Final report

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Optimising chemical and cultural control of onion white rot

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Public summary

Onion white rot, caused by the soilborne fungal pathogen *Sclerotium cepivorum*, is a major constraint of commercial onion crops in many regions of Australia. Strategies primarily used to manage onion white rot in Tasmania include cultural practices (crop avoidance, planting date) and protecting the growing crop with group 3 fungicides at planting and during the crop growing season. However, these strategies do not effectively manage disease outbreaks or provide a long-term solution to control of onion white rot.

This project was conducted to develop an integrated disease management strategy for onion white rot caused by *Sclerotium cepivorum*, primarily focusing on:

1. Development of a pre plant soil DNA test to identify disease risk prior to planting.
2. Evaluation of sclerotia germination stimulants to reduce disease inoculum levels prior to planting.
3. Improved understanding and efficacy of current fungicides in relation to disease epidemiology.
4. Identification of new fungicides and biologicals for disease control crop growth.

A new quantitative PCR assay was developed for the specific detection and quantification of onion white rot. The test has been made available to researchers, agronomists and onion growers as part of the PREDICTA Hort Veg pathogen DNA service provided by SARDI. Field validation of the test was conducted on 30 onion crops over three seasons to validate the test and develop thresholds for disease risk. The test will not only assist growers to determine disease risk prior to planting but will also assist in monitoring disease levels in response to different crop rotations and management practices over time.

A commercially available garlic extract (NemGuard 1280 g/L garlic extract) is currently registered for control of nematodes in vegetable crops in Australia. NemGuard was tested and compared to onion juice in laboratory and field trials as a potential germination stimulant for onion white rot sclerotes to reduce soil inoculum levels prior to planting onions. NemGuard did not reduce onion white rot levels in soil at the rates and timings tested.

Two fungicides have recently been registered in onions for management of onion white rot, Luna Experience (Fluopyram, group 7 + Tebuconazole, group 3) and Intuity (mandestrobin, group 11) which will offer growers two new fungicide groups (group 7 and 11) for management of onion white rot, in addition to the group 3 fungicides tebuconazole and triadimenol. This project has demonstrated both Intuity and Luna Experience provide effective control of onion white rot when used as part of an integrated management strategy. Tebuconazole at sowing should be considered the foundation treatment where onion white rot risk is present, as it provides important early in-furrow protection during crop establishment. A range of biologicals were also screened for their effect on suppression of onion white rot, root health and yield of onions. Their use may be most appropriate as part of an integrated program, particularly in lower to moderate risk paddocks or where the aim is to strengthen early root development, suppress disease and improve overall crop health.

Regular extension events and publications were conducted throughout the project to communicate results to the industry.

Technical summary

Onion white rot, caused by the soilborne fungal pathogen *Sclerotium cepivorum*, is a major constraint of commercial onion crops in many regions of Australia. Strategies primarily used to manage onion white rot in Tasmania include cultural practices (crop avoidance, planting date) and protecting the growing crop with group 3 fungicides at planting and during the crop growing season. However, these strategies do not effectively manage disease outbreaks or provide a long-term solution to control of onion white rot.

Cultural strategies to manage onion white rot in Tasmania include a combination of avoidance of known badly infected fields and late planting of crops. These strategies, however, have several drawbacks: 1) disease epidemics still occur in less badly infested fields in cool seasons despite this approach, although late planting reduces the risk of crop loss from a wet March and/or April harvest period, late planting reduces the proportion of crop available for exporting to European markets, as these require onions to be shipped between January and March. A a greater proportion of onions are being grown in the northern Midlands, as a means of avoiding onion white rot, even though soils are often poorly drained or contain an abrasive gravel component that reduces crop quality.

This project was conducted to develop an integrated disease management strategy for onion white rot caused by *Sclerotium cepivorum*, primarily focusing on:

1. Development of a pre plant soil DNA test to identify disease risk prior to planting.
2. Evaluation of sclerotia germination stimulants to reduce disease inoculum levels prior to planting.
3. Improved understanding and efficacy of current fungicides in relation to disease epidemiology.
4. Identification of new fungicides and biologicals for disease control during crop growth.

A new quantitative PCR (TaqMan MGB qPCR) assay was developed for the specific detection and quantification of *Sclerotium cepivorum*. The test has been made available to researchers, agronomists and onion growers as part of the PREDICTA Hort Veg pathogen DNA service provided by SARDI. The assay, targeting the internal transcribed spacer (ITS) genomic region was optimised based on publicly available sequence data and sequencing of cultures and DNA extracted from sclerotes isolated from onions sourced from Tasmania and Queensland. The assay specificity was assessed using a collection of DNA from the target and closely related species, including *Sclerotium rolfsii*, *Sclerotinia sclerotiorum*, *S. minor* and *S. trifoliorum*. The *S. cepivorum* assay efficiently detected pure DNA from the target and did not detect any of the other species assessed, indicating the assay is specific.

As part of the field validation of soil qPCR tests for *Sclerotium cepivorum* tests were conducted over 3 growing seasons, 2023-24, 2024-25 and 2025-26, within commercial onion crops. Each year 10 field sites were selected for pre-plant soil sampling and monitoring of diseases in the onion crops. When the average qPCR test result of four soil samples from a paddock exceeded 1 kDNA *S. cepivorum* per g soil this confirms a paddock has a moderate to high risk of onion white rot occurring. Reject bulbs due to onion white rot of 1-10% can be expected in most crops grown in these paddocks, even when protected with a program of fungicides. Disease became more noticeable and agronomically important above approximately 5 kDNA/g soil, while levels around 10 kDNA/g soil or higher represented elevated high-risk situations where substantial disease pressure could still occur despite fungicide protection. Testing allows growers and advisors to confirm disease risk, anticipate possible field outcomes, and make informed decisions about paddock selection, rotation planning, and the intensity of disease management required. Importantly, they also highlight that soil inoculum alone does not fully predict disease expression. Fungicide inputs, environmental conditions, crop management practices and within paddock variability all contribute to the final level of onion white rot observed at harvest.

Pre-plant soil testing showed that *S. cepivorum* inoculum was highly variable between paddocks and within individual paddocks. Some sites had no detectable onion white rot inoculum, while others recorded moderate to high levels. Large differences between subsamples within the same one-hectare area confirmed that onion white rot inoculum is often patchy, which means a single aggregate soil sample can miss localised disease hot spots. In contrast, *Setophoma terrestris*, the pink root pathogen, was more widespread and generally present at higher and more consistent levels across most sites. *Fusarium oxysporum f. sp. cepae* was not detected in the soil samples tested.

A commercially available garlic extract (NemGuard 1280 g/L garlic extract) is currently registered for control of nematodes in vegetable crops in Australia. NemGuard was tested and compared to onion juice in laboratory and field trials as a potential germination stimulant for onion white rot sclerotes to reduce soil inoculum levels prior to planting onions. NemGuard did not appear to reduce sclerotia recovery, viability, or soil DNA levels. Minor increases in kDNA observed in some treatments were small, inconsistent, and statistically non significant. Overall, NemGuard did not suppress onion white rot inoculum at the rates and timings tested. It is important to note that qPCR assays for *Sclerotium*

cepivorum quantify total pathogen DNA and cannot distinguish between viable and non viable sclerotia. The assay detects DNA originating from living sclerotia, dead or dying sclerotia, fragmented sclerotia, and residual mycelial material in soil. As a result, qPCR measurements may not accurately reflect true changes in sclerotia viability or germination in the absence of an Allium host. Apparent stability or even slight increases in kDNA levels following NemGuard application should therefore be interpreted cautiously, as they may represent persistence of non viable DNA rather than a lack of biological decline in inoculum.

Biological products based on *Bacillus* spp., *Trichoderma* spp. and *Streptomyces* spp. showed some potential to improve root health, but performance was variable and appeared to depend on disease pressure and soil conditions. Biological treatments were most promising where they shifted onions into healthier categories, particularly bulbs with no or mild root rot symptoms. This suggests they may help reduce background root disease and improve root and bulb condition. Biological products should be positioned primarily as root health and soil biology support tools rather than stand-alone onion white rot control treatments. Their performance is likely to be greatest under warmer, biologically active soil conditions where beneficial organisms can establish, multiply and interact with the onion root zone. Under these conditions, biologicals may help promote root vigour, improve rhizosphere activity and support plant resilience against soilborne disease pressure. Their use may be most appropriate as part of an integrated program, particularly in lower to moderate risk paddocks or where the aim is to strengthen early root development and overall crop health.

At the commencement of this project growers were reliant on group 3 fungicides for control of onion white rot. Recently Luna Experience (Fluopyram, group 7 + Tebuconazole, group 3) and Intuity (mandestrobin, group 11) have both been registered for control of onion white rot. Field trials conducted over multiple seasons showed post emergence fungicide programs which included Luna Experience and Intuity performed similarly to the Allitron (triadmenol, group 3) only programs, indicating that these products will provide useful rotation options within integrated onion white rot management programs. However, these post emergence fungicides should be used to complement the tebuconazole application at planting rather than replace it. In trials in moderate to high disease pressure sites where tebuconazole was excluded, early post-emergent applications of Luna Experience and other fungicides provided some disease suppression but were less consistent than tebuconazole at sowing. The fungicide trials confirmed the importance of tebuconazole applied at sowing as the foundation treatment for onion white rot suppression. Programs based on tebuconazole-treated Microstar generally improved bulb health and reduced the proportion of onion white rot affected bulbs compared with untreated controls. Follow-up post-emergent fungicide programs also contributed to disease suppression, with products such as Luna Experience, Intuity and Allitron evaluated in different seasonal and site contexts. The results indicate that program performance should be assessed not only by total marketable yield, but also by the proportion and yield of healthier bulbs, because onion white rot affected onions may remain marketable after drying but can still represent increased quality and storage risk.

As onion white rot infection occurs below ground, the optimal efficacy of post emergent fungicide sprays may depend on sufficient soil moisture to move the active ingredient to the basal plate and developing roots. Allitron is usually applied by boom spray before rainfall or irrigation to move the active ingredient into the soil, but the optimal timing of irrigation after application can be difficult to achieve in commercial practice. There was no significant difference in the irrigation timing with Allitron treatments, sprays applied 3 days prior to irrigation were as effective as irrigation after sprays on the same day although numerically the plots treated with Allitron at 0 or 1 days before irrigation had a higher yield of onions with healthy roots than Allitron applied 3 days prior to irrigation. There was also no significant improvement when comparing Allitron applied with Transformer soil conditioner over Allitron by itself. Allitron applied with Stream jet nozzles was equivalent to flat fan nozzles, in reducing root rots.

Overall, the project demonstrates that onion white rot management requires an integrated approach combining representative pre-plant soil testing, paddock history and risk classification, targeted fungicide use, careful monitoring and long-term crop rotation planning. Soil qPCR testing is a valuable planning tool, but its accuracy depends on sampling strategy and the patchy distribution of inoculum. Fungicide programs can substantially suppress disease expression, but they do not eliminate risk in paddocks with moderate to high inoculum levels. Biological products may support future integrated strategies, but further validation is required before they can be recommended as primary control options. For growers, the key practical outcome is that paddocks with detectable or increasing *S. cepivorum* levels should be managed proactively using test-informed risk thresholds, strengthened fungicide programs where appropriate, and continued monitoring through to harvest.

Keywords

Onions, Onion white rot*, Sclerotium cepivorum,* fungicides, biologicals, germination stimulants, qPCR.

Introduction

Onion white rot, caused by the soilborne fungal pathogen *Sclerotium cepivorum*, is a major constraint of commercial onion crops in many regions of Australia. The pathogen is established in all Australian states except WA (Plant Health Australia). In Tasmania ca. 80% of land sown to onions annually is infected with the pathogen (Pung, H. 2008) with crop losses of 10-30% attributed to the disease (Villalta et al., 2005). Crop production is also potentially reduced as fields that were previously heavily infected with the pathogen are not normally planted with onions (Wilson et al. 2018). Strategies primarily used to manage onion white rot in Tasmania include cultural practices (crop avoidance, planting date) and protecting the growing crop with group 3 fungicide spraying regimens. However, these strategies do not effectively manage current disease outbreaks or provide a long-term solution to control of onion white rot.

Cultural strategies to manage Onion white rot in Tasmania include a combination of avoidance of known badly infected fields and late planting of crops. These strategies, however, have several drawbacks: 1) disease epidemics still occur in mildly infested fields in cool seasons despite this approach, 2) late planting reduces the risk of crop loss from a wet March and/or April harvest period, 3) but late planting reduces the proportion of crop available for exporting to European markets, as these require onions to be shipped between January and March and, 5) a greater proportion of early sown onions are being grown in the northern Midlands, as a means of avoiding onion white rot, even though soils are often poorly drained or contain an abrasive gravel component that reduces crop quality.

A potential long-term solution for onion white rot is to develop a management package that reduces populations of the soil borne pathogen prior to planting an onion crop and targeting in-season fungicide applications to the crop according to pathogen activity and environmental conditions.

Sclerotium cepivorum produces sterile mycelium and sclerotia within the soil. Sclerotia can remain dormant and survive more than 20 years in soil without the presence of a host. Sclerotia germination is triggered by exudation of sulphoxides from the roots of Allium crops; these are metabolised by soil microorganisms to produce volatile thiols and sulphides, the compounds that activate the dormant sclerotia (Coley-Smith 1969). Diallyl sulphide (DADS), the sulphide bio-stimulant that activate sclerotia, can be produced synthetically as a by-product from petroleum refining and has reduced sclerotia populations and/or onion white rot incidence in New Zealand, Australia and the USA. However, the adoption of synthetic DADS has been hampered by a lack of consistent supply, high cost of registration, logistics and/or cost of treatment.

Alternative bio-stimulant compounds, such as those found in garlic and onion products, have been effective in reducing sclerotia populations of *S. cepivorum* in soil in the absence of Allium crops in Australia and California; however, the efficacy of these products has varied depending upon the quality of the compound. For example, the effectiveness of alternative bio-stimulants (dehydrated garlic powder and liquid garlic extract) under field conditions were positive under low and moderate sclerotia density in onion crops in Victoria (project VN05009); however, results were mixed under high sclerotia density. Environmental conditions (low soil moisture) and timing of bio-stimulant applications were suggested as reasons for mixed results under high sclerotia density. Repeated applications of bio-stimulants over two or more years were suggested, depending upon initial sclerotia populations and bio-stimulant concentrations, for effective control of disease.

Maintaining sufficient concentration of bio-stimulant compounds within the soil for a sufficient interval, to simulate the effect of a growing onion crop, may be required to achieve effective germination of sclerotia. Stimulating germination of sclerotia in the soil prior to planting of onion crops may reduce in-season disease pressure, and as such, enable in-season fungicides to better manage disease outbreaks.

In-season fungicide programs are currently a valuable short-term strategy for management of Onion white rot. The fungicides are thought to help manage the disease by temporarily inhibiting mycelial growth of *S. cepivorum* such that 1) the rate of initial infection from sclerotia is reduced, 2) disease progression upwards and towards the bulbs is inhibited or reduced and/or 3) the rate of root-to-root spread of mycelia is inhibited or reduced (Pung, H. 2008). Hence, maintaining an effective concentration of fungicide in the relevant root zone during fungal activity was suggested as a potential key to effective control.

The findings from project VN14001 showed the risk of onion white rot developing in onion plants was primarily determined by the prevalence of inoculum in the top 100 mm of soil (Wilson et al. 2018). Furthermore, most onion roots (>80%) were found within the top 100 mm of soil in commercial crops. However, disease incidence decreased in the top 50 mm of soil during hot weather conditions, where it was suggested that higher soil temperatures may have killed or reduced mycelia growth of the pathogen. In contrast, pathogens present at greater depth may have survived higher soil surface temperature and caused late infections of bulbs. Project VN14001 recommended further research to determine the effect of elevated temperatures on sclerotial germination and survival and fungal activity.

A key finding of VN14001 was that targeting the appropriate root zone with fungicides by irrigating the fungicide into the soil has the potential to increase the effectiveness of fungicide applications and reduce the incidence of bulb infection. However, the effect of environmental conditions, i.e., rainfall duration and intensity, and soil condition i.e., type and profile on fungicide efficacy is not well understood i.e., do high rain intensity leach triadimenol more than the less water soluble tebuconazole. VN14001 recommended further research to evaluate the effectiveness of fungicide applications in this target zone, and to determine the effective dose.

Methodology

1. Development of DNA assay for *Sclerotium cepivorum*

A new quantitative PCR (TaqMan MGB qPCR) assay was developed for the specific detection and quantification of *Sclerotium cepivorum*. The assay is based on that of Woodhall et al. (2012). The assay, targeting the internal transcribed spacer (ITS) genomic region, was optimised based on publicly available sequence data and sequencing of cultures and DNA extracted from sclerotes isolated from onions sourced from Tasmania and Queensland.

The assay specificity was assessed using a collection of DNA from the target and closely related species, including *Sclerotium rolfsii*, *Sclerotinia sclerotiorum*, *S. minor* and *S. trifoliorum*. The *S. cepivorum* assay efficiently detected pure DNA from the target and did not detect any of the other species assessed, indicating the assay is specific.

To enable assessment of soil and plant samples a calibration standard was prepared to convert qPCR results into amount of target DNA per gram sample (kDNA per g sample).

Detection of *S. cepivorum* was confirmed in diseased onion tissue collected from the field and infected soil samples using the developed assay. The test has been made available to researchers, agronomists and onion growers as part of the PREDICTA Hort Veg pathogen DNA service provided by SARDI.

2. Field validation of soil qPCR tests for soilborne onion diseases (*Sclerotium cepivorum* and *Setophoma terrestris*)

Tests were conducted over 3 growing seasons, 2023-24, 2024-25 and 2025-26, within commercial onion crop sites. Each year 10 field sites were selected for pre-plant soil sampling and monitoring of diseases in the onion crops. For logistical purposes, at all sampling sites pre-plant soil samples were collected in winter, onion crops were sown in spring, and onions were assessed for root or bulb diseases in summer.

Soil samples were collected from a one square hectare area (100 m x 100 m) within a selected site. The area selected was relatively homogenous in soil type, drainage and even slope.

Pre plant soil sampling involved collecting 30 soil cores in a W shaped transect across the 1 ha assessment area. Each core was taken to a depth of 15 cm using a soil auger. The 30 cores were combined to form an approximate 10 kg composite sample, which was thoroughly mixed before subsampling, approximately 500 g for submission to SARDI for qPCR analysis. This entire sampling procedure was repeated four times within the same 1 ha block to assess how consistently pathogen levels were distributed across the paddock and to quantify within site variability in the soil bioassays.

Onion crops were sown and managed as per grower standard practice with tebuconazole applied at sowing, followed by regular pest and disease management, nutrition, irrigation and other agronomic inputs.

Prior to commercial lifting of onions at maturity, 50 onions were lifted from each of four areas within the one hectare area where soil was sampled. Onions were topped and the bulbs and roots were examined and graded into the following categories, healthy bulbs and roots, healthy bulbs with mild root rots, healthy bulbs with severe root rots, onion white rot affected bulbs (marketable) and onion white rot reject bulbs (unmarketable). The incidence of onion bulbs found in each of the five categories was tabulated.

3. Sclerotia Germination Stimulants - Laboratory tests

Onion white rot sclerotia were produced by artificially inoculating onion bulbs in the laboratory. Sclerotia were conditioned for 6–8 weeks in nylon bags buried in soil or potting mix, then collected for use in laboratory and pot trials. For germination assays, batches of 30 sclerotia were placed in nylon bags containing fine sand and buried 5–12 cm deep in loam soil in 2 L mason glass containers (total soil depth 27 cm). In treated soil, NemGuard solution was mixed into the soil. In untreated control, only water was applied. All containers were incubated at 18 °C for 56 days or 8 weeks, with soil moisture maintained near field capacity.

After incubation, bags were retrieved and intact sclerotia was recovered and counted as viable sclerotes. The solid sclerotes was also surface sterilised and plated onto potato dextrose agar discs (20 mm diameter), incubated at 17 °C and assessed after 5-14 days for saprophytic germination and growth.

4. Sclerotia Germination Stimulants - Pot trial

A controlled pot trial was conducted outdoors at Moriarty to evaluate the effect of NemGuard liquid applications on *Sclerotium cepivorum* soil DNA levels under high inoculum pressure. Soil was uniformly infested to 1×10^4 kDNA/g at trial establishment (9 October 2024), and treatments were applied twice, on 9 October 2024 (Application A) and 18 September 2025 (Application B). NemGuard liquid was applied at 2.5, 5.0, 10, and 2.0 L/ha, and an onion juice treatment (1.25 L/ha) was included for comparison; an untreated control received no product. Soil samples were collected at 112 days after Application A (112 DAAA) and 145 days after Application B (145 DAAB), and *S. cepivorum* DNA was quantified using qPCR assays conducted by SARDI.

