What are foliar fungal diseases in wheat really costing us?

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Key words

cereal disease, stripe rust, rust, septoria tritici, yellow leaf spot, fungicide, resistance, yield gap

GRDC code

GOA2006-001RTX

Take home messages

- Several wheat varieties have become popular in recent years because of their perceived higher yield potential despite low levels of stripe rust (Yr) resistance
- These varieties perform well when diseases are absent or adequately controlled, however if fungicide application is compromised yield penalties can be more than 50%
- There are alternate wheat varieties with genetically higher resistance ratings that can achieve yields close to the better yielding susceptible varieties, but where disease is present, yield penalties may only amount to ~10% if fungicide control is not possible
- Selecting wheat varieties with improved disease ratings may result in slightly lower yields when no disease is present but have far less downside risk to yield and profit where fungicide applications are delayed or missed
- Growing wheat varieties with better disease resistance is good for the industry as it reduces the risk of breakdowns in genetic resistance to disease and/or the development of fungicide resistance.

Background

Wheat diseases were estimated to be costing Australian growers as much as $400 m dollars (GRDC, 2016) in the 1980s. In 2009 the estimate had grown to $913 m (GRDC, 2009), and it is likely that this loss would be substantially more in today's dollars. Stripe rust (Yr), yellow leaf spot (YLS), and septoria tritici blotch (STB) are the main foliar diseases and are estimated to contribute close to 50% of these losses.

Effective genetic protection from these fungal diseases tends to follow an ebb and flow. When effective genetic resistances are overcome by pathogen mutations (e.g. Yr pathotypes), breeders then need to identify new effective sources of genetic resistance to incorporate into new varieties. This takes time to integrate into commercial varieties, and the resistance is at risk of being overcome as well. Because of this, the need for fungicide intervention to manage cereal leaf diseases will often be needed to maintain yields and profitability where genetic resistance is not enough.

Wheat breeders also have many competing attributes they 'breed' for. Disease resistance is not always the number one priority and often, varieties with good resistance may not have the best yield potential, or the opposite, that the most productive varieties can have low levels of resistance.

Thankfully, fungicides are relatively cheap and generally effective in controlling cereal leaf diseases but there is still a cost to growers in terms of time, product, and application. In many cases the saved or protected yield covers the cost of control, but there may be more to consider in choosing to grow susceptible wheat varieties.

Improved seasonal conditions coupled with changes in the prevalence and distribution of the Yr pathotypes 238 & 239 since 2020 resulted in several widely grown wheat varieties (e.g. Vixen(D)) displaying unexpected disease responses as they were more susceptible to these new pathotypes. These varieties were commonly grown in the years from 2017 to 2019 which were less conducive to disease due to the drier conditions, where Yr incidence was low and control measures often unnecessary.

Successive years of disease build up since 2020 and very wet conditions in 2022 preventing or at least delaying access to many paddocks for timely foliar fungicide applications, and significant disease infections resulted in major yield losses. The 2022 season really highlighted the increased risk growers take when employing a strategy of growing large areas of high yielding but Yr susceptible varieties and rely solely on fungicides to manage this disease.

Although Yr is often blamed for losses, these same wet conditions would have also favoured the development of other cereal leaf diseases such as YLS and STB, which can also affect yield and profitability.

In high disease pressure years, such as 2022, it is likely the varieties with better disease resistance would not have incurred such yield losses but by how much?

There are wider ramifications of growing more susceptible wheat varieties in our farming systems such as:

- potentially require more inputs, such as fungicides and application costs, dollars that could be spent elsewhere to improve yields, for example urea applications.
- Increased prevalence of diseases in the environment leads to a greater chance of pathotype changes and a breakdown of the currently effective genetic resistances.
- The more use of fungicides the greater the chance of development of fungicide resistance and of selecting for resistance in secondary or non-target pathogens such as powdery mildew.

Grain Orana Alliance (GOA), with the support of the Grains Research and Development Corporation (GRDC) has conducted trials in central and southern NSW in 2023 and 2024 to help growers understand the impact foliar fungal diseases have on a range of current wheat varieties.

With a better understanding of the yield gap created by controllable foliar fungal diseases, growers and advisors will be able to make more informed choices around wheat varieties based on both their risk and reward proposition.

The trials

In 2023 and 2024, 9 small plot trials were established using a split plot trial design with 4 replications.

The trials investigated the performance of a range of commonly grown, regionally specific wheat varieties where they were either treated or untreated with fungicides for foliar disease control.

