Cereal disease management in 2023: what does a return to a 'normal' spring mean?

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leaf diseases, perspective, Fusarium head blight, Fusarium crown rot, climatic conditions

GRDC codes

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Take home message

- The 2022 season was very conducive to a range of cereal leaf diseases and Fusarium head blight (FHB) during flowering and grain fill
- However, this exceptional season for cereal diseases needs to be kept in perspective
- Leaf disease pressure, especially stripe rust, will likely be high again in 2023 requiring management early in the season, but plans need to be responsive to spring conditions
- Widespread FHB in 2022 was the Fusarium crown rot (FCR) fungus letting you know that it has not gone away with wetter and milder spring conditions the last few seasons
- It was important to test seed retained from any crop where FHB or white grains were evident in 2022 as Fusarium infection negatively impacts on germination and vigour but can also introduce FCR into paddocks
- However, retained cereal stubble is still likely to be the main source of FCR inoculum
- Help is available with testing, and stay abreast of cereal disease management communications throughout the season, as 2023 is likely to be another dynamic year

Introduction

Cereal disease management has been more complicated over the past three consecutive wet seasons with multiple stripe rust pathotypes blowing around and an increase in diseases not frequently seen in central and northern areas (e.g., Septoria tritici blotch, wheat powdery mildew and Fusarium head blight). This has all occurred in combination with the added stress of increased input costs, with many growers stating that '2022 was the most expensive wheat crop they have ever grown'. This certainly created an elevated level of anxiety for growers and their agronomists.

So, if 2022 taught us nothing else, it is that we cannot control the weather. However, nothing has changed and in 2023 growers need to have extra focus on 'controlling the controllable'. The 2022 season needs to be kept in perspective, as it was the year for leaf diseases and by default multiple fungicide applications in susceptible varieties. However, what are the chances of a wet and prolonged mild spring again in 2023? Current long-term Bureau of Meteorology (BoM) forecasts are indicating a warmer and drier spring for much of the northern grain region in 2023 which needs to be considered in cereal disease management and other decisions this year.

2022 – an exceptional season

The 2022 season was wet! Records were broken and flooding was widespread in some areas. Frequent rainfall is very conducive to the development of leaf diseases such as stripe rust, as causal pathogens require periods of leaf wetness or high humidity for spore germination and initial infection. However, just as significant a contributing factor to the prevalence of cereal leaf diseases was the spring (Sep–Nov) temperatures in 2022, even compared with 2020, which remained mild (Figure 1).

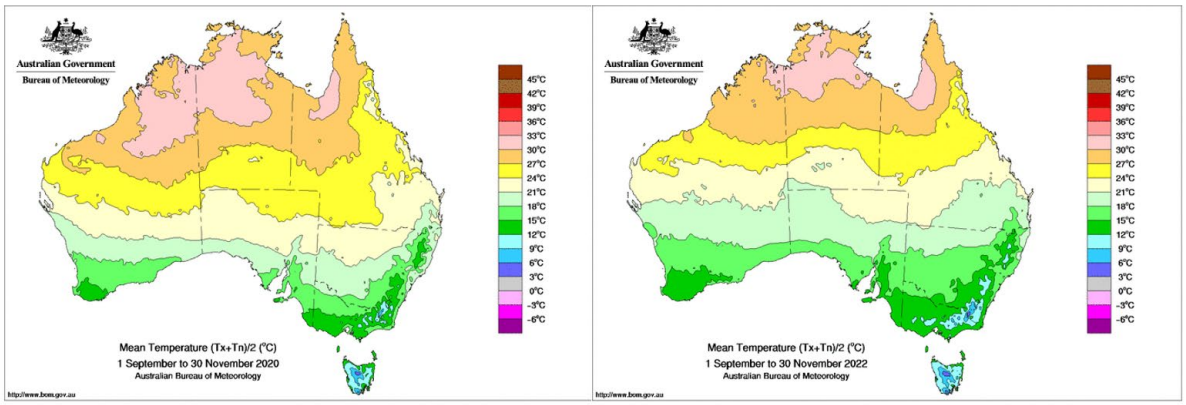

Figure 1. Mean daily temperature for spring (Sep–Nov) in 2020 (left) compared with 2022 (right).

