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Passionfruit Virus Disease and Integrated Crop Management in Vietnam

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ABSTRACT

In Vietnam, passionfruit has become a major crop in many regions of the country such as the Central Highlands, Nghe An, Son La provinces. Passion fruit plantation area in Vietnam rapidly increased to 10,000 ha in 2019. However, the occurrence of passionfruit diseases caused by viruses has become a serious limiting factor in its production. In Vietnam, six viruses infecting passionfruit have been identified. Among these, East Asian Passiflora virus (EAPV) and Passiflora mottle virus (PaMoV), which cause woodiness disease, are considered the most damaging. It affected the quality and yield of passionfruit in the Central Highlands, Son La, and Nghe An, resulting in serious damage to orchards. A total of 270 passionfruit samples collected from Son La, Nghe An province and Central Highlands areas were analyzed using RT-PCR and PCR. The results showed the presence of three potyviruses (EAPV, PaMoV, and Telosma mosaic virus), one cucumovirus (Cucumber mosaic virus), and two begomoviruses (Euphorbia leaf curl virus and Papaya leaf curl Guangdong virus) infecting passionfruit in Vietnam. The field survey also revealed that EAPV and PaMoV are mainly causes of passionfruit woodiness disease in Vietnam with 38 and 56 positive samples, respectively. Mixed infections, such as those involving two strains of EAPV, two potyviruses, or a potyvirus combined with a begomovirus, often generate severe synergistic symptoms. Integrated management strategies, including the use of virus-free seedlings, early detection of symptomatic plants, and strict vector control from planting, can reduce viral disease incidence by more than 70%.

Keywords: passionfruit woodiness disease, East Asian Passiflora virus (EAPV), Passiflora mottle virus (PaMoV), Telosma mosaic virus (TelMV)

INTRODUCTION

Passionfruit (*Passiflora edulis* Sims; *Passifloraceae*) is an important crop commonly grown in tropical and subtropical regions around the world. In Vietnam, passionfruit has become a major crop in several regions, particularly in the Central Highlands and the provinces of Nghe An, Son La, and Hoa Binh. However, the production of passionfruit faces many challenges due to pests and diseases, particularly those caused by viruses. Globally, many viruses causing diseases in passionfruit have been recorded, particularly those belonging to the genus *Potyvirus*. These include the passion fruit woodiness disease (PWV) in Australia (McKnight, 1953), cowpea aphid-borne mosaic virus (CAMBV) in Brazil (Nascimento et a*l., 2006)*, East Asian Passiflora virus (EAPV) in Japan and Taiwan (Chong *et al*., 2018; Iwai *et al*., 2006), Telosma mosaic virus (TelMV) in Thailand and China (Chiemsombat *et al*., 2014; Yang *et al*., 2018). Some potyvirus species cause less severe damage to passion fruit, such as Passiflora ringspot virus (PRV) in Ivory Coast (De Wijs, 1974), bean yellow mosaic virus (BYMV) in Italy (Parrella & Castellano, 2002), and passionfruit crinkle virus (PCV) in Taiwan (Chang *et al*., 1996). Additionally, passionfruit is also infected by two species of begomoviruses: Euphorbia leaf curl virus (EuLCV) and papaya leaf curl Guangdong virus (PaLCuGdV) (Cheng *et al*., 2014).

In Vietnam, six virus species causing diseases in passionfruit plants have been identified. Among these, the most dangerous are the diseases caused by the EAPV and the Passiflora mottle virus (PaMoV), which result in fruit hardening (woody fruit). These diseases cause severe damage, directly affecting the yield and quality of the fruit. Many passionfruit orchards in Son La, Nghe An, and the Central Highlands have been severely affected and

subsequently eradicated. This study will provide information on the composition of viral diseases affecting passionfruit in Vietnam.

The objective of this study was to identify and characterize the major viruses infecting passionfruit in Vietnam and to assess their geographic distribution and associated symptoms. By integrating field surveys with molecular diagnostics, we aimed to provide a clearer understanding of the current viral disease situation. The findings of this study are significant for guiding passionfruit breeding, the production of virus-free seedlings, and the development of integrated crop management strategies that can help sustain and expand passionfruit production in Vietnam.

