Barley diseases – an autopsy of 2022 and what could be done better in 2023?

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Take home messages

- High levels of leaf rust and powdery mildew were present in 2022 barley crops
- Wet conditions over summer favoured survival of pathogens on the green bridge
- Managing the green bridge will limit disease load of rust diseases early in the season
- Management strategies for foliar diseases includes resistant varieties, crop rotation, seed treatment, regular crop monitoring and timely fungicide application
- Resistance to fungicides have previously been reported in powdery mildew, net form net blotch (NFNB) and spot form net blotch (SFNB) in Australia and more recently in the leaf rust pathogen of both barley and wheat
- Fungicide resistance development should be managed by using an Integrated Disease Management (IDM) strategy.

Background

Above average rainfall from November 2021 onwards resulted in a green bridge over summer favouring the survival of biotroph pathogens such as leaf rust. As a result, high loads of inoculum were present early in the 2022 cropping season. Environmental conditions remained favourable for disease establishment and spread throughout autumn and winter. Many barley crops were severely impacted by foliar diseases. Leaf rust and powdery mildew were the most widespread diseases present, with net form of net blotch (NFNB) observed mostly in the variety RGT Planet⦶. As in previous years, smut was present in some crops.

Leaf rust

Leaf rust of barley is widely distributed and occurs in all Australian barley-growing regions. It is considered one of the five major barley diseases in Australia and can significantly reduce yield and quality. Yield losses in excess of 50% have been reported under experimental conditions.

A new pathotype of leaf rust (5457P+), virulent on *Rph3* was identified in eastern Australia in 2009. (Cereal Rust Report 2009, Vol 7, Issue 5). This virulence is present in all major production areas. The emergence of this pathotype had a major impact on not only production, but also on barley breeding as it rendered a large portion of elite breeding material susceptible. Many current commercial varieties are still reliant on *Rph3* (Cereal Rust Report 2020, Vol 17, Issue 1).

Barley leaf rust was widespread in Queensland in 2016, but due to the prolonged drought conditions, was only present at very low levels until 2021. In the presence of a green bridge, the pathogen can survive over summer and be present at high levels early in the growing season.

Environmental conditions favourable for disease establishment and spread have led to an increase in leaf rust inoculum. Leaf rust is favoured by temperatures ranging between 15°C and 22°C and prolonged periods of leaf-wetness. Conditions remained favourable until late spring, resulting in heavy disease levels in commercial crops.

The disease is caused by the obligate parasite, *Puccinia hordei.* It spreads by means of airborne spores that have the ability to travel long distances. The pathogen spreads rapidly when conditions are favourable and large areas are planted to susceptible varieties, resulting in the development of epidemics. High inoculum levels put pressure on major resistance genes and can lead to the development of new, more virulent pathotypes.

Large areas sown to S to VS varieties across a range of environments almost ensures that leaf rust will be a problem in some areas contributing to high inoculum levels causing epidemics whilst adding selection pressure on the pathogen to mutate and acquire new virulences.

Powdery mildew

Powdery mildew (*Blumeria graminis* f. sp. *hordei*) is a disease synonymous with barley cultivation in the northern region. Under mild and humid conditions, it will infect leaves and leaf sheaths of plants eventually covering them with white, fluffy mycelium and conidia. Generally, it does not persist once conditions turn to warm and dry, consequently, in our environment yield loss is usually less than 15%.

Powdery mildew survives between seasons on barley stubble and on volunteer plants. Once conditions become less favourable, the pathogen forms fruiting bodies (cleistothecia) in existing colonies. These are visible as small brown and black spheres which persist until the new growing season. When cleistothecia mature and conditions are favourable, they release ascospores to infect the new crop. These soon produce conidia (asexual spores) that spread the disease within and between crops.

Unless a variety is very susceptible to powdery mildew it is unlikely that the disease will progress to upper leaves of adult plants. In susceptible varieties where yield potential is high, fungicidal control can be justified. In 2022, environmental conditions remained favourable until late in the season, resulting in very high infection levels in susceptible varieties.

Powdery mildew resistance in Australia has a history of breakdown. Varieties such as Commander, Compass, La Trobe and Shepherd were all resistant when released; but changes in the powdery mildew population have rendered these susceptible. Continuous monitoring of the powdery mildew population provides knowledge on the virulences in the Australian powdery mildew population. This information guides the breeders when choosing resistance sources and facilitates screening of breeding material with relevant virulences.

Smut

Smut in barley crops has been increasing in recent years, with both forms detected in crops annually. Varieties of the Hindmarsh lineage e.g., Hindmarsh, La Trobe and Rosalind, are particularly prone to loose smut infection.

