Euphytica 26 (1977) 793 796

RELATION IN THE INHERITANCE OF RESISTANCE TO *PSEUDOPERONOSPORA CUBENSIS* ROST AND *SPHAEROTHECA FULIGINEA* POLL. IN CUCUMBER (*CUCUMIS SATIVUS* L.)

G. J. A. VAN VLIET and W. D. MEIJSING

Sluis & Groot Seed Company, Enkhuizen, the Netherlands

Received 2 September 1976

INDEX WORDS

Cucumis sativus, cucumber, resistance, downy mildew, *Pseudoperonospora cubensis*, powdery mildew, Sphaerotheca fuliginea, linkage.

SUMMARY

Among the genes for resistance against *Sphaerotheca fuliginea*, the gene s for resistance of the hypocotyl is linked to or identical with gene p for resistance to *Pseudoperonospora cubensis*. This gene s is present in the cultivars Ashley, Poinsett, Natsufushinari, Pixie, Taipei and in accessions PI 179676, PI 212233 and PI 234517.
Although gene s initially brings about some resistance of the true leaf, it appears that when s is present, other genes are necessary for complete resistance to *S. fuliginea*.

INTRODUCTION

According to BARNES & EPPS (1956) and VAN VLIET & MEIJSING (1974) the resistance to downy mildew is accompanied by some resistance to powdery mildew caused by *Pseudoperonospora cubensis* (BERK and CURT). ROST. and *Sphaerotheca fuliginea* (SCHLECHT ex FR.) POLL., respectively.

VAN VLIET & MEIJSING (1974) demonstrated that the resistance to downy mildew in the cultivar Poinsett is based on one recessive gene p which is either linked or identical with one of the genes for powdery mildew resistance, designated gene s.

Resistance to powdery mildew is attributed by KOOISTRA (1968) to three recessive genes. In the F2 of the cross Natsufushinari × PI 200818 he selected plants that were more resistant than the best parent Natsufushinari.

SHANMUGASUNDARAM et al. (1971), however, concluded that resistance to powdery mildew of the hypocotyl is based on a recessive gene s in Natsufushinari. Leaf resistance is controlled by the dominant gene R which only expresses itself in the presence of recessive gene s. Gene I is an inhibitory gene which prevents the expression of complete resistance but does not affect s.

The resistance to *P. cubensis* in cultivars Ashley and Poinsett developed by W .C. Barnes, found its origin in an Indian variety PI 197087 (PETERSON, 1975).

The present study was carried out to learn more about the relation between some of the above mentioned sources of resistance and to establish which of the genes for *S. fuliginea* resistance is linked with the recessive gene p for *P. cubensis* resistance.

MATERIALS AND METHODS

Line PMR, developed at our station and resistant to *P. cubensis*, *S. fuliginea* and with shiny fruit skin colour was crossed with line PMS which is susceptible to both diseases. Crosses were also made with the cultivars: Ashley, Poinsett (kindly supplied by HARRIS SEED CO., New York, USA), Natsufushinari (kindly supplied by MIKADO SEED CO., Japan), Taipei (ex Taiwan, received as I.V.T. no. 69255 and kindly supplied by ir. Q. P. van der MEER), and with PI 179676 (ex India, cv. Kakri, received as I.V.T. no. 73142 and kindly supplied by ir. Q. P. VAN DER MEER, IVT, Wageningen, the Netherlands), using PMR as the pollen parent in all cases.

All these cultivars are reported to have at least some resistance to *S. fuliginea* and/or *P. cubensis* (LEPPIK et al., 1964; KOOISTRA, 1968; SHANMUGASUNDARAM et al., 1971; SITTERLY, 1972).

The F2 of PMS × PMR together with its parental lines PMS and PMR were tested for resistance to *P. cubensis* as described by VAN VLIET and MEIJSING (1974). The resistant plants were separated from the susceptible ones and both groups were inoculated simultaneously with conidia of *S. fuliginea* by dusting the plants with leaves covered with sporulating powdery mildew fungus.

F2's of PMR with Ashley, Poinsett, Natsufushinari, Tapei and PI 179676, together with their parents, were also tested for resistance to *P. cubensis*. In a separate test this material was further investigated for hypocotyl resistance to *S. fuliginea*.

RESULTS AND DISCUSSION

Table 1 shows the F2 (PMS × PMR) to segregate for resistance to *P. cubensis* as a monogenic recessive. The 475 *P. cubensis* susceptible plants from this F2 turned out to be susceptible for *S. fuliginea* on the hypocotyl as well as on the leaf. The 155 *P. cubensis* resistant plants of this F2 however remained symptomless for 14 days after inoculation with *S. fuliginea*, while 21 days after inoculation a segregation for leaf resistance became apparent. The hypocotyls of these 155 plants remained resistant.

The degree of mildew infection on the leaf was divided into three classes: R = no powdery mildew and MR = some powdery mildew, MS = same amount of powdery mildew on the leaf as the susceptible control. The number of plants in these classes was 44,75 and 36, respectively.