RESULTS AND DISCUSSION

Symptoms of viral diseases on passionfruit plants

The symptoms of viral diseases on passionfruit plants are diverse and manifest in various ways, including: 1) On the shoots: Curling and stunting of shoots; 2) On the leaves: Yellow mosaic on young leaves, while older leaves become wrinkled and blistered; and 3) On the fruit: The fruit becomes small, the rind becomes woody, the fruit deforms, and the fruit color changes from green to white. These symptoms are illustrated in Figure 1.

Similar symptoms of potyvirus infection in passionfruit have been reported in Thailand (Chiemsombat et al., 2014), Japan (Fukumoto et al., 2012), and Taiwan (Chong et al., 2018). In the early stages of infection, viral symptoms in passionfruit are difficult to distinguish from damage caused by insect pests or nutrient deficiencies.

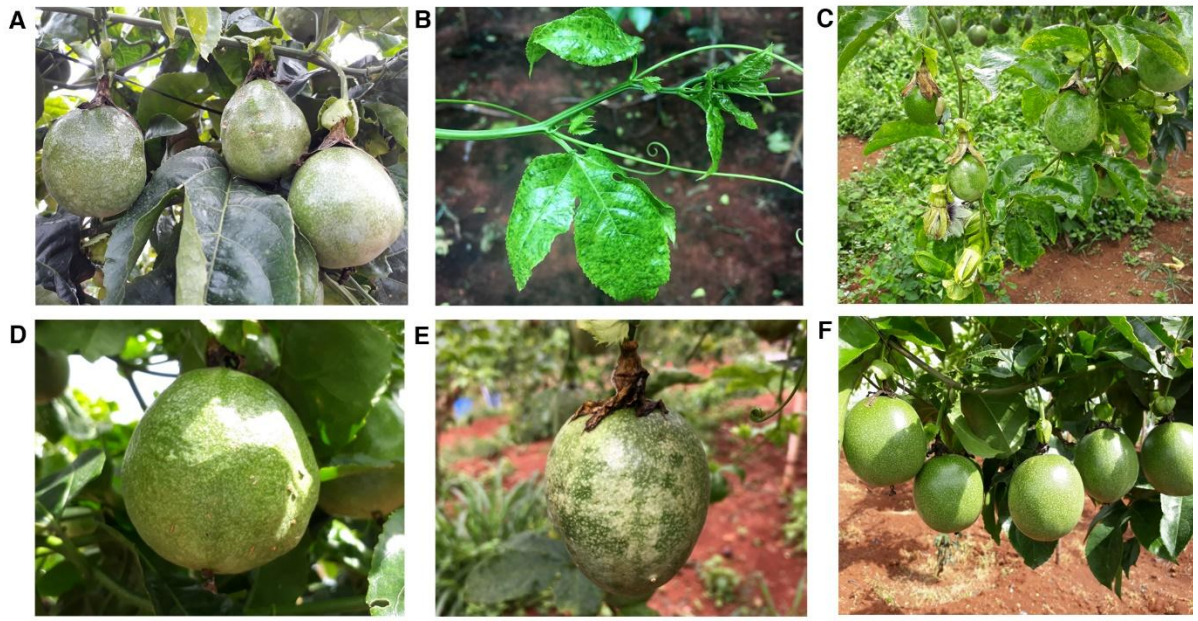

Figure 1. Symptoms of viral diseases on passionfruit. (A) Woody deformation of young fruit on a sample infected with East Asian Passiflora virus (EAPV)-AO. (B) Mosaic and mottling of young leaves on a sample infected with EAPV-IB. (C) Leaf mosaic and woody fruit on a sample infected with Passiflora mottle virus (PaMoV). (D) Distorted woody fruit on a sample infected with Telosma mosaic virus (TelMV). (E) Deformed woody fruit on a sample co-infected with EAPV-AO and PaMoV. (F) Healthy leaves and fruits.

