides the direct damages inflicted by feeding, stink bugs transmit the yeast *Nematospora coryli* that affects seed quality and the commercial value of the grain. The resistance to the yeast is, therefore, a component of the resistance to stink bug (Rossetto et al. 1995).

The resistance to chewing insects was evaluated in field conditions in the initial developmental stages of thesoybean plants (up to 45 days), in order to prevent the mitigating effect of the damage due to leaf mass that would impair the discrimination among the genotypes. A smaller value of CLA was detected for the resistant parents Crockett, Lamar, IAC 100 and D72 9601-1, in accordance to the previous results of Rezende et al. (1980), Hartwig et al. (1990), Bowers Jr (1990) and Rossetto et al. (1995), who evaluated the same genotypes. The resistance of cultivar Lamar to chewing insects was also reported by Gina et al. (1993) and Kilen and Lambert (1998). Autumn/ winter crops increase the infestation of chewing insects.

The occurrence of leaf retention is not only caused by stink bug attack but also to identify the genotypes showing adequate development under out-of-season cultivation conditions.

In the trials in Piracicaba, it was observed that the resistance and yield traits (GFP, LRP, HSW and GY) are clustered in some parent lines according to the effects of gi. Parent IAC 100 is doubtlessly the most remarkable one, since it carries all the afore mentioned traits. Parent OCEPAR 4 comes in second for the evaluated traits. For grain yield alone, the parents Davis and Crockett also had high performances. In short, the following g_i´s were observed in parent line IAC 100: GPF (-2.994 days), LRP (-2.198%), HSW (-2.092 g) and GY (15. 207 g plant^{-1}), these

Table 2. Summary of the genetic analysis of the lines x testers, with figures and significance of the mean squares for soybean traits. Six replicates, 24 genotypes; four insect susceptible (lines) and four resistant (testers) materials, and 16 F_2 partial diallel crosses.

Sources of variation[1]	df	MEAN SQUARES[2]					
		Piracicaba				Campinas	
		GFP	LRP	GY	HSW	CLA1	CLA2
Genotypes	23	6.74**	27.78**	193.46**	2.99**	4.95**	5.69**
Parents	7	12.00**	58.20**	199.50**	3.30**	11.38**	14.98**
Susceptible	3	7.30**	11.75·	64.72*	2.66**	4.09*	5.24*
Resistant	3	16.36**	124.49**	386.76**	6.57**	2.76	2.69
S vs R	1	13.01**	7.70·	42.09	9.41**	59.13**	81.09**
Parent vs Cross	1	2.03	32.92*	261.98**	2.02**	0.90	1.41
Crosses	15	4.60**	13.24**	186.11**	1.98**	2.22*	1.64
GCA (lines)	3	3.74**	8.61	104.50**	1.29*	2.10	0.22
GCA (testers)	3	18.51**	35.74*	783.80**	8.01**	2.89	4.06
SCA (LxT)	9	0.24	7.29	14.04	0.20	2.03·	1.31
Residue	115	0.60	5.89	16.21	0.11	1.11	1.57

Sources of variation[1]	df	MEAN SQUARES [2]				
		Campinas			Mococa	
		LRP	GY	LRP	GY	PSS
Genotypes	23	242.33**	30.71**	55.82	27.87	26.37*
Parents	7	373.07**	32.74**	65.53	24.15	34.79*
Susceptible	3	329.17**	19.70**	53.44	21.39	31.29
Resistant	3	533.64**	55.83**	26.06	24.54	30.50
S vs R	1	23.09	8.61	220.18*	31.24	58.16
Parent vs Cross	1	169.09	95.01**	5.77	26.45	9.61
Crosses	15	186.20**	25.47**	50.03	29.71	23.56
GCA (lines)	3	220.88**	40.37*	0.34	41.74	4.70
GCA (testers)	3	612.86**	63.69**	140.36	58.51	82.44**
SCA (LxT)	9	32.42	7.76*	36.49	16.09	10.24
Residue	115	44.37	3.87	37.89	23.67	16.24

