Cereal disease management: using learnings from 2021 to improve management in 2022

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Take home messages

- Favourable climatic conditions in 2021 resulted in the increased prevalence of a range of cereal diseases across NSW, especially the wheat leaf diseases: stripe rust, Septoria tritici blotch (STB) and yellow leaf spot
- In combination with increased cereal stubble loads produced in 2021, pathogen levels are likely to be elevated again in 2022
- Predicted La Niña conditions over summer will maintain or increase the risk of stripe rust in 2022
- Multiple stripe rust pathotypes were prevalent across NSW in 2021. Keep up to date with latest varietal resistance ratings
- STB pathogen (*Zymoseptoria tritici*) can grow saprophytically on senescent wheat plants regardless of their resistance status
- Minimise disease impacts in 2022 by using an integrated approach to management
- NSW DPI plant pathologists can assist with correct diagnosis and advice on appropriate management options.

Introduction

A cereal diagnostic service is provided to NSW cereal growers and their advisers under projects BLG207 and BLG208 as part of a NSW DPI and GRDC co-investment, Grains Agronomy & Pathology Partnership (GAPP), at no charge. Evidence based methods are used to confirm diagnosis which includes a combination of visual symptoms, crop management history, paddock distribution and recovery/identification of the causal pathogens (microscopy, humid chamber or plating). Any suspect virus samples are confirmed using ELISA antibody testing at the NSW DPI Elizabeth Macarthur Agricultural Institute at Menangle.

Wheat, barley and oat rust samples (stripe, leaf and stem) are sent to the Australia Cereal Rust Control Program (ACRCP). The submission of samples to ACRCP facilitates the tracking of pathotype populations and distribution across the cropping belt of NSW and Australia. This includes a new interactive map (Australian Cereal Rust Survey 2021 Sample Map - Google My Maps) which is regularly updated throughout the growing season by the ACRCP. Growers can access this resource to see which pathotypes dominate in their region. This can be very important to guide in-crop management decisions given five different stripe rust pathotypes were present at varying levels across NSW in 2021. Individual wheat varieties can have vastly different reactions to these pathotypes, so identification of the dominant pathotype for a particular region and time provides useful guidance for development of appropriate seasonal in-crop management.

The project also records disease enquiries received from growers and advisers throughout each season. These project activities support NSW cereal producers to obtain correct in-crop diagnosis of diseases and independent management advice. Correct diagnosis limits adverse economic impacts via minimisation of unnecessary application of in-crop fungicides.

Collation of this data across NSW provides an annual 'snapshot' of the key biotic and abiotic constraints to cereal production (Table 1).

Table 1. Cereal diagnostics and enquiries processed across NSW between 2019 and 2021. Disease/issues are ranked in order of frequency in 2021

Disease/issue	2021	2020	2019
Stripe rust (wheat)	343	194	13
Fusarium crown rot	99	61	14
Septoria tritici blotch	56	17	13
Yellow leaf spot	56	10	4
Other non-disease (e.g. soil constraint, leaf blotching/mottling)	53	34	24
Spot form of net blotch	50	65	32
Leaf rust (wheat)	37	35	2
Take-all	33	16	1
Common root rot	26	2	3
Frost damage	24	45	4
Rusts crown and stem (oats)	24	29	4
Wheat streak mosaic virus	23	3	1
Net form of net blotch	20	23	0
Physiological/melanism	20	65	10
Fusarium head blight	18	10	0
Nutrition	18	16	2
Wheat powdery mildew	17	53	1
Seedling root disease complex (Pythium, crown rot, Rhizoctonia, take-all)	13	8	2
Loose smut	11	9	1
Rhizoctonia	9	12	7
Barley powdery mildew	8	12	0
Herbicide	7	28	6
Scald	7	65	4
Bacterial blight (other cereals)	4	30	0
Barley yellow dwarf virus	4	19	1
Leaf rust (barley)	3	0	0
Red leather leaf	3	1	7
Septoria oats	3	3	2
Oat leaf blotch	2	0	0
Other minor diseases	2	5	2
Ring spot	2	0	1
Barley grass stripe rust	2	20	1
Bacterial blight (oats)	1	22	3
Total	**998**	**912**	**165**

Individual seasons have a strong influence on the demand for cereal diagnostic support provided to NSW growers/advisers, with over five-times the number of activities in the wetter 2020 and 2021 seasons compared with much drier conditions experienced in 2019 (Table 1). These increases were primarily due to more conducive conditions for the development of a range of cereal leaf diseases.