Viral diseases affecting passionfruit in Vietnam

From 2017 to 2020, 270 passionfruit samples were collected from Son La and Nghe An provinces and the Central Highlands. Samples were analyzed using PCR and RT-PCR with specific primers (Chong et al., 2018; Do *et al*., 2021). The results revealed three potyviruses (EAPV, PaMoV, TelMV), two begomoviruses (PaLCuGdV and EuLCV), and one cucumovirus (CMV) infecting passionfruit in Vietnam (Table 1; Figure 2).

Table 1. Detection of viruses infecting passionfruit in Vietnam by RT-PCR and PCR

Virus species	Genome type	No. of positive samples (out of 270)	Typical symptoms observed
East Asian Passiflora virus – AO strain (EAPV-AO)	RNA (Potyvirus)	38	Mosaic leaves, woody fruit
East Asian Passiflora virus – IB strain (EAPV-IB)	RNA (Potyvirus)	15	Mosaic leaves, rough fruit surface
Co-infection of EAPV-AO + EAPV-IB	RNA (Potyvirus)	12	Severe mosaic, small woody fruit
Passiflora mottle virus (PaMoV)	RNA (Potyvirus)	56	Leaf mosaic, wrinkling, woody fruit
Co-infection of EAPV-AO + PaMoV	RNA (Potyvirus)	10	Severe woody fruit, stunted growth
Telosma mosaic virus (TelMV)	RNA (Potyvirus)	6	Mosaic leaves, deformed woody fruit
Cucumber mosaic virus (CMV)	RNA (Cucomovirus)	9	Mild leaf mosaic
Papaya leaf curl Guangdong virus (PaLCuGdV)	DNA (Begomovirus)	34	Inconspicuous symptoms alone
Euphorbia leaf curl virus (EuLCV)	DNA (Begomovirus)	17	Inconspicuous symptoms alone
Co-infection of PaLCuGdV + EuLCV	DNA (Begomovirus)	45	Curling of leaves, severe woody fruit
Total		**242** (including co-infections)	

PaMoV, a potyvirus associated with woodiness disease in passionfruit, has been reported in Vietnam since 2018. PaMoV has been found to cause damage in all major passionfruit growing regions, including Son La, Nghe An, and the Central Highlands (Figures 2A and 2B). Fifty-six passionfruit samples tested positive for PaMoV using RT-PCR with specific primer pairs. Typical symptoms include leaf mosaic, wrinkled leaves, and woody were also detected fruit. PaMoV has also been reported to cause woody fruit disease in passionfruit plants in China (Xie *et al*., 2019).

RT-PCR diagnosis with specific primer pairs also detected both strains of EAPV, EAPV-AO and EAPV-IB (Fukumoto *et al*., 2012), affecting passionfruit plants in Vietnam. Among the samples, 38 were infected with EAPV-AO and 15 were infected with EAPV-IB. The EAPV-AO CP and EAPV-IB CP primer pairs (Chong *et al*., 2018) effectively differentiated the two EAPV strains (Table 1; Figure 2A). Co-infection of both AO and IB strains of EAPV were also detected in 12 samples. In samples with co-infection, the symptoms were more severe compared to those with a single-strain infection. This result is consistent with studies from Japan and Taiwan regarding the two EAPV strains (Chong *et al*., 2023; Fukumoto *et al*., 2012).