estimates are three times higher than the respective standard errors. Moreover, the g_i effects associated to the parent lines were also observed in the trial in Mococa (Table 4), where the response to sucking insects was evaluated. Similarly, the best parent lines were IAC 100 and OCEPAR 4, since these cultivars carry several favorable g_i to LRP, HSW and GY. In the trial in Campinas, where the response to chewing insects was evaluated, the favorable g_i effects are clustered mostly in the parents IAC-100 and OCEPAR-4, in accordance to the previous trials. The cultivars resistant to chewing insects Lamar and Crockett presented favorable g_i to CLA (Table 4).It was observed that most of the crosses did not result in clustering of the favorable sij effects (Table 5) for the traits related to resistance and yield. However, the crosses with superior performances involved the parent lines with higher gi effects. For the experiments in Piracicaba, the cross between Davis and IAC 100 presented a remarkably better performance with the following effects s_{ij}: GFP (-0.147 days), LRP (-1.317%), HSW (-0.393G) and GY (2.660 g plant^{-1}). Favorable effects of s_{ij} for all traits were not observed for the crosses carried out in the trial in Mococa. In Campinas, it was observed that the crosses involving the parents resistant to chewing insects presented negative s_{ij} effects to CLA1 and CLA2. This behavior can be explained by the presence of resistance genes in the chosen parent lines; D72-9601-1 (Rezende et al. 1980), Lamar (Hartwig et al. 1990), Crockett (Bowers Jr 1990) and IAC-100 (Rossetto et al. 1995).

The results from the trial in Piracicaba reinforce the predominance of the variance for the general combining ability (GCA) and of the additive one for the traits GFP, HSW and GY, as well as of the specific combining ability variance (SCA) and the dominant one for LRP. The results for LRP and GY obtained from Mococa were similar to the ones from the previously mentioned trial, and for PSS, there was predominance of the additive variance and of GCA. In Campinas, a different behavior was observed for

Table 3. Averages and classification (C)[a] of 24 genotypes: eight parent lines and 16 F_2 partial diallel crosses in three trials based on six replicates.

Genotype [b]	Average for the Traits [c]																					
	Piracicaba								Mococa						Campinas							
	GFP	C	LRP	C	HSW	C	GY	C	LRP	C	GY	C	PSS	C	CLA1	C	CLA2	C	LRP	C	GY	C
1	41.65	A	9.93	A	17.78	B	58.21	A	32.03	A	35.19	A	27.20	A	11.81	C	15.99	C	54.85	A	18.62	E
2	38.99	B	12.30	A	18.39	A	37.57	B	19.27	A	23.64	A	26.35	A	10.55	D	16.26	C	47.16	A	19.22	E
3	37.52	C	9.67	A	15.59	C	67.41	A	14.64	A	34.96	A	19.93	A	12.97	C	18.83	B	19.93	C	23.11	D
4	41.58	A	13.38	A	17.71	B	54.83	A	15.92	A	30.95	A	27.48	A	16.99	A	21.26	B	54.41	A	20.91	E
5	39.58	B	11.06	A	19.50	A	64.76	A	15.23	A	32.87	A	23.08	A	11.97	C	16.51	C	39.25	B	25.52	C
6	38.06	C	5.08	A	18.57	A	39.32	B	37.24	A	28.78	A	35.48	A	11.92	C	16.40	C	17.39	C	20.27	E
7	34.25	D	5.15	A	15.59	C	65.63	A	11.76	A	32.89	A	15.16	A	9.93	D	18.75	B	10.38	D	37.21	A
8	38.90	B	15.21	A	18.05	B	51.02	B	19.06	A	29.13	A	23.70	A	11.04	D	19.10	B	40.70	B	23.44	D
9	41.44	A	8.45	A	18.48	A	71.20	A	21.29	A	28.93	A	28.15	A	14.36	B	19.72	B	52.88	A	25.82	C
10	39.07	B	10.70	A	18.47	A	44.66	B	27.68	A	33.15	A	31.75	A	11.90	C	17.81	C	35.87	B	25.01	D
11	36.23	D	5.00	A	14.98	C	83.64	A	10.14	A	44.76	A	16.67	A	10.54	D	17.93	C	12.87	D	30.33	B
12	40.49	B	10.64	A	17.85	B	63.52	A	22.42	A	30.72	A	27.89	A	14.80	B	19.00	B	29.18	C	27.19	C
13	40.39	B	5.63	A	16.83	B	61.86	A	13.01	A	33.10	A	16.41	A	12.03	C	15.86	C	40.46	B	27.48	C
14	39.94	B	3.68	A	17.46	B	43.02	B	32.43	A	36.45	A	36.31	A	12.76	C	17.43	C	29.35	C	22.00	E
15	35.83	D	6.25	A	14.80	C	79.39	A	12.42	A	40.08	A	14.17	A	12.90	C	20.59	B	9.25	D	33.05	B
16	40.01	B	13.81	A	17.09	B	55.78	A	23.23	A	43.34	A	23.69	A	12.89	C	18.41	B	28.70	C	24.35	D
17	41.96	A	5.65	A	17.27	B	40.38	B	10.66	A	29.41	A	18.44	A	17.87	A	26.02	A	62.30	A	15.83	F
18	37.07	C	10.59	A	18.83	A	46.73	B	24.85	A	33.60	A	29.69	A	13.40	C	20.69	B	22.30	C	22.27	D
19	43.10	A	7.43	A	19.30	A	59.73	A	29.52	A	30.90	A	37.34	A	16.68	A	23.10	A	59.71	A	23.87	D
20	41.54	A	3.57	A	15.68	C	50.53	B	28.97	A	40.72	A	31.94	A	12.68	C	18.10	C	21.64	C	26.18	C
21	40.57	B	0.93	A	15.60	C	66.03	A	22.03	A	36.08	A	32.05	A	7.66	E	11.61	D	70.36	A	14.04	F
22	35.18	D	2.82	A	17.93	B	26.72	B	15.71	A	25.40	A	29.98	A	9.00	E	11.99	D	45.22	B	17.97	E
23	34.51	D	1.09	A	12.01	D	73.26	A	6.89	A	43.77	A	16.15	A	8.14	E	13.50	D	6.71	D	30.67	B
24	42.87	A	22.64	A	17.08	B	54.77	A	9.78	A	36.13	A	16.41	A	11.38	D	16.15	C	32.35	C	17.17	F
General Mean	39.19		8.31		17.11		56.56		19.91		33.71		25.23		12.34		17.92		35.02		23.60	