Temperature interacts with cereal diseases in two ways. Each pathogen has an optimal temperature range for infection and disease development (Table 1). Time spent within these temperatures dictates the latent period (time from spore germination to appearance of visible symptoms) of each disease, which is also often referred to as the cycle time. Disease can still develop outside the optimum temperature range of a pathogen, but this extends the latent period. Hence, prolonged mild temperatures in 2022 were favourable to extended more rapid cycling of leaf diseases such as stripe rust, Septoria tritici blotch and wheat powdery mildew (Table 1).

Table 1. Optimum temperature range and latent period of common leaf and head diseases of wheat.

Disease	Optimum temperature range (°C)	Latent period (opt. temp)
Stripe rust	12–20	10–14 days
Septoria tritici blotch	15–20	21–28 days
Wheat powdery mildew	15–22	7 days
Leaf rust	15–25	7–10 days
Yellow leaf spot	15–28	4–7 days
Fusarium head blight	20–30	4–10 days

The second effect that temperature can have on disease is more indirect, on the plants themselves. The expression of adult plant resistance (APR) genes to stripe rust can be delayed under lower temperatures. However, cooler temperatures also delay development (phenology) of wheat plants, extending the gap between critical growth stages for fungicide application in susceptible wheat varieties. The slower development under cooler spring temperatures therefore increases the time of exposure to leaf diseases in between fungicide applications, which is the case for stripe rust which is also on a rapid cycle time under these temperatures. Hence, underlying infections can be in their latent period and also beyond the curative activity (~1/2 of cycle time with stripe rust) when foliar fungicides are applied. This can result in pustules appearing on leaves 5 or more days after fungicide application. The fungicide has not failed, rather the infection was already present but hidden within leaves and was too advanced at the time of application to be taken out by the limited curative activity of fungicides. At optimum temperatures, stripe rust has a 10-day cycle time in an S rated variety, whereas it is a 14-day cycle in a MRMS variety. Disease cycles quicker in more susceptible varieties!

Reliance on fungicides for management made susceptible (S) wheat varieties critically reliant on correct timing of fungicide application. Frequent rainfall in 2022 caused plenty of logistical issues with timely foliar fungicide applications related to paddock accessibility by ground rig and/or delay in

aerial applications. The associated yield penalty was significantly higher in more stripe rust susceptible varieties due to the shorter disease cycle time. There were plenty of reports of 10-day delays in fungicide applications around flag leaf emergence (GS39) due to uncontrollable logistics that saw considerable development of stripe rust, particularly in S varieties. Yield loss at harvest has been estimated at around 30–50% due to this 10-day delay. This simply does not happen in more resistant varieties, where there is more flexibility in in-crop management, because the disease is not on speed dial when climatic conditions are optimal. The 2022 season has certainly challenged the risk vs reward of growing susceptible varieties – the management of which does not fit logistically within all growers' systems.

The prolonged cool conditions in spring 2022 also extended the flowering period in wheat and durum varieties, which in combination with extended high humidity, was very conducive to Fusarium head blight (FHB). The prevalence of FHB and white grain disorder (*Eutiarosporella* spp.) across large areas of eastern Australia in 2022 is unprecedented. However, what is the likelihood of these specific conditions occurring at a time-critical growth stage (early flowering) again in 2023?

Can we really grow susceptible varieties in the long term?

Always a solid topic for debate. From a plant pathologist viewpoint, the following are simply fact.

- Pathogens with longer distance wind dispersal (e.g., stripe rust and powdery mildew) are 'social diseases'. What you do impacts your neighbours and the rest of industry. Yes, 'it blows'
- Stripe rust has a shorter cycle time in more susceptible varieties which increases disease pressure
- More susceptible varieties can place increased disease pressure on surrounding MS, MRMS and MR varieties
- The more susceptible the variety, the greater 'green bridge' risk volunteer plants are to survival of biotrophic pathogens such as stripe rust and wheat powdery mildew during fallow periods
- Mutations within the pathogen population which lead to 'break down' of resistance genes or development of fungicide resistance is all a numbers game. More susceptible varieties produce more fungal spores, which increase the risk of mutations
- Susceptible varieties have less flexibility with in-crop fungicide timings. The yield penalty is much larger if application is delayed (i.e., increased production risk)
- Susceptible varieties are reliant on fungicides, often multiple within conducive seasons, to control leaf diseases. This increases selection for fungicide resistance or reduced sensitivity within the pathogen population either directly (e.g., with rust) or indirectly on other fungal pathogens also present at the time of application (e.g., powdery mildew)
- Rust pathogens CAN develop fungicide resistance!! (Park *et al.* 2023)

