Take-all (Gaeumannomyces graminis var. tritici)

Take-all is the most widespread cereal root disease in the world. In Australia, total crop losses are possible and 20-30% loss can occur with few visible symptoms (Figure 1). Take-all costs the Australian grain industry an average of $81m per year in lost production.

Take-all has the potential to be widespread and severe across the Murrumbidgee catchment in 2006 due to favourable conditions for inoculum build-up in 2005, i.e. high seasonal rainfall and a warm, moist spring.

**KEY POINTS**

- Take-all is the most prevalent cereal root disease in the world.
- It has the potential to be widespread and severe in 2006 due to favourable conditions for inoculum build-up in 2005.
- Crop rotation is the key management tool.

**Causes**

Take-all is caused by the fungus Gaeumannomyces graminis var. tritici (Ggt). The fungus penetrates the root surface and invades the phloem and xylem of the plant, preventing uptake and movement of assimilates, water and ions. The presence and severity of take-all is a result of the Ggt-wheat-environment interaction (Table 1).

**Table 1. Components of the wheat plant, Ggt fungus and environment that are favourable for take-all (Hornby 1998).**

<table>
<thead>
<tr>
<th>Wheat Plant</th>
<th>Ggt (Take-all fungus)</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient deficiency</td>
<td>Highly virulent</td>
<td>Low microbial activity</td>
</tr>
<tr>
<td>Nutrient inefficiency</td>
<td>Large population</td>
<td>Alkaline soil pH</td>
</tr>
<tr>
<td>Susceptibility</td>
<td>Fast growth rate</td>
<td>Imbalanced nutrients</td>
</tr>
<tr>
<td>Slow root growth</td>
<td>Insensitive to antagonists</td>
<td>High soil moisture</td>
</tr>
<tr>
<td>High yield potential</td>
<td>Insensitive to temperature</td>
<td>Conductive soil</td>
</tr>
<tr>
<td>High plant population</td>
<td></td>
<td>Loose seedbed</td>
</tr>
<tr>
<td>Stress sensitive</td>
<td></td>
<td>Early seeding</td>
</tr>
<tr>
<td>Nitrate nitrogen</td>
<td></td>
<td>Lime application</td>
</tr>
</tbody>
</table>

**Distribution in NSW**

Take-all is prevalent throughout the Murrumbidgee catchment. It prefers light, well drained, neutral to alkaline soils with a growing season soil temperature of 5-15°C, a water potential above permanent wilting point at the surface and good aeration.

**Symptoms**

A black crust around the base of the stem and blackening of roots are the most distinguishing features of take-all infection (Figure 2). The fungus turns the root core black which can be seen if the root is snapped and observed end-on. In severe infections, the roots will turn rotten and brittle enabling the plant to be pulled from the soil easily. The blackening may extend to the stem base under the leaf sheath. Seedlings can die leaving bare patches in the crop.
Figure 2. Wheat plants with increasing take-all severity (left = slight take-all, right = extreme take-all)

Take-all affected plants are stunted and yellow, and have few tillers. Infection is most obvious after flowering with the appearance of white heads which have ripened prematurely (Figure 3). These white heads will produce few or no filled grains. Be aware that white heads can result from other causes and a correct diagnosis of the cause should be obtained.

Typically, affected plants occur in patches (up to several metres in diameter) within a crop but they may also be scattered individually or be spread uniformly over the crop.

Figure 3. White heads in a mature wheat crop

Hosts

Take-all is only hosted by members of the Gramineae family, i.e. grass species. It affects wheat and barley but the effect on barley yield is less than wheat. One of the 3 races of take-all affects oats but this race is rare in NSW. Oats that are free of grass weeds are therefore considered a break crop. barley grass is the most susceptible grass weed followed by silver grass, brome grass and ryegrass (Table 2). Broadleaf plants such as clover, medics, lupins and canola are not hosts of take-all and make excellent break crops providing they are free of grass weeds.

Table 2. Grasses and their ability to host take-all (Yeatman 2003).

<table>
<thead>
<tr>
<th>Grass species</th>
<th>Take-all hosting ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley grass</td>
<td>Very high</td>
</tr>
<tr>
<td>Brome grass, silver grass, fescue, tall wheat grass</td>
<td>High</td>
</tr>
<tr>
<td>Ryegrass, cocksfoot, phalaris</td>
<td>Low</td>
</tr>
<tr>
<td>Wild oats</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Survival

Ggt survives between cereal crops in the roots and tiller bases of previously infected plants. During the non-cropping phase, it survives on host grass species, particularly in pastures with a high grass content.

