NURSERY PAPERS
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Managing a Plant Virus in Nursery Production

SUMMARY

- Plant viruses are minute pathogens which infect and multiply within the host plant. They are almost always of detriment to the host plant and can potentially cause dramatic economic consequences to production nurseries and the industry.
- Viruses can infect a number of different plant species and can be transmitted and transferred via insects, mites, nematodes, fungi as well as nursery tools, equipment and machinery.
- This Nursery Paper provides an overview of the symptoms, diagnosis, management and prevention of a plant virus, using reference to the common Apple Mosaic Virus.
- With the world focused on the management of the current global pandemic of Coronavirus, it's important to remind industry of the importance of plant health and nursery biosecurity with respect to managing a plant virus.

BACKGROUND

Apple Mosaic Virus (ApMV) from the *Bromoviridae* virus family, is a common plant pathogen worldwide, including Australia, and presents certain challenges in early detection due to many hosts not displaying obvious symptoms. Recorded hosts include a wide range of ornamental species, fruit trees and nut crops. This virus is of economic importance because it can cause reduced plant growth, an increase in vegetative cutting mortality in propagation and a reduction in yield of commercial crops. Nursery stock losses may occur, but prevention of viruses is possible, and every effort must be made not to introduce a virus into a production nursery. ApMV is primarily transmitted from infected host to uninfected host through mechanical means e.g. secateurs', saws, etc., with no known insect vector recorded therefore high health production systems can prevent infection.

Image 1. Mosaic pattern on Apple (*Malus domestica*) leaves. *Source: Utah State University Extension IPM Program.*

Host Plants

Over 65 species from 19 plant families have been recorded as hosts since the pathogen was first documented in Denmark on Apple trees during the 1920's. Refer to examples below:

TABLE 1. WOODY AND HERBACEOUS PERENNIALS AFFECTED BY APMV

Almonds – *Prunus dulcis*	**Hops –** *Humulus lupulus*
Apricots – *Prunus armeniaca*	**Horse Chestnut –** *Aesculus hippocastanum*
Birch – *Betula spp*	**Peach –** *Prunus persica*
Cherries – *Prunus spp*	**Plums –** *Prunus domestica*
Chestnut – *Castanea sativa*	**Quince –** *Cydonia oblonga*
Currants – *Ribes spp*	**Raspberry –** *Rubus idaeus*
European mountain ash – *Sorbus aucupari*	**Rose cultivars –** *Rosa spp*
Hazelnuts – *Corylus avellana*	**Strawberry –** *Fragaria spp*

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Apple Mosaic Virus

Description

Name: Apple Mosaic Virus (ApMV)

Synonyms: Rose Mosaic Virus, Plum Line Pattern Virus and Birch Line Pattern virus.

Group: RNA Viruses

Family: *Bromoviridae*

Genus: *Ilavirus*

Symptoms

In Australia, leaf symptoms of ApMV typically appear in October and November, particularly during a season of mild spring temperatures. The number of leaves affected, and the severity of symptoms varies depending on temperature, the pathogenicity of the strain and sometimes susceptibility of a given plant variety. Initially visible on new leaves of single shoots, the disease can progress then appear on the leaves of all shoots. Yellow mosaic patterns, ringspots, mottling and banding around major veins can appear. Yellow colouring can seem paler on leaves with a darker green or grey/green foliage. Ring spots, when present, are often clearly defined on foliage showing as a yellow ring in contrast to the green colour of the leaf. Refer images 2 and 3 below.

Image 5. *Rosa sp.* Mottling symptoms caused by ApMV. *Source: Lesley Ingram.*

Images 2 and 3. *Corylus avellana* v. 'Mortarella' showing ringspots (red) and vein banding (blue). *Source: Emma De Landre.*

Virus symptoms may also be misleading as two separate viruses can infect the one plant at the same time. ApMV and Prunus Necrotic Ringspot Virus (PNRSV) can be seen in roses at the same time due to both being present. For this reason, both virus species can be referred to as 'Rose Mosaic' however PNRSV and ApMV are separate plant pathogens and behave differently. Refer image 4.

