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Key Viruses of Pulses in Australia: General Detection and Management Methods

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Pulse crops, including chickpeas, lentils, faba beans, field peas etc., are vital to Australia's agricultural economy, supporting domestic consumption, exports, and sustainable farming through nitrogen fixation. However, viral diseases pose a significant threat, causing substantial yield losses and compromising crop quality. This concise review synthesizes current knowledge on major viruses affecting Australian pulse crops, such as alfalfa mosaic virus (AMV), bean yellow mosaic virus (BYMV), cucumber mosaic virus (CMV), pea seed-borne mosaic virus (PSbMV), turnip mosaic virus (TuMV) and other common viruses. It highlights their transmission modes (e.g., aphids, seeds, mechanical), characteristic symptoms (e.g., chlorosis, stunting, leaf deformation), and economic impacts. The review also outlines common detection methods, including serological (ELISA, LFIA)

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and molecular techniques (RT-PCR, LAMP, HTS), and integrated disease management strategies, such as virus-free seeds, vector control, crop rotation, and resistant cultivars. By consolidating these aspects, this review provides a small look into the viruses of pulse crops in Australia.

Keywords: Pulses; viruses; alfalfa mosaic; bean yellow mosaic; cucumber mosaic; detection; management.

1. INTRODUCTION

The significance of plant viruses has been recognized for centuries, with one of the earliest well-documented instances being tulip mania in the Netherlands. During this period, the tulip mosaic virus caused the striking streaks in tulip petals that captivated society, contributing to an economic bubble that eventually burst (Öztürk, 2022). Although the role of viruses in this phenomenon was unknown at the time, later scientific advancements revealed these streaks were the result of infectious particles, or viruses, which are now known for their invisible yet damaging effects on plants.

As molecular detection techniques evolved, scientists could identify the causal agents of many plant diseases as viruses which can be morphologically described as infectious nucleic acids encased in protective protein coats. Unlike bacterial or fungal pathogens, viruses are mesobiotic and require a living host to survive and replicate. This dependency on a host makes the viral infections particularly challenging as they utilize the host biosynthetic machinery (Jiang & Zhou, 2023). Once a plant is infected, there are limited strategies for its management, and complete eradication of plant viruses remains an unachievable goal despite the implementation of quarantine and biosecurity measures. The modes of transmission for plant viruses are varied, encompassing mechanical means, vectors such as insects, infected seeds/pollen, wild reservoir plants, etc. These diverse pathways complicate control efforts, making viruses formidable pathogens. In addition to bacterial and fungal threats, viruses are a major cause of plant diseases that can drastically reduce agricultural productivity, with serious economic implications for global food security.

2. AUSTRALIAN SCENARIO

In Australia, viral diseases have increasingly impacted key crops, including pulses. Pulses are crucial to Australian agriculture and are a major component of the country's exports. Australia is the world's largest exporter of chickpeas (US$357 million) and broad beans (US$249 million), the second-largest exporter of lentils (US$752 million), and ranks among the top exporters of mung beans and peas (DAFF, 2023). Australia produces an average of over 3 million metric tonnes of pulses from more than 2 million hectares. South Australia, Western Australia, and Victoria are the largest pulse-producing states on average (AEGIC, 2024). The main pulse crops include *Cicer arietinum* (chickpea), *Pisum sativum* (field pea), *Vicia fab*a (faba bean), *Cajanus cajan* (pigeon pea), *Lens culinaris* (lentil), *Lupinus spp*. (lupin), *Vigna radiata* (mungbean/ green gram), *Phaseolus vulgaris* (common bean), *Vigna unguiculata* (cowpea), *Glycine max* (soybean), *Arachis hypogaea* (peanut).

Across Australia's various climatic regions, pulses are cultivated under different conditions. In tropical northern Australia, crops such as chickpea, pigeon pea, mungbean/ green gram, soybean (*Glycine max)*, peanut (*Arachis hypogaea)*, cowpea, lentils (*Lens culinaris)*, and common bean (*Phaseolus vulgaris*) are widely grown. In the subtropical northern grain belt, farmers primarily cultivate mungbean, soybean, peanut, lupin, field pea, chickpea, and lentil, meanwhile, in the Mediterranean and temperate climates of the southern grain belt, lupin, chickpea, faba bean, lentil, and field pea dominate (AEGIC, 2024; Jones *et al*., 2021). The major viruses infecting these pulse crops include afalfa mosaic virus (AMV), bean yellow mosaic virus (BYMV), cucumber mosaic virus (CMV), turnip yellows virus (TuYV), pea seed-borne mosaic virus (PSbMV), turnip mosaic virus (TuMV) etc. Additionally, some minor but important viruses affecting pulse crops include Broad bean stain virus, Broad bean wilt virus, Cowpea mild mottle virus, and Peanut mottle virus etc.

