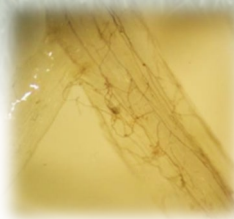


Best Practice Guide for Onion Stunt



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Australia**



Best Practice Guide for Onion Stunt

The following document incorporates information essential for economic and sustainable control of onion stunt. It has been developed from the work of various HIAL projects (VN05011, VN08004, VN07007, VN11000, VN13003) and incorporates information from other sources where relevant to onion production in Australia.

It is intended to provide information on “best practice” control of onion stunt using integrated management strategies, known variously as IPM (Integrated Pest Management), IDM (Integrated Disease Management) or even IPDM (Integrated Pest and Disease Management).

All 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 economically effective methods to achieve disease control in crops;
- be effective as long as possible; and
- minimise adverse effects on users, environment and other crop management systems.

There are a range of issues to consider in determining what solution is the “most appropriate”. These include:

- correct identification of the pest or disease;
- understanding the threat it poses to production;
- identifying the possible actions needed to minimise the impact;
- undertaking the most appropriate management strategies; and
- assessing the effectiveness of the management strategies undertaken.

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Funding:

This project has been funded by Horticulture Innovation Australia Limited using the research and development onion industry levy and funds from the Australian Government.

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ONION STUNT

This document focuses on the disease onion stunt, providing information on the biology and detection of the pathogen and possible management strategies developed from research into the disease as well as knowledge gained from managing the pathogen in onions and cereals.

The disease onion stunt was first observed in the 1980's in onion plantings around the River Murray (Twigden 2005). The issue became a concern when the size of stunted areas increased, with patches of stunted onions wide spread in onion crops grown in the Mallee region of South Australia.

The stunting is due to root rotting of young onion plants caused by a strain (known as AG8) of the soil borne fungus *Rhizoctonia solani* (Wicks et al 2011). It has only recently been recognised as a problem in onions both in Australia and the USA, where onions are typically grown in cereal-pasture paddocks, with cereals also used as nurse crops. It has long been recognised as the cause of the disease barepatch in cereals.

While other strains, apart from *R. solani* AG8, cause stunting in onions, the effect is variable and not always as severe. For example stunting in Western Australia was associated with *R. solani* AG4.

Reports of *R. solani* causing disease and yield loss in onion bulb crops overseas have been from the Columbia basin (Patzek et al 2013) and Georgia (Sumner et al 1997) in the USA and Turkey (Erper et al 2006).

More recently, work has shown that the presence of the root lesion nematode, *Pratylenchus neglectus*, has been associated with increasing the likelihood and severity of onion stunting in the Mallee region of South Australia.

***Rhizoctonia solani* AG8**

Rhizoctonia solani is a basidiomycete fungus, a soilborne pathogen widespread throughout soils of the Mallee. *Rhizoctonia solani* is comprised of a diverse range of strains of the fungi that cannot be distinguished on the basis of morphology alone. The strains are grouped on the basis of hyphal reactions with other strains (anastomosis groups: "AG") and the range of hosts that they parasitise. The AG8 strain of *R. solani* is known as a serious pathogen of cereals, pastures, legumes and onions.

The life cycle of *R. solani* AG8 consists of a survival phase throughout the hot dry summer in soil protected within organic debris or as clumps of fungal hyphae. The fungus can survive (not multiply) as a saprophyte on organic residues and does not need a live host.

With sufficient soil moisture, fungal hyphae germinate seeking soft tissue of recently germinated seedling roots. The fungus then enters a parasitic phase where it destroys cortical root tissue and causes stunting of the host plant.

Onions are most susceptible to infection during early growth, but plants may remain infected until harvest. Unlike susceptible cereal crops where a build-up of the pathogen occurs over the life of the crop, levels of the pathogen in an onion crop have normally declined at harvest. Compared with cereal crops, onions are not a preferred host of *R. solani* AG8.

Pratylenchus neglectus

Pratylenchus neglectus is a root lesion nematode that is widespread throughout soils of the Mallee, and has been associated with increasing the likelihood and severity of onion stunting. This nematode has also been associated with large areas of reduced plant growth and loss of yield in onion paddocks in the absence of infection by *R. solani* AG8.

