THE ONION PROJECT

Stemphylium leaf blight in onions

SEPTEMBER 2025

A Global Scan for Hort Innovation Project *VN 21000*

Contents

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Executive Summary

Stemphylium leaf blight (SLB), caused by *Stemphylium vesicarium*, is a destructive foliar disease affecting onion crops globally. It also infects other *Allium* species like garlic, leek, and shallots, and a wide range of alternative hosts including asparagus, tomato, radish, sunflower, and various weeds

This scan provides a comprehensive overview of SLB, beginning with its identification through characteristic symptoms such as watery, then tan-coloured to dark brown lesions and rapid leaf senescence. The disease's epidemiology is explored, highlighting its lifecycle, modes of spread, and environmental conditions that favour outbreaks in temperate and subtropical climates.

Several interconnected factors influence the disease's development, spread, and severity:

1. **Host crops or weeds on the farm or region**
2. **Sources of Inoculum**
    a. Primary inoculum often originates from infected crop residues, volunteer onions, and alternative hosts.
    b. Secondary spread occurs via airborne conidia (asexual spores), which are dispersed by wind and rain-splash.
3. **Environmental Conditions**
    a. SLB outbreaks are favoured by moderate temperatures (≥15°C), high humidity, and frequent rainfall.
    b. Leaf wetness duration of > 4 hours is critical for spore germination and infection.
    c. Disease severity tends to increase with rainfall and humidity, while higher temperatures than 25-28°C may slow down or suppress its development.
4. **Disease Cycle**
    a. Initial symptoms appear as small, watery, then tan to brown lesions that expand and coalesce, leading to leaf blight and dieback.
    b. Sporulation occurs on necrotic tissue, producing conidia (spores) that perpetuate the disease cycle.
    c. Epidemics often begin in mid to late growing season, especially when bulbs are around 2.5cm in diameter.
5. **Agronomic Factors**
    a. Crops with poor crop rotation, inadequate residue management, or dense canopy cover are more prone to SLB than those with good airflow.
    b. Susceptibility varies among onion cultivars, with some showing moderate resistance while others are highly susceptible.

The apparent increase in fungicide resistance in some regions around the world further complicates control efforts, necessitating integrated management strategies and regional/area wide management initiatives. Insights into managing resistance to fungicides and potential biological control options are summarised.

This scan also presents the global distribution of SLB, with emphasis on regions where it poses major economic threats. Management practices from various countries are included, comprising cultural, chemical, and biological approaches. Special attention is given to current and potential strategies for managing SLB in Australia, where the disease is gaining prominence in some areas.

RD&E SUGGESTIONS

Onion growers in affected regions in Australia will benefit from information on the following:

- Stemphylium epidemiology in subtropical climates of Australia including:
  - how far spores travel to infect other crops
  - how many generations can the fungus go through in one onion season in different regions and what it means for control and avoiding fungicide resistance
- Fungicide resistance occurrence (in progress) – ongoing monitoring required
- Biological products to support fungicide programs
- Integrated and areawide management of Stemphylium
- Biological control agents and methods (products and programs) to support fungicide programs
- Soil and plant DNA testing (in progress)
- Forecasting, does it work?
- Getting rid of crop residues and other hosts quickly, what is the best method in an integrated system?
- Benefits of cover crops to manage SLB
- The role of soil health and site-specific nutrition management for SLB risk, occurrence and severity
- Cost benefit of different management approaches in different regions.

1 Introduction

1.1 Overview

Stemphylium leaf blight (SLB), caused by the fungal pathogen *Stemphylium vesicarium*, has become a significant foliar disease affecting onion and other *Allium* crops worldwide. The disease causes leaves to show necrotic lesions and premature leaf senescence. It can be misdiagnosed because symptoms are like those of other fungal diseases of *Allium* crops.

SLB can severely reduce bulb size and yield, particularly under conducive environmental conditions such as prolonged leaf wetness and moderate temperatures. The disease has emerged as a major challenge in onion production systems. Misdiagnosis and using ineffective fungicides can worsen the impact of SLB. The emergence of fungicide resistance contributes to the lack of effective control. Another factor that makes SLB control problematic is the limited genetic resistance in currently used commercial cultivars.

This scan on SLB explores the symptomatology, epidemiology and management strategies of SLB, with a focus on risk management and integrated approaches that can mitigate its impact on onion yield and quality.

1.2 Global distribution of Stemphylium leaf blight

The first report of SLB was from Varanasi in India[1] and it later was discovered to cause onion and garlic leaf blight in Spain and Brazil respectively[2]. One study found a greater SLB presence in onion seed crops compared to commercial bulb crops[3]. SLB is now common around the world[4]. Globally, countries including Brazil, Canada, Cuba, Egypt, Ethiopia, Germany, India, Japan, Korea, Mexico, Myanmar, Netherlands, New Zealand, South Africa, Spain, Taiwan, Turkey, Tonga, Portugal, United States, Venezuela, as well as Australia have all documented cases of SLB[5].

Crops that have been affected worldwide are onion, garlic, leek, shallot, faba bean, lentil, tomato, radish, European pear, mango, sunflower, soybean, parsley, and asparagus.

Table 1 provides an overview of significant SLB occurrence reported from various crops, especially onions, by region. The economic impact is described based on this scan but studies specifying it in monetary terms have not been found.

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1 Rao, N. N. R., & Pavgi, M. S. 1975. Stemphylium leaf blight of onion. Mycopathologia, 56, 113–118. Accessed here: doi.org/10.1007/BF00491252.

2 Basallote, M. J., Prados, A. M., Pérez, D. A., & Melero-Vara, J. M. 1993. First report in Spain of two leaf spots of garlic caused by *Stemphylium vesicarium. Plant Disease*, 77(9), 952. Accessed here: doi.org/10.1094/PD-77-0952B.

3 Boiteux, L. S., Lima, M. F., Menezes Sobrinho, J. A., & Lopes, C. A. 1994. A garlic (*Allium sativum*) leaf blight caused by *Stemphylium vesicarium* in Brazil. Plant Pathology, 43(3), 412–414. Accessed here: doi.org/10.1111/j.1365-3059.1994.tb01578.x.

4 Jakhar, S. S.; Duhan, J. C. & Suhag, L. S. 1994. Prevalence and incidence of Stemphylium blight of onion and its management through cultural practices. *Crop Res. (Hissar).,* 8(3): 562-564.

5 Bhatia J. N and Chahal D. 2014. Studies on effectiveness of certain new fungicides in controlling Stemphylium blight of onion seed crop. *Agricultural Science Direct.* 2014;34(3):237-239.

TABLE 1 *Stemphylium vesicarium* **presence, crop affected and impact by region**

REGION	COUNTRIES/STATES	CROPS	NOTES	IMPACT
Oceania[6]	Australia (QLD, NSW, SA)	Garlic, onions, faba beans	SLB identified in multiple states	Not specified
North America[7]	USA (NY, MI, CA, GA, ID, OR, WA, TX)	Onions	Major foliar disease in some states	High impact due to widespread outbreaks
North America[8]	Canada (Ontario)	Onions	Fungicide resistance documented	**Economic concern due to resistance**
South Asia[9]	India, Pakistan	Onions	Widespread and economically damaging	Significant economic losses reported
East Asia[10]	South Korea	Onions	Resistant and susceptible germplasm identified	Implied economic importance due to breeding efforts
Europe[11]	Spain, Italy, Netherlands	Onions, pears	Fungicide resistance and breeding program observations	**Economic impact due to resistance and seed production relevance**
Middle East	Iran	Onions, garlic	Often misidentified due to similarity with purple blotch	Not specified
Africa	Egypt, Tunisia, South Africa	Onions	Occurs under high humidity and poor crop rotation	Likely economic impact due to conducive environmental and management conditions and high crop losses

6 AUSVEG 2024. Stemphylium leaf blight in onions. Factsheet. Accessed here: ausveg.com.au/app/uploads/2025/04/Stemphylium-leaf-blight-Factsheet-Feb-25-1.pdf.

7 Pethybridge S. *et al.* Not Dated. Fight the blight: Stemphylium leaf blight, (SLB) an emerging threat to United States onion production. Accessed here: alliumnet.com/wp-content/uploads/2024/01/FIGHT-THE-BLIGHT-STEMPHYLIUM-LEAF-BLIGHT-AN-EMERGING-THREAT-TO-UNITED-STATES-ONION-PRODUCTION.pdf.

8 Hay, F. *et al.* 2021. Stemphylium Leaf Blight: A re-emerging threat to onion production in eastern North America. Plant Disease, December 2021. Accessed here: apsjournals.apsnet.org/doi/pdf/10.1094/PDIS-05-21-0903-FE.

9 Bayer Crop Science. Not Dated. Disease guide - Stemphylium Leaf Blight. Accessed here: vegetables.bayer.com/gb/en-uk/knowledge-centre/disease-guides/onions/stemphylium-leaf-blight.html.