Keep the 2022 season in perspective

The 2022 season was the year for fungicides, especially in more susceptible varieties and with the mix of diseases that occurred. The prolonged mild conditions also extended the length of grain filling so there was a benefit of retaining green leaf area through this period in 2022. Remember, fungicides do NOT increase yield, they simply protect yield potential (i.e., stop disease from killing green leaf area). As highlighted above, disease is very dependent on individual seasonal conditions, so the same returns are not guaranteed from fungicide use in 2023. What's your disease management plan if spring returns to closer to normal temperatures and rainfall? There is no talk of La Niña again in 2023 and seasonal outlook must be part of disease management planning. Early leaf disease pressure is likely to be high again in 2023, given elevated inoculum levels from 2022 and decent levels of stored soil moisture. However, dry conditions during April-May and into June in some areas, especially more western regions, has been less conducive to green bridge survival of rusts and leaf disease development in cereal seedlings. Manage early leaf disease pressure in 2023 if

present, then adapt management to spring conditions. The most effective fungicide can often be 2 to 3 weeks of warmer and dry weather in spring.

Where has Fusarium crown rot gone?

Fusarium crown rot (FCR) has NOT disappeared with the last few seasons of wetter and milder spring conditions. FCR risk was particularly elevated in more northern areas leading into planting in 2022. Increased frequency of cereal crops within rotations following drought conditions from 2017–2019, along with reduced sowing of chickpea crops being underlying causes. However, FCR requires moisture for infection, so inoculum levels have progressively been building up within paddocks (Figure 2). The wetter and milder spring conditions have limited the expression of FCR infection as whiteheads.

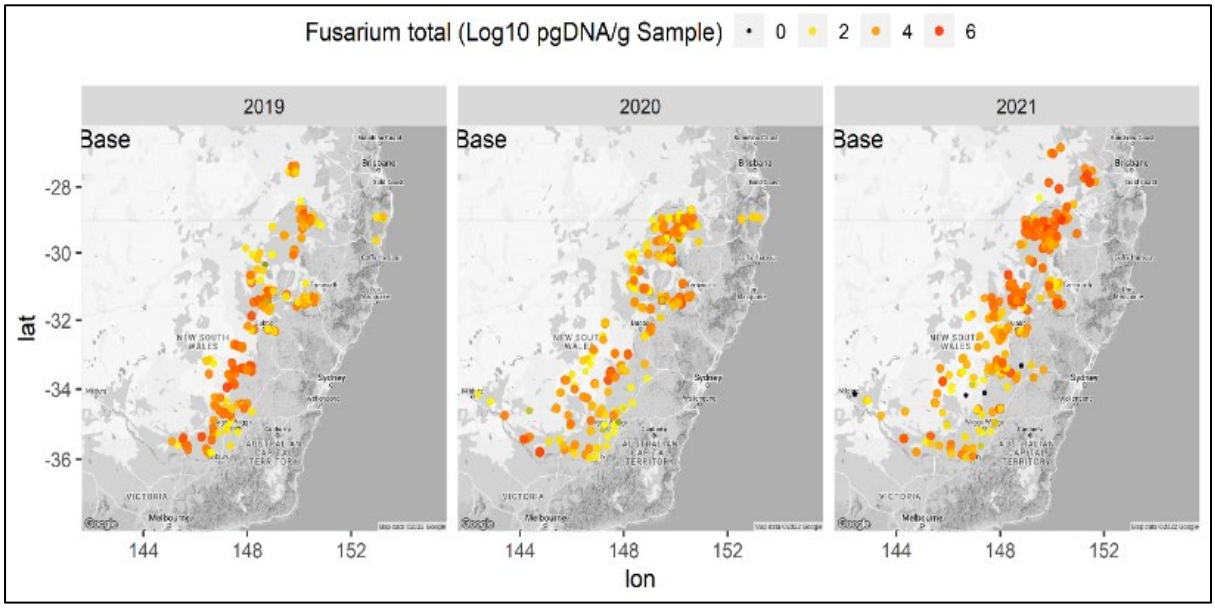

Figure 2. Levels of Fusarium crown rot within the base of randomly surveyed winter cereal crops (2019 to 2021) as assessed using quantitative PCR of pathogen DNA levels. Map from collaborative surveys conducted with Dr Andrew Milgate and Brad Baxter, NSW DPI Wagga Wagga.