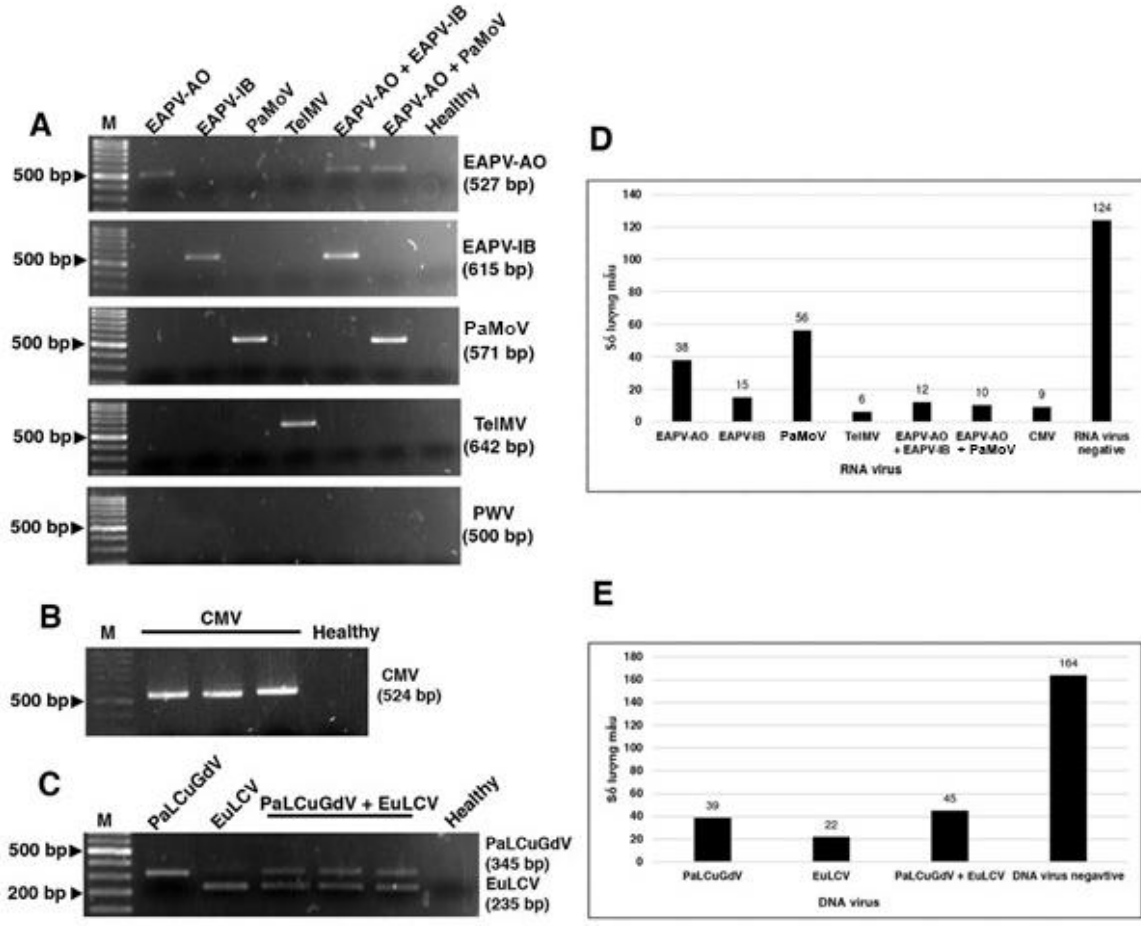

Figure 2. Detection of three Potyviruses and two Begomoviruses using RT-PCR and PCR (A) RT-PCR results of the three potyviruses causing disease in passionfruit plants, with East Asian Passiflora virus (EAPV) identifying both EAPV-AO and EAPV-IB strains. Each lane shows the result of a sample infected with a single virus, a mixed infection of two strains, or two viruses. The primer pair for EAPV-AO produces a 527 bp product, EAPV-IB a 615 bp product, Passiflora mottle virus (PaMoV) a 571 bp product, Telosma mosaic virus (TelMV) a 642 bp product, and Passionfruit woodiness virus (PWV) a 500 bp product. (B) Number of RNA virus-infected samples diagnosed by RT-PCR. (C) PCR results of the two begomoviruses causing disease in passionfruit. Lane 1 contains the sample infected with Papaya leaf curl Guangdong virus (PaLCuGdV) (345 bp), lane 2 with Euphorbia leaf curl virus (EuLCV) (235 bp), and lane 3 with both viruses. (D) Number of RNA virus-infected samples diagnosed by PCR, including EAPV-AO, EAPV-IB, PaMoV, TelMV, and their mixed infections. (E) Number of DNA virus-infected samples diagnosed by PCR, including PaLCuGdV, EuLCV, and their mixed infections.

