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New aphid vectors of potato virus Y^N

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Abstract

During three successive years, 1983, 1984 and 1985, winged aphids were caught alive in a potato field with a conical net and with transportable suction traps.

One hundred and one aphid species or species groups were checked for their ability and efficiency in transmitting potato virus Y^N (PVY^N) from potato to potato. Seventy-eight species or species groups were found unable to transmit PVY^N, whereas twenty-three species did transmit, among them being *Aphis nasturtii, Brachycaudus helichrysi, Cryptomyzus galeopsidis, Cryptomyzus ribis, Hyadaphis foeniculi, Hyalopterus pruni, Hyperomyzus lactucae, Sitobion avenae* and *Sitobion fragariae.* All species, with the exception of *A. nasturtii,* are recorded the first time as vectors for PVY^N.

In transmission experiments alatae caught with a conical net yielded better results than did those caught with a suction trap.

Additional keywords: PVY^N transmission, suction traps, conical net, aphids.

Introduction

Several investigators found that aphids not colonizing potato could transmit one or more strains of potato virus Y (PVY) (Edwards, 1963; De Bokx and Piron, 1978, 1984, 1985; Kostiw, 1979; Van Hoof, 1980; Singh et al., 1983; Bell, 1983; Rydén et al., 1983; Sigvald, 1984; Katis and Gibson, 1985; Harrington et al., 1986).

Mainly apterous aphids, reared under laboratory conditions, were used in their transmission experiments. Moreover, tobacco plants were used as infector and test plants. Therefore, it is not clear whether those aphid species substantially contribute to the rate of infection of a field-grown potato crop.

The main goal of the present study was to find out whether alatae of various aphid species, caught in the field, were able to transmit the N-strain of PVY from potato to potato.

Since PVY^N poses a more serious problem than PVY^O in the Netherlands, all transmission experiments were carried out with PVY^N.

Materials and methods

To catch aphids alive, two types of traps were used during the potato seasons of 1983, 1984 and 1985. The traps were placed in a potato field of 1 ha at Wageningen, at a distance of about 200 m of a few buildings and of about 100 m of shrubs and trees.

A conical net, as developed by Williams and Milne (1935) and modified by Ashby (1976), was used. It was made of plastic gauze, with an inlet diameter of 25 cm and an outlet diameter of 1.5 cm. The inlet was kept open by a wire hoop. Both ends of the net were attached to a boom, at the end of which a wind vane of galvanized iron was attached. The boom in balance could pivot upon a vertical pole, which was placed in a potato field. A plastic bottle was fitted to the outlet.

A transportable suction trap was constructed according to a modified design of Johnson (1950), Simpson and Berry (1973) and Taylor (1951). It consisted of a vertical tube, with a length of 1.35 m and with a diameter of 0.25 m. At the end of the tube a horizontal ventilator, 2460 rev./min, 127 W, and an air flow of 1600 $m^3\ h^{-1}$ was attached. Between the inlet of the tube and the ventilator a plastic bottle was fitted to collect the aphid catches.

On each day, not later than at 0800, the samples were collected and brought into the laboratory. After identification with a stereomicroscope, magnification 10-30×, the aphids were allowed to feed for 20 to 30 s on a 'Bintje' potato leaf infected with PVY^N. Each year the same virus strain was used. All aphids were observed individually during their presence on the leaf and only those which actually probed were transferred to a healthy potato plantlet, cv. Bintje (15-25 cm), grown from excised eyes and planted in small pots. The aphids were allowed to feed on the plants for 2 to 3 h in a small clip-cage (Walrave, 1951). Then the plantlets were transferred to an aphid-free greenhouse and were sprayed with an insecticide twice a week as an extra precaution to prevent contamination with unwanted viruses. Four weeks later the leaves, on which the aphids had fed were sampled and tested serologically with the enzyme-linked immunosorbent assay (ELISA) for presence of PVY^N. Four months later the progenies of the plants were checked too with ELISA. Without any exception the results of both tests corresponded with each other.

Results

Since the transmission experiments were performed with alatae captured in the open, the numbers of aphids used, fluctuated considerably. In general, a large number of the family of the Aphidinae were caught.

