Virus diseases of cucurbits in Australia

VG 16086 Area-wide management of vegetable diseases, viruses and bacteria

FACT SHEET

Introduction

Cucurbits is a collective name for about 800 species of plants belonging to the botanical family Cucurbitaceae.

Four cultivated cucurbit groups dominate commercial production worldwide: cucumber, melon, watermelon and squash/pumpkin (Table 1). Around twenty other cucurbits are important crops in at least some countries (Table 2). Several species are also widely used as rootstocks to provide disease resistance in cucumber and watermelon production, for example *Cucurbita moschata* and *Lagenaria siceraria.*

Cucurbits are susceptible to over 50 viruses, a significant number of which cause considerable economic losses in one or more countries.

Australia is fortunate in being free of many of the viruses that have a considerable economic impact elsewhere. However, several viruses occurring in Australia do cause production losses of several million dollars each year and require careful management to minimise losses.

In this booklet the symptoms, spread and control measures for viruses affecting cucurbits are outlined. The symptoms of many virus diseases are similar and more than one virus may be present in a plant or crop. Virus disease symptoms can also be similar to those caused by nutritional disorders, herbicide damage, insect feeding and environmental influences.

It is important to seek good advice and have samples tested for viruses and other possible causes before undertaking control measures.

TABLE 1 Major cucurbit crops

Botanical species	Major crop type	Other names / related types
Cucumis sativus	Cucumber	Gherkin
Cucumis melo	Rockmelon; Honeydew	Melon, cantaloupe, muskmelon, sweet melon
Citrullus lanatus	Watermelon	
Cucurbita maxima	Pumpkin	Marrow, winter squash, buttercup squash
Cucurbita moschata	Butternut pumpkin	Crookneck squash
Cucurbita pepo	Zucchini, Squash	Zucchini, marrow, summer squash, acorn squash

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TABLE 2 Additional cultivated cucurbits

Botanical Name	Common names
Benincasa hispida	Ash gourd, wax gourd, Chinese watermelon
Cucumis anguria	Gherkin, bur cucumber
Cucumis metuliferus	African horned cucumber, kiwano
Cucurbita ficifolia	Fig leaf gourd, Malabar gourd
Cucurbita foetidissima	Buffalo gourd
Lagenaria siceraria	Bottle gourd
Luffa acutangula	Angular luffa
Luffa cylindrica	Sponge gourd
Momordica charantia	Bitter gourd
Sechium edule	Chayote, choko, vegetable pear
Trichosanthes cucumerina	Snake gourd

Viruses spread by aphids

Mosaic

The three viruses causing mosaic disease in cucurbit crops in Australia are *Papaya ringspot virus* type W (PRSV-W), *Watermelon mosaic virus* (WMV) and *Zucchini yellow mosaic virus* (ZYMV). All belong to the potyvirus group of plant viruses and all three viruses are spread by aphids.

Papaya ringspot virus occurs as two strains, designated PRSV-P and PRSV-W. The former infects papaya and occasionally cucurbits while PRSV-W (watermelon) does not infect papaya but causes severe symptoms in a wide range of cucurbit species. The two strains are closely related in many biological and molecular properties.

The symptoms caused by each of the three viruses are similar and often difficult to separate visually. A crop or plant may be infected by more than one species of potyvirus. The management methods for all three viruses are very similar.

Symptoms

Watermelon mosaic virus causes mosaic symptoms on leaves but rarely fruit distortion. Light to dark green mottling and slight roughening of the skin can occur on fruit from affected plants.

Papaya ringspot virus (PRSV-W) causes a prominent light green and dark green mosaic pattern on leaves, which become distorted and blistered. Terminals of recently affected watermelon plants stand more erect, with the mosaic pattern developing later. The yield of severely affected zucchini plants reduces drastically and fruit produced is small and severely distorted. Leaves become claw-like with a severe blister mosaic pattern. Pumpkin fruit are often lumpy and distorted while watermelon fruit can develop ringspot patterns on the skin.