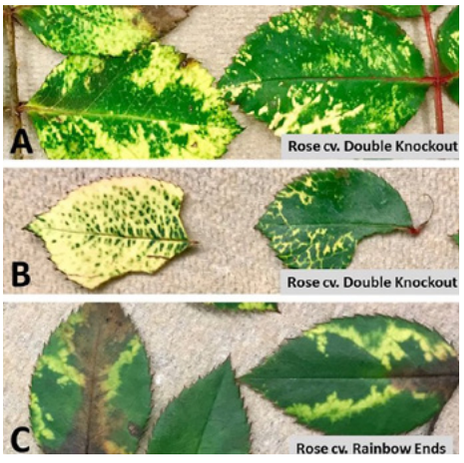

Image 4. ApMV and PNRSV symptoms on Rose Cultivars 'Double Knockout' and 'Rainbow Ends'. **A**. Positive diagnosis ApMV and PNRSV. **B**. Positive diagnosis of ApMV only. **C**. Positive diagnosis ApMV and PNRSV. *Source: Francisco M. Ochoa Corona, Ph.D. Oklahoma Staete University, Institute for Biosecurity & Microbial Forensics.*

It is important to note that plants infected with ApMV are often asymptomatic meaning that they can be infected and not show any symptoms. Some varieties are less susceptible than others. For example: 'Johnathon' and 'Golden Delicious' apple varieties are particularly susceptible and symptomatic showing disease symptoms.

Nutrient imbalances can produce similar symptoms to ApMV, particularly in roses, which can be treated by correcting the deficiency, but not if infected with ApMV. Therefore testing is vital if virus symptoms are present for an accurate diagnosis.

Conditions

ApMV prefers climates where there is a clear distinction between spring and summer temperatures. Case studies in Australia have shown an increase in symptoms on host plants after

Images 6 and 7. Left Rosa 'Tangles' shows Iron deficiency. Right Rosa 'Crepuscle' shows Manganese deficiency. *Source: Emma De Landre.*

heavy rain events and lower than average spring temperatures. This was particularly evident following significant rain in New South Wales in September 2016.

Dry heat impacts multiplication and survival of ApMV. This could explain why symptoms are usually observed in spring. In some crops, hotter spring and summer conditions result in fewer symptoms of ApMV, however overnight temperatures still drop, so plants remain infected even if asymptomatic.

Identification

Common symptoms:

- Bright yellow mosaic patterns, ring spots and banding around major veins.
- Leaf drop, common in roses infected with Ilaviruses.
- Reduction of blossoming in *Prunus* species. For example – Almonds.
- Reduced fruit yield in pome fruit trees. For example – Apples (*Malus sp.*)
- Reduced nut yield and size of nuts. For example – Hazelnut (*Corylus avellana*).
- Increase in empty nut shells. For example – Hazelnut (*Corylus avellana*).
- Increase in softwood cutting mortality. For example – Hops (*Humulus lupulus*).
- Reduced plant growth or vigour in susceptible varieties.

Note: Infected plants may be asymptomatic and not show symptoms.

Tips for Visual Diagnosis of ApMV

- Monitor foliage for disease symptoms in spring and summer as leaves expand.
- Inspect leaves with a hand lens to rule out insect damage as the cause e.g. mites.
- Consider the likelihood of nutritional disorders such as iron deficiency.
- Check herbicide application records and confirm if timing coincides with symptoms.
- Note patterns of symptoms within the crop, if predominately on older growth there may be another cause such as manganese deficiency.
- Observe weather conditions, infections often occur when temperatures are mild.
- Continue monitoring grafted plants, scions can remain asymptomatic for up to two years.
- Compare symptoms to photos of infections on the same host plant species.
- Take photos as a visual record and record date and location.
- Organise testing for accurate identification if ApMV is suspected.

Testing

Testing for plant viruses is available at specialist diagnostic laboratories. Check with plant pathologists in your state to confirm availability of testing. Refer to laboratory instructions for preparation of samples. It is recommended to send photos showing plant symptoms first to rule out other causes. Virologists use visual inspection, biological and molecular testing to diagnose ApMV. Further information can be accessed following these links:

DIAGNOSTIC SERVICES FOR PLANT DISEASES	
NSW	https://www.dpi.nsw.gov.au/about-us/services/laboratory-services/plant-health
QLD	https://yourlevyatwork.com.au/poor-plant-growth-get-grow-help/
VIC	http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/diagnostic-services#crop-health-services
WA	https://www.agric.wa.gov.au/taking-samples-plant-disease-diagnostics
TAS	https://dpipwe.tas.gov.au/biosecurity-tasmania/plant-biosecurity/plant-diagnostic-services/plant-pathology-laboratory

Prevention

If possible all planting material coming into a production nursery should be from an accredited, reputable and reliable source of 'clean' stock supplier. Production nurseries should establish a 'quarantine' area to isolate and inspect incoming stock for weeds, pests and diseases. Staff should be trained on correct monitoring procedures and follow the correct process if a pest and/or disease is identified.