Table 2 shows that the F1's and F2's from crosses of line PMR with the 5 *P. cubensis* resistant parents do not segregate for resistance to this disease. With exception of line PMS as susceptible control, all material listed in Table 2 is resistant to *P. cubensis* on the cotyledons and to *S. fuliginea* on the hypocotyls. From these results it is clear that the 5 cultivars tested all carry the same gene p, which is either closely linked, allelic to, or identical with gene s (designations VAN VLIET & MEIJSING, 1974). Gene s is responsible for resistance to *S. fuliginea* of the hypocotyl and delays the expression of susceptibility of the leaf. Furthermore, it is essential for leaf resistance in co-operation with other genes. It is linked with a dull green fruit colour which, as previously reported by us (1974), has been broken. The gene s reported by SHANMUGASUNDARAM et al. (1971), and according to them present in cultivars Natsufushi-

Table 1. Segregation for resistance to *Pseudoperonospora cubensis* and subsequently for resistance to *Sphaerotheca fuliginea* on the hypocotyl and the leaf of plants of two cucumber cultivars and their F_1 and F_2 plants.

Material tested	Number of plants tested	Resistance or susceptibility to *P. cubensis*[1]	
		R	S
PMR	10	10	
PMS	10		10
F_1 (PMS × PMR)	10		10
F_2 (PMS × PMR)	630	155	475

		Resistance or susceptibility to *S. fuliginea* on the[1]					
		hypocotyl		leaf			
		R	S	R	MR	MS	S
PMR	10	10		10			
PMS	10		10				10
F_1 (PMS × PMR)	10		10				10
F_2 (PMS × PMR): R to *P. cub.*	155	155		44	75	36	
F_2 (PMS × PMR): S. to *P. cub.*	475		475				475

[1] R = Resistant; MR = Moderately resistant; MS = Moderately susceptible; S = Susceptible.

Table 2. Reaction to *Pseudoperonospora cubensis* and *Sphaerotheca fuliginea* on the cotyledons resp. the hypocotyls of 5 different cucumber cultivars together with their F_1 and F_2's with line PMR.

Material tested	Number of plants tested	Resistance (R) or susceptibility (S) to			
		P. cubensis		*S. fuliginea*	
		R	S	R	S
Ashley (= A)	10	10		10	
Poinsett (= P)	10	10		10	
Natsufushinari (= N)	10	10		10	
Taipei (= T)	10	10		10	
PI 179676 (= PI)	10	10		10	
PMR	10	10		10	
PMS	10		10		10
F1 (A × PMR)	10	10		10	
F1 (P × PMR)	10	10		10	
F1 (N × PMR)	10	10		10	
F1 (T × PMR)	10	10		10	
F1 (PI × PMR)	10	10		10	
F2 (A × PMR)	200	200		200	
F2 (P × PMR)	200	200		200	
F2 (N × PMR)	200	200		200	
F2 (T × PMR)	200	200		200	
F2 (PI × PMR)	200	200		200	

nari (ex Japan), Pixie (ex South Carolina, USA), PI 212233 (ex Japan, known as Kurume Natuhusinari), and PI 234517 (ex South Carolina, USA; known as SC-50 which derives from (Ashley × PI 197087) × Ashley.), is obviously the same gene s as mentioned by us. Since the resistance to *S. fuliginea* obtained by Kooistra was mainly based on the resistance of Natsufushinari, this gene plays an important role in the development of resistant varieties in the Netherlands, just as in the USA.

Because the resistance to downy mildew in Ashley and Poinsett is attributed to PI 197087 from India (PETERSON, 1975), it is highly probable that this accession also carries gene s. The cultivars Ashley, Poinsett, Pixie and PI 234517 all have PI 197087 from India in their ancestry. Our Natsufushinari, and PI 212233 known as Kurume Natuhusinari, both from Japan, are probably the same cultivars. It can be concluded that the origin of the resistance genes p and s, found in the material described above can be traced back to India, Japan and Taiwan and that they probably occur there in high frequency. The segregation of leaf resistance to *S. fuliginea* of the *P. cubensis* resistant F2 plants indicates the presence of other resistance genes in our PMR-line. The number of plants in the 3 classes fits the hypothesis of an incomplete dominant gene, probably the same gene R of SHANMUGASUNDARAM et al. (1971). Observations in the glasshouse of plants tested for resistance of the leaf in the way described above indicates that other gene(s) in addition to s and R, are needed for complete resistance. The precise mode of inheritance of these minor gene (s) is difficult to study because division into different classes of leaf resistance is rather arbitrary, and depends to a great extent on the period between inoculation and observation. In our experience age and condition of the plants greatly influence the reaction of plants inoculated with *S. fuliginea* while environmental factors play an important role too.

REFERENCES

BARNES, W. C. & W. M. EPPS, 1956. Powdery mildew resistance in South Carolina cucumbers. Plant Dis. Reptr 40: 1093.

KOOISTRA, E., 1968. Powdery mildew resistance in cucumber. Euphytica 17: 236–244.

LEPPIK, E. E., G. SOWELL, S. W. BRAVERMAN, S. M. DIETZ & H. F. WINTERS, 1964. A summary of reports on the resistance of plant introductions to diseases, insects and nematodes. *Cucumis sativus* and *Cucumis* spp. North Central Regional Plant Introduction Station, Ames, Iowa.

PETERSON, C. E., 1975. Plant Introductions in the improvement of vegetable cultivars. HortScience 10 (6): 575–579.

SHANMUGASUNDARAM, S., P. H. WILLIAMS & C. E. PETERSON, 1971. Inheritance of resistance to powdery mildew in cucumber. Phytopathology 61: 1218–1221.

SITTERLY, W. R., 1972. Breeding for disease resistance in cucurbits. Ann. Rev. Phytopathology 10: 471–490.

VLIET, G. J. A., VAN & W. D. MEIJSING, 1974. Inheritance of resistance to *Pseudoperonospora cubensis* ROST in cucumber. (*Cucumis sativus* L.). Euphytica 23: 251–255.