EFFECT OF STINK BUGS ON YIELD, SEED DAMAGE AND AGRONOMIC TRAITS OF SOYBEANS (*GLYCINE MAX*)[1]

DÉCIO LUIZ GAZZONI[2] and ANDRÉA BRANCALHÃO MALAGUIDO[3]

ABSTRACT - To evaluate the stability of the trait resistance to insects, under different dates of planting, three resistant and three susceptible genotypes were tested in an experiment set up at the experimental station of the Centro Nacional de Pesquisa de Soja (Soybean National Research Center), Embrapa, in Londrina, PR, Brazil. The study consisted of soybeans planted at six different dates, starting on 18 October and spaced ca. 15 days from each other. At harvesting, height of plants, height of first pod, indexes of lodging and leaf area retention were evaluated. Seeds of three meters of row were harvested and of another three meters were harvested one week later. Results indicated that delay of harvesting did not significantly increase stink bug damage to seeds. The best seed quality were observed on soybeans planted between November 15 and December 15. The highest and lowest yields were obtained on soybeans planted on November 30 and October 18, respectively. Early maturity genotypes showed lower yields when planted up to November 15, the medium group had the lowest yield when planted at October 18, while late genotypes yielded less when planted at October 18 and at both December dates. An interaction between genotypes and dates was observed both for yield and quality of seeds, indicating the need of identifying sources of resistance to stink bugs with more stable behavior.

Index terms: host plant resistance, stink bug damage, seed damage, time of planting.

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RESUMO - Com o objetivo de estudar a resistência da soja a percevejos, em diferentes épocas de plantio, foram avaliados três genótipos resistentes e três suscetíveis, em um experimento realizado no Centro Nacional de Pesquisa de Soja (CNPSo, Embrapa), em Londrina, PR. O estudo consistiu de soja plantada em seis diferentes datas, iniciando em 18 de outubro de 1993, e com intervalos de 15 dias entre os plantios. Por ocasião da colheita, foram avaliados os índices de queda e de retenção das folhas. Quando as parcelas alcançaram a maturação, foram colhidos três metros de uma fileira e outros três metros uma semana depois. A colheita tardia não aumentou significativamente o dano por percevejos. As melhores sementes foram colhidas nos plantios feitos entre 15 de novembro e 15 de dezembro. A produtividade mais baixa foi do plantio de 18 de outubro, e a mais alta, a do plantio de 30 de novembro. Os genótipos de maturação precoce mostraram produtividade mais baixa quando plantados até 15 de novembro; o grupo médio, plantado em 18 de outubro, apresentou a menor produção, e os genótipos tardios produziram menos quando plantados em 18 de outubro e nas datas de dezembro. Observou-se interação entre os genótipos e datas quanto à produção de sementes e a qualidade delas. Isto significa a necessidade de identificar fontes de resistência aos percevejos caracterizadas por comportamento mais estável.

Termos para indexação: resistência de planta hospedeira, danos às sementes, danos de percevejos, épocas de plantio.

INTRODUCTION

The stink bug complex is considered the most important threat to soybeans yield and seed quality among all the insect pests which attack the plant, being *Nezara viridula* (L.), *Piezodorus guildinii*

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[2] Agronomist, M.Sc., Embrapa - Centro Nacional de Pesquisa de Soja (CNPSo), Caixa Postal 231, CEP 86001-970 Londrina, PR, Brazil. E-mail gazzoni@cnpso.embrapa.br

[3] Agronomist, Fundação Universidade Estadual de Londrina, Caixa Postal 6001, CEP 86001-970 Londrina, PR, Brazil.