Fungicides were applied to reduce disease levels to as low as practically possible in treated plots with current registered fungicides, whilst also having plots of the same varieties

completely untreated for disease. This aim was to quantify yield loss across a range of popular varieties to help better inform growers of the level of risk (yield loss) associated with growing varieties when disease control is not possible or compromised.

The fungicide program was aimed primarily at reducing to a minimum the disease incidence and impact. No consideration was given to the economic viability of this approach and the treatment strategy is not a recommendation and is in no way suggested to be commercially relevant.

The varieties included in each of the regions and years and their resistance ratings to the 3 most prevalent foliar diseases, stripe rust (*Puccinia striiformis* f.sp. *tritici*), yellow leaf spot (*Pyrenophora tritici-repentis*), and septoria tritici blotch (*Zymoseptoria tritici)* are outlined in Table 1.

The trials were assessed for disease, but detailed assessments were not budgeted for. Plant samples from the 2024 trials have been submitted for quantitative polymerase chain reaction (qPCR) testing which will confirm pathogen presence and incidence. Results were not available at the time of reporting.

The trial locations and seasons

Trials in the Central West (CW) of NSW were managed by GOA and in the Riverina region of NSW by Brill Ag.

The 2023 season was drier than average in both regions with relatively low levels of disease (Figure 1). In the CW, the 2024 growing season was very wet with relatively consistent rainfall received throughout the growing period, conducive to fungal disease development. Conditions were closer to average in the Riverina but still favoured disease development at all sites.

Table 1. Varieties, the number of trials and location over the two years they were investigated, and their disease ratings[1] to Yr 2023 and 2024 (East Coast ratings), YLS and STB. Note the changes in ratings for some varieties from 2023 to 2024.

	2023[2]		2024[3]		Disease resistance rating			
Variety	**North**	**South**	**North**	**South**	**Yr 2023**	**Yr 2024**	**YLS**	**STB**
Beckom	2	2	2	2	MRMS	MRMS	MSS	S
Boree				2		SVS	MRMS	SVS
Calibre		2		2	S	S	MRMS	S
Catapult	2		2		S	S	MRMS	MSS
Condo	2		2		MS	MRMS/MS	MS	S
Coolah	2	2	2		MSS	MSS	MSS	MSS
Coota		2		1	S	S	MSS	S
Leverage				3		MRMS	MRMS	S
Longsword	2	2	2	3	R/S	MRMS/MS	MRMS	MS
LRPB Hellfire	2	2	2	2	MRMS	MR	MSS	S
LRPB Lancer	2	2	2	3	RMR	RMR	MS	MS
LRPB Major				1		MRMS	MS	MSS
LRPB Raider	2	2	2	3	MR	MR	MSS	S
LRPB Reliant	2		2		MR	MR	S	MSS
LRPB Trojan	2		2		S	S	MSS	S
Rockstar		2		3	S	S	MRMS	S
Scepter	2	2	2	2	MSS	MSS	MRMS	S
Sundancer				1		MR	MS	MSS
Sunmaster		2		2	MRMS	MRMS	MSS	S
Vixen	2	2	2	2	SVS	SVS	MRMS	S

[1] NVT Disease Ratings | NVT. https://nvt.grdc.com.au/nvt-disease-ratings
[2] North: Wellington and Gilgandra; South: Ganmain and West Wyalong
[3] North: Gollan and Manildra; South: Ganmain and Caragabal

The treated plots were managed by a programmed approach and applications were tailored to crop and weather conditions. Product choice, rate and application dates varied between trial sites and years but overarching their use was a desire to reduce disease as well as possible.

The trial design allowed for the performance of each variety grown at each location to be compared when both treated for foliar fungal disease to when not. This is the basis for most of the findings discussed below.

All treated plots, except sites at Caragabal and Ganmain, had flutriafol applied at sowing with the starter fertiliser. All plots at Caragabal and Ganmain sites were sown with MAP, without flutriafol.

The number of foliar fungicide applications and the relevant growth stages at application are outlined in **Error! Reference source not found.**.

Untreated plots received the same fertiliser type and rate but had no fungicides applied (at sowing or foliar).

Trial seed was accessed through the GRDC experimental seed supply channels to guarantee purity. No seed was treated with seed dressing.

Table 2. Fungicide applications treatments and time (days after sowing) at each site.