Zucchini yellow mosaic virus produces a severe, yellow mosaic, usually with associated leaf distortion and blistering. The first few leaves affected on rockmelons may progress from chlorosis

to full necrosis. Plants are frequently stunted and have poor fruit set. Zucchini plants regularly fails to set fruit, with those that do being small and distorted. Squash fruit are reduced in size and may develop conspicuous yellow blotches and rings. Pumpkin fruit often develop lumps, with a yellow mottled pattern throughout.

Symptoms of papaya ringspot virus on a susceptible zucchini variety

Deformed zucchini fruit caused by papaya ringspot virus infection

Papaya ringspot symptoms on a squash plant

Dark and light mosaic pattern on leaves infected with watermelon mosaic virus

Distorted and chlorotic leaf symptoms caused by Watermelon mosaic virus

Zucchini yellow mosaic virus symptoms on a pumpkin leaf

Disease cycle and spread

PRSV has very few hosts outside of the cucurbit family. By contrast, WMV has a wide host range, including crop and weed species across several plant families. These hosts include carrot, spinach, beans, clovers and weed species in several families including *Apiaceae*, *Asteraceae* and *Fabaceae*.

The role played by these hosts as sources of virus for cucurbit crops is not clear, although they most likely assist survival of the virus between seasons, particularly in temperate areas where old cucurbit crops may not survive.

ZYMV has a relatively narrow range of natural hosts, with most being members of *Cucurbitaceae*.

The major virus reservoirs for all three viruses are old, virus-infected cucurbit crops, cucurbits in the home garden, and weedy cucurbits species such as wild gherkin (*Cucumis anguria*) and paddy melon (*Cucumis myriocarpus*).

The three viruses are spread by many species of aphids moving through and within crops.

Common and efficient vector species include the melon aphid (*Aphis gossypii*), green peach aphid (*Myzus persicae*) and cowpea aphid (*Aphis craccivora*).

The aphids take up the virus on their stylet after feeding on an infected plant for only a few seconds and can spread the virus to another plant in the same extremely short feeding time. Aphids remain

capable of spreading the virus for several hours after feeding on an infected plant. Once an aphid has fed on another plant it loses the virus from the stylet and needs to feed again on an infected plant to recharge with virus.

Both resident and migrating aphids can spread virus, with the latter often playing a major role as they move through a crop briefly tasting as they search for suitable host plants.

The three viruses can also be spread mechanically during farming operations through sap contamination of equipment such as irrigators, and particularly, cutting knives used to harvest crops such as zucchini.

Seed transmission can be an important pathway for virus spread between countries and regions. Low levels of seed transmission of ZYMV occur in zucchini and squash. Although infected seeds often lack vigour and germinate poorly, seed transmission has likely provided a pathway for the worldwide dispersal of ZYMV. Transmission of WMV through buttercup squash seed has been found in New Zealand. PRSV is not known to be transmitted through seed.

Importance

The three viruses occur worldwide and are among the most important causes of economic loss due to virus infection.

In Australia, PRSV dominates in field grown cucurbits in Queensland while ZYMV is the most important and widespread virus infecting cucurbits in Western Australia. At least two strains of ZYMV occur in Western Australia with the strain in Kununurra being more severe than those in southern Western Australia and Queensland.

WMV occurs in all production areas and often as dual infections with either ZYMV or PRSV.

Management

As the greatest yield losses will occur in plants infected early in life, management should aim to delay infection and minimise the level of virus disease in a crop.

No single measure is likely to be effective alone and best results will be achieved from integrating options appropriate to the crop and farming system.

These options include:

- destroy harvested or abandoned cucurbit crops and crop debris as these are usually the major source of virus at the beginning and during the production period. Co ordinating this across neighbouring farms or in a production district will have much greater impact
- destroy weeds and volunteer cucurbits within and around crops as these harbour the viruses and/or aphids.
- separate new crops from maturing ones as the latter are likely to have high levels of virus infection. Separating crops by as little as 50 to 100 m can be beneficial, particularly if there is fallow soil or an unrelated non-host species planted between.
- plant new crops upwind of existing cucurbit blocks
- consider tall barrier crops to separate blocks e.g cereals. These are sown well before the

cucurbits and provide a barrier to impede aphid vector movement into the young crops

