Fusarium basal rot

Onions

Hort Innovation Strategic levy investment | ONION FUND

This project has been funded by Hort Innovation using the onion research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au

Government of South Australia
Department of Primary Industries and Regions

SARDI
SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

Fusarium basal rot of onions

This document focuses on the disease Fusarium basal rot, providing information on the biology, drivers of disease development and possible management strategies available to onion growers.

It is intended to provide information to assist best practice control of fusarium basal rot using integrated disease management strategies, known as IDM.

All integrated disease management strategies aim to determine the cause of the problem and apply the most appropriate management solutions to limit unacceptable loss in marketable yield. The solutions should:

- utilise all cost-effective methods to achieve disease control in crops
- be effective for as long as possible
- minimise adverse effects on users, the environment and other crop management systems.

There are a range of issues to consider when deciding what solution is the most appropriate.

These include:

- correctly identifying the pest or disease
- understanding the threat posed to production
- identifying the possible actions needed to minimise the impact
- undertaking the most appropriate management strategies
- assessing the effectiveness of the management strategies undertaken.

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This project has been funded by Hort Innovation, using the onion industry research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

Information current as of 1 June 2022

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Fusarium basal rot

Fusarium basal rot (FBR) is a major disease of onions throughout the world. Records of onions with symptoms of this disease in Australia go back as far as the early 1900s. The disease has become of greater concern in recent years, particularly in South Australia, but also in other regions of Australia where onions are grown in hot conditions. FBR may be evident in the field, however greatest losses occur in storage.

Pathogens that cause Fusarium basal rot

Fusaria are a type of fungi that inhabits most agricultural soils. The majority of *Fusarium* spp. are non-pathogenic, posing no risk to crops including onions. A small number of *Fusarium* spp. can infect onions and cause disease.

Fusarium oxysporum forma specialis (f. sp.) *cepae* (abbreviated to FOC) is recognised as the most common cause of FBR around the world, including in Australia. The pathogen can also cause damping off and root rot of onions. There are many other forms, known as formae specialis, of *Fusarium oxysporum* that cause disease of other crops in Australia, however, none of these are documented to cause basal rot of onions.

Other species of *Fusarium* are reported to cause disease in onions, including basal rot. These include *Fusarium proliferatum*, *F. solani* and *F. redolens*. While known to be present in onion growing areas, the importance of these pathogens in causing basal rot, root rot and damping off in onions is not documented in Australia.

FBR occurs in other Allium species including garlic, leek, and shallot.

Fusarium oxysporum* f. sp. *cepae* (FOC) is the fungal **pathogen, whereas Fusarium basal rot (FBR) is the **plant disease**, most commonly caused by FOC.

Inoculum and how it spreads

Soilborne inoculum is considered the main source of infection risk in direct seeded crops.

FOC produces long lived spores, called chlamydospores, which can survive in soil for more than four years, waiting to infect onions when they are planted.

FOC can survive in the soil on organic residues, and on roots of non-symptomatic host species.

Seed is a possible source of inoculum if adequate controls are not in place to prevent and manage seed infection or contamination and could introduce the pathogen to new locations.

Water movement and machinery can carry infected soil, spreading the pathogen.

Overseas, the use of sets for planting, rather than direct seeding, is a common way new paddocks are infected.

Infection by *Fusarium oxysporum* f. sp. *cepae* (FOC)

Infection by FOC can occur at any stage of crop development, including prior to emergence. While infection is possible at any time, the development of symptoms is most likely early (damping off before or soon after emergence) or during bulb maturation and storage (basal rot).

Fungus living in the soil infects roots or basal plates. It may also infect lower parts of the bulb scales. Wounding of tissue, such as cracking caused by rapid growth, mechanical or pest damage, increases the risk of infection. Enzymes released by the pathogen assist with infection and in the disintegration of root and basal plate tissue as the disease progresses.

Infection of the basal plate does not immediately result in infection of the bulb scales. Depending on conditions and variety this can take many months, if infection of the bulb scales occurs at all. In some varieties there is a stronger barrier to progression of infection from the basal plate to the bulb scales.

Development of FBR in storage has mostly been linked to infection of the basal plate that occurred in the field, with minimal spread between bulbs in storage.

