Cereal pathology update – learnings from 2020, planning for 2021

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Take home messages

- High levels of powdery mildew infection were observed in 2020 barley crops
- Powdery mildew is a highly variable pathogen of barley with virulence varying in response to varietal resistance
- Continuous barley cropping increases the risk of stubble-borne diseases
- Management strategies for foliar diseases include resistant varieties, crop rotation, seed treatment, regular crop monitoring and timely fungicide application
- Resistance to fungicides have been reported in powdery mildew, net form of net blotch (NFNB) and spot form of net blotch (SFNB) in Australia
- Limit fungicide application by spraying only when necessary, rotate fungicides with different modes of action and use recommended rates
- Seed-treatment will provide protection against seed-borne diseases, smut and early development of powdery mildew
- Effective seed treatment depends on product choice, application rate and efficacy of application.

Background – learnings from 2020

Rainfall in the 2020 season in Queensland was lower than expected, hence disease incidence was also lower than anticipated.

However, conditions resulted in high levels of powdery mildew (PM) infection, particularly on varieties with low levels of resistance. Powdery mildew (*Blumeria graminis* f. sp. *hordei*) is a disease synonymous with barley cultivation world-wide. Under mild humid conditions, it will infect leaves and leaf sheaths of plants. It is easily recognisable by the white, fluffy mycelial growth, particularly on upper leaf surfaces. Older colonies turn dull grey and often produce small, black fruiting bodies. Environmental conditions in Qld generally become unfavourable for the pathogen and disease does not persist to adult plant stages. Consequently, yield losses are usually below 15%. In the 2020 season, infections persisted later into the season, despite conditions becoming less favourable.

Both loose smut and covered smut were detected in a number of barley crops in Qld in 2020, with losses in yield and quality reported. Affected crops had not been treated with an effective seed treatment. Seed-treatment applied effectively would have avoided yield loss.

Net blotch was present at low levels and was most conspicuous in irrigated crops. Net blotch in barley is caused by one of two forms of *Pyrenophora teres* (*P. teres*). Net form net blotch (NFNB) is caused by *P. teres* f. *teres* (*Ptt*) and spot form net blotch (SFNB) is caused by *P. teres* f. *maculata* (*Ptm*). The two forms share the same shape and structure (morphology) and can only be distinguished by plant symptoms and molecular characterisation. Symptoms of NFNB are characterised by net-like dark brown necrotic lesions, whereas SFNB symptoms are characterised by dark circular or elliptic brown spots surrounded by a yellow chlorotic area.

Net form net blotch occurs regularly in the northern region and samples are collected from crops annually. However, only 5 samples of NFNB were collected or submitted for pathotyping in 2020. SFNB was present at very low levels in isolated crops, unlike 2019 where despite dry conditions SFNB was widespread in Qld barley crops. Moisture stress may have contributed to crops being more vulnerable to infection.

Spot blotch (SB) (*Bipolaris sorokiniana)* has previously been confined to the warmer and more humid coastal areas of Qld. In recent years however, an increased number of SB samples have been collected from Central Qld (CQ). This could be attributed to the increased area sown to barley in CQ. With an increasing area sown to barley, the incidence of SB is expected to increase under favourable conditions and may become a significant yield constraint.

Powdery mildew

Powdery mildew (PM) survives between seasons on volunteer barley and barley stubble. When conditions become less favourable, the pathogen undergoes sexual reproduction and forms fruiting bodies (cleistothecia) in existing colonies. These persist until the new growing season and release ascospores under favourable temperature and moisture conditions, infecting the new crop. The mildew colonies produce airborne conidia (asexual spores) that spread the disease within and between crops.

A survey of Australia’s barley powdery mildew population was conducted by Dreiseitl and Platz in 2010 and 2011. This study identified 27 pathotypes and 16 major genes effective against all PM isolates tested. Largely as a result of its sexual reproductive stage, the pathogen can evolve rapidly, resulting in new pathotypes which can damage previously resistant varieties. Since then, pathotypes that are virulent against the resistance genes *Mla3*, *Mla9*, *Mla12* and *MlLa* have been identified, thus reducing the number of effective major resistance genes.

Virulence for *MlLa* is responsible for the increased disease levels occurring in certain varieties i.e. CommanderΦ, Mackay, CompassΦ, HindmarshΦ, and La TrobeΦ. This gene is present in many of the current varieties, with high levels of PM observed on RosalindΦ and Spartacus CLΦ in Qld in 2020.

The *mlo* gene provides resistance to all isolates. Varieties that have this gene include GrangerΦ, WestminsterΦ and RGT PlanetΦ. Other commercial varieties resistant to powdery mildew and their effective resistance genes include FairviewΦ (*Mla13*), FlindersΦ (*Mla1*) and ScopeΦ (*Mla7*).

Smut

Barley hosts two species of smut – loose smut (*Ustilago nuda)* and covered smut (*Ustilago hordei*). In both, infection results in florets producing thousands of spores, instead of grain. Spore masses are encased in a membrane. This membrane is quite fragile in loose smut and ruptures soon after head emergence, releasing the spores. However, in covered smut, the membrane is much more persistent, often breaking during harvesting.