For 2021, wheat stripe rust maintained top ranking as the most diagnosed and queried cereal disease with 34% of the total activities. Fusarium crown rot in winter cereals was in second place in 2021 followed by Septoria tritici blotch (STB) and yellow leaf spot (YLS) tied for third place. In fourth spot were other 'non-disease' related issues which emphasises the on-going importance of correct diagnosis.

Are you getting a correct diagnosis?

Importantly, 13% of activities in 2021, 21% in 2020 and 28% in 2019 were not related to disease. These samples were either diagnosed as being plant physiological responses to stress, frost damage, herbicide injury, related to crop nutritional issues or other non-disease issues. All 132 samples in 2021 were submitted as suspected of having disease issues. This highlights the ongoing importance of the diagnostic service provided by these projects to NSW growers and their advisers to support correct identification and implementation of appropriate management strategies.

A second opinion from a plant pathologist can ensure the correct diagnosis – (see contact details below)

What we saw in 2021

Wheat stripe rust

Wheat stripe rust made up 34% of activities in 2021, far exceeding 21% in 2020 and 8% in 2019. The conducive 2020 season enabled the build-up of stripe rust inoculum which was then hosted by wheat volunteers over the wet 2020/2021 summer. Resultant high inoculum levels combined with early opportunity for sowing grazing wheat kickstarted the epidemic for the 2021 cropping season.

There were two predominate pathotypes identified in NSW in 2021, along with three other pathotypes with reduced incidence. The predominate pathotypes identified by the Australian Cereal Rust Survey in 2021 were 198 E16 A+ J+ T+ 17+ (198) and 239 E237 A- 17+ 33+ (239), making up around 90% of the samples submitted (pers comm, R. Park) The other pathotypes identified to a lesser extent than 198 and 239 in 2021 included 134E16A+17+, 134E16A+17+ 27+ and 64E0A-.

Each of these pathotypes may affect a particular variety (host) differently. This is due to the genetic makeup of the host plant i.e. the resistance genes within the plant and the individual pathotypes virulence or avirulence status on those genes. It is important to keep up to date with the latest variety resistance ratings because the ratings can change from year to year. Disease resistance ratings are developed through the National Variety Trial (NVT) pathology screening project. These ratings are released annually on the GRDC website and in state based sowing guides, such as the NSW DPI Sowing Guide. There have been some significant reductions (more than one resistance level) to the ratings of varieties for the 2022 season, these include Astuteᶲ (triticale), Boreeᶲ, Catapultᶲ, Coolahᶲ, Cootaᶲ, Devilᶲ, Fusion (Triticale), KM10 (Triticale), LRPB Oryxᶲ, Rockstarᶲ, Sheriff CL Plusᶲ, Stingᶲ, Valiant CL Plusᶲ, Vixenᶲ and Yitpiᶲ.

Minor reductions (one resistance level only) to the ratings of varieties including Ascotᶲ, Caparoi ᶲ, Chief CL Plusᶲ, Corackᶲ, Cutlassᶲ, Denisonᶲ, DS Tullᶲ, Emu Rockᶲ, Illaboᶲ, Kinseiᶲ , LRPB Flankerᶲ LRPB Havocᶲ, LRBP Impalaᶲ, LRPB Kittyhawkᶲ, LRPB Mustangᶲ, LRPB Nighthawkᶲ, LRPB Nyalaᶲ, Mitchᶲ, RGT Ivoryᶲ, SEA Condamineᶲ, Sunblade CL Plusᶲ, Suncentralᶲ and Sunmasterᶲ.

Septoria tritici blotch (STB)

On the back of a conducive 2020 season and heavy residual wheat stubble loads, the stubble-borne wheat disease STB ranked equal third in 2021 (Table 1). STB has a fungal structure produced on wheat stubble (perithecia) which releases airborne spores (ascospores) under ideal environmental conditions. The ascospores produced can spread long distances (>km's) to infect susceptible wheat, durum and triticale crops. Even after a non-host break crop (e.g. canola) is sown in a paddock, any remaining stubble residues from preceding wheat crops can still be a source of inoculum and infect newly emerging wheat crop.

After an infection event, lesions will appear up to 28 days later and produce pycnidia (small black structures inside tan leaf lesions that give a speckled appearance). The pycnidia produce a different type of spore called conidia which are then splash dispersed by rainfall within the wheat canopy causing new infections and further driving STB infections.

