

Resistance of *Capsicum* species to tobacco, tomato and pepper strains of tobacco mosaic virus

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Abstract

A number of *Capsicum* accessions including nine species were tested for resistance to TMV based on hypersensitivity. The tobacco strain MA and the tomato strain SPS, which were both isolated from tomato, and two pathogenically distinct pepper strains P 11 and P 8, were used. Of the 73 *Capsicum* accessions tested 58 were resistant to MA and SPS, 31 were resistant to P 11 and five were resistant to P 8.

Additional keywords: TMV strains, pathogenicity, resistance, hypersensitivity, susceptibility.

Introduction

An outbreak of a mosaic disease caused by tobacco mosaic virus (TMV) in glass-house crops of sweet pepper (*Capsicum annuum* L.) in the Netherlands in 1975 initiated a search for resistance among *Capsicum* collections by private breeding companies and by the Institute for Horticultural Plant Breeding (IVT), Wageningen. For this purpose a large number of *Capsicum* accessions was also made available by the Southern Regional Plant Introduction Station at Experiment, Georgia, USA.

Many *Capsicum* accessions were tested by the author, at first with 13 sweet pepper isolates of TMV and later with two pathogenically distinct pepper strains of TMV designated P 11 and P 8 (Rast, 1979). A third pepper strain (P 14), isolated in 1979, was not included in the tests because it was reported to overcome resistances so far found in pepper (Boukema et al., 1980) and its use may have increased the risk of further spread to commercial crops.

This paper is a report on the results obtained with the pepper strains P 11 and P 8 compared with the tobacco strain MA and the tomato strain SPS of TMV. Contrary to MA and SPS neither P 11 nor P 8 was capable to infect tomato (Rast, 1979). MA and SPS were both isolated from tomato (Rast, 1975).

The tobacco and tomato strains have been described as separate viruses (Zaitlin and Israel, 1975; Hollings and Huttinga, 1976). However, for practical reasons MA and SPS are referred to in this paper as strains of TMV rather than distinct viruses.

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Materials and methods

As previously described (Rast, 1979) the test plants were raised on benches in a glass-house at 18-23 °C with additional light to provide a 12 h day between October and March. Using potting soil as a rooting substrate, the test plants were grown either individually in plastic pots of 10 cm diameter or in groups up to 30 plants in plastic trays measuring 60 × 40 × 12 cm. Plants grown for seed were transplanted into 10-l plastic pails with perforated bottoms.

Inocula of the pepper strains P 11 and P 8 were at first freshly prepared from systemically infected leaves until purified suspensions became available. These were prepared following 20 cycles of selective host passage for which P 11 was passed intermittently through local lesions on *C. baccatum* P.I. 260549 and systemic infections of *C. annuum* cv. Tisana. P 8 was passaged through systemically infected *C. frutescens* cv. Tabasco, sometimes via a transfer of local lesions from *Nicotiana glutinosa*. For the tobacco strain MA and the tomato strain SPS purified suspensions were used as inocula.

The strains were mechanically inoculated to four to ten plants of each *Capsicum* accession tested. Plants grown in a plastic tray were inoculated with one strain only. Carborundum 600 mesh, used as an abrasive, was either added to the inocula or dusted on the leaves of the plants prior to inoculation. The test plants, depending on size or numbers involved, were inoculated by rubbing two to four leaves gently with inoculum-wet fingers or by swabbing them with cotton wool soaked in inoculum. With small batches of plants, inoculation was done with the cotton-wool wrapped around a 6-8 cm bamboo pricker meanwhile supporting the leaves with a disk of filter paper. After inoculation the plants were rinsed with water to remove excess carborundum.

Symptoms were recorded after 10 and 21 days. If plants reacted with only local necrotic lesions followed by abscission of the inoculated leaves, such hypersensitivity was considered as resistance. Plants which developed systemic mosaic symptoms or were killed by a rapidly progressing systemic necrosis were regarded as susceptible.

Sometimes it was necessary to grow plants for seed for tests on their progeny. This occurred when batches of test plants segregated for resistance in which case only resistant plants were seeded. Also when a batch consisted of phenotypically distinct plant types, one of the most occurring phenotypes was chosen for seeding. Also when seed-borne TMV caused untimely infection of test plants, fresh virus-free seed was obtained.

Results and discussion

Susceptible *Capsicum* accessions differed in their reactions to infection by the TMV strains from tomato and those from pepper. MA and SPS usually killed plants with a rapidly progressing, systemic necrosis but, with P 11 and P 8, plants usually developed only mosaic symptoms. An exception was found with *C. microcarpum* P.I. 215699 (Table 1) which reacted with mosaic symptoms when infected with MA and SPS. Mosaic symptoms caused by P 8 were accompanied by an interveinal bronzing and appeared more severe than those caused by P 11. Minor differences between the strains were also shown by the size of local lesions and the rapidity of leaf abscission. Thus,

plants of *C. chinense* P.I. 281417 developed larger lesions on inoculated leaves and the inoculated leaves abscised more promptly when infected with SPS than with P 11. On resistant *Capsicum* accessions the size of lesions caused by P 8 was consistently smaller than those caused by the other strains.