In addition to samples co-infected with both strains of EAPV, samples co-infected with two potyviruses, EAPV-AO and PaMoV, were also identified, with 10 positive samples recorded. Samples co-infected with two viruses showed severe symptoms such as small deformed fruit, woody fruit, leaf mosaic, shoot stunting, and stunted growth.

TelMV has been detected, causing passionfruit woodiness disease in Gia Lai province, with six positive samples (Figure 2B). TelMV has been identified as the cause of passionfruit woodiness disease in Thailand (Chiemsombat *et al*., 2014) and China (Yang *et al*., 2018). RT-PCR diagnosis using the PWV CP primer pair (Chong *et al*., 2018) did not detect the presence of passionfruit woodiness virus (PWV) in Vietnam. The PWV primer pair was designed based on the sequence of the coat protein (CP) region of PWV-MU2 (HQ122652).

Among the diagnosed samples, nine samples infected with Cucumber mosaic virus (CMV) were identified using RT-PCR with specific primer pairs designed on the coat protein region (Chong *et al*., 2018). Aside from CMV, which does not cause severe symptoms like woody fruit disease, only mild leaf mosaic symptoms were observed.

PCR diagnosis of 270 samples revealed 34 samples infected with PaLCuGdV, 17 samples infected with EuLCV, and 45 samples co-infected with both viruses (Figures 2C and 2D). Simultaneously using three primers (CP up, Edw, Pdw) (Chong *et al*., 2018) in one PCR reaction, samples infected with a single begomovirus exhibited a product at 345 bp for PaLCuGdV and 235 bp for EuLCV, while samples co-infected with both viruses showed two products simultaneously at 345 bp and 235 bp (Figure 2C). Samples infected only with begomovirus showed inconspicuous symptoms, difficult to detect in the field. Co-infection with both begomovirus and potyvirus was also noted to cause leaf mosaic and severe woody fruit disease.

Study on the timing of infection: The timing of virus infection greatly affects yield and fruit quality. Mechanical inoculation experiments of EAPV on 7, 14, 28, 60, and 90-day-old passionfruit plants showed that the earlier the plant is infected, the more it affects yield and fruit quality. Plants infected at the seedling stage up to 30 days after planting did not yield or produce quality fruit, while those infected with the virus at 60-90 days after planting still yielded fruit in the first fruiting cycle.

In our survey, we observed a clear relationship between the geographical distribution of virus species and the timing or severity of symptom expression. In the Central Highlands, where passionfruit is cultivated intensively and vector pressure is high, infections with PaMoV and mixed infections of EAPV-AO and PaMoV were predominant. These plants typically showed severe leaf curling, mosaic patterns, and rough or woody fruit, resulting in substantial yield loss. In contrast, in Son La and Nghe An provinces, single infections of EAPV-IB or CMV were more common, and symptoms were generally milder, such as slight leaf mosaic or deformation of the fruit rind without extensive woodiness. Importantly, early infection (at seedling or early vegetative stages) in all regions was associated with stronger symptom expression and more severe yield reduction, while infections occurring after 60–90 days of planting often resulted in less obvious symptoms and partially marketable fruit. These findings suggest that both the regional ecology and the timing of infection strongly influence symptom severity, providing valuable insights for designing localized disease management strategies.

MANAGEMENT MEASURES FOR VIRAL DISEASES ON PASSIONFRUIT IN VIETNAM

Management measures applied in the experimental model include four solutions:

Use of disease-free seedlings: Tainung No. 1 seedlings were produced in a three-tiered greenhouse system (primary, secondary, and tertiary nurseries), which ensures strict exclusion of viruses at each stage.

Elimination of disease sources: Remove infected plants, especially in orchards affected by viral diseases in the previous season.

