Genetics and Molecular Biology, 25, 3, 339-342 (2002)

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Research Article

Genetics of resistance to powdery mildew (*Microsphaera diffusa*) in Brazilian soybean populations

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Abstract

Crosses between resistant and susceptible soybean cultivars were performed and the F_2 populations were obtained to study the inheritance of soybean resistance to powdery mildew and to estimate the number and action of genes related to resistance. The reaction to powdery mildew was studied in a greenhouse and pots carrying plants with symptoms were distributed among the pots carrying the genotypes to be tested as a source of inoculum. Individual plants were scored according to the method of Yorinori (1997), with modifications, and classified as resistant or susceptible. The results showed that adult soybeans plants can present resistance to powdery mildew, which is controlled by one major gene with a dominant effect.

Key words: powdery mildew, *Glycine max*, genetic control.

Received: March 5, 2002; accepted: July 23, 2002.

Introduction

Brazil occupies an important position worldwide as a soybean producer and exporter. Nowadays Brazil is the second largest exporter of grain and bran and the third of soybean oil (Embrapa, 2000). Among the main factors limiting soybean production are the diseases that attack the plants.

A limited incidence of powdery mildew was verified in the 1996/97 crop. The disease is caused by the fungus *Microsphaera diffusa* in diverse cultivars, and is favored by rainy weather and mild temperatures. Today the disease reaches all the production regions in Brazil, with losses ranging from 30 to 40% (Yorinori, 1997).

The most typical symptom of powdery mildew is the presence of a fine layer of mycelium and powdery spores (conidia), white or grayish-brown in color covering the aerial part of the plant, being less typically observed in the pods. This covering layer, indicating serious infection, prevents photosynthesis, causing leaf dryness and premature fall. Moreover, the plants present a grayish-brown to bronze coloration that looks like the dryness (desiccation) caused by herbicides (Sartonato and Yorinori, 2001).

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Studies about the adult-plant resistance in soybean have reported that the plants, especially their leaves, may present differences in the level of infection with powdery mildew during their different stages of development. Mignucci and Lim (1980) observed that 1-parted leaves were found to be more susceptible in plants inoculated at the V_1 stage than in those inoculated at the V_3 stage and that the lower leaves of young plants were more susceptible than those in higher positions. They also observed that some time after the inoculation a reduction of the symptoms occured in all types of leaves some time after the inoculation, showing that the mildew develops better in young plants. Therefore, it can be seen that either the pathogen or the presentation of the symptoms are affected by the cultivar, the position of the leaves and the age of the plant at the time of inoculation.

Previous studies by Grau and Laurence (1975) and Mignucci and Lim (1980) showed that resistance to powdery mildew is inherited in a Mendelian way, *i.e.*, it is controlled by major genes, although with a varying influence on the intensity and severity of the disease. Under field conditions three types of reactions can be observed under field conditions: susceptibility, adult-plant resistance, and full resistance.

Studies carried out in other countries (Lohnes and Bernard, 1992) have shown that in some soybean populations the entire resistance is controlled by an Rdm-c gene with a dominant effect, allelic to genes that confer adult-plant resistance (Rdm) and susceptibility (rdm). The Rdm-c gene originates from the CNS cultivar and is associated with the Rps2 gene which confers resistance to Phytophthora root rot. In contrast, adult-plant resistance is controlled by a pair of genes (Rdm, rdm), with the Rdm allele having a dominant effect and acting on adult-plant resistance and the rdm allele conferring susceptibility (Mignucci and Lim 1980). In Brazil there are no reports of studies related to the inheritance of soybean resistance to powdery mildew.

For the development of new cultivars resistant to powdery mildew it is of great importance to have previous knowledge about the genetic control of resistance in segregating populations, as well as about the existence of variability. As a result, a selective process can be applied, resulting in significant genetic gains. Thus, the objective of the present study was to develop segregating populations (a total of eight) derived from crosses between cultivars resistant and susceptible to powdery mildew in order to study the inheritance of soybean resistance to the disease.

Materials and Methods

The experiments were conducted in the experimental area of the Department of Crop Production of the Faculty of Agronomy and Veterinary Sciences, São Paulo State University, Jaboticabal Campus. Table I shows the relationship between the cultivars used in the crosses and the reactions of each one to powdery mildew.