10 Lee, J.J. *et al.* 2024. Evaluation of Onion Germplasm for Resistance to Leaf Blight Caused by *Stemphylium vesicarium*. Res. Plant Dis. 30(4): 342-352 (2024). Accessed here: online-rpd.org/upload/pdf/RPD-2024-30-4-342.pdf.

11 BIMCO International. 2023. Fungicide Resistance in Stemphylium Leaf Blight: Threats and Management Strategies. Accessed here: bimcointernational.com/en/stemphylium-leaf-blight-fungicide-resistance-management.

2 The Disease

2.1 Identifying the Disease - Symptomatology

Early detection and correct identification are vital for disease control. It therefore is important to conduct regular scouting, especially after rain or irrigation if leaf wetness exceeds four hours. Focus should be on lower leaves and older foliage as well as leaf tips. A hand lens is required to inspect for early symptoms and to check lesion margins for subtle discoloration.

- Symptoms start as small, water-soaked lesions that often appear on older leaves first. Infection often begins at the leaf tip and moves downward[12].
- The watery lesions will turn into oval to elongated spots or distinctive small yellow to orange streaks that quickly grow into elongated scattered spots that are light tan or pale brown in colour. The typically small, elliptical lesions may be surrounded by a faint yellow halo.
- Spots and lesions expand and can merge into larger necrotic areas that are darker brown in colour. The tissue becomes dry and papery as the disease progresses, eventually leading to leaf tip dieback and tips may curl or collapse prematurely.
- Note that there will be no visible fungal growth on lesions initially. Unlike Botrytis, SLB lesions do not show fuzzy growth early on. Conidia (orange coloured) may appear later under humid conditions.

Stemphylium vesicarium may be confused with other pathogens that cause foliar blight type diseases in onions. Common lookalike pathogens are:

- *Alternaria porri,* Purple blotch; symptoms are purple to brown concentric lesions, often with pinkish edges or halos. Lesions tend to be more circular and purplish than those caused by SLB.
- *Botrytis squamosa*, Botrytis leaf blight; symptoms are small white spots that expand into tan lesions with greenish margins. Lesions are typically smaller and more water-soaked in appearance.

FIGURE 1: Stemphylium (2 images on left) and Alternaria symptoms (right) - (Images courtesy of Dr Ben Evert, Metagen)

FIGURE 2: Stemphylium vesicarium
Source https://plantix.net/en/library/plant-diseases/

Alternaria porri

Botrytis squamosa symptoms

Figures 1 and 2 illustrate symptoms of Stemphylium and other diseases that can look similar in the field.

Stemphylium vesicarium can be misdiagnosed across plant species as Powdery mildew which also can cause similar symptoms, or it can look either like nutrient deficiency, fertiliser burn or pesticide damage.

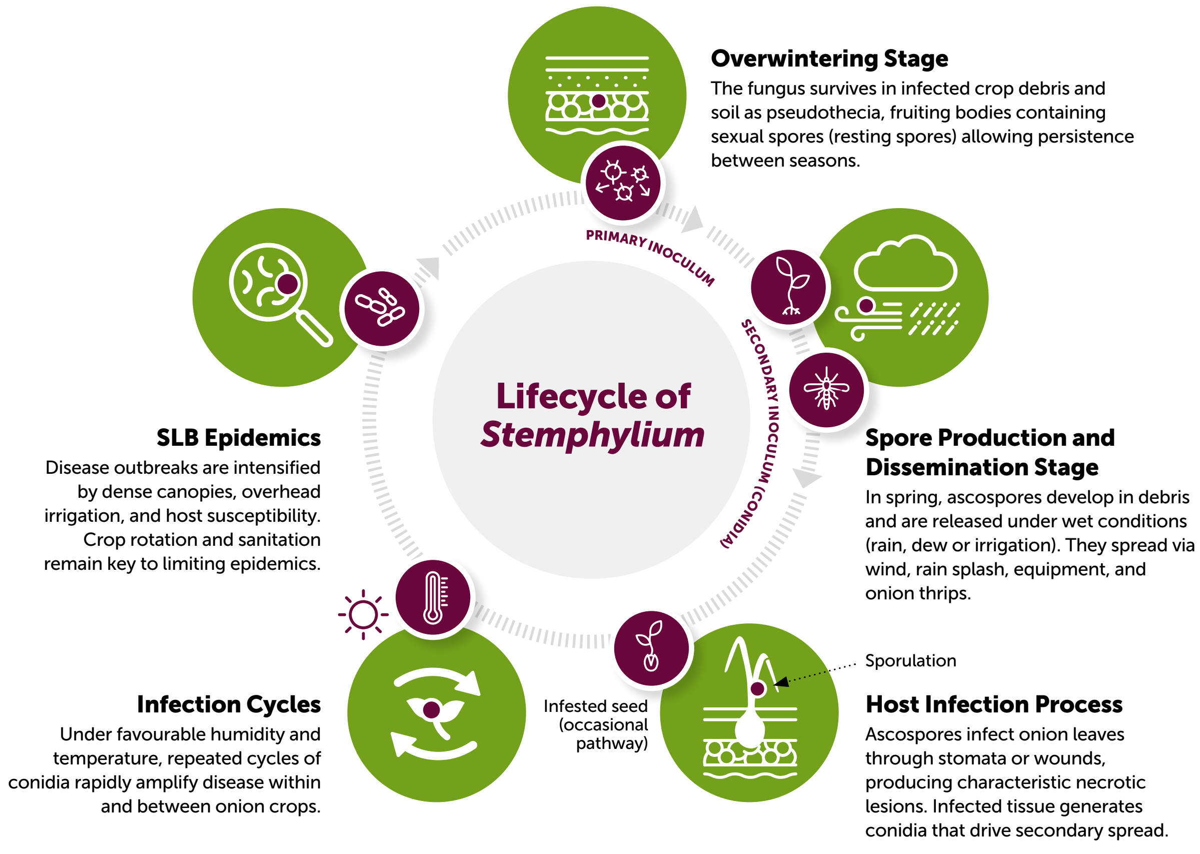
If not 100% sure what the symptoms mean, samples should be submitted to a diagnostic laboratory for identification. Correct diagnostics is vital for successful disease prevention and control as well as fungicide resistance management.

Misdiagnosis can lead to the use of mostly ineffective control methods which can hasten fungicide resistance development and are a waste of money.

[12] Hay, F. et al. 2019. Emergence of Stemphylium Leaf Blight of Onion in New York Associated With Fungicide Resistance. Published Online by APS Online 8 Oct 2019. Accessed here: doi.org/10.1094/PDIS-03-19-0676-RE.

2.2 Lifecycle and Disease Spread - Epidemiology

The disease development, persistence, spread and infection conditions and cycles are outlined below. *Figure 3* shows an infographic diagram of the lifecycle



Adapted from Hay *et al.* 2022[13]. Image ©AUSVEG

FIGURE 3 Lifecycle of Stemphylium

- The fungus 'overwinters' (survives) in infected crop residues, culled onions, and onion debris left on the soil surface. The fungus remains viable in the soil for at least one year.
- Spores (ascospores and conidia) are released from this debris in the following season under favourable conditions (temperatures between 18°C and 25°C and humidity >95% and leaf wetness > 4hrs).
- The disease may be brought in via infected seed.
- Onion thrips may distribute the disease; they create entry wounds for the fungus.
- Crop rotation away from *Allium* species for 3–4 years can reduce soil inoculum levels.

[13] Adapted from Hay, F. *et al.* 2022. Stemphylium Leaf Blight of Onion. The Plant Health Instructor Volume: 22, 2022, Article Type: Plant Disease Profiles. Accessed via: apsnet.org/edcenter/pdlessons/Pages/Stemphylium-leaf-blight-Onion.aspx.

Overwintering Stage

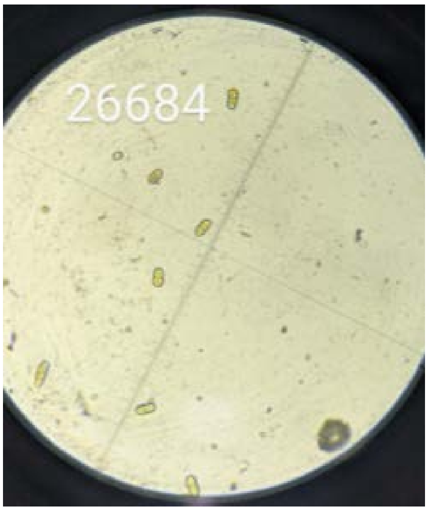
During winter the fungus survives in a dormant stage (as pseudothecia or resting spores) in infected plant debris and soil. That way it persists from year to year across seasons[14].

Spore Production and Dissemination Stage

In spring, the fungus produces sexual spores (called ascospores) as the primary inoculum. Ascospores develop from the pseudothecia in debris. Their development is triggered by rain, dew or irrigation (humidity >95%, leave wetness >4hrs) when temperatures are between 18°C and 25°C. Ascospores are then released from the debris and spread via wind, rain splash, and contaminated equipment or onion thrips and infect new plants.