When plant material is accepted into a production nursery for propagation, grafting or on growing, good nursery hygiene should be practised at all times through the sterilising of tools, equipment, recycled pots and surfaces before use. This will reduce stock losses caused by plant pathogens and improve overall plant health within the production environment. Accurate propagation records, regular plant monitoring and integrated pest management (IPM) techniques should be used to analyse patterns and traceability of virus infections. Further details on monitoring and other IPM strategies can be found at: ***http://nurseryproductionfms.com.au***

Commercial fruit and nut growers should purchase virus indexed plant material and use disease resistant varieties for propagation wherever possible. Generally new varieties are trialled for disease resistance and virus tested budwood is produced for some crops in Australia. For example, establishment of high health, ApMV tested almond mother plantings provides budwood material that production nurseries can then use for grafting. Production nurseries growing ApMV susceptible crops should consider planting certified or virus tested mother plants to reduce stock losses and increase profitability.

Mother stock should be grown at adequate spacings to reduce root grafting occurring naturally in the field. Root grafting has been shown to cause virus transmission in hazelnut crops. In fact, plants used as mother stock for propagation, particularly new varieties introduced to the production nursery, should be grown in a separate area if possible.

For example – a nursery propagating apples may set up two separate areas one for 'Johnathon' budwood and one for 'Pink Lady'. In this instance, if infection was detected in one variety it would not impact the other.

Control

For all plant virus infections, prevention is best, as there is no cure. If ApMV infection is confirmed during the quarantine or growing process, all infected plants should be removed and destroyed. Propagation records and plant movement tracing can be used to identify individual plants or batches that may be infected or asymptomatic. If asymptomatic infection is suspected, ensure potential hosts are quarantined, marked appropriately and are not considered for propagation.

Purchasers of nursery stock may reject plants infected with ApMV based on aesthetics whilst being unaware of the cause. Therefore, responsibility for managing ApMV lies with propagators and growers. The good news is that infections can be easily reduced by following recommended management, testing, mother stock, prevention and control measures to maintain aesthetic appeal of stock, reputation and overall profitability of the business.

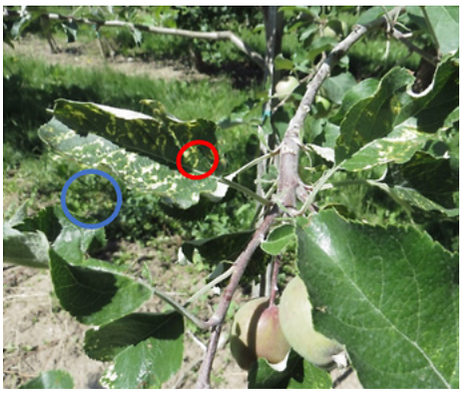

Image 8. *Source: Utah State University Extension IPM Program.*

For valuable plant material or budwood, thermotherapy (heat therapy) may be used in laboratory or controlled growing environments to kill ApMV, however it is not practical in normal growing conditions as prolonged exposure to heat has a negative impact on plant growth.

Impact

Although not all infected plants show significant disease symptoms, significant losses in crop productivity have been recorded. For example: apple orchard trials have recorded reductions in yield of infected stock ranging from 0 to 50%, infected hazelnut trees have been recorded to produce 33% less nuts and ApMV in susceptible almond cultivars can cause blossoming and leaf bud opening failure which may reduce crop yield by up to 25%.

Similarly, the economic impact is a concern in the hops industry, as infection with ApMV results in a reduction of bittering acids in end products. Hops with a low alpha acid content are less efficient in production of bitter beer.

ADDITIONAL INFORMATION

Further information on disease identification and Integrated Pest Management can be found by using the following links:

Hints for Diagnosing Diseases: ***https://pestid.com.au/disease***

Virus Identification and Management Video: ***https://youtu.be/2Mq0q0Inoig***

Integrated Pest Management Information: ***http://nurseryproductionfms.com.au/***

Pest ID is a tool developed for industry to assist in identifying and managing pests, diseases and weeds. This resource is free and can be accessed at: ***https://pestid.com.au***

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