Table 1 shows a number of aphid species which did transmit PVY^N from potato to potato. A number of them are already known to be vectors, viz. *Acyrthosiphon pisum, Aphis fabae, Aphis nasturtii, Brachycaudus helichrysi, Capitophorus hippophaes, Macrosiphum euphorbiae, Metopolophium dirhodum, Myzus certus, Myzus persicae, Phorodon humuli, Rhopalosiphum insertum* and *Rhopalosiphum padi.* However, in my experiments *Aulacorthum solani,* a known vector of PVY (Kennedy et al., 1962; Van Hoof, 1980), did not transmit PVY^N. After rearing more individuals of *A. solani* in the laboratory, more transmission experiments were carried out with the same negative results. Although *B. helichrysi* was mentioned by Bell (1983) as a vector, this species was not found earlier to be a vector in the Netherlands (Van Hoof, 1980). However, the results of my experiments support the findings of Bell.

There were great differences in transmission efficiency between the species. *M. certus* and *A. nasturtii* were found to be rather good vectors of PVY^N. The efficiency of *M. persicae* is just about two times better. The next group of species, such as *A. pisum, A. fabae, B. helichrysi, Brachycaudus* spp., *M. euphorbiae, M. dirhodum, P. humuli,*

Table 1. Alate aphid species, captured in the open during three successive years, transmitting PVY^N under laboratory conditions from potato to potato.

Species	Transmission			
	suction traps	conical net	%	REF[3]
Acyrthosiphon pisum	0/5[1]	2/16	12.5	0.05
Aphis fabae	0/11	7/72	9.7	0.10
A. nasturtii	0/4	3/11	27.3	
Aphis spp.	0/98	9/135	6.7	
Brachycaudus helichrysi	—[2]	9/72	12.5	0.01
Brachycaudus spp.	13/43	7/51	14.7	
Capitophorus hippophaes	0/13	2/64	3.1	
Cavariella aegopodii	0/32	1/229	0.4	
Cryptomyzus galeopsidis	0/8	4/23	17.4	
C. ribis	1/11	2/13	15.4	
Hyadaphis foeniculi	0/22	5/34	14.7	
Hyalopterus pruni	1/18	5/36	13.9	
Hyperomyzus lactucae	0/20	4/23	17.4	
Macrosiphum euphorbiae	0/66	10/68	14.7	0.10
Metopolophium dirhodum	1/52	12/120	10.0	0.01
Myzus certus	0/16	12/35	34.3	
M. persicae	47/79	145/204	71.1	1.00
Phorodon humuli	0/19	12/67	17.9	0.15
Rhopalosiphum insertum	5/62	26/193	13.5	0.05
R. padi	5/93	26/227	11.5	0.02
Sitobion avenae	0/74	3/163	1.8	
S. fragariae	0/3	1/10	10.0	
Uroleucon spp.	3/42	2/24	8.3	

[1] Numerator: number that transmitted PVY^N; denominator: total number tested.
[2] —: not caught.
[3] REF: relative efficiency factor as computed by Van Harten (1983).

R. insertum, R. padi, Sitobion fragariae and *Uroleucon* spp., did transmit PVY^N in more or less the same proportion. Other species such as *C. hippophaes* and *Sitobion avenae* transmitted PVY^N very poorly. New vectors found are: *Cryptomyzus galeopsidis, Cryptomyzus ribis, Hyadaphis foeniculi, Hyalopterus pruni, Hyperomyzus lactucae, S. avenae* and *S. fragariae.*

The aphids caught with the conical net transmitted PVY^N more successfully than those caught with the suction traps.

In Table 2 the numbers of alate species tested which failed to transmit PVY^N are listed. The numbers of aphids trapped during the years are totalized. The species listed under 'others' mainly colonize trees and none of them transmitted PVY^N.

Table 3 shows the time of arrival and of the ability to transmit PVY^N of four aphid species not colonizing potato in comparison with those of *M. persicae.* The data of arrival and transmission of PVY^N of each species fluctuated strongly each season.

