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Reactions of various plant species to inoculation with potato virus S

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Abstract

In total 98 plant species belonging to 15 families were tested on their possible value as indicator hosts for potato virus S. Plants were sap-inoculated with six virus isolates respectively. In only three families (Amaranthaceae, Chenopodiaceae and Solanaceae) suspectible species were found. The susceptible Chenopodiaceae reacted with local lesions. Seven of those Chenopodiaceae were not mentioned before as local lesion hosts for PVS, viz. *Chenopodium ambrosioides*, *C. hybridum*, *C. murale*, *C. opulifolium*, *C. polyspermum*, *C. rubrum* and *C. urbicum*.

Introduction

Potato virus S (PVS) is common in most countries of Europe (Rozendaal and Brust, 1955; MacArthur, 1956; Bode, 1958; Lovisolo and Benetti, 1959; Le Guen 1959; Kassanis, 1961; Christensen, 1961; Bailova-Yankulova, 1966; Spire et al., 1967; Ghena, 1967; Jermoljev and Brčák, 1965; Gabriel and Roztropowicz, 1959; Nohejl, 1965; Panjan, 1967), in the United States (Bagnall et al., 1956; Vaughan and van Slogteren, 1956, Larson and Oshima, 1959; Alfieri, 1960), in South America (MacKee, 1964), in South Africa (Herold, 1967), in India (Ganguly, 1963), and in Australia (Thomson, 1959).

Indexing of PVS is usually performed with serological procedures, but for unknown reasons this testing is not always reliable. Under Dutch conditions the most reliable results are obtained when potato plants grown in the open are tested around the longest day. It is thought that at that time the concentration of PVS in the plants is highest making detection successful. Attempts have been made to develop more sensitive methods to detect the virus. An improvement of serology is described by Bercks (1967), but it is not successful for indexing PVS.

Promising results were obtained using the electron-microscope as a diagnostic tool for the detection of PVS (Sampson and Taylor, 1968; de Bokx, 1969). However, the commonly used electron-microscopes holding one specimen at a time are not suitable for practical application.

Therefore since long various workers have searched for a suitable test plant for PVS (Bagnall et al., 1956; Bode, 1958; Wetter, 1959; Horváth, 1964; Scholz, 1965; de Bokx, 1966, 1967; Vulič and Hunnius, 1967; Ross, 1968).

Since 1965 I have carried out inoculation experiments to find systemic and local lesion hosts of PVS. The inoculations were performed with six isolates of PVS. The present paper reports on the findings obtained so far under Dutch conditions.

Literature

According to Bagnall et al. (1956) *Cyamopsis tetragonoloba* "Guar" developed local lesions 12 days after inoculation with PVS. This was confirmed by Horváth (1964). The first authors did not find *Vigna sinensis* to develop local lesions, although Vulič and Hunnius (1967) observed local lesions on the cotyledons 3 weeks after inoculation with PVS.

Nicotiana debneyi and *Datura metel* were found to be systemic hosts (Bagnall et al., 1956; Horváth, 1964; Scholz, 1965; Bailova-Yankulova, 1966; de Bokx, 1966; Vulič and Hunnius, 1967).

Solanum rostratum reacted with local and systemic necrotic lesions about 25 days after inoculation with PVS (Bagnall et al., 1956; de Bokx, 1966; Vulič and Hunnius, 1967).

On *Saracha umbellata* necrotic lesions and on *Solanum villosum* chlorotic leaf blotches were incited (Bagnall et al., 1956).

PVS induced small chlorotic spots on the inoculated leaves of *Chenopodium album* about 20 days after application (Bagnall et al., 1956; Scholz, 1965; Vulič and Hunnius, 1967). Horváth (1964) obtained negative results.

Chenopodium amaranticolor was found to be a local lesion host (Hollings, 1956; Vulič and Hunnius, 1967), but Horváth (1964) did not obtain symptoms.