5. Sclerotia Germination Stimulants - Field trials

Two field trials were established in commercial fields that were naturally infested with *S. cepivorum*. The two sites selected had a history of severe onion white rot disease on onion crops. NemGuard Liquid was applied at 2.5, 5, and 10 L/ha as broadcast sprays with a backpack pressurized sprayer onto cultivated soil and then incorporated 20 cm deep with a rotary hoe. Plot size was 10 m x 4 m, with 6 replicates in a randomised complete block design.

NemGuard Liquid was applied once at Kindred on 24 April 2025 and at Sassafras on 31 October 2025. Soil samples were collected 0 days after application (0DAA), 127 and 341 DAA at Kindred, and -1 and 147DAA at Sassafras and *S cepivorum* DNA was quantified using qPCR assays conducted by SARDI.

6. Fungicide Carriers

A field trial was conducted at the TIA Vegetable Research Facility at Forthside, Tasmania, in 2023–24 in a red onion crop to evaluate granular carriers for tebuconazole delivery at sowing. The trial compared tebuconazole applied on Microstar carrier vs Attapulgite carrier, with and without subsequent post-emergence fungicide applications. The site was inoculated with onion white rot sclerotia before sowing by spreading inoculum and incorporating it with a rotary hoe. Tebuconazole was film-coated onto either Microstar fertiliser granules or attapulgite clay granules and applied at sowing just below the seed using an onion seed drill. The Forthside trial was arranged as a randomised complete block design with six replicates. The carrier treatments were compared with an untreated control and with treatment programs that included post-emergence fungicide applications. The post-emergence program included Luna Experience, Intuity and Allitron. Harvested bulbs were sorted into healthy disease free bulbs, onion white rot affected but marketable bulbs, and onion white rot reject bulbs. Total onion white rot affected bulbs and total yield were calculated. Statistical analysis was conducted using analysis of variance and Fisher's protected least significant difference test.

7. Alternative Post Emergence Fungicide Screening

Two field trials were conducted in commercial onion crops at Forthside and Table Cape during the 2021–22 season to evaluate alternative fungicides for crop safety and efficacy against onion white rot and associated root rots. All plots, including the untreated control, received tebuconazole-treated Microstar fertiliser at sowing, reflecting the current commercial standard for early onion white rot protection.

The trial compared the commercial standard Allitron 375 SC with several alternative fungicide products and programs, including Luna Experience 400 SC, Luna Experience plus Serenade Soil Activ, Intuity 250 SC, GF-4536 100 SC plus Maxx adjuvant, EXP 1, EXP 3, EXP 2, and a program of Luna Experience followed by Allitron followed by EXP 3. Products were applied at the rates listed in the results table.

Three post-emergent foliar sprays were applied before rainfall or irrigation using AirMix 110-02 air induction flat fan nozzles in a spray volume of 273 L/ha. At Forthside, applications commenced 36 days after sowing, with subsequent applications at 28 and 29 days after the previous application. At Table Cape, applications commenced 56 days after sowing, with subsequent applications at 22-day intervals. Onion bulbs were harvested and assessed for average bulb weight, yield of healthy onions, yield of marketable onions with root rots, and total marketable yield. There were negligible levels of rejected onions due to severe onion white rot infections. Data was analysed statistically using LSD comparisons at P = 0.05, with transformed data used where required.

8. Post Emergence Fungicide Programs – Intuity and Luna Experience

Two post-emergent fungicide trials were conducted in commercial onion crops in Tasmania during the 2022–23 season to evaluate new fungicide programs for control of onion white rot, caused by *Sclerotium cepivorum*. The trials were conducted at Latrobe and Moriarty in paddocks with a history of onion white rot. Both trials compared new post-emergent fungicide programs based on Luna Experience and Intuity against the industry standard program of three Allitron applications and an untreated control.

The two trials were arranged as a randomised complete block design with five replicates in the Latrobe trial and four replicates in the Moriarty trial. Tebuconazole was applied across the whole trial area at sowing with Microstar PMX micro-granular fertiliser as the carrier in both trials (Tebuconazole in Microstar, Application A). Post-emergent fungicide treatments were applied at three timings, beginning 96 days after sowing at Latrobe and 62 days after sowing at Moriarty. Applications B, C and D were made at approximately 1 month intervals, timed before rainfall or irrigation to assist movement of products into the soil zone for root disease control. All post-emergent fungicide treatments were applied as broadcast sprays in 280 L/ha water using an air-pressurised backpack sprayer fitted with TeeJet AIXR 110 02 flat fan nozzles. Applications were made under suitable conditions before rainfall or irrigation so products could be washed into the soil profile for root disease control.

PCR soil tests were carried out to determine levels of *Sclerotium cepivorum* and *Septophoma terrestris* in the trial areas, and at harvest, onions were assessed for onion white rot on bulbs and marketability. Above-ground onion white rot symptoms were not observed during the crop growth phase, and the disease was only evident on lifted bulbs and roots at harvest.

9. Post Emergence fungicide programs without tebuconazole at planting

Onion field trials aimed to evaluate alternative fungicide programs for crop safety and efficacy against onion white rot and associated root diseases, including pink root, were compared with the current commercial standard of tebuconazole applied on Microstar at sowing followed by post-emergent fungicide applications. The trials also assessed whether Luna Experience applied as an early post-emergent spray drench after onion seedling emergence could replace tebuconazole at sowing, and whether EXP 3 could provide an alternative post-emergent fungicide option for onion white rot control and fungicide resistance management.

There trials were conducted over two seasons within commercial onion crops. Two field trials were conducted in red onion crops cv. Cabernet in Tasmania during the 2023–24 season. One trial was located at Forthside and the second at Forth. A further field trial was conducted at Forthside, Tasmania, during the 2024–25 season in a commercial brown onion crop cv. Trailblazer.

All trials were arranged as randomised complete block designs with five replicates. Tebuconazole on Microstar was applied at sowing as Application A in the relevant treatments. Luna Experience was applied at approximately 33–44 days after sowing as Application B where included. Follow-up post-emergent fungicide applications were applied at 20–28 day intervals as Applications C, D and E.

Post-emergent treatments were applied as broadcast spray drenches in approximately 267 L/ha water using an air-pressurised backpack sprayer fitted with TeeJet AIXR 110 02 flat fan nozzles. Rainfall or irrigation was used after application to wash fungicides into the soil and root zone. At harvest, onions were lifted and assessed for root rots, onion white rot on bulbs, bulb marketability and yield. Onion foliage was examined after spray applications for signs of phytotoxicity, leaf discolouration or other crop injury.

10. Evaluation of biologicals for root health and onion white rot control

Four field trials were conducted in commercial onion crops in Tasmania during the 2024–25 and 2025–26 seasons to evaluate biological products and fungicide programs for suppression of onion white rot and associated root rots. Trial sites were in paddocks with a history or presence of severe onion white rot, with two trials conducted at Sassafras and two at Forthside. The trials were established to compare the performance of biological products used alone, fungicide standards, and integrated programs that included tebuconazole applied at sowing. Treatments varied between trials but generally included an untreated control, post-emergent biological products, post-emergent fungicide programs, tebuconazole at sowing, and combinations of tebuconazole with subsequent biological or fungicide applications.

In the 2024–25 season trials, the Sassafras trial was set up without tebuconazole applied at sowing, while in the Forthside trial, tebuconazole was applied across the trial area at sowing, to evaluate whether post-emergent biological products provided additional benefit.

The 2025–26 season trials at both locations but different paddocks included comparisons with and without tebuconazole at sowing to separate the contribution of a sowing treatment from later biological or fungicide applications. Field trials at Forthside and Sassafras were conducted within commercial onion crops to evaluate various biological products for the control of onion white rot and root rots, with or without tebuconazole at sowing. At each site, the trial consisted of two distinct blocks in a randomised complete blocks with 5 replicates. One block received no tebuconazole soil treatment at sowing, while the other block received a tebuconazole soil treatment at sowing. As a result, the experiment functioned as two separate randomized complete block trials, each with five replicates. The two trials were analysed independently and are presented as the trial without tebuconazole and the trial with tebuconazole.

Products were applied according to the treatment schedules specified for each trial. Tebuconazole treatments were applied at sowing where included (Application A), while biological and post-emergent fungicide treatments were applied after crop emergence at scheduled timings (Applications B-E). Standard commercial crop management practices, including irrigation, nutrition, weed control and other pest and disease management, were maintained by the grower except where treatments formed part of the trial protocol.

At harvest, onion bulbs from each plot were assessed for disease, marketability and yield. Root health was assessed by grading bulbs according to healthy onion bulbs with no root rot, mild root rot or severe root rot. Onion white rot affected bulbs and bulbs rejected due to severe onion white rot were recorded to determine treatment effects on disease suppression and marketability. Treatment effects were interpreted using the trial-level statistical analysis, with emphasis on differences in onion white rot incidence, severe root rot, healthy onion categories and marketable yield. Crop safety was assessed visually during the season, including checks for phytotoxicity.

11. Effect of application methods and irrigation timing on efficacy of triadimenol

At Forthside, Tasmania, in 2021-22, a field trial was conducted within a commercial onion crop cv. Redstone to examine the effects of spray timing and types of nozzles on the efficacy of Allitron 375 SC for the control of onion white rot (*Sclerotium cepivorum*). Allitron 375 SC at 1 L/ha was applied at 3, 1 or 0 day prior to rainfall or irrigation, with TeeJet AIXR 110-02 flat fan nozzles or StreamJet nozzles. Allitron also applied with Transformer soil conditioner at 5 L/ha once in Application A to determine if the soil conditioner may have improved spray solution penetration and distribution and hence improve disease control. The trial design wasa randomised complete blocks with 5 replicates. The onion crop was sown in September 2021 and tebuconazole was applied at sowing with Microstar PMX micro-granular fertiliser as a carrier, for early onion white rot control, as per the commercial standard in the whole trial area. All fungicide treatments were then applied at three timings (A, B and C) commencing 36 days after sowing (0 days after application A (0DAAA), 28DAAA and 29DAAB. Sprays were applied in a spray volume of 273 L/ha with TeeJet AIXR 110 02 flat fan nozzles or 263 L/ha with Stream Jet nozzles.

Details of biologicals and fungicides evaluated in the trials

Product name	Active ingredient (ai)	Concentration of active ingredient	Formulation	Fungicide Group
ACB-LM200	*Trichoderma atroviride*	5 x 108 cfu/g	Wettable powder	BM02
Actinovate	*Streptomyces lydicus*	1x107 cfu/g	Wettable powder	BM02
Allitron 375 SC	triadimenol	375 g/L	Suspension concentrate	3
F4018 87.7 SC	Bacillus spp	87.71 g/L	Suspension concentrate	BM02
F4034 100 SC	*Bacillus* spp	100 g/L	Suspension concentrate	BM02
GF-4536 100 SC	GF-4536	100 g/L	Suspension concentrate	21
GO Isolates®	*Bacillus amyloliquefaciens* *Bacillus subtilis*	1 x 108 cfu/mL 1 x 106 cfu/mL	Suspension concentrate	BM02
ISOGREEN®	*Bacillus amyloliquefaciens* *Bacillus subtilis* Microalgae Humic acid fulvic acid	1 x 103 cfu/mL 1 x 103 cfu/mL 3 x 103 cfu/mL 2% 1%	Suspension concentrate	BM02
Intuity 250 SC	mandestrobin	250 g/L	Suspension concentrate	11
Luna Experience 400 SC	fluopyram + tebuconazole	200 + 200 g/L	Suspension concentrate	7 & 3
EXP 2	Confidential	Confidential	Confidential	7 & 12
EXP 1	Confidential	Confidential	Confidential	11 & 7
Rhizovital 42	*Bacillus velezensis* strain FZB42	2.5 x 1013 spores/L	Suspension concentrate	BM02
EXP 3	fluxapyroxad	300 g/L	Suspension concentrate	7
Serenade Soil Activ	*Bacillus amyloliquefaciens* strain QST 713	3.0 x 1013 cfu/L	Suspension concentrate	BM02
Tebuconazole	tebuconazole	430 g ai/ha	polymer coated onto 30 kg/ha Microstar fertiliser granules	3
Transformer Soil Conditioner	alcohol ethoxylate	194 g/L	Liquid	NA
Turboroot	Humic, amino acid & EDTA chelated nutrients	N/A	Water soluble granules	NA
Wiibio OR-623	Calcium oxide and *Bacillus subtilis*, organic matter and rhizogenic substances	N/A	Soluble concentrate	BM02

Photos

Photograph 1 and 2. Healthy onions (left) and rejected onions due to severe onion white rot on the bulbs (right). Photos taken by Hoong Pung on 3rd January 2023.

Photograph 3. Pink root (*Septophoma terrestris*) affected roots. Photo taken by Hoong Pung on 18th February 2022.

Results and discussion

1. Calibration of *Sclerotium cepivorum* qPCR test

Three spiking trials were conducted to calibrate the qPCR test developed by SARDI for *Sclerotium cepivorum* from kDNA per g soil to sclerotia per 200 g sterile soil, Table 1. Sclerotia produced in culture from a Tasmanian and a Queensland *S. cepivorum* isolate along with sclerotia from diseased bulbs out of storage (Tasmania) were added to sand at 1, 2 (10 replicates) and 4, 8, 16, 32 (4 replicates) sclerotia per 200 g sand.

Sclerotia of *S. cepivorum* obtained from culture were larger and more consistent than those from infected bulbs. This resulted in a stronger relationship (r2 = 0.96 and 0.76) between the number of sclerotia added and the qPCR result for the cultured sclerotia from Tasmania and Queensland respectively compared with the naturally produced sclerotia (r2 = 0.70), Figure 1.1. Based on the spiking experiment with the naturally produced sclerotia added at 4 to 32 per 200 g sterile sand, an inoculum level of 1 sclerotia per 200 g equates to 1.73 kDNA / g soil.

Table 1.1: Detection of *Sclerotium cepivorum* by qPCR in 200 g samples of sterile sand spiked with 1, 2, 4, 8, 16 and 32 sclerotia.

Source of *Sclerotium cepivorum*	Density of spiking (sclerotia / 200g sand)	Number of detections / number of replicates	*Sclerotium cepivorum* Average kDNA / g soil when detected
Natural sclerotia Tasmania	1	5/10	1.4
	2	6/10	5.0
	4	4/4	19.1
	8	4/4	12.7
	16	4/4	35.4
	32	4/4	36.5
Cultured sclerotia Tasmania	1	10/10	3.9
	2	10/10	10.1
	4	4/4	17.6
	8	4/4	32.5
	16	4/4	75.1
	32	4/4	137.4
Cultured sclerotia Queensland	1	7/10	2.3
	2	9/10	6.3
	4	4/4	10.2
	8	4/4	11.3
	16	4/4	35.2
	32	No samples	

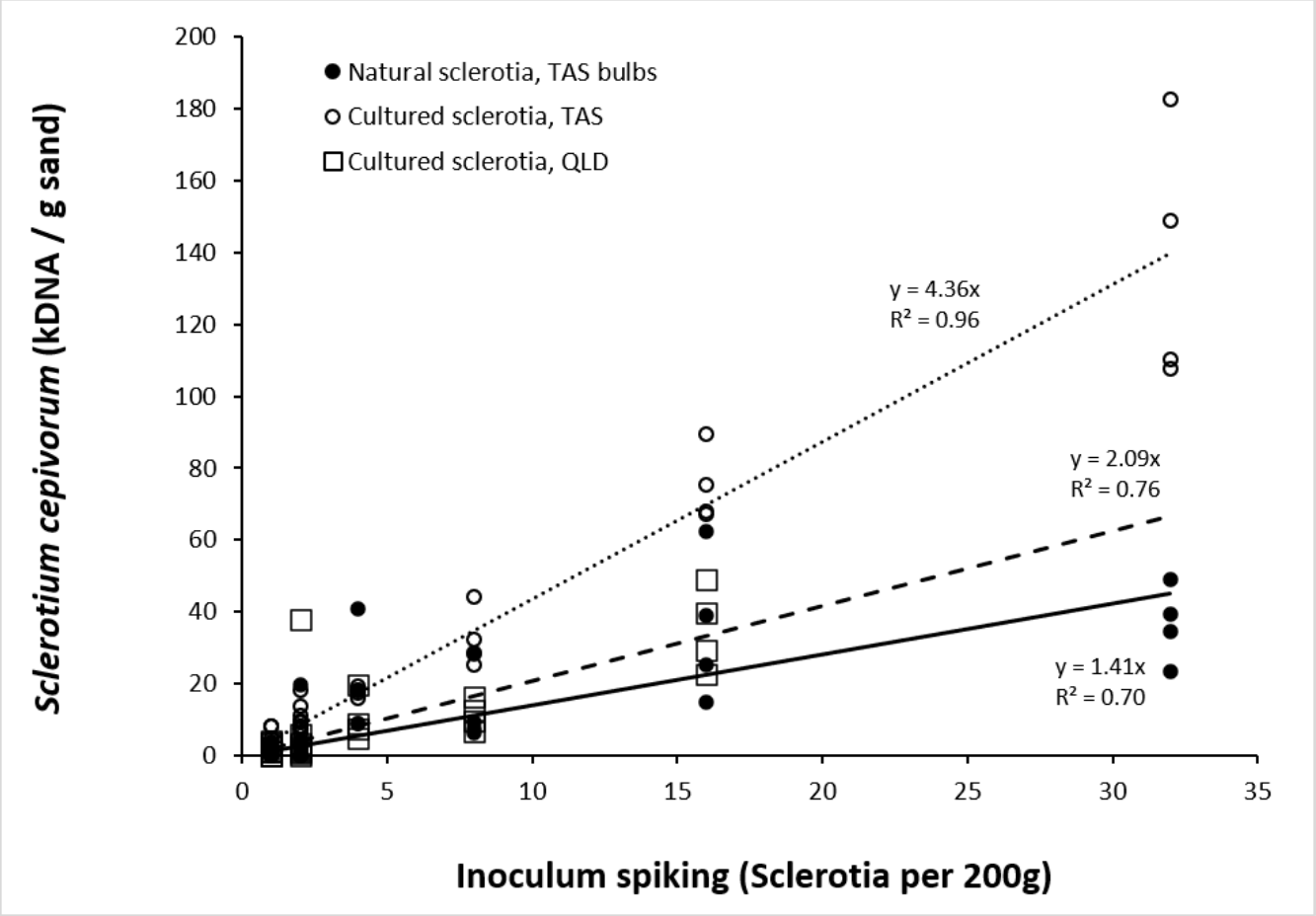

Figure 1.1: Relationship between number of *Sclerotium cepivorum* sclerotia added to 200 g of sterile sand with the concentration of *S. cepivorum* DNA measured by qPCR. Data compares naturally produced sclerotia sourced from stored bulbs (Tasmania) with sclerotia produced in culture on agar from isolates originating from Tasmania and Queensland.

Trials conducted on a range of soils from California by Crowe et al. (1980) found that onion white rot disease incidence ranged from 10-85% for inoculum densities between 1 and 10 sclerotia per kg soil, while at inoculum densities of less than 1 sclerotia per kg soil disease incidence was less than 10%.

There is an upper limit of approximately 500 g of dry soil that can be included in a single sample for testing by SARDI. Data where 1 sclerote was added to 200 g sterile sand suggests that 1 sclerote per 500 g is below the level that can be reliably detected (Table 1.1). This indicates the collection of multiple samples per sampling location, or a sieving process to concentrate inoculum (sclerotia) prior to testing may be required to provide a reliable indication of disease risk. Applicability of the 1 sclerotia per kg soil threshold for the developed *S. cepivorum* and proposed field soil sampling strategies need to be evaluated in Tasmania.

2. Field validation of soil qPCR tests for soilborne onion diseases (*Sclerotium cepivorum* and *Setophoma terrestris*)

Soil tests for *Sclerotium cepivorum, Setophoma terrestris* and *Fusarium oxysporum f. sp. cepae* were conducted using qPCR by SARDI. *Fusarium oxysporum f. sp. cepae* was not detected in all soil samples over 3 years.