Ascospores can infect the umbel (dome shaped flowering structure of onions) and or seed stalk, potentially reducing seed yield and quality. Seed may become infected. If seed is infected, it can start the disease cycle.

Figure 4 shows a microscopic image of Stemphylium spores (left) and Alternaria spore (right) for comparison.



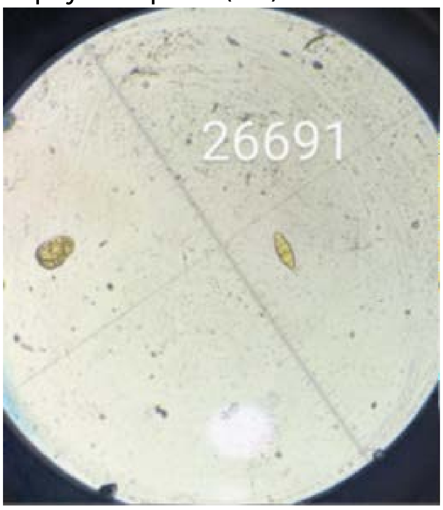


FIGURE 4: Stemphylium (left) and Alternaria spores (right) - (Images courtesy of Dr Ben Evert, Metagen)

Host Infection Process

If conditions remain favourable for the fungus, the ascospores germinate on host plant leaves and invade leaves through wounds and openings like stomata. The infection and resulting cell deaths cause leaf blight symptoms. The fungus in infected leaves produces asexual spores (conidia) which serve as secondary inoculum, rapidly spreading the disease within and between crops. Lesions often begin as small, water-soaked spots that expand into elliptical, tan to dark brown necrotic areas.

Infection Cycles

Multiple infection cycles occur in a season if conditions (leaf wetness, humidity, temperature) are right. Extended leaf wetness due to overnight dew, irrigation or prolonged rain creates ideal conditions for ascospore germination starting spring and conidial spread later in the season. It is therefore important to use crop rotation and an effective fungicide program as well as a fungicide resistance strategy for effective control.

[14] Misawa, T, Yasuoka, S. The life cycle of *Stemphylium vesicarium*, the causal agent of Welsh onion leaf blight. J Gen Plant Pathol 78, 18–29 (2012). Accessed via: doi.org/10.1007/s10327-011-0352-8. link.springer.com/article/10.1007/s10327-011-0352-8#citeas.

SLB Epidemics

SLB epidemics are influenced by infected crops in the production area combined with environmental conditions, agronomic practices, and host susceptibility. Dense canopies, poor air circulation, and overhead irrigation can exacerbate disease development. The pathogen's ability to infect a wide range of hosts and survive in residues makes crop rotation and sanitation critical components of disease management.

2.3 Lifecycle and Disease Spread in Subtropical Climates

In subtropical onion-growing regions such as Queensland, particularly the Lockyer Valley, the traditional lifecycle concept of *Stemphylium vesicarium* (SLB) involving survival ('overwintering') in debris and spring sporulation still applies, but with regional adaptations due to the subtropical climate. The main points to consider are:

- The pathogen still survives in crop debris and soil between seasons, especially in culled onions and infected leaf material.
- Even in milder winters, pseudothecia (sexual fruiting bodies) can form and persist, allowing ascospores to be released when conditions become favourable.
- While in cooler climates, ascospore release typically begins in early spring, in Queensland, sporulation is likely to begin earlier, or is less distinct seasonally, due to the warmer overnight temperatures (often 13-25°C, optimal for SLB development) and high humidity and irrigation imitate spring-like conditions even in late summer or autumn.
- The subtropical climate allows for continuous disease pressure due to extended periods of leaf wetness, enabling conidia (asexual spores) to be produced and spread throughout the growing season, not just after spring initiation as described above for temperate climates.

The above-described epidemiology means that SLB can persist longer with several lifecycles in a season and re-emerge more quickly after harvest if debris is not managed.

2.4 Alternative Hosts

Stemphylium vesicarium can survive on a broad range of alternate host plants, providing a reservoir for infection in the next growing season. Therefore, managing the disease involves removing infected host plant material to reduce sources of inoculum. Crop rotation, weed management and appropriate fungicide applications are essential for managing *Stemphylium* in all susceptible crops.

***Allium* crops** are highly susceptible to *S. vesicarium.*

- **Onions:** Red onion cultivars are more susceptible to *Stemphylium* than Yellow onion cultivars
- **Garlic is susceptible**
- **Leeks:** *S. vesicarium* causes white fleck which enlarge to produce sunken purple lesions occasionally surrounded by a yellow to pale brown border on garlic
- **Shallots are susceptible**

In ***Brassica* crops**, *S. vesicarium* often causes leaf spot symptoms which can lead to leaf necrosis and reduced photosynthesis, affecting plant growth and marketability.

- **Cabbage**
- **Broccoli**
- **Cauliflower**
- **Kale**

Spinach and leafy green crops can be infected.

- **Spinach:** *S. vesicarium* can cause leaf spot on spinach, creating circular to oval grey-green leaf spots which coalesce and dry up becoming papery in texture. The symptoms can resemble the tan circular spots of pesticide or fertiliser damage.
- **Lettuce:** Known to be susceptible, though infections are relatively rare.

Some **Cucurbit crops** are susceptible

- **Melons:** Susceptible to Stemphylium leaf spot in humid, warm conditions, which can cause necrotic lesions on leaves, potentially reducing yield.
- **Cucumbers** and **squash**: Also known hosts, though infections are less common. Symptoms are similar, with leaf spots impacting plant vigour and yield.
  Susceptibility and leaf damage can be an issue in market gardens where *Allium* and other vegetable crops are often grown close to each other and in rotation.

TABLE 2 Crop Hosts of ***Stemphylium vesicarium*** other than Allium crops

WEED SPECIES	EVIDENCE OF HOSTING S. VESICARIUM	SOURCE TYPE	PUB DATE	HOST SUSCEPTIBILITY	REFERENCE (APA)
Spinach (Spinacia oleracea)	Yes – major disease (Stemphylium leaf spot)	Peer-reviewed	1994	High	Correll, J. C., Koike, S. T., & Gordon, T. R. (1994). Stemphylium leaf spot of spinach: Etiology and epidemiology. Plant Disease, 78(6), 622–626. https://doi.org/10.1094/PD-78-0622
Lettuce (Lactuca sativa)	Occasional reports of infection		2000	Moderate	Koike, S. T., & Subbarao, K. V. (2000). Diseases of lettuce in California. University of California ANR Publication.
Brassica oleracea crops (Cabbage, Broccoli, Cauliflower, Kale)	Occasional infection under conducive conditions		2003	Low/Moderate	Thomma, B. P. H. J. (2003). Alternaria spp. and related pathogens of Brassicaceae. Plant Pathology Journal, 52(2), 145–157.
Melons (Cucumis melo) and cucumbers (Cucumis sativus) (Cucurbitaceae)	Reported in some regions, not primary pathogen	Database (USDA ARS)	2023	Low	Farr, D. F., & Rossman, A. Y. (2023). Fungal Databases, U.S. National Fungus Collections. USDA ARS.

Weeds and non-crop hosts can act as a reservoir, allowing the fungus to survive and potentially spread to nearby crops. Below weeds have been identified as potential hosts for *S. vesicarium* and may contribute to the spread and persistence of SLB[15]:

- Nutsedge (*Cyperus* spp.)
- Pigweed (*Amaranthus* spp.)
- Purslane (*Portulaca oleracea*)
- Bull thistle (*Cirsium vulgare*)
- Sow thistle (*Sonchus* spp.)
- Marshcress (*Rorippa* spp.)
- Horsetail (*Equisetum* spp.)
- Jimsonweed (*Datura stramonium*)
- Field pennycress (*Thlaspi arvense*).

[15] Cornell Vegetables, Resources for commercial growers. Not Dated. Stemphylium Leaf Blight of Onion. Factsheet. Accessed via: vegetables.cornell.edu/pest-management/disease-factsheets/stemphylium-leaf-blight-of-onion.

