

## Acquisition of potato virus Y<sup>N</sup> by *Myzus persicae* from primarily infected ‘Bintje’ potato plants

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### Abstract

When ‘Bintje’ potato plants were inoculated mechanically with potato virus Y<sup>N</sup> (PVY<sup>N</sup>), *Myzus persicae* acquired PVY<sup>N</sup> from both the inoculated and non-inoculated leaves about one week earlier than when plants were inoculated by *M. persicae*. Only when young plants of about four weeks after planting were inoculated by *M. persicae*, this aphid acquired PVY<sup>N</sup> from the non-inoculated top leaves within a fortnight. When plants later than four weeks after planting were inoculated by *M. persicae* it generally took at least four weeks for this aphid to acquire PVY<sup>N</sup> from non-inoculated top and other leaves of such plants. A number of leaves situated on the potato stems near to the inoculated ones did not serve as a PVY<sup>N</sup>-source for *M. persicae* within the experimental period of 38 days. The results indicate that it is possible that in seed potato growing areas primarily infected PVY<sup>N</sup>-infected plants, not yet showing symptoms, can act as virus sources for further spread. This is especially true in the beginning of the season.

*Additional keywords:* Mature plant resistance, seed potato production.

### Introduction

To produce seed potatoes free from viruses a good understanding of the interactions between viruses, vectors and hosts is a prerequisite. Some of these have been studied extensively, as e.g. the role of aphids by using yellow traps and bait plants (Van Hoof, 1977, 1978) and virus translocation in potato plants (Beemster, 1972). Till now relatively little is known concerning the question in how far primarily infected potato plants can act as an important virus source for plants in the same season. Aphids appearing early in the season may spread viruses before or during the period of rogueing, by which primarily infected plants, not yet showing symptoms (and thus escaping rogueing) are continually present from which further spread to healthy plants can take place. If so, rogueing might not always give the expected positive result. Stevenson (1959) working with potato virus Y and tobacco as a host reported recovery of this virus from the inoculated leaves by *Myzus persicae* already four days after mechanical inoculation by sap and six days after inoculation by aphids. Using potato as a host he established recovery of the virus by *M. persicae* from the inoculated leaves 10–14 days after inoculation and from the non-inoculated leaves 15–20 days after inoculation. In the present study similar experiments were carried out with potato virus Y<sup>N</sup> (PVY<sup>N</sup>) and ‘Bintje’ as a host with the aim of obtaining detailed information on the subject.

## Materials and methods

The experiments were carried out in aphid-free greenhouses at temperatures ranging from 20–24°C under natural light conditions. Single-stemmed potato plants were grown in pots. Before the experiments started the plants were tested serologically or by using test plants for the presence of the potato viruses M, S, X, Y, A and leaf roll; only plants free from these viruses were used. Mechanical inoculations with PVY<sup>N</sup> from infected 'White Burley' tobacco leaves were performed using carborundum (500 mesh) as an abrasive. Inoculations by *M. persicae* were performed by allowing *M. persicae* an access period of five minutes on PVY<sup>N</sup>-infected 'Bintje' potato plants after a fasting period of 2–4 h. For the inoculation of each plant 10 aphids were used, the inoculation feeding period was 2 h, after which the aphids were killed. In experiment 1 32 potato plants were planted on 6 February 1976; on each of the dates: 20 February, 5 March, 19 March and 2 April four plants were inoculated mechanically and four plants by *M. persicae*. The youngest fully developed leaf was inoculated. Particulars as to the age at which the groups of plants were inoculated and the dates on which it was tried to recover PVY<sup>N</sup>, either from the inoculated leaves or from one of the top leaves are given in Table 1, together with the results obtained. The possibility for recovery of PVY<sup>N</sup> from the potato plants was studied by allowing 20 *M. persicae* (after fasting for 2–4 h) to feed for five minutes on the inoculated leaves or one of the top leaves of each of the plants after which the aphids were transferred to two *Physalis floridana* plant, each of them getting 10 aphids. After a 4–6 h infection feeding period the aphids were killed with an insecticide. *P. floridana* is a susceptible and sensitive host of PVY<sup>N</sup>, in most cases both *P. floridana* plants reacted identically, in rare cases only one out of the two plants became infected, indicating that this test was fairly reliable. In Table 1, 2 and 3 a positive reaction is recorded when at least one of the two plants had become infected.