As Australia continues to be a major player in global pulse production, addressing viral diseases and their management is critical to sustaining agricultural productivity. Enhanced biosecurity measures, early detection systems, and innovative control strategies will be vital in mitigating the impact of these viruses on Australia's pulse crops (Maina & Jones, 2023).

Table 1. Common viruses with their nucleic acid structure, hosts, transmission, and symptoms

Sl no	Viruses with their genus	Nucleic acid	Pulse hosts	Transmission	Characteristic symptoms	References
1	Bean yellow mosaic virus (BYMV)- *Potyvirus*	positive-sense single-stranded RNA (+ssRNA)	Common bean, pigeon pea, peanut, chickpea, soybean, broad bean, lentils, lupins	Seed, aphids (*Aphis fabae* (black bean aphid), *Myzus persicae* (green peach aphid (GPA))*,* *Aphis craccivora (*black cowpea aphid*),* *Acyrthosiphon pisum* (pea aphid), pollen, mechanical means	Leaf mosaic, chlorosis, deformation and etiolation, local or systemic necrosis	Jones, (2025); Mishra *et al.*, (2025)
2	Alfalfa mosaic virus (AMV)- *Potyvirus*	+ssRNA	chickpeas, lentils, faba beans, lupins	Seed, GPA, mechanical means, pollen, dodder (*Cuscuta sp*.)	chlorotic mottling, interveinal chlorosis, and mosaic patterns, later stages- leaf deformation, curling, and brittleness	Ng & Falk, (2006); Pallas *et al.,* (2020); Wang *et al*., (2022)
3	Pea seed-borne mosaic virus (PSbMV) - *Potyvirus*	+ssRNA	Field pea, lentil	Seed, aphids	mild to severe leaf mottling, chlorosis, stunted growth, leaf tip necrosis, and downward leaf curling, reduced pod set and malformed seeds	Beck-Okins *et al*., (2022); Meena & Biswas, (2024)
4	Cucumber mosaic virus (CMV)- *Potyvirus*	+ssRNA	Lupins, chickpeas, lentils, faba beans	Seed, GPA, *black bean aphid, pea aphid,* weed host like alfalfa, *Sonchus oleraceus* (sow thistle),	systemic chlorosis, reddening of the foliage, stunting of the entire plant	Hamim *et al.,* (2024); Jones *et al.,* (2021); Yang *et al.,* (2021)
5	Turnip yellows virus (TuYV)/ beet western yellows virus (BWYV)- *Polerovirus*	+ssRNA	Chickpeas, fieldpea, lentil, faba beans, lupins, vetch	Aphids- GPA, b*revicoryne brassicae (cabbage aphid)*, *Aphis gossypii (cotton/melon aphid)* and *Macrosiphum euphorbiae (potato aphid)* pea aphid, black cowpea aphid	Leaf distortion. Purple, red, or yellow leaf discoloration. Stunting, particularly with early infection. Thickened, leathery, or brittle leaves. Reduced branching, pod numbers, and seeds per pod.	Filardo *et al.*, (2021); Singh *et al*., (2025)

Sl no	**Viruses with their genus**	**Nucleic acid**	**Pulse hosts**	**Transmission**	**Characteristic symptoms**	**References**
6	Pea Early Browning Virus (PEBV)- *Tobravirus*	+ssRNA	Field pea, faa bean, chickpea, lentil, lupins	soil-borne trichodorid nematodes - *Paratrichodorus pachydermus* and *Trichodorus primitivus,* low seed and mechanical transmission	early browning, stunting, leaf curling and distortion	Maina *et al.,* (2020); Mishra *et al.,* (2025)
7	Turnip mosaic virus (TuMV)- Potyvirus	+ssRNA	Chickpea, faba bean, lentils, lupins, peas	GPA, cabbage aphid, mechanical means, low seed transmission	light and dark green patches, along with chlorosis, leaf distortion, and stunting,	Nellist *et al*., (2022)
8	Tomato Spotted Wilt Virus (TSWV)- Orthotospovirus	Negative-sense single-stranded RNA (-ssRNA)	Chickpea, fieldpea, lentil, fab bean, lupins	western flower thrips (*Frankliniella occidentalis*), onion thrips (*Thrips tabaci*)	necrotic or chlorotic ringspots, mosaic patterns, leaf deformation, stunting, and wilting, which often culminate in reduced flowering, poor pod set, and significant yield losses, may exhibit bronzing of foliage	Kamran *et al*., (2024); LaBonte *et al*., (2024); Jones, (2021)
9	Bean Leafroll Virus (BLRV) - Luteovirus	+ssRNA	field pea, faba beans, lentils, chickpea, lupins	Pea aphid, GPA, bluegreen aphid (*Acyrthosiphon kondoi*)	upward leaf rolling, yellowing or chlorosis of leaves, reduced leaf size, and stunted growth, leading to fewer pods and smaller seeds	Jones *et al*., (2021)