Year	Site	Number of foliar applications	Application timing (days after sowing)
2023	Ganmain	5	37, 56, 88, 112 & 133
	Gilgandra	3	70, 93 & 113
	Wellington	3	70, 93 &114
	West Wyalong	5	37, 77, 92, 119 & 133
2024	Caragabal	5	35, 64, 78, 106 & 121
	Ganmain (early sown)	5	54, 80, 101, 124 & 139
	Ganmain (main season)	5	43, 69, 90, 113 & 128
	Gollan	4	45, 76, 105 & 126
	Manildra	6	37, 57, 86, 128 & 149

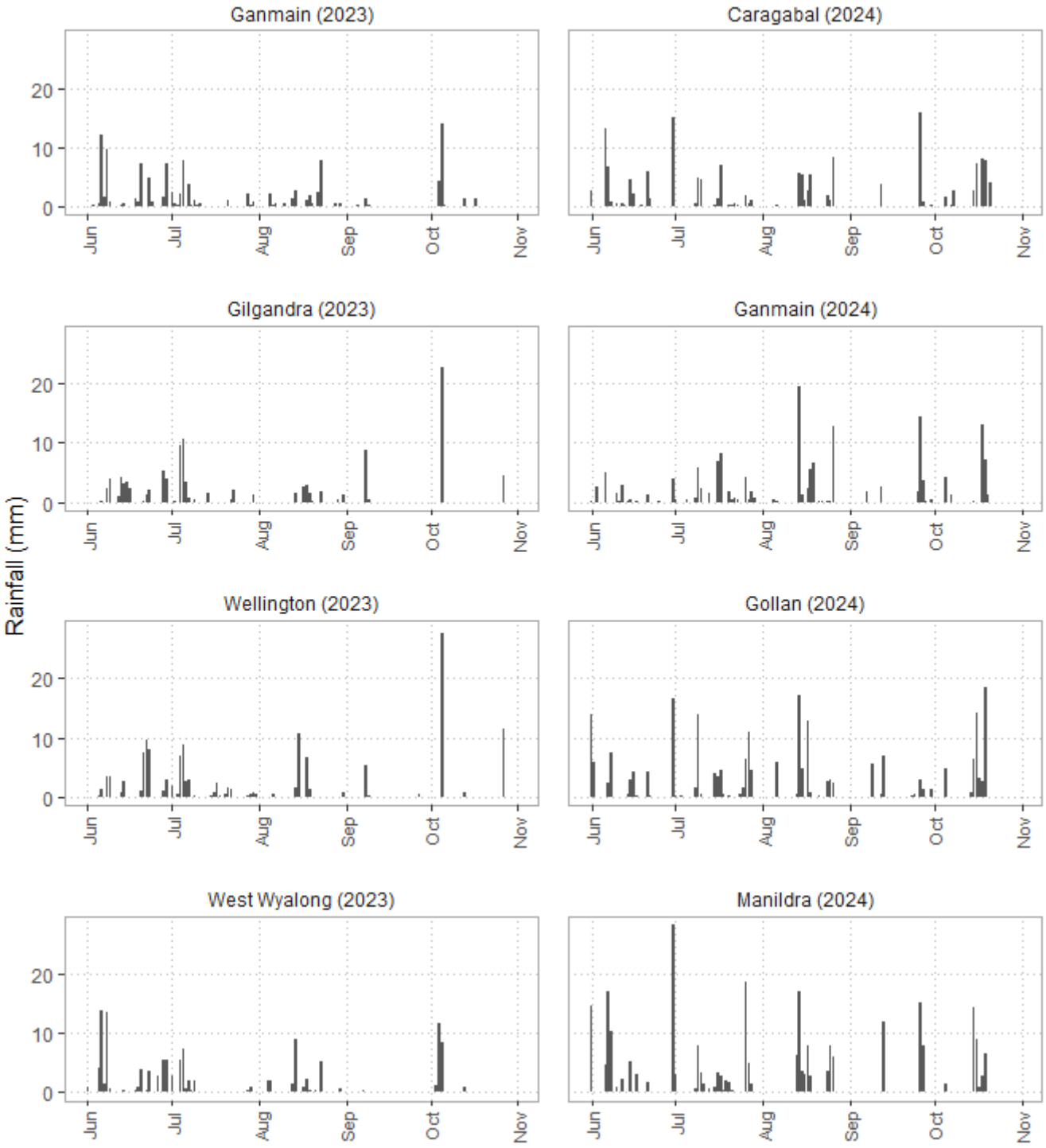

Figure 1. Growing season rainfall (Queensland Government (2025). SILO Gridded Data. Retrieved from LongPaddock. https://www.longpaddock.qld.gov.au/silo/) at trial sites.

Summation of impacts at each site

Full details of individual site trial results can be found at www.grainorana.com.au/documents

Ganmain 2023

- The 2023 season was drier with below average rainfall, 177 mm growing season rainfall (GSR) versus 272 long term average (LTA) gridded data- SILO.

