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Phytophthora root rot of sweet pepper

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Abstract

Phytophthora capsici proved to be the causal agent of a root and crown rot of sweet pepper in the Netherlands. *P. capsici* was pathogenic on sweet pepper, tomato and sometimes on eggplant but not on tobacco 'Xanthi'. Of these test plants only tomato was infected by *P. nicotianae*.

No different symptoms in plants infected with either *P. capsici* or *P. nicotianae* were found. Dipping the roots of tomato and sweet pepper plants in a suspension of *P. capsici* resulted in a more severe attack than pouring the suspension on the stem base.

Resistance in tomato to *P. nicotianae* did not include resistance to *P. capsici*. A method to distinguish *P. capsici* from *P. nicotianae* after isolation from soil is described. Both species were able to infect green fruits of tomato and sweet pepper. *P. capsici* survived in moist soil in the absence of a host for at least 15 months.

Additional keywords: Capsicum annuum, tomato, *Phytophthora capsici*, *P. nicotianae*.

Introduction

Sweet pepper, *Capsicum annuum* L., has become an important glasshouse crop in the Netherlands. The cultivated area increased from a few ha ten years ago to more than 170 ha in 1978. Apart from attacks by *Botrytis* and *Sclerotinia*, no fungus diseases occurred until recently. *Fusarium solani* (Mart.) Sacc. has been isolated frequently from rotten roots and stem bases of dying sweet pepper plants since 1974, but this pathogen is probably not the primary cause of plant death (Van Steekelenburg, 1976).

Plants infected with *F. solani* showed a brown to black discolouration of the stem bases resulting in a dry rot and often the red perithecia of the perfect state (*Nectria haematococca* Berk. & Br.) of this fungus could be observed.

Dying plants with slightly different symptoms were observed on two holdings in the province of South Holland in 1977. The stem base of the deseased plants showed a dark green to black discoloured lesion up to about 10 cm above the soil surface followed by a soft wet rot. Usually the vascular system was somewhat discoloured brown above these lesions. Roots of even large plants were completely rotted. Diseased plants wilted and died irrespective of age. On one holding the crop was finished three months earlier than usual due to heavy losses. On one third of the other holding hardly any plants were left four months after the first plant had died. *Phytophthora capsici* Leonian was isolated from roots and crowns of diseased plants of both holdings. Identification of the isolates

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was confirmed by the 'Centraalbureau voor Schimmelcultures' (CBS) at Baarn. *P. capsici* is known to be the cause of a devastating disease in sweet pepper crops in many parts of the world (Messiaen and Lafon, 1970).

On tomato this pathogen can cause a wet fruit rot (Kreutzer, et al. 1940) and a root and crown rot (Critopoulos, 1955; Satour and Butler, 1967). In the Netherlands *P. nicotianae* van Breda de Haan var. *nicotianae* is nearly always found in association with such disorders in tomato, while *P. capsici* has never been found (Weststeijn, 1973).

Although *P. capsici* is difficult to control outdoors in southern parts of Europe, in the Netherlands it did not recur in 1978 and 1979 after removing all plants at the end of the crop, washing pathways, packing house, tools etc. with formaldehyde and fumigating the soil with methyl bromide.

In this paper the incidence of *P. capsici* on sweet pepper in the Netherlands is reported, the results of pathogenicity tests with *P. capsici* and *P. nicotianae* on sweet pepper, tomato, eggplant and tobacco are presented and a method of trapping these fungi from soil is described.

Materials and methods

Several isolates of *P. capsici* from sweet pepper were used. A *P. nicotianae* isolate from tomato, known to be highly virulent on this host, was included in the tests. These fungi were grown on cherry decoction or lima bean agar. Full-grown cultures (10 cm in diameter) were homogenized with water in a blender, usually one plate in 500 ml water. The fungal suspension was chilled at 5 °C for 15 min to induce zoospore formation and used after storing for 30 min at 20 °C.

Sweet pepper 'Bell Boy', 'Bruinsma's Wonder' and 'Propenza', tomato 'Moneydor', eggplant 'Mammouth' and tobacco 'Xanthi' served as test plants. The root systems of three- to four-week-old seedlings were either dipped in the fungal suspension prior to planting, or the stem base of these plants was watered with 3 ml inoculum immediately after planting. The plants were grown in normal potting soil of pH c. 5.8 in the glasshouse at 20–25 °C.