Fusarium head blight (FHB) which caused premature partial bleaching of heads and white or pink grains was widespread at varying levels across eastern Australia in 2022 along with white grain disorder (WGD) caused by *Eutiarosporella* spp. in some regions, especially southern Qld. More detailed information around the specific causes, management and implications of this epidemic in 2022 are available (Simpfendorfer and Baxter 2023). Testing of 1880 grower retained grain samples from the 2022 harvest showed that the dominant cause of FHB across eastern Australia in 2022 was related to tiller bases infected with FCR. That is, Fusarium infection of bread wheat, durum and barley crops in 2022 expressed as FHB due to the wetter/milder conditions during flowering and grain fill. This basal Fusarium infection would have expressed as whiteheads if crops had been temperature and/or moisture stressed during this period in 2022. This was a massive warning sign of the levels of FCR risk that have developed and largely gone unnoticed within some cropping systems over the past three wetter seasons.

Why was seed testing so important prior to sowing in 2023?

FHB was widespread in 2022 with implications for seed retained from infected crops. Fusarium grain infection reduces germination and vigour of seed retained for sowing along with causing seedling blight (death) in plants arising from infected grain. The fungus replaces the contents of infected seed with its own mycelium, so while seed treatments can help reduce the level of seedling blight, they cannot restore the quality of heavily infected seed sources. Sowing Fusarium infected seed also

introduces FCR into paddocks. The level of pink or white grains in a grain sample is likely an underrepresentation of the true level of Fusarium grain infection, as later infections (i.e., high humidity) during grain fill, can allow some fungal spread into formed grains which appear normal. Sourcing quality seed for sowing in 2023 created issues in some regions.

General advice if retaining seed for sowing is:

- <1% Fusarium grain infection = no issues;
- 1% to 5% Fusarium grain infection = consider using seed treatment (full rate Vibrance® or EverGol® Energy) to limit seedling blight and slightly increase sowing rate;
- >5% Fusarium grain infection = source cleaner seed if possible.
- Same values apply for Eutiarosporella and are additive for mixed infections where the combined Eutiarosporella + Fusarium infection level should not be greater than 5% in a seed source.

A 'free' seed testing service was offered to growers to support them in determining Fusarium grain infection levels. In total 1,880 grower retained seed lots from 2022 and 64 from the 2021 harvest were tested through the NSW DPI laboratory at Tamworth under a collaborative project with GRDC. Fusarium grain infection levels were considerably lower in seed retained from 2021 (average 0.75%; range 0 to 9%) compared with 2022 harvested grain (average 6.5%; range 0 to 70.5%). This highlights that FHB was also present in 2021 but went largely unnoticed. If available, seed retained from 2021 was likely a good source of planting seed with low Fusarium infection levels. However, appropriate storage of seed over this extended period appears to have impacted on germination of some 2021 retained seed. With 2021 retained seed 63% of grower seed lots had greater than 90% germination, 17% had 70 to 90% germination, 14% had 50 to 70% germination and 6% had less than 50% germination.

In total, 1,880 seed lots from the 2022 harvest were tested, consisting of 1,566 bread wheat, 183 durum and 131 barley samples (Table 2). The biggest issue with Fusarium grain infection levels was in durum wheat, which is very susceptible to FCR and FHB, with 81% of 2022 seed lots having greater than the recommended 5% level of Fusarium infection (average 20.3% infection, range 0 to 70.5%). Fusarium grain infection levels were still a widespread issue in bread wheat and barley seed retained from 2022 with 33% of bread wheat (average 5.0% infection, range 0 to 43%) and 29% of barley (average 4.2% infection, range 0 to 49%) seed lots having greater than the recommended 5% level of infection (Table 2).

Table 2. *Fusarium* spp. grain infection levels in bread wheat, durum wheat and barley seed lots harvested across eastern Australia in 2022.