[a] In columns, averages followed by the same letters belong to a common cluster, that is, are not different according to Scott-Knott clustering method (P<0,05)
[b] The genotypes are identified in Table 1
[c] Coded as in Table 2

GY, since the variances of SCA and dominant variance were predominant. Similar results were also obtained by Chaudhary and Singh (1974), where the authors verified the superiority of the dominant over the additive variance. In Campinas, observed LRP was due to the autumn/winter cultivation, since stink bugs were chemically controlled. In this case, the predominance of the GCA and additive variance was observed, differently from the other trials, where LRP was a function of the attack of sucking insects and there was predominance of the SCA variance. In general, the cross resulting in grouping of the majority of the favorable traits was Davis x IAC 100, with a high level of GY at the three evaluated locations and high resistance. Taking only GY into consideration, the cross OCEPAR 4 x IAC 100 also showed a high performance. Based on the broad-sense heritability estimates, it can be suggested that a small number of genes is associated with insect resistance traits (Table 5).

CONCLUSIONS

1. The cultivar IAC 100 and its progenies presented superior performances to most of the traits evaluated at three locations;
Table 4. Effects of $i\ \hat{g}$ from the general combining ability (GCA) associated to eight parent lines: four insect-susceptible (lines) and four resistant (testers) to soybean traits1

1Coded as in Table 2
2. The general combining ability and additive effects represented the main cause of variation of the evaluated traits;
3. Cultivar IAC 100 presented the highest general combining ability, involving insect resistance and yield traits, thus, being considered an important source of genes for these characteristics;
4. Cross Davis x IAC 100 is the most promising in terms of specific combining ability for the tested traits;
5. Leaf retention may have been caused by stink bug attack or by autumn/winter cultivation.

Table 4. Effects of $\hat{g}_i$ from the general combining ability (GCA) associated to eight parent lines: four insect susceptible (lines) and four resistant (testers) to soybean traits[1].

	EFFECT OF CGC										
	Piracicaba				Mococa			Campinas			
Susceptible Parent Lines	GFP	LRP	HSW	GY	LRP	GY	PSS	CLA1	CLA2	LRP	GY
BR-6	0.979	1.974	0.042	-4.207	-0.236	-2.387	0.384	0.482	-0.042	10.482	-4.756
IAS-5	1.306	-0.218	0.590	-3.555	0.011	-2.417	-0.096	-1.078	-0.282	-5.196	1.389
Davis	0.375	-0.181	0.143	6.874	0.406	0.373	1.146	0.354	0.290	0.079	1.867
OCEPAR-4	0.048	-1.576	-0.755	0.887	-0.181	4.431	-1.434	0.242	0.035	-5.366	1.499
Resistant Parent Lines											
Crockett	1.817	-1.801	0.858	5.132	0.051	-1.802	-0.789	0.112	-0.730	12.999	-0.861
Lamar	-0.098	-1.138	0.876	-17.932	7.446	-4.227	5.594	-0.593	0.992	-0.121	-3.595
IAC-100	-2.994	-2.198	-2.092	15.207	-7.044	4.973	-5.431	-0.678	0.717	-16.911	5.704
D72-9601-1	1.270	4.417	0.358	-2.587	-0.454	0.336	0.626	1.159	1.005	4.732	-1.248
Standard Error ($\hat{g}_i$)	0.386	1.213	0.165	2.013	3.078	2.433	2.015	0.526	0.626	3.330	0.984
Standard Error ($\hat{g}_i - \hat{g}_i$)	0.546	1.716	0.233	2.846	4.353	3.440	2.850	0.745	0.886	4.710	1.391

[1] Coded as in Table 2

Table 5 Effects of $\hat{s}_{ij}$ of the specific combination ability (SCA) and heritability ($\hat{h}^2_m$) associated to 16 F_2 partial diallel crosses of soybean traits[1].