Table 2.1. Pre-plant soil tests on levels of *S. cepivorum* and *S. terrestris*

		***Sclerotium cepivorum* level**					***Setophoma terrestris* level**			
		kDNA/g soil					**kDNA/g soil**			
No.	**Site #**	**Mean**	**Hits/4****	**Min**	**Max**	**StDev**	**Mean**	**Min**	**Max**	**StDev**
1	2023-1	4.3	3	0	15	7.2	186.8	158	219	25
2	2023-2	5.5	3	0	12	5.9	187.5	178	196	7.4
3	2023-3	11.3	4	5	18	5.6	134.5	112	163	21.6
4	2023-4	3.8	1	0	15	7.5	135.3	125	160	16.7
5	2023-5	3.3	4	2	5	1.5	57.8	38	79	17.5
6	2023-6	0	0	0	0	0	102.3	97	108	6.1
7	2023-7	0.3	1	0	1	0.5	15.5	13	20	3.1
8	2023-8	10.3	4	6	16	5.1	172.8	165	186	9.1
9	2023-9	1.8	2	0	4	2.1	41.3	34	47	5.6
10	2023-10	0	0	0	0	0	103	92	113	9.3
11	2024-1	7.5	4	2	14	5.2	63.8	58	78	9.5
12	2024-2	0	0	0	0	0	84.3	79	90	5.6
13	2024-3	0	0	0	0	0	0	0	0	0
14	2024-4	0.3	1	0	1	0.5	123.3	108	137	12.1
15	2024-5	1.5	3	0	4	1.7	56.8	47	64	7.5
16	2024-6	24.3	4	13	34	11.3	414.3	359	473	47
17	2024-7	8.3	4	4	10	2.9	931	864	1058	86.5
18	2024-8	0.8	1	0	3	1.5	12.8	10	15	2.2
19	2024-9	0.3	1	0	1	0.5	109	97	121	10.1
20	2024-10	3.5	4	2	7	2.4	15	13	18	2.2
21	2025-1	0	0	0	0	0	367.8	343	379	17
22	2025-2	1.5	3	0	3	1.3	425.8	342	604	120.2
23	2025-3	7.3	3	0	10	4.9	371	341	401	25.2
24	2025-4	0	0	0	0	0	105.3	87	127	16.6
25	2025-5	0	0	0	0	0	126.5	111	151	18.1
26	2025-6	0	0	0	0	0	918.8	795	1135	149.4
27	2025-7	0	0	0	0	0	0	0	0	0
28	2025-8	9.8	4	5	13	3.6	68.3	57	87	13.3
29	2025-9	0	0	0	0	0	413.5	322	519	84.8
30	2025-10	2.5	3	0	5	2.4	219.5	184	253	28.3

Spread of pathogen levels between 4 sub-samples within 1 hectare area, as shown in Min = minimum, Max = maximum and StDev = standard deviation. Note that sites 2024-3 and 2025-7 were from Turners Beach river flat where no onion white rot or pink root pathogens had been detected. Site 2025-9 was located at Stowport. ** Hits/4 = number of times *S. cepivorum* was detected in 4 separate sub-samples

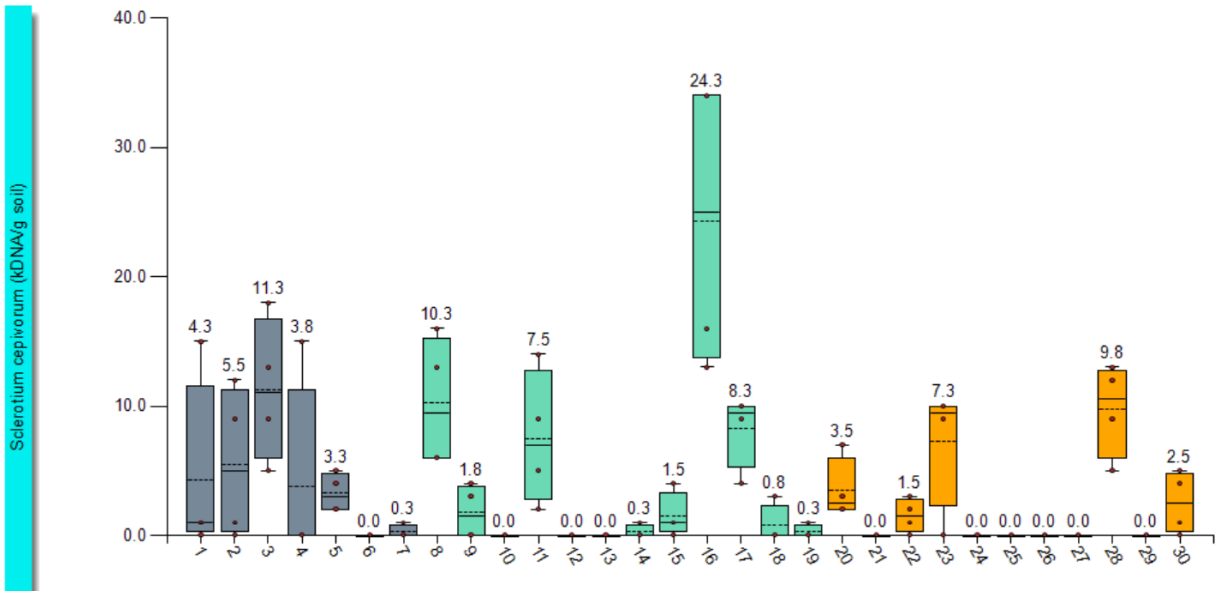

Figure 2.1. A chart of the means and spread of onion white rot pathogen (*Sclerotium cepivorum)* detected in pre-plant soil samples at each site

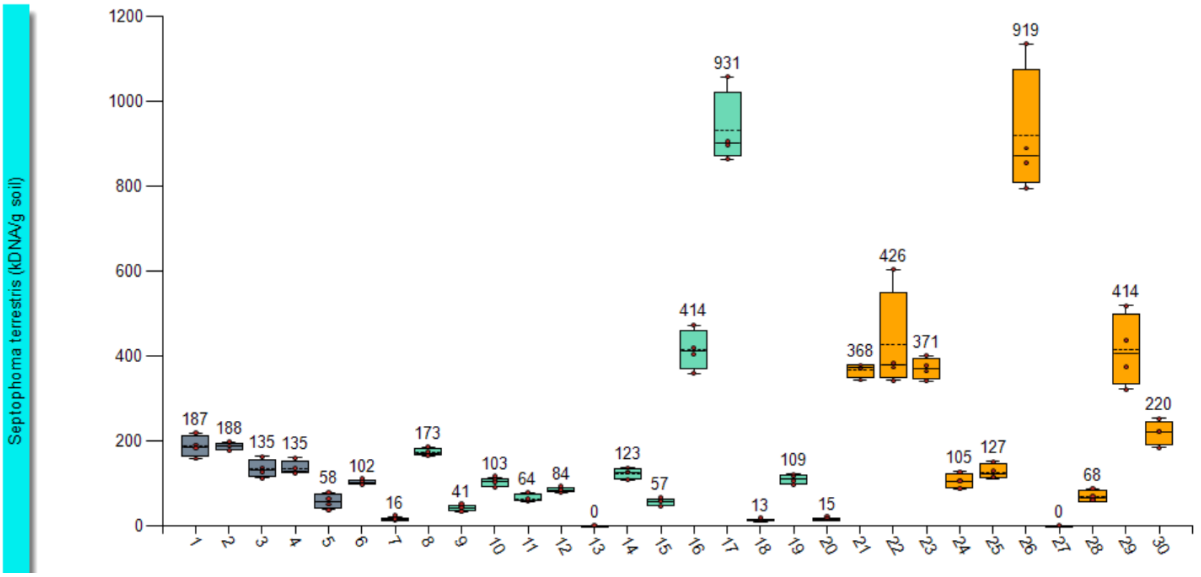

Figure 2.2. A chart of the means and spread of the levels of pink root pathogen (Setophoma terrestris) detected in pre-plant soil samples at each site

Table 2.2. Root disease severity and onion white rot on bulbs at harvest

		Onion root rot and white rot incidence (% bulbs affected)																					
		Healthy bulbs												White rot affected bulbs									
		Healthy root				Mild root rot				Severe root rot				Marketable				Rejects				Total (Marketable + Rejects)			
No.	Site #	Mean	Min	Max	StDev	Mean	Min	Max	StDev	Mean	Min	Max	StDev	Mean	Min	Max	StDev	Mean	Min	Max	StDev	Mean	Min	Max	StDev
1	2023-1	38	26	47	9	50	39	58	8	7	4	10	3	2	0	4	2	2	0	6	3	4	0	8	4
2	2023-2	30	12	50	17	51	46	64	9	18	2	30	12	0	0	0	0	2	0	2	1	2	0	2	1
3	2023-3	63	54	69	7	13	7	15	4	1	0	2	1	24	16	33	7	0	0	0	0	24	16	33	7
4	2023-4	46	22	58	16	37	28	48	10	3	0	8	4	14	4	28	10	1	0	2	1	14	4	30	11
5	2023-5	31	22	37	7	21	16	28	6	0	0	0	0	43	33	52	8	5	4	6	1	48	39	56	7
6	2023-6	12	4	22	9	82	74	92	9	6	4	8	2	0	0	0	0	0	0	0	0	0	0	0	0
7	2023-7	0	0	0	0	69	55	82	14	22	12	31	9	4	0	8	4	5	0	12	5	8	2	14	5
8	2023-8	3	2	4	1	57	38	65	13	22	15	31	8	14	11	18	3	5	2	11	4	19	15	29	7
9	2023-9	0	0	0	0	30	8	62	24	11	2	24	10	38	28	46	8	22	8	32	11	60	36	78	18
10	2023-10	0	0	0	0	67	62	74	5	27	20	36	7	6	2	8	3	0	0	0	0	6	2	8	3
11	2024-1	27	19	35	9	33	26	37	5	20	2	37	15	19	13	27	6	2	0	4	2	21	17	29	5
12	2024-2	89	87	90	2	3	2	6	2	3	2	6	2	4	2	8	3	1	0	2	1	5	2	8	3
13	2024-3	79	76	87	5	0	0	0	0	21	14	25	5	0	0	0	0	0	0	0	0	0	0	0	0
14	2024-4	67	60	75	8	13	12	16	2	2	0	2	1	19	10	28	8	0	0	0	0	19	10	28	8
16	2024-6	0	0	0	0	81	72	98	12	10	2	14	6	8	0	12	6	1	0	2	1	9	0	14	6
17	2024-7	32	19	43	10	28	22	34	6	14	9	17	4	27	18	42	10	0	0	0	0	27	18	42	10
18	2024-8	75	55	82	13	17	13	26	6	3	0	10	5	5	2	8	3	1	0	2	1	5	2	10	3
19	2024-9	19	15	24	4	47	45	49	2	28	24	31	3	5	2	8	3	1	0	2	1	5	2	8	2
20	2024-10	70	65	76	5	27	22	31	4	2	0	4	2	1	0	2	1	1	0	2	1	2	0	2	1
21	2025-1	83	78	86	3	15	11	20	4	1	0	2	1	1	0	4	2	0	0	0	0	1	0	4	2
22	2025-2	10	2	20	9	62	46	74	12	13	7	18	5	12	7	20	6	4	0	13	6	16	7	33	12
23	2025-3	7	0	21	10	56	44	63	8	14	6	18	6	14	4	23	8	10	4	17	6	24	13	40	12
24	2025-4	21	9	29	9	68	65	72	4	3	0	7	3	5	4	6	1	4	0	9	4	8	4	14	4
25	2025-5	20	9	34	11	47	43	52	4	16	2	24	10	10	6	16	4	7	2	11	4	17	12	22	4
26	2025-6	70	54	84	13	30	16	46	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	2025-7	100	100	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	2025-8	10	4	16	5	37	22	44	10	24	22	26	2	23	16	30	6	7	0	26	13	29	21	41	9
29	2025-9	92	83	98	7	8	2	17	7	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
30	2025-10	1	0	2	1	52	36	65	13	24	14	32	9	18	12	23	5	7	5	11	3	24	18	34	7

Spread of disease between 4 sub-samples within 1 hectare area, as shown in Min = minimum, Max = maximum and StDev = standard deviation.
Sites 2024-3 and 2025-7 were from Turners Beach river flat – root rots were due to bacterial rot or Fusarium rots and not related to white rot or pink root pathogens.

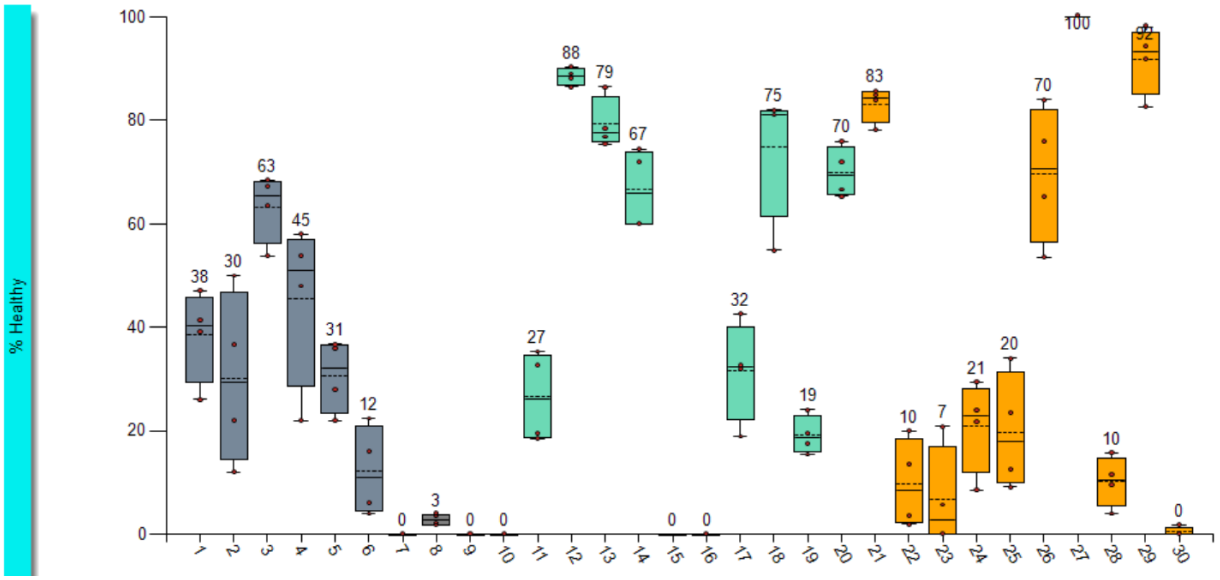

Figure 2.3. A chart of the means and spread of healthy onions (healthy roots and bulbs) on harvested onions at each site

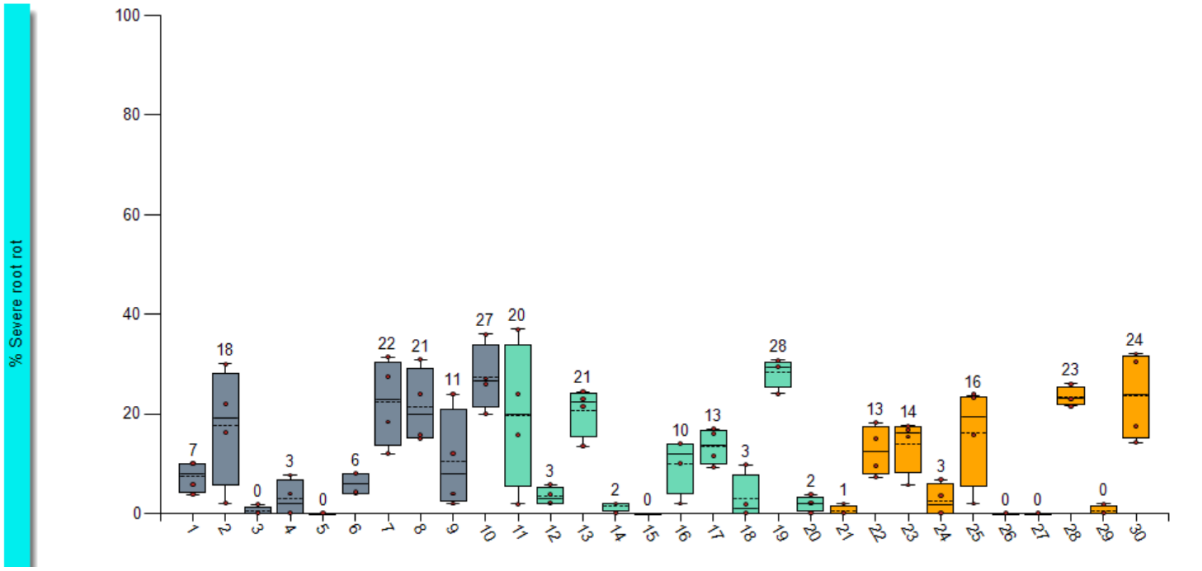

Figure 2.4. A chart of the means and spread of healthy onions that had severe root rots at each site

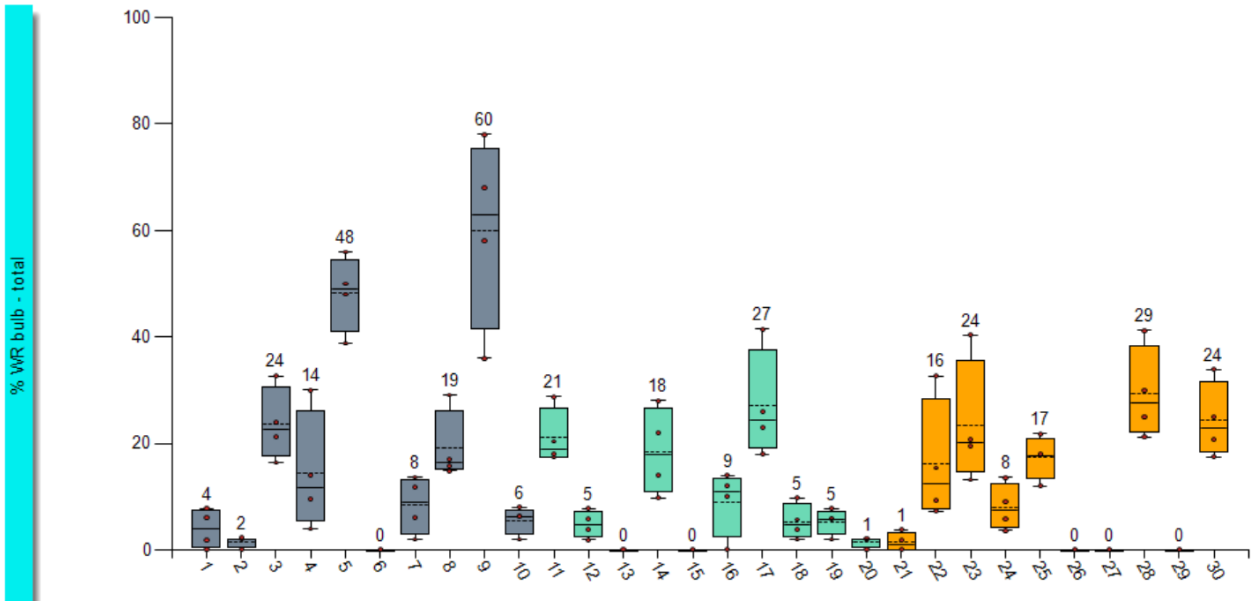

Figure 2.5. A chart of the means and spread of total onion bulbs that were affected by onion white rot (marketable + unmarketable bulbs) at each site

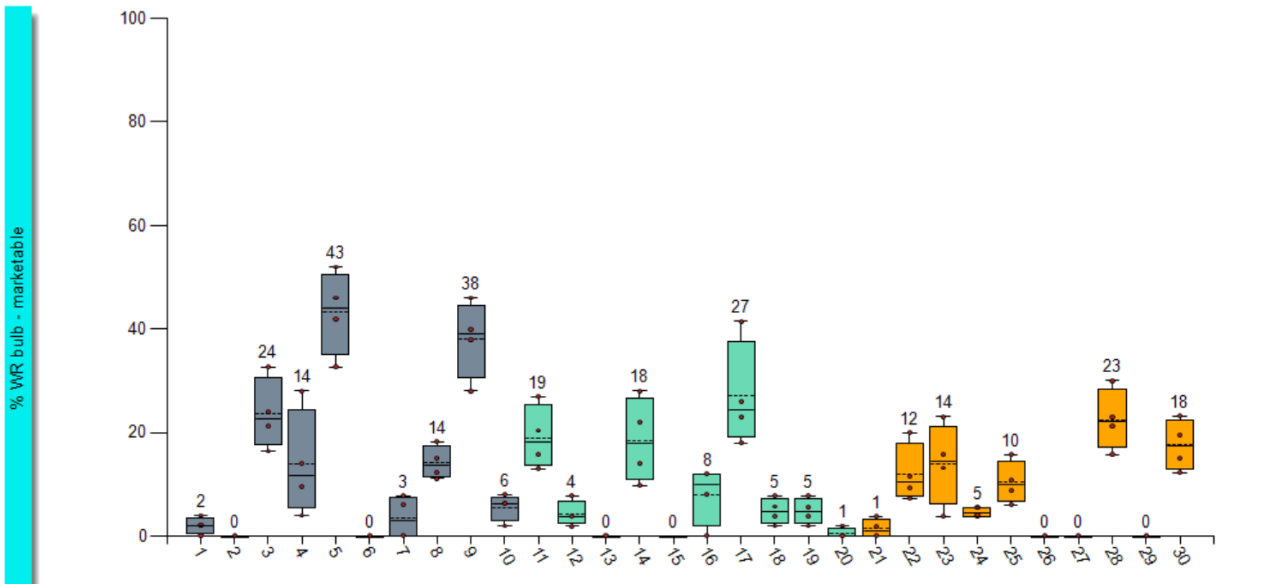

Figure 2.6. A chart of the means and spread of onion white rot affected onion bulbs that were still marketable at each site