In *Gomphrena globosa* some virus strains could incite local lesions (Rozendaal and van Slogteren, 1958; Bode, 1958; Vulič and Hunnius, 1967).

Material and methods

Young plants of various species were inoculated at the six-to-eight leaf stage. All plantlets were grown from seed in plastic pots (diam. 12 cm) with sterilized potting soil and placed in aphid free greenhouses. During winter they were additionally illuminated for 14 h a day, in summer the greenhouses were shaded. The temperature fluctuated between 15 °C (winter) and 30 °C (summer).

Two to three leaves of one plant of each species were inoculated. Observations for the presence of symptoms were made up to 6 weeks after inoculation. Before discarding the plants uninoculated top leaves were tested serologically for the presence of virus. Uninoculated plants served as controls.

Potato varieties 'IJsselster', 'Industrie', 'Fortuna', potato virus X-free 'Eersteling', 'Saucisse Rouge' and 'Leona', all carrying PVS were used as sources of inoculum. The isolates concerned will be indicated as Yss, Ind, Fort, E, SR and L, respectively.

The inoculation was performed with infectious fresh potato foliage, using Carborundum powder 500 mesh as an abrasive.

Results

In Table 1 the species are mentioned which were not susceptible to either one of the six isolates of PVS, in Table 2 those are presented which were susceptible.

Of the susceptible hosts *Gomphrena globosa* shows many contradictory results. According to Vulič and Hunnius (1967) only young not flowering plants reacted to inoculation with PVS with small local reddish spots. However, the name of the isolate

Table 1. Plant species not susceptible to six isolates of PVS as tested visually and serologically.

Apocynaceae
Vinca rosea

Aizoaceae
Tetragonia expansa

Boraginaceae
Borago officinalis

Amaranthaceae
Amaranthus caudatus
A. emarginatus
A. gangericus
A. hypochondriacus
A. paniculatus
A. retroflexus
A. tricolor
Axyrus amaranthoides
Celosia cristata
Celosia argentea
Celosia huttonii
Obione sibirica

Chenopodiaceae
Chenopodium anthelminticum
C. ambrosioides var. ambrosioides
C. ambrosioides var. anthelminticum
C. botrys
C. capitatum
C. ficifolium
C. foetidum
C. foliosum
C. giganteum
C. glaucum
C. hybridum
C. opulifolium
C. schaderianum
C. vulvaria
Atriplex crassifolia

Compositae
Artemisia dracunculus
Bidens pilosus
Callistephus chinensis
Chrysanthemum leucanthemum
Cineraria maritima
Coreopsis grandiflora
Doronicum caucasicum
Gaillardia grandiflora
Zinnia elegans

Cruciferae
Alyssum montana
Brassica campestris var. rapa
Brassica nigra
Sinapis alba

Cucurbitaceae
Cucumis sativus 'Gele Tros'
Cucurbita pepo 'Small Sugar'
Cucurbita pepo var. melopepo 'Caserta'

Euphorbiaceae
Ricinus communis

Labiatae
Ocimum basilicum
Hyssopus officinalis

Leguminosae
Crotalaria spectabilis
Cyamopsis tetragonoloba
Pisum sativum 'Rondo'
Vicia faba
Vigna sinensis 'Black local'

Scrophulariaceae
Antirrhinum majus
Torenia fournieri

Papaveraceae
Papaver somniferum

Umbelliferae
Pimpinella anisum

Solanaceae
Browallia viscosa
Capsicum annuum 'California Wonder'
C. frutescens 'Tabasco'
Nicotiana tabacum 'Kentucky 35', Havana 425'
– 'Dixie Shade 4', 'Dutch A'
– 'Burley 21' and 'White Burley'
Nicotiana rustica
Nicandra physaloides
Physalis floridana
Physalis alkekengi
Lycopersicum esculentum 'Ailsa Craig'
Solanum aculeatissimum
S. aethiopicum
S. citrullifolium
S. giganteum
S. luteum
S. miniatum
S. nigrum
S. nipponense
S. pattersonii
S. racemigerum
S. rostratum
Petunia hybrida

Tabel 1. Plantesoorten onvatbaar voor zes isolaten van het aardappelvirus S volgens visuele beoordeling en serologische toetsing.