Symptoms of onion stunt

Stunting in onions develops as circular to irregular patches varying in size from 1 m to 25 m or more in diameter. The patches usually have distinct borders between stunted and adjacent healthy plants (Fig 1).

Stunted onions are most obvious 6 to 12 weeks after sowing when diseased plants develop to less than 60 % the size of healthy plants (Fig 2).

The fungus attacks the roots of young plants, pruning roots and causing rotted root tips (“spear tipping”) and cortex (Fig 3). Brown melanised mycelium typical of *Rhizoctonia* can be seen microscopically on the roots and around the basal areas of stunted plants (Fig 4). However stunted onion seedlings can often appear otherwise healthy, without obvious rotted roots or root lesions.



Figure 1 (A-D). Stunted patches in onions grown in the Mallee region of South Australia.

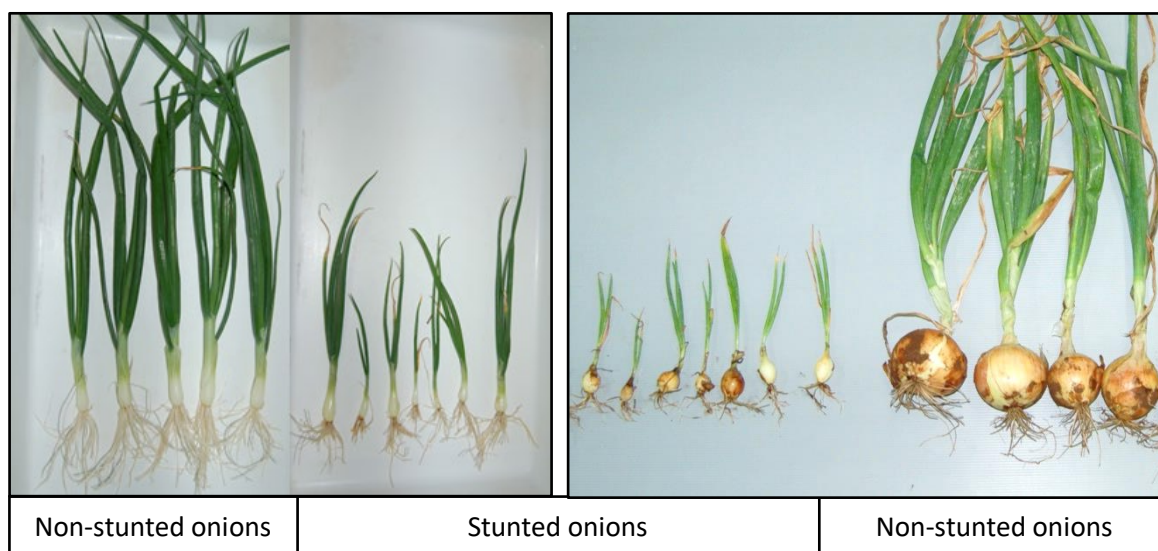


Figure 2. Comparative size of onions affected by stunting. 3 leaf stage (left) and mature bulbs (right).



Figure 3. "Spear tipping" of onion roots (left) and cortex damage (right)