In a second and third experiment the same procedure was applied. Experiment 2 consisted of a group of 30 'Bintje' potato plants, planted on 14 April 1976 of which 10 plants were inoculated on 7 May, 27 May and 17 June, respectively, using 10 *M. persicae* for each plant. In this experiment sap inoculation was not included. Additional data on dates of attempted recovery of PVY<sup>N</sup> and other particulars are given in Table 2.

In a third experiment only six plants were used in which it was tried to detect differences with respect to possible PVY<sup>N</sup>-recovery by *M. persicae* between the different leaves of a potato plant. Planting date was 15 June 1976, inoculation by *M. persicae* on 19 July on a prefixed leaf as is given in Table 3. On a number of leaves *M. persicae* was allowed to feed on a number of dates. In Table 3 detailed data and the results of the experiment are schematically given.

## Results

The results of experiment 1 (Table 1) show clearly that *M. persicae* can acquire PVY<sup>N</sup> from both the inoculated leaves and the non-inoculated leaves from the top of the plants one week earlier when plants are inoculated mechanically than when inoculated by aphids. After about seven days PVY<sup>N</sup> was acquired from the mechanically inoculated leaves from plants inoculated when 2, 4 and 6 weeks old; data on the inoculated leaves of eight-week old plants are scarce due to senescence of the inoculated

Table 1. Acquisition of PVY<sup>N</sup> by *Myzus persicae* from primarily infected 'Bintje' potato plants.

Time of inoculation (weeks after planting)	Days after inoculation	Inoculation by															
		sap								<i>Myzus persicae</i>							
		I	T	I	T	I	T	I	T	I	T	I	T	I	T	I	T
2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
	10	+	-	+	-	+	+	+	+	-	-	-	-	-	-	-	-
	12	+	+	+	-	+	+	+	+	-	-	-	-	-	-	-	-
	14	+	+	+	+	+	+	+	+	-	-	-	-	-	+	+	-
	20	+	+	+	+	+	+	+	+	-	+	+	-	-	+	-	-
4	5	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
	10	+	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-
	12	+	-	+	+	+	-	+	-	+	+	-	-	-	-	+	-
	14	+	+	+	+	+	+	+	-	+	+	-	-	-	-	+	+
	18	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	+	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-
	9	+	-	+	-	-	-	+	-	-	-	-	-	+	-	-	-
	11	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-
	14	+	+	+	-	+	-	+	-	-	-	+	-	-	-	-	-
	16	+	+	+	-	+	-	+	-	-	-	+	-	-	-	+	-
	21		+		-		-		-		-		-		-		-
	24		+		-		-		-		-		-		-		-
8	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10		-		-		-		-		-		-		-		-
	13		-		-		-		-		-		-		-		-

I = inoculated leaf; T = one of the top leaves; + = *M. persicae* acquired PVY<sup>N</sup>; - = *M. persicae* did not acquire PVY<sup>N</sup>.

Tabel 1. Opname van PVY<sup>N</sup> uit primair geïnfecteerde aardappelplanten ('Bintje') door *Myzus persicae*.

leaves at the end of the experimental period.

*M. persicae* acquired PVY<sup>N</sup> from the top leaves of the plants about two weeks after inoculation by aphids from plants inoculated when two and four weeks old. No aphid did acquire any virus from the top leaves within 24 days after the aphid-inoculation of six-week old plants (about the time of flowering). The group inoculated when eight weeks old could only be tested up to the 17th day after primary inoculation; no aphid did acquire any virus in this part of the experiment.

The results of experiment 2 (Table 2) in which only inoculation by *M. persicae* was included, confirm those of experiment 1, viz. PVY<sup>N</sup> can be acquired earlier from the inoculated leaves than from the non-inoculated leaves in the top of the plants, the difference being about five days in the group inoculated when three weeks old, whereas

Table 2. Acquisition of PVY<sup>N</sup> by *Myzus persicae* from ' Bintje' potato plants after inoculation by *M. persicae*.

W	D	I	T	I	T	I	T	I	T	I	T	I	T	I	T
3	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	12	+	-	-	-	+	-	-	-	+	-	-	-	-	-
	14	-	-	+	-	+	-	-	-	+	-	-	-	+	-
	17	-	+	+	-	+	+	-	-	+	+	-	+	+	-
	19	+	+	-	+	+	-	-	+	+	+	-	-	+	+
6	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	-	-	-	-	-	+	-	+	-	-	-	-	+	-
	14	-	-	-	-	-	+	-	+	-	-	-	-	+	-
	17	-	-	-	-	-	-	-	+	-	-	-	+	-	-
	19	-	-	-	-	-	+	-	+	-	-	-	-	-	-
	21	-	-	-	-	-	-	+	-	-	-	+	-	+	-
9	7	-	-	+	-	-	-	-	-	-	-	-	-	-	-
	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-

I = inoculated leaf; T = one of the top leaves; + = *M. persicae* acquired PVY<sup>N</sup>; - = *M. persicae* did not acquire PVY<sup>N</sup>; W = time of inoculation in weeks after planting; D = days after inoculation.

