

THE INHERITANCE OF BROCCOLI (*BRASSICA OLERACEA* L. VAR. *BOTRYTIS* L.) LEAF RESISTANCE TO DOWNY MILDEW — *PERONOSPORA PARASITICA* (PERS.) EX FR.¹

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Summary. The studying material consisted of two American broccoli lines and their F_1 - F_4 hybrids. One of these lines was resistant at the cotyledon stage, whereas another one — at the leaf stage. The method of the fungus reproduction, inoculation and estimation of cotyledon and leaf infection using a 6-grade scale were in agreement with the method of P. H. Williams, USA.

It has been found that resistance of the American broccoli line to the Polish isolate of downy mildew at the 4 - 5-true leaf stage was determined by a single recessive gene different from genes determining plant resistance at the cotyledon stage. In the F_3 and F_4 generations of resistant plants a certain per cent of incompletely resistant individuals produced leaf necroses with out sporing. That phenomenon was probably a result of a modifying influence of the environment on both infected plants and development of the fungus.

The studies carried so far on the inheritance of *Brassica* crop resistance to downy mildew (*Peronospora parasitica* (Pers.) ex Fr.) concerned only cotyledon resistance (Natti et al. 1967, Hoser-Krauze et al. 1984). There are more publications and communications dealing with the results of variety and species testing for susceptibility to this fungus and with resistance sources — also at the cotyledon stage (Natti et al. 1967, Greenhalgh, Dickinson 1976, Lenng 1981). It has been found that cotyledon resistance is not equivalent to the resistance of other plant parts. Therefore, in order to make resistance culture more effective further studies on the resistance inheritance are much required. Studies presented in this paper are dealing with these problems.

MATERIAL AND METHODS

A source of resistance were two lines of broccoli received from R. L. Gabrielson from the Washington State University, USA, one of which was determined as resistant at the cotyledon stage and another one — as possessing resistance at the

¹ Received for publication: April, 1987.

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leaf stage. These lines were randomly intercrossed and the obtained F_1 was pollinated inbreedingly. The both parental broccoli lines of F_1 and F_2 of these lines were tested for susceptibility to downy mildew in the autumn of 1984. For further studies on leaf resistance we chose resistant plants. The F_3 generation of these plants was tested in the autumn of 1984 and F_4 — in 1986. Plant response to the pathogen was studied under controlled conditions at the stage of developed cotyledons during the last decade of October, after which the same plants were tested at the stage of 4-5 leaves in the end of November. Cotyledons as well as leaves were inoculated through spraying with fungus suspension at the concentration of 10^5 spores per 1 ml of water. Reproduction of the pathogen and inoculation conditions conformed to the method of Williams. The host plant for reproduction of the fungus was a susceptible cauliflower variety and the source of inoculum — broccoli seedlings infected by downy mildew under natural conditions of the infection. Fungus inoculum was obtained from the third passage of host plants. The infection degree of the studied plants at the stage of both cotyledons and true leaves was determined visually according to the 6-grade scale of Williams from 0 to 9:

- 0 — no symptoms,
- 1 — very few small necrotic spots in the place of inoculation to small necroses on the lower surface of the cotyledon, the lack of sporing,
- 3 — very weak sporing, 1-several conidiospores, on the upper or lower surface of the cotyledon necrotic spots are frequent, necrosis of the leaf blade is present,
- 5 — rarely scattered sporing on the upper or lower or on the both surfaces of the cotyledons; necrosis of tissue,
- 7 — strong to very strong sporing chiefly on the lower surface, necrosis and chlorosis may occur,
- 9 — strong sporing on the lower surface of the cotyledons, no or slight sporing on the upper surface, slight or no necrosis and chlorosis.

Plants exclusively from classes 0-1 were determined as resistant at the stage of cotyledons and true leaves. Plants from class 3 were determined as tolerant, but on the susceptibility limit, and those from the remaining classes 5-9 were referred to susceptible ones.

RESULTS AND DISCUSSION

On the basis of the studied plant response at the stage of both cotyledons and true leaves it has been found that genes determining leaf resistance differ from those determining cotyledon resistance. Plants qualified at the cotyledon stage in class 0 regarding their cotyledon susceptibility were in classes from 0 to 5 and vice versa, plants resistant at the true leaf stage with regard to their cotyledon susceptibility were in classes from 1 to 9. These results are in agreement with the report of Lennig (1981), who informs that cotyledon resistance does not provide the resistance of other plant parts. The obtained results of plant response at the stage of cotyledons

and 4-5 leaves of the parental lines (Table 1) showed that the broccoli line P_1 resistant to downy mildew at the cotyledon stage was 100% susceptible at the leaf stage. On the other hand, the line (P_2) susceptible at the cotyledon stage, which had to be homozygously resistant at the leaf stage, segregated in this respect. The response of

Table 1. Response of broccoli plants at the 4 - 5-leaf stage to downy mildew

Generation and pedigree	Plant segregation			Segregation ratios		χ^2	P
	resistant class 0-1	tolerant class 3	susceptible class 5-9	expected	obtained		
Broccoli -- control susceptible variety	0	11	22	% of resistant	% of resistant		
P_1 broccoli American line	0	6	15	% of resistant	% of resistant		
P_2 broccoli American line	3	11	8	100% of resistant	15% of resistant 50% of tolerant		
F_1 ($P_1 \times P_2$)	0	—	9	0% of resistant	% of resistant		
F_2 (F_1)	36	63	24	1 : 3	36 : 87	1.29	0.50 - 0.20
Cauliflower -- control susceptible	—	8	20	0% of resistant	% of resistant		
F_3 (F_2 class 0-1)	198	66	—	100% of resistant	75% of resistant 25% of tolerant		
Broccoli -- control susceptible variety	—	7	12	0% of resistant	0% of resistant		
F_4 (F_3 class 0-1)	364	91	—	100% of resistant	80% of resistant 20% of tolerant		