Table 2. Plant species susceptible to PVS.

Amaranthaceae	C. quinoa (Valdivia)
Gomphrena globosa	C. quinoa (Berlin-Dahlem)
Chenopodiaceae	C. quinoa (U.S.A.)
Chenopodium album (Bangalore)*	C. quinoa var. viridescens
C. amaranticolor	C. rubrum
C. ambrosioides (Bangalore)	C. urbicum
C. hybridum	**Solanaceae**
C. murale	Nicotiana debneyi
C. opulifolium	Solanum rostratum
C. polyspermum	S. tomentilla
C. quinoa (Bangalore)	S. demissum

* In parentheses = origin of seeds.

Tabel 2. Plantesoorten, vatbaar voor het aardappelvirus S.

was not mentioned. Rozendaal and van Slogteren (1958) reported that a 'Fortuna' isolate could induce local lesions on this test plant.

In one of our experiments performed during summer, *Gomphrena globosa* showed reddish local lesions 3 weeks after inoculation with the isolates Fort and Yss only. PVS was demonstrated serologically in the inoculated leaves of all plants inoculated with each isolate. However, a test carried out in fall was negative.

As far as Chenopodiaceae were susceptible, they reacted to inoculation with local lesions (Fig. 1 and 2). However, only *Chenopodium album*, *C. polyspermum* and *C. mu-*

Table 3. Species of *Chenopodium* which reacted with local lesions to inoculation with PVS.

Test plants	Virus isolates					
	Yss	SR	E	L	Ind	Fort
Chenopodium album	+	+	+	+	+	+
C. amaranticolor	−	+	−	+	−	+
C. ambrosioides (Bangalore)[1]	−	−	+	−	−	−
C. hybridum	+	−	−	+	−	+
C. murale	+	+	+	+	+	+
C. opulifolium	−	+	−	+	−	+
C. polyspermum	+	+	+	+	+	+
C. quinoa (Bangalore)	−	+	+	+	+	+
C. quinoa (I.P.O.)	+	+	+	+	+	+
C. quinoa (Valdivia)	+	*[2]	−	+	−	+
C. quinoa (Berlin-Dahlem)	−	*	+	+	+	+
C. quinoa (U.S.A.)	−	+	−	−	−	+
C. quinoa var. viridescens	−	*	+	+	+	+
C. rubrum	+	+	+	+	−	+
C. urbicum	+	+	−	+	+	+

[1] In parentheses = origin of seeds.
[2] Inoculation not carried out.

Tabel 3. Chenopodium-soorten, die na inoculatie met aardappelvirus S reageren met lokale vlekken.

rale were susceptible to all six virus isolates. The other susceptible Chenopodiaceae reacted only to five or even less of the isolates used. The results are presented in Table 3. It is shown that not only may one species of *Chenopodium* react differently to the various isolates, but that also one single species can react differently upon inoculation with one isolate of the virus, depending on the origin of that species.

One might suggest that with help of these differential reactions the virus strains could be identified. However, we have to bear in mind that the experiments were not performed under controlled conditions and that the symptoms expression greatly depends on conditions.

Fig. 1. Local lesion formation with PVS, 2 weeks after inoculation: A = *Chenopodium murale*, B = *Chenopodium opulifolium*; 3 weeks after inoculation: C = *Chenopodium quinoa*. D = *Chenopodium hybridum*.