Tabel 2. Opname van PVY<sup>N</sup> uit door *Myzus persicae* geïnoculeerde aarappelplanten (' Bintje') door *M. persicae*.

from the top leaves of the groups inoculated when six and nine weeks old, respectively, no PVY<sup>N</sup> was recovered. It is clear that the older the plants were at the time of inoculation, the less PVY<sup>N</sup> was acquired from both the inoculated leaves and the non-inoculated top leaves.

The inoculated leaves and the top leaves of the plants inoculated when three weeks old were tested separately on A6 test leaves 19 days after inoculation. All tests were positive, except those of plant nr 4: apparently *M. persicae* had failed to infect this plant. A6 leaf tests were not performed with plants from the other two groups (6 and 9 weeks old). Probably some of them had not become infected either. It can be concluded that PVY<sup>N</sup> was only acquired from the top leaves 17 days after inoculation. This was the case in five out of ten plants in the group inoculated when three weeks old. In all other cases this period was longer or no virus at all was acquired.

The results of experiment 3 (Table 3) show that 11 and 15 days after inoculation by *M. persicae* no aphid acquired PVY<sup>N</sup> from any leaf; 21 days after inoculation the virus was recovered in only one case. In general it took 28 or 38 days before PVY<sup>N</sup> could be recovered from some of the leaves, whereas no virus was recovered from quite a number of leaves, not even 38 days after the inoculation. The two or three leaves situated on the stem close to the inoculated leaves generally did not allow the aphids to acquire PVY<sup>N</sup>.

In all of the experiments only those of the group inoculated when two weeks old (Table 1) in experiment 1 showed symptoms about 14 days after inoculation, in none of the other plants symptoms appeared.

Table 3. Acquisition of PVY<sup>N</sup> by *Myzus persicae* from a number of leaves of six potato plants inoculated by *M. persicae*.

Leaf number	Plant number					
	1	2	3	4	5	6
top	38	38	—	—	—	38
16	.	.	.	.	.	.
15	.	.	.	.	.	38
14	.	.	.	.	38	21
13	.	.	.	.	28	—
12	.	.	38	.	38	—
11	.	28	28	—	—	—
10	38	28	—	—	x —	x38
9	—	28	—	—	—	—
8	—	28	—	x28	—	—
7	—	—	—	—	.	.
6	—	—	—	—	.	.
5	—	—	x28	—	.	.
4	x28	x —	.	.	.	.

. = leaves not tested; x = inoculated leaf; — = aphids did not acquire PVY<sup>N</sup> 11, 15, 21, 28 and 38 days after inoculation by *M. persicae*.

The numbers denote the number of days after inoculation that aphids first acquired PVY<sup>N</sup> from the leaf concerned.

Tabel 3. Opname van PVY<sup>N</sup> door *Myzus persicae* uit een aantal bladeren van 6 aardappelplanten ('Bintje') na inoculatie door *M. persicae*.

## Discussion

It can be concluded that *M. persicae* acquires PVY<sup>N</sup> much more quickly from mechanically inoculated plants than from those inoculated by *M. persicae*. This is true for both the inoculated leaves and the leaves which had not been inoculated. When we consider both types of inoculation, it can be stated that the initial sites of infection in case of mechanical inoculation must be much more numerous than when *M. persicae* (in the experiments 10 per plant) infects a leaf. We may assume that aphids can acquire PVY<sup>N</sup> only from these initial sites of infection and some cells around them during the first period after inoculation. Therefore, chances that after a few days the aphids will feed exactly on those centres of virus multiplication apparently are much smaller in case of initial infection by *M. persicae*, than is the case after initial infection by mechanical inoculation with undiluted sap from infected plant material. In the latter case we may expect that practically no uninfected cells will be present a few days after inoculation, due to cell-to-cell movement of PVY<sup>N</sup>. The difference in results between the two types of inoculation can thus be explained. The same holds for the differences found with respect to the possibility of recovery from non-inoculated leaves. The more virus is multiplied in inoculated leaves, the quicker and more intensive virus transport to uninoculated leaves normally is (Beemster, 1958, 1965). Such differences may be leveled out when the period between inoculation and testing, as was performed in the experiments, is longer. Because then the number of sites of virus multiplication will

gradually increase and eventually give rise to an enhanced rate of virus translocation.