Variable reactions, consisting of both local necrotic lesions and systemic symptoms on almost every plant of a *Capsicum* accession tested, often occurred when screening for resistance was begun with 13 pepper TMV isolates. Such variability, however, could be accounted for when the two pepper strains of TMV could be separately isolated from the mixture after passing the isolates several times through selective hosts (Rast, 1979).

This procedure did not eliminate the variation in reactions of the *Capsicum* accessions caused by genetic variation when plants reacted either with local lesions, or with local lesions followed by systemic top necrosis, or with mosaic symptoms. In some cases the progeny of single resistant plants reacted uniformly and were resistant as with *C. chinense* P.I. 257117 (Table 1). When first tested with the isolates MA, SPS, P 11 and P 8 this accession segregated into resistant and susceptible plants in ratios of 7 : 3, 8 : 2, 4 : 6 and 3 : 7 respectively. However, with *C. chinense* P.I. 281417, which also segregated in a 4 : 6 (resistant/susceptible) ratio when inoculated with P 11, attempts to obtain a line with uniform resistance to this strain have not so far been successful.

Nevertheless, in general a certain pattern was observed in the segregation ratios in that these tended to decrease with the strains used. More resistant plants were found using the strains MA and SPS compared with pepper strains P 11 and P 8 and with the use of strain P 11 rather than with P 8.

Apart from variation in symptom expression and segregation ratios the differences in pathogenicity between the strains were also evident when the reactions of all *Capsicum* accessions tested was considered as a whole. Of the 73 *Capsicum* accessions listed, 58 were resistant to both MA and SPS, 31 were resistant to P 11 and five were resistant to P. 8. However, the total number of *Capsicum* accessions tested was too small for conclusions to be drawn regarding the distribution of TMV resistance in *Capsicum* species and it appears unlikely that resistance will be found within the cultivated species *C. annuum*. All of its representatives were susceptible except for current Dutch cultivars and the American breeding line 'P 11' which were resistant to MA and SPS, and the semi-wild cvs Rama and Turrialba which were also resistant to the pepper strain P 11. Resistance to MA and SPS was found in all other species, notably in *C. baccatum* and *C. frutescens*.

As regards *C. annuum* line 'P 11', it should be noted that, while susceptible to pepper strain P 11, it was resistant to the unusual pepper strain of TMV as described by Feldman and Oremianer (1972) indicating that, contrary to an earlier suggestion by Rast (1977), the pepper strain P 11 is probably not identical to the latter strain. Resistance to P 11 occurred in every *Capsicum* species tested in this study except in the only accession of *C. pubescens* that was available. This resistance might be used effectively in a breeding program intended for pepper growing areas where specific pepper strains like that described by Feldman and Oremianer (1972) are rare.

As two pepper strains occur in the Netherlands, breeders have had to find combined resistance to both strains. After screening 425 *Capsicum* accessions of eight different *Capsicum* species, Boukema (1977) found resistance to P 8 and similar isolates in only seven accessions of *C. chinense*. This was confirmed with five of those accessions in

Table 1. Reactions of *Capsicum* accessions to tobacco, tomato and pepper strains of TMV (+ = systemic mosaic or necrosis; susceptibility; - = local lesions and leaf abscission: resistance).

Species	Cultivar, origin, accession no.	Source ¹	Tobacco strain MA and tomato strain SPS ²	Pepper strains	
				P 11	P 8
<i>Capsicum annuum</i>	Black Negro, U.S.A., P.I. 194881	B	+	+	+
	Mexico, P.I. 203523	B	+	+	+
	Aji Extranjero, Colombia, P.I. 257053	B	+	+	+
	Black Cuban Cluster, U.S.A., P.I. 267730	B	+	+	+
	Cuban Chili, P.I. 267731	B	+	+	+
	Violet, U.S.A., P.I. 267740	B	+	+	+
	Soroksari, Hungary, B. 745050	B	+	+	+
	Hot Lips, U.S.A.	IVT	+	+	+
	Westlandia	VDB	+	+	+
	Tisana	VDB	-	+	+
	Bruinsma's Wonder	B	-	+	+
	Other current Dutch sweet pepper cvs		-	+	+
	P 11, U.S.A., P.I. 264281	IVT	-	+	+
	Rama	INRA	-	-	+
	Turrialba	INRA	-	-	+
<i>Capsicum baccatum</i>	Peru, P.I. 260549	B	-	-	+
	Christmas Bell, the Netherlands, P.I. 273420	B	-	-	+
	Yugoslavia, B. 720127	B	-	-	+
	Chilefen, I.V.T. 76219	IVT	-	-	+
	Bolivia, P.I. 260426	IVT	+	+	+
<i>Capsicum chacoense</i>	Argentina, P.I. 260429	IVT	-	+	+
	Bolivia, P.I. 260433	IVT	-	+	+
	Bolivia, P.I. 260435	IVT	-	+	+
	Bolivia, P.I. 260437	IVT	-	+	+
	Bolivia, P.I. 260431	IVT	-	+	+
	Bolivia, P.I. 260434	IVT	-	-	+