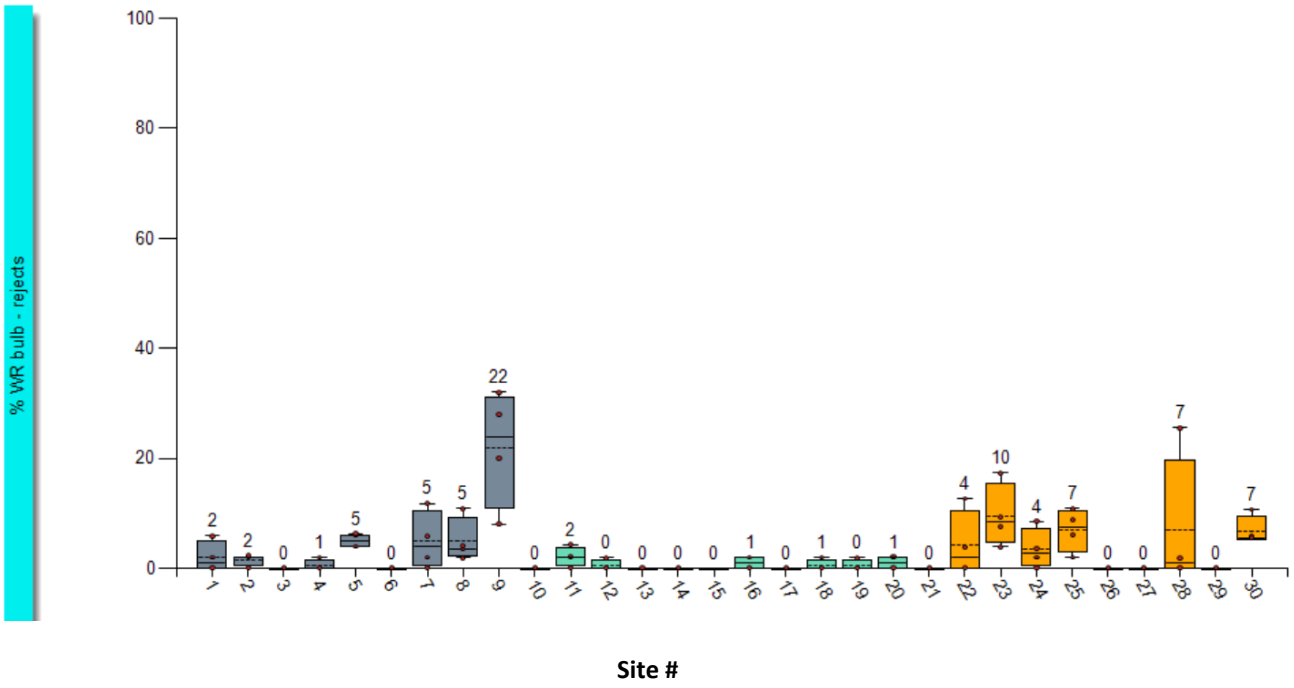

Figure 2.7. A chart of the means and spread of white rot affected onion bulbs that were rejected at each site

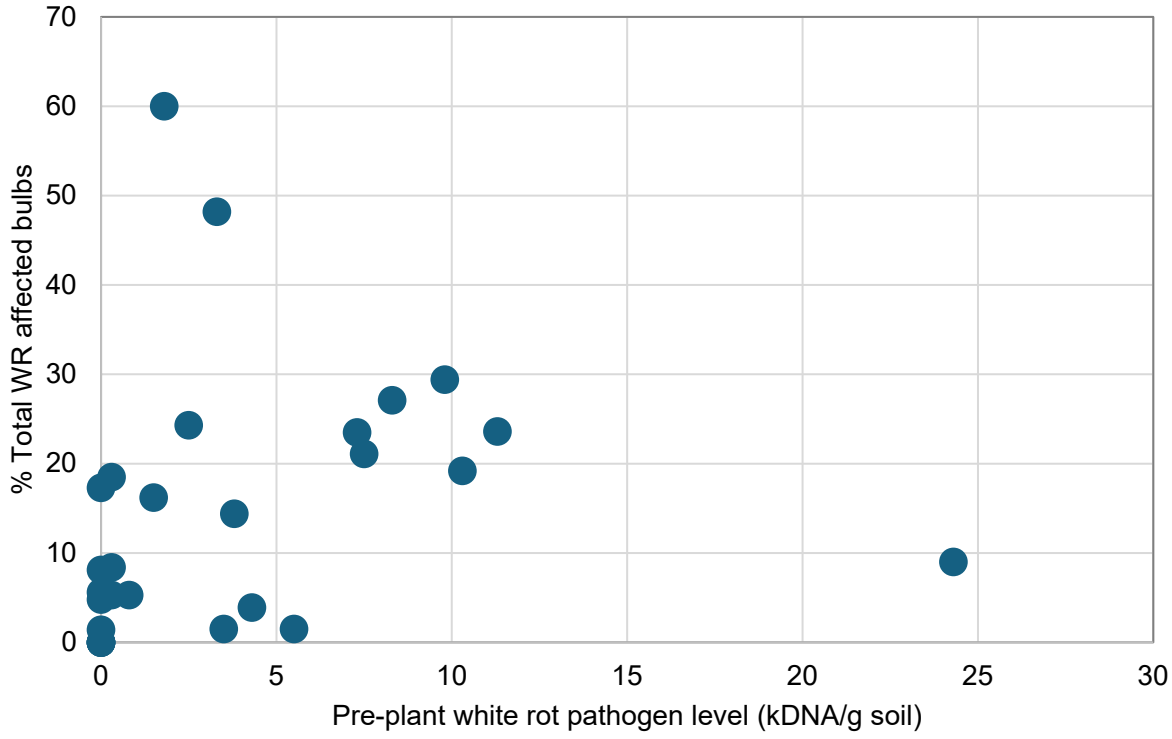

Figure 2.8. Correlations between pre-plant white rot pathogen levels to the total white rot affected bulbs

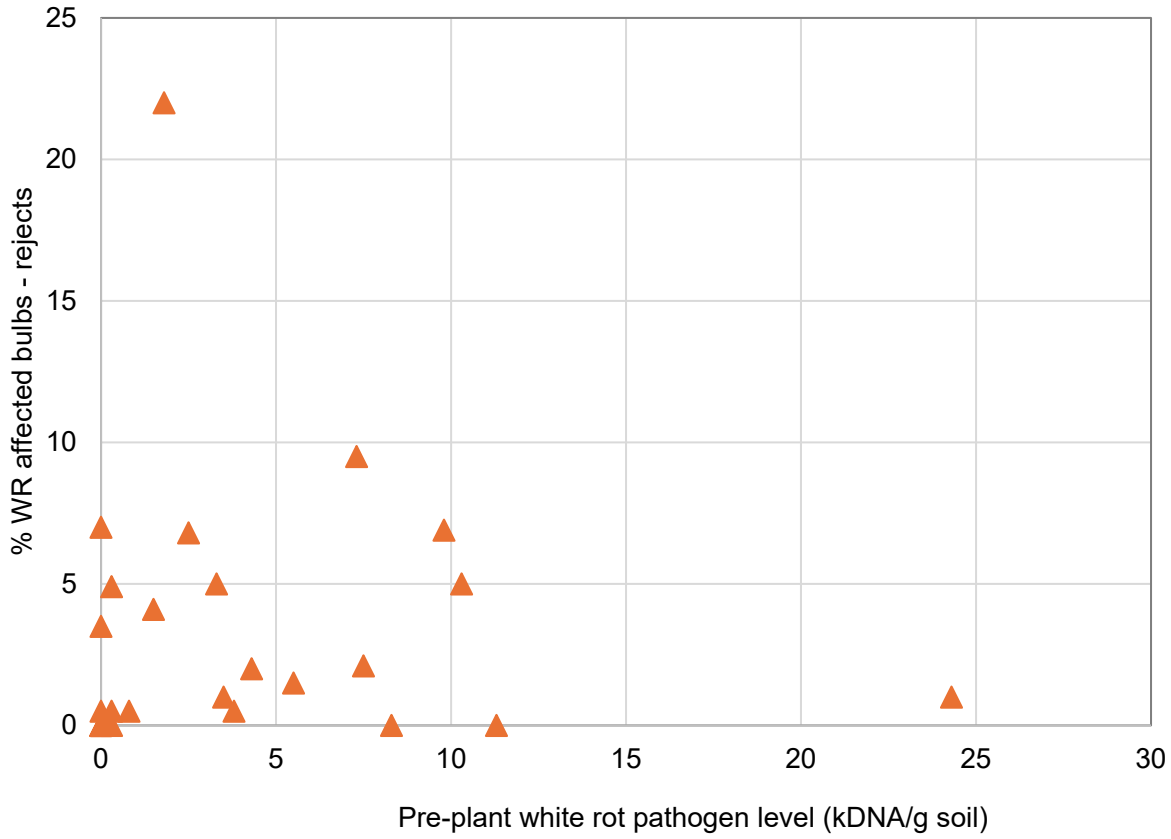

Figure 2.9. Correlations between pre-plant white rot pathogen levels to the severe white rot affected bulbs

Table 2.3. Onion white rot affected onions in fungicide treated area vs untreated areas at the same sites

	Pre-plant soil test				White rot affected onions (% onion bulbs affected)											
	Sclerotium cepivorum				Marketable				Rejects				Total (Marketable + Rejects)			
Site #	Mean	Min	Max	StDev	Mean	Min	Max	StDev	Mean	Min	Max	StDev	Mean	Min	Max	StDev
Commercial - 2023-3	11	5	18	6	23.6	16.4	32.7	6.8	0.0	0.0	0.0	0.0	23.6	16.4	32.7	6.8
Commercial - 2024-1	8	2	14	5	19.0	13.0	26.9	6.1	2.1	0.0	4.3	1.8	21.1	17.4	28.8	5.3
Commercial - 2024-7	8	4	10	3	11.8	7.7	15.7	4.5	0.0	0.0	0.0	0.0	11.8	7.7	15.7	4.5
Commercial - 2025-3	7	0	10	5	14.0	3.8	23.1	8.0	9.5	3.9	17.3	5.7	23.5	13.2	40.4	11.8
Commercial - 2025-8	10	5	13	4	22.5	15.7	30.0	5.9	6.9	0.0	25.5	12.5	29.4	21.2	41.2	8.7
Untreated - 2023-3	11	5	18	6	70.9	58.8	82.7	11.9	1.5	0.0	3.9	1.9	72.3	60.8	82.7	10.3
Untreated - 2024-1	8	2	14	5	44.0	28.0	56.0	12.6	17.5	12.0	22.0	4.1	61.5	40.0	74.0	15.2
Untreated - 2024-7	8	4	10	3	38.8	20.0	51.0	14.4	0.0	0.0	0.0	0.0	38.8	20.0	51.0	14.4
Untreated - 2025-3	7	0	10	5	14.1	3.8	20.8	7.7	21.7	7.7	36.5	12.1	35.8	11.5	55.8	19.2
Untreated - 2025-8	10	5	13	4	9.2	3.9	15.7	4.9	20.8	11.5	32.7	9.0	30.0	19.2	37.3	8.6

Commercial – onion samples taken from area treated with standard commercial fungicide control program; Untreated – onion samples taken from area not treated with fungicides
StDev = standard deviation

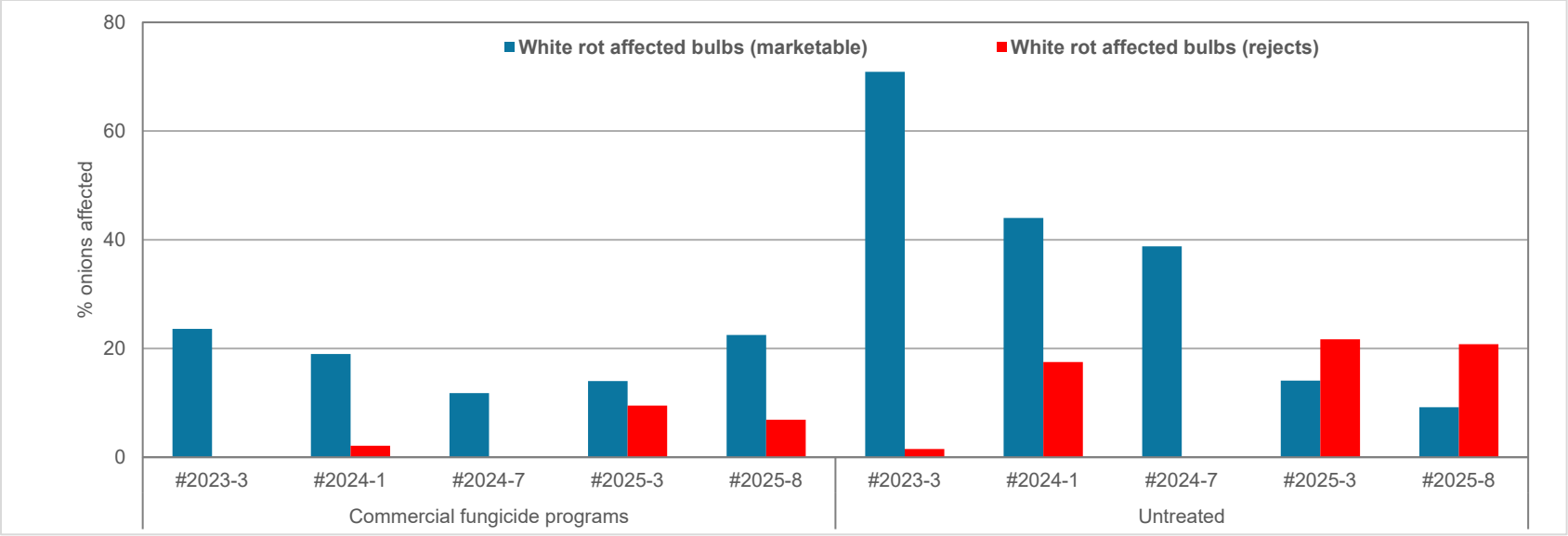

Figure 2.10. A chart comparing onion white rot in areas treated with commercial fungicide treatments to areas left untreated by fungicides

Pre-plant soil pathogen levels
Across thirty monitored onion sites over three seasons, pre-plant soil qPCR tests showed high variability in the levels of *Sclerotium cepivorum* (cause of onion white rot) but more consistent levels of *Setophoma terrestris* (cause of pink root) (Table 2.1).

Onion white rot inoculum ranged from 0 to 11 kDNA/g soil in 2023–24, 0 to 24 kDNA/g in 2024–25, and 0 to 9.8 kDNA/g in 2025–26, with several sites recording zero detectable inoculum. Within site variability was common, with wide spreads between minimum and maximum values and standard deviations indicating heterogeneous pathogen distribution across the one hectare sampling zones (Figure 2.1).

Pink root pathogen levels were higher and more consistently detected, ranging from 12 to 931 kDNA/g soil, with some sites showing extremely elevated levels (>900 kDNA/g) (Figure 2.2). Levels were below the limit of detection in soil at 2 sites.

Disease severity at harvest
Disease assessments of 200 onions per site revealed large differences in root health between sites (Table 3). Healthy bulbs with healthy roots ranged from 0 to 100%, while mild root rot ranged from 0 to 82% and severe root rot from 0 to 28% (Figures 2.3-2.4).

White rot incidence also varied substantially: total onion white rot (marketable + rejects) ranged from 0 to 60% in 2023–24, 0 to 27% in 2024–25, and 0 to 29% in 2025–26 (Figure2.5).

Rejected bulbs due to severe onion white rot ranged from 0 to 22% in 2023-24, 0-2% in 2024-25, and 0-10% in 2025-26. The levels of rejects in 2024-25 were lower due to drier weather conditions compared to the other two seasons (Figure 2.7).

It is important to note that all sampling sites were commercial onion crops that received tebuconazole-treated Microstar at sowing, followed by broadcast fungicide sprays and drench applications. These treatments were applied to control both pink root and onion white rot, so the disease levels observed in this study were expected to be considerably lower than what would typically occur in untreated paddocks.

Patterns across seasons
Across all years, sites with detectable pre-plant *S. cepivorum* levels generally corresponded to higher total onion white rot incidence, although several sites with low or zero detectable inoculum still recorded measurable disease.

Root infection severity due to pink root or onion white rot (mild and severe root rot categories) was widespread across seasons, aligning with the consistently high *S. terrestris* soil levels. Some sites showed high healthy bulb percentages despite elevated pathogen levels, indicating variability in disease expression within and between seasons.

Correlation observations
Correlation plots (Figures 2.8 and 2.9) show a weak positive relationship between detection of pre-plant onion white rot inoculum and both total onion white rot incidence and severe onion white rot incidence at harvest, compared with non-detection. The strength of correlation varied between seasons and other crop management factors such as fungicide applications, irrigation frequency and soil types.

Onion white rot incidence in treated vs untreated areas
Across all five sites where treated and untreated areas could be compared, the untreated areas consistently showed much higher onion white rot incidence than the fungicide-treated commercial crop (Table 2.3). In treated areas, total onion white rot incidence ranged from 11.8% to 29.4%, with reject levels of 0 to 9.5%. In untreated areas, total onion white rot incidence ranged from 30.0% to 72.3%, with reject levels reaching up to 21.7% (Figure 2.10).

All commercial areas received tebuconazole-treated Microstar at sowing, followed by broadcast fungicide sprays and drench applications. These fungicide inputs significantly reduced the incidence of onion white rot impacted but marketable onions as well as rejects, confirming that fungicide programs play a key role in limiting disease expression even when soil inoculum is present.

Onion white rot inoculum threshold levels (with standard onion white rot fungicide control program)
Threshold levels for *Sclerotium cepivorum* were calculated from the full dataset of inoculum values and corresponding onion white rot incidence. These thresholds apply specifically under commercial fungicide practice, where crops received tebuconazole-treated Microstar at sowing followed by broadcast fungicide sprays and drench applications.

These thresholds reflect disease expression with fungicide protection (Table 2.4). Without fungicides, disease levels are substantially higher, as demonstrated in untreated comparison strips. Therefore, threshold categories should be interpreted as risk levels under standard commercial management, not as absolute biological limits.

Table 2.4. Proposed white rot inoculum threshold levels with standard white rot fungicide control program

Biological Risk Category	**Pre-plant inoculum of *S. cepivorum* (kDNA/g)**	**Interpretation (based on data from field validation in commercial crops treated with commercial fungicide program)**
Low to moderate risk	0–2	Disease generally low; standard fungicide programs keep symptoms minimal.
High risk threshold	2-5	Fungicides reduce but do not eliminate symptoms. Rejects become detectable and may be economically significant depending on fungicide program strength and environmental conditions.
Elevated high risk threshold	≥5	Fungicides reduce but do not eliminate symptoms. Rejects can be consistently high under disease-favourable conditions. Strengthened fungicide programs to reduce yield loss.

Overall, these inoculum thresholds provide a practical and evidence-based framework for interpreting pre-plant soil PCR results. They allow growers and advisors to confirm disease risk, to anticipate possible field outcomes and make informed decisions about paddock selection, rotation planning, and the intensity of disease management required. Importantly, they also highlight that soil inoculum alone does not fully predict disease expression. Fungicide inputs, environmental conditions, crop management practices and within-paddock variability all contribute to the final level of onion white rot observed at harvest.

3. Sclerotia Germination Stimulants - Laboratory trial

Sclerotia of *Sclerotium cepivorum* (30 per plot) were buried at 12 cm deep in moist loamy soil in jars and incubated for 8 weeks at 18 °C to assess the effect of NemGuard treatments on sclerotia stimulation. Plots received either no treatment (untreated control) or NemGuard applied as liquid (1–10 L/ha) or granule (5.8 or 14.5 kg/ha) formulations. At the end of the incubation period, sclerotia were recovered by wet sieving and enumerated. Only sclerotia that remained firm and solid were recovered, while any that were broken, empty or degraded were discarded. Saprophytic germination of the solid sclerotes was determined by plating individual sclerotia onto potato dextrose agar (PDA) discs on petri dishes.

Recovered solid sclerotes were checked for germination on potato dextrose (PDA) agar discs. Note that germination of *S. cepivorum* sclerotia on agar provides only a partial indication of viability because the agar media triggers saprophytic growth rather than the host induced germination required for infection in soil. Only sclerotia with low dormancy respond to nutrient driven cues on agar, while many physiologically alive sclerotia remain dormant in the absence of Allium sulphur compounds. As a result, the proportion that germinates on PDA typically underestimates true viability and does not reflect the sclerotia's capacity to germinate in soil or cause disease.