Preliminary stubble spore release research conducted at Wagga Wagga Agricultural Institute (WWAI) has shown that the resistance rating of the wheat variety grown has little influence on inoculum levels produced, i.e. the number of spores released in the following season. This indicates that the STB pathogen (*Zymoseptoria tritici*) can grow saprophytically on senescent wheat plants regardless of their resistance status. Which means stubble management to reduce inoculum loads is important in wheat on wheat paddocks for 2022 when STB is prevalent across the southern NSW region.

The first instance of the G143A mutation in STB in Australia was confirmed at Millicent in South Australia in 2021. Mutation G143A is linked to resistance to the Group 11 fungicides (QoIs), known as strobilurins. Reduced sensitivity to demethylase inhibitor fungicides (DMI, Group 3) also known as triazoles has been well documented in NSW and more widely throughout Australia in the past. However, the triazole 'epoxiconazole' at label rates is still effective against STB. Many fungicides use mixtures of both Group 3 and Group 11 modes of action (MOA) Any grower who suspects reduced sensitivity after the application of one of these products should contact a state based pathologist for details about submitting a sample to Curtin University's Centre of Cereal Disease Management (CCDM) for resistance testing (see contact details below). Submission of samples due to spray failure also applies to other diseases such as powdery mildew in both wheat and barley, net-form of net blotch (NFNB) and SFNB, which have known reduced sensitivities to fungicides.

Wheat streak mosaic virus (WSMV)

Wheat streak mosaic virus was more prevalent in 2021 with 23 confirmed cases, up from three in 2020 and one in 2019. The majority of these came from the high rainfall, mixed farming regions of southern NSW around the Young, Harden and Cootamundra regions. However, cases were reported as far north as Cumnock in central NSW. WSMV is transmitted by the wheat curl mites (WCM) which host on cereal volunteers and grass weeds, which were favoured by the mild wet 2020/2021 summer in cropping paddocks or nearby pasture paddocks. WCM migrate or are windblown into newly emerging crops where they transmit WSMV as they feed on seedling wheat plants. The earlier the infection occurs, the more severe the yield penalty. Early infection in young plants can cause death and as the season progresses, expression can include sterile empty heads, heads trapped in the boot due to leaf curling and pinched grain. Early infections can be devastating as seen in 2005, with up to 80% loss observed in infected paddocks.

WSMV can be seed-borne at low infection (<1%) levels. On a paddock scale, this can still result in a considerable number of plants infected in the newly emerged wheat crop. Seed ideally should not be retained from crops or areas of crops known to be infected with WSMV in 2021. Seed-borne transmission is a distinct risk for spreading WSMV into other paddocks or regions. It is expected the risk of WSMV will be further elevated for 2022.

Disease risk in 2022

On the back of conducive weather conditions in 2020 and 2021, inoculum and disease risk levels for the 2022 season are elevated. Diseases require a susceptible host, a source of inoculum and conducive environmental conditions to develop.

Climatic conditions (rainfall, temperature and humidity) play a significant role in initiating and driving disease epidemics. Individual pathogens each have a specific set of climatic conditions that must be met to promote initial infection and favour disease development.

If 2022 is mild and wet, there is a higher risk of foliar disease epidemics. These include biotrophic diseases such as rusts and necrotrophic diseases such as STB and YLS in wheat and SFNB, NFNB and scald in barley. These conditions will also favour soil borne diseases take-all and Pythium. If the 2022 season is drier, there will likely be a reduction of foliar diseases and increase in root diseases, such as Fusarium crown rot and Rhizoctonia where expression is favoured by the drier conditions.

The outlook for the 2021/2022 summer is wet and mild conditions, much like 2020/2021. If the forecast is correct and summer cereal volunteers and weeds are not controlled, the 'green bridge' will provide the ideal platform for biotrophs such as wheat stripe rust epidemics to initiate early on in the 2022 season.

The final inoculum consideration is from seed borne diseases and virus such as bacterial blight, smuts, bunts, Fusarium infected grain and WSMV. Sourcing clean seed for sowing in 2022, that is, not from crops infected in 2021, is important to reduce risk of these diseases.

Integrated disease management for 2022

There are integrated management strategies that growers can use to assist reduction in disease pressure from foliar, soil and stubble-borne diseases.