Barley is impacted by two species of smut – loose smut and covered smut, caused by *Ustilago nuda* and *Ustilago hordei*, respectively. In both, grain is replaced by black spore masses. These are encased in a membrane. This membrane is quite fragile in loose smut and ruptures soon after head emergence, releasing the spores. In covered smut, the membrane is much more persistent, breaking during harvesting.

Loose smut is most often observed around flowering when infected heads, bearing a mass of dark brown to black sooty spores, are visible. In plants infected with loose smut, the membrane ruptures soon after head emergence, releasing airborne spores which infect surrounding florets. Infection occurs under moist conditions at temperatures around 16 – 22°C. Florets are susceptible to infection from flowering to about one week after pollination. Germinating spores infect the ovary and the fungus survives as mycelium within the embryo of the infected seed. Once infected seed is sown, it germinates and carries the fungus in the growing point of the plant, becoming visible as a black spore mass at head emergence. Loose smut is well adapted for survival with infected plants usually flowering slightly earlier than healthy plants, ensuring an adequate supply of inoculum when the bulk of the crop is flowering.

Heads infected with covered smut frequently emerge later than healthy heads and tend to be shorter, hence may go unnoticed. As with loose smut, grains are replaced with a mass of black powdery spores. The membrane however remains intact and only breaks during the harvesting process, contaminating healthy grain. The spores germinate after planting, infecting emerging seedlings, growing through the plants where they eventually replace the grain with spores. The fungus is favoured by temperatures of 14 – 25°C.

Loose smut is exclusively internally seed-borne, while covered smut is either externally seed-borne or survives in the soil. The life cycle of loose smut in barley is the same as in wheat; however, barley loose smut will not infect wheat and vice versa.

Since seed treatment has been effective for so long, smut is not a breeding priority. There are various seed-treatment products available, however it is important to ensure that it is applied properly, and that seed is appropriately covered. If left untreated smut will result in yield and quality loss. If smut is detected in a crop, growers are advised to source new, disease-free seed for sowing.

Fungicides - resistance risk and timing

Fungicides are essential in maintaining healthy crops and are applied routinely in most barley crops. The choice of fungicide is determined by registration, efficacy, availability and price. Fungicide efficacy varies with disease. When conditions are favourable for disease development, a repeat application may be required for effective disease control.

The efficacy of some fungicides has been impacted by the development of resistance in pathogens. Thus, a previously effective fungicide fails to control disease, despite correct application. Without intervention, more fungicides are likely to become ineffective.

Repeated use of fungicides with the same mode of action (MoA), selects for individuals in the fungal population with reduced sensitivity to the fungicide. The risk of developing fungicide resistance varies between MoA groups, fungal pathogens and environments.

Higher disease pressure indicates larger pathogen populations and increased probability of developing resistance to fungicides.

In Australia, fungicide resistance in barley pathogens has been identified to date in powdery mildew, spot form net blotch and net form net blotch. Most recently fungicide insensitivity has been reported in leaf rust of both barley and wheat in Australia (Cereal Rust Report 2022, Vol 19, Issue 3). This will have a major impact on the management of leaf rust epidemics in cereal crops in future.

Fungicide resistance can be managed through the use of an integrated disease management (IDM) strategy to reduce disease pressure and reliance on fungicides. Relying on:

- Resistant varieties
- Crop rotation
- Clean seed
- Green bridge management
- Stubble management
- Use fungicides only when necessary and apply strategically
- Rotate and mix fungicide MoA groups

- Monitor regularly for disease - fungicides are more effective at lower disease levels.

Conclusion

Barley foliar pathogens cause devastating yield and quality loss worldwide. Research has proven that the more susceptible a variety, the bigger the yield and quality loss resulting from disease. Thus, growing a susceptible variety increases risk and requires dedicated effort towards persistent monitoring and decision making. The presence of a green bridge will present an opportunity for many pathogens to survive over summer (e.g., rusts which require a green host for survival) and be present at high levels early in the growing season. Thus, the green bridge will need to be carefully monitored and appropriate measures taken to reduce inoculum load at the start of the season.

Planting barley on barley will increase the risk and disease pressure of stubble-borne pathogens and may aid the survival of fungicide resistant individuals. Growing resistant varieties is the most cost-effective and eco-friendly method of preventing yield loss. The most up-to-date disease ratings are available on the NVT website (https://nvt.grdc.com.au/nvt-disease-ratings).

The epidemiology of the pathogen, the biology of the host and environmental conditions all impact disease management. Foliar fungicides are very effective but need to be applied early in the epidemic as disease can increase rapidly. The use of an IDM approach will not only limit the development of fungicide resistance but will also reduce economic input and support sustainable farming.

Further reading

Australian Fungicide Resistance Extension Network (AFREN): https://afren.com.au/resources.

Cereal Rust Reports: https://www.sydney.edu.au/science/our-research/research-areas/life-and-environmental-sciences/cereal-rust-research/rust-reports.html

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