A modification of the technique described by Banihashemi (1970) and used by E. Ilieva in Bulgaria (personal communication) was used for trapping *P. capsici* from soil. A 15 mm deep layer of soil was placed in a glass jar (100 mm high and 90 mm in diameter) and flooded with sterile water to a depth of 20 mm. Mature green sweet pepper fruits were washed, surface sterilized with ethanol, dried and placed in the glass jars so that only the lower part of the fruit was in contact with the soil. The jars were covered with a polyethylene sheet and incubated at room temperature under laboratory conditions for five to seven days. The fruits were then removed, cut into halves and placed in empty glass jars for a few days after which the fruits were examined macro- and microscopically.

Results

Inoculation experiments. Symptoms developed rapidly on inoculated sweet pepper and tomato seedlings in glasshouse experiments. The roots turned brown and rotted and/or the stem base was shrivelled by black coloured lesions. Some plants collapsed within three days after inoculation. Most of the susceptible plants collapsed within a week, but in some experiments the number of collapsed plants still increased after that period. *P.*

Table 1. Inoculation experiments with two *Phytophthora* species and various hosts. Number of diseased seedlings counted one week after dipping the root system or drenching the stem base (means of two replicates of ten plants each).

Hosts	*P. capsici*		*P. nicotianae*	
	dipping	drenching	dipping	drenching
sweet pepper 'Bell Boy'	9.5	0	0	0
sweet pepper 'Bruinsma's Wonder'	8.5	0	0	0
sweet pepper 'Propenza'	9	0	0	0
tomato 'Moneydor'	10	0	10	9
eggplant 'Mammouth'	0	0	0	0
tobacco 'Xanthi'	0	0	0	0

Tabel 1. Inoculaties met twee Phytophthora spp. en verscheidene waardplanten. Aantallen aangetaste zaailingen een week na het dompelen van het wortelstelsel of begieten van de stengelbasis (gemiddelden van twee herhalingen van elk 10 planten).

Table 2. Inoculation experiment with *Phytophthora capsici*. Number of diseased seedlings one week and one month after inoculation (means of 16 replicates of ten plants each).

Host	One week		One month	
	dipping	drenching	dipping	drenching
sweet pepper 'Bruinsma's Wonder'	6.1	2.9	9.4	7.1
tomato 'Moneydor'	2.6	1.4	3.5	2.5
eggplant 'Mammouth'	0.1	0.4	0.3	0.6
tobacco 'Xanthi'	0	0	0	0

Tabel 2. Inoculatie met Phytophthora capsici. Aantallen aangetaste zaailingen een week en een maand na inoculatie (gemiddelden van 16 herhalingen van elk 10 planten).

capsici could be re-isolated from inoculated plants and with this re-isolate the same disease symptoms could be reproduced. The number of collapsed plants were counted weekly. One month after inoculation the standing plants were uprooted and assessed for root infection. This root observation did not give much additional information so only the numbers of diseased seedlings are given in the tables. Representative data out of several experiments are given in Tables 1 and 2. Disease severity varied from test to test (compare Table 1 with 2). No different percentages diseased plants were found if the *P. capsici* suspension was used after storing for 30, 60, 120 of 240 min at 5 °C, nor if 15- of 30-day-old cultures were used. Different inoculum concentrations of *P. capsici*, viz. one agar plate suspended in 100, 500 or 2500 ml of water, did not result in different disease development on sweet pepper, tomato, eggplant and tobacco seedlings. Cultures maintained on agar during 21 months were as virulent as fresh isolates from infested soil.

The *P. nicotianae* isolate appeared to be only pathogenic to tomato 'Moneydor', *P. capsici* to sweet pepper cultivars and tomato breeding lines with resistance to *P. nicotianae* as well (Tables 1 and 3). No differences in susceptibility were found between

Table 3. Testing of tomato lines for resistance to *P. capsici* and *P. nicotianae*. Number of diseased seedlings counted one week after inoculation by dipping (means of two replicates of ten plants each).

Plant species	*P. capsici*	*P. nicotianae*	Control (water)
sweet pepper 'Bruinsma's Wonder'	10	0	0
tomato 'Moneydor'	10	10	0
tomato IVT 711452	7	0	0
tomato IVT 711492	10	0	0

Tabel 3. Toetsen van lijnen van tomaat op resistentie tegen P. capsici en P. nicotianae. Aantallen zieke planten een week na inoculatie (gemiddelden van twee herhalingen van elk 10 planten).

three sweet pepper cultivars frequently grown in the Netherlands (Table 1). Eggplant remained healthy in most experiments but was sometimes infected by *P. capsici* (Table 2). On some plants of tobacco 'Xanthi' small brown lesions could be observed on the roots.