(West.) and *Euschistus heros* (Fab.) the most common species (Gazzoni et al., 1981; Lourenção et al., 1987; Fernandes et al., 1991). The intensity of the damage of stink bugs depend specially on the insect population and on the stage of development of soybeans. Studies had proven that managing the insect population in order to avoid surpassing the limit of two stink bugs per meter of row during the reproductive stages of the crop prevents reduction of soybean yield and damage to the seeds (Villas Boas et al., 1990). Alteration of cultural practices can also reduce damage by stink bugs (Pitre & Porter, 1989) and the substitution of chemical insecticides by biological control of the velvetbean caterpillar, through the use of *Baculovirus anticarsia* is currently accepted as the main factor provoking the reduction of stink bug populations on soybeans grown in the state of Rio Grande do Sul. Lourenção et al. (1985) also did not recommend early applications of insecticides, and referred that correct management of stink bugs avoid damage to seeds and yield reduction.

According to Rosseto (1973), time of planting may affect intrinsic resistance of soybean through the interference of factors such as temperature, relative humidity and soil fertility. Also plant reaction to photoperiod, which differs among planting dates (Bonetti & Vieira, 1981) can interact with soybean resistance to insects. Painter (1951) cited cases of false resistance that are found when the insect population is low during the most critical stages of the plants. Reduction of seed filling period due to alteration of time of planting can produce better quality seeds of soybean and be confused with resistance to insects. Miner (1966) and Jones & Sullivan (1978) referred that early planted soybeans were more damaged by stink bugs than soybean planted one month later. Similar results were obtained by Rosseto et al. (1989), who recommended late planting of 'IAC-100', a variety resistant to stink bugs, as the best strategy to minimize use of pesticides. According to a most recent official recommendation (Embrapa, 1994), late soybeans cultivars planted at the end of December might be severely damaged by stink bugs, indicating the importance of time of planting on the severity of seed damage by stink bugs.

The main objective of this study was to investigate the behavior of resistant and susceptible genotypes of different cycles, when planted at different dates, to evaluate the stability of the response of resistant lines when interacting with alterations on environment, insect population and soybean physiology.

MATERIALS AND METHODS

The experiment was located on the experimental station of the Embrapa/CNPSo located at Londrina, PR, Brazil (26° S), with two genotypes of each of the main soybean maturity cycle (early=M; medium=N; late=O), being one a line or variety resistant to stink bugs, and other a variety susceptible to those insects. Genotypes were chosen among resistance source lines more suitable to local ecological conditions, while susceptible varieties were the standards for breeding essays of each maturity group. Dates of planting were chosen to cover all the period of soybean planting, as used by growers and were: 1) October 18; 2) November 1; 3) November 14; 4) November 30; 5) December 15; and 6) December 30. A split plot design, with four replications was used, locating dates on the plots, and genotypes on the sub-plots, which consisted of four rows of soybeans, measuring 4 m long and spaced 0.5 m. Genotypes tested are presented on Table 1. The experimental area was prepared and the cultural practices applied followed official recommendations (Organização das Cooperativas do Estado do Paraná, 1993).

When soybeans on each plot reached the stage R_4 (Fehr et al., 1971), they were sampled weekly till R_8, using the beat cloth method, with a single sample located in the center of each plot. Insects were collected, transferred to plastic bags and evaluated in the laboratory, counting large nymphs and adults of phytophagous stink bugs. When plants on the plots reached harvest maturity, leaf retention and lodging were evaluated using a scale from 1 (normal plants) to 5 (intense retention or lodging) and height of plants and of insertion of first pod were measured. Three meters of one

TABLE 1. Maturity groups, reaction to stink bugs, genotypes and their genealogies.

Cycle	Reaction	Genotype	Genealogy
Early	Susceptible	DAVIS	D 49 2573 X N 45 1497
	Resistant	LAMAR	[(TRACY M X CENTENNIAL) X D75-10169(3)]
Medium	Susceptible	BOSSIER	Sel. in LEE (super) 100 X CNS
	Resistant	BR 82-12551	(UFV1 X E74111) X M67
Late	Susceptible	FT-5	FT 9510 X SANTANA
	Resistant	BR 82-12431	(IAC 74-2832) X LD 76 761-30

central row were harvested at that time, while the other central row was harvested one week after.

