Influence of potato variety and PVY infection on aphid behaviour: preferences from *Myzus persicae* and *Macrosiphum euphorbiae*

Haibo Zhou1,2*, Teng Yu1,2, Longsheng Chen1,2, Weiwem Li3, Ling Dong3, Song Sun4

1. Anhui Academy of Science and Technology, Heifei, 230088, China
2. Anhui Center for Promoting Transformation of Scientific and Technological Achievements, Heifei, 230088, China
3. Anhui Academy of Agricultural Sciences, Heifei, 230031, China
4. Hefei yuanzhi pharmaceutical R&D company LTD., Heifei, 230000, China

*corresponding author’s e-mail: zhouhaibo417@163.com

Abstract. In order to determine the potential effects of potato plant infected by Potato virus Y (PVY) on the biology of aphid vectors, plastic box experiments were set up to study the preference of two of the most efficient PVY vectors, *Myzus persicae* (Sulzer) and *Macrosiphum euphorbiae* (Thomas). Aphid-plant selections were assessed 4h and 8h after aphid set in observation chamber presenting dual choices using two potato varieties, cv. Désirée and cv. Bintje. Experiments show that both *M. persicae* and *M. euphorbiae* preferentially settled on cv. Bintje potato plants infested by PVY when compared to healthy potato plants after 4h and 8h. Compared healthy cv. Désirée plant and infested cv. Désirée plant, *M. persicae* tended to choose healthy plant, no significant preference for *M. euphorbiae* was found. When both cv. Bintje and cv. Désirée plant were infested by PVY, *M. persicae* tended to choose cv. Désirée plant, whereas *M. euphorbiae* made a choice to cv. Bintje plant. While the healthy plants were also compared, no significant preference for *M. euphorbiae* was observed, *M. persicae* preferred to cv. Désirée plant in dual-choice experiment. Results of our studies could help to further increase the knowledge on aphid dynamics and viral epidemiology in the potato cropping systems.

1. Introduction

Plant viral infection is known to effect host-plant preference of aphids by visual, olfactory, tactile, and gustatory cues. Potato virus Y (PVY, genus Potyvirus, family Potyviridae) causes economic losses all over the world, especially in the production of potatoes (*Solanum tuberosum*), and its control strategies rely on controlling virus pressure and vector pressure in fields[1]. PVY is effectively transmitted by vector-aphid, the green peach aphid, the potato aphid, *Macrosiphum euphorbiae* (Thomas) (Hemiptera: Aphididae) and *Myzus persicae* (Sulzer) (Hemiptera: Aphididae), [2,3] and provides shorter feeding periods by its vector sufficient to transmit virus[4].

Vector activity and behaviour play an increasingly important role in determinants of the rate and extent of epidemic virus development. In the tri-trophic interactions, direct interactions occur between virus, host, and vectors. More importantly, virus infections could change hosts in such a way that...
interactions among host and vector are effected\cite{5}. An aphid’s performance on virus-infected plants may ultimately relate to the nature of the relationship between aphids and virus\cite{6}. On the evidence of olfactory and visual cues and factors present at cuticular and subcuticular levels, it was also showed that more \textit{M. persicae} individuals settled on PLRV-infected leaves of \textit{S. tuberosum} L. over on leaves of virus-free, PVX-infected or PVY-infected plants \cite{7}. Bioassays with both winged and wingless peach aphid also indicated that the preference for potato leafroll virus-infected plants over non-infected plant\cite{8}. Viral infection has been known to enhance plant amino acids and soluble carbohydrate concentrations and subsequently to influence vector-aphids biology\cite{6,9,10,11}. Such the infection phenomenon could have a profound influence on aphid preference or host behavior and remains to be investigated for \textit{M. persicae} and \textit{M. euphorbiae}. Changes in the attraction between aphid-vector and infected plants and changes in the benefits acquired by aphid from the relationship could certainly influence the probability of virus dispersal\cite{12}. Discovering the mechanisms of mediating interactions is fundamental to understand their evolution and ecology comprehensively. However, few studies have examined the influence of PVY infected potato plants on vector preference for \textit{M. persicae} and \textit{M. euphorbiae}. In the study, Potential effects in host preference by \textit{M. persicae} and \textit{M. euphorbia} according to the infection status of two test plants was examined.

2. Materials and methods

2.1. Plants and Insects

Tissue culture-derived potato plantlets (\textit{Solanum tuberosum} L. cv. Désirée and cv. Bintje) were selected for the experiments to ensure no initial viral infection in potato propagating material. The plantlets were potted in 20-cm plastic pots in a growth room maintained at 20 ± 1°C, 60 ± 5% r.h., and L16:D8 photoperiod.

Broad bean plants, \textit{Vicia faba} L., were grown in 9-cm plastic pots filled with a mix of perlite and vermiculite (1:1) and maintained in controlled-environment growth room under the same conditions as above. Two aphid species, namely \textit{M. persicae} and \textit{M. euphorbiae}, were reared on broad bean and potato cv. Désirée in separated air-conditioned rooms under the same conditions as above respectively.