Dipping the roots in a *P. capsici* suspension caused quicker and heavier attack than pouring the suspension on the stem base (Tables 1 and 2). With *P. nicotianae* no significant differences were found between these two inoculation methods (Table 1).

Trapping from soil. Sweet pepper fruits recovered from the soil-water mixture and infected by *P. capsici* showed a soft wet rot under and just above the water line. In most cases a thin layer of white mycelium could be observed on the outside of the fruits just above the water line. A white fluffy mycelial mat often covering half or more of the infected fruit developed on the inside. Infected seeds were discoloured brown. Pure cultures were easily obtained by transferring these seeds to an agar medium. The mycelium on the inside of the fruits did not sporulate when the fruit was opened but after four to seven days it sporulated abundantly with markedly papillate zoosporangia with a pedicel more than 10 μm long.

If soil infested with *P. nicotianae* was used, green sweet pepper fruits were also infected and showed the same symptoms as with *P. capsici*. The mycelium on the outside of the fruits was, however, more fluffy and the zoosporangia did not have an obvious pedicel. Using green tomato fruits as a bait resulted in a soft wet rot both with *P. capsici* and with *P. nicotainae*.

Survival in soil. Infested moist soil from commercial nurseries and from inoculation experiments was stored in closed plastic bags at room temperature (approximately 20 °C). Using sweet pepper fruits as a bait *P. capsici* could be isolated from this soil after storing during 15 months but not after 21 months.

Discussion

Both *P. capsici* and *P. nicotianae* are known to infect plants via the roots and stem (Messiaen and Lafon, 1970; Weststeijn, 1973), but in most of our experiments, only dipping the roots in a suspension resulted in a heavy attack with *P. capsici*. With *P. nicotianae* disease development on tomato was the same both after dipping the roots

and after drenching the stem base. No explanation could be found to explain differences in disease development observed between tests.

As *P. capsici* was pathogenic on both sweet pepper and tomato and *P. nicotianae* attacked tomato only these two plants can therefore be used as differential hosts for these two *Phytophthora* species. However, both species were able to infect detached green fruits of sweet pepper and tomato with no differences in symptoms.

P. capsici has not been found on tomato plants in the Netherlands up till now. The disease was reported on holdings on which sweet pepper was grown for the first time after a tomato crop in the previous year without a soil disinfection between these two crops. Probably the pathogen was present in the tomato crop and survived in the soil. Critopoulos (1955) and Satour and Butler (1967) reported that *P. capsici* can remain viable for five months in moist soil in the absence of a host. In our experiments the fungus survived 15 months in soil. Longer periods of survival for *P. nicotianae* (at least four years) are reported, amongst others, by Weststeijn (1973). The reason for the shorter survival of *P. capsici* in soil in comparison with *P. nicotianae* may be due to the inability of this fungus to form chlamydospores (Newhook et al., 1978) as has already been stated by Satour and Butler (1967). It is of great importance to know if *P. capsici* does occur on commercial holdings with tomato crops as the resistance in certain tomato lines to *P. nicotianae* does not include resistance to *P. capsici*.

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Samenvatting

Phytophthora wortelrot van paprika

Phytophthora capsici bleek de oorzaak te zijn van een voet- en wortelrot in paprika op twee bedrijven in 1977 in Nederland. *P. capsici* was pathogeen op paprika, tomaat en soms op aubergine maar niet op tabak 'Xanthi'. *P. nicotianae* tastte van deze toetsplanten alleen tomaat aan. Verschillen in symptomen tussen *P. nicotianae* en *P. capsici* werden bij tomaat niet waargenomen.

Het dompelen van de wortels in een *P. capsici* suspensie gaf een ernstiger aantasting dan het begieten van de wortelhals met deze suspensie.

Resistentie in tomaat tegen *P. nicotianae* bleek geen resistentie tegen *P. capsici* in te houden.

P. capsici kan in grond worden aangetoond door groene paprikavruchten als vangsubstraat te gebruiken. *P. capsici* en *P. nicotianae* kunnen beide zowel vruchten van tomaat als paprika aantasten.

P. capsici overleefde een periode van 15 maanden in vochtige grond waarop geen waardplant werd geteeld.

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