TABLE 3 Confirmed and potential weed hosts of *Stemphylium vesicarium* other than Allium crops

WEED SPECIES	EVIDENCE OF HOSTING S. VESICARIUM	SOURCE TYPE	PUB DATE	HOST SUSCEPTIBILITY	REFERENCE (APA)
Nutsedge *(Cyperus spp.)*	Yes – confirmed	Peer-reviewed	2022	Moderate (inoculation + re-isolation trials)	McDonald, M. R., Stricker, S., & Gossen, B. D. (2022). Weed hosts and winter survival of Stemphylium vesicarium on onion in Ontario, Canada. Canadian Journal of Plant Pathology. https://doi.org/10.1080/07060661.2022.2130433
Pigweed *(Amaranthus spp.)*	Yes – confirmed (redroot pigweed)				
Purslane *(Portulaca oleracea)*	Yes – confirmed				
Bull thistle *(Cirsium vulgare)*	Yes – confirmed				
Sow thistle *(Sonchus spp.)*	Yes – confirmed (perennial sow thistle)				
Marsh cress *(Rorippa spp.)*	Yes – confirmed (yellow marsh cress)				
Horsetail *(Equistum spp.)*	No peer-reviewed evidence found	Extension/Other – industry publications	Not dated	Low/unknown	Invasive, declared weed in Vic and NSW Likelihood in vegetable fields is very low, unless near waterways or poorly drained areas.
Jimson weed *(Datura stramonium)*					Declared weed in most states. Rare in intensive vegetable production with good weed management, possible in low-input or neglected areas.
Field pennycress *(Thlapi arvense)*					Unlikely to occur in Australian vegetable systems. Typical of temperate regions in North America and Europe.

2.5 Factors Affecting Development and Impact of *Stemphylium*

The following factors affect the development and impact of *Stemphylium*:

Environmental factors that support the disease

- Overnight temperatures of 4-25°C
- Day temperatures of 18-25°C
- Leaf wetness > 4 hours (influenced by weather and irrigation)
- Relative humidity > 85-90%

Management factors that support the disease incidence and severity

- Lack of rotation with non-host crops (less than a 3-to-4-year break between host crops
- Farm hygiene (leaving debris on top of the soil)
- Poor biosecurity practices leading to transfer of debris or soil between paddocks
- Amount of disease inoculum and other diseases in the soil (on debris)
- Poor nutritional balance (especially excess nitrogen)
- Poor irrigation management e.g., overnight irrigation leading to prolonged leaf wetness
- Plant spacing and direction impacting airflow and drying of leaves
- Fungicide resistance
- Late detection in a crop or misdiagnosis and thus using the wrong control methods
- Area wide management failures

2.6 Fungicide Resistance

Repeated use of fungicides for the control of SLB can result in fungicide resistance. The management approach for reducing the risk of fungicide resistance should be to rotate different fungicide modes of action groups, avoiding the use of fungicides with high levels of resistance present in the pathogen population, and reducing the number of sprays or switching to 'bio-fungicides' or protectant multi-site mode of action fungicide groups including FRAC M1 or M5. Refer to Section 5 for further information on FRAC groups and resistance management.

[15] Cornell Vegetables, Resources for commercial growers. Not Dated. Stemphylium Leaf Blight of Onion. Factsheet. Accessed via: vegetables.cornell.edu/pest-management/disease-factsheets/stemphylium-leaf-blight-of-onion.

3 Management of *Stemphylium*

3.1 Stemphylium history and management in New Zealand

3.1.1 History in New Zealand

Stemphylium vesicarium was first documented in New Zealand in the 1970s during taxonomic studies of plant pathogenic fungi. Singh (1977) identified three species of Stemphylium in NZ: S. vesicarium, S. botryosum, and S. globuliferum. Among these, S. vesicarium was the most common, infecting crops like asparagus, onion, tomato, lucerne and lupins[16].

Historically, Stemphylium leaf blight (SLB) was considered a minor disease for decades, occurring sporadically. However, in 2017–2018, severe outbreaks were reported in onion-growing regions such as Auckland, Waikato, Hawke's Bay, and Canterbury. This marked a shift from a SLB as a secondary disease to a major threat[17]. Ongoing research focuses on integrated disease management and alternative control strategies to mitigate economic damage

Since the 2017-2018 outbreak, Onions NZ and Plant & Food Research NZ are leading resistance management programs, fungicide sensitivity screening, and trials for alternative management solutions.

3.1.2 Economic Impact - NZ

SLB can cause up to 60% yield loss in severely affected onion fields. The disease also predisposes bulbs to secondary infections, reducing storage quality and marketability[18]. In response to the recent outbreak, Onions NZ and Plant & Food Research have invested heavily in research and fungicide resistance management strategies. Fungicide resistance has emerged as a major concern, with resistance detected in three modes of action, leaving only two effective chemical options. This limits growers' ability to rotate fungicides, increasing production risk and costs[4].

Growers face higher production costs due to increased fungicide applications, resistance management programs, and trials for alternative controls (biological and chemical). Cultural practices like irrigation and nutrition management are used to reduce disease pressure[19].

While onions are the primary crop affected, asparagus and other vegetables as well as weeds also host the pathogen, posing a risk to diversified vegetable producers.

3.1.3 Integrated Control Strategies - NZ

Fungicide-based strategies offer limited registered options. Currently, only two fungicide modes of action remain effective in NZ due to widespread resistance in three other groups. This severely restricts fungicide rotation possibilities.[19]

Cultural Practices include irrigation water management to avoid prolonged leaf wetness and to reduce humidity around foliage.[19] Airflow through the crop is improved by adjusting plant spacing and row orientation to reduce humidity in the crop.[20]

16 mro.massey.ac.nz, biotanz.la...arch.co.nz
17 journal.nzpps.org
18 journal.nzpps.org
19 a-lighter-...ouch.co.nz, natlib.govt.nz
20 bimcointer...tional.com

Nutrition management is focused on maintaining balanced nutrient levels within a desirable range for onions at defined growth stages to reduce plant stress and susceptibility.[19] Overapplication of nitrogen must be avoided.

Crop hygiene measures involve destroying crop residues after harvest to reduce inoculum, control of volunteer onions and weeds as well as susceptible crops that can act as alternative hosts.

Biological and alternative controls are investigated to reduce reliance on fungicides.

Trials are underway under the “A Lighter Touch” program4 in Pukekohe to evaluate seven biological and five synthetic alternatives for SLB control. These include biocontrol agents and novel chemistries.

Resistant onion varieties are not yet available.

3.2 Overview of Practices from other Countries

3.2.1 Minimise Crop Residues

Leaf debris and crop residues from onions, weeds and other host crops serve as a major inoculum source in the spring. A New York study[21] showed that onions grown where there is no onion leaf residue left, or where leaf residue from the previous crop was either buried or mechanically disrupted had a delay in the initiation of Stemphylium leaf blight. This indicates that getting rid of or reducing the amount of decaying leaf matter which could harbour the disease inoculum can reduce the incidence of disease in the following onion crop. The fact that a delay was achieved rather than compete freedom of SLB would have been due to spores coming in from other crops in the area. It is therefore important to use area-wide management of the disease.

3.2.2 Incorporate Non-Host Crops in the Crop Rotation

In two international studies both rye and barley plants were used as companion plants in onion cropping fields and were shown to be effective in the control of *Stemphylium* disease spread as no SLB was detected in the barley companion crop in onion fields[21] or in rye plants according to a study by University of Guelph, Ontario USA[22]. Grains may be a suitable cover crop following or preceding onions.

3.2.3 Integrate Companion or Cover Crops into the Cropping System

In a New York study by Hay[21], thrips were identified as a vector for the secondary spread of *Stemphylium vesicarium.* Thrip damage will produce entry points for the disease. Integrated Pest Management (IPM) approaches should therefore be adopted to control thrips and minimise the spread of *Stemphylium vesicarium*. Introducing companion planting e.g., in field margins to host beneficial insects which predate thrips, the vector of the disease has been suggested. Cover crops in neighbouring paddocks may be an alternative option.

3.2.4 Managing the Risk of Infected Seed

Airborne spores and infected crop debris are the main sources of SLB in onions and garlic. Seed contamination is a possible secondary pathway, particularly in dense plantings of seed production systems. Seed infection has not yet been confirmed for *Allium* crops. However, the fungus has been found in spinach[23] and oat seed[24].

S. vesicarium has been found infecting seed stalks of onions, which can reduce seed yield and quality[25]. This suggests a potential for seed contamination in seed production areas. According to the detailed study by Hay[21], the 1990 SLB outbreak in New York state was characterised by widespread foliar dieback across nearly all surveyed onion fields in the state. It was investigated whether contaminated seed played a role in this epidemic.

[21] Hay, F. *et al.* 2019. Emergence of Stemphylium Leaf Blight of Onion in New York Associated with Fungicide Resistance. Plant Disease Vol. 103, No. 12.

[22] Foster, J.M. *et al.* 2019. Susceptibility to *Stemphylium vesicarium* of asparagus, onion, pear, and rye in Canada. Can. J. Plant Pathol. 41(2): 228–241. Accessed via: tandfonline.com/doi/full/10.1080/07060661.2019.1574901.

[23] Spawton, K.A. 2024. Characterization of *Stemphylium* Species Associated with Stemphylium Leaf Spot of Spinach (*Spinacia oleracea*). Published Online 2 Dec 2024 Accessed via: apsjournals.apsnet.org/doi/10.1094/PDIS-10-23-2223-RE.

[24] Al-Salami, I. *et al.* 2025. First record of *Stemphylium vesicarium* associated with oat grains in Iraq: Phenotypic and molecular characterization. Microbial Biosystems 10(3) (2025) 2025.341985. Accessed here: mb.journals.ekb.eg/article_448805_aa5a337a0ee1f3e0a5e8f5b6d3a1ba69.pdf.