Table 3.1. Onion white rot sclerotia recovery and their viability after 8 weeks incubation at 18oC (2022)

No.	Treatment	Product rate (L or kg/ha)	8 weeks after moist incubation in soil					
			No. of solid sclerotes recovered/plot		% of solid sclerotes recovered		% of sclerotes that germinated on agar	
1	Untreated control	Nil	18	6	60	19	25	21
2	NemGuard Liquid	1 L	20	4	66	12	43	14
3	NemGuard Liquid	2 L	21	7	71	24	43	28
4	NemGuard Liquid	5 L	20	7	66	22	39	20
5	NemGuard Liquid	10 L	21	7	68	23	23	9
6	NemGuard Granule*	5.8 kg	19	6	64	19	37	5
7	NemGuard Granule**	14.5 kg	16	5	53	17	45	17
		P-value	0.9077		0.9063		0.4342	
		LSD = 0.05	NSD		NSD		NSD	

* Equivalent to NemGuard Liquid at 2 L/ha; ** Equivalent to NemGuard Liquid at 5 L/ha
Means ± standard error means; 30 sclerotes buried in each plot

Across all treatments, 16–21 sclerotia were recovered per plot, corresponding to 53–71% recovery, with no reduction relative to the untreated control (60 ± 8%). Germination of sclerotia on agar ranged from 23–45% among NemGuard treatments and did not differ meaningfully from the untreated control (25 ± 9%). NemGuard Liquid applied at 1 and 2 L/ha and NemGuard Granule at 14.5 No dose-response relationship was observed for either formulation (Table 3.1). These results indicate that moist soil incubation at 18 °C reduces sclerotia viability only moderately and that NemGuard, at the rates tested, does not decrease sclerotia recovery or viability under these conditions.

4. Sclerotia Germination Stimulants - Pot trial

A controlled pot trial was conducted to evaluate the effect of NemGuard liquid applications on *Sclerotium cepivorum* soil DNA levels under high inoculum pressure. Soil was uniformly infested to 1×10^4 kDNA/g at trial establishment (9 October 2024), and treatments were applied twice, on 9 October 2024 (Application A) and 18 September 2025 (Application B). NemGuard liquid was applied at 1.25, 2.5, 5.0 and 10 L/ha, and an onion-juice treatment (1.25 L/ha) was included for comparison; an untreated control received no product. Soil samples were collected at 112 days after Application A (112 DAAA) and 145 days after Application B (145 DAAB), and *S. cepivorum* DNA was quantified using qPCR tests.

At 112 DAAA, DNA concentrations ranged from $2.37–2.68 \times 10^4$ kDNA/g across treated pots compared with 2.78×10^4 kDNA/g in the untreated control, with no significant treatment effects detected (P = 0.624). Similarly, at 145 DAAB, DNA levels ranged from $1.79–2.03 \times 10^4$ kDNA/g among treatments versus 2.02×10^4 kDNA/g in the control, again with no significant differences (P = 0.4089).

NemGuard and onion-juice treatments did not lower onion white rot inoculum, with soil DNA levels remaining similar to the untreated control at both assessment times (Table 4.1).

Table 4.1. Onion white rot sclerotia levels based on qPCR soil tests (2024-26)

No.	Treatment	Product rate (L/ha)	Application timing	*Sclerotium cepivorum* (1 x 10^4 kDNA/g soil)			
				112 DAAA (29/01/25)		145 DAAB (10/02/26)	
				Mean	StDev	Mean	StDev
1	Untreated control	Nil	N/A	2.78	0.06	2.02	0.22
2	NemGuard Liquid	1.25	AB	2.45	0.19	1.88	0.18
3	NemGuard Liquid	2.5	AB	2.44	0.25	1.93	0.21
4	NemGuard Liquid	5.0	AB	2.37	0.34	2.03	0.21
5	NemGuard Liquid	10.0	AB	2.68	0.36	1.85	0.24
6	Onion Juice	2.0	AB	2.66	0.24	1.79	0.21
			***P*-value**	0.1624		0.4089	
			LSD (*P* = 0.05)	NSD		NSD	

NSD = No significant difference due to a P-value > 0.05
DAA# = Days after application timing
Initial level at trial set up 9/10/24 = 2.15 x 10^4 kDNA/g soil

5. Sclerotia Germination Stimulants Field Trials at Kindred and Sassafras

Two commercial paddocks with a history of high onion white rot pressure were selected to evaluate whether pre-plant applications of NemGuard could reduce *Sclerotium cepivorum* inoculum by stimulating sclerotia germination in the absence of an Allium host. NemGuard Liquid was applied at 2.5, 5 and 10 L/ha as broadcast sprays onto cultivated soil and then incorporated 20 cm deep with a rotary hoe.

Table 5.1. Levels of *S. cepivorum* at Kindred

No.	Treatment	Procut rate (L/ha)	*Sclerotium cepivorum* (kDNA/g soil)					
			0DAA (23/04/25)		127DAA (28/08/25)		341DAA (30/03/26)	
			Mean	StDev	Mean	StDev	Mean	StDev
1	Untreated control	Nil	77	17	62	12	58	8
2	NemGuard Liquid	2.5	67	8	81	13	63	10
3	NemGuard Liquid	5.0	94	15	91	13	61	13
4	NemGuard Liquid	10.0	70	12	77	18	71	11
		P-value	0.3415		0.5081		0.8250	
		LSD = 0.05	NSD		NSD		NSD	

StDev = standard deviation
Treatments applied at 23/04/25 and paddock was sown with barley after treatments in 2025-26

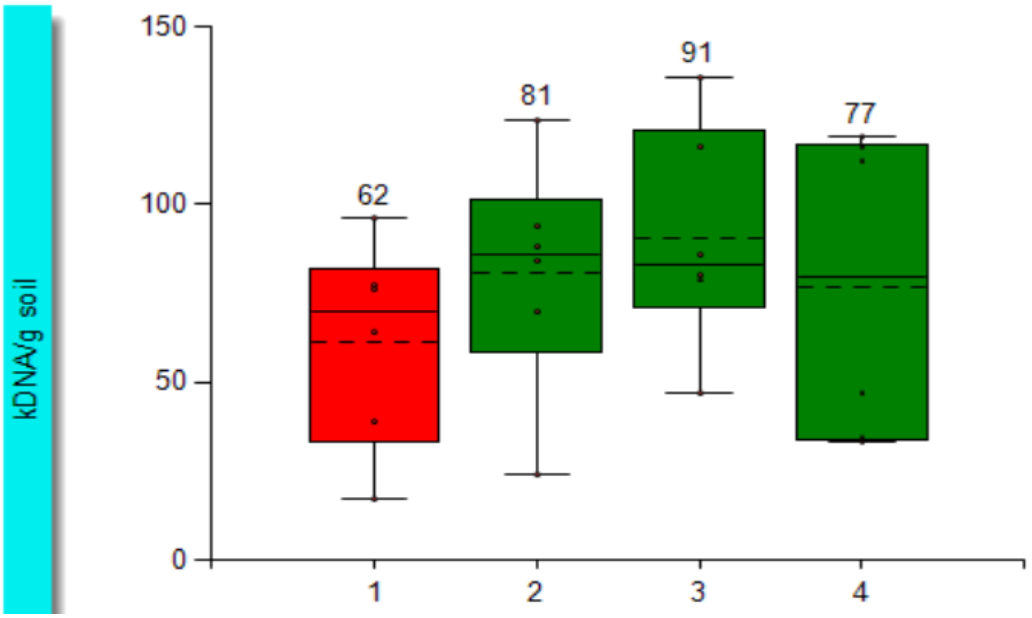

Figure 5.1. A Box-Whisker chart of *S. cepivorum* levels at 127DAA, Kindred

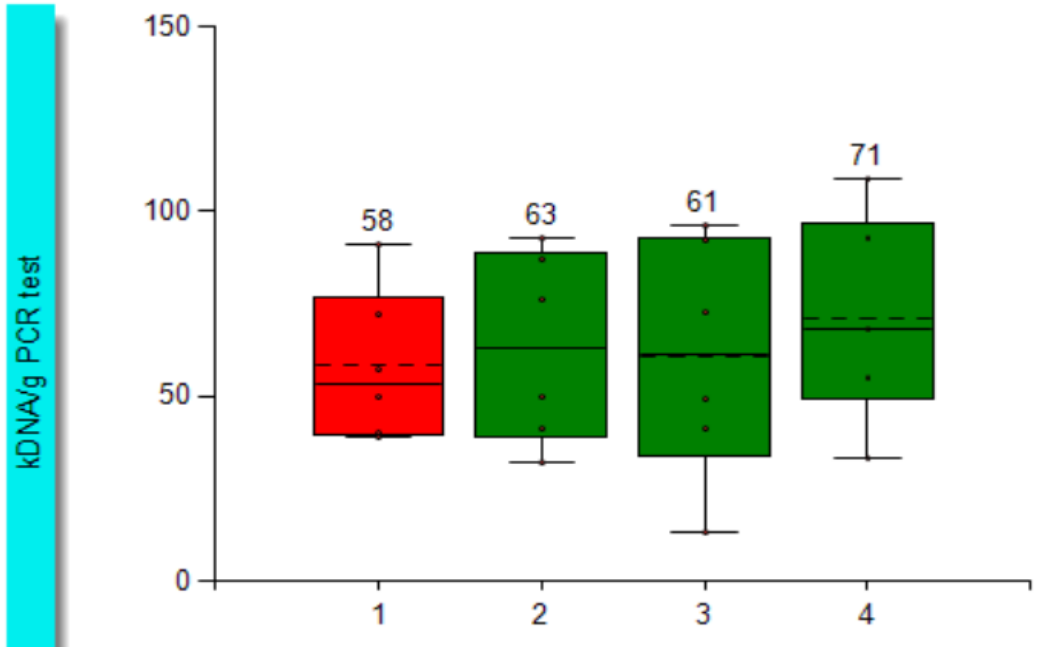

Figure 5.2. A Box-Whisker chart of *S. cepivorum* levels at 341DAA, Kindred

At Kindred, initial inoculum levels were considered as very high risk in disease pressure (67-94 kDNA/g), and although DNA concentrations declined slowly over the season, the magnitude of decline was negligible and similar across all treatments, including the control. By 127 days after application, values ranged from 62–91 kDNA/g, and by 341 days after application, from 58–71 kDNA/g, with all differences statistically non-significant (Table 5.1, Figure 5.1-5.2). All these levels are still too high and likely to expose onion crops to severe onion white rot.

Table 5.2. Levels of *S. cepivorum* at Sassafras

No.	Treatment	Product rate (L/ha)	*Sclerotium cepivorum* (kDNA/g soil)			
			-1DAA (30/10/25)		147DAA (27/03/26)	
			Mean	StDev	Mean	StDev
1	Untreated control	Nil	40	14	19	5
2	NemGuard Liquid	2.5	17	2	21	5
3	NemGuard Liquid	5.0	33	6	26	5
4	NemGuard Liquid	10.0	37	6	31	5
		P-value	0.1513		0.2743	
		LSD = 0.05	NSD		NSD	

StDev = standard deviation
Treatments applied on 31/10/25 and paddock was planted with potatoes after treatments in 2025-26.

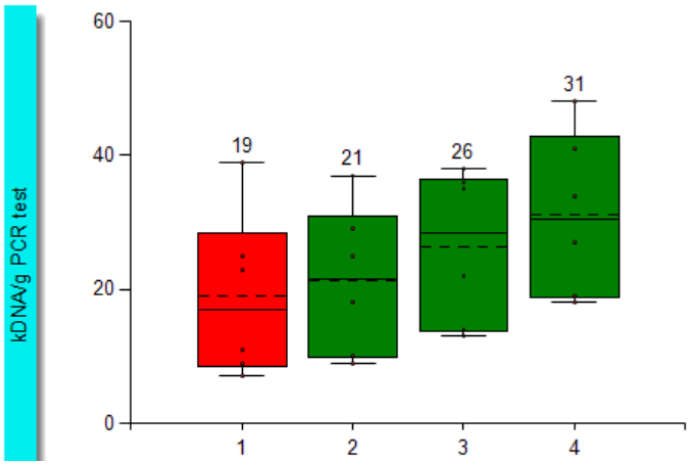

Figure 5.3. A Box-Whisker chart of *S. cepivorum* levels at 147DAA, Sassafras

At Sassafras, soil DNA levels also declined slightly over time. Initial levels ranged from 17–40 kDNA/g, reflecting natural spatial variability. By 147 days after application, DNA concentrations had decreased slightly to 19–31 kDNA/g, but treatment means remained statistically not significantly different from the control (Table 5.2, Figure 5.3). As at Kindred, the magnitude of decline in the DNA levels was negligible and the resulting pathogen levels are still too high.

It is important to note that qPCR assays for *Sclerotium cepivorum* quantify total pathogen DNA and cannot distinguish between viable and non-viable sclerotia. The assay detects DNA originating from living sclerotia, dead or dying sclerotia, fragmented sclerotia, and residual mycelial material in soil. As a result, qPCR measurements may not accurately reflect true changes in sclerotia viability or germination in the absence of an Allium host. Apparent stability or even slight increases in kDNA levels following NemGuard application should therefore be interpreted cautiously, as they may represent persistence of non-viable DNA rather than a lack of biological decline in inoculum.

Taken together, the two field trials demonstrate that NemGuard Liquid, applied at 2.5–10 L/ha, did not cause useful decline in the pathogen levels relative to untreated plots. Changes in inoculum levels over time appear to reflect natural seasonal fluctuations rather than treatment effects. These findings align with pot-trial results showing no reduction in soil DNA following NemGuard application, indicating that the product does not suppress onion white rot inoculum under the conditions tested.

Across laboratory, pot, and field experiments, NemGuard did not reduce *Sclerotium cepivorum* sclerotia viability or soil

DNA levels, and in several assessments a slight upward trend in kDNA was observed with increasing NemGuard rate as opposed to a downward trend over time in untreated plots, presumably due to natural degradation of sclerotia. Although counter to the expected direction of effect with NemGuard, these increases were small, inconsistent between sites, and statistically non-significant, indicating that they do not represent a true biological increase in viable inoculum. This pattern is readily explained by the characteristics of qPCR-based soil assays, which quantify total pathogen DNA rather than viable propagules. DNA from dead or degraded sclerotia, fragmented mycelium, or non-infective residues can persist in soil for extended periods and contribute to measured kDNA levels. As a result, qPCR values may remain stable or fluctuate slightly even when sclerotia viability declines or when treatments have no biological effect. The combined evidence therefore indicates that NemGuard did not cause a significant decline in the pathogen levels in soil, and the minor increases in kDNA reflect methodological detection of total DNA rather than treatment-driven changes in inoculum viability.

6. Fungicide Carriers

Table 6.1. Comparison of Microstar and Attapulgite as carriers for tebuconazole (Tebuconazole) on onion quality and yield

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha)				
				Healthy bulbs	Onion white rot affected bulbs			Total yield
					Marketable	Rejects	Total	
1	Untreated control	Nil	N/a	12.9 c	37.1 a	4.2 *	41.3 a	54.1
2	Tebuconazole on Microstar	1.0 L	A	24.5 ab	30.0 ab	0	30.0 ab	54.5
3	Tebuconazole on Microstar Luna Experience Intuity Allitron	1.0 L 1.0 L 1.2 L 1.0 L	A B C D	32.7 a	20.8 c	0	20.8 b	53.4
4	Tebuconazole on Attapulgite	1.0 L	A	21.9 b	29.1 abc	0	29.1 b	51.0
5	Tebuconazole on Attapulgite Luna Experience Intuity Allitron	1.0 L 1.0 L 1.2 L 1.0 L	A B C D	24.7 ab	25.0 bc	0	25.0 b	49.6
			***P*-value**	0.0020	0.0537	1.000	0.0230	0.9333
			***LSD* = 0.05**	8.37	-	NSD	11.92	NSD
			LSD = 0.10	-	8.88	-	-	-

Means followed by the same letter are not significantly different (P = 0.05 or 0.10, LSD); NSD = No significant difference due to a P-value > 0.05; * Treatment 1 was excluded from statistical analysis due to heterogeneity of variance

The results indicate that both Microstar and Attapulgite were suitable carriers for tebuconazole applied at sowing, with both carrier treatments reducing total onion white rot affected bulbs when compared with the untreated control (Table 6.1). However, there was no clear statistical separation between the two carriers, either when tebuconazole was applied alone or when it was combined with the follow-up fungicide program.

When tebuconazole was applied on either Microstar or Attapulgite without follow-up fungicides, the treatments generally produced an intermediate response. They improved the crop health profile compared with the untreated control, particularly for total onion white rot, but were not consistently separated from the more intensive fungicide programs. This indicates that carrier-applied tebuconazole alone provided useful disease suppression but may not provide maximum protection where onion white rot pressure is high.

The addition of the follow-up fungicide program appeared to strengthen disease control and improve the proportion of healthy bulbs, particularly where tebuconazole was applied on Microstar. However, because the Microstar and Attapulgite programs with follow-up fungicides were not statistically separated for most measures, the data does not provide strong evidence that one carrier performed better than the other under a full fungicide program. Overall, the trial indicated that Attapulgite was a suitable alternative to Microstar as a carrier for tebuconazole.

7. Alternative Post Emergence Fungicide Screening

At Forthside, treatment effects were significant for average bulb weight and yield of marketable onions with root rots, but not for healthy onion yield or total marketable yield. Luna Experience produced the highest average bulb weight and was significantly greater than the untreated control. Several other fungicide treatments, including Allitron, Intuity, GF-4536, EXP 2and the Luna Experience–Allitron–EXP 3 program, were statistically similar to the highest performing treatment for bulb weight. All fungicide treatments significantly reduced the yield of onions with root rots compared with the untreated control at Forthside. The untreated control produced 25.5 t/ha of marketable onions with root rots, whereas fungicide-treated plots ranged from 11.8 to 15.7 t/ha. This indicates that all post-emergent fungicide treatments reduce root rot expression compared with the untreated control. However, there were no significant differences between fungicide treatments regarding healthy onion yield or total marketable yield. Total marketable yield ranged from 90.8 to 98.8 t/ha in fungicide-treated plots, compared with 86.5 t/ha in the untreated control, but these differences were not statistically significant (Table 7.1).

At Table Cape, treatment effects were significant only for healthy onion yield. The rotation program of Luna Experience followed by Allitron followed by EXP 3 produced the highest healthy onion yield at 26.7 t/ha and was significantly higher than the untreated control, Allitron, GF-4536 and EXP 1. Luna Experience alone also produced a high healthy onion yield and was statistically similar to the rotation program. EXP 2, Luna Experience plus Serenade Soil Activ and EXP 3 produced intermediate healthy onion yields. In contrast, Allitron alone did not significantly increase healthy onion yield compared with the untreated control at this site. There were no significant treatment effects at Table Cape on average bulb weight, yield of marketable onions with root rots, or total marketable yield. This suggests that although some treatments improved the proportion of onions with healthy roots, the high yield of marketable onions with root rots reduced the ability to detect treatment differences in total marketable production. Total marketable yield was numerically highest in the Luna Experience–Allitron–EXP 3 rotation program, but this was not statistically significant (Table 7.2).

There was no evidence of phytotoxicity by any of the fungicide treatments on onion plants at both trial sites
Across both sites, the results suggest that several alternative fungicides were crop safe and provided similar or improved root health compared with the current commercial standard. Luna Experience showed consistent potential, either alone or as part of a fungicide program, with strong performance in bulb weight at Forthside and healthy onion yield at Table Cape. The rotation program of Luna Experience followed by Allitron and EXP 3 was the strongest treatment at Table Cape, suggesting that alternating fungicide groups may improve disease management while supporting resistance management. However, because total marketable yield responses were not statistically significant at either site, product performance should be interpreted primarily in terms of root health and disease suppression rather than yield increase alone.

The results also highlight the importance of evaluating products individually before developing integrated fungicide programs. Products from alternative fungicide groups, including Group 7, Group 11 and Group 21 fungicides, showed potential for inclusion in onion white rot and root rot management programs. This is important because the current commercial program relies heavily on Group 3 DMI fungicides, increasing the need for alternative modes of action to support long-term disease management and fungicide resistance stewardship.