Region	Bread wheat			Durum wheat			Barley		
	<5%	>5%	Max	<5%	>5%	Max	<5%	>5%	Max
SE NSW	163	27	16%				3	1	6%
SW NSW	144	56	43%	12	45	71%	12	4	9%
CE NSW	141	74	37%	0	2	30%	17	4	49%
CW NSW	259	169	43%	0	2	45%	20	14	45%
NE NSW	81	94	42%	16	83	69%	13	11	34%
NW NSW	61	39	28%	1	15	68%	13	4	13%
Sth Qld	117	24	26%	0	1	23%	9	0	4%
Vic	71	36	33%	1	1	35%	6	0	5%
SA	10	0	2%	5	0	2%			

Values are the number of grower seed lots with less than or greater than 5% Fusarium grain infection.
Max = maximum level of Fusarium grain infection (%) measured in each cereal crop type and region.

Levels of FHB infection and resulting Fusarium grain infection were prevalent across eastern Australia in 2022 but varied between regions. For example, in bread wheat the incidence of grain infection levels greater than 5% was most common in north-east NSW (54% of samples) followed by

north-west and central-west NSW (both 39% of samples), then central-east NSW and Victoria (both 34% of samples) and south-west NSW (28% of samples). Fusarium grain infection levels in bread wheat greater than 5% were less prevalent in Qld (17% of samples) and south-east NSW (14% of samples) with the lowest level in South Australia (0% of samples; maximum 2% infection) from limited testing (10 samples) conducted from that state (Table 2).

WGD and resulting grain infection by *Eutiarosporella* spp., although detected in all regions except South Australia, was predominantly an issue within southern Qld bread wheat crops in 2022. In southern Qld, 19% of bread wheat samples had greater than 5% Eutiarosporella grain infection (Table 3). Eutiarosporella grain infection levels were only greater than 5% in one south-east NSW bread wheat, three south-west NSW durum and four north-east NSW durum grain samples (all maximum 8% infection)(Table 3).

Table 3. *Eutiarosporella* spp. (white grain disorder) grain infection levels in bread wheat, durum wheat and barley seed lots harvested across eastern Australia in 2022.

Region	Bread wheat			Durum wheat			Barley		
	<5%	>5%	Max	<5%	>5%	Max	<5%	>5%	Max
SE NSW	189	1	8%				4	0	0%
SW NSW	200	0	1%	54	3	8%	16	0	0%
CE NSW	215	0	4%	2	0	1%	21	0	0%
CW NSW	428	0	2%	0	2	0%	34	0	1%
NE NSW	175	0	5%	95	4	8%	24	0	2%
NW NSW	100	0	2%	16	0	2%	17	0	1%
Sth Qld	114	27	48%	1	0	0%	9	0	0%
Vic	107	0	2%	2	0	0%	9	0	0%
SA	10	0	0%	5	0	0%			

Values are the number of grower seed lots with less than or greater than 5% Eutiarosporella grain infection.
Max = maximum level of Eutiarosporella grain infection (%) measured in each cereal crop type and region.

Identifying FCR risk prior to sowing in 2023

It was recommended to test any paddock planned for a cereal-on-cereal crop for FCR risk prior to sowing in 2023, using either PreDicta® B (SARDI) or 'free' cereal stubble plating by NSW DPI with GRDC co-investment. This was particularly imperative in any paddock where FHB was noticed in 2022, as there is a high probability that the infection came from FCR in the base of plants. A random survey of 198 cereal crops conducted across central/northern NSW in 2022 found that 5% had nil (0%), 39% had low (1 to 10%), 26% moderate (11-25%), 16% high (26-50%) and 14% very high (>50%) FCR infection at the time of sampling during grain filling.

In total, growers and their agronomists collected and submitted for 'free' testing of FCR infection levels, 152 cereal stubble samples after harvest in 2022 (Table 4).