- crops, particularly high value ones, can be protected from insect transmitted virus by floating row covers which provide protection until flowering when they generally need to be removed to allow pollination
- planting into highly reflective plastic mulch which repel aphids and spraying refined mineral oils (stylet oil) can delay virus infection. Reflective mulch is most effective early before plants cover the rows. Mineral oil needs to be applied frequently (at least weekly) to protect the rapidly emerging new growth. Neither strategy is likely to be very effective if there is high virus pressure early in the crop cycle.
- Plant virus resistant or tolerant varieties if available. Zucchini varieties with high tolerance to all three viruses are now available. Several resistant pumpkin varieties are available while some varieties of Japanese pumpkin tolerate virus, producing few deformed fruit.
- Sanitise cutting knives in sodium hypochlorite or Virkon solution
- Select and use insecticides with caution. Insecticides generally have no useful effect on the spread of potyviruses by aphids. Instead, they can have a negative effect if they disrupt natural enemies and make the plants less pleasant for the aphids to feed on which increases their movement through the crop. If the aphids are active and taste plants rather than settling and feeding, they will spread virus as they move, resulting in more disease in the crop..

Cucumber mosaic virus (CMV) *Cucumovirus*

Cucumber mosaic virus symptoms
Courtesy W M Wintermantel

Symptoms

Symptom type and severity can be affected by plant age, variety and weather conditions.

Symptoms first appear on young leaves which develop mottling and curl downwards. Leaves may become distorted and reduced in size. As the disease progresses plants become stunted with shortened internodes.

Fruit become mottled and may be distorted.

Disease cycle and spread

CMV has one of the largest natural host ranges of any plant virus, infecting many crop, ornamental and weed species across diverse plant families.

The virus is spread from plant to plant by many species of aphids with only very short feeding times needed for spread.

The virus is not considered to be spread by plant to plant contact in the field. Although CMV is seed transmitted in several crop and weed hosts, there is no good evidence of seed transmission in cucurbit seed.

Importance

CMV is common in cucurbits worldwide, particularly in temperate regions.

Although found in cucurbits in Australia, the virus is seldom a problem.

Management

The management methods suggested for cucurbit-infecting potyviruses can also be applied to CMV.

Several cucumber and zucchini varieties are resistant or tolerant to CMV.

Viruses spread by whitefly

Cucumber yellows-Beet pseudoyellows virus (BPYV) (Crinivirus)

Symptoms

Symptoms first appear on older leaves as yellow spots followed by the development of yellow blotchy raised areas between the veins which generally remain green. The raised areas combine to form large, brittle thickened areas. Leaf margins on older leaves curl downwards. Symptoms develop progressively on the younger leaves and plants may remain stunted.

A greenhouse cucumber crop severely affected by Beet pseudo yellows virus

Specific symptoms do not develop on fruit, although fruit set and quality may be reduced

The symptoms of cucurbit yellows can be very similar to those resulting from nutrient deficiencies, poor growing conditions, and premature aging of plants.

Symptom development is favoured by high light intensity.

Symptoms of Beet pseudo yellows virus on a mature cucumber leaf

Disease cycle and spread

The virus is transmitted efficiently by the greenhouse whitefly (*Trialeurodes vaporariorum*) but not by other whitefly species. The virus can be acquired by whitefly from infected plants in feeding periods of a few hours, but transmission efficiency increases if whitefly feed for one to two days on infected source plants. Whitefly retain the virus for up to six days, during which time they can transmit the virus to other plants.

BPYV has a relatively wide host range including melon, squash, pumpkin, lettuce, beet, endive and spinach. Several weed species, including marshmallow (*Malva parviflora*) and dandelion (*Taraxacum officinale*) host the virus and whitefly vector.

BPYV is not seed-borne and is not spread by contact.

Importance

BPYV is largely a problem in greenhouse grown cucurbit crops, particularly cucumber.

The virus is common in greenhouse cucumber crops in southern Australia and disease levels often exceed 50% of infected plants as crops mature.

Management

The aim of management is to reduce whitefly numbers and sources of virus.

- Remove and destroy virus and whitefly- infested crops before planting new crops
- Design greenhouses to reduce whitefly entry through access doors and other locations. Consider UV absorbing cladding and screens to manage whitefly populations
- Use insecticide-based or biological control agents to manage whitefly populations, particularly when crops are young
- Organise plantings so that new crops are not adjacent to old crops which may have high virus and whitefly levels

Viruses spread by seed and contact

Squash mosaic virus (SqMV) *(Comovirus)*

Symptoms

Symptoms are variable and are affected by cucurbit species and variety. Symptoms can include mosaic, mottling, vein banding and sometimes enations, or outgrowths, on leaves.