Early infections in the field, even if they do not progress to cause bulb rot, can reduce plant growth and increase susceptibility of infected plants to other diseases.

Symptoms of Fusarium basal rot

Basal rot is most obvious late in the crop or in storage, particularly ambient storage. Field infection by pathogenic *Fusarium* spp. can occur at any stage from germination to harvest.

Mature bulbs

Basal rot, as the name suggests, starts from the base of the bulb. Symptoms at harvest may go unnoticed. When cut, basal plates of infected bulbs will usually have a brown discolouration. Bulbs with cracked or damaged basal plates are more likely to be infected than other bulbs.

As disease advances, basal plate tissue breaks down (due to the action of enzymes released by the pathogen) taking on a soft texture and light tan to brown colour. White cobweb-like growth (fungal hyphae) may be present around and on the basal plate. Infected bulb scales are light tan to brown in colour, flesh is broken down with a slightly watery appearance. Infection of bulb scales extends from the base of the bulb and may infect the entire bulb. Infected bulb scales may have pink to purple discolouration, most often observed towards the base when outer scales are removed. On white onions this can be obvious on the outer scales.

External symptoms at onset of bulb rot are shrinking and darkening of leaf scales around the basal plate. Eventually the onion bulb shrinks and collapses within the intact outer dry leaf scales.

Secondary infection by bacterial pathogens often contributes to breakdown of infected bulbs. Severely rotted bulbs attract infestation of the basal end by maggots.

Figure 1. Fusarium basal rot of mature bulbs

Field symptoms in maturing crops

In the field, severely diseased plants can be seen from a distance. Diseased plants show dieback or yellowing of the leaf tips, which curl down or collapse. Leaves wilt and in severe cases plants die. Considerable decay of the roots and basal plate will have occurred by the time above-ground symptoms are visible.

When pulled up, infected plants have poor root health (reduced number of roots, and roots that are browned and shrunken) or no roots. Closer observation will reveal discolouration and rot of the basal plate. In plants with advanced symptoms, the basal plate will detach easily from the bulb. Rot may extend into the base of the bulb leaf scales.

Depending on the time of infection, bulbs may not be fully formed at harvest, having an elongated shape.

Disease may occur on isolated plants or small patches of plants, which in turn are usually grouped in larger areas within a paddock. Under conducive conditions in heavily infested paddocks these areas can extend over large portions of the paddock.

FBR is more likely in areas with poor drainage but can also occur in well drained areas. Monitoring or scouting should focus on poorly drained areas in the first instance. Basal rot is most likely along wheel tracks where drainage is impeded, and soil movement occurs from the passing of machinery or irrigator.

Figure 2. Fusarium basal rot of young plants and developing bulbs.

Damping off seedlings

Fusarium spp. can infect germinating seeds and seedlings, killing them before or soon after emergence. Other pathogens including *Pythium* spp. may cause similar symptoms. Plants with infected roots and basal plates that survive will lack vigour.

Plants may be infected in the field, without the development of obvious symptoms. If conducive conditions occur as bulbs mature or after harvest, these infections may develop into FBR of bulbs.

Other possible causes of bulb rot

Correct diagnosis of the cause of bulb rots is important. Decay may not be the result of *Fusarium* spp. Rotting of the base of the bulb may also be caused by white rot (*Sclerotium cepivorum*). If bulbs are not exhibiting typical FBR symptoms (particularly rotting of the basal plate, which then extends into the bottom bulb leaf scales) other possible causes should also be investigated. If bulb rotting starts from the stem end, other diseases such as Botrytis neck rot (*Botrytis* spp.) or bacterial rots (Pectobacterium, *Burkholderia* spp., *Pantoea* spp.) are more likely causes. Decayed bulbs are frequently infected by more than one pathogen.

If unsure, consult with a plant diagnostic laboratory.

Factors affecting *F. oxysporum f. sp. cepae* inoculum build-up

History of allium crops

Risk of FBR increases with the number of infected onion crops grown on a site and the shortness of rotations.

Allium crops including onions and shallots (*Allium cepa*), garlic (*Allium sativum*) and leeks (*Allium porrum*) are hosts of FOC.