1. Risk identification prior to sowing

Be proactive instead of reactive. Consult paddock notes, management plans and rotation sequences from previous years to identify known and potential disease issues. Gain an understanding of your underlying inoculum levels through PreDicta®B DNA based testing method. PreDicta B quantifies a wide range of pathogen levels in your paddock and provides an associated risk level. Alternatively, 2021 cereal stubble can be submitted to the NSW DPI Tamworth laboratory for free plating of Fusarium crown rot, common root rot and take-all risk (contact Steven Simpfendorfer, details below). This provides information necessary to develop management plans and identify changes if the associated risk is unacceptable. It is recommended that growers and advisors review extension materials and disease bulletins as well as assess stubble for disease indicators such as formation of yellow leaf spot or net blotch fruiting bodies (raised small black lumps on outside of stubble).

Assess the 'green bridge' risk!!

2. Crop rotation

Sow break crops for one or more years between cereal crops. Break crops include pulses, canola and grass free pasture legumes (e.g. lucerne). This will facilitate the breakdown of cereal pathogen inoculum present. Grass weed control is vital in break crops as most grass weeds are alternative hosts of winter cereal pathogens.

As inoculum levels in 2022 are likely to be elevated, sowing cereal-on-cereal will have increased risk of yield loss. If there is a perceived or known disease issue in a paddock, switch out to a break crop to eliminate yield loss and drive inoculum pressure down.

3. Variety selection

Select varieties that provide the best resistance ratings to known or likely disease issues. This gives wheat crops the best chance of optimising yield in the presence of a pathogen. If there are multiple known disease issues, select the variety with the best resistance rating to the potentially most damaging disease.

This is particularly important for wheat stripe rust in 2022 as many widely grown wheat varieties have seen a reduction in their levels of resistance to new pathotypes and therefore will require more intensive management. Effective varietal selection will reduce the likelihood of requiring repeated in-crop fungicide applications, which will be a benefit in 2022 with potential tight fungicide supply, much like the 2021 cropping season.

4. Stubble management

Retained stubble systems are driving the prevalence of soil and stubble-borne diseases in NSW farming systems. On the back of successive high yielding years in 2020 and 2021, heavy cereal stubble loads exist in many paddocks across NSW. The stubble provides a source of inoculum for necrotrophic foliar diseases such as STB, YLS in wheat and SFNB, NFNB and scald in barley. Cutting height at harvest can affect the physical amount of stubble left standing in the paddock for pathogens such as Fusarium to further vertically colonise post-harvest. Other reduction management options for stubble-borne diseases include burning, mulching, grazing, baling stubble or soil incorporation of stubble.

Burning may have minimal effect on the inoculum levels of Fusarium crown rot, common root rot and take-all, as most of the inoculum is in the crown or root system below ground. The decision to burn cereal stubble should be weighed up against disadvantages such as nutrient loss, reduced storage of fallow moisture and increased erosion risk.

Lowering harvest cut height, mulching and incorporating stubble can reduce the amount of standing stubble but can potentially also spread pathogen inoculum more uniformly across a paddock. The risk and benefits must be weighed up before undertaking these operations.

Inter-row sowing is another effective stubble management technique. This physically distances the plant from the previous stubble row, reducing contact with pathogens that cause soil and stubble borne root diseases.

5. Volunteer cereals and grass weed control- the 'green bridge'

Chemical or mechanical control of cereal volunteers and weeds during the summer fallow period is critical to reducing the survival of rusts and insect virus vectors such as aphids or WCM. Controlling the green bridge reduces or breaks the inoculum cycle of diseases or lifecycle of virus vectors. Control of volunteer cereals and grasses in non-crop areas such as fence lines, around dams, creek lines and silos, is also important.

Controlling the green bridge is vital as a management tool for all cereal rusts. Stripe rust (especially 198 pathotype) developed early in grazing wheats in 2021, particularly in DS Bennett[A]. The disease survived on wheat volunteers over summer and infected these crops early, kick starting what was a high-pressure stripe rust season which then spread onto main season plantings. The 2022 season is potentially shaping up to be similar to 2021 so if sowing grazing crops early in 2022, spray out volunteers and weeds well in advance (4 weeks) of sowing to delay the onset of stripe rust infections. As wheat stripe rust is highly wind dispersed, this approach is much more effective if adopted across a whole region. Note that the more susceptible a wheat variety is to stripe rust, the greater the importance to control the green bridge.

Green bridge control will also reduce your risk of WSMV. This is critical as there are no effective in-crop management options for WCM such as insecticides. Early sown grazing wheat crops are generally sown in high rainfall, mixed farming regions of NSW which are the same locations in which WSMV was prevalent in 2021. The WCM hosts on cereal volunteers and grass weeds and under ideal conditions can survive for 2 weeks without a host. One contributing factor of WSMV infections in 2021 was the knock down herbicide spray being applied to paddocks just in front of sowing operations. The WCM was hosting on the green bridge (mainly volunteer wheat) in these paddocks, which by the time the herbicide spray had taken affect, the new wheat crop was emerging. The WCM moved off the senescing green bridge and straight onto emerging wheat plants, infecting large numbers of plants and continuing the cycle.