The seeds were weighed and the humidity equalized to 12%. A sample of 50 g of each plot was visually evaluated for stink bug damage, separating the seeds into three groups: 1) Seeds without apparent damage (SND) caused by stink bugs; 2) Seeds with light damage (SLD) caused by stink bugs; and 3) seed with intense damage (SHD) caused by stink bugs, including deformed and shrinkled ones. The seeds broken by mechanical impact, or damaged by humidity or other factors, where considered as a fourth group, but not in the same category as those affected by stink bugs. Statistical analysis was performed with the help of the SANEST package (Zonta et al., 1982), with a mathematical model that considered the effect of complex variances due to the experimental design. The means of the treatments were separated by the Duncan's test at p = 0.05.

RESULTS AND DISCUSSION

Stink bug population

The population of stink bugs present on the different combinations of genotypes and time of planting are presented on Table 2, which shows the number of large nymphs and adults of phytophagous stink bugs per sample (2 m of row), by genotype and by date of planting; it also shows the means of dates and genotypes, and the means by date of sampling. Exception made to the early group, susceptible cultivars presented higher stink bug population, when compared to the resistant genotype of the same group. The seasonal lowest stink bug population was found on the line BR82-12431, probably due to its resistant trait, and specially due to low stink bug populations on the last four dates of planting. March is considered a month of higher stink bug populations, as happened in this study. In the present case, February mean was 3 and March 5 stink bugs/2 m of row, not considering the BR 82-12431 values, whose mean exclusively for March samplings was 3 bugs/2 m. Among the susceptible cultivars, FT-5 showed the highest population on the majority of the dates of planting, what is expected for a late maturity cultivar. Direct comparison between the two genotypes of the late group indicated that stink bugs clearly preferred FT-5 in a proportion of 2:1. Populations of the bugs were lower on the December plantings, and on the last date presented a mean almost 80% lower than the first four dates mean. The low stink bug population found on the plantings of November 14 and 30 should be attributed to the intense concentration of soybean planted around this date, which usually concentrates 70% of total planted area. In this case, the adequate availability of food caused the distribution of stink bugs among different soybean fields, instead of concentrated populations when there is shortage of adequate food.

Analysis of population by date of sampling showed that from March 9 to March 23, stink bug density was at or above the economic damage level (EDL) of four individuals per meter of row (Gazzoni et al., 1981), which also happened with the sampling of February 18, while the overall mean of the experiment was 3 stink bugs/2 m. Normally, migration from soybean fields which are being harvested on the vicinities causes exponential increase on the stink bug population from mid to the end of March, and was not the case of this experiment.

Seed damage

No statistical difference was found between data from the same plots harvested at the correct time or with one week delay, for any of the evaluated parameters, so all results will be represented by the mean between the two situations. Exception made for 'Lamar', whose less damaged seeds were obtained on the December plantings, the two resistant lines produced better seed when planted in November 14, meaning that they are adapted for such time of planting; but also have to be considered that the best results were obtained when large amount of adequate food (pods) for stink bugs was available in the field. Significant differences were detected among means of dates of planting in respect to the percent of seeds without apparent damage (SND), and less damage was verified on soybeans planted from November 14 to December 15, while first planting dates showed highest damage (Table 3). No significant correlation was found between mean population of stink bug and mean SND by date (r=0,43), indicating that although important, the population of stink bugs solely do not explain the whole damage caused to the seeds, and interaction with other factors, as critical stages

TABLE 2. Population of stink bugs per 2 m of row of six soybean genotypes, planted at six different dates. Londrina, PR, 1995[1].