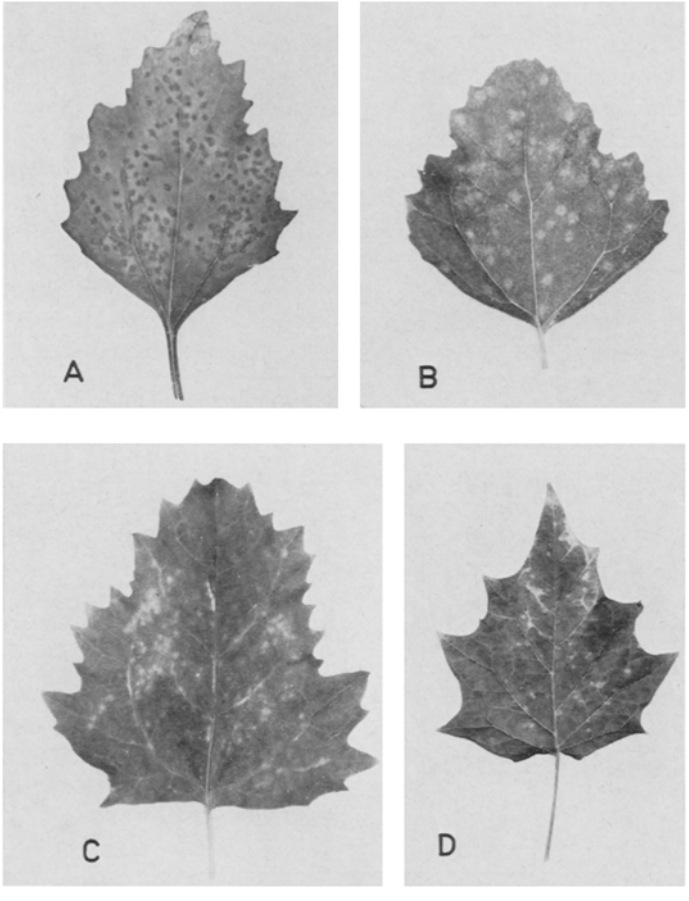

Fig. 1. Het verschijnen van lokale vlekken met PVS, 2 weken na inoculatie: A = Chenopodium murale, B = Chenopodium opulifolium; 3 weken na inoculatie: C = Chenopodium quinoa, D = Chenopodium hybridum.

Fig. 2. Local lesion formation with PVS, 3 weeks after inoculation: A = *Chenopodium polyspermum*, B = *Chenopodium rubrum*; 4 weeks after inoculation: C = *Chenopodium ambrosioides*, D = *Chenopodium urbicum*.

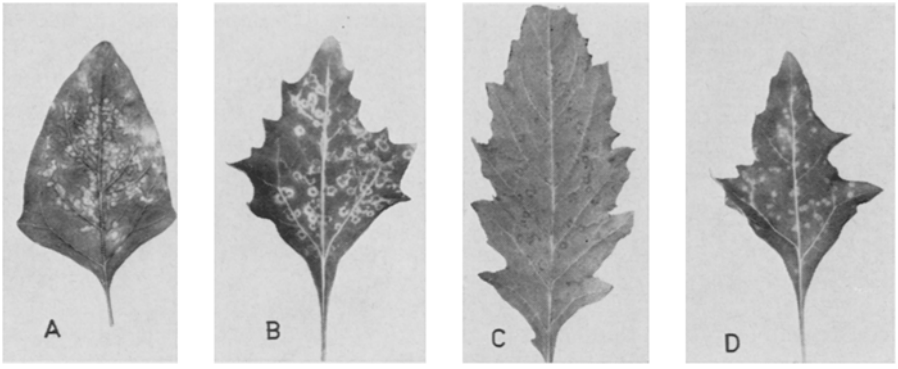

Fig. 2. Het verschijnen van lokale vlekken met PVS, 3 weken na inoculatie: A = Chenopodium polyspermum, B = Chenopodium rubrum; 4 weken na inoculatie; C = Chenopodium ambrosioides, D = Chenopodium urbicum.

Fig. 3. Systemic symptoms in *Solanum rostratum* 35 days after inoculation with PVS (six isolates).

Fig. 3. Systemisch necrotische symptomen in Solanum rostratum 35 dagen na inoculatie met PVS (zes isolaten).