3. GENERAL DETECTION METHODS OF VIRUSES

Effective detection of viral infections in pulse crops is critical for disease management, early intervention, and breeding virus-resistant cultivars (Rubio *et al*., 2020). Detection methods are broadly categorized into serological and molecular techniques, each offering unique advantages in specificity, sensitivity, and applicability. Serological methods rely on antibody-based detection of viral proteins, while molecular techniques target viral nucleic acids for high-precision identification (Kalimuthu *et al*., 2022). Recent advancements have enhanced the efficiency, accuracy, and portability of these methods, supporting robust surveillance and control strategies for pulse crop viruses in Australia. This review outlines the key detection methods, focusing on their applications, strengths, and limitations in the Australian context.

3.1 Serological Methods

Serological techniques are widely used for detecting plant viruses due to their specificity, scalability, and cost-effectiveness. These methods identify viral proteins, typically coat proteins, using antibodies, making them suitable for both laboratory and field diagnostics (Boonham *et al*., 2014). Below are the primary serological techniques employed for pulse crop virus detection.

3.1.1 Enzyme-Linked Immunosorbent Assay (ELISA)

ELISA is a cornerstone serological method valued for its high specificity, scalability, and affordability. In this technique, virus-specific antibodies are immobilized on a microplate to capture viral coat proteins from plant extracts. A secondary enzyme-conjugated antibody, often linked to alkaline phosphatase or horseradish peroxidase, binds to the captured antigen, producing a colorimetric reaction upon substrate addition. The Double Antibody Sandwich ELISA (DAS-ELISA) is the most common format, utilizing two antibodies targeting distinct viral epitopes for enhanced specificity and sensitivity. For closely related viruses, Triple Antibody Sandwich ELISA (TAS-ELISA) provides greater discriminatory power. ELISA has been extensively used to detect BYMV, AMV, and CMV in Australian pulse crops such as chickpeas and faba beans (Koeberl *et al*., 2018). However, its accuracy depends on virus titer, and low viral loads or asymptomatic infections may lead to false negatives as well (Naidu & Hughes, 2003).

3.1.2 Lateral Flow Immunoassay (LFIA)

Lateral Flow Immunoassay, also known as ImmunoStrip tests, enables rapid, on-site virus detection without laboratory equipment. LFIA uses a membrane strip embedded with virus-specific antibodies that react with plant extracts. A visible colored test line indicates a positive result. Commercially available for detecting CMV, BYMV, and TSWV in pulse crops, LFIA is ideal for field diagnostics where quick decisions are needed (Ng & Perry, 2004). Despite its convenience, LFIA is less sensitive than ELISA or molecular methods, making it better suited for preliminary screening rather than confirmatory testing (Dietzgen *et al*., 2016).

3.1.3 Dot-Blot Immunoassay (DBIA)

Dot-Blot Immunoassay is a membrane-based technique where plant extracts are spotted onto a nitrocellulose or PVDF membrane and probed with virus-specific antibodies. An enzyme-conjugated secondary antibody triggers a colorimetric or chemiluminescent reaction to indicate viral presence. DBIA is simple, cost-effective, and requires minimal equipment, making it an alternative to ELISA. It has been used to detect AMV and BYMV in faba beans and chickpeas in Australia (Maina & Jones, 2023). However, its lower sensitivity limits its use for routine diagnostics compared to more advanced methods (Freeman *et al.,* 2013).

3.1.4 Tissue Blot Immunoassay (TBIA)

Tissue Blot Immunoassay is designed to detect systemic viral infections in vascular tissues. Freshly cut plant tissues, such as stems or petioles, are blotted onto a nitrocellulose membrane, followed by antibody probing and enzymatic detection. TBIA is effective for viruses like CMV, AMV, and PSbMV, which are systemically distributed in pulse crops (Pallas *et al*., 2020). Its ability to visualize virus distribution within plants makes it valuable for epidemiological studies, though it is less commonly used for routine screening due to its moderate sensitivity (Van Leur & Kumari, 2011).