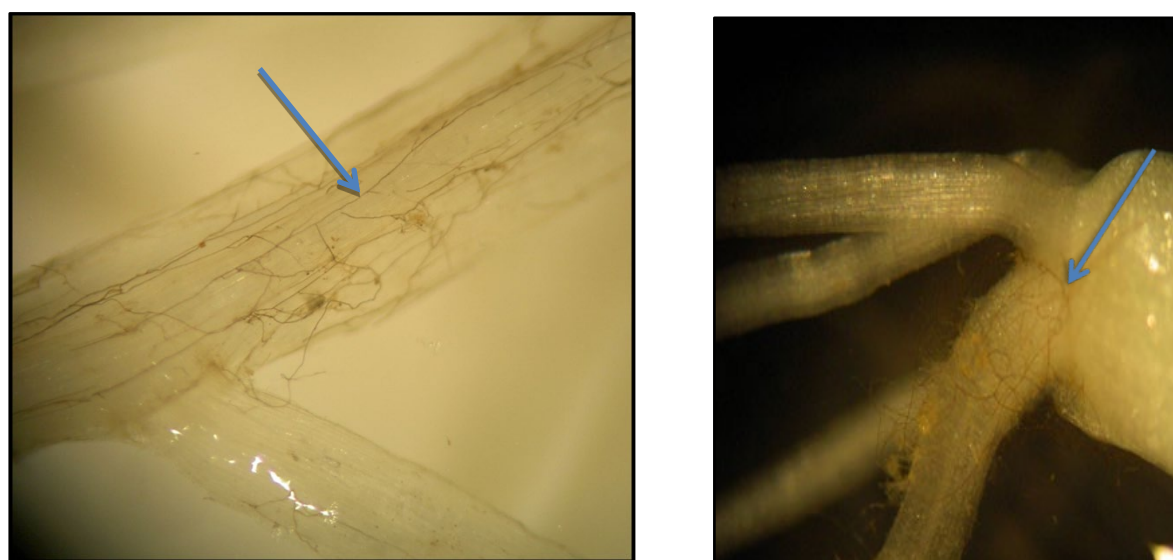


Figure 4. *Rhizoctonia* hyphae on onion roots under 200x (left) and 60x (right) magnification.

Other possible causes stunting and reduced growth

Correct diagnosis of the cause of stunting and reduced growth is important. Patches seen may not be the result of *R. solani*. If plants are not exhibiting typical root symptoms of onion stunt caused by *R. solani* (particularly spear tipping) other possible causes should also be investigated. These include salinity, localised nutrient deficiency, chemical injury, variability in soil type and topography interacting with irrigation effectiveness, nematodes such as root lesion (*P. neglectus*) or stubby root (*Paratrichodorus* spp.). If unsure, consult with a plant diagnostic laboratory.

Symptoms caused by root lesion nematode

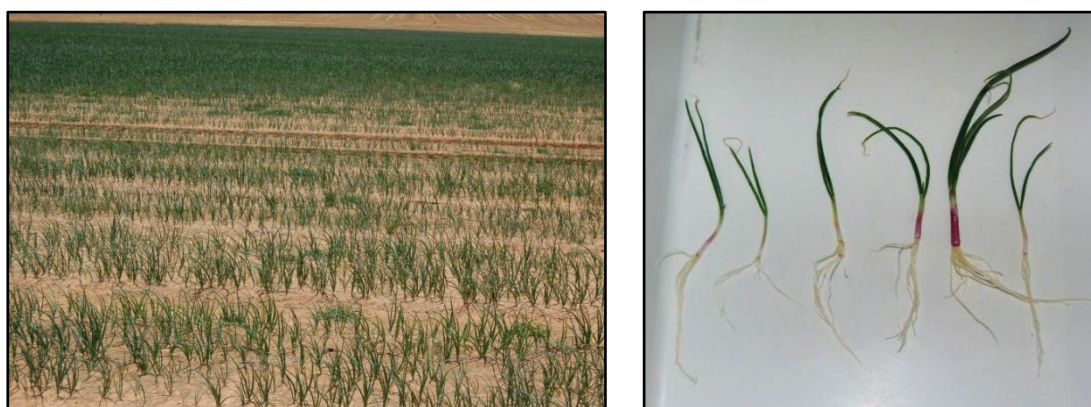


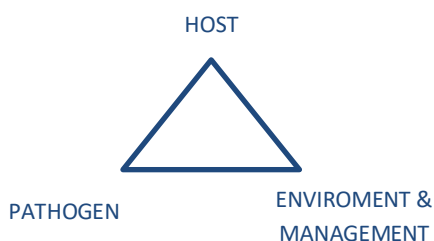
Figure 5. Large area of reduced growth (left) and root distortion (right) caused by nematodes.