Table 7.1. Quality and yield of harvested onions Forthside 2021-22

No.	Treatment	Product rate (L/ha)	Application timing code	Average weight of onion (g/bulb)	Yield of onion bulbs (adjusted to t/ha) 52DAAC, 145DAS		
					Healthy onions	Onions with root rots (marketable)	Total marketable onions
1	Untreated control	Nil	N/a	130 d	61.0	25.5 a	86.5
2	Allitron 375 SC	1.0	ABC	143 abc	79.1	15.0 b	94.1
3	Luna Experience 400 SC	1.0		148 a	84.3	13.1 b	97.4
4	Luna Experience 400 SC + Serenade Soil Activ	1.0 1.4		139 abc	83.1	14.4 b	97.5
5	Intuity 250 SC	1.2		142 abc	83.5	15.4 b	98.8
6	GF-4536 100 SC Maxx adjuvant	1.5 60 mL/100 L		141 abc	75.1	15.7 b	90.8
7	EXP 1	0.84		134 cd	82.3	12.3 b	94.6
8	EXP 3	0.5		139 bcd	78.6	15.1 b	93.6
9	EXP 2	1.0		141 abc	83.7	11.8 b	95.5
10	Luna Experience 400 SC fb Allitron 375 SC fb EXP 3	1.0 1.0 0.5	A B C	144 ab	77.5	14.9 b	92.3
		***P*-value**		0.0178	0.1574	0.0104	0.7461
		LSD (*P* = 0.05)		8.9	NSD	6.41	NSD

Tebuconazole on Microstar applied at sowing to whole trial including untreated control
Three foliar sprays applied before rain or irrigation, using AirMix 110-02 Air induction flat fan in a spray volume of 273 L/ha.
Application timing code: A - 36 days after sowing (0 days after application A (0DAAA); B - 28DAAA and C - 29DAAB
DAA# = Days after application timing; DAS = Days after sowing
Means followed by the same letter are not significantly different (P = 0.05, LSD)
NSD = No significant difference due to a P-value > 0.05

Table 7.2. Quality and yield of harvested onions Table Cape 2021-22

No.	Treatment	Product rate (L/ha)	Application timing code	Average weight of onion (g/bulb)	Yield of onion bulbs (adjusted to t/ha) 63DAAC, 163DAS		
					Healthy onions	Onions with root rots (marketable)	Total marketable onions
1	Untreated control	Nil	N/a	89	2.5 e	82.3	84.8
2	Allitron 375 SC	1.0	ABC	74	5.7 e	83.7	89.4
3	Luna Experience 400 SC	1.0		103	17.6 ab	74.5	92.0
4	Luna Experience 400 SC + Serenade Soil Activ	1.0 1.4		82	15.7 bcd	68.9	84.6
5	Intuity 250 SC	1.2		91	8.4 cde	89.1	95.4
6	GF-4536 100 SC Maxx adjuvant	1.5 60 mL/100 L		81	7.6 de	85.3	83.6
7	EXP 1	0.84		87	5.9 de	85.6	95.0
8	EXP 3	0.5		78	12.5 bcd	84.3	97.8
9	EXP 2	1.0		95	15.8 bc	89.1	101.3
10	Luna Experience 400 SC fb Allitron 375 SC fb EXP 3	1.0 1.0 0.5	A B C	101	26.7 a	85.3	111.0
		***P*-value**		0.7434	0.0004	0.7364	0.2323
		LSD (*P* = 0.05)		NSD	tS	NSD	NSD

Tebuconazole on Microstar applied at sowing to whole trial including untreated control
Three foliar sprays applied before rain or irrigation, using AirMix 110-02 Air induction flat fan in a spray volume of 273 L/ha.
Application timing code: A - 56 days after sowing (0 days after application A (0DAAA); B - 22DAAA and C - 22DAAB
DAA# = Days after application timing; DAS = Days after sowing
tS = Original plot means are presented with P-values and letters of separation from data transformed using y = SQRT (x + 0.5)
Means followed by the same letter are not significantly different (P = 0.05, LSD)
NSD = No significant difference due to a P-value > 0.05

8. Post Emergence Fungicide Programs – Intuity and Luna Experience

The Latrobe trial was conducted in an early winter sown onion crop sown on 4 June 2022 when crop growth was slow during the cold and wet winter period. PCR soil tests on soil sample from the trial area showed that there were 4 kDNA copies/g soil of *Sclerotium cepivorum* (onion white rot pathogen) and 268 k DNA copies/g soil of *Septophoma terrestris* (pink root pathogen). At harvest on 3 January 2023, almost all bulbs were affected by root rots due to pink root and onion white rot diseases. With only tebuconazole applied at sowing, approximately 18% of bulbs were rejected due to severe onion white rot. All post-emergent fungicide programs significantly reduced the incidence of rejected onions compared with the untreated control. However, there were no significant differences between the post emergent fungicide programs. Programs based on Luna Experience followed by Intuity and Allitron, or Luna Experience followed by Intuity and Luna Experience, appeared slightly more effective than some other programs. The post-emergent fungicide programs did not significantly increase yield of marketable onions compared with tebuconazole applied only at sowing, although the yields tended to be numerically higher.

Table 8.1. Onion white rot affected onions and yield of harvested onions 2022-23, Latrobe and Moriarty

No.	Program sprays	Active ingredient rate (g ai/ha)	Application code	Latrobe		Moriarty	
				% rejected onions	Yield of marketable onions (t/ha)	% rejected onions	Yield of marketable onions (t/ha)
1	Tebuconazole Microstar	430	A	18.1 a	42.1	4.9	63.1 b
2	Tebuconazole Microstar Allitron	 430 375	 A BCD	11.1 b	47.3	2.2	72.7 a
3	Tebuconazole Microstar Luna Experience Intuity Allitron	 430 400 300 375	 A B C D	7.3 b	45.6	3.0	68.7 a
4	Tebuconazole Microstar Luna Experience Intuity Luna Experience	 430 400 300 400	 A B C D	5.0 b	47.4	1.9	72.6 a
5	Tebuconazole Microstar Luna Experience Intuity	 430 400 300	 A B CD	10.4 b	49.3	1.6	73.1 a
6	Tebuconazole Microstar Intuity Luna Experience	 430 300 400	 A B CD	10.4 b	46.5	3.0	70.0 a
			***P*-value**	0.0592	0.5738	0.6246	0.0900
			LSD (*P* = 0.10)	6.75	NSD	NSD	4.91

Tebuconazole Microstar = Tebuconazole coated onto Microstar carrier applied at sowing, an industry standard for onion white rot control in Tasmania
Means followed by the same letter are not significantly different (P = 0.10, LSD); NSD = No significant difference due to a P-value > 0.10
Rejected onions due to severe onion white rot on onion bulbs

The Moriarty field trial was conducted in a spring-sown onion crop established on 29 August 2022 and harvested on 31 January 2023. Pre-plant soil testing confirmed the presence of both major root rot pathogens, with quantitative PCR detecting 4 kDNA copies/g soil of *Sclerotium cepivorum* and 167 kDNA copies/g soil of *Septophoma terrestris*. Because the crop was grown under warmer spring soil conditions, the proportion of onions rejected due to onion white rot ranged from 1.6% to 4.9%. In the treatment where tebuconazole was applied only at sowing, only 4.9% were rejected due to severe disease. No statistically significant differences were detected among treatments on the incidence of rejected onions. This lack of detectable treatment effects was likely due to high variability among plots, combined with reduced statistical power because only four replicates could be established instead of the five originally planned. Nevertheless, post-emergent fungicide programs significantly increased yield of marketable onions compared with tebuconazole applied only at sowing.

Across both trials, all tested fungicide programs were safe on onions under the conditions of the trials, with no evidence of crop phytotoxicity.

9. Post Emergence Fungicide programs without tebuconazole at planting

The 2023-24 season Forthside trial was sown on 17 September 2023 and harvested on 1 February 2024 (Tables 9.1-9.2). Onion white rot was widespread in the untreated control, with 65% of onions affected but still marketable after drying. Only 0.4% were rejected due to severe onion white rot, indicating that disease was present, but severe bulb breakdown was limited, likely due to warm, dry conditions.

Fungicide programs improved bulb health by increasing the proportion of onions classed as healthy with only root rot and reducing marketable onion white rot affected bulbs. The untreated control had 35% healthy onions, compared with 57% for tebuconazole followed by Luna Experience, Intuity and Allitron, and also 57% for tebuconazole followed by EXP 3 at 0.5 L/ha. The early Luna Experience program without tebuconazole at sowing performed similarly to the untreated control.

Yield results followed the same trend. The untreated control produced 13.9 t/ha of healthy onions, compared with 23.7 t/ha for the standard tebuconazole-based program, 26.6 t/ha for tebuconazole followed by EXP 3 at 0.5 L/ha, and 22.7 t/ha for tebuconazole followed by EXP 3 at 1.0 L/ha. The early Luna Experience program produced 16.9 t/ha. Total marketable yield did not differ significantly among treatments because many onion white rot affected bulbs remained marketable after drying.

The Forth trial in 2023-24 was sown on 16 September 2023 and harvested on 7 February 2024 (Tables 9.1-9.2). Onion white rot incidence was also high in he untreated control, with 68% of onions affected but still marketable and 1.6% rejected due to severe disease. All fungicide programs significantly improved bulb health. Healthy onion incidence increased from 31% in the untreated control to 57–59% in treated plots, while marketable onion white rot affected onions decreased from 68% to 41–43%. Yield data confirmed this quality improvement. Healthy onion yield increased from 17.9 t/ha in the untreated control to 36.7–40.8 t/ha in treated plots. Tebuconazole followed by EXP 3 at 0.5 or 1.0 L/ha produced the highest healthy onion yields, at 40.8 and 40.2 t/ha, respectively, followed by the standard tebuconazole, Luna Experience, Intuity and Allitron program at 37.5 t/ha. Rejected yield was low but was reduced from 1.4 t/ha in the untreated control to 0.0–0.3 t/ha in fungicide treatments.

Total marketable yield at Forth was not significantly different among treatments. However, fungicide programs improved the quality composition of the crop by increasing healthier onions and reducing onion white rot affected but marketable bulbs. This is commercially important because affected bulbs may remain saleable after drying but may have lower quality and carry greater storage risk.

The Forthside trial in the 2024-25 season was sown on 23 September 2024 and harvested on 17 February 2025 (Table 9.3. Warm soil temperatures and dry topsoil from November 2024 to January 2025 also limited severe onion white rot development. Although 40% of bulbs in the untreated control were affected by onion white rot, infection was limited to the outer scales and all affected bulbs remained marketable after drying and peeling.

All fungicide treatments improved bulb quality compared with the untreated control by increasing healthy-root onion yield and reducing marketable onion white rot affected yield. The untreated control produced 22.6 t/ha of healthy-root onions, and 38.6 t/ha of marketable onion white rot affected onions. Tebuconazole applied on Microstar at sowing increased healthy-root yield to 39.3 t/ha and reduced marketable onion white rot yield to 12.6 t/ha. The standard tebuconazole, followed by Luna Experience, Intuity and Allitron program produced 43.2 t/ha of healthy-root onions, and 15.1 t/ha of marketable onion white rot affected onions.

EXP 3 performed strongly when applied after tebuconazole at sowing. Tebuconazole, followed by EXP 3 at 0.5 L/ha produced 41.6 t/ha of healthy-root onions and 12.6 t/ha of marketable onion white rot affected onions. Increasing EXP 3 to 1.0 L/ha produced the highest healthy-root yield, at 48.5 t/ha, and the lowest marketable onion white rot affected yield, at 10.8 t/ha, indicating the strongest improvement in bulb quality in this trial. A single early Luna Experience application after seedling emergence was less effective than tebuconazole at sowing. It produced 34.5 t/ha of healthy-root onions, and 21.8 t/ha of marketable onion white rot affected onions. In the full spray programs, using tebuconazole as the first application also appeared more effective than beginning with Luna Experience. Total marketable yield and mean bulb weight did not differ significantly among treatments. The main treatment benefit was therefore improved bulb quality, with yield shifted from onion white rot affected bulbs into healthier categories.

In the 2023-24 and 2024-25 seasons, all fungicide treatments were safe on onions when applied at sowing or as post-emergent spray drenches, with no phytotoxicity observed under the trial conditions.

Table 9.1. Root rot and onion white rot diseases on onions

No.	Treatment	Product rate (per ha)	Application timing	Incidence of onions (% onion bulbs affected)					
				Forthside (01/02/2024)			Forth (07/02/2024)		
				Healthy onions with only root rot	Marketable onion white rot affected onions	Rejected onions	Healthy onions with only root rot	Marketable onion white rot affected onions	Rejected onions
1	Untreated control	Nil	Nil	34.8 b	64.9 a	0.4	30.9 b	67.5 a	1.6 a
2	Luna Experience Luna Experience Intuity Allitron	1.0 L 1.0 L 1.2 L 1.0 L	B C D E	41.0 b	59.0 a	0.0	57.0 a	41.7 b	1.3 ab
3	Tebuconazole on Microstar Luna Experience Intuity Allitron	1.0 L 1.0 L 1.2 L 1.0 L	A C D E	57.1 a	42.9 b	0.0	58.9 a	40.7 b	0.3 bc
4	Tebuconazole on Microstar EXP 3	1.0 L 0.5 L	A CDE	56.9 a	43.1 b	0.0	57.8 a	42.2 b	0.0 c
5	Tebuconazole on Microstar EXP 3	1.0 L 1.0 L	A CDE	49.4 ab	50.6 b	0.0	56.7 a	43.0 b	0.3 bc
			***P*-value**	0.0927	0.0976	0.4307	0.0001	0.0001	0.0997
			P = 0.05	-	-	-	10.87	10.61	-
			***P* = 0.10**	15.77	15.74	NSD	-	-	tA

Means followed by the same letter are not significantly different (P = 0.05 or 0.10, LSD)
NSD = No significant difference due to a P-value > 0.10
tA = Original plot means are presented with P-values and letters of separation from data transformed using y = Arcsine square root percent (x)
Healthy onions with only root rot – healthy bulbs that only has root infections by pink root or onion white rot diseases
Marketable onion white rot onions were onions that had mild onion white rot infections on outer scales and were still marketable after drying
Rejected onions had severe and deep onion white rot infections on onion scales and onion basal plates

Table9.2. Quality and yield of marketable onions

No.	Treatment	Product rate (per ha)	Application timing	Yield of onions (adjusted to t/ha)					
				Forthside (01/02/2024)			Forth (07/02/2024)		
				Healthy onions with only root rot	Marketable onions	Rejected onions	Healthy onions with only root rot	Marketable onions	Rejected onions
1	Untreated control	Nil	Nil	13.9 c	46.8	0.2	17.9 b	69.5	1.4 a
2	Luna Experience Luna Experience Intuity Allitron	1.0 L 1.0 L 1.2 L 1.0 L	B C D E	16.9 bc	46.5	0.0	36.7 a	66.0	0.3 b
3	Tebuconazole on Microstar Luna Experience Intuity Allitron	1.0 L 1.0 L 1.2 L 1.0 L	A C D E	23.7 ab	47.3	0.0	37.5 a	71.0	0.1 b
4	Tebuconazole on Microstar EXP 3	1.0 L 0.5 L	A CDE	26.6 a	49.4	0.0	40.8 a	74.5	0.0 b
5	Tebuconazole on Microstar EXP 3	1.0 L 1.0 L	A CDE	22.7 ab	51.0	0.	40.2 a	75.8	0.3 b
			***P*-value**	0.0646	0.7822	0.4307	0.0015	0.5384	0.0437
			P = 0.05	-	-	-	10.93	NSD	0.92
			***P* = 0.10**	7.82	NSD	NSD	-	-	-

Means followed by the same letter are not significantly different (P = 0.05 or 0.10, LSD)
NSD = No significant difference due to a P-value > 0.10
Rejected onions due to severe onion white rot on onion bulbs
Marketable onions included healthy onions with root rots and onion white rot affected onions but still marketable

Table 9.3. Forthside trial 2024-2025 - quality and yield of onions bulbs

No.	Treatment	Product rate (L or kg/ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha) (17/02/2025)						Mean bulb weight (g/bulb)
				Healthy onion bulbs			Onion white rot affected bulbs		Total marketable onions	
				Healthy roots	Mild root rot*	Severe root rot*	Marketable onions	Rejected onions		
1	Untreated control	Nil	Nil	22.6 c	29.2	1.4	38.6 a	0	91.8	162
2	Luna Experience	1 L	B	34.5 bc	34.1	3.4	21.8 b	0	93.8	168
3	Tebuconazole + Microstar	1 L + 30 kg	A	39.3 ab	48.3	1.7	12.6 bc	0	101.9	182
4	Luna Experience Luna Experience Intuity Allitron	1 L 1 L 1.2 L/ha 1 L/ha	B C D E	38.4 ab	35.8	2.6	18.6 bc	0	95.2	170
5	Tebuconazole + Microstar Luna Experience Intuity Allitron	1 L + 30 kg 1 L 1.2 L 1 L	A C D E	43.2 ab	38.7	3.3	15.1 bc	0	100.3	177
6	Tebuconazole + Microstar EXP 3	1 L + 30 kg 0.5 L	A C, D & E	41.6 ab	43.9	2.7	12.6 bc	0	100.7	170
7	Tebuconazole + Microstar EXP 3	1 L + 30 kg 1 L	A C, D & E	48.5 a	40.2	5.4	10.8 c	0	105.0	175
***P*-value**				0.0801	0.3833	0.3127	0.0001	-	0.4656	0.9754
LSD (*P* = 0.05)				-	NSD	NSD	9.93	-	NSD	NSD
LSD (*P* = 0.10)				13.39	-	-	-	-	-	-

Means followed by the same letter are not significantly different (P = 0.05 or 0.10, LSD); NSD = No significant difference due to a P-value > 0.05
* Bulbs with mild or severe root rots including roots affected by pink root and onion white rot disease on roots: i.e. excluding bulbs that were affected by onion white rot
Tebuconazole + Microstar = Tebuconazole treated Microstar granules

10. Evaluation of biologicals for root health and onion white rot control

At Sassafras, in the 2024–25 season, red onions were sown on 26 September 2024 and harvested on 12 February 2025. Treatment responses differed between the two trials, reflecting differences in site conditions and the use of tebuconazole at sowing (Tables 10.1-10.2). Soil temperatures recorded with dataloggers 20 cm deep indicated that soil temperatures in the Sassafras site were generally warmer ranging 16 to 22oC from than those at Forthside ranging from 10 to 21oC.

At Sassafras, where tebuconazole was not applied at sowing, the untreated control had lower healthy bulbs with healthy-root yield and the highest level of onion white rot reject bulbs (Table 10.1). All biological products applied as post-emergent treatments reduced onion white rot rejected onions when compared with the untreated control and increased total marketable onions. With biological treatments, the onion loss due to rejected onions ranged from 2.6 to 7.7 t/ha compared with 16 t/ha in the untreated control.

The Sassafras trial indicates that biological products may have potential to support root health and reduce disease-related losses where tebuconazole is not applied at sowing. Although treatment effects on healthy roots and root rot categories were not statistically significant, biological treatments generally increased healthy-root yield, increased average bulb weights and total marketable yield relative to the untreated control. More importantly, all biological treatments reduced onion white rot reject yield. These results suggest that biologicals may help reduce severe disease losses and improve marketability.

At Forthside, in the 2024-25 season, brown onions were sown on 15 September 2024 and harvested on 7 February 2025. At Forthside, all treatments were applied to plots that had received tebuconazole at sowing (Table 10.2). Disease pressure was very high, but onion white rot disease appeared to be suppressed by tebuconazole applied at sowing, which was likely to reduce the proportion of reject onions even when onions had high levels of severe root rots. Healthy bulbs with healthy-root yield were negligible and most marketable yield was derived from healthy bulbs with root rot symptoms or onion white rot affected bulbs that were still marketable. Post-emergent treatments did not consistently increase total marketable yield above the untreated control, with yields ranging from 75.5 to 87.9 t/ha compared with 84.3 t/ha in the control. The only significant treatment effect was observed in marketable onion white rot affected bulbs, where Serenade Soil Activ and the fungicide program Luna Experience/Intuity/Allitron program recorded the lowest values. This suggests that Serenade Soil Activ has potential to be comparable to the post emergent fungicide program to reduce onion white rot on bulbs.

Overall, for trials in the 2024-25 season, Table 10.1 suggests that under the Sassafras conditions, where no tebuconazole was used at sowing, most biological post-emergent programs reduced onion white rot rejects and gave numerically higher marketable yields than the untreated control. In contrast, Table 10.2 indicates that where tebuconazole had already been applied at sowing at Forthside, the benefits of later post-emergent biological treatments were not clearly expressed. Tebuconazole appeared to provide the main disease control effect, which may have masked any additional benefit from subsequent biological applications on yield or root health.

