The adoption of conservation farming practices in the Mallee has given benefits through increased moisture conservation, increased surface cover and reduced erosion. Stubble retention and reduced tillage practices can have a positive impact on the soil physical characteristics by creating an environment that enhances soil structure and water infiltration. Stubble retention also improves the chemical characteristics e.g. organic carbon, and improves nutrient supply and biological activity of the soil which, can lead to improved plant nutrition. Improved biological activity can also lower inoculum persistence and disease severity.

However, stubble and crop residue borne diseases such as crown rot (Fusarium pseudograminearum), take-all (Gaeumannomyces graminis var. tritici), rhizoctonia root rot (Rhizoctonia solani AG8), common root rot (Bipolaris sorokiniana) eyespot (Oculimacula yallundae), yellow leaf spot (Pyrenophora tritici-repentis), SFNB (barley spot form of net blotch) and NFNB (barley net form of net blotch) can increase with stubble retention in particular in continuous cereal cropping systems.

Environmental conditions in the preceding summer and during the growing season are also important in determining how much impact soil-borne diseases have on yield. For example, low summer rainfall reduces the potential for the breakdown of pathogen inoculum, reduces potential to store moisture within the soil profile, reduces breakdown of herbicide residues and limits N mineralization. These all limit the ability of the crop to tolerate soil-borne pathogens. This Farm Talk explains the disease and stubble interactions in low rainfall farming systems and the effect of stubble management on stubble and soilborne diseases.

Is stubble a source of pathogen inoculum for soilborne diseases?

Stubble and crop residues including crowns are a significant sources of pathogen inoculum for a number...
of soilborne diseases. For example, stubble is the major source for crown rot pathogen whereas crowns and roots are the key sources of pathogen inoculum for take-all, rhizoctonia and common root rot.

Persistence of crowns is generally longer in the stubble retained systems hence they are a significant source of pathogen for rhizoctonia and take-all, in particular in reduced till systems. Therefore, stubble management practices that hasten the decomposition of stubble, such as incorporation and flattening stubble using harrows, will reduce inoculum levels and disease risk.

Summer rainfall is the key factor in facilitating stubble decomposition thereby reducing pathogen inoculum but controlling summer weeds is critical to remove hosts and potentially building-up inoculum.

**Is stubble a source of pathogen inoculum for foliar diseases?**

Stubble is the major source of pathogen inoculum for foliar diseases such as yellow leaf spot, eye spot, SFNB, NFNB. Practices that reduce surface stubble such as cutting low, incorporation, and grazing, removing infected stubble by burning or mechanical means and practices that increase stubble decomposition would reduce inoculum levels. However, removal of stubble would also remove the carbon source reducing biological activity and associated soil health related benefits. Management practices that reduce contact between infected stubble and seedlings would help reduce diseases such as eyespot.

**Can we lower disease risk using different stubble management practices?**

Effects of different stubble management practices on disease risk from soilborne and stubble-borne pathogens vary with disease type. The removal of infected stubble and crop residues by burning, grazing or bailing would reduce stubble-borne pathogen inoculum such as crown rot, thereby reducing immediate disease risk.

However, with above ground stubble removal, infected crowns may still carry over pathogens including crown rot and take-all. Additionally, in the long run removing stubble the main source of carbon for soil microorganisms would reduce biological activity and can increase disease impacts in the future.

Stubble management practices that knock down stubble and increase contact between crop residues and soil and disturb crowns will accelerate stubble decomposition generally reducing inoculum levels and disease risk for rhizoctonia and take-all. However, for crown rot disease standing stubble is better than flattened stubble as flattened stubble brings inoculum close to the seedlings unless done early in the summer resulting in sufficient decomposition to reduce inoculum.

For rhizoctonia, soil openers that disturb soil below the seed would facilitate quick root growth away from inoculum that is generally concentrated in the surface soil layers.

**Can crop rotation be a management choice to reduce soilborne diseases in stubble retained systems?**

Crop rotation is an important management strategy for a number of soilborne and stubble-borne diseases, mainly through reducing pathogen inoculum levels due to the lack of a host and decomposition of stubble, roots and crowns.

In intensive cropping systems, cereal-cereal rotations and stubble retention will increase pathogen inoculum levels and disease risk significantly. Growing non-cereal crops help reduce inoculum of cereal pathogens for
rhizoctonia, take-all, crown rot diseases and many foliar pathogens. For rhizoctonia and take-all, oilseed crops such as canola and mustard are the best rotational options to reduce inoculum levels, but for a number of stubble and soil-borne pathogens, the effect of rotations generally lasts for one cereal crop season and therefore a two year break from cereals and grass weeds may be required to reduce disease risk. In non-cereal phases, growing pulses and canola that form early canopy closure can accelerate stubble breakdown leading to lower stubble-borne inoculum levels.