Table 2. Alate aphid species caught in the open, not transmitting PVY^N under laboratory conditions from potato to potato.

Species	Total number of aphids tested	Species	Total number of aphids tested
Aphidinae		*Aphidinae*	
Amphorophora rubi	8	*Pterocomma pilosum*	2
Anthracosiphon hertae	1	*Rhopalosiphum maidis*	1
Aphis rumucis	1	*R. nymphaeae*	2
A. sambuci	3	*R. pilipes*	1
Aulacorthum palustre	1	*Staegeriella necopinata*	2
A. solani	17	*Thuleaphis rumexicolens*	2
Brachycaudus cardui	3	*Tubaphis ranunculina*	3
Brevicoryne brassicae	11	*Wahlgreniella arbuti*	4
Capitophorus carduinus	8		
C. eleaegni	22		
C. horni	31	Others	
C. similis	1		
Cavariella theobaldi	78	*Anoecia corni*	10
Ceruraphis eriophori	1	*Betulaphis quadrituberculata*	2
Diuraphis spp.	4	*Callipterinella tuberculata*	2
Dysaphis plantaginea	1	*Chaitophorus beuthani*	9
Dysaphis spp.	18	*C. leucomelas*	31
Elatobium abietinum	3	*C. populalbiae*	2
Hayhurstia atriciplis	3	*C. salicti*	1
Hyalopteroides humulis	2	*Drepanosiphum dixoni*	4
Hyperomyzus pallidus	6	*D. platanoides*	11
Juncobia leegei	1	*Eriosoma ulmi*	7
Liosomaphis berberidis	11	*Euceraphis punctipennis*	6
Lipaphis erysimi	12	*Kallistaphis basalis*	10
Longicaudus trirhodus	2	*Myzocallis castanicola*	7
Macrosiphoniella artemissiae	1	*M. coryli*	16
M. persequens	2	*Periphyllus californiensis*	1
M. tapuskae	2	*P. hirticornis*	1
M. spp.	1	*P. testudinatus*	13
Megoura viciae	2	*Phyllaphis fagi*	22
Microlophium carnosum	4	*Pterocallis alni*	38
Myzaphis rosarum	1	*Sipha glyceriae*	5
Myzus ascalonicus	18	*Subsaltusaphis* spp.	2
M. cerasi	3	*Tetraneura ulmi*	7
Nasonovia pilosellae	1	*Thecabius affinis*	1
N. ribisnigri	35	*Thelaxes dryophila*	1
Neonasonovia picridis	1	*Thripsaphis thripsoides*	2
Ovatomyzus stachyos	1	*Trama* spp.	1
Ovatus insitus	43	*Tuberculatus querceus*	2
Pentatrichopus potentillae	8	*Tuberculoides annulatus*	5
Pleotrichophorus glandulosus	2	*T. borealis*	18

Table 3. Dates of first capture and first successful transmission of PVY^N by some early-flying aphid species and *M. persicae* in laboratory tests.

Species	Year					
	1983		1984		1985	
	FC[1]	FT[1]	FC	FT	FC	FT
Brachycaudus helichrysi	1 June	9 June	27 June	—[2]	19 June	—
Metopolophium dirhodum	3 June	13 June	14 May	7 June	10 May	19 June
Rhopalosiphum insertum	18 May	16 July	16 July	—	18 May	30 July
R. padi	11 June	20 June	23 May	23 May	18 May	30 July
Myzus persicae	8 June	25 June	19 May	20 July	6 June	6 June

[1] FC: first capture; FT: first transmission of PVY^N.
[2] —: no transmission of PVY^N.

Discussion

During the three seasons of observation the greatest numbers of aphids were captured with the conical net. Moreover, the best results in transmission were obtained with the aphid species caught with this net.

Although the traps differed in their efficiency for trapping aphids, records of the seasonal distribution of species of the two traps were found to be similar. This was in agreement with the findings of Loughlin (1963).

The observation first mentioned is difficult to explain. One might assume that the size of the entry to the trap plays a role. As far as transmission experiments are concerned I think that aphids caught with the suction traps dryed up and were possibly damaged, so that probing activity was reduced, whereas with aphids caught with the conical net this would not be the case.