Prevention of reinfection by viruses: Planting new crops in isolated areas away from old orchards. Protecting plants by managing intermediaries during flowering periods (spraying pesticides with systemic or residual mechanisms listed in the authorized list of plant protection products in Vietnam, dosages as recommended on the packaging; sterilizing gardening tools (pruners) with bleach solution to prevent virus spread during pruning and leaf removal.

Comprehensive management of other pests and diseases: Through intercropping, fertilization, irrigation, regular inspection for pests and diseases, and timely deployment of flexible biological, chemical, and mechanical measures for prevention. Using highly effective pesticides, especially for spraying to prevent and control pests, diseases, and mites. Strictly managing the timing of fruiting.

Effectiveness

Through measures such as using disease-free seedlings, immediate control of viral vector insects after planting, early removal of plants showing symptoms of viral diseases before they mature, and comprehensive care measures, the model orchards have minimized damage caused by viral diseases. After 6 months, the trees in the trial fields were not infected with any viral diseases, while outside the model, the infection rate ranged from 32.5% to 37.8%. After 9 months, the infection rate decreased to 10-20% in the model orchards compared to over 50% outside the model.

POLICY RECOMMENDATION FOR SUSTAINABLE PASSIONFRUIT PRODUCTION IN VIETNAM

To support the sustainable development of Vietnam's passionfruit industry and to align with phytosanitary and export standards, the following agricultural policy directions are recommended:

- Establish national standards and a certification system for virus-free passionfruit seedlings, ensuring quality control and traceability across the production chain.
- Invest in research and breeding programs to develop virus-resistant passionfruit varieties. Simultaneously, support the creation of integrated, closed-loop production models that incorporate cultivation techniques, plant protection practices, and postharvest processing methods tailored to different agro-ecological zones and market demands.
- Develop and disseminate official Integrated Pest and Disease Management (IPDM) protocols through policy-backed training and extension campaigns. The protocols should emphasize three key aspects: (i) accurate recognition of pest and disease symptoms; (ii) proper orchard sanitation, particularly in old passionfruit plots; and (iii) best practices to minimize disease transmission.
- Promote the adoption of VietGAP and GlobalGAP standards through targeted support and awareness campaigns. Policies should ensure the rational use of pesticides, compliance with export regulations, and encourage transparency in plant protection product use.
- Facilitate the establishment of passionfruit production zones and strengthen linkages within the value chain. Incentivize public–private partnerships for technical support, market access, and investment in sustainable production infrastructure.

These policy recommendations aim to improve the resilience, productivity, and market competitiveness of Vietnam's passionfruit sector while meeting international quality and safety standards.

CONCLUSION

Three potyviruses (EAPV, PaMoV, TelMV), two begomoviruses (EuLCV and PaLCuGdV), and one cucumovirus (CMV) have been identified in passionfruit in Vietnam. Among these, EAPV and PaMoV are the most damaging, while CMV and the begomoviruses generally cause milder symptoms or occur at lower incidence. Effective management requires the use of virus-free seedlings for new plantings, combined with the reduction of inoculum sources through field sanitation, regular monitoring, and early removal of symptomatic plants. Controlling vector populations with pesticides is also critical. Additionally, agronomic practices such as soil and water management and balanced fertilization may improve overall plant health and resilience. While these measures do not directly suppress viral diseases, they can indirectly reduce yield losses by supporting stronger plant growth.

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AUTHOR’S CONTRIBUTION

Nguyen Thi Bich Ngoc is the lead and corresponding author, who conceived and designed the study, coordinated and conducted field surveys and sample collection, supervised laboratory analyses, interpreted the results, and wrote the original draft of the manuscript. Do Duy Hung, Ngô Thị Thanh Huong carried out molecular diagnostics (PCR and RT-PCR), data analysis, and contributed to result interpretation. Nguyen Nam Duong, Vu Duy Minh, Pham Thi Dung participated in field investigations, data collection, and contributed to the development and evaluation of integrated disease management strategies. All authors critically reviewed, revised, and approved the final version of the manuscript.

COMPETING INTEREST

The authors declare that they have no competing interests.