Alternate hosts

Crops

FOC has been shown to persist on non-Allium crop species, even though they do not show any symptoms. These crops are sometimes referred to as ‘reservoir hosts’ or ‘non-symptomatic hosts’, assisting the pathogen to survive, and include: corn (*Zea mays*), black bean (*Phaseolus vulgaris*), oat (*Avena sativa*) and Sudan grass (*Sorghum x drummondi*).

Contribution to FOC inoculum and disease risk by rotation crops used in Australian onion growing systems is untested and not understood.

If the cause of basal rot is *Fusaria* other than FOC that is a pathogen of many other crops, such as *F. proliferatum*, growing these crops in rotation may increase disease risk to onions. It is important to confirm the causal pathogen in a paddock, before considering what rotation and cover crops are suitable to assist management of inoculum levels.

Weeds

Oxalis corniculata (creeping oxalis) and *Oxalis pes-caprae* (soursob) are reported to host FOC and would assist maintain inoculum levels between onion crops. It is likely that other weeds host the pathogen, with further research required.

Factors affecting disease development

Onion variety

Onion varieties vary in their susceptibility to FBR, with plant breeding companies actively selecting varieties for their level of resistance. For further information refer to your seed suppliers.

Resistance rating is mainly based on infection caused by FOC. Limited information is available in relation to disease caused by other *Fusarium* spp.

Soil type

FBR can occur across a wide range soil types. However, drainage is the main factor influencing disease development. Therefore, heavier soils or soils with subsoil constraints such as compaction are likely to have greater FBR problems.

Soil moisture

Excessive soil moisture favours infection, especially when accompanied with optimum soil temperatures.

Saline soil conditions also appear to favour disease.

Soil temperature

Infection and disease development is possible within the range 15-32°C but is favoured by higher temperatures within this range. FOC grows most rapidly at 26-28°C (optimal temperature). The pathogen has minimal activity at temperatures below 15°C. Infection and disease development can still occur above 32°C but is less likely.

Risk of FBR is greater for late plantings in spring when soil temperatures are higher. Under these conditions seedling damping off may also occur in paddocks if high levels of inoculum are present. Early infection (even without obvious symptoms) increases the risk of FBR developing later or in storage.

Plant nutrition

High nitrogen levels increase the risk of FBR. Balanced nutrition that promotes even growth and maintains adequate calcium levels in the bulbs is important to producing onions with long storage potential.

Damage to roots and basal plate

Basal plates that have been damaged are more susceptible to infection. Root and basal plate damage can be caused by soil dwelling insects (particularly onion maggots) or nematodes. Cracking and splitting of the basal plate, such as that caused by fluctuating soil moisture levels, excessive nitrogen or weather conditions increases risk of FBR.

Increased risk of basal rot has been associated with infection by other pathogens, such as *Setophoma terrestris* (cause of pink root).

Summer thunderstorms

Summer thunderstorms can produce ideal conditions for infection; that is, warm wet conditions coinciding with potential for cracking of the basal plate.

Table 1: Factors affecting development and impact of fusarium basal rot

Driver of disease	Decreased disease risk
• high pathogen inoculum level	• low pathogen inoculum level
• susceptible variety	• tolerant variety
• root and basal plate damage	• absence of pests, healthy soil biota
• other soil pathogens present	• absence of soil pathogens
• planting into warm soils	• cool conditions during early growth
• soil temperature > 26°C	• soil temperature < 15°C
• excess nitrogen	• optimum nutrition
• excess moisture, poor drainage	• uniform adequate moisture availability
• summer thunderstorms	• mild consistent weather
• ambient storage.	• cool storage.

Strategies to reduce disease development

Management strategies for FBR can be separated into three main areas:

- management of the paddock between onion crops
- management of the onion crop
- management of the harvested bulbs.

Reduce inoculum - management of the paddock between onion crops

Paddock management is aimed at reducing inoculum build up prior to planting onions.

Crop rotation

Effectiveness of rotations is compromised by the pathogen's ability to survive in soil without a host. Rotation lengths of four or more years are considered good practice to reduce the risk of FBR. To be of benefit, an even longer rotation may be required in paddocks with a high incidence of disease in the previous crop. Because FOC persists between hosts on organic matter, the efficacy of break crops will depend on the breakdown of suitable organic residues.