[25] UC IPM Pest Management Guidelines: Onion and Garlic UC ANR Publication 3453. Purple Blotch and Stemphylium Leaf Blight. Accessed here: ipm.ucanr.edu/agriculture/onion-and-garlic/purple-blotch-and-stemphylium-leaf-blight/#gsc.tab=0.

The study findings highlighted the following key points: SLB was first reported in New York in 1985, and the 1990 epidemic marked a significant increase in severity. The disease was sporadic in 1991 and 1992, and rare in 1993, suggesting environmental and agronomic factors played a significant role in the epidemic. The dominant inoculum sources were considered to likely be infested crop debris and airborne conidia, with no direct evidence linking seed as the cause of the epidemic. Fungicide resistance was identified as a contributing factor.

Still, for integrated control and prevention, seed is treated with fungicide prior to planting to reduce disease transmission via seed has been recommended.

4 Managing *Stemphylium* in Australia

4.1 Overview

The management strategies recommended overseas apply to Australian onion production. Note that in subtropical climates:

- Farm hygiene/biosecurity and debris removal are critical year-round. Healthy soils can break down crop residues quickly and reduce the risk of spore survival. Fungicide programs may need to start earlier and continue longer than in temperate climates because conducive conditions last over a long period.
- Weather-based forecasting should be implemented to consider humidity, leaf wetness, and temperature.

Although no single tactic will manage SLB, integrating several control practices can help onion growers to maintain crop quality while minimising economic losses due to the disease. Some key considerations are:

- Maintaining a healthy crop - Since the pathogen is likely to enter leaves that have been physically damaged or infected by other diseases, it is important to maintain healthy plant stands and control other common foliar diseases of onions such as downy mildew and botrytis leaf blight and thrips. Fungicides effective against purple blotch are also effective against SLB, but fungicides that control downy mildew do not always control SLB (e.g. Mancozeb).
- Avoid injuring bulbs during production. Do not overfertilise the onion crop with nitrogen because excessive N applications can increase SLB severity.
- Fungicide seed treatments (e.g. carbendazim, thiram, procymidone) are not effective in eradicating
- the SLB pathogen from onion seed. Hot water soaking seed at 50°C for 20 min reduced S. vesicarium in seed but germination was also reduced.
- Various disease forecast systems have been used or developed to predict incidence of diseases like SLB, with the goal of reducing the number of fungicide applications. Models such as Tom-Cast, STREP and FAST use the relationship between the duration of wetness or humidity and temperature to determine disease infection periods and to predict disease risk. They have not been trialed in Australia

Table 4 provides a summary of management strategies by crop stage.

TABLE 4 Overview of management practice to control Stemphylium leaf blight

Farm hygiene is always essential		**Do not leave onion or other host crop and host weed residues on the soil surface.** Apply biosecurity principles as per the *Onion Growers Biosecurity Manual*[26] to avoid transfer of disease inoculum between crops and farms with soil, water and wind.
Before planting	**Rotation planning**	• Rotation with non-host crops over 3-4 years.
	Soil testing	• Conventional soil test should be used to adjust nutrient levels and pH. *Refer to* the soil test interpretation guide at: soilwealth.com.au. • Soil DNA should be used test to assess risks of *Stemphylium* infection and that of other soilborne onion diseases.
	Nutrient budgeting and management	• Refer to the onion nutrient management guide. *Refer to* the onion nutrition guide here: soilwealth.com.au/wp-content/uploads/2025/07/Onion-Nutr-Guide_V2-230627-.pdf • **Guide:** Nitrogen (N) removal by an onion crop is about 2-4kg/tonne of onion bulbs. This means about 120–240kg N for a 60-tonne crop. Depending on the soil type, organic matter content and rotation, onion can get 'free' N from mineralisation of organic matter. This should be included in a nutrient budget. N may wash out of light soils due to heavy rain. Suitable soil testing can be used to measure available soil N.
	Soil preparation	• Prepare a suitable seedbed with a minimum number of passes to preserve beneficial soil life.
	Weed control	• Ensure weed hosts are not in the vicinity of the onion crop.
	Variety selection	• Use of seed from a 'clean' source and clean, certified transplants (e.g., for shallots or garlic) is recommended to avoid disease spread. • Look out for resistant or tolerant varieties.
	Seed treatment	• Use fungicide treated seed, if seed borne SLB is a concern.
In crop	**Seed Treatment**	• Registered fungicides are not effective. Hot water soaking seed at 50°C for 20 min reduced S. vesicarium in seed but germination was also reduced.
	Sowing date	• The sowing date affects the disease incidence of Stemphylium vesicarium. If possible, avoid crops growing during conditions that are conducive to the disease. This may be challenging in subtropical climates.
	Crop spacing	• Use a spacing and row direction that provides good airflow through the crop. Crop spacing of 60 x 45 cm showed the lowest incidence of Stemphylium blight in trials. However, the spacing has must be economically viable.
	Irrigation and drainage	• Avoid overhead irrigation late in the day or overnight to reduce leaf wetness. • Ensure paddocks are well drained and there is no compaction that reduces water infiltration. • Soil health management improves drainage.
	Monitoring / scouting	• Collect soil samples for DNA testing to identify risks. Follow sampling procedures provided by the laboratory. • Use weather-based forecasting models to predict outbreaks and to time fungicide applications. • Conduct regular scouting after conducive conditions that allow leaves to remain wet for more than 4 hours, especially at warm temperatures. • The optimum temperature range for sporulation is 15°C to 25°C but spores can develop at lower temperatures if leaves are wet for long enough.

[26] Accessed here: farmbiosecurity.com.au/wp-content/uploads/2019/03/Biosecurity-Manual-for-Onion-Growers.pdf.

In crop CONTINUED	**Nutrient management**	• Refer to the onion nutrition guide at: soilwealth.com.au/wp-content/uploads/2025/07/Onion-Nutr-Guide_V2-230627-.pdf • Overly high nitrogen rates can increase the susceptibility to fungal leaf diseases because it leads to lush, soft foliage. • Calcium strengthens cell walls which could help against leaf damage and infection.
	Diseases Fungicide resistance management	• Use a fungicide program that includes preventative measures and commences early enough in the season before conducive conditions happen, and symptoms appear. • *Refer to section 3.2.2* for resistance management information.
	Pests	• Control thrips well because they will cause entry wounds for fungal diseases including SLB (and can transmit virus diseases).
	Weeds	• Weeds can reduce air movement and increase relative humidity and leaf wetness duration. • Weeds can be alternative hosts for SLB.
	Spray application	• Ensure that the spray unit is set up correctly, water rate, ground speed and nozzles are suitable for good leaf coverage, and the unit is calibrated.
	Integrated crop protection (ICP)	• Integrated methods, a combination between cultural, biological and chemical methods work best when crop rotation is adequate and soil health is managed well.
	Biological control	• *Refer to section 3.2.3* for examples of biological control options.
Harvest	**Remove crop residues**	• Work crop residues in as soon as possible after harvest to prevent a new disease cycle.
After harvest	**Non-host cover crop or biofumigation crop**	• A good way to improve soil health and suppress diseases is to use suitable cover or biofumigation crops. • Refer to the many available resources on this topic at soilwealth.com.au.
Maintain or improve soil health - always		• **Soil health management principles are reduced tillage, controlled traffic/permanent beds, evening out differences in fertility across paddocks (precision ag) crop rotation, cover crops, balanced nutrition, reduce heavy machinery/truck traffic across the paddock as much as possible.** • **Install drainage and erosion control where needed.**
Area wide management		• **Get together with regional growers to practice area wide management to avoid wind borne infections occurring between farms.**

4.2 Integrated Approaches to Consider

4.2.1 Area-wide Management

Area-wide management of diseases like Stemphylium leaf blight (SLB) is essential to minimising incidence and severity of diseases outbreaks especially in warm climates. It involves coordinated efforts across multiple farms in a region to reduce disease pressure, prevent development of fungicide resistance and achieve long-term reduction of disease risks. In Australia, this approach is increasingly important due to SLB's persistence and spread in onion-growing regions like for instance the Lockyer Valley where the climate allows for much longer infection risk periods due to the conducive climate.

Key components of area-wide management for SLB control

Regional coordination

- Share disease warnings and management strategies among growers in the region.
- Consider barriers against prevailing winds in the landscape to intercept spores. However, barriers must allow enough air movement to dry leaves.

Monitoring / scouting and early detection

- Collect soil samples for DNA testing to identify risks ahead of sowing. Follow sampling procedures provided by the laboratory.
- Use weather-based forecasting models to predict outbreaks and time fungicide applications.
- Conduct regular scouting after conducive conditions that allow leaves to remain wet for more the 4 hours, especially at warm temperatures. The optimum temperature range for sporulation is 15°C to 25°C but spores can develop at lower temperatures if leaves are wet for long enough.