Symptoms of squash mosaic virus

Seedlings grown from infected seed develop green vein banding on the first or second leaf. Subsequent leaves tend to cup upwards, and produce a mottled pattern of light and dark green. Characteristic symptoms on squash plants are curved leaves, and regular projections from the veins on the leaf margins resulting from unequal growth of leaf tissue. New foliage may be symptomless or may develop yellow spots, vein clearing or leaf distortion. Infected plants are stunted with fewer branches and fruit. Mild mottling to severe deformation may occur on fruit.

Disease cycle and spread

The virus is introduced into regions or crops in infected seed. Seed transmission is most likely in squash and melon with seed infection levels of <1% to 10% been found. The virus is carried within the seed; not on the seed coat. Once introduced into a crop secondary spread can occur via leaf chewing beetles, for example the 28-spotted ladybird. Insects can acquire the virus from

infected plants in feeding periods of around five minutes and the virus is retained by insects for approximately 20 days but does not multiply in the insect.

The virus is most likely able to spread mechanically by workers and contaminated equipment

The host range of SqMV is largely confined to cucurbits.

Importance

Squash mosaic is now a generally a minor disease in most countries as extensive use of virus-free seed has greatly reduced the incidence and impact. Occasional serious outbreaks may occur from harvesting and sowing infected seed.

Management

The virus is usually well controlled by eliminating seed lots containing the virus and producing seed in areas where the virus is not prevalent.

Controlling the beetle carriers (vectors) is also effective in restricting spread within a crop.

Cucumber green mottle mosaic virus (CGMMV) *(Tobamovirus)*

The tobamovirus CGMMV was first found in Australia during 2014 on watermelon crops in the Northern Territory. It is now established in Australia with sporadic outbreaks in several States, particularly in greenhouse-grown cucumber crops.

The virus is carried in seed of some cucurbit species and is an extremely stable pathogen allowing spread by contact and survival for up to several years in crop debris, soil and on inert structures. Once introduced into an area, eradication and management is very difficult.

Leaf mottling caused by Cucumber green mottle mosaic virus

Mottling on cucumber fruit caused by CGMMV

Green wilt of greenhouse grown cucumber plants caused by CGMMV

Watermelon fruit with pale, spongy flesh resulting from CGMMV

Symptoms

Cucumber, watermelon and pumpkin are the

crops most likely to be affected.

Symptoms within and between each species are variable. It is also possible that another virus, for example, a potyvirus may be present causing a very wide range of varying and often confusing symptoms.

Affected plants may show leaf mottling and mosaic. Leaves may be yellow or chlorotic and appear distorted or blistered.

Infected cucumber plants can wilt without lower leaf death and have mild mottling on young leaves.

Affected watermelon fruit may be spotted or streaked. However, external symptoms are often absent but when the fruit is cut the flesh is spongy with a meat –like texture and is totally unmarketable.

Disease cycle and spread

CGMMV can infect all cultivated cucurbits with cucumber, watermelon, pumpkin, zucchini and several gourds being the most common hosts.

The virus is carried in cucurbit seed, generally at a low rate (<1%) and in a relatively small number of seed lots. However, seed transmission has proven to be an effective pathway to disperse the virus to most countries, particularly over the last eight years.

Once introduced into a crop, virus is spread extremely easily by contact. The virus reaches very high concentrations in the fine leaf hairs and gentle brushing and contact is all that is required for spread. Hence, the virus spreads efficiently during cultural and harvesting operations, particularly in protected cropping situations. The virus can also spread through water and in nutrient solutions in soil-less culture and via infected root stock plants and grafts.

CGMMV, like all tobamoviruses, is very stable and concentrated which allows survival in a variety of situations outside of the plant.

The virus can survive in crop debris, on equipment, greenhouse structures and packaging equipment for up to two years.

Honey bees can also spread the virus from infected to healthy flowering cucurbit crops while foraging.