3.2 Molecular Methods

Molecular techniques detect viral nucleic acids with high specificity and sensitivity, making them indispensable for accurate virus identification, especially in low-titer or mixed infections (Kalimuthu *et al.,* 2022). These methods are particularly valuable for research and confirmatory diagnostics in Australian pulse crops. The following are the key molecular techniques used.

3.2.1 PCR and reverse transcription PCR (RT-PCR)

PCR and RT-PCR are cornerstone molecular techniques for detecting plant viruses with high sensitivity and specificity. PCR amplifies DNA sequences, making it ideal for detecting DNA viruses, while RT-PCR targets RNA viruses by first converting viral RNA to complementary DNA (cDNA) using reverse transcriptase, followed by PCR amplification with virus-specific primers. Amplified products are visualized through gel electrophoresis or fluorescent probes. These methods reliably detect viruses such as CMV and AMV in Australian chickpeas and lentils, even at low titers (Maina & Jones, 2023). Despite their precision, PCR and RT-PCR require specialized laboratory equipment, restricting their application in field settings (Boonham *et al.,* 2014).

3.2.2 Quantitative real-time PCR (RT-qPCR)

RT-qPCR, an advanced form of RT-PCR, quantifies viral RNA levels in real time using fluorescent probes like SYBR Green or TaqMan. This method provides both detection and viral load estimation, making it ideal for studying virus-host interactions, resistance screening, and monitoring disease progression. RT-qPCR has been used to quantify TSWV infection levels in chickpea genotypes under varying environmental conditions (Pallas *et al.,* 2020). Despite its precision, RT-qPCR's reliance on expensive reagents and trained personnel restricts its use for routine diagnostics (Rubio *et al*., 2020).

3.2.3 Loop-mediated isothermal amplification (LAMP)

LAMP is a rapid nucleic acid amplification technique that operates at a constant temperature (60–65°C), eliminating the need for a thermal cycler. It produces amplified DNA in 30–40 minutes, detectable via colorimetric, fluorescent, or turbidimetric methods. LAMP's simplicity and speed make it ideal for on-site detection of viruses like CMV, PSbMV, AMV, and BYMV in pulse crops (Cassedy *et al*., 2021; Notomi *et al*., 2015; Rizzo *et al*., 2021). Its field applicability is a significant advantage over RT-PCR, particularly in regions with limited laboratory infrastructure (Ullah *et al*., 2025).

3.2.4 High-Throughput Sequencing (HTS)

High-Throughput Sequencing, or Next-Generation Sequencing (NGS), enables whole-genome sequencing of plant viruses, facilitating the detection of novel strains, mixed infections, and mutations. HTS has been instrumental in characterizing emerging CMV and PSbMV variants in Australian pulse crops (Bester *et al.*, 2021; Maina *et al*., 2024). Its metagenomic approach is critical for understanding viral evolution and developing resistant varieties. However, HTS is costly and requires extensive bioinformatics expertise, limiting its use to research rather than routine diagnostics (Maree *et al.,* 2018).

3.2.5 CRISPR-based diagnostics

CRISPR-based systems, such as CRISPR-Cas12 and CRISPR-Cas13, offer rapid and highly specific virus detection. These systems use guide RNAs to target viral sequences, triggering fluorescence-based detection. CRISPR-Cas13 assays have detected TSWV in pulse crops within 30–60 minutes (Sharma *et al*., 2021). Platforms like SHERLOCK and DETECTR enhance field-deployable diagnostics with high sensitivity (Jiang & Zhu, 2021; Aman *et al*., 2022). While promising, CRISPR diagnostics require further optimization for widespread adoption in plant virology (Ali *et al.,* 2018).

3.2.6 Biosensor-based detection

Biosensors employ biological recognition elements, such as antibodies or nucleic acids, to detect viruses in plant tissues. Electrochemical and optical biosensors are portable and field-deployable, offering rapid detection of viruses like BYMV and AMV (Sellappan *et al*., 2022). Miniaturized biosensor devices enhance on-site diagnostics, providing a cost-effective alternative to traditional methods. Their development is ongoing, with potential for broader application in pulse crop surveillance (Maqsood *et al*., 2025).

4. GENERAL MANAGEMENT OF PULSE VIRUSES

Managing viral diseases in pulse crops necessitates an integrated disease management

(IDM) approach that combines multiple strategies to reduce virus incidence and mitigate yield losses. Since direct chemical treatments for viruses are unavailable, effective control focuses on preventing infection, limiting spread, and developing resistant cultivars. This section outlines key IDM strategies for pulse crops in Australia, emphasizing seed quality, cultural practices, vector control, and genetic resistance.