For this same reason, it is advised to spray out volunteers in any adjoining wheat paddocks from 2021 or fallow paddocks well in advance of sowing to avoid the same WCM migration pattern onto emerging wheat crops in 2022.

6. Grazing

Grazing can be a technique to reduce the incidence and severity of cereal foliar diseases. By grazing the crop, green leaf area is removed along with infected tissue present at the time. Grazing also reduces humidity within the crop by opening up the canopy and allowing airflow, thus creating an environment which is less conducive to development of leaf diseases.

Early crash grazing can be an option to reduce wheat stripe rust pressure. However, be mindful of grazing withholding periods if flutriafol was applied to starter fertiliser at sowing. If taking the grazing crop through to grain harvest, stock must be removed from the crop by GS31 to avoid yield penalties. Note that grazing is not as effective as a management strategy if infection is patchy, or stripe rust hotspots are already present in a crop.

7. Fungicide use

Due to the evolution of fungicide resistance in some cereal pathogens, such as *Zymoseptoria tritici* (STB) and *Blumeria graminis f. sp. tritici* (wheat powdery mildew- WPM) and the risk of further resistance development, it is essential that fungicide MOA's are rotated if there is to be more than one fungicide application per year. This reduces the risk of resistance development in target and non-target pathogens.

Moving forward into 2022, due to the changes in resistance ratings of widely grown varieties showing increased susceptibility to the 198 and 239 stripe rust pathotypes, fungicide management will have to change to suit. Widely grown varieties such as Catapult⟨PBR⟩, Coolah⟨PBR⟩, Coota⟨PBR⟩, Rockstar⟨PBR⟩ and Vixen⟨PBR⟩ have seen their ratings drop by two or more levels. What this means is that a previously rated moderately resistant to moderately susceptible (MRMS) variety is now classed as susceptible (S) and will require a more robust fungicide management package to what was employed on that variety in previous years.

Due to the high inoculum pressure expected in the 2022 cropping season, the recommended fungicide regime for an S or worse rated variety to stripe rust should include an up-front fungicide such as flutriafol on starter fertiliser at sowing, followed by a GS31 and GS39 in-crop fungicide application.

Alternatively, if an up-front fungicide is not used, a minimum of two in-crop fungicide applications should be planned, timed at GS31 and GS39. Earlier in-crop invention may be needed if stripe rust appears prior to GS31.

Fungicide applications can be altered to suit another key growth stage such as flowering, seasonal conditions and outlook along with yield potential. Fungicide resistance management through rotation of MOA and individual triazole actives within season should also be considered (see AFREN- https://afren.com.au/).

8. Adequate nutrition

Ensure adequate nutrition is applied to optimise crop health and yield potential which is balanced to meet seasonal conditions. Application of too much nitrogen can cause the development of excessive canopy biomass exacerbating foliar diseases. Increased nitrogen application can also increase moisture stress during anthesis and grain filling if in crop rainfall or stored soil water supply is limited. Late season water stress can also exacerbate the expression of Fusarium crown rot in infected crops.

9. In-crop monitoring

Inspection of cereal crops for the presence and extent of disease development and the resulting management decisions are vital to economic performance. Missed fungicide spray timings on susceptible varieties can have significant yield penalties in conducive seasons.

Wheat stripe rust can cycle every 10-14 days at optimum average daily temperatures of around 15°C (max + min temp/2). Due to changes in resistance ratings of widely grown wheat varieties to stripe rust, regular monitoring is required to identify early infections as fungicides are considerably more effective when used in a preventative rather than curative strategy.

Early disease detection through regular monitoring is therefore important. Irregular inspections may miss the expression of disease after an infection event.

Conclusions

Overall cereal crop production was above average across a large proportion of NSW in 2021 even though late rain impacted on quality in some areas. The 2022 season is already shaping as another favourable year for crop production with high soil moisture levels already accumulating. Cereal disease risk is likely to be higher due to pathogen build-up in 2020 and 2021. Well-planned integrated management strategies in the face of higher input costs and potential tight fungicide availability in 2022 will assist minimisation of disease levels whilst maximising profitability. NSW DPI is here to support correct diagnosis and discuss management options prior to sowing and as required throughout the season.

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