In Australia, CGMMV has been found in several weedy cucurbit species, e.g. *Citrullus lanatus*, and in several non-cucurbit species, e.g. Amaranth (*Amaranthus virdis*) and Black nightshade (*Solanum nigrum*).

Their importance in the disease cycle has not been fully determined.

Management

Management aims to exclude the virus from crops and minimise spread if an incursion occurs.

The virus is highly contagious and is spread very easily by contact

» Ensure seeds for sowing are from a reliable source and have certification confirming testing under the Australian seed testing protocol. Keep a record of variety, batch number and supplier

- If suspicious symptoms are seen isolate the area and have a sample tested urgently
- Early detection provides the best opportunity to limit spread
- Practice good sanitation and hygiene as a routine including restricting entry to production areas and cleaning equipment before moving sites
- Design greenhouse structures so that areas can be separated and movement controls can be implemented
- Use appropriate disinfectants e.g. sodium hypochlorite, Virkon to clean footwear, tools, implements.
- Use footbaths at greenhouse entrances and maintain these with recommended concentrations of disinfectant
- If infected plants are confirmed, restrict access to the area and destroy plants where found,or safely remove in plastic bags for disposal, minimising movement through the greenhouse
- Do not replant affected areas with cucurbits for two years. Plant unrelated crop or cover crop species
- Several cucumber varieties with tolerance or partial resistance to the virus are available.

Dark necrotic leaf spotting symptoms caused by Melon necrotic spot virus. Courtesy L. Tesoriero

Melon necrotic spot virus (MNSV) *(Carmovirus)*

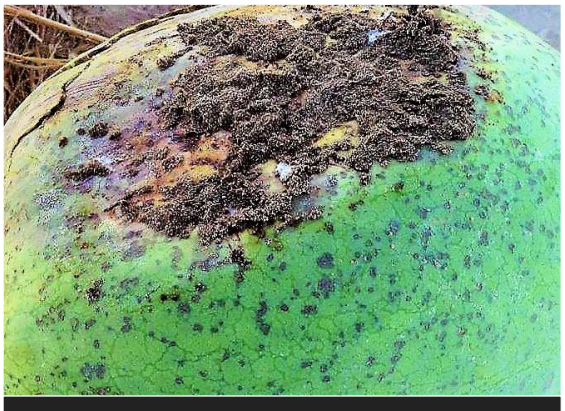
The carmovirus melon necrotic spot occurs in many countries, including Australia. Outbreaks are sporadic and usually involve seed transmitted virus and very susceptible varieties.

Symptoms

The virus affects melon, watermelon and cucumber plants. The symptoms can appear similar to those associated with fungal and bacterial diseases.

On rock melon, leaves may curl, wilt and develop brown and light –coloured spots. Brown spots can also develop on the fruit stalk and on the outside of fruit. The flesh can become dark, hollow and rotten.

In watermelons, small, transparent, yellow spots appear on the youngest leaves. These spots turn brown and enlarge as the plant matures with affected leaves curling and wilting.



Fruit spotting symptoms due to Melon necrotic spot virus. Courtesy L. Tesoriero

Infected watermelon fruit often develops yellow or brown spots on the skin.

The flesh and rind become discoloured, hollow or watery and the fruit may decay.

Disease cycle and spread

MNSV can be transmitted in melon seed and the virus occurs both on the seed coat and within the seed. Varieties differ in susceptibility to MNSV and most likely in the potential rates of seed transmission.

The virus is spread from plant to plant by cucurbit infecting strains of the fungus *Olpidium bornavanus* which survive in the soil as resting spores. Swimming spores (zoospores) of the fungus move in soil moisture and infect the roots of susceptible cucurbits. The virus survives in crop debris from where the Olpidium fungus obtains virus for further spread.

MNSV can also spread via irrigation water, contaminated soil and mechanical damage through contact and grafting.

The host plants of MNSV are largely confined to the cucurbit family.

Importance

MNSV occurs in most countries where cucurbits are grown.

In Australia, sporadic outbreaks of the virus have occurred in melon crops in southern New South Wales and Victoria.

MNSV occurs as several strains, more than one of which is present in Australia.