Pathogen detection and monitoring

Rhizoctonia solani is a soil borne pathogen that can be detected by testing the soil using traditional bioassays or molecular methods. Molecular testing that quantifies the level of the specific *R. solani* AG8 strain in the soil is offered commercially as part of a suite of soil tests through the Molecular Diagnostic Centre.¹

Assessing disease risk prior to planting

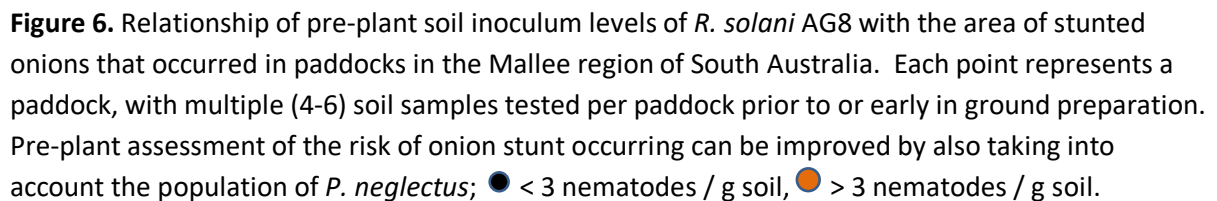
Disease risk prediction tests for onion stunt have been validated as part of research project VN13003. The results of pre-plant soil pathogen DNA tests for *R. solani* AG8 and *P. neglectus* provide an indication of the risk of onion stunt. Molecular testing can quantify the level of *R. solani* AG4 at the same time, which has been associated with onion stunt.



Inoculum level of the pathogen is only one of the factors that contribute to the development of onion stunt in a paddock. The occurrence and severity of onion stunt is strongly influenced by environmental conditions and management practices.

¹ http://pir.sa.gov.au/research/research_specialties/sustainable_systems/soil_biology_and_molecular_diagnostics

Level of *R. solani* AG8 inoculum in the soil prior to planting provides an indication of the risk of onion stunting occurring, with paddocks rated as low, medium or high risk of stunting developing (Fig 6).



Correct sampling procedures are critical when conducting pre-plant pathogen DNA testing. Paddocks should be sampled when fallow or early in the paddock preparation phase. Multiple tests are required to adequately assess the risk of disease in an onion paddock. For example in a centre pivot, a sample from each $\frac{1}{4}$ of the pivot should be tested separately and the results from all samples taken into consideration when assessing the risk of disease.

Factors affecting *R. solani* AG8 inoculum build-up

Prior crop and grasses – crop rotations and cover crops

Cereals are the main hosts of *R. solani* AG8 and soil populations increase significantly in soil where cereals are grown, including summer grown sorghum crops. Other crops including legumes can host *R. solani* AG8, but the build-up of inoculum is lower than on most cereal crops.

Alternate hosts – weed control

Rhizoctonia solani has been found on a variety of weeds that have diverse root systems including those with woody type root systems. Scientists at CSIRO found that complete weed control over summer significantly reduced the inoculum levels of *R. solani* in the soil with a corresponding decrease in the disease incidence in the following cereal crop.

Cropping system- soil disturbance

Rhizoctonia solani lives in the top 15 cm of soil (80% in top 5cm of undisturbed soil) as a threaded web like structure and on organic debris. Tillage of the soil breaks up the fungal structure and reduces its ability to cause disease. It also assists in breaking down the organic matter that harbors the fungus. Mixing of the topsoil that contains the inoculum helps to dilute the fungus with clean deeper soil. Burying inoculum to depths below 20cm significantly reduces the ability of the fungus to survive. In contrast, cereal production using minimal tillage favours the build-up of soil inoculum.

Summer rainfall

Summer rainfall reduces *R. solani* AG8 inoculum as warm wet soils favour biological activity that antagonises the fungus.

Nurse crop – selection and duration

Cereal nurse crops contribute to the build-up, size and strength of *R. solani* AG8 hyphal networks in the soil. Type of nurse crop, duration and timing in relation to the planting of the onion crop can have a significant impact on disease risk. Under favorable conditions in a controlled environment room, inoculum levels of *R. solani* AG8 doubled from week 4 to week 5 on barley. These levels were 4 times as high as measured in soil where a less susceptible triticales variety was grown for 5 weeks. Under field conditions crop differences are less dramatic, but can still impact disease risk.