Date of sampling	Oct 18	Nov 1	Nov 14	Nov 30	Dec 15	Dec 30	Sampling date mean[1]	Oct 18	Nov 1	Nov 14	Nov 30	Dec 15	Dec 30	Sampling date mean	Sampling date mean by group
	Lamar							Davis							
Feb 4	3	2	2				2	5	5	2				4	3
10	6	3	1				3	4	4	4				4	4
18	10	2	4				5	3	4	4				4	5
24	0	3	4	4	1		2	5	4	2	4	0		3	3
Mar 2	9	3	4	2	1	0	3	5	5	7	4	3	0	4	4
9	8	10	4	3	1	1	5	4	4	3	4	3	1	3	4
16	9	8	4	3	2	6	5	7	5	4	5	2	2	4	5
23	14	7	9	3	3	2	6	1	3	6	6	4	5	4	5
Mean	7	5	4	3	2	2	4	4	4	4	5	2	2	4	4
	BR 82-12551							Bossier							
Feb 4	5	3	1				3	6	3	0				3	3
10	3	2	0				2	4	3	2				3	2
18	5	2	4				4	1	11	6				6	5
24	6	0	1	4	0		2	1	6	2	3	0		2	2
Mar 2	4	6	2	3	0	0	3	3	5	5	1	0	0	2	2
9	6	5	2	3	2	1	3	1	5	5	23	3	0	6	5
16	6	7	4	6	7	2	5	0	7	6	7	3	0	4	5
23	17	13	2	3	4	0	7	0	4	10	6	0	1	4	5
Mean	7	5	2	4	3	1	3	2	6	5	8	1	0	4	4
	BR 82-12431							FT-5							
Feb 4	1	1	1				1	2	1	1				1	1
10	1	1	0				1	6	3	1				3	2
18	2	0	1				1	10	3	2				5	3
24	1	4	0	1	1		1	1	4	3	4	3		3	2
Mar 2	3	0	2	1	0	0	1	10	3	3	2	1	0	3	2
9	4	6	0	1	0	0	2	8	13	2	5	1	2	5	4
16	7	6	3	0	1	1	3	9	10	1	4	2	4	5	4
23	8	6	1	1	7	3	4	14	7	9	6	3	2	7	6
Mean	3	3	1	1	2	1	2	8	6	3	4	2	2	4	3
Planting date mean by group	6	4	2	3	2	1	3	5	5	4	6	2	1	4	3
Planting date overall mean	6	5	3	3	2	1	3								

Sampling date overall mean

Date	Feb 4	Feb 10	Feb 18	Feb 24	Mar 2	Mar 9	Mar 16	Mar 23	Mean
Mean	2	3	4	2	3	4	4	5	3

[1] All means were rounded to the nearest integer.

thus pointing out the need of further investigation on the relationship of the interaction among soybean genotype•cycle•date of planting•population of stink bugs of commercial varieties, in order to verify the need to adapt present recommendations to growers. It also became evident the necessity of additional investigation searching for more stable genotypes that do not react so strongly with environmental and cultural practices, to be used as source of resistance for stink bugs.

Agronomic traits

Leaf retention index decreased from the 1st. to the 5th. date of planting (Table 7), roughly following the pattern of stink bug population, seed damage and productivity. First date of planting presented intense leaf area retention, even on resistant genotypes. Also intense leaf retention was observed on 'Lamar' on all dates up to November 30. The lowest index was shown by BR82-12551, which also presented less damaged seeds, indicating the association between the two traits. Lodging of soybeans (Table 8) did not correlate with stink bug population, yield or seed damage of soybeans, and also had low variation among dates of planting or genotypes. The height of plants (Table 9) was affected by date of planting and genotypes, but showed no association with stink bug population or damage, as also happened with insertion of first pod (Table 10), highly correlated with plant height but not with stink bug population

TABLE 7. Leaf retention index (LRI) of six soybean genotypes, planted at six dates, submitted to natural infestation of stink bugs. Londrina, PR, 1995[1].