Management

- Purchase seed from reliable sources and avoid known MNSV susceptible varieties where the virus has been a problem previously
- Rotate crops out of cucurbits for three years if MNSV has occurred
- Clean and disinfect machinery and tools before moving from an affected area to new land.

TABLE 3 Virus diseases of cucurbits in Australia

Virus	Virus group	Spread by:	Is it carried in/on seed?	Cucurbit types most affected	Comments
Papaya ringspot	Potyvirus	Aphids	NR#	All crops	Most common in Queensland
Zucchini yellow mosaic	Potyvirus	Aphids	Y*	All crops	Most common in Western Australia
Watermelon mosaic	Potyvirus	Aphids	Y	All crops	Common
Cucumber green mottle mosaic	Tobamovirus	Contact	Y	Cucumber, watermelon	More likely in greenhouse crops
Beet pseudo yellows	Crinivirus	Greenhouse whitefly	NR#	Cucumber	Most likely in greenhouse crops

Squash mosaic	Comovirus	Several leaf eating beetles	Y	Melon, squash	Uncommon
Melon necrotic spot	Carmovirus	Olpidium fungus	Y	Melons	Uncommon in cucurbits in Australia
Cucumber mosaic	Cucumovirus	Aphids	N (in cucurbits)	All crops	Uncommon in cucurbits in Australia

N = no reports, Y = yes, N = no

Virus diseases not present in Australia

Despite the significant economic losses in cucurbits from virus diseases in Australia, the country is free of many viruses that have a major impact on cucurbit crops in many other countries (Table 4).

Although the risk of entry of many may not be high, it is still possible, given the large international movement of seed, produce and people.

The vectors of members of most virus groups are present in Australia, for example the silver leaf whitefly *Bemisia tabaci* and several thrips species. If a virus transmitted by one of these vector insect species enters Australia then the risk of rapid spread is high, particularly if the incursion is into or near a vegetable production area.

As can be seen from the images in this booklet, the symptoms of many virus diseases in cucurbits are similar and difficult to accurately identify on symptoms alone. It is also not unusual for a plant or crop to be infected by more than one virus.

The best advice is to have samples checked by a diagnostic laboratory. This is an essential first step in deciding on future actions.

Leaf symptoms caused by the whitefly transmitted Cucurbit yellow stunting disorder virus.
Courtesy W. M. Wintermantel

Squash leaf with vein yellowing caused by Squash vein yellowing.
Courtesy S. Adkins

Symptoms of the whitefly transmitted Cucurbit leaf crumple virus.
Courtesy S. Adkins

Symptoms of the tospovirus melon yellow spot on melon fruit (right).
Courtesy Tsung-Chi Chen

Table 4 Examples of virus diseases of cucurbits not present in Australia

Virus	Virus group	Main crops affected	Spread	Is vector present in Australia?	Carried in seed?	Distribution
Squash leaf curl	Begomovirus	Pumpkin, squash	Whitefly *Bemisia tabaci*	Y	N	USA, Middle East, Mexico, Egypt
Tomato leaf curl New Delhi	Begomovirus	Most cucurbits	*Bemisia tabaci*	Y	N	Asia, Spain, Pakistan
Cucurbit yellow stunting disorder	Crinivirus	Most cucurbits	*Bemisia tabaci*	Y	N	Widely distributed including Middle East, Mediterranean, North America, Central America
Kyuri green mottle mosaic	Tobamovirus	Most cucurbits	Contact	-	Y	Japan, Korea
Watermelon silver mottle	Tospovirus	Melon, watermelon	Thrips	Y	N	India, SE Asia
Watermelon yellow spot	Tospovirus	Melon, watermelon	Thrips	Y	N	Asia
Squash vein yellowing	Ipomovirus	Squash, watermelon	*Whitefly Bemisia tabaci*	Y	N	North America

Further information

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Acknowledgements: The assistance of Tony Cooke and John Fletcher is gratefully acknowledged

This project has been funded by Hort Innovation using vegetable industry levies and contributions from the Australian Government with co-investment from the Queensland Department of Agriculture and Fisheries; Victorian Department of Economic Development, Jobs, Transport and Resources; The Northern Territory Department of Primary Industry and Resources; the Western Australia Department of Primary Industries and Regional Development and the University of Tasmania.