Warm, damp spring conditions favour inoculum build-up resulting in a higher level of infection in the following wheat crop. Inoculum build up is greatest in damp soils at temperatures of 15-20°C. Temperatures between 20 and 25°C favour soil microbes that are antagonistic to the take-all fungus preventing further build up of inoculum. Above 25°C Ggt stops growing and antagonistic organisms can decrease take-all levels providing moisture is adequate. This is why take-all levels can decrease significantly following a summer rainfall event of more than 25mm. An ideal season for take-all would be a dry summer followed by an early break and a wet winter and spring.

Yield losses in wheat are found to be strongly correlated with Ggt level and September rainfall. Results have shown that if August-September rainfall is above 62mm, take-all will be increased in the following season, and if it is below 62mm, take-all levels will be decreased (Roget & Rovira 1991).

Soil-borne inoculum is the source of infection. It is not carried in the seed or by insects.

Disease Cycle

The Ggt disease cycle has 2 distinct stages (Figure 4). The first is the saprophytic stage where it survives over summer on infected cereal and grass weed stubble. Following the autumn break, fine filaments (hyphae) from the inoculum grow onto new crop plants or grass weeds where the second, or parasitic, stage commences. It then penetrates and destroys the root core preventing movement of water and nutrients.
Management

Cultural Options

Rotation and paddock selection

The single most effective method of controlling take-all is crop rotation. Use break crops and grass free pastures to utilise the weakest link in the disease cycle, i.e. survival between susceptible crops.

- **Break crops**- Plan at least a one year, grass-free break between susceptible crops. Options include grain or pasture legumes and oilseed crops.

- **Grass free pastures**- In the second last year of pasture, combine grazing and spray-topping to prevent grass seed production. In the last year, remove grasses with a selective herbicide in late winter. The timing of this is critical as time and soil moisture is needed for breakdown of infected grass residues. In high rainfall areas (>400mm) this should be done by mid August and in low rainfall areas (<400mm) by the end of June. Spray-topping in the final year of pasture will not control take-all.

If inoculum levels are assumed to be high (Table 3), or if herbicide resistance prevents the removal of grasses from pasture, avoid sowing wheat as the first crop in the rotation. Plant canola or lupins instead and control in-crop grass weeds. If a cereal is still preferred, use a seed or fertiliser applied fungicide such as Jockey® or Impact®. Barley could also be substituted for wheat as it suffers a lower yield penalty.

Disease Prediction (PreDicta®B)

The PreDicta® B soil test by C-Quentec Diagnostics is a risk management tool available for soil-borne diseases including take-all. From a representative soil sample, the test detects and quantifies soil-borne pathogens. It can be used to determine the take-all risk of a particular paddock prior to sowing.

Stubble

Field experiments to evaluate the effect of stubble management on Ggt levels give varied results. Some show no advantage of stubble retention (standing stubble, mulching, or incorporating into the soil) over the conventional practice of burning. Others show incorporating infected material to a depth of 5-15cm creates warm, moist conditions favourable for microbial activity thus breakdown of stubble and Ggt. However if done close to sowing there will not be enough time for sufficient breakdown of infected material and infection of the new crop may be increased due to inoculum being placed near the crop seedlings. Variable results may be due to differences in straw quantities, cropping sequence, management practices and the season.
Table 3. Crop sequences and estimated risk of take-all (MacNish 1994).

<table>
<thead>
<tr>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Take-all risk in wheat</td>
</tr>
<tr>
<td>Grass clover ley</td>
<td>Grassy clover ley</td>
<td>2004</td>
</tr>
<tr>
<td>Wheat or barley</td>
<td>Grassy clover ley</td>
<td>2005</td>
</tr>
<tr>
<td>Oats</td>
<td>Grass free fallow</td>
<td>2006</td>
</tr>
<tr>
<td>Grass free lupins or canola</td>
<td>Grassy clover ley</td>
<td>****</td>
</tr>
<tr>
<td>Grass clover</td>
<td>Grassy lupins or canola</td>
<td>****</td>
</tr>
</tbody>
</table>
| Pure clover | Pure clover | **
| Wheat or barley | Wheat or barley | *
| Wheat or barley after grassy clover | Grassy clover | **** |
| Oats | Wheat or barley | **** |
| Grass free lupins or canola | Oats | ** |
| Continuous wheat or barley (>4 years) | Wheat or barley | **** |
| Oats | Grass free lupins or canola | **** |
| Cultivation

Tillage affects the distribution of Ggt within the soil profile. Again, results show variation of the benefits of cultivation versus no-till systems.