Rotation, farm hygiene / biosecurity

- Crop rotation for onions and other *Alliums* with non-host crops for three or more years (*Refer to section 2.4* – Alternative Hosts for other crops hosting SLB).
- Elimination of alternative weed hosts (*Refer to section 2.4* – Alternative Hosts for a list of weed hosts).
- Removal or working in of plant debris from any host crop after harvest to prevent survival of SLB in crop residues.
- Control of volunteer onions, shallots or garlic that can harbour the SLB.
- Implement farm biosecurity plans to lessen the risk of cross farm infection with SLB (and other diseases and pests carried by soil, water and wind).

Integrated crop protection (ICP)

Adopt a coordinated approach of combining chemical, cultural and biological control practices to treat the disease more successfully and cost effectively.

4.2.2 Biological Control

An option to support the control of *Stemphylium vesicarium* is the use of biological products.
An overview of biological products can be found at the Soil Wealth and ICP website soilwealth.com.au (biologicals database).

Benefits of biological control are:

- Environmentally friendly alternative to chemical fungicides.
- Reduces chemical fungicide use and associated resistance risks.
- Can be integrated into Integrated Pest Management (IPM) strategies.

Biological control products containing microbes (biocontrol agents)

These products contain live microorganisms. It is vital that they are fresh i.e., the microorganisms are alive. They must be used within the used by period according to label instruction. Below mentioned biocontrol agents have shown inhibition of Stemphylium vesicarium mycelial growth in trials where they were compared to other microbiological agents.

Fungal biocontrol agents

Trichoderma spp. (e.g., *Trichoderma harzianum*) is a fungal biocontrol agent that has been shown to reduce SLB incidence and severity while promoting onion growth and yield.[27]

A study showed that Trichoderma harzianum reduced SLB severity by 26% in Egypt[28]. and by 68% when applied prior to inoculation of S. vesicarium[29]. Abo-Elyousr[30] demonstrated the effectiveness of Trichoderma harzianum isolate 3013 and Stachybotrys chartarum isolate 2031 in reducing SLB severity under greenhouse conditions, with reductions comparable to synthetic fungicides.

In NZ 'Trichoderma harzianum' was most effective in in vitro trials, showing up to 85% growth inhibition of S. vesicarium. T. viride, T. hamatum, T. virens were also tested with moderate success.

Bacterial biocontrol agents

Pseudomonas fluorescens has been shown to be effective in reducing SLB severity and enhancing plant health.. Tested in onion trials it was less effective than Trichoderma but still provided some inhibition (around 53%). [27]

Bacillus subtilis can suppress SLB through antagonism and induced plant resistance.

Both, P. florescens and Bacillus subtilis reduced disease severity in field trials.

[27] journalarja.com

[28] Hussein, M.A.M. *et al.* 2007. Management of Stemphylium Blight of Onion by using Biological Agents and Resistance Inducers. Egypt. J. Phytopathol., Vol. 35, No. 1, pp. 49-60 (2007)

[29] Mishra, R.K, R.P Gutpa. In vitro evaluation of plant extracts, bio-agents and fungicides against purple blotch and Stemphylium blight of onion.

[30] Abo-Elyousr, K.A.M. *et al.* 2017. Control of Stemphylium Leaf Blight Disease of Onion and Elevation of Seed Production Using Certain Bioagents. International Journal of Plant Pathology, 8(1), 1-7. Accessed here: scialert.net/abstract/?doi=ijpp.2017.1.7

Biochemical based products with biocontrol potential

Biochemical based products used to stimulate the expression of defence mechanisms in plants have been successful in the partial suppression of SLB. One study showed a reduction of 40% of SLB when salicylic acid was applied as a foliar application[31].

Examples of extracts that may be able to reduce the use of synthetic fungicides are for instance:

- Neem (Azadirachta indica) oil is a botanical extract with antifungal properties, sometimes showing efficacy comparable to conventional fungicides.
- Jimsonweed (Datura stramonium) botanical extract has been shown to inhibit fungal growth under greenhouse conditions.

Mishra R.K. and R. P. Gupta[32] investigated plant extracts and bioagents against Stemphylium vesicarium. Table 5 provides an overview of biocontrol agents used in trials to suppress SLB and the effect of the best inhibitors in vitro.

TABLE 5 Overview of biocontrol agents for Stemphylium Leaf Blight (SLB)

AGENT	TYPE	MODE OF ACTION	EFFECTIVENESS/INHIBITION
Trichoderma harzianum	Fungus	Mycoparasitism, enzyme secretion, competition for space	Up to 85% inhibition in vitro
Trichoderma viride		Similar to T. harzianum	Moderate (50–70%)
Trichoderma hamatum		Antagonism, nutrient competition	Moderate
Trichoderma virens		Antagonism, volatile compounds	Moderate
Bacillus subtilis	Bacterium	Antibiotic production, induced systemic resistance	Good (60–70%)
Pseudomonas fluorescens		Antagonism, siderophore production	Lower (~53%)
Clove	Plant extract	Inhibition of mycelial growth	57.31%
Aloe vera		Inhibition of mycelial growth	47.15%

[31] Kamal A.M. 2007. Salicylic acid induced systemic resistance on onion plants against *Stemphylium vesicarium*.
[32] *Mishra, R.K. and R. P. Gupta 2012. In vitro evaluation of plant extracts, bio-agents and fungicides against Purple blotch and Stemphylium blight of onion. Journal of Medicinal Plants Research Vol. 6(45), pp. 5658-5661, 25 November 2012. Accessed here: academicjournals.org/JMPR*

4.2.3 Effect of Nutrition Management and Soil Health on SLB

Nutrition management can significantly reduce the risk of Stemphylium vesicarium infections in onion crops because plant health and disease susceptibility are closely linked to soil the nutrient balance. Proper nutrition supports root health, improving water uptake and reducing stress during dry periods. Stressed plants are more vulnerable to SLB. Balanced nutrients help maintain optimal leaf architecture, reducing prolonged leaf wetness which is a key factor for Stemphylium spore germination.

Plant stress e.g. due to water logging, dry soil or herbicide damage or nutrient imbalances or deficiencies can increase risk of infection.

Soil health is key to good nutrition and water access by onion crops. It supports beneficial mycorrhiza association with onion roots. Good soil health also assists in the fast breakdown of crop residues and this infection sources.

A practical recommendation is to conduct soil tests before planting and tissue or sap tests during crop growth. **It is important to monitor soil salinity (EC) and chloride levels in soils and in plant tissue or sap through regular testing.** Plants do not need much chloride (Cl). It is therefore important to avoid over-application without monitoring, as high chloride can cause salt stress in sensitive soils and crops. If chloride levels are low in plants, calcium chloride can be used as a foliar spray. At the right level in plants, chloride can assist in strengthening plant defence.

Potassium chloride, also called Muriate of Potash (KCl contains 46% chloride) or calcium chloride ($CaCl_2$) must be used in moderation and not when soils are saline (high in Cl).

Strengthening Plant Defence

Nitrogen (N)

Excess nitrogen promotes lush, soft foliage, which is more susceptible to fungal infection. Maintaining moderate nitrogen levels helps avoid overly dense canopies that trap moisture. Excess nitrogen later in the season must be avoided. The focus should be on potassium and calcium especially for bulb development and disease resistance.

Potassium (K)

Adequate potassium improves cell wall strength and stomatal regulation (plant water balance), reducing leaf wetness duration and making tissues less penetrable to fungal pathogens.

Calcium (Ca)

Calcium is essential for strong cell walls and membrane integrity. Strong cell walls reduce leakage of nutrients that pathogens exploit. Healthy membranes help maintain osmotic balance and reduce stress under adverse conditions. Calcium deficiency can lead to weak tissue that is easily invaded by fungi.

Calcium is involved wound healing and defense via activation of defense enzymes after infection. It helps plants respond quickly to pathogen attack by reinforcing cell walls at infection sites. Adequate calcium (but not too much improves uptake of other nutrients like potassium and magnesium, which also contribute to disease resistance.

Calcium nitrate or calcium chloride can be used as foliar sprays during bulb development. Excess potassium or magnesium can reduce calcium uptake. Monitoring of sap or tissue nutrient levels are the best way of getting nutrition right and save on expensive fungicides and other control methods.

Micronutrients

Zinc (Zn) and Manganese (Mn) can activate enzymes involved in plant defense responses.

If Silicon (Si) is applied it can strengthen epidermal layers and act as a physical barrier against fungal penetration.

Use foliar applications of micronutrients can be used just ahead of and during critical growth stages to boost defense.

Figure 5 provides on overview of key nutrients and their role in reducing Stemphylium susceptibility of onions.