Crosses	EFFECTS OF SCA										
	Piracicaba				Mococa			Campinas			
	GFP	LRP	HSW	GY	LRP	GY	PSS	CLA1	CLA2	LRP	GY
BR-6 x Crockett	-0.90	-1.589	-0.460	-0.932	9.209	4.359	1.704	-1.152	-0.655	-2.452	-0.984
BR-6 x Lamar	-0.862	2.148	0.106	0.842	-8.339	-2.566	-5.189	-1.587	-0.622	3.478	2.351
BR-6 x IAC-100	0.590	1.098	0.307	-2.587	3.291	-1.086	2.476	0.798	-0.132	-3.802	-3.059
BR-6 x D72-9601-1	0.363	-1.657	0.048	2.677	-4.159	-0.708	1.009	1.941	1.410	2.776	1.693
IAS-5 x Crockett	0.062	2.733	0.735	4.545	-4.281	2.198	-0.566	0.758	-0.065	-1.404	-0.229
IAS-5 x Lamar	0.390	-.3029	-2.211	2.040	6.074	1.214	2.881	1.023	-0.172	-8.544	-2.744
IAS-5 x IAC-100	-0.383	-1.369	-0.271	-4.730	-0.916	-2.626	-1.564	-0.402	0.257	2.846	4.896
IAS-5 x D72-9601-1	-0.068	1.666	-0.253	-1.855	-0.876	-1.508	-0.751	-1.379	0.020	7.103	-1.922
Davis x Crockett	0.346	-0.054	0.300	0.355	1.744	-4.291	2.641	1.106	1.752	5.901	-0.407
Davis x Lamar	-0.123	3.483	0.061	-3.590	-1.801	1.594	-1.891	-0.169	0.385	2.111	1.518
Davis x IAC-100	-0.147	-1.317	-0.393	2.660	-2.911	5.564	-0.926	-1.374	-1.375	-0.309	-2.462
Davis x D72-9601-1	-0.076	-2.112	0.033	0.575	2.969	-2.868	0.176	0.438	-0.762	-7.702	1.351
OCEPAR-4 x Crockett	-0.317	-1.089	-0.575	-3.967	-6.669	-2.988	-3.779	-0.712	-1.032	-2.044	1.621
OCEPAR-4 x Lamar	0.595	-2.602	0.044	0.707	4.066	-0.243	4.199	0.733	0.410	2.956	-1.124
OCEPAR-4 x IAC-100	-0.060	1.588	0.357	4.657	0.536	-1.853	0.014	0.978	1.250	1.266	0.626
OCEPAR-4 x D72-9601-1	-0.218	2.103	0.173	-1.397	2.066	5.084	-0.434	-0.999	-0.627	-2.177	-1.122
Standard Error ($\hat{s}_{ij}$)	0.773	2.426	0.330	4.026	6.156	4.865	4.030	1.053	1.252	6.661	1.972
Standard Error ($\hat{s}_{ij} - \hat{s}_{kl}$)	1.093	3.432	0.467	5.693	8.706	6.881	5.700	1.489	1.771	9.420	2.789
Heritability ($\hat{h}^2_m$)	87.00	55.54	94.50	91.30	24.26	20.30	31.00	50.00	5.00	76.17	84.72

[1] Coded as in Table 2

Potencial de genótipos de soja como fontes de resistência a insetos

RESUMO - *Cruzamentos dialélicos parciais foram realizados entre genótipos resistentes e suscetíveis a insetos, com o objetivo de verificar a possibilidade de reunir, num mesmo genótipo, alelos favoráveis para resistência e para alta produtividade de grãos. A geração F_2 foi avaliada em três locais, cada um deles com uma finalidade principal, que foram produtividade de grãos, reação a insetos sugadores e reação a insetos mastigadores. O delineamento de blocos casualizados foi utilizado, com seis repetições, para avaliar a geração F_2 dos 16 cruzamentos e os oito genitores, totalizando 24 tratamentos. A parcela experimental foi representada por 12 covas de plantas individuais espaçadas 0,5 x 0,6 m. Foi observada para o genitor IAC-100 a melhor capacidade geral de combinação envolvendo os caracteres de resistência a insetos e produtividade. O cruzamento Davis x IAC-100 foi o mais promissor em termos de capacidade específica de combinação para produtividade, resistência a insetos sugadores e resistência a insetos mastigadores.*