Table 1: Factors affecting *R. solani* inoculum build-up

Favours build-up	Favours decline
Cereal crops	Grass free oilseeds, pulses or pastures, especially canola or other brassica in rotation
Zero or minimum tillage	Cultivation
Low fertility soil	Healthy soil biota
Persistence of summer weeds	Good summer weed control
Dry summer	Wet summer, multiple rainfall events >20mm or summer irrigation
Susceptible nurse crop used, delay in nurse crop spray out	Minimal competition or cross-over with less susceptible type nurse crop

Factors affecting disease development

Onion variety

All varieties tested in Australia were susceptible to *R. solani* AG8. The use of seed with high viability and good seed vigour will assist in achieving the best yield.

Soil type

Onion stunt caused by *R. solani* AG8 was shown to be more severe in coarse sandy soil. This concurs with findings in wheat where increasing the coarseness of soil increased *Rhizoctonia* disease severity (Gill et al 2001a, b). Sandy soils are more prone to poor moisture and nutrient retention, which are conditions that favour development of onion stunt. *Rhizoctonia* disease effects are greater in soils with low organic matter (low overall biological activity).

Soil moisture

Water stress increases impact of disease.

Soil temperature

Risk of onion stunt is greater for early plantings in late autumn and winter, when temperatures are lower. Higher populations of *R. solani* AG8 were detected in soil at 15°C compared to 20°C. Temperatures affect growth of both the fungus and the onion plants. The fungus is more active at lower temperatures and as soil temperatures increase going into spring soil there is increased microflora activity that is antagonistic to *Rhizoctonia*. In addition, plant growth is faster with the warmer temperatures, which can reduce the effect of the pathogen on the plant.

Plant nutrition

Ensuring adequate nutrition that supports strong early plant growth will minimize impact of onion stunt. Adequate availability of zinc to the plant is particularly important.

Nurse crop

In addition to contributing to *R. solani* AG8 inoculum buildup, nurse crops compete with the onion seedlings for water, nutrients and light, increasing the impact of the disease. Competition impact of a cereal nurse crop increases rapidly as the plant approaches and begins to tiller.

Table 2: Factors affecting development and impact of onion stunt

Conducive to disease	Decreased disease risk
High <i>R. solani</i> inoculum level	Low <i>R. solani</i> inoculum level
Root lesion nematodes present	Healthy soil biota
Low fertility sandy soil	Fertile soil with high organic matter
Low seed vigour	Rapid emergence and early seedling growth
Soil temperature < 15°C	Soil temperature > 20°C
Inadequate zinc, nitrogen or phosphorus	Optimum nutrition
Moisture stress early in crop growth	Uniform adequate moisture availability
Susceptible nurse crop used, delay in nurse crop spray out	Minimal competition or cross-over with less susceptible type nurse crop

Strategies to reduce disease development

Management strategies for onion stunt can be separated into two main areas: management of the paddock between onion crops and management of the onion crop.

Reduce inoculum - management of the paddock between onion crops

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

Crop rotation

Levels of *R. solani* AG8 in the soil can rise and fall dramatically in one growing season. The crop immediately preceding the onion crop has the greatest impact on inoculum levels of *R. solani* AG8. If a cereal crop is grown, risk to the onion crop may be reduced by selecting a cereal type less conducive to the buildup of *R. solani* AG8. In cereals, oats are most tolerant, followed by rye, triticale, wheat and then barley, which is the most susceptible. Varieties within each type of cereal vary in their susceptibility. Similarly cereal types and varieties differ in their susceptibility to *P. neglectus*. Disease susceptibility ratings for varieties are continually updated; check latest crop variety guides for new resistance classifications.

Continuous cropping of susceptible cereals in a minimal tillage farming system can build up high levels of *R. solani* and *P. neglectus* in the soil.

Growing canola has been shown to reduce the amount of *R. solani* AG8 in the soil. However, canola and other brassica crops can host *R. solani* AG4, and they do not support arbuscular mycorrhizal populations which can be beneficial to onions. Canola is a good host of *P. neglectus*, which poses a significant risk to onion production.

Legumes (e.g. field peas, narrow leaf lupins, medics) may be considered prior to onions, with varieties available that will limit buildup of both *R. solani* AG8 and *P. neglectus*. Compared with canola, legumes are not as effective a break crop for *R. solani* AG8. However, where *P. neglectus* is present they are a better option than most brassicas (including canola). Both brassica and legume crops are generally more challenging to establish and manage in the Mallee region than cereals.