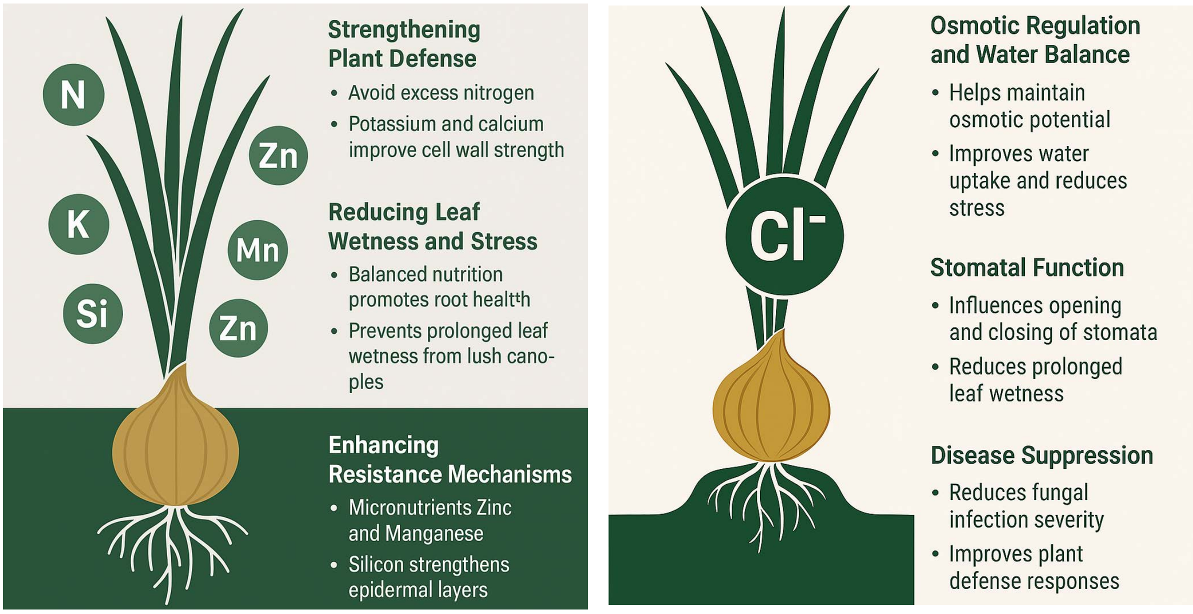


Figure 5: Key nutrients and their role in reducing Stemphylium susceptibility of onions. The benefits of optimum chloride (Cl).

Table 6 shows relative nutrient removal rates per tonne of onions harvested as a guide for nutrition management that helps to reduce the risk of infection.

TABLE 6: Nutrient Removal per tonne of onions

NUTRIENT	TYPE	REMOVAL PER TONNE OF ONIONS
Nitrogen (N)	Major nutrient element	2.50kg
Potassium (K)		3.5kg
Calcium (Ca)		0.6kg
Magnesium (Mg)		0.4kg
Sulphur (S)		0.5kg
Chloride (Cl)	Minor nutrient element	0.3kg
Zinc (Zn)	Trace element	5g
Manganese (Mn)		10g
Boron (B)		15g
Copper (Cu)		3g
Iron (Fe)		50g

5 Fungicide Resistance and Management

Fungicide resistance management is essential for SLB control and to avoid resistance. It is important to correctly identify the disease to choose the right products and strategies.

As *Stemphylium vesicarium* (SLB has a short asexual life-cycle (producing asexual spores followed by multiple generations of sexual airborne spores per cropping season, especially in warm climates. Having multiple generations of the fungus each year poses a high risk of developing fungicide resistance.

Once SLB diagnosis has been confirmed and to avoid resistance, fungicides with different modes of action (different FRAC group have to be rotated. The FRAC groups refer to the Fungicide Resistance Action Committee classification system, which categorises fungicides based on their mode of action i.e., how they affect fungal pathogens at the biochemical level.

FRAC groups help to rotate fungicides with different modes of action to reduce the risk of resistance development. Fungicide labels often include the FRAC code to guide proper usage. Product rotation by FRAC group supports integrated crop protection (ICP strategies.

Each fungicide is assigned a FRAC code (a number or letter) that represents its mode of action.

Table 7 provides an overview of FRAC groups and information relevant to SLB control. The fungicides listed are examples. Growers need to check product labels to ensure the fungicide they want to use is registered for the purpose of SLB control.

TABLE 7 FRAC groups, their mode of **action**, example fungicides, effectiveness against SLB and resistance status

FRAC GROUP	MODE OF ACTION	EXAMPLE FUNGICIDES	EFFECTIVENESS AGAINST SLB	RESISTANCE STATUS
7 (SDHI)	Succinate dehydrogenase inhibitors	Boscalid, Fluopyram	Effective when rotated properly	**Resistance reported in some regions**
9 (AP)	Anilinopyrimidines	Cyprodinil	Sometimes used in mixes	Low to moderate resistance risk
11 (QoI)	Quinone outside inhibitors (strobilurins)	Azoxystrobin, Pyra-clostrobin	Historically effective, now **less reliable**	**Widespread resistance globally**
M3 (Multi-site)	Multi-site contact activity inhibitors e.g., copper-based fungicides	Mancozeb	Useful in tank mixes for resistance management	**Low resistance risk**

Fungicide groups with reported resistance issues are:

- **QoI fungicides (FRAC 11):** Resistance is a growing concern globally and likely in Australia
- **DMI fungicides (FRAC 3):** May show reduced efficacy if used repeatedly.

Fungicide Rotation by FRAC Group is critical to prevent resistance. Repeated use of single-site fungicides (e.g., FRAC 11 - QoIs) should be avoided due to their reduced efficacy.

5.1 Fungicide resistance research in New Zealand

A large-scale national survey to investigate fungicide resistance in NZ was conducted by Plant and Food Research for Onions New Zealand Incorporated (Onions NZ) in 2024. For the survey, 18 onion fields in five production areas (Pukekohe, Matamata, Hawke's Bay, Manawatu and Canterbury) were sampled.[33] After sampling, 360 S. vesicarium isolates were tested with 13 fungicides from seven MOA groups.

Fungicide MoA (Mode of Action) groups categorize fungicides based on their biochemical mechanism for controlling fungi, such as inhibiting respiration or disrupting cell wall formation. These groups are assigned international letter and/or number codes found on product labels to help growers manage fungicide resistance. Rotating or mixing fungicides from different MoA groups is a key strategy to prevent fungi from developing resistance to a particular group.

An established agar-based growth assay was used to determine EC50 values (fungicide concentration that inhibits growth by 50%) for each isolate. High EC50 values indicate high resistance (low sensitivity) and low EC50 values indicate high sensitivity (low resistance).

The EC50 values were used in conjunction with field application rates of fungicide active ingredients from product label information to calculate the dose:EC50 ratio as an indicator of the degree to which resistance may be compromising disease control for each fungicide in each region. A high dose:EC50 ratio (e.g. > 1,000) implies potentially good disease control, and a low value (e.g. < 100) implies poor disease control.

Cross resistance of S. vesicarium to fungicide active ingredients within in the same MOA group was examined for the FRAC (Fungicide Resistance Action Committee) groups 2, 3, 7, and 9, for which more than one fungicide active ingredient per group was tested. Table 8 lists the fungicide FRAC group, its known resistance risk, the fungicide active ingredients tested and the products used.

TABLE 8 FRAC group resistance risks and fungicide active ingredients and products used for sensitivity tests

FRAC GROUP CODE & MODE OF ACTION	FRAC RESISTANCE RISK	FUNGICIDE ACTIVE INGREDIENT TESTED	PRODUCT USED IN SENSITIVITY TESTS
2 DCA	Medium to High	Procymidone, Iprodione	Sumisclex®, Ippon®
3 DMI	Medium	Difenoconazole, Propiconazole, Tebuconazole, Prothioconazole	Score®, Condor®, Hornet® 430 SC, Vitalis®
7 SDHI	Medium to High	Fluopyram, Fluxapyroxad	Luna® Privilege, Sercadis
9 AP	Medium	Cyprodinil, Pyrimethanil	Chorus®, Diva®
11 QoI	High	Azoxystrobin	Amistar®
12 PP	Low to Medium	Fludioxonil	Geoxe®
29	Low	Fluazinam	Pinnacle®

The degree of cross resistance was determined from correlations in EC50 values between pairs of fungicides within a group. Cross resistance in S. vesicarium was found to all the fungicides within each of groups 3, 7, and 9 but not within group 2 (procymidone and iprodione). This may have been because the very high sensitivity to procymidone (mean 0.12 mg/L) meant insufficient resistance was present to detect a correlation in relation to iprodione.

[33] Beresford R.M. and Wright P.F. 2024. Sensitivity of Stemphylium vesicarium to fungicides used for onion Stemphylium leaf blight control, 2023–24, Plant & Food Research August 2024

The diagram in figure 6 is a colour coded summary by region of dose EC50 ratios for all the fungicides tested in the NZ research.