The incubation period of the isolates of PVS varied from 2 weeks in *Chenopodium album*, *C. murale* and *C. opulifolium*, 3 weeks in *C. hybridum*, *C. rubrum*, *C. polyspermum* and *C. quinoa*, to 4 weeks in *C. ambrosioides*, *C. amaranticolor* and *C. urbicum*.

Generally the local lesions were faint rings, appearing first on the oldest inoculated leaves, and were very clear when the leaves were yellowing.

Systemic infection was obtained after inoculation with all isolates on *Nicotiana debneyi*, *Solanum rostratum*, *S. tomentilla*, and *S. demissum*. *Nicotiana debneyi* yielded very faint mosaic symptoms whereas *Solanum tomentilla* and *S. demissum* did not show symptoms. *S. rostratum* expressed symptoms after inoculation with PVS as described in the literature, viz. local lesions (Fig. 3) and a stunted growth.

Discussion

As can be seen in Table 3 a number of Chenopodiaceae react with local lesions after inoculation with certain isolates of PVS. A number of them were not investigated before as test plants for PVS, viz. *Chenopodium ambrosioides*, *C. hybridum*, *C. murale*, *C. opulifolium*, *S. polyspermum*, *C. rubrum* and *C. urbicum*. The results obtained with the other species agree with those mentioned in the literature (Bagnall et al., 1956; Horváth, 1964; Scholz, 1965).

It can be said that the reaction of the above-mentioned test plants to the different isolates of PVS varies greatly. Bode (1966) already stated for potato virus M that symptom expression greatly differed to isolate and depended on the environmental conditions. Although Horváth (1964) and Vulič and Hunnius (1967) worked with one and two isolates of PVS respectively, they were of the opinion that the controversial results mentioned are partly due to the use of different virus isolates.

Moreover, as Vulič and Hunnius (1967) showed, the symptom expression is effected by the stage of test plant development. Seed origin is another important factor as demonstrated by Demski (1968) for local lesion development in *Chenopodium quinoa*. Light intensity, duration of illumination, and temperature are further very important factors in sympton expression. This was shown for potato virus Y^N in the test plant 'A6' (de Bokx, 1964), for Wisconsin pea streak virus in *Chenopodium amaranticolor* (Rosenkranz and Hagedorn, 1964) and for cucumber mosaic virus in *Vigna sinensis* (Marrou et al., 1968).

Under normal greenhouse conditions these factors cannot be controlled. Consequently, literature data on incubation period and size of local lesions will differ greatly. For that reason it is advocated to grow test plants under completely controlled conditions before and after inoculation.

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Samenvatting

De reacties van verschillende plantesoorten na inoculatie met aardappelvirus S

In totaal 98 plantesoorten behorende tot 15 families werden onderzocht als mogelijke toetsplanten van het aardappelvirus S. De planten werden met respectievelijke zes verschillende isolaten van het aardappelvirus S in bladsap geïnoculeerd. Slechts in de plantefamilies Amaranthaceae, Chenopodiaceae en Solanaceae werden soorten gevonden, die vatbaar zijn voor één of meer isolaten van het virus. De vatbare Solanaceae werden systemisch geïnfecteerd, terwijl de Amaranthaceae en Chenopodiaceae met lokale vlekken reageerden. De vatbaarheid van de lokale-vlekkenplanten was zeer ongelijk voor de zes isolaten van het aardappelvirus S (Tabel 3).

Chenopodium album, *C. polyspermum* en *C. quinoa* (I.P.O.) reageerden met lokale vlekken na inoculatie met elk van de zes isolaten, de andere Chenopodiaceae deden dit na inoculatie met slechts enkele isolaten. Ook de herkomst van één en dezelfde plantesoort (*Chenopodium quinoa*) had invloed op het al of niet verschijnen van lokale vlekken op de waardplant na inoculatie met de verschillende virusisolaten.

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