Paddock management during summer

Summer rainfall reduces *R. solani* AG8 inoculum. This suggests that summer irrigation and use of an appropriate non host cover crop may form part of an integrated program to reduce *R. solani* inoculum. Weeds should be controlled so that inoculum sources are not maintained over summer.

Cover crops

Cover crops are important to protect the soil from erosion especially in the lead up to spring plantings. If cereals are used in paddocks where onion stunt may be a risk, select types least likely to build up the levels of *R. solani* AG8 and *P. neglectus*. Use of certain brassicas (e.g. canola) or legumes (e.g. field peas, narrow leaf lupins, medics) can reduce or prevent buildup of *R. solani* AG8. Canola in particular has been shown to reduce levels of *R. solani* AG8. However canola is a good host of *P. neglectus*, whereas narrow leaf lupins are a poor host. The inability of canola and other brassicas to harbor arbuscular mycorrhizal fungi may also be a consideration. In many instances a carefully selected variety of cereal is a more versatile and appropriate choice of cover crop in the onion production systems of the Mallee region.

Cultivation

Tillage of the top soil breaks up the structure of the *R. solani* hyphal network, assists in breaking down organic matter that harbors the fungus and reduces the ability of the fungus to cause disease. Mixed soil cultivation of both shallow and deep disturbance over a period of several months provides the best reduction in *R. solani* AG8 soil inoculum. Depending on the soil profile, spading can be a good option, providing both deep soil disturbance and mixing to depth.

Ground preparation of this type to reduce the risk of onion stunt leaves soils at a greater risk of erosion and so it is important that this practice is combined with appropriate cover crop management.

Deep ripping does not have an immediate impact on *R. solani* inoculum, but encourages deep root growth and improves soil drainage.

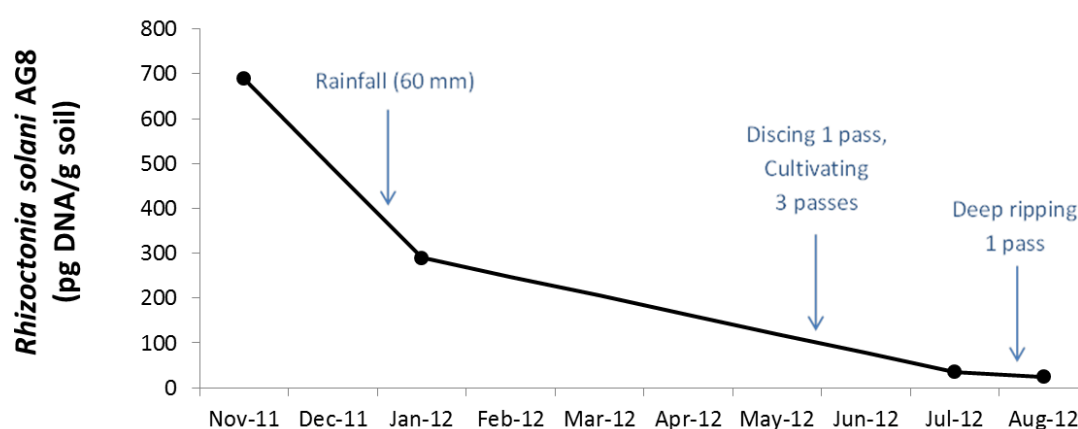


Figure 6. The persistence of *R. solani* AG8 inoculum in a field undergoing preparation for onion production following a winter cereal crop. Arrows indicate significant cultivation and rainfall events.

Chemical control

Fumigation is effective at reducing *R. solani* populations, however it is not recommended as the fungus can regenerate very quickly in soil with reduced biota. If fumigation is used, it is advisable to replace the soil biota as soon as possible. There are many commercial products available; however none have been tested for this purpose in onions.

There are currently no fungicides registered for the control of *Rhizoctonia* in onions. There are seed and in furrow treatments available for management of *Rhizoctonia* in cereals which protect the seedlings. These treatments do not reduce the soil inoculum, but can reduce the rate of *R. solani* AG8 inoculum buildup on a cereal crop. If in furrow treatments are applied to cereal crop close to planting of onions, potential risk of phytotoxicity to the onion seedlings must be considered.