4.1 Virus-Free Seeds

Using certified virus-free seeds is critical to prevent the introduction of seed-transmitted viruses like PSbMV, CMV, and AMV. Even low seed transmission rates (0.1–5%) can lead to significant outbreaks under favorable conditions (Pallas *et al*., 2020). Seed health testing, including ELISA-based indexing and RT-PCR certification, ensures seed lots are free of viral inoculum before planting. Sourcing seeds from reliable suppliers minimizes the risk of introducing viruses into new fields, forming a foundational IDM strategy.

4.2 Crop Rotation and Sanitation

Crop rotation with non-host crops, such as cereals, disrupts virus life cycles by reducing inoculum in soil and plant debris. Viruses like BYMV and CMV persist in volunteer crops, weeds, and alternative hosts (e.g., alfalfa, clovers, vetch), serving as reservoirs for aphid transmission in subsequent seasons (Jones, 2021). Regular sanitation, including removing infected plants, eliminating volunteer crops, and controlling weed hosts, is essential to limit these reservoirs and reduce virus spread.

4.3 Vector Management

Pulse viruses are primarily transmitted by aphids, thrips, and nematodes, making vector control a key component of IDM. Non-persistent transmission by vectors, such as thrips for TSWV or aphids for BYMV, allows rapid virus spread within seconds, rendering insecticides largely ineffective (Lv *et al*., 2023). Integrated pest management (IPM) employs non-chemical methods like reflective mulches, intercropping, trap cropping, and biological control. Reflective mulches (silver or aluminum) deter aphid and thrips landings, lowering transmission rates (Jones, 2021). Intercropping with non-hosts like barley or wheat creates barriers to vector movement, while trap crops (e.g., mustard) divert aphids from pulses (Ng & Perry, 2004). Biological control using predators like ladybugs (*Coccinellidae*), lacewings (*Chrysopidae*), and parasitic wasps (*Aphidiidae*) reduces aphid populations, further curbing virus spread (Pritchard *et al*., 2005).

4.4 Genetic Resistance

Breeding virus-resistant pulse varieties offers a sustainable, long-term solution. Resistance genes can block virus replication, systemic movement, or vector transmission. Resistance to PSbMV has been identified in pea genotypes, with efforts ongoing to incorporate these traits into commercial cultivars (Jones, 2021). For BYMV, lupin resistance has been advanced through molecular marker-assisted selection (Jones, 2021). RNA interference (RNAi) technology, using virus-derived siRNAs, is being explored to develop CMV-resistant chickpeas (Pritchard *et al*., 2005). These breeding efforts aim to combine resistance with high yield and stress tolerance for Australian conditions.

4.5 Cultural Practices

Cultural practices, such as early sowing and dense planting, reduce virus incidence. Early sowing aligns crop growth with periods of low vector activity, decreasing infections by CMV and BYMV (Maina & Jones, 2023). Dense planting creates a canopy that limits vector movement within fields, further reducing transmission. These practices enhance the effectiveness of other IDM components.

4.6 Integrated and Sustainable Approach

A comprehensive IDM approach integrating virus-free seeds, crop rotation, sanitation, vector management, resistant cultivars, and cultural practices is the most sustainable strategy for managing pulse viruses in Australia. Overuse of insecticides must be avoided to prevent resistance in vectors like green peach aphid and Western flower thrips. IPM prioritizes vector monitoring, biocontrol agents, and host resistance for long-term control. By adopting these strategies, Australian growers can protect pulse crop productivity and ensure the sustainability of this vital agricultural sector.

5. CONCLUSION

Australia's stringent quarantine and biosecurity measures play a critical role in managing viral diseases across its agricultural sector, including pulse crops essential for domestic and export markets. However, viruses like AMV, BYMV, CMV, PSbMV, and TuMV remain significant threats, causing substantial yield losses and quality declines in pulse production. Effective management is crucial to maintaining Australia's status as a leading pulse producer. Timely and precise detection using advanced serological (e.g., ELISA, LFIA) and molecular techniques (e.g., RT-PCR, LAMP, HTS) is vital for early intervention. Integrated disease management, incorporating virus-free seeds, vector control, crop rotation, and resistant cultivars, is essential to reduce viral impacts. Ongoing research continues to advance detection and management methods, exploring innovations like CRISPR-based diagnostics and RNA interference for resistance. This review offers a concise examination of pulse viruses in Australia, their transmission, symptoms, detection, and management, highlighting the need for sustained research and vigilance to ensure the long-term sustainability of pulse crop production.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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