- Conditions were not very conducive to development of cereal leaf diseases with low levels of Yr observed in the untreated plots of Vixen only. STB was common early in the season but did not progress into the mid or upper canopy.
- The site average yield in the treated plots was 4.80 t/ha. Yield was boosted by subsoil moisture that carried over from the 2022 season.
- Four varieties yielded lower when left untreated. Yield reductions ranged from ~9 - 11% (LRPB Raider and LRPB Hellfire Rockstar and Scepter).
- Only one variety, Vixen, had increased screenings when untreated. Screenings increased from 1.2% to 1.5%, still below the levels that would incur a penalty at grain receival.

Gilgandra 2023

- The 2023 season had well below average rainfall (111 mm GSR, 230 mm LTA)
- Conditions were not conducive to disease development. Only very low levels of Yr and YLS observed in some varieties in untreated plots.
- The site average yield in the treated plots was 2.94 t/ha.
- There was no significant difference in yield or screenings between the treated and untreated plots in any variety.

Wellington 2023

- The 2023 season had below average rainfall (266 mm GSR, 303 mm LTA).
- Conditions were not conducive to disease development with only very low levels of Yr observed in the untreated plots in several varieties.
- The site average yield in the treated plots was 2.61 t/ha.
- There was no significant difference between the treated and untreated plots in either yield or screenings for any variety.

West Wyalong 2023

- At West Wyalong in 2023 rainfall was below average (177 mm GSR, 272 mm LTA). Conditions were not conducive to disease development with no detection of Yr and only low levels of early season infection of STB.
- The site average yield in the treated plots was 1.35 t/ha.
- Vixen was the only variety that yielded less (15%) when untreated compared to treated.
- No varieties had an increase in screenings when untreated.

Caragabal 2024

- In 2024 Caragabal received above average in-crop rainfall (327 mm GSR, 278 mm LTA).
- Conditions were conducive to disease development. Significant infections of Yr were observed at this site. STB was also noted but the infection was secondary to the Yr.
- The site average yield in the treated plots was 4.30 t/ha.
- Six varieties (Leverage, Scepter, Calibre, Rockstar, Boree and Vixen) yielded lower when untreated. All had an East Coast Yr disease rating of MS or less. Yield reduction ranged from 18% in Leverage to 44% in Vixen.
- The yield of 6 varieties with a rating of MRMS or better were no different between the treated or untreated plots.

- Leverage, Rockstar, Boree and Vixen had higher screening levels when untreated. However, screenings levels were still low at <3% and would not have resulted in any change to receival grade.

Ganmain 2024 early season

- Ganmain had a slightly below average season, with 230 mm GSR (v 275 mm long term)
- Average rainfall was received in August with below average rain in spring. Yr and STB were observed in the untreated plots of some varieties with Yr being the dominant disease.
- The site average yield in the treated plots was 4.98 t/ha.
- Four varieties (LRPB Raider, LRPB Major, Coota and Rockstar) yielded lower when untreated. Reductions ranged from ~5% (LRPB Raider and LRPB Major) to 25 and 27% for S rated varieties, Rockstar and Coota respectively.
- Four varieties yielded no differently in the treated or untreated treatments LRPB Lancer, Sundancer, Leverage and Longsword, these all had a Yr East Coast disease rating of MS or higher.
- Two varieties (Coota and Rockstar) had an increase in screenings when untreated, but at levels not high enough to cause a quality downgrade.

Ganmain 2024 main season

- This trial was sown 11 days after the early season trial at the same location, as such had similar rainfall and environmental conditions. Yr was observed in the untreated plots in some varieties.
- The site average yield in the treated plots was 4.99 t/ha.
- Five varieties (Scepter, Calibre, Rockstar, Boree and Vixen) with a rating of MSS or less yielded lower when untreated. Losses were from 19% (Scepter) to 52% (Vixen).
- Seven varieties yielded no differently between the treated or untreated.
- Five varieties had increased screenings when untreated. Untreated Vixen had screenings of 6.2%, an increase of 5%. This was the only variety where a change in bin grade at delivery would result.

Gollan 2024

- Gollan received close to average in-crop rainfall (294 mm).
- Conditions were conducive to disease development. Yr and YLS was observed in the untreated plots of some varieties.
- The site average yield in the treated plots was 4.36 t/ha.
- Six varieties (LRPB Raider, Coolah, Scepter, Catapult, LRPB Trojan, and Vixen) with a rating of MSS or less yielded lower when untreated. Yield reduction ranged from 11% (LRPB