Table 10.1. Quality and yield of onions bulbs 2024–25 Sassafras (without tebuconazole)

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha)						Mean bulb weight (g/bulb)
				Healthy bulbs			Onion white rot affected bulbs		Total marketable	
				Healthy roots	Mild root rot only*	Severe root rot*	Marketable	Reject		
1	Untreated Control	Nil	Nil	6.7	17.4	5.8	40.6 a	16.0 a	70.4	104
2	F4034 100 SC	1.0 L	AB	15.9	25.1	12.3	28.8 b	5.9 b	82.2	117
3	F4018 87.71 SC	1.0 L	AB	13.3	19.6	12.1	28.2 b	5.9 b	78.6	114
4	Rhizovital 42	1.0 L	AB	15.4	24.3	15.0	32.0 ab	7.6 b	86.8	121
5	Serenade Soil Activ	2.0 L	AB	12.1	29.6	11.9	32.2 ab	3.0 b	85.8	128
6	Turboroot + Wiibio	3.0 kg 5 L	AB	15.8	32.1	16.2	24.5 b	4.5 b	88.6	125
7	ACB-LM200	1 kg	AB	18.5	32.1	16.1	22.6 b	2.6 b	89.3	132
8	Actinovate	850 g	AB	17.4	26.3	12.5	23.4 b	7.7 b	79.6	116
9	Luna Experience Intuity Allitron	1 L 1.2 1 L	BC D E	11.9	33.8	14.4	28.3 b	4.9 b	88.4	129
***P*-value**				0.7405	0.3315	0.5547	0.0998	0.0024	0.1326	0.1205
LSD (*P* = 0.10)				NSD	NSD	NSD	9.71	5.76	NSD	NSD

Means followed by the same letter are not significantly different (P = 0.10, LSD); NSD = No significant difference due to a P-value > 0.10
* Bulbs with mild or severe root rots including roots affected by pink root disease and onion white rot disease on roots: these excluded bulbs that were affected by onion white rot

Table 10.2. Quality and yield of onions bulbs 2024–25 Forthside (with tebuconazole)

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha)						Mean bulb weight (g/bulb)
				Healthy bulbs			Onion white rot affected bulbs		Total marketable	
				Healthy roots	Mild root rot only*	Severe root rot*	Marketable	Reject		
1	Untreated Control	Nil	Nil	0.0	47.9	20.5	15.9 ab	5.3	84.3	130
2	F4034 100 SC	1.0 L	AB	0.0	48.9	17.4	13.4 ab	10.9	79.7	128
3	F4018 87.71 SC	1.0 L	AB	0.4	48.6	18.2	14.3 ab	9.6	81.6	129
4	Rhizovital 42	1.0 L	AB	1.1	38.5	19.8	18.2 a	12.8	77.6	131
5	Serenade Soil Ac	2.0 L	AB	0.0	53.6	21.0	8.0 bc	6.1	82.6	126
6	Turboroot + Wiibio	3.0 kg 5 L	AB	0.0	41.3	18.4	15.8 ab	10.0	75.5	127
7	ACB-LM200	1 kg	AB	0.0	49.8	23.3	14.8 ab	7.2	87.9	136
8	Actinovate	850 g	AB	0.5	50.1	17.4	12.0 abc	9.4	80.1	131
9	Luna Experience Intuity Allitron	1 L 1.2 1 L	BC D E	0.4	58.2	18.9	5.8 c	2.8	83.3	126
			***P*-value**	0.4551	0.8697	0.9979	0.0447	0.1998	0.6982	0.9214
			LSD (*P* = 0.05)	NSD	NSD	NSD	7.47	NSD	NSD	NSD

Means followed by the same letter are not significantly different (P = 0.05, LSD); NSD = No significant difference due to a P-value > 0.05;
* Bulbs with mild or severe root rots including roots affected by pink root disease and onion white rot disease on roots: these excluded bulbs that were affected by onion white rot

In the 2025-26 season, two field trials were conducted at Forthside and Sassafras. Each trial consisted of two distinct blocks. One block received no tebuconazole soil treatment at sowing, while the other block received a tebuconazole soil treatment at sowing. As a result, the experiment functioned as two separate randomized complete block trials, each with five replicates. The two trials were analysed independently and are presented as the trial without tebuconazole and the trial with tebuconazole.

At Forthside, brown onions were sown late in October 2025, approximately one month later than expected due to wet weather conditions. Weather conditions were unusually wet and cold from October 2025 to February 2026. Soil temperatures were also relatively low ranging from 12 to 18ºC at 20 cm depth, which was ideal for onion white rot fungal growth and infections. Onions were lifted on 7 March 2026 and assessed for root rots, onion white rot and marketability. Treatment responses differed between programs used without tebuconazole at sowing and those established on a tebuconazole background (Tables 10.3A and 10.3B). In Table 19A, where tebuconazole was not applied at sowing, there were no significant treatment effects on disease and quality of onions. Total marketable yield ranged from 71.2 to 77.2 t/ha, and premium onion yield ranged from 34.5 to 44.6 t/ha. These results indicate that, under the Forthside conditions without tebuconazole, the post-emergent fungicide and biological programs did not provide a clear or consistent improvement in root health, onion white rot suppression or yield. In contrast, Table 19B shows that programs including tebuconazole at sowing produced numerically higher healthy-root yield, lower severe root rot, fewer onion white rot rejects and higher marketable and premium yields than the corresponding programs without tebuconazole. Total marketable yield ranged from 86.0 to 96.0 t/ha where tebuconazole was included, compared with 71.2 to 77.2 t/ha without tebuconazole.

Premium onion yield also increased substantially, ranging from 73.6 to 87.5 t/ha with tebuconazole compared with 34.5 to 44.6 t/ha without tebuconazole. The highest marketable and premium yields were recorded from the tebuconazole plus Luna Experience/Intuity/Allitron program, which also had the highest healthy-root yield and the lowest severe root rot and onion white rot reject values. Although treatment effects within Table 3B were not statistically significant, the comparison between Tables 10.3A and 10.3B indicates that tebuconazole at sowing was the main factor associated with improved root health, reduced disease severity and higher marketable onion yield at Forthside in 2025–26.

Table 10.3A. Quality and yield of onions bulbs 2025-26 Forthside (without tebuconazole)

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha)							Premium onions % increase relative to Treatment 7	Average bulb weight (g/bulb)
				Healthy bulbs			Onion white rot affected bulbs		Total marketable	Premium onions		
				Healthy roots	Mild root rot only*	Severe root rot*	Marketable	Reject				
1	Intuity 1.2 L/ha Allitron 1 L/ha	1.2 L 1 L	D E	5.9	36.0	20.9	14.5	18.8	77.2	41.8	100	121
2	F4034 Intuity Allitron	1 L 1.2 L 1 L	BC D E	1.9	32.6	23.6	14.4	17.8	72.4	34.5	82	117
3	GO Isolates® Intuity Allitron	14 L 1.2 L 1 L	BC D E	5.2	39.4	16.4	10.4	17.6	71.4	44.6	107	119
4	Serenade Soil Activ Intuity Allitron	2.0 L 1.2 L 1 L	BC D E	2.5	36.0	23.1	13.8	13.2	75.4	38.5	92	110
5	ACB-LM200 Intuity Allitron	0.3 kg 1.2 L 1 L	BC D E	2.1	36.9	25.9	10.9	16.2	75.8	39.0	93	116
6	Luna Exp Intuity Allitron	1 L 1.2 L 1 L	C D E	4.5	33.5	22.7	10.6	16.6	71.2	38.0	91	106
			***P*-value**	0.7921	0.9781	0.8709	0.8021	0.9830	0.9435	0.9381		0.3737
			LSD (*P* = 0.05)	NSD	NSD	NSD	NSD	NSD	NSD	NSD		NSD

Means followed by the same letter are not significantly different (P = 0.05, LSD); NSD = No significant difference due to a P-value > 0.05
* Bulbs with mild or severe root rots including roots affected by pink root disease and onion white rot disease on roots: these excluded bulbs that were affected by onion white rot
Premium onions consisted of healthy onion bulbs with healthy roots or mild root rots, which store well.

Table 10.3B. Quality and yield of onions bulbs 2025-26 Forthside (with tebuconazole)

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha) 140DAS							Premium onions % increase relative to Treatment 7	Average bulb weight (g/bulb)
				Healthy bulbs			Onion white rot affected bulbs		Total marketable	Premium onions		
				Healthy roots	Mild root rot *	Severe root rot*	Marketable	Reject				
7	Tebuconazole Microstar	1 L	A	13.2	62.4	7.4	8.6	3.6	91.6	75.6	181	124
8	Tebuconazole Microstar F4034	1 L 1 L	A BC	16.1	57.5	6.8	8.0	4.6	88.4	73.6	176	121
9	Tebuconazole Microstar GO Isolates® + ISOGREEN®	1 L 14 L + 14 L	A BC	19.6	56.9	4.3	5.2	2.3	86.0	76.5	183	114
10	Tebuconazole Microstar Serenade Soil Activ	1 L 2.0 L	A BC	20.9	54.1	4.7	10.0	8.2	89.7	75.0	179	125
11	Tebuconazole Microstar ACB-LM200	1 L 0.3 kg	A BC	16.6	60.7	7.7	6.2	4.8	91.2	77.3	185	122
12	Tebuconazole Microstar Luna Experience Intuity Allitron	1 L 1 L 1.2 1 L	A BC D E	26.8	60.7	2.7	5.8	1.9	96.0	87.5	209	129
***P*-value**				0.5061	0.5900	0.4306	0.4939	0.4042	0.8062	0.6624	-	0.6092
LSD (*P* = 0.05)				NSD	NSD	NSD	NSD	NSD	NSD	NSD	-	NSD

Means followed by the same letter are not significantly different (P = 0.05, LSD); NSD = No significant difference due to a P-value > 0.05
* Bulbs with mild or severe root rots including roots affected by pink root disease and onion white rot disease on roots: these excluded bulbs that were affected by onion white rot
Premium onions consisted of healthy onion bulbs with healthy roots or mild root rots, which store well.
** Treatment 7 was not included in the analysis and was shown only for comparisons

At the Sassafras trial in 2025-26, red onions were sown on 22 September 2025 and harvested on 16 February 2026. Soil temperatures were also relatively low ranging from 12 to 18°C at 20 cm depth, which was ideal for onion white rot fungal growth and infections but not favourable to growth of biological products. Treatment responses were compared

between programs used without tebuconazole at sowing and those established on a tebuconazole background (Tables 10.4A and 10.4B). In Table 10.4A, where tebuconazole was not applied at sowing, there were no significant treatment effects on root health or onion white rot disease. Total marketable yield was similar across treatments, ranging from 52.1 to 55.9 t/ha compared with 54.8 t/ha in the untreated control. These results indicate that, under the Sassafras conditions without tebuconazole, the biological and post-emergent fungicide programs did not provide a clear improvement in root health, onion white rot suppression or total marketable yield.

Table 10.4B indicates that the inclusion of tebuconazole at sowing improved overall crop performance compared with the corresponding programs without tebuconazole. The tebuconazole-based treatments produced higher healthy-root yield, lower severe root rot and fewer onion white rot reject bulbs, and total marketable yield was generally higher than in Table 20A. The addition of biological products to the tebuconazole plus Intuity/Allitron program did not provide a significant improvement over the Tebuconazole on Microstar/Intuity/Allitron standard. These results indicate that, under the Sassafras 2025–26 conditions, biological additions to the tebuconazole-based program showed some numerical trends, particularly for Serenade Soil Activ, but did not provide a consistent or statistically significant benefit over the Tebuconazole on Microstar/Intuity/Allitron program.

Table 10.4A. Quality and yield of onions bulbs 2025-26 Sassafras (without tebuconazole)

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha)						Average bulb weight (g/bulb)
				Healthy bulbs			Onion white rot affected bulbs		Total marketable	
				Healthy roots	Mild root rot only*	Severe root rot*	Marketable	Reject		
1	Untreated Control	Nil	Nil	6.2	21.4	20.8	6.4	14.8	54.8	104
2	Actinovate	0.85 kg	BC	5.5	20.8	24.5	5.1	12.6	55.8	97
3	GO Isolates® ISOGREEN®	14 L 14 L	BC	2.8	22.8	25.4	4.9	13.7	55.9	103
4	Serenade Soil Activ	2.0 L	BC	5.8	22.0	18.4	5.9	12.6	52.1	97
5	ACB-LM200	0.3 kg	BC	1.9	22.6	24.0	5.4	16.4	53.8	101
6	Luna Experience Intuity Allitron	1 L 1.2 1 L	BC D E	5.9	25.6	18.1	5.6	8.0	55.2	96
			***P*-value**	0.9288	0.9797	0.9121	0.9831	0.8608	0.9971	0.9698
			LSD (*P* = 0.10)	NSD	NSD	NSD	NSD	NSD	NSD	NSD

NSD = No significant difference due to a P-value > 0.10

* Bulbs with mild or severe root rots including roots affected by pink root disease and onion white rot disease on roots: excluding bulbs that were affected by onion white rot

Table 10.4B. Quality and yield of onions bulbs 2025-26 Sassafras (with tebuconazole)

No.	Treatment	Product rate (per ha)	Application timing	Quality of onion bulbs (yield adjusted to t/ha)						Mean bulb weight (g/bulb)
				Healthy bulbs			Onion white rot affected bulbs		Total marketable	
				Healthy roots	Mild root rot only*	Severe root rot*	Marketable	Reject		
7	Tebuconazole Microstar Intuity 1.2 L/ha Allitron 1 L/ha	1 L 1.2 L 1 L	A D E	5.5	37.3	27.8	7.0	6.2	77.6	115
8	Tebuconazole Microstar Actinovate Intuity Allitron	1 L 0.85 kg 1.2 L 1 L	A BC D E	4.3	31.4	27.6	8.7	6.9	72.0	116
9	Tebuconazole Microstar GO Isolates® Intuity Allitron	1 L 14 L 1.2 L 1 L	A BC D E	8.1	33.7	23.2	7.9	8.7	72.9	127
10	Tebuconazole Microstar Serenade Soil Activ Intuity Allitron	1 L 2.0 L 1.2 L 1 L	A BC D E	8.1	44.5	21.4	8.3	3.9	82.3	121
11	Tebuconazole Microstar ACB-LM200 Intuity Allitron	1 L 0.3 kg 1.2 L 1 L	A BC D E	7.1	35.0	25.5	8.0	5.8	75.6	117
12	Tebuconazole Microstar Luna Experience Intuity Allitron	1 L 1 L 1.2 L 1 L	A C D E	10.6	37.3	23.0	6.2	5.9	77.1	119
***P*-value**				0.8347	0.4914	0.8579	0.9843	0.1994	0.7901	0.7101
LSD (*P* = 0.10)				NSD	NSD	NSD	NSD	NSD	NSD	NSD

NSD = No significant difference due to a P-value > 0.10; * Bulbs with mild or severe root rots including roots affected by pink root disease and onion white rot disease on roots: excluding bulbs that were affected by onion white rot

Across the 2024–26 trials, tebuconazole applied at sowing was the most consistent factor associated with improved onion health and marketable yield. Biological products showed variable performance across sites and seasons. Seasonal conditions appear to have strongly influenced biological product performance. The 2024–25 season was warmer and drier, and biological treatments performed better under these conditions, particularly in the Sassafras trial where tebuconazole was not applied at sowing. In contrast, the 2025–26 season was wet and cold, with relatively low soil temperatures that favoured onion white rot infection but were less favourable for biological activity. Under these cooler, wetter conditions, biological products used without tebuconazole did not improve root health, onion white rot suppression or yield. This seasonal contrast suggests that biological products may perform best when soil conditions are warm enough to support microbial activity and disease pressure is not excessive.

Biologicals showed some potential to improve root health by shifting bulbs into healthier categories, including bulbs with no or mild root rot. However, responses were inconsistent and depended on disease pressure, soil conditions and tebuconazole use. They performed better under warmer, drier conditions but were less reliable under wet, cold conditions and high disease pressure. Overall, biologicals are best considered supplementary treatments within an integrated program, rather than stand-alone replacements for tebuconazole.

Overall, the trials indicate that biological products may have a role as complementary tools within an integrated disease management program, particularly where they support root health or reduce the severity of disease-related losses. However, they should not be considered replacements for tebuconazole in paddocks with high onion white rot risk. Further work is needed to confirm which biological products, application timings and soil conditions provide reliable benefits, and whether these products can improve consistency when used alongside fungicide and other disease management practices.

11. Effect of application methods and irrigation timing on efficacy of triadimenol

Onion white rot is commonly managed with tebuconazole-treated fertiliser at planting, followed by up to three post-emergent applications of triadimenol (Allitron 375 SC). As onion white rot infection occurs below ground, the efficacy of post emergent fungicide sprays may depend on sufficient soil moisture to move the active ingredient to the basal plate and developing roots to optimise their efficacy. Allitron is usually applied by boom spray before rainfall or irrigation to move the active ingredient into the soil, but the optimal timing of irrigation soon after application can be difficult to achieve in commercial practice.

This trial investigated the effects of irrigation timing after Allitron applications and types of nozzles. Allitron was also applied with Transformer soil conditioner at 5 L/ha. Transformer is a soil conditioner that has potential to improve the infiltration, distribution, and drainage of irrigation water and rain into the soil, and to move the spray solution throughout the soil profile.

This trial was conducted within a commercial onion crop that had been treated with tebuconazole on Microstar carrier at sowing for early onion white rot control. Although this trial was set up in a paddock that had high onion white rot disease pressure in previous onion crops, there was negligible onion bulbs affected by onion white rot with only one affected bulb found in the whole trial during assessments. Early tebuconazole application and warmer topsoil conditions in December to February 2022 may have limited onion white rot disease severity in the trial.

Instead, many onion plants had mild to moderate root infections. However, all bulbs that had root infections were unaffected and still marketable. Fungal isolations detected root rots due to pink root (*Septophoma terrestris*), *Fusarium root* rot (*Fusarium oxysporum*) and onion white rot (*Sclerotium cepivorum*). Separations of root infections according to pathogens were too difficult and hence were grouped together and classified as roots assessed as root rots. It is interesting that although there was no obvious onion white rot disease symptoms, many infected roots were found to have the onion white rot fungus.

Across the trial, all Allitron spray programs increased the proportion of healthy onions with healthy roots as well as increasing the yield of onions. All fungicide applications significantly increased healthy onions that had no root rots from 50 t/ha in the untreated control to 70-78 t/ha (Table 11.1).

There was no significant difference in the irrigation timing with Allitron treatments, sprays applied 3 days prior to irrigation were as effective as irrigation after sprays on the same day although numerically the plots treated with Allitron at 0 or 1 days before irrigation had a higher yield of onions with healthy roots than Allitron applied 3 days prior to irrigation. There was also no significant improvement when Allitron was applied with Transformer soil conditioner over Allitron by itself. Allitron applied with Stream jet nozzles was equivalent to flat fan nozzles, in reducing root rots.

Table 11.1. Quality and yield of harvested onions

No.	Treatment*	Nozzle	Timing	Average weights of marketable bulbs (g/bulb)	Onion bulbs and roots (adjusted to t/ha)		
					Healthy onion with healthy rootss - marketable (t/ha)	Healthy onions with root rots - marketable (t/ha)	Total marketable onions (t/ha)
1	Untreated control	Nil	Nil	135	50.2 b	26.3 a	76.5 b
2	Allitron 375 SC	Flat fan	-3ABC	148	70.0 a	17.5 b	87.6 a
3	Allitron 375 SC	Stream jet	-3ABC	149	73.4 a	18.7 ab	86.1 a
4	Allitron 375 SC	Flat fan	-1 or 0 ABC	145	77.3 a	16.2 b	93.4 a
5	Allitron 375 SC	Flat fan	ABC	147	76.4 a	14.7 b	91.1 a
6	Allitron 375 SC Transformer *	Flat fan	ABC A	138	77.6 a	12.8 b	90.5 a
7	Allitron 375 SC	Stream jet	ABC	136	69.8 a	19.7 ab	89.5 a
			***P*-value**	0.2393	0.0001	0.0351	0.0157
			LSD (*P* = 0.05)	NSD	6.77	7.64	8.79

Means followed by the same letter are not significantly different (P = 0.05 or 0.10, LSD)
Whole trial had been treated with tebuconazole at sowing
Allitron 375 SC applied at 1 L/ha in all treatments

Plant and soil samples were also collected in plots of Treatment 2 and Treatment 5 at 3 and 28 days after application timing C for residue tests for triademinol, to determine the distribution of the fungicide after application (Tables 22-24). Triademinol residues were detected in the onion bulbs and roots, and soil 15 cm deep, and there were generally higher levels of triadimenol in the soil after 28 days in plots irrigated on the same day as application compared to irrigation 3 days after application.