F_1 and F_2 plants indicates that resistance of the American broccoli line to that pathogen at the leaf stage was determined by a single recessive gene, which is supported by the *chi*-square test and the lack of further segregation in the F_3 and F_4 generations of resistant plants. The variation range of these generations regarding their response to the pathogen did not exceed the first three classes in the survey scale, about 80% being in classes 0-1; the remaining plants showed tolerance expressed in the occurrence of necroses and in the lack of fungus sporing.

CONCLUSIONS

1. The resistance of the American lines of broccoli to the Polish isolate of downy mildew, *Peronospora parasitica* (Pers.) ex Fr. at the stage of 4-5 true leaves was determined by a single recessive gene different from genes determining plant resistance at the stage of cotyledons. This assures the effectiveness of resistant plant selection in the progeny of F_2 hybrid obtained from crossing resistant line to susceptible one.

2. Taking into consideration the influence of variation in the fungus pathogenicity as well as a modifying influence of the environment in host plants, it should be reckoned with a certain varying per cent of not completely resistant individuals, producing leaf necroses without sporing in the progeny of resistant plants.

REFERENCES

1. Greenhalgh J. R., Dickinson C. H. (1975). Differential reactions of three crucifers to infection by *Peronospora parasitica* (Pers. ex Fr.). *Phytopath. Zeitschrift* 84, 131 - 141.
2. Greenhalgh J. R., Dickinson C. H., (1976). Studies of crucifer seedling resistance to *Peronospora parasitica*. *Ann. Apl. Biol.* 84: 278 - 281.
3. Hoser-Krauze J., Łąkowska-Ryk E., Antosik J. (1984). Resistance of cauliflower and broccoli (*Br. ol. L. botrytis* L.) seedlings to downy mildew, *Peronospora parasitica*. *Cruciferae Newsletter*, No 9, December 1984, Eucarpia.
4. Lenng H. (1981). Breeding for multiple disease resistance in cytoplasmic male sterile *Brassica campestris* L. M. S. Thesis Univ. of Wisconsin, Madison 73 pp. Dep. of Plant Pathology.
5. Natti J. J., Dickson M. H., Atkin I. D. (1967). Resistance of *Brassica oleracea* varieties to downy mildew. *Phytopathology* 57: 144 - 147.
6. Williams P. H., Cr. G. C. Resource Book. Dep. of Plant Pathology 1630 Linden D. R., Univ. of Wisconsin, Madison 53706.

DZIEDZICZENIE ODPORNOŚCI LIŚCI BROKUŁA (*BRASSICA OLERACEA* L. VAR. *BOTRYTIS* L.) NA MĄCZNIAKA RZEKOMEGO — *PERONOSPORA PARASITICA* (PERS.) EX FR.

Streszczenie

Badano dwie amerykańskie linie brokuła oraz ich $F_1 - F_4$. Jedna z tych linii miała odporność w fazie liścieni, druga w fazie liści. Sposób rozmnażania grzyba, inokulacja, jak i ocena w 7-stopniowej skali porażenia liścieni oraz liści, zgodne były z metodą P. H. Williamsa (USA). Stwierdzono, że odporność amerykańskiej linii brokuła na polski izolot mączniaka rzekomego w fazie 4 - 5 liści właściwych, determinowana była jednym recesywnym genem, różnym od genów warunkujących odporność roślin w fazie liścieni.

W pokoleniach F_3 i F_4 roślin odpornych występował pewien procent osobników niecałkowicie odpornych, które wytwarzały nekrozy liści bez zarodnikowania. Zjawisko to było prawdopodobnie wynikiem modyfikującego wpływu środowiska zarówno na infekowane rośliny jak i rozwój grzyba.

НАСЛЕДОВАНИЕ УСТОЙЧИВОСТИ ЛИСТЬЕВ БРОККОЛИ (*BRASSICA OLERACEA* L. VAR. *BOTRYTIS* L.) К ЛОЖНОЙ МУЧНИСТОЙ РОСЕ — *PERONOSPORA PARASITICA* (PERS.) EX FR.

Резюме

Исследуемый материал состоял из двух американских линий брокколи и их гибридов поколения $F_1 - F_4$. Одна из этих линий была устойчива в стадии семядолей, в то время как другая — в стадии листьев. Метод размножения гриба, инокуляция и оценка инфекции семядолей с помощью 6-градусной шкалы были в соответствии с методом П. Х. Вилльямса (США).

Было установлено, что устойчивость американской линии брокколи к польскому изоляту ложной мучнистой росы в стадии 4—5 настоящих листьев обуславливалась одним рецессивным геном, отличающимся от генов, определяющих устойчивость растений в стадии семядолей. В поколениях F_3 и F_4 устойчивых растений определённый процент неполностью устойчивых растений имел листья с некрозами и не производил спор. Это явление было вероятно результатом модифицирующего влияния окружающей среды на заражённые растения и на развитие гриба.