Enough seeds were cultivated from F_2 to obtain about 60 F_2 plants per cross, so that the evaluations of powdery mildew resistance could be completed. The seeds were cultivated in pots from March through September 2000, the most appropriate period for studying powdery mildew resistance. The plants were inoculated naturally as follows: right after sowing, pots containing plants of highly susceptible varieties (BR-16 and IAC Foscarim 31) and with powdery mildew symptoms were placed among the pots of the studied plants, so that natural infection occurred rapidly and regularly.

Two evaluations were performed in the populations, one 20 days after sowing (CV1) and the other after flowering (CV2). Plants were scored for diseases according to a 0-to-5 grade scale, as proposed by Yorinori (1997), as follows: 0 = no leaf symptoms, 1 = 10% of the leaf surface with symptoms, 2 = 11 to 25% of the leaf surface with symptoms, 3 = 26 to 50% of the leaf surface with symptoms, 4 = 51 to 75% of the leaf surface with symptoms, 5 = more than 75% of the leaf surface with symptoms. In the present study, plants scored as grades 0, 1, 2, and 3 were considered resistant (R) and plants scored as grades 4 and 5 were considered susceptible (S).

Table I - Genealogy of the crosses used to study resistance to powdery mildew in soybeans.

Cross number	Genealogy
1	Liderança (R) X Embrapa 48 (S)
2	Embrapa 48 (S) X IAC – 17 (R)
3	IAC Foscarim–31 (S) X Renascença (R)
4	MGBR 95 – 20973 (R) X BR – 16 (S)
5	IAC – 17 (R) X BR 16 (S)
6	Embrapa 48 (S) X MGBR 95 – 20973 (R)
7	Renascença (R) X Embrapa 48 (S)
8	IAC Foscarim–31 (S) X Liderança (R)

(R) = Resistant; (S) = Susceptible.

The chi-square test (χ^2) was used to study the genetics of resistance to powdery mildew for a 3:1 segregation, as suggested by Snedecor and Cochran (1989) and Ramalho *et al*. (1989), as follows:

$$\chi^2 = \sum \frac{(F_0 - F_E)^2}{F_E}$$

where F_0 = Observed frequency and F_E = expected frequency.

The heterogeneity test was applied to the results of the chi-square test for the eight populations studied to check the consistency of the same results for the eight populations. The procedure was carried out by the method by Mather (1957).

Results and Discussion

The results of the evaluations performed in each population at two different times (CV1 and CV2) are listed in Table II. The results of the first evaluation were inconsistent with 3:1 segregation, as confirmed by the chi-square test (Table III), a fact possibly explained by the occurrence of resistance in adult plants, as mentioned by Mignucci and Lim (1980). When the first evaluation was performed, the plants were still at the seedling stage, when the individuals tested may present susceptibility, even if carrying the resistance gene. Furthermore, according to Mignucci and Lim (1980), after the formation of the second 3-parted leaf, the symptoms tend to disappear and the same plants that appear to be susceptible in the young-plant stage may present a resistance reaction to the disease when adult.

Based on prior studies conducted in the United States, which pointed out that the genetic control of soybean resistance to powdery mildew is ruled by major genes (Grau and Laurence, 1975), the chi-square test was applied to each population evaluated and to each evaluation. Table III pres-

Table II - Number of plants classified as resistant and susceptible within each studied cross.

Tested populations and Plant reactions		Greenhouse	
		1st Evaluation	2nd Evaluation
1	(NPR)	1	44
	(NPS)	59	16
2	(NPR)	5	44
	(NPS)	55	16
3	(NPR)	8	42
	(NPS)	52	18
4	(NPR)	0	46
	(NPS)	60	14
5	(NPR)	0	44
	(NPS)	60	16
6	(NPR)	0	47
	(NPS)	60	13
7	(NPR)	0	45
	(NPS)	60	15
8	(NPR)	0	43
	(NPS)	60	17

(NPR) = number of resistant plants per cross.
(NPS) = number of susceptible plants per cross.

ents the results of the chi-square test for both evaluations, with 3:1 segregation being considered. It was confirmed that population 7 presented a high level of probability to accept 3:1 segregation, indicating that soybean resistance to powdery mildew is ruled by a single gene with a dominant effect, with two alleles. On the other hand, populations 1, 2, 4, and 5 also presented 3:1 segregation ($0.70 < p < 0.80$), while populations 3, 6, and 8 presented a slightly lower probability ($0.30 < p < 0.50$ and $0.50 < p < 0.70$, respectively). These results agree with the observations of Grau and Laurence (1975), Mignucci and Lim (1980) and Lohnes and Bernard (1992).