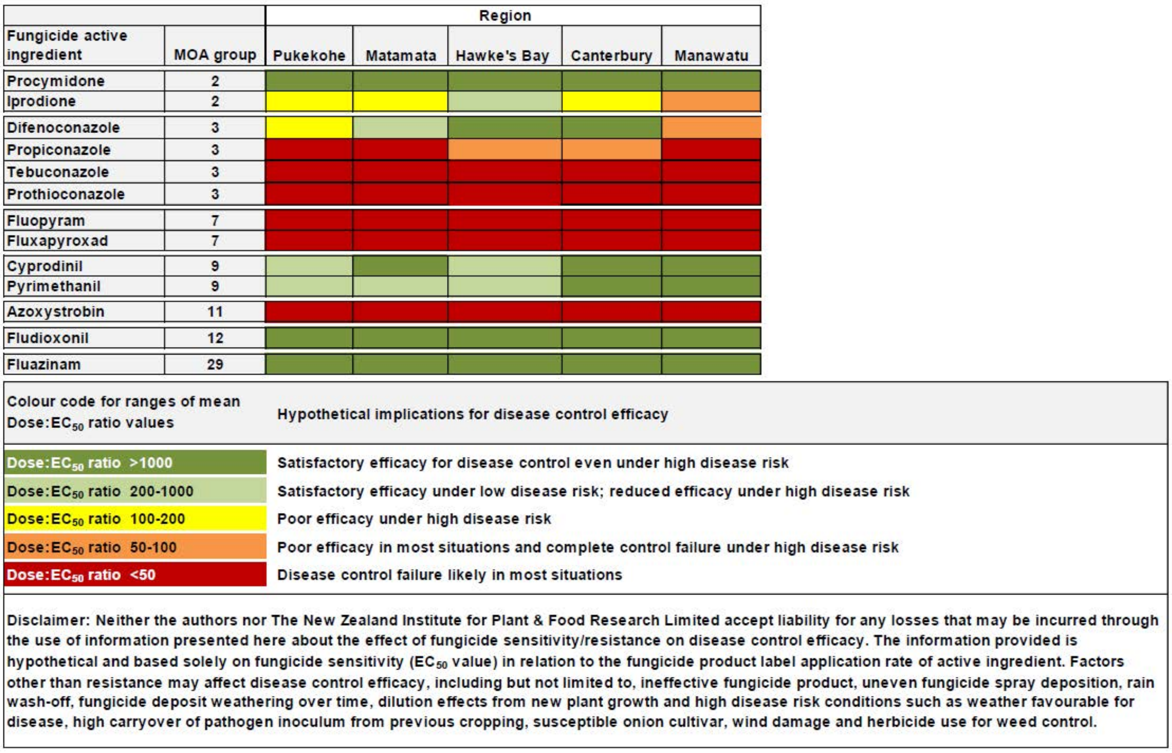


Figure 6: Colour coded summary by region of dose EC50 ratios for all the fungicides tested in the NZ research (courtesy of Vegetables NZ)

This research team concluded that all the Group 3 DMI, Group 7 SDHI and Group 11 QoI fungicides tested are severely affected by resistance in S. vesicarium in NZ. NZ onion growers should not rely on these groups for SLB control. The DMI, difenoconazole, was less affected by resistance than the other DMIs, particularly in Canterbury and Hawke's Bay.

Continued use of difenoconazole is likely to further increase resistance to it. There was complete loss of fungal growth inhibition everywhere by the QoI (Group 11, azoxystrobin). This loss of sensitivity was probably caused by a known resistance gene mutation that would also give resistance to other QoI active ingredients. Azoxystrobin and other Group 11 fungicides should not be used for SLB control.

The Group 2 DCA and Group 9 AP fungicides are expected to still have good efficacy but these MOA groups are still affected by resistance to some extent. The Group 12 PP (fludioxonil) and Group 29 (fluazinam) fungicides do not appear to be affected by resistance at all and should still provide reliable control of SLB.

This study indicates that the onion industry has lost three of the seven fungicide groups available for SLB control to resistance and two other groups are affected by resistance. This is concerning because it increases the reliance on the remaining MOA groups that are still effective and there is a risk that these may also succumb to resistance over time.

The research team advised that industry should be engaging in a serious discussion about viable alternative non-chemical strategies for disease management, and even strategies that may require changes to current onion production practices. The future sustainability of the industry is likely to depend on moving away from the current over reliance on resistance-prone chemical controls.

5.2 Fungicide resistance research in Australia

Current research by Metagen conducted in late 2025 and ongoing identified that Stemphylium vesicarium in the Lockyer Valley has genetic mutations that may impart fungicide resistance to group 11 and group 7 chemicals.

This was confirmed by lab testing results which demonstrated significantly reduced susceptibility to azoxystrobin, penthiopyrad, and chlorothalonil. Slight reduction in susceptibility to boscalid and fluopyram has also been demonstrated (Ben Evert, pers. com. Jan. 2026).

The research has been conducted as part of the ongoing project “Rapid test and fungicide resistant screening for Stemphylium leaf blight in onion” (Hort Innovation project code VN24003).

5.3 Recommended resistance management practices

Applying preventive fungicides regularly, ideally starting well before canopy closure and before conducive conditions appear

- Using multi-site fungicides (e.g., mancozeb, FRAC M3) in tank mixes to reduce resistance pressure
- Rotating fungicides between available FRAC groups where possible
- Avoiding consecutive applications of the same mode of action.
- Using multi-site protectants (e.g., mancozeb) in tank mixes to reduce resistance pressure.
- Managing alternate crop and weed hosts and thrips populations is essential, as thrips damage increases SLB infection risk
- Combining fungicides with cultural controls (e.g., crop residue removal/quick breakdown, crop rotation), soil health and area wide management.
- Annual sensitivity testing of fungal isolates is recommended to track resistance trends.

5.4 Fungicides registered for onions in Australia

At the time of preparing this scan (September 2025), 13 fungicides were registered for SLB control in Australia. Table 9 provides information about active ingredients, FRAC group and mode of action of registered fungicides for SLB control.

Resistance testing of registered fungicides is currently underway as part of the project "Rapid test and fungicide resistant screening for Stemphylium leaf blight in onion" (Project VN24003). Hort Innovation funds the project through the onion research and development levy and Australian Government contributions.

Metagen based in Gatton, Queensland is leading the research and testing (Dr Ben Evert). They are developing DNA-based diagnostic tools and conducting fungicide resistance screening. AUSVEG supports extension and communication to growers. Collaborators include agronomists and partners from Lockyer Valley Growers Inc.

The project develops rapid molecular diagnostics for Stemphylium leaf blight (SLB) and other onion pathogens. It uses genome sequencing to monitor pathogen diversity and resistance evolution. In vitro and field trials are conducted to assess fungicide efficacy. A national dataset on pathogen diversity and resistance profiles as well as extension materials and best-practice guidelines for growers and diagnostic labs are produced as part of the project.

TABLE 9 Active ingredients, FRAC group and mode of action of fungicides registered for SLB control in Australia*

ACTIVE INGREDIENT(S)	FRAC GROUP	MODE OF ACTION
Difenoconazole	3 (DMI)	Demethylation inhibitor (sterol biosynthesis)
Propiconazole	3 (DMI)	Demethylation inhibitor
Tebuconazole	3 (DMI)	Demethylation inhibitor
Pydiflumetofen	7 (SDHI)	Succinate dehydrogenase inhibitor
Boscalid	7 (SDHI)	Succinate dehydrogenase inhibitor
Fluopyram	7 (SDHI)	Succinate dehydrogenase inhibitor
Pyrimethanil	9 (AP)	Anilinopyrimidine (methionine biosynthesis inhibitor)
Cyprodinil	9 (AP)	Anilinopyrimidine
Azoxystrobin	11 (QoI)	Quinone outside inhibitor (strobilurin)
Pyraclostrobin	11 (QoI)	Quinone outside inhibitor
Mancozeb	M3 (Multi-site)	Multi-site activity (dithiocarbamate)
Metiram	M3 (Multi-site)	Multi-site activity
Chlorothalonil	M5 (Multi-site)	Multi-site activity (chloronitrile)

**At the time of preparing this document September 2025.*

[34] Kamal A.M. 2007. Salicylic acid induced systemic resistance on onion plants against Stemphylium vesicarium.

6 RD&E Suggestions

Onion growers in affected regions in Australia will benefit from information on the following:

- Stemphylium epidemiology in subtropical climates of Australia including:
  - how far spores travel to infect other crops
  - how many generations can the fungus go through in one onion season in different regions and what this means for control and avoiding fungicide resistance
- Fungicide resistance occurrence (in progress) - ongoing monitoring required
- Integrated and areawide management of Stemphylium
- Biological control agents and methods (products and programs) to support fungicide programs
- Soil and plant DNA testing (in progress)
- Forecasting, does it work?
- Getting rid of crop residues, and other hosts quickly, what is the best method in an integrated system?
- Benefits of cover crops to manage SLB
- The role of soil health and site-specific nutrition management for SLB risk, occurrence and severity
- Cost benefit of different management approaches in different regions.

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