2.2. PVY Inoculation

Two-week-old potato plantlets were mechanically inoculated using foliar-abrasive carborundum with 6 mg/ml sap from an infected plant. After infection was confirmed based on symptoms, plants from all treatments were used for assay.

2.3. Preference assay

The host plant preference of aphids to the infection of PVY on two potato varieties using the plastic box (L×W×H= 24×18×10 cm) in a controlled environment room (22±1°C, 40% r.h) were assessed. The leaves of potatoes were positioned in the plastic box through a 0.5-cm-diameter hole drilled at two sides as described in Fig. 1. Ten aphids were introduced into the plastic box, and three replications were performed for each tested in order to test 30 individuals. The number of aphids on potato plants was recorded at the 4 h and 8 h time points after release of aphids. The following treatment pairs were examined: (1) Bintje versus Désirée, (2) Bintje versus Bintje with PVY, (3) Bintje with PVY versus Désirée, (4) Bintje with PVY versus Désirée with PVY, (5) Désirée versus Désirée with PVY, (6)Bintje versus Désirée with PVY. Observed frequencies related to the preferences of aphids were compared to corresponding theoretical frequencies by using a $\chi^2$ goodness-of-fit test\cite{13}.
3. Results

3.1. Symptom expression
Symptoms of virus-infected plants were observed. Non-infected potato plants did not show any symptoms (Fig. 2A,C). Bintje PVY-infected plants exhibited visible leaf malformation (Fig. 2B). Désirée PVV-infected plants were stunted and showed visible yellowing, veinal necrosis and leaf malformation (Fig. 2D).

3.2. M. persicae preference
The foraging behavior of M. persicae was influenced by PVY infection on two potato varieties (Fig. 3). There was a significant preference of M. persicae for the healthy Désirée plant compared to the healthy Bintje after 4h ($\chi^2=14.48$, $P<0.001$) and 8h ($\chi^2=8.04$, $P=0.005$), while no significant preference was observed between Bintje with PVY and healthy Désirée (4h: $\chi^2=0.89$, $P=0.345$; 8h: $\chi^2=0.00$, $P=1.000$). M. persicae was showing less attractive to Bintje with PVY after 4h ($\chi^2=27.16$, $P<0.001$), but the percentage of preference related to Bintje infested by PVY was higher than the ones observed with healthy plants after 8h ($\chi^2=5.56$, $P=0.018$). Désirée with PVY also increased significantly the percentage of host plant preference between Désirée and Désirée with PVY after 4h and 8h (2h: $\chi^2=8.612$, $P=0.003$; 8h: $\chi^2=19.04$, $P<0.001$), as well as between Bintje and Désirée with PVY (2h: $\chi^2=14.48$, $P<0.001$; 8h: $\chi^2=22.22$, $P<0.001$).
3.3. M. euphorbiae preference

In dual-choice bioassays, no significant preference for M. euphorbiae was observed between healthy Bintje and healthy Désirée plant, as well as Désirée and Désirée with PVY plant (Fig. 4). M. euphorbiae preferred the Bintje plant infected by PVY to the healthy Bintje plant after 4h and 8h (2h: $\chi^2=22.32$, P<0.001; 8h: $\chi^2=43.56$, P<0.001), while the host plant preference of M. euphorbiae was increased significantly in response to the presence of healthy Désirée plant compared to Bintje plant infected by PVY (2h: $\chi^2=32.14$, P<0.001; 8h: $\chi^2=10.90$, P=0.001). Finally, the preference for M. euphorbiae on Bintje plant infected by PVY was significantly improved when both Bintje and Désirée plant infested PVY was compared in the plastic box (2h: $\chi^2=5.61$, P=0.018; 8h: $\chi^2=18.18$, P<0.001).

4. Discussion and conclusion

In the experiments, both Désirée and Bintje potato plants with infection of PVY exhibited pronounced symptoms. Those mild symptoms in potato upon inoculation with PVY strain N were also observed[14].

Our settling bioassays with two aphid species indicated an increased preference of both M. persicae and M. euphorbiae for PVY infected Bintje plants compared with healthy Bintje plants in 4h and 8h. Previous study also showed that a mass of winged aphids of several species was attracted to tobacco etch virus-infected tobacco over healthy plant[15].

The absence of an increased response by M. persicae and M. euphorbiae to PVY-infected Désirée, when compared to the Bintje experiments, shows that influence of PVY infected on aphid settling could vary according to potato cultivar. Different aphid studies have indicated that multiple factors effect the relative quality of host plants. The response of M. persicae to volatiles from PLRV-infected
and non-infected potato seemed to depend on the age of potato leaves. These changes may provide gustatory evidences that effect aphids preference toward virus-infected plant. Hence, tactile, volatile, or gustatory cues should account for the observed preferential selection by aphids on virus-infected potato plant versus noninfected plants. Such the change in aphids preference in the PVY-potato plants could increase the PVY spread. More experiments of the relationship between vector-aphids and PVY should require fields study to ensure whether behavioral responses of M. persicae and M. euphorbiae to PVY-infected potato plants that were observed in the laboratory are repeatable in natural environment.

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