Both species were detected in a number of barley crops in Qld in 2020. Loose smut has been reported in previous years, with crops of the HindmarshΦ lineage e.g. HindmarshΦ, La TrobeΦ and RosalindΦ, often infected.

Loose smut is most conspicuous 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 heading, 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 being 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 often being shorter and harder to see. As with loose smut, grains are replaced with a mass of black powdery spores. These are released during the harvesting process and contaminate 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.

Disease management

Barley foliar pathogens are a significant challenge to the grains industry and a major constraint to profitable barley production, affecting both yield and quality. Many of these pathogens are genetically and pathogenically diverse, able to reproduce sexually and can rapidly develop new virulence and overcome genetic resistance.

The adoption of stubble retention practices has led to an increase in the incidence of stubble-borne diseases. Planting successive barley crops in the same paddock increases pathogen incidence.

Growing a high yielding, well adapted, resistant variety provides the most economic and environmentally friendly means of disease control. Genetic resistances need to be durable to provide long-term protection. The PM resistance gene *mlo* has been effective in Europe for more than 50 years but has not been widely adopted in Australian breeding programs due to its association with lower yields in the Australian environment. It is however present in some varieties, mostly from European descent including Grangerᶲ, Westminsterᶲ and RGT Planetᶲ. Other commercial varieties resistant to powdery mildew and their effective resistance genes include Fairviewᶲ (*Mla13*), Flindersᶲ (*Mla1*) and Scopeᶲ (*Mla7*).

In susceptible varieties where yield potential is high, fungicidal control of PM can be justified. Foliar fungicides should be aimed at protecting the top two leaf layers. The identification of PM populations that are resistant to or have reduced sensitivity to Group 3 (DMI) fungicides in WA, highlights the importance of resistance breeding.

Net form net blotch is best controlled by sowing varieties rated MS or better and a combination of cultural practices. The NFNB pathogen persists on plant residue. Cultivation of the same variety will lead to an increase in the presence of pathotypes virulent on that particular variety and put increased pressure on effective resistance genes. Best practice includes crop rotation with non-host crops such as wheat, canola and chickpea. NFNB is also seed-borne and can spread with infected seed. Various seed treatment products are registered for NFNB control.

Resistance to Group 7 and Group 3 fungicides has been identified in NFNB populations in SA and WA, respectively, with reduced sensitivity identified in WA populations to other Group 3 (DMI) fungicides. To ensure that fungicides remain effective, it is important to limit fungicide application by spraying only when necessary, rotate fungicides with different modes of action and use fungicides at recommended rates. Avoid using tebuconazole as a stand-alone product in barley to avoid indirect fungicide resistance selection. By applying it for PM control, you can indirectly select for NFNB or SFNB isolates resistant to tebuconazole, without the intention of controlling those diseases. Isolates resistant to fungicides can be spread through infected seed. It is beneficial to all to ensure that we use fungicides in such a way that we protect their longevity.

Fungicide applications are more effective if applied before disease becomes established in the crop. This requires regular monitoring to ensure crops can be sprayed at the first sign of disease. When conditions are favourable for disease development, more frequent crop inspections will be needed and repeat fungicide applications may be necessary.

The level of smut in a crop is a function of

- Varietal susceptibility
- The number of grains infected in the previous seed crop
- The efficacy and rate of the seed treatment applied and
- The precision of the seed treatment process.

Resistance to smut is available; but has never been a priority of Australian barley breeding programs. Seed treatment has provided economical control in the past and is likely to continue to do so. Several fungicides are registered for the control of smut; but the levels of control vary among products.

Conclusion and 2021 planning

The absence of many diseases in 2020 in the northern region does not mean that we can be complacent. With favourable environmental conditions, pathogens will continue to cause yield and quality loss and we have to make the right decisions to ensure that we can stay ahead of disease development and the evolution of the pathogen.

Continuous monitoring of the pathogen populations provides information on the virulence in the Australian pathogen populations and aids in the identification of effective resistance for use in the development of resistant varieties. There are still a range of major resistance genes effective against our powdery mildew population and increasing evidence of useful adult plant resistance genes. These need to be used in a manner that ensures the resistances will be durable. We know that *mlo* resistance is effective and durable and encourage Australian breeders and pre-breeders to utilise it as a source of resistance.

The reappearance of smut in barley is a reminder to maintain effective fungicide treatment of planting seed. If seed is sourced from a crop known to have been infected with loose smut, it would be useful to treat seed at the higher recommended rate. The increased incidence may be due to a variety of reasons, including good infection conditions, application of lower rates of fungicide or ineffective application or varietal susceptibility. Quality routine seed treatment should continue to provide effective smut control.

References

2020 Queensland winter crop sowing guide

https://grdc.com.au/queensland-winter-crop-sowing-guide

2021 Queensland winter crop sowing guide

https://grdc.com.au/2021-queensland-winter-crop-sowing-guide

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