No-till systems can increase the incidence and severity of take-all due to:

- Lack of cultivation to break up the infected wheat plant and stimulate microbial breakdown
- Viable inoculum remaining on the soil surface until sowing when it is placed near the seed, easily infecting the developing seedlings
- Fragments of infected material being larger and more potent
- A greater amount of natural inoculum in the soil.

Conversely, no tillage has been shown to reduce take-all in some situations. This may be due to the inability of the fungus to grow through the compacted soil or the seed being placed below the most infective layer at the soil surface.

Variatel choice

There are only small varietal differences in susceptibility to take-all in cereals. A distant relative of wheat, *Dasypyrum villosum*, shows true physiological resistance to Ggt but the resistance has not yet been transferred to wheat.

Nutrition

Nutrient deficiencies predispose plants to diseases and losses due to take-all are more severe when nutrition levels are inadequate. Healthy levels of nitrogen, phosphorus, copper, zinc and manganese reduce the effects of take-all by promoting vigorous roots that can escape the fungus.

Ammonium nitrogen (NH$_4$-N) is more effective in reducing take-all than nitrate nitrogen (NO$_3$-N), possibly because it decreases soil rhizosphere pH and increases rhizosphere organisms creating an unfavourable environment for Ggt.

Adding chloride (Cl) to ammonium nitrogen at sowing also helps by enhancing plant uptake of the nitrogen.

Split nutrient applications have been shown to be more effective in suppressing take-all than one application.

Applying lime to amend soil acidification increases take-all levels because Ggt thrives in neutral to alkaline soils. Liming also increases available calcium which favours take-all. However, liming may not necessarily reduce crop yields because it improves root penetration and uptake of nutrients by the crop.

Precision placement of fertiliser near the seed (no more than 5-6cm away) gives the seedling better access to the nutrients and can reduce the effects of take-all.

Weed control

Yield losses can be minimised by ensuring the paddock is free of grass weeds prior to sowing, eliminating the green bridge. Experimental results show significantly lower take-all levels where good grass weed control was obtained the previous spring and summer, intermediate take-all levels where some grass weed control was obtained and severe take-all levels with no weed control. In the second year of this experiment, take-all was still greatest where there had been no weed control but not significantly different between the other treatments due to the presence of volunteer wheat plants. This experiment emphasized the importance of managing the green bridge (Wong, Dowling, Tesoriero & Nicol 1993).
Delayed sowing

Delayed sowing can reduce take-all by allowing more time for infected residues to break down. A 6 week delay can reduce inoculum levels by up to 50%. In addition, late sowing also gives Ggt less time to develop on the wheat roots and causes less damage. As a general rule, sow paddocks with a high take-all risk last. NB: Sowing later than the recommended date decreases yield potential.

Row spacing and plant density

Row spacing and plant density has little or no effect on take-all incidence. However one experiment showed that paired row spacing of 17/43cm resulted in significantly higher yields of wheat in the presence of take-all when the straw residue was left on the soil surface and the fertiliser was placed directly below the seed (Cook 2001).

Seeding at an angle/between rows

Seeding at an angle to, or between, existing stubble rows can reduce take-all infection as it prevents complete rows being planted directly over infected stubble rows containing high concentrations of inoculum.

Burning

Burning has limited value because it has no effect on the infected material below ground.

Seedbed

A firm seedbed restricts the spread of the fungus between seedling roots but also reduces the roots ability to grow away from the fungus.

Chemical Options

Several fungicide products are available for suppression of take-all. These can be useful if the take-all potential is medium but not when the potential is high. Several field trials have confirmed the suppression on take-all from the fungicides listed below through an increase in yield, dry matter and grain weight. Additional products to those mentioned below have proven effective but are not yet registered.


Option 2: Seed applied fluquinconazole (Jockey®, Maxiflo® and Prowess/Quantum®).

Biological Options

‘Take-all decline’ is the spontaneous decline of Ggt to an acceptable level. It occurs after 3-5 consecutive cereal crops and is due to the build-up of antagonistic soil-micro-organisms. Although widely reported in Europe and shown in one part of South Australia, this phenomenon has not been seen in the Murrumbidgee catchment (G. Murray pers. comm.). Several strains of these naturally occurring soil micro-organisms have been identified but none are commercially available.

Brassica crops, including canola, have been reported to suppress take-all by releasing a range of chemicals with broad biocidal activity (Brown & Morra 1997). This effect has not been confirmed in NSW.

References


Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (2008). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of New South Wales Department of Primary Industries/Murrumbidgee Catchment Management Authority or the user’s independent adviser.

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