Table III - Result of the χ^2 test for the crosses evaluated in terms of reaction to powdery mildew.

	Greenhouse	
Cross	1st.Evaluation	2nd Evaluation
1	172.09^{**}	0.089^{ns} ($0.70 < p < 0.80$)
2	142.30^{**}	0.089^{ns} ($0.70 < p < 0.80$)
3	121.69^{**}	0.8^{ns} ($0.30 < p < 0.50$)
4	180.00^{**}	0.089^{ns} ($0.70 < p < 0.80$)
5	180.00^{**}	0.089^{ns} ($0.70 < p < 0.80$)
6	180.00^{**}	0.36^{ns} ($0.50 < p < 0.70$)
7	180.00^{**}	0.0^{ns} ($p = 1.0$)
8	180.00^{**}	0.36^{ns} ($0.50 < p < 0.70$)

** - Significant values ($p < 0,001$).
ns - Non-significant values.

The second evaluation of the level of leaf infection with *M. diffusa* was performed when the plants had already flowered. By comparing the data obtained in the first and second evaluations (Table II), it can be seen that the studied plants presented adult-plant resistance, as suggested by Mignucci and Lim (1980).

The results of the heterogeneity test are presented in Table IV. The non-significance of this test indicates that the results obtained by applying the chi-square test to the data for the eight populations studied are consistent, confirming that the genetic control of soybean resistance to powdery mildew is associated with a single gene with a dominant effect.

References

Embrapa (2000) Centro Nacional de Pesquisa de Soja. Recomendações Técnicas Para a Cultura de Soja na Região Central do Brasil-2000/01. Londrina, pp 245 (Documento 146).

Table IV - Results of the heterogeneity test applied to the values obtained from the second evaluation of plant resistance to powdery mildew.

Cross number	Resistant (R)	Susceptible (S)	(χ^2)	d.f.	p
1	44	16	0.089	1	($0.70 < p < 0.80$)
2	44	16	0.089	1	($0.70 < p < 0.80$)
3	42	18	0.8	1	($0.30 < p < 0.50$)
4	46	14	0.089	1	($0.70 < p < 0.80$)
5	44	16	0.089	1	($0.70 < p < 0.80$)
6	47	13	0.36	1	($0.50 < p < 0.70$)
7	45	15	0.0	1	($p = 1.0$)
8	43	17	0.36	1	($0.50 < p < 0.70$)
Total			1.876	8	($p > 0.95$)
Deviation	355	125	0.278	1	($0.50 < p < 0.70$)
Heterogeneity			1.598	7	($p > 0.95$)

Grau CR and Laurence JA (1975) Observations on resistance and heritability of resistance to powdery mildew of soybean. Plant Disease Reporter 59(6):458-460.

Lohnes DG and Bernard RL (1992) Inheritance of resistance to powdery mildew in soybeans. Plant Disease 76(9):964-965.

Mather J (1957) The measurement of linkage in heredity. London: Butler and Tanner Ltda, pp 149.

Mignucci JS and Lim SM (1980) Powdery mildew (Microspraera diffusa) development on soybeans with adult-plant resistance. Phytopathology 70(9):919-921.

Ramalho MAP dos Santos, JB and Pinto CB (1989) Genética na agropecuária. São Paulo: Globo/Fundação de Apoio ao Ensino, Pesquisa e Extensão, pp 113-127.

Sartorato A and Yorinori JT (2001) Oídios de Leguminosas: Feijoeiro e Soja. In: Sadnik MJ and Rivera MC Oídios. Jaguariúna, SP. Embrapa Meio Ambiente, pp 262-284.

Snedecor GW and Cochran WG (1989) Statistical methods. 8 ed. Ames: Iowa State University Press, pp 107-130.

Yorinori JT (1997) Oídio da Soja. Londrina: EMBRAPA – soja. Oidiosja. Doc, 13 pp.