Selection of suitable non-host crops is limited by a lack of information on which crops host FOC. Weeds in non-host rotations may act as a reservoir of inoculum and need to be managed effectively. It is critical to control *Allium* spp. and *Oxalis* spp. between onion crops, as they are known to host FOC.

Manage risk – onion crop

Timing of planting

Infection of seedlings is favoured under hot moist conditions. Paddocks that are known to be at high risk of FBR may be better suited to sowing in timeslots when soil temperatures are cooler (for example autumn-winter as opposed to spring plantings in South Australia). Risk of other diseases favoured by cool conditions at planting, such as onion stunt, need to be considered.

Plant nutrition

Onion plants with above optimum levels of nitrogen are more vulnerable to FBR. Ensure adequate nitrogen nutrition throughout the crop.

Irrigation and drainage

Overirrigation should be avoided as FBR is favoured by wet soil conditions. Use best practice irrigation technologies, such as soil moisture monitoring linked to crop water use and predicted weather conditions. Onions grown on raised beds may have a lower incidence of FBR.

Improvement of drainage using land planning and/or installation of surface and subsurface drainage infrastructure can result in reduced risk of FBR, as well as increased uniformity leading to higher overall productivity and quality of onions produced.

Soil amendments should be applied to improve uniformity of soil moisture and irrigation efficiency at sites with non-wetting soils or inadequate infiltration rates.

Depending on the soil types and topography, use of variable rate irrigation may assist in achieving more uniform soil moisture conditions across the paddock.

Biological control

Several biological control organisms have demonstrated ability to reduce the incidence of FBR including strains of:

- *Trichoderma harzianum*
- *Trichoderma viride*
- *Bacillus subtilis*
- *Pseudomonas fluorescens*.

Arbuscular mycorrhizal fungi populations which can be beneficial to onions may also assist the plant's resilience to disease.

Achieving meaningful disease control can depend on the suitability of each biocontrol strain to site-specific field conditions and the level of disease pressure. Information on products containing these organisms relating to control or suppression of FOC in onions under Australian conditions is limited.

Chemical control

Correctly applied fumigation is effective at reducing *Fusarium* spp. inoculum in the soil. If fumigation is used, it is advisable to replace the beneficial soil biota as soon as possible. There are many commercial products available; however, none have been tested for this purpose in onions.

Growers need to be aware that the introduction of pathogens back into sterilised soils can result in higher levels of disease, due to the lack of competition

There are currently no fungicides registered in Australia for the control of FBR in onions.

Manage risk – harvested crop

Harvesting practices

Minimise mechanical damage to bulbs during harvest.

Do not dispose of infected (cull) bulbs in paddocks used for onion production.

Storage conditions

Ambient storage conditions can favour progression of basal rot, with rapid progression of symptoms at temperatures between 25 to 32°C.

Activity of the pathogen is reduced at temperatures of 8-15°C, with disease progression inhibited at long term storage temperatures of 4°C and below. Storage facilities require adequate ventilation and low (65-70%) relative humidity.

Check for disease and infected basal plates prior to harvest and avoid storing bulbs from paddocks where field infection detected.

Fusarium basal rot – Summary of management strategies

Know your risk

- Conduct pre-plant disease risk assessment of paddocks (history, environment).
- Manage paddocks using best available practices and according to risk.

Pre-crop

- extend rotation length in paddocks with known risk: > 4 years
- control host weeds: *Oxalis* spp., Allium volunteers
- improve surface and subsurface drainage if inadequate
- grow non-host cover crop and incorporate prior to onions.
- in fumigated soil, follow with soil amendments to replace beneficial biota and improve suppression.

Crop

- select less susceptible varieties
- manage other pests and pathogens that cause root damage, such as onion maggot and pink root
- promote even growth to protect integrity of basal plate
- optimise nutrition for balanced growth and bulb quality: Avoid excess nitrogen
- avoid over irrigation and development of wet spots
- plant into cooler soils where possible (<20°C).

Storage

- Avoid storing bulbs with high incidence of field infection
- Store crop in cool storage at 4°C or lower, with low humidity and ventilation management to avoid condensation

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