Improve plant growth: management of the onion crop

Onion crop management is aimed at improving early plant growth to minimise the impact of the disease.

Timing of planting

Development of disease is favoured under cool dry conditions (particularly at soil temp $<15^{\circ}\text{C}$). Paddocks with high inoculum levels (as determined by soil testing) may be better suited to sowing later in the season when soil temperatures have warmed ($>20^{\circ}\text{C}$).

Nurse crop management

The timing between sowing the nurse crop, onion sowing and nurse crop 'spray off' has a significant impact on the productivity of the onion crop. The timing of each of these events will vary with the time of year. However, the general rules of thumb should be; spray off the nurse crop as soon as it provides sufficient protection for the germinating onion seedlings; encourage good onion growth by managing the nurse crop timing to ensure minimum competition for water, nutrients and light. Even in paddocks where initial *R. solani* AG8 levels are low or have been reduced, careful nurse crop management is important to reduce the risk of onion stunt. Selection of the type of nurse crop is a balance between choosing varieties that provide the best protection of the onion seedlings from wind and soil movement, which can be sprayed out effectively, and are least likely to quickly build up the levels of *R. solani* AG8.

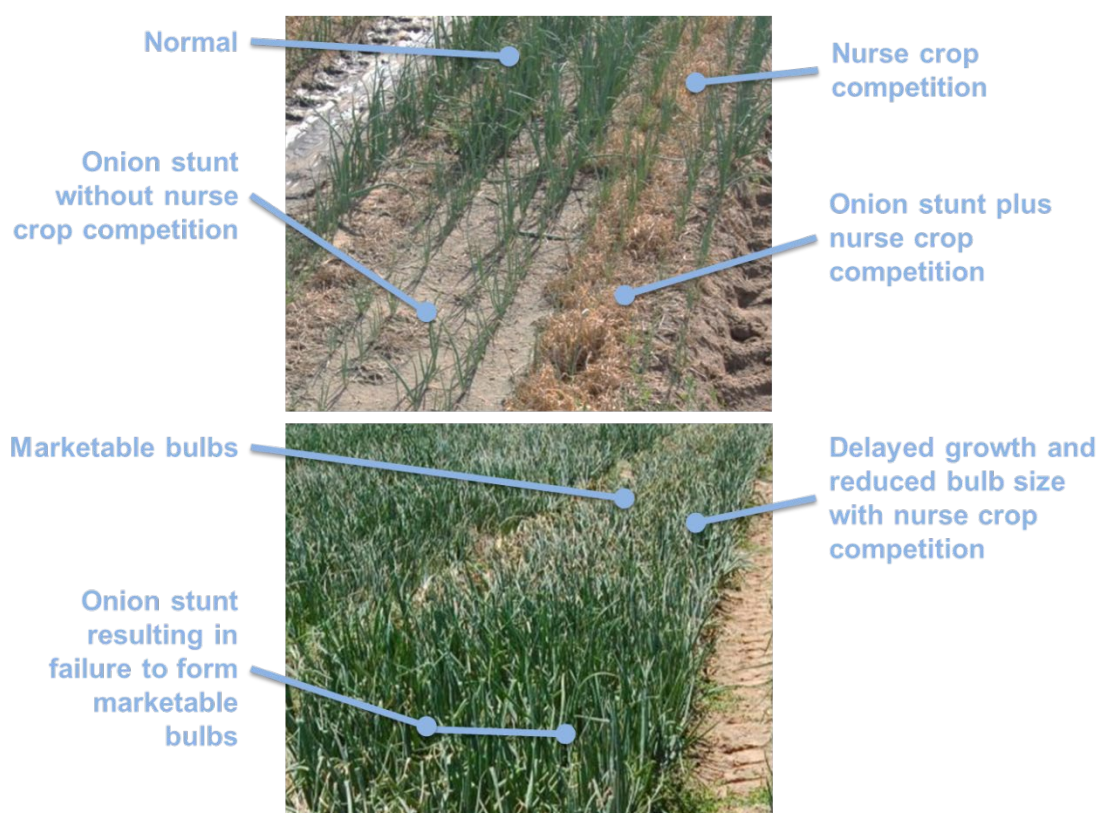


Figure 7. Impact of nurse crop management in a paddock with onion stunt patches.