When the results are related to what might happen under field conditions, those obtained after primary infection by *M. persicae* are of interest. It can be noted that the shortest period after which *M. persicae* was able to acquire PVY<sup>N</sup> from such plants was 10 days from inoculated leaves and 12 days from uninoculated leaves under optimal conditions, when dealing with young plants (Table 1, four weeks). The general impression from the results of the three experiments is, that potato plants soon reach a stage in which aphids cannot acquire PVY<sup>N</sup> until at least three weeks after primary infection by *M. persicae*.

E.g., using six-week old plants, PVY<sup>N</sup> could not be recovered from the uninoculated leaves within 21 days (Table 1) and using five-week old plants not within 24 days (Table 2). In experiment 3 (Table 3) PVY<sup>N</sup> could be recovered from the uninoculated leaves only once after 21 days, but generally after 28 days or more. With the inoculated leaves, the period was always shorter, but chances that aphids are feeding on the leaves on which the initial infection took place, probably will normally be remote in seed potato growing areas, where the numbers of virus-carrying aphids can be considered to be small. The results presented in Table 3 give some information as to the question which leaves are most dangerous as PVY<sup>N</sup> sources. There seems to be a tendency that from about the fourth leaf above the inoculated one chances that PVY<sup>N</sup> can be acquired are greatest. This will probably hold for plants which still show length growth and development of new leaves.

In conclusion current season infection with PVY<sup>N</sup> by *M. persicae* (and most probably also by other aphids) can generally give rise to new PVY<sup>N</sup> sources especially when plants are primarily infected in a young stage. It is hard to state exactly at which age of the potato plants the possibility can be excluded that primary infections will give rise to new PVY<sup>N</sup> infection sources. Factors such as potato variety, weather conditions, type of fertilization, will certainly play a part.

Curiously enough, the above stated problems seem to be closely related to those of virus translocation and mature plant resistance. In the present studies PVY<sup>N</sup> transport to the tubers was not included, but comparing the results with those obtained in earlier work on virus translocation in potato plants (Beemster 1972), we can schematically differentiate the following stages in PVY<sup>N</sup>-infection when considering the stages of growth in which potato plants are inoculated.

- (1) When young plants are inoculated, symptoms develop, complete tuber infection occurs and aphids readily acquire PVY<sup>N</sup> from these plants.
- (2) Inoculation of plants around the time of flowering generally will not lead to the development of symptoms, partial tuber infection will occur, but aphids will hardly acquire PVY<sup>N</sup> from such plants.
- (3) Inoculation of plants after the time of flowering and later will not lead to the development of symptoms, the rate of tuber infection will gradually decrease (depending on the stage of growth at the time of infection) and aphids will not acquire PVY<sup>N</sup> from these plants.

## Samenvatting

### *Opname van aardappel Y<sup>N</sup> virus door Myzus persicae uit primair geïnfecteerde 'Bintje' aardappelplanten*

*Myzus persicae* bleek uit geïnoculeerde aardappelbladen ('Bintje'), zowel als uit de niet geïnoculeerde, eerder aardappel Y<sup>N</sup> virus op te kunnen nemen wanneer de planten mechanisch waren geïnoculeerd, dan na inoculatie door *M. persicae* (Tabel 1). Alleen bij inoculatie door *M. persicae* van jonge aardappelplanten (ca. vier weken na poten) bleek deze luis in staat het virus in minder dan 14 dagen uit niet geïnoculeerde topbladeren op te kunnen nemen (Tabel 1).

Na inoculatie door *M. persicae* van planten die ouder waren dan vier weken duurde het meestal minstens vier weken voor *M. persicae* in staat bleek PVY<sup>N</sup> uit niet geïnoculeerde bladen op te nemen (Tabel 1 en 2).

De bladeren, direct boven het geïnoculeerde blad, bleken zeer lang (38 dagen) niet als bron te kunnen dienen voor opname van PVY<sup>N</sup> door bladluizen (Tabel 3).

De resultaten tonen aan, dat bij de teelt van aardappelpootgoed rekening moet worden gehouden met de mogelijkheid dat bij vroege PVY<sup>N</sup> infecties oorspronkelijk gezonde planten nog hetzelfde seizoen op kunnen treden als nieuwe PVY<sup>N</sup> bronnen.

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