Rhizoctonia pathogen build-up is generally higher in barley compared to that in other cereal crops, wheat, triticale and rye. Significant variation has been found in rhizoctonia inoculum build-up between cereal crops (wheat, barley, cereal rye and triticale). Although all winter cereals host crown rot, barley usually shows lower yield losses as it finishes early. Crop and variety selection is the best way to manage root lesion nematode populations.

FOR WHICH DISEASES DOES VARIETY SELECTION REDUCE DISEASE IMPACTS?

Genetic resistance or tolerance provide a valuable tool both to reduce disease impacts and/or minimise inoculum build-up in a crop sequence. However, the effect of environment was found to be greater than varietal effects both on yield loss and pathogen build-up.

<table>
<thead>
<tr>
<th>CROP TYPE</th>
<th>DISEASE INOCULUM LEVELS AT HARVEST COMPARED TO THAT AT SOWING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat, Barley, Triticale</td>
<td>Increase</td>
</tr>
<tr>
<td>Cereal Rye</td>
<td>Increase</td>
</tr>
<tr>
<td>Summer active grasses</td>
<td>Increase</td>
</tr>
<tr>
<td>Oats</td>
<td>Variable</td>
</tr>
<tr>
<td>Canola and Mustard</td>
<td>Decrease</td>
</tr>
<tr>
<td>Peas, Vetch, Chickpeas (grass-free)</td>
<td>Decrease</td>
</tr>
<tr>
<td>Medic pasture (grass-free)</td>
<td>Decrease</td>
</tr>
<tr>
<td>Lupins</td>
<td>Variable</td>
</tr>
<tr>
<td>Weed free fallow</td>
<td>Decrease</td>
</tr>
</tbody>
</table>

For fungal disease such as crown rot, take-all and Rhizoctonia there is limited varietal based resistance and tolerance to reduce disease impacts and crop type variation is generally a better option for reducing inoculum build-up or yield losses.

For crown rot, it is recommended that selecting a well-adapted cultivar for the region is best to reduce yield losses. Durum is most susceptible followed by wheat and barley. There is potential that differences in rhizoctonia inoculum build-up exists between varieties of cereal crops wheat and barley.

Image 4: Non-cereal rotation crops help reduce inoculum levels (Bill Davoren, CSIRO)
Among nematode diseases, there is a broad range of resistance/tolerance among different cereals; using the latest cereal variety guide to select the least susceptible variety is recommended. There is a good genetic resistance for cereal cyst nematodes and variety choice is available for all regions.

**CAN SOWING ON-ROW AND INTER-ROW SOWING HELP WITH REDUCING DISEASE IMPACTS?**

As stubble retention can have a direct impact on soil borne pathogen inoculum levels, depending on the type of soilborne disease there could be benefits to sowing crops on or off the previous year’s crop row, especially in continuous cereal rotations.

Sowing on or near last year’s crop row would expose the seedlings to higher load of take-all, crown rot, rhizoctonia and common root rot inoculum which are carried over through infected stubble and crown material thus inter-row sowing with GPS guidance between intact standing previous cereal rows reduces contact with inoculum reducing infection and disease severity and impacts on yield.

However, impacts of inter-row sowing on rhizoctonia disease depend upon the inherent biological fertility of the soil. Research on Mallee sands at Karoonda and Loxton showed that in low fertility sands, lower biological activity in the inter-row soil resulted in higher rhizoctonia disease severity. Additionally, plants benefited from the higher moisture and N mineralization capacity in on-row soils overcoming disease impacts.

**FOR WHICH DISEASES ARE FUNGICIDES A VIABLE OPTION AS SEED TREATMENTS OR IN-FURROW APPLICATION?**

There are no general chemical control ‘magic bullet’ options available for the complete control of soilborne diseases. Any available fungicide options are recommended as part of an integrated control strategy to effectively reduce disease impacts and provide maximum benefits in yield.

For take-all and crown rot diseases, registered seed dressings generally provide moderate benefits to yield on their own. Whereas, seed treatments registered for rhizoctonia root rot have been shown only to provide on average 5% yield benefit in the presence of rhizoctonia infection. However, liquid streaming fungicides, with dual placement above and below the seed, can provide the best protection to the roots with up to 30% yield responses in above average rainfall seasons, particularly in years with good spring rainfall.