Top - onions at 4 leaf stage, Bottom - 1 week prior to onion harvest.

Plant nutrition and irrigation

Onion plants under nutrient stress and or moisture stress are more vulnerable to onion stunt. Ensure adequate nutrition, particularly nitrogen, phosphorus and zinc and avoid water stress, especially during early growth.

Soil amendments prior to planting

Soil amendments can be used to improve soil properties and to manage disease.

Clay:

Clay amendments are used to overcome problems in sandy soils such as erosion, water and nutrient retention and wettability of soil. While clay amendments can have an overall benefit on production, there is no direct benefit on the pathogen, however as conditions for plant growth are improved disease symptoms are reduced. Chemical analysis should be undertaken on the clay before use, as high levels of elements such as sodium and boron which may be present can reduce onion growth.

Composts:

The use of composts can improve soil structure and soil biology which suppress pathogens. Composts vary in quality and composition and can be incorporated or applied as mulch.

- In pot trials, mature composts applied at 200mL per 1kg of sand (20% v:w) reduced populations of *R. solani*, but also reduced onion seedling growth. Lower rates (5% v:w) improved plant growth but there was no effect on *R. solani* inoculum load.
- Compost applied as surface mulch (100m³/Ha) a week after sowing increased bulb weight at harvest, and decreased symptoms of pink root infection. However compost did not reduce the incidence and severity of plant stunting.
- Composted chicken litter improved early plant growth, but there was no difference in bulb weight at harvest. There was a low incidence of stunting at the trial site, so the effect of the manure could not be evaluated on stunting, however it did increase the incidence of pink root.

Other products:

A range of alternative products have been evaluated.

- Seaweed extract improved plant growth and reduced stunting but did not reduce the population of *R. solani* in the soil.
- Neem oil reduced *R. solani* in the soil but also reduced plant growth.
- Perlka at high rates (1000 kg/ha) controlled *R. solani*, but also inhibited plant growth. Application has potential to reduce inoculum, but the residues need sufficient time to dissipate before planting. Low rates (250 kg/ha) do not seem to be effective in reducing inoculum. *Rhizoctonia solani* can regenerate very quickly in soil with reduced biota.

ONION STUNT

SUMMARY OF MANAGEMENT STRATEGIES

Know your risk

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

Reduce inoculum

- Grow less susceptible cereal or a non-grass crop in rotation prior to onions: canola and legume crops are usually less susceptible than cereals
- In cereals, oats are most tolerant, followed by rye, triticale, wheat and then barley, which is the most susceptible
- Control summer weeds
- Cultivate and deep rip / spade to breakup fungal hyphal networks
- If multiple summer rainfall events (>20mm) do not occur, replicate with irrigation where feasible
- In fumigated soil, follow with soil amendments to replace beneficial biota and improve suppression
- Plant less susceptible cereal or non-grass cover crop: legume crops are usually less susceptible than cereals

Improve plant growth

- Improve soil structure and fertility with amendments such as clay or composts to encourage plant growth
- Optimise nurse crop growth to reduce competition
- Encourage early seedling vigour – plant varieties and seed with high viability and good vigour
- Manage nematodes, especially *Pratylenchus neglectus*
- Avoid deep sowing
- Plant into warmer soils where possible (>20°C), avoid cool dry soil
- Ensure adequate nutrition, particularly plant available zinc, along with nitrogen and phosphorus
- Avoid moisture stress, especially during early growth



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Websites

Onion stunt information on Onions Australia website: <http://www.onionsaustralia.org.au/>

Cereal disease variety guides:

- <http://www.nvtonline.com.au/>
- http://www.pir.sa.gov.au/_data/assets/pdf_file/0010/276841/Cereal_Variety_Disease_Guide_2016_web.pdf
- <http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-disease-guide>

Rhizoctonia bare patch in cereals: http://www.grdc.com.au/uploads/documents/GRDC_FS_rhizo.pdf

Soil biology information:

- http://www.ccmaknowledgebase.vic.gov.au/brown_book/35_Biology.htm,
- <http://www.dpi.nsw.gov.au/agriculture/resources/soils/biology/soil-biology-basics>