High (>26%) FCR infection levels were most prevalent in cereal crops in north-east NSW (100% of crops), then south-west NSW (89%), central-west NSW (75%), north-west NSW (63%), southern Qld (50%) and central-east NSW (42%) in 2022. The prevalence of high FCR infection levels was lowest in south-east NSW (31%), Victoria (29%) and South Australian (14%) cereal crops in 2022 (Table 4). This was important information for the collaborating grower and their agronomist who used this individual paddock data to consider appropriate management options. The picture provided by these two surveys of FCR infection levels in 2022 has further implications across regions given that the 2022 season did not favour FCR expression as whiteheads. FCR infection often goes unrecognised in wetter seasons when significant levels of whitehead expression does not occur. However, significant infection levels and inoculum build-up within retained cereal stubble still occurs. FCR inoculum load and, hence, disease risk in 2023 is a function of the percentage of plants infected in 2022 (Table 4) and the stubble load produced in that season. This is particularly

concerning as much higher cereal stubble loads were produced in 2022 and the prediction of drier or even El Niño conditions in spring 2023 is likely to favour expression and yield loss from FCR infection. These levels of underlying FCR infection across the survey regions also appeared to have some link to the prevalence of Fusarium head blight within these same areas in 2022 (Table 2).

Table 4. Percentage of paddocks with varying levels of Fusarium crown rot infection across eastern Australia from 152 cereal stubble samples submitted post-harvest in 2022.

Region (no. crops)	Nil	Low	Medium	High	Very High
	0%	1-10%	11-25%	26-50%	>50%
SE NSW (26)	27	8	35	23	8
SW NSW (9)	0	11	0	33	56
CE NSW (12)	0	17	42	42	0
CW NSW (16)	0	6	19	56	19
NE NSW (17)	0	0	0	35	65
NW NSW (24)	0	17	21	29	33
Sth Qld (20)	0	35	15	25	25
Vic (14)	0	21	50	29	0
SA (14)	0	43	43	7	7
Total (152)	5	17	25	30	23

Data based on plating of 50 surface sterilised primary tillers/crop from cereal stubble collected after harvest in 2022.

FCR integrated disease management, all options are prior to sowing so knowing the risk level within paddocks is important.

If medium to high FCR risk, then:

1. Sow a non-host break crop (e.g., faba bean, chickpea, canola).

If still considering sowing a winter cereal:

1. Consider stubble management options
2. Sow more tolerant bread wheat or barley variety (not durum)
3. Sow at start of recommended window for each variety in your area
4. If previous cereal rows are intact – consider inter-row sowing (cultivation is bad as it spreads inoculum)
5. Be conservative on N application at sowing (urea exacerbates FCR and 'hyper yielding' is potentially 'hyper risk' when FCR is present)
6. Apply zinc at sowing – ensure that crops are not deficient
7. Current fungicide seed treatment is suppression only – useful but limited control
8. Determine infection levels around GS39 to guide other in-crop management decisions.

Summary

Cereal disease management is heavily dependent on climatic conditions between and within seasons. Therefore, the situation can be quite dynamic, including the unpredictable distribution of different stripe rust pathotypes across regions. Arm yourself with the best information available including the latest varietal disease resistance ratings.

FCR risk is at record highs across much of the northern grain region. Widespread FHB in 2022 was predominantly the FCR fungus letting you know that it has not gone away with wetter and milder spring conditions the last few seasons. Do not ignore the signs. Did you know your FCR risk in paddocks planned for cereals in 2023, especially if sowing durum? We cannot keep banking on wet and mild spring conditions as our main FCR management strategy. Sowing seed with as low a level of Fusarium grain infection as possible was an important first step to maximising crop establishment but also restricting the level of FCR introduced into paddocks. However, seed is only one source of

inoculum with retained cereal stubble still likely to be the dominant source of FCR infection in 2023. It is not too late to submit cereal stubble for 'free' testing to NSW DPI. This is particularly important for any cereal-on-cereal rotations and could be useful data to assist understanding of where FCR infection arose from if we have a season conducive to disease expression. Contact details below if you want further information around 'free' stubble sampling.

Keep abreast of in-season GRDC and NSW DPI communications which address the dynamics of cereal disease management throughout the 2023 season. Do not just focus on leaf diseases in 2023. Pull up a few plants randomly across paddocks when doing crop inspections and look for browning of the outer leaf sheathes and lower stems which is characteristic of FCR infection. Unfortunately, this is already being observed in cereal crops during the seedling stage in 2023.

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Further resources

PreDicta®B sampling procedure - https://www.pir.sa.gov.au/__data/assets/pdf_file/0007/291247/Sampling_protocol_PreDicta_B_Northern_regions.pdf

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