Inheritance of Resistance to Cucumber Mosaic Virus in Melons

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ABSTRACT

Inheritance of resistance to cucumber mosaic virus (CMV) in melons was studied in F_1, F_2 and BC_1 progenies derived from a cross between a line of the resistant melon cultivar Freeman's Cucumber and the susceptible honeydew cultivar Noy-Amid. Data obtained indicate that resistance is controlled by three recessive factors. The wide range of degrees of mosaic symptoms, of which the susceptible class was composed, might be explained by the various combinations of the dominant factors. Virus concentration was significantly lower in the resistant than in the susceptible parent, and that of the F_1 hybrid was intermediate, indicating incomplete dominance of susceptibility.

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One of the common maladies of melons in Israel is caused by cucumber mosaic virus (CMV) (2). This virus frequently causes substantial loss in yield and inferior fruit quality, especially in the early spring seeding. Investigations were therefore carried out in a search for sources of resistance. Many melon cultivars of different origin were tested, and two were found to be resistant. Best resistance was found in *Cucumis melo* var. *conomon* 'Freeman's Cucumber' (3). The initial material of this cultivar segregated a few susceptible plants, therefore resistant plants were selfed for three generations to obtain homozygous-resistant lines. The aim of the present work is to study the inheritance of resistance to CMV in Freeman's Cucumber.

MATERIALS AND METHODS.—A CMV homozygous-resistant line of melon cultivar Freeman's Cucumber (F.C.) was used as the resistant parent, and the honeydew cultivar Noy-Amid (N.A.) was used as the susceptible parent. Reciprocal crosses were made to obtain seeds of F_1 and F_2 generations (Table 1). F_1 hybrids were used as male or female parents in crosses with the resistant parent to obtain the respective backcross generations.

Inoculation experiments were carried out in an insect-proof greenhouse which was sprayed weekly with nicotine sulfate or with 0,0-dimethyl-2,2 dichlorovinylphosphate. During the winter the greenhouse was heated and the temperature was not allowed to drop below 20 C.

CMV culture was maintained on Bet Alfa cucumbers or on Sihi Lavan squashes. The cultures were renewed by mechanical inoculation every 2-3 weeks. Plants of all study groups were grown in pots irrigated weekly with complete nutrient solution. Beginning at the cotyledonary stage, the seedlings were dusted with Carborundum powder 30-μm (500-mesh), and inoculated mechanically using undiluted CMV extracts. The plants were routinely re-inoculated at two-day intervals until all of the N.A.-susceptible plants exhibited infection symptoms. Thereafter two additional inoculations were carried out on all plants of the F_1, F_2, and BC_1 groups. All N.A. plants showed infection symptoms after about four inoculations, when the plants reached the third or fourth true leaf stage. Observations were continued until all the plants reached the eighth-to-tenth true leaf stage. Data were accumulated from two sets of experiments carried out from January through March; the results were analyzed by the chi-square test.

A third experiment was carried out in December, but the results were characterized by an unexpectedly large number of symptomless plants in the F_2 and BC_1 progenies, but not in the susceptible cultivar. Results might be explained by the short-day (10 hours) effect of this month (5). Consequently, the data of this trial were not included in this report.

TABLE 1. The resistance to cucumber mosaic virus in reciprocal F_1, F_2 and backcross (B.C.) populations of a cross between the melon cultivars Noy-Amid (N.A., susceptible) and Freeman's Cucumber (F.C., resistant)

Generation	Cultivar or cross	Number of plants			
		Susceptible	Resistant	Total	P[a]
P_1	N.A.	205	0	205	
P_2	F.C.	0	157	157	
F_1	F.C. × N.A.	120	0	120	
F_1	N.A. × F.C.	143	0	143	
F_2	F.C. × N.A. selfed	424	6	430	0.70-0.80
F_2	N.A. × F.C. selfed	544	7	551	0.50-0.70
BC_1F_1	F.C. (N.A. × F.C.)	292	34	326	0.20-0.30
F_1BC_1	(N.A. × F.C.) F.C.	416	48	464	0.10-0.20

[a]Expected ratio of resistant:susceptible is 1:63 for F_2, and 1:7 for BC_1 to resistant parent.