For foliar diseases, a range of seed dressings, in-furrow and foliar application products are currently available but as the length of the protection varies between products, a range of factors such as crop variety, potential yield, the disease present, future weather, the amount of disease present and crop growth stage need to be considered.

**WOULD IMPROVING NUTRITION / FERTILIZER APPLICATION REDUCE DISEASE EFFECTS ON CROP YIELD?**

Adequate nutrition is one of the key factors that could potentially reduce the disease impacts on crop yield however the responses to fertilizers in a diseased crop vary with season and depends upon the disease.

In stubble retained systems the effects of early seedling diseases would be greater with nutrient deficiency therefore application of starter fertilizer, preferably below the seed to facilitate early vigour and establishment of deep root system quickly is important. For example, to compensate for the reduced root system with low to moderate levels of rhizoctonia, adequate supply of major nutrients, N and P, and minor elements, Zn and Mn, is critical to reduce effects of yield.

![Figure 1: Disease incidence in 8 week old wheat seedlings, in the Dune experiments, as influenced by the location of sowing during 2015 crop season.](image-url)
In good rainfall seasons, post emergent N application will help crops compensate for lost root system. However, for crown rot to avoid excess early growth, reduced N applied before or at sowing and matched N rates and timing of application to stored soil moisture achieves the best outcome. Ensuring adequate Zn and Mn nutrition is also essential to keep take-all and crown rot in check and suppress effects on yield.

Crop rotation with legumes and long term adoption of conservation stubble management practices that improve soil biological fertility and nutrient supply capacity would generally help reduce disease effects on crop yields.

**HOW DOES DISEASE PRESENCE AFFECT MY HERBICIDE MANAGEMENT IN STUBBLE RETAINED SYSTEMS?**

Herbicide use is an integral part of weed management with no-till stubble retained systems, with an increase in herbicide application in particular for summer weed control. Therefore, stubble retained systems with reduced tillage can increase the risk for persistence of herbicide residues.

Summer weed control will reduce pathogen inoculum levels and rhizoctonia in the following winter by decreasing the living host plants for the disease. This would also complement the stored moisture and mineral N benefits of summer weed control. Herbicide residues such as the Group B’s have been shown to increase disease risk for soilborne diseases such as rhizoctonia, therefore where there is disease inoculum it is prudent to avoid repeated application of persistent herbicides for weed management.

**Image 6:** Above-ground symptoms of crop unevenness (main picture) are seen when Rhizoctonia damages crown roots, even when seminal roots (inset) escape the infection. (VVSRGupta, CSIRO)
WHAT EFFECT DOES STUBBLE RETENTION HAVE ON IMPROVING BIOLOGICAL DISEASE SUPPRESSION?

Biological disease suppression can prevent soilborne fungal diseases such as rhizoctonia, take-all and crown rot occurring in farmer’s crops and at present provides the best long-term control option. All soils have the ability to suppress soil-borne diseases to some extent through the activity of soil microbes. Increasing soil microbial activity and improving disease suppression are related to increasing carbon inputs in the system. This can be achieved through stubble retention and greater cropping frequency.

A management regime that increases carbon inputs and turnover over a number of years (5 to 7 years in the Mallee) will improve suppressive activity. Management practices which encourage suppression include reduced tillage and stubble retention, no grazing or stubble burning, avoiding bare falls and controlling weed hosts. Increased carbon inputs result in changes to the composition and activity of the soil microbial community over time. The development of disease suppression occurs at a faster rate under no-till. However, tillage practice does not appear to change the final level of suppression.

Effective soil suppression has now been identified across a range of soils and environments. However, the opportunity to improve suppressive activity may be limited in soils where there are inherent limitations to production to <60% of water limited potential (non-wetting sands, highly calcareous soils) due to limited carbon inputs and therefore limited biological activity.

The most effective management decisions that reduce the impact of soil and stubble-borne diseases need to be made before seeding. Therefore knowing which pathogens pose the greatest disease risk can be instrumental when planning which crop/variety to grow, and which other practices need to be implemented. PREDICTA B root disease tests can identify which soil and stubble-borne fungal and nematode pathogens pose significant risk at the paddock level to the production of various winter crops. Agronomic advice is recommended to help interpret the tests and work out the best crop management moving forward.

MORE INFORMATION

A full list of research cited in this Farm Talk is available at [www.msfp.org.au](http://www.msfp.org.au)

This Farm Talk was published in 2018 based on research conducted by CSIRO in conjunction with Mallee Sustainable Farming through the GRDC project MSF00003 ‘Maintaining profitable farming systems with retained stubble in the Mallee’.

Other useful resources:


Acknowledgements: Dr Gupta Vadakattu, Dr Therese McBeath

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