Palavras-chave: *Glycine max, Piezodorus guildinii, Nezara viridula, Cerotoma arcuata, Diabrotica speciosa, Anticarsia gemmatalis.*

REFERENCES

Bento JMS (2000) Comedores de lucro. **Cultivar 22**:18-21.

Boerma HR and Walker DR (2004) Discovery and utilization of QTLs for insect resistance in soybean. **Genetica 123**: 181-189.

Bowers Jr GR (1990) Registration of 'Crockett' soybean. **Crop Science 30**: 427.

Chaudhary DN and Singh BB (1974) Heterosis in soybean. **Indian Journal of Genetics and Plant Breeding 34**: 69-74.

Gina BR, Boerma HR, All JN and Todd JW (1993) Soybean maturity effect on expression of resistance to lepidopterous insects. **Crop Science 33**: 433-436.

Hartwig EE, Lambert L and Kilen TC (1990) Registration of 'Lamar'soybean. **Crop Science 30**: 231.

Kilen TC and Lambert L (1998) Genetic control of insect resistance in soybean germoplasm PI 417601. **Crop Science 38**: 652-654.

Lourenção AL and Miranda MAC (1986) Resistência de soja a insetos. V. Preferência para alimentação de *Diphaulaca viridipennis* Clark, 1865, em cultivares e linhagens. **Bragantia 45**: 37-44.

Massariol AA, Ramiro ZA and Calcagnolo G (1979) Insetos observados na cultura da soja no Estado de São Paulo. **O Biológico 45**: 85-87.

Panizzi AR, Panizzi MCC, Bays IA and Almeida LA (1986) Danos por percevejos em genótipos de soja com semente pequena. **Pesquisa Agropecuária Brasileira 21**: 571-577.

Pimentel D (1997) **Techniques for reducing pesticides use - Economic and environmental benefits**. John Wiley and Songs, New York, 444p.

Pinheiro JB and Vello NA (1997) Ocorrência de *Gynandrobrotica cavipes adumbrata* Bech (Coleoptera-Galerucinae) na cultura da soja em Piracicaba- SP. **Scientia Agricola 54**: 251-252.

Rezende JAM, Miranda MAC and Mascarenhas HAA (1980) Comportamento de cultivares de soja em relação à área foliar comida por lagartas das folhas. **Bragantia 39**: 161-165.

Rossetto CJ and Nagai V (1980) Ensaio de livre escolha para o coleóptero *Colaspis sp.* em seis variedades de soja. **Bragantia 39**: 195-198.

Rossetto CJ, Miranda MAC, Link D, Rezende JAM, Lourenção AL, Mascarenhas HAA and Miyasaka S (1981a) Cultivares resistentes aos insetos pragas. In: Miyasaka S and Medina JC (eds.) **A soja no Brasil**. ITAL, Campinas, p.311-24.

Rossetto CJ, Nagai V, Igue T, Rossetto D and Miranda MAC (1981b) Preferência de alimlentação de adultos de *Diabrotica speciosa* (Germar) e *Cerotoma arcuata* (Oliv.) em variedades de soja. **Bragantia 40**: 179-83.

Rossetto, CJ, Gallo PB, Razerra LF, Bortoletto N, Igue T, Medina PF, Tisselli Filho O, Aguilera V, Veiga RFA and Pinheiro JB (1995) Mechanisms of resistance to stink bug complex in the soybean cultivar IAC-100. **Anais da Sociedade Entomológica do Brasil 24**: 517-522.

Scott AJ and Knott M (1974) A cluster analysis method for grouping means in the analysis of variance. **Biometrics 30**: 507-512.

Singh RK and Chaudhary BD (1977) **Biometrical methods in quantitative genetic analysis**. Kalyani, New Delhi, 304p.

Vello NA (1992a) Ampliação da base genética do germoplasma da soja na ESALQ/USP. In: **Simpósio sobre a cultura e produtividade da soja**. Anais, Piracicaba, p. 60-81.

Vello NA (1992b) Métodos de melhoramento da soja. In: **Simpósio sobre a cultura e produtividade da soja**. Anais, Piracicaba, p. 41-59.