Table 11.2. Triademinol residues in foliage

No.	Treatment	Nozzle	Timing	Triadimenol residue in foliage (mg/kg WMB)			
				Replicate 1	Replicate 2	Replicate 3	Mean
Samples collected 3 days after Application C followed by irrigation							
2	Allitron 375 SC	Flat fan	-3ABC	0.77	0.65	0.93	**0.78**
5	Allitron 375 SC	Flat fan	ABC	0.86	0.53	0.60	**0.66**
Samples collected 28 days after Application C							
2	Allitron 375 SC	Flat fan	-3ABC	0.10	0.07	0.10	**0.09**
5	Allitron 375 SC	Flat fan	ABC	0.17	0.07	0.11	**0.12**

Table 11.3. Triademinol residues in bulbs and roots

No.	Treatment	Nozzle	Timing	Triadimenol residue in bulbs and roots (mg/kg WMB)			
				Replicate 1	Replicate 2	Replicate 3	Mean
Samples collected 3 days after Application C followed by irrigation							
2	Allitron 375 SC	Flat fan	-3ABC	0.06	0.05	0.07	**0.06**
5	Allitron 375 SC	Flat fan	ABC	0.07	0.06	0.06	**0.06**
Samples collected 28 days after Application C							
2	Allitron 375 SC	Flat fan	-3ABC	0.04	0.04	0.04	**0.04**
5	Allitron 375 SC	Flat fan	ABC	0.05	0.04	0.05	**0.05**

Table 11.4. Triademinol residues in top 15 cm soil

No.	Treatment	Nozzle	Timing	Triadimenol residue in soil (mg/kg DMB)			
				Replicate 1	Replicate 2	Replicate 3	Mean
Samples collected 3 days after Application C followed by irrigation							
2	Allitron 375 SC	Flat fan	-3ABC	1.3	1.2	1.2	**1.23**
5	Allitron 375 SC	Flat fan	ABC	2.1	0.98	1.0	**1.36**
Samples collected 28 days after Application C							
2	Allitron 375 SC	Flat fan	-3ABC	0.77	0.52	0.63	**0.64**
5	Allitron 375 SC	Flat fan	ABC	1.00	0.70	0.86	**0.85**

Integrated onion white rot management strategies

Overall, the project demonstrates that onion white rot management requires an integrated approach combining representative pre-plant soil testing, paddock history and risk classification, targeted fungicide use, careful monitoring and long-term crop rotation planning. Soil PCR testing is a valuable planning tool, but its accuracy depends on sampling strategy and the patchy distribution of inoculum. Fungicide programs can substantially suppress disease expression, but they do not eliminate risk in paddocks with moderate to high inoculum levels. Biological products may support future integrated strategies, but further validation is required before they can be recommended as primary control options. For growers, the key practical outcome is that paddocks with detectable or increasing *S. cepivorum* levels should be managed proactively using test-informed risk thresholds, strengthened fungicide programs where appropriate, and continued monitoring through to harvest.

Tebuconazole-treated Microstar applied at sowing is currently the foundation treatment for suppressing onion white rot. Across commercial monitoring sites and fungicide trials, crops receiving Tebuconazole-treated Microstar generally had lower onion white rot incidence and better bulb health than untreated areas, confirming the value of early in-furrow protection where *Sclerotium cepivorum* inoculum is present. However, Tebuconazole-treated Microstar did not eliminate disease risk, particularly in paddocks with moderate to high pre-plant inoculum levels, indicating that soil test results, paddock history and seasonal conditions should still guide risk management. Post-emergent fungicide programs, including broadcast sprays and drench applications with products such as Luna Experience, Intuity and Allitron, provided additional suppression and helped reduce disease expression under commercial conditions. Overall, the best control strategy was a program approach: Tebuconazole-treated Microstar at sowing to protect early crop establishment, followed by targeted post-emergent fungicide applications to maintain suppression through the main onion white rot infection period.

Outputs

Table 12. Output summary

Output	Description	Detail
Development of soil DNA test.	DNA test methodology based on extracting PCR quality DNA from soil samples for testing by qPCR for specific detection of *Sclerotium cepivorum* has been developed by SARDI	Test now commercially available for growers through SARDI PREDICTA soil tests.
Optimise spray timing and dose rates of in-season chemical treatments.	Development of recommendations on rates and timings of fungicides.	Field trial completed to quantify the effects of irrigation timing and application rate of post emergence fungicides. Field trials completed to evaluate post emergence fungicide programs integrating two new fungicides (Intuity and Lubna Sensation). Trials evaluated various programs and timings. Field trials completed to demonstrate the importance of tebuconazole applied at planting as the basis for fungicide programs.
Identification of potential new chemistry and natural sclerotia germination stimulants.	Development of an integrated management strategy for onion white rot disease in onions	The evaluation and development of fungicide programs with new fungicide modes or action as previously the industry relied solely on group 3 fungicides. The two new fungicides (Luna Experience and Intuity) are registered with the APVMA and available to onion growers. A commercially available garlic exctract (NemGuard 1280 g/L garlic extract) is currently registered for control of nematodes in vegetable crops in Australia. NemGuard was tested and compared to onion juice in laboratory and field trials as a potential germination stimulant for onion white rot sclerotes to reduce soil inoculum levels prior to planting onions. NemGuard did not reduce onion white rot levels in soils at the rates and timings tested.
Annual Industry updates.	Project update to industry and industry publications.	Annual extension events were held to provide projects updates and also seek input from industry on future direction of the project. These events were held in key onion growing regions of Australia, NW Tasmania, Murray Bridge South Australia and Gatton Queensland. These events were all well attended by industry as onion white rot is an issues which affects most of the industry. See details below for extension events and publications.
Reporting	Project reports, milestone reports and final reports.	Milestone reports completed and submitted to Hort Innovation. All trials written up as separate individual reports with full trial details, data analysis and interpretation. Project final report.

Extension events

Annual extension events were held to provide projects updates and also seek input from industry on future direction of the project. These events were held in key onion growing regions of Australia, NW Tasmania, Murray Bridge South Australia and Gatton Queensland. Events were all well attended by industry as onion white rot is an important issue which affects most of the industry. The assistance of Ausveg and RMCG staff in the extension and communication of this project is gratefully acknowledged. A number of publications were also produced through the project to communicate information to industry who were unable to attend the presentations.

- Project presentation at a field trial site during the Onion Growers Farm Walk as part of TIA Forthside Field Day in NW Tasmania on 3rd Nov 2021.
- Project update to industry provided via webinar organized by RMCG on 28th April 2022. Participants from all major onion growing regions in Australia.
- Project update provided to Cox-Inall for publication, May 2022.
- Project update and planning meeting, held May 27th 2022, in Forth Tasmania.
- Project update provided to Onions Australia at their annual meeting in October 2022.
- Project update provided to Onions Australia at their annual meeting in May 2023.
- Project update provided to the Tasmanian Onion Agronomy Group meeting in May 2023.
- Project update presented to industry at the Farm Innovation Expo at Hagley on 18 April 2024.
- Project updated presented at the “pub in paddock” onion growers meeting in Penguin Tasmania on 21st November 2024.
- Article published by Ausveg in Australian Grower (Winter 2024) (Appedix ii).
- Project update presented at the Ausveg onion growers meeting in Gatton Queensland on 4th December 2024.
- Project update presented at Muir’s 2025 Onion Grower Night at Murray Bridge, South Australia on 12 June 2025.
- Project update presented at Forthside Vegetable Research Farm field day on 9th December 2025
- Presentation on final project outcomes presented at Forthside Vegetable Research Farm on 21st May 2026, attended by key onion growers, packers and exporters along with onion agronomists and Hort Innovation.
- Onion white rot fact sheet published on Ausveg website (Appendix i).

Outcomes

Table 13. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Development of an integrated management strategy for onion white rot disease in onions	Outcome 2, Strategy 1, KPI Increase in adoption of integrated pest and disease management (IPDM) strategies and decrease in crop loss from key weeds, insect pests and diseases	The project has contributed to developing a more integrated management strategy for onion white rot disease in onions.	The development and availability of a soil test to measure pathogen levels over time. Identification and evaluation of sclerotia germination stimulants applied prior to planting. The evaluation and development of fungicide programs with new fungicide modes or action as previously the industry relied solely on group 3 fungicides. The two new fungicides are registered with the APVMA and available to onion growers. Identification of biologicals and their effect on disease suppression and root health. Quantified the effects of irrigation timing and application rate of post emergence fungicides

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Increased grower understanding of onion white rot disease.	Outcome3, Strategy 1, KPI Establishment of a baseline to develop relevant measurables and demonstrate increased share of industry (hectares) with positive change in knowledge, attitudes, skills and aspirations (KASA), practice and impact in targeted high-priority areas (e.g., trade, quality, biosecurity, soil health, plant health)	Communication of project results to industry.	Annual extension events were held to provide projects updates and also seek input from industry on future direction of the project. These events were held in key onion growing regions of Australia, NW Tasmania, Murray Bridge South Australia and Gatton Queensland. Events were all well attended by industry as onion white rot is an issue which affects most of the industry. A number of publications were also produced through the project to communicate information to industry who were unable to attend the presentations.
Availability of new onion white rot management strategies for growers	Outcome 2, Strategy 1, KPI Increase in adoption of integrated pest and disease management (IPDM) strategies and decrease in crop loss from key weeds, insect pests and diseases	Availability of new management strategies to allow growers to have a more integrated approach to management of onion white rot.	Soil DNA test now commercially available for growers through SARDI PREDICTA soil tests. New fungicides identified and evaluated in trials. Two new fungicides registered for control of onion white rot. New sclerotia germination stimulants identified and evaluated in field trials. New biologicals identified and effects on crop health and disease suppression investigated.

Monitoring and evaluation

Table 14. Key Evaluation Questions

Key Evaluation Question	Project performance	Continuous improvement opportunities
To what extent has the project achieved its expected outcomes?	The project has contributed to developing a more integrated management strategy for onion white rot disease in onions. • The development and availability of a soil test to measure pathogen levels over time. • Identification and evaluation of sclerotia germination stimulants applied prior to planting. • The evaluation and development of fungicide programs with new fungicide modes or action as previously the industry relied solely on group 3 fungicides. The two new fungicides are registered with the APVMA and available to onion growers. • Identification of biologicals and their effect on disease suppression and root health. • Quantified the effects of irrigation timing and application rate of post emergence fungicides.	• Use of soil DNA test to better understand the pathogen levels in soils over time and the effects of different management strategies and rotations. • Further evaluation and incorporation of biologicals and green manure crops in integrated management strategies for onion white rot and other diseases of onions. • Optimising the use of tebuconazole at planting and the evaluation of other fungicide actives to be applied at planting.
How relevant was the project to the needs of intended beneficiaries?	The outcomes from the project have been communicated to industry through regular extension events and some of the tools and strategies are available to industry levy payers to implement on their farms.	NA
How well have intended beneficiaries been engaged in the project?	Regular extension events were held through the project and were well attended by industry. A number of growers also hosted and participated in the field trials.	NA
To what extent were engagement processes appropriate to the target audience/s of the project?	The extension events were always well attended by industry and growers. The events were held annually in the main onion growing region of Tasmania on the NW coast so were accessible to levy payers. An extension event was also held in Gatton, SE Qld.	NA

Recommendations

- A Soil DNA test was developed and validated in the field and laboratory as part of this project. The test is now commercially available for growers through SARDI PREDICTA soil tests. Testing allows growers and advisors to confirm disease risk, anticipate possible field outcomes, and make informed decisions about paddock selection, rotation planning, and the intensity of disease management required.
- Across laboratory, pot, and field experiments, NemGuard did not reduce *Sclerotium cepivorum* sclerotia viability or soil DNA levels, and in several assessments a slight upward trend in kDNA was observed with increasing NemGuard rate. Although counter to the expected direction of effect, these increases were small, inconsistent between sites, and statistically non-significant, indicating that they do not represent a true biological increase in viable inoculum. This pattern is readily explained by the characteristics of qPCR-based soil assays, which quantify total pathogen DNA rather than viable propagules. DNA from dead or degraded sclerotia, fragmented mycelium, or non-infective residues can persist in soil for extended periods and contribute to measured kDNA levels. As a result, qPCR values may remain stable or fluctuate slightly even when sclerotia viability declines or when treatments have no biological effect. The combined evidence therefore indicates that NemGuard did not cause a significant decline in the pathogen levels in soil, and the minor increases in kDNA reflect methodological detection of total DNA rather than treatment-driven changes in inoculum viability.
- Trials over multiple seasons have demonstrated the importance of tebuconazole at planting, which provides the basis for onion white rot management, particularly in high disease pressure situations. Other strategies such as biologicals or post emergence fungicides can complement tebuconazole at planting but should not be used as replacements. Further work optimising the efficacy of tebuconazole treatments at planting or looking at alternative products at planting to provide improved disease control is justified.
- Two new post emergence fungicides have recently been registered in onions for management of onion white rot, Luna Experience (Fluopyram, group 7 + Tebuconazole, group 3) and Intuity (mandestrobin, group 11) which will offer growers two new fungicide groups (group 7 and 11) for management of onion white rot, in addition to the group 3 fungicides tebuconazole and triadimenol. Trials conducted as part of this project have demonstrated both Intuity and Luna Experience provide effective control of onion white rot when used as part of an integrated management strategy.
- Biological products may have a role as complementary tools within an integrated disease management program, particularly where they support root health or reduce the severity of disease-related losses. Further work is needed to confirm which biological products, application timings and soil conditions provide reliable benefits, and whether these products can improve consistency when used alongside fungicide and other disease management practices.
- Overall, the project demonstrates that onion white rot management requires an integrated approach combining representative pre-plant soil testing, paddock history and risk classification, targeted fungicide use, careful monitoring and long-term crop rotation planning. Soil PCR testing is a valuable planning tool, but its accuracy depends on sampling strategy and the patchy distribution of inoculum. Fungicide programs can substantially suppress disease expression, but they do not eliminate risk in paddocks with moderate to high inoculum levels. Biological products may support future integrated strategies, but further validation is required before they can be recommended as primary control options. For growers, the key practical outcome is that paddocks with detectable or increasing *S. cepivorum* levels should be managed proactively using test-informed risk thresholds, strengthened fungicide programs where appropriate, and continued monitoring through to harvest.

Refereed scientific publications

Not applicable.

References

Clarkson, J., 2016. Investigation into the control of onion white rot in bulb and salad onion crops, Final Report, University of Warwick, project FV499.

Coley-Smith, J.R, King, J.E., 1969. The production by species of Allium of alkyl sulphides and their effect on germination of sclerotia of *Sclerotium cepivorum* Berk. in Ann. appl. Biol. (1969), 64, 289-301.

Crowe FJ, Hall DH, Greathead AS & Baghott KG (1980). Inoculum density of *Sclerotium cepivorum* and incidence of onion white rot of onion and garlic. *Phytopathology* 70:1, 64-69.

Pung, H. 2008, VN05010 Investigations on the efficacy of Folicur in lime super carrier and development of alternative carriers for onion white rot control in onions. HAL Project Final Report VN05010

Villalta, O., Porter, I.J., Wite, D., Stewart, A., McLean, K.L., 2005. Stop the rot: Managing onion white rot in spring onions (VG01096). Horticulture Australia Limited Final Report, Sydney, Australia.

Woodhall JW, Webb KM, Giltrap PM, Adams IP, Peters JC, Budge GE & Boonham N (2012), A new large scale soil DNA extraction procedure and real-time PCR assay for the detection of *Sclerotium cepivorum* in soil. *Eur J Plant Pathol* 134, 467–473.

Wilson, C., Jones, S., 2018. Development of an onion white rot forecast model for Tasmania (VN14001). Hort Innovation Final Report, Sydney, Australia.

Intellectual property

No project IP or commercialisation to report.

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- Arvensis staff who were involved in this project.
- Ausveg and RMCG staff for assistance with the extension and communication of this project.

Appendices

Appendix i – Fact sheet

https://ausveg.com.au/app/uploads/2024/10/FINAL_Onion White Rot-Factsheet-Oct-24.pdf

Management of white rot

Before planting

Crop rotation

Method: In paddocks where white rot has been an issue (or where it has been detected), there should be a break of at least 5-7 years with non-host crops.

Biological and chemical controls

Method: Biological control agents can compete with and inhibit white rot fungus when applied as granular treatments early in the season. However, relying solely on biological controls may not be sufficient; an integrated approach is necessary for effective management.

Registered fungicides include:

Product Name	Active(s)	Fungicide Groups
Various trade names	Tebuconazole	3 (DMI)
Allitron	Triadimenol	3 (DMI)
Luna Experience	Fluopyram & Tebuconazole	7 (SDHI) & 3 (DMI)
Intuity	Mandestrobin	II (Strobilurin)

In crop

Timing of planting

Method: planting onions in warmer soil temperatures (above 25.5°C) can inhibit the growth of the fungi. Soil temperature range for infection is 9°C – 25°C, with an optimum of 15 – 18°C.

Plant nutrition

Method: Regularly test soil to monitor nutrient levels and pH. Adjust soil fertiliser inputs and other amendments accordingly to maintain optimal soil health, and avoid over-fertilising.

Irrigation and drainage

Method: Over-irrigation and poor drainage favour infection. Manage irrigation and moisture where possible. Drainage improvements, soil amendments and variable rate irrigation should also be considered as part of management.

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Appendix ii – Article published by Ausveg in Australian Grower (Winter 2024).

https://ausveg.com.au/app/uploads/2024/05/AUSVEG_AustralianGrower_WINTER_2024_FA-lowres.pdf

Developing strategies to inhibit onion white rot

The project *Optimising chemical and cultural control of onion white rot (VN20007)* spanning five years, aims to develop an integrated disease management strategy for this soil borne disease caused by *Sclerotium cepivorum*.

The effects of onion white rot are far reaching with reduced yield in the field and the potential for disease spread in storage.

Onion white rot is a fungal disease that affects yields in commercial onion crops and it is prevalent throughout Tasmania but is also found in other onion growing regions. To date Western Australia is free from the disease. The fungi can remain dormant for as long as 20 years in the soil, but spreads quickly in the presence of Allium crops.

Onion white rot thrives in cool, moist soils with soil temperatures in the range of 7°C-22°C, with research showing that above 25°C, the disease is substantially inhibited. This suggests that planting later in the season in warmer conditions will limit the effects of the disease, but the drawback is missed early plantings and harvest.

Typical symptoms of onion white rot are brown to black rot predominantly on the roots near the soil. As the disease takes hold, a fluffy white fungal growth will appear at the base of the stem. Small poppy-seed size sclerotia will also be present on the bulbs. The disease can spread quickly, particularly through free-flowing water, with as little as one sclerotium per 10 kilograms enough to set the fungi spread in motion.

Recommendations for onion growers are to be vigilant around farm hygiene – minimising soil movement through personnel and equipment. Soil that is free draining so that it does not retain water will be of assistance as well as choosing varieties that have a strong root growth to assist with disease resistance.

During this project a soil DNA testing protocol is being developed to establish sampling procedures and pathogen thresholds. Further testing of the DNA test compared to field trials will determine the best method of soil sampling, as white rot can be sporadic throughout the paddock.

At a recent presentation at the Tasmania Ag Innovation Day, researcher Phillip Frost of Arvensis Research, said that white rot can be difficult to manage and can lie dormant until the next onion planting.

"Thankfully, white rot only affects allium crops particularly onion and garlic and is not hosted by other vegetables or weeds," he said.

"It is spread through physical movement in the soil, unlike botrytis and downy mildew which can be airborne.

"It has a pretty simple lifecycle – the sclerotes stay in the soil until the onion crop is planted, which triggers germination. From there mycelium fungal filaments develop and spread through the soil. It has no sexual reproduction, it is more like a clone, so there is low genetic variability, making it easier to manage."

It is known that germination of the schlerotes can be triggered by sulphide compounds released by the Allium root system. As a means of reducing disease pressure in the soil of onion white rot, the use of onion juice from waste onions or garlic extract may be useful. With the presence of the Allium compound as a germination stimulant, onion white rot will soon die away without the ongoing presence of an Allium plant. Further trials will determine application rates and timings with field trials commencing in the next growing season.

During field trials sampling for soil DNA tests showed the presence of pink root - it is unknown whether there is an interaction between the two pathogens. In the later stages of pink root, when the roots turn brown, it is difficult to visually distinguish between the two and the diseases often co-exist on onion roots.

Above. Phil Frost, Arvensis Research gives the latest update on white onion rot at the Tasmanian Ag Innovation Day.

Two new fungicides have recently been registered in onions for management of onion white rot, Luna Experience (Fluopyram, group 7 + Tebuconazole, group 3) and Intuity (Mandestrobin, group 11) which will offer growers two new fungicide groups (group 7 and 11) for management of onion white rot.

Trials conducted as part of this project have demonstrated both Intuity and Luna Experience provide effective control of onion white rot. Trials in the current season are focusing on optimising the placement and timing of fungicides to maximise their effectiveness.

"In terms of cultural management, later plantings definitely help but for the grower that puts a lot of pressure on harvest if it is wet. We estimate that 80 per cent of the cropping areas of Tasmania have white rot present so the risk is that growers push into more marginal soils creating pressures on quality and yield.

"In the next planting season, we will continue to compare soil samples in the field with lab tests to verify the DNA tests and the sampling methods. The use of a germination stimulant still has merit so we will continue to investigate a system for timing and application.

"With two new fungicides available, it will be about maintaining an optimum amount in the soil to hold the mycelium filaments at bay to protect the onion roots. It's not about eliminating the white rot pathogen but inhibiting it."

FIND OUT MORE
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