TABLE 2. Total number of cucumber mosaic virus (CMV) local lesions on *Chenopodium amaranticolor* half-leaves inoculated with extracts of infected melon cultivars Freeman's Cucumber (F.C., resistant), Noy-Amid (N.A., susceptible) and F_1 plants

CMV sources	Total number of local lesions from five tests	Number of tests differing significantly
F.C.	571	5
N.A.	4866	
F.C.	2342	5
F_1 (F.C. × N.A.)	6167	
N.A.	1391	5
F_1 (N.A. × F.C.)	256	

Differences in the content of CMV particles in the sap of parental and F_1 plants were examined on *Chenopodium amaranticolor* Coste & Reyn., which reacts to CMV inoculation with local lesions. The inocula used in these tests were diluted with distilled water to 10^{-1} or 10^{-2}. These CMV concentrations were found, in preliminary tests, to fall in the straight line section of the dilution curve, when N.A. sap was used as the source of inoculum. The inocula were applied with a soft hair brush on Carborundum-dusted leaves of *C. amaranticolor* using the half-leaf method (1). Eight to sixteen leaves were inoculated in the different tests. The results were analyzed by the "sign test" (6).

RESULTS.—*Inheritance of resistance to CMV.*—Following inoculation with CMV, seedlings of the susceptible N.A. cultivar became markedly stunted, the leaves became distorted and exhibited severe mosaic symptoms. Plants of the resistant F.C. cultivar, on the other hand, showed no leaf distortion, but often exhibited numerous yellow pinpoint dots or a few small yellow patches. These symptoms, which were usually observed in the first-to-third true leaves of the inoculated F.C. plants, subsequently disappeared.

Reciprocal F_1 progenies were uniformly susceptible, showing mosaic symptoms and leaf distortion similar to those exhibited by the susceptible parent.

Reciprocal F_2 and BC_1 progenies segregated resistant plants similar to the F.C. cultivar in their reaction and susceptible plants showing a wide range of degrees of mosaic symptoms. Since there was no objective means of subclassifying the susceptible group, plants were divided into two groups. The resistant group included plants which resembled the F.C. parent in their reaction to CMV. The susceptible group included plants which exhibited all degrees of mosaic infection.

Segregation in the F_2 progenies ranged between 70 and 77 susceptibles to every resistant plant (Table 1). To rule out the possibility of escape plants, resistant F_2 plants were selfed and the resulting F_3 progenies inoculated with CMV. Reaction of these F_3 plants proved to be uniformly similar to the resistant F.C. cultivar.

The observed ratio of resistant to susceptible in the reciprocal BC_1 progenies was one resistant to 8.7 susceptible (Table 1).

Results from the F_2 and BC_1 progenies can best be explained on the basis of three recessive factors conditioning resistance.

The content of CMV in the sap of plants.—The CMV content in plants of the resistant F.C. and the susceptible N.A. parents and their F_1 progenies, was compared in a series of five experiments.

On reaching the fifth-leaf stage, the fourth leaf was collected from the plants for preparation of the inocula. The results (Table 2) show that less CMV could be recovered from plants of the resistant F.C. parent than from the susceptible N.A. parent or plants of the F_1 progenies. Similarly, fewer local lesions were produced with inoculum from the F_1 than with that from the susceptible N.A. parent.

These data may point out the possibility that the differences in the CMV content could be the result of an inhibitor to CMV associated with the extracts from the resistant parent (7). To examine this hypothesis, six groups of ten seeds each of cultivars F.C. and N.A. were sown. When the plants reached the seventh-leaf stage the second leaf from the top was collected from the plants, homogenized separately for each of the parents, and filtered through cheesecloth. The sap was then diluted with distilled water to three concentrations: 10^{-1}, 10^{-2} and 10^{-3} (two groups were tested for each dilution), each of which was mixed with an equal volume of crude CMV solution diluted 1:5. Then the mixtures of F.C. sap and CMV, and that of N.A. and CMV, were inoculated on the opposite half-leaves of *C. amaranticolor.*

No significant differences were found in any of the six tests. The number of local lesions produced on the half-

leaf sides inoculated with sap from plants of the N.A. cultivar totaled 4,082 as compared with 4,443 local lesions produced on the half-leaf sides inoculated with sap from plants of the F.C. cultivar. These results suggest that no inhibitor, produced during extraction of plant sap, was responsible for the differences in virus concentration between the N.A. and F.C. cultivars.

DISCUSSION.—Results (Table 1) based on visual classification are consistent with the hypothesis that resistance to CMV is conditioned by three recessive factors. However, the F_1 plants contained more virus than the resistant parent, but less virus than the susceptible one (Table 2). This relationship indicates an incomplete dominance of susceptibility which may be due to any one, two, or all three factors involved. The different degrees of susceptibility in the F_2 and backcross generations might be accounted for by various combinations of the dominant factors, but yields no information on the exact relationships among them. Also, the possibility that additional minor factors might be involved cannot be excluded. The lack of visible mosaic symptoms from the fourth-leaf stage on, and the significantly lower level of CMV concentration in the resistant parent (Table 2), make the Freeman's Cucumber melon a valuable source of resistance in breeding programs (4).

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