Learnings from 2021 – how to improve barley disease management in 2022?

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Take home messages

- High levels of net form net blotch (NFNB) infection were present in 2021 barley crops
- Continuous barley cropping increases the risk of stubble-borne diseases such as net blotch
- Management strategies for foliar diseases includes resistant varieties, crop rotation, seed treatment, regular crop monitoring and timely fungicide application
- Managing the green bridge will limit disease load of rust diseases early in the season
- Resistance to fungicides have been reported in powdery mildew, NFNB and spot form net blotch (SFNB) in Australia
- Fungicide resistance development can be managed by using an Integrated Disease Management (IDM) strategy.

Background

Above average rainfall from May to July delayed planting of many barley crops in SE QLD in 2021. Despite higher-than-normal annual rainfall, disease incidence was not as prolific as anticipated. Dry conditions during August and September were unfavourable for disease development and most likely limited disease incidence, particularly in the late planted crops. Despite that, some crops were severely impacted by disease during 2021. Net form of net blotch (NFNB) was the most widespread disease observed during the season, with leaf rust and smut present in many crops.

Net form net blotch is covered in the paper 'Net form net blotch management in barley' and will not be discussed here.

Leaf rust

Leaf rust of barley is widely distributed and occurs regularly in the northern region. It is considered one of the five major barley diseases in Australia and can significantly reduce yield and quality. Barley leaf rust was widespread in Queensland in 2016, but due to the drought conditions, was only present at very low levels until 2021. Samples submitted from Qld crops during 2021 to the Plant Breeding Institute, Sydney University, were collected from varieties Compass(b), Laperouse(b) and Leabrook(b). These varieties are rated as susceptible to very susceptible (SVS) to very susceptible (VS) in Qld.

The disease is caused by the obligate parasite, *Puccinia hordei.* It spreads by means of airborne spores, able 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. In the presence of a green bridge, the pathogen can survive over summer and be present at high levels early in the growing season. 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.

Smut

The presence of smut in barley crops seems to be on the increase 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 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 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, clean 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 different MoA groups, different fungal pathogens and different environments.

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

In Australia, fungicide resistance in barley pathogens have been identified to date in powdery mildew, spot form net blotch (SFNB) and net form net blotch (NFNB) (Table 1).

Table 1. Fungicide resistance and reduced sensitivity identified in pathogens of Australian barley crops since 2010. X = resistance, # = reduced sensitivity, ● = lab detections. Source: Fungicide resistance management guide (AFREN).

Fungicide group	Compounds affected	Resistance status						Industry implications
		NSW	Qld	SA	Tas	Vic	WA	
Barley powdery mildew - *Blumeria graminis* f. sp. *hordei*								
3 (DMI)	Tebuconazole, propiconazole, flutriafol	●	●		●	●	X #	Field resistance and reduced sensitivity to some Group 3 fungicides.
Net form net blotch (NFNB) - *Pyrenophora teres* f. *teres*								
3	Tebuconazole, propiconazole, prothioconazole, epoxiconazole			#		#	X #	Field resistance and reduced sensitivity to some Group 3 fungicides.
7 (SDHI)	Fluxapyroxad			X #				Field resistance to fluxapyroxad.
3 + 7	Tebuconazole (3), fluxapyroxad (7)			X #				Risk of field resistance and reduced sensitivity to both Group 3 and Group 7 fungicides due to the existence of double mutants.
Spot form net blotch (SFNB) - *Pyrenophora teres* f. *maculata*								
3	Tebuconazole, propiconazole, prothioconazole, epoxiconazole					●	X #	Field resistance and reduced sensitivity to some Group 3 fungicides.
7	Fluxapyroxad						X #	Field resistance and reduced sensitivity to Group 7 fungicides.
3 + 7	Tebuconazole (3), fluxapyroxad (7)						●	Risk of field resistance and reduced sensitivity to both Group 3 and Group 7 fungicides due to the existence of double mutants.
Hybrid net/spot form net blotch – caused by *Pyrenophora teres* f. teres x f. *maculata*								
3	Tebuconazole, propiconazole, epoxiconazole						X	Field resistance to some Group 3 fungicides.

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.

The epidemiology of the pathogen, the biology of the host and environmental conditions all impact disease management. The use of a proper 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.

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