In my opinion the conical net is an excellent device to catch aphids alive. Since it does not need electric power it can operate anywhere.

Van Hoof (1980) found *Brachycaudus helichrysi, Hyalopterus pruni, Hyperomyzus lactucae* and *Sitobion avenae* to be non-transmitters of PVY, while I got the opposite result. In addition some species of the genus *Uroleucon* were found to be vectors (De Bokx and Piron, 1985). As far as known this was the first time that these species were mentioned as vectors. This finding was supported by Harrington et al. (1986).

Rhopalosiphum padi is known to transmit PVY^O and PVY^N (Sigvald, 1984; Katis and Gibson, 1985) and *Rhopalosiphum insertum* transmits PVY^N (Van Hoof, 1980) from and to both tobacco and potato. Contrary to Katis and Gibson (1985) I found *S. avenae* to be a vector of PVY^N, though not a very efficient one.

In spite of one positive transmission, it is doubtful whether *Cavariella aegopodii* can transmit PVY^N, for many individuals were tested, both alatae (De Bokx and Piron, 1984; Table 1) and apterae (Piron, not published), and always with negative results.

Several species such as *Acyrthosiphon pisum, B. helichrysi, Macrosiphum euphorbiae, Metopolophium dirhodum, Myzus certus, Phorodon humuli, R. insertum* and

R. padi which can transmit PVY^N, fly earlier than *Myzus persicae* (Table 3). However, transmission of PVY^N by specimens caught at that early time was very poor. I found that aphids of these species, captured early in the season did not transmit PVY^N under laboratory conditions. At the time *M. persicae* arrives and starts transmitting PVY^N, those species are able to transmit PVY^N too. So the early-flying aphids probably do not infect substantially potato fields early in spring.

According to Van Harten (1983) nine species (*A. pisum, Aphis fabae, B. helichrysi, M. euphorbiae, M. dirhodum, M. persicae, P. humuli, R. insertum, R. padi*) are potential vectors of PVY^N. However, the relative efficiency factor (REF), he applies need more investigation. In my opinion, it is not certain that the use of the REF for only nine species will suffice as there are other species and species groups (Table 1) which can also transmit PVY^N relatively well. It is questionable too at which REF value one differentiates between dangerous and not dangerous. The results of the present experiments show that at least *Aphis nasturtii* and *M. certus* should be included in the list of nine, since these two species are more efficient transmitters of PVY^N than a number of the species mentioned by Van Harten. Transmission of PVY^N by *M. certus* is in agreement with the findings of MacGillivray and Bradley (1960), who reported *M. certus* to be an even more efficient vector of PVY^N than *M. persicae.*

It is realized that aphid transmission in nature may be different. Performing virus transmission in the laboratory is in a way an artificial procedure of transmission. Aphids not having other hosts at their disposal are forced to probe the available plant. Thus *A. nasturtii* and *M. certus* may not be as efficient vectors in the field as under laboratory conditions.

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Samenvatting

Nieuwe bladluisvectoren voor het aardappelvirus Y^N

Gedurende drie opeenvolgende jaren (1983, 1984, 1985) werden gevleugelde exemplaren van 101 bladluissoorten levend gevangen met een fuik en met verplaatsbare zuigvallen, en in een kas getoetst op hun vermogen om aardappelvirus Y^N (PVY^N) van aardappel naar aardappel over te brengen.

Achtenzeventig soorten brachten het PVY^N niet over. Naast de reeds algemeen bekende vectorsoorten werden nog enkele soorten gevangen die in staat bleken PVY^N over te brengen in het laboratorium, te weten: *Aphis nasturtii, Brachycaudus helichrysi, Cryptomyzus galeopsidis, Cryptomyzus ribis, Hyadaphis foeniculi, Hyalopterus pruni, Hyperomyzus lactucae, Sitobion avenae* en *Sitobion fragariae.*

Met bladluizen gevangen in de fuik werden betere overdrachtsresultaten behaald dan met de bladluizen gevangen in de zuigvallen.

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