Date	Genotype						
	Davis	Lamar	Bossier	BR 82-12551	FT-5	BR 82-12431	Mean
1	5,0a	5,0a	5,0a	4,5a	4,8a	3,3ab	4,6a
2	5,0a	4,8a	5,0a	2,3b	3,5b	3,3ab	4,0b
3	5,0a	4,3a	4,3a	1,5b	2,3c	2,5b	3,3c
4	2,8b	4,5a	2,3b	1,5b	1,8c	3,3ab	2,7d
5	1,3c	2,8b	2,3b	1,5b	2,0c	3,0ab	1,9e
6	2,0bc	1,8c	1,0c	2,3b	2,5c	3,8a	2,4de
Mean	3,5ab	3,8a	3,3b	2,3d	2,8c	3,1b	3,1

[1] Means followed by the same letter, in the same column, are not different by the Duncan's test at p=0.05; means followed by the same letter, in the same line, are not different by the Duncan's test at p=0.05.

TABLE 8. Lodging index (LI) of six soybean genotypes, planted at six dates, submitted to natural infestation of stink bugs. Londrina, PR, 1995[1].

Date	Genotype						
	Davis	Lamar	Bossier	BR 82-12551	FT-5	BR 82-12431	Mean
1	1,8a	2,0ab	2,0b	2,0a	1,8bc	1,5c	1,8bc
2	2,0a	1,3ab	2,3ab	1,8a	2,8ab	2,8ab	2,1abc
3	2,0a	2,3a	2,3ab	2,3a	3,0a	3,5a	2,5ab
4	2,5a	1,8ab	3,3a	2,0a	2,8ab	3,3a	2,6a
5	1,5a	1,8ab	2,3ab	2,0a	1,5c	1,8c	1,8c
6	2,0a	1,0b	2,8ab	2,0a	2,0abc	2,0bc	2,0abc
Mean	1,9cd	1,7d	2,5a	2,0bc	2,3ab	2,5a	2,1

[1] Means followed by the same letter, in the same column, are not different by the Duncan's test at p=0.05; means followed by the same letter, in the same line, are not different by the Duncan's test at p=0.05.

TABLE 9. Plant height (PH) of six soybean genotypes, planted at six dates, submitted to natural infestation of stink bugs. Londrina, PR, 1995[1].

Date	Genotype						
	Davis	Lamar	Bossier	BR 82-12551	FT-5	BR 82-12431	Mean
1	46b	31c	51b	36c	58c	63b	47d
2	60a	45b	63ab	52ab	76ab	83a	63bc
3	63a	47b	71a	55ab	78a	82a	66ab
4	69a	58ab	70a	62a	81a	91a	72a
5	64a	68a	75a	61a	85a	91a	74a
6	47b	55b	62ab	44bc	64bc	66b	56c
Mean	58d	51e	65c	52e	74b	79a	63

[1] Means followed by the same letter, in the same column, are not different by the Duncan's test at p=0.05; means followed by the same letter, in the same line, are not different by the Duncan's test at p=0.05.

TABLE 10. First pod height (FPH) of six soybean genotypes, planted at six dates, submitted to natural infestation of stink bugs. Londrina, PR, 1995[1].

Date	Genotype						
	Davis	Lamar	Bossier	BR 82-12551	FT-5	BR 82-12431	Mean
1	5c	6ab	6b	3c	9ab	6c	6d
2	5bc	5b	5b	6bc	9ab	5c	6d
3	7abc	7ab	8b	10a	7b	5c	7cd
4	9ab	6ab	6b	10a	10ab	11b	8bc
5	10a	10a	12a	11a	11a	13ab	11a
6	8abc	8ab	7b	9ab	10ab	15a	9ab
Mean	7b	7b	7b	8ab	9a	9a	8

[1] Means followed by the same letter, in the same column, are not different by the Duncan's test at p=0.05; means followed by the same letter, in the same line, are not different by the Duncan's test at p=0.05.

or its damage. The most probable explanation is that plant height and pod insertion were quite defined by the time of the stink bug attack.

CONCLUSION

There is interaction between time of planting and reaction of genotypes to stink bug damage.

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