Table 1. (Continued)

Species	Cultivar, origin, accession no.	Source ¹	Tobacco strain MA and tomato strain SPS ²	Pepper strains	
				P 11	P 8
<i>Capsicum microcarpum</i>	Peru, P.I. 215699	IVT	+	+	+
	Bolivia, P.I. 238061	IVT	-	- ⁵	+
	Brazil, P.I. 260533	IVT	-	-	+
	Bolivia, P.I. 260567	IVT	-	- ⁵	+
	P.I. 281306	IVT	-	- ⁵	+
	P.I. 281398	IVT	-	-	+
<i>Capsicum pendulum</i>	Argentina, P.I. 337524	IVT	-	- ⁵	+
	U.S.A., P.I. 159249	IVT	+	+	+
	P.I. 260258	IVT	-	-	+
	Bolivia, P.I. 260561	IVT	-	-	+
	Bolivia, P.I. 260580	IVT	-	-	+
<i>Capsicum praetermissum</i>	U.S.A., P.I. 342947	IVT	+	+	+
	I.V.T. 78123	IVT	-	-	+
<i>Capsicum pubescens</i>	I.V.T. 77246	IVT	-	+	+

¹ Abbreviations used for sources of seed: B = Bruinsma Seed Company, Naaldwijk; IVT = Institute for Horticultural Plant Breeding, Wageningen; VDB = Van den Berg Seed Company, Naaldwijk; INRA = INRA Plant Breeding Station, Montfavet, France; RZ = Rijk Zwaan Seed Company, Naaldwijk; UG = University of Groningen, Botanical Garden.

² The tomato isolates MA and SPS representing tobacco and tomato strains of TMV, respectively, were not distinct pathogenically.

³ A line with resistance to P 11 was isolated from an initially segregating population.

⁴ A line with resistance to both P 11 and P 8 was isolated from an initially segregating population.

⁵ Segregating for resistance to P 11.

⁶ Most probably *C. chinense* and not *C. annuum* as listed in the S-9 catalogue of the Regional Plant Introduction Station, Experiment, Georgia, U.S.A. (Boukema et al., 1980).

Table 1. *Resistenz van Cnecirum herkomsten op tabaks-, tomate- en paprikastammen van TMV* (+ = systemisch mozaiek of systemische necro-

the present work and a few more resistant lines were also isolated from *C. chacoense* P.I. 260429 (see Table 1) suggesting that resistance to P 8 might also occur in other *Capsicum* species.

It is not certain whether P 8 is identical with the Samsun latent strain of TMV (SL-TMV) isolated by McKinney (1952) and investigated by Greenleaf et al. (1964). The latter authors tested 141 accessions of *C. annuum* and one accession ('Tabasco') of *C. frutescens* and found that all of them were susceptible. The assumption that P 8 could be related to SL-TMV was based on the fact that both strains caused mosaic symptoms in 'Tabasco'. Work is in progress to establish more precisely the biological and serological relations between Dutch and foreign pepper strains of TMV.

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Samenvatting

Resistentie van Capsicum-soorten tegen tabaks-, tomate- en paprikastammen van tabaksmozaïekvirus

Om verschillen in pathogeniteit tussen twee in Nederland voorkomende paprikastammen van het TMV nader vast te stellen, werd een aantal *Capsicum*-herkomsten, waaronder negen soorten, op resistentie getoetst. Hierbij werden de representatieve paprika-isolaten P 11 en P 8 vergeleken met de uit tomaat afkomstige isolaten MA en SPS als vertegenwoordigers van respectievelijk de tabaks- en tomatestam van het TMV. Bij het beoordelen van de symptomen duiden lokale, necrotische vlekken en afvallen van geïnoculeerde bladeren op resistentie, systemische necrosen of mozaïeksymptomen op vatbaarheid. In deze symptomen kwamen tussen de gebruikte stammen verschillen in virulentie tot uitdrukking. Er werden echter vooral verschillen in agressiviteit waargenomen met betrekking tot zowel afzonderlijke, voor resistentie uitsplitsende, *Capsicum*-herkomsten als het totale aantal getoetste herkomsten. Van de ruim 73 herkomsten waren er 58 resistent tegen MA en SPS, 31 daarvan tegen P 11, maar slechts vijf daarvan tegen P 8. Deze resistentie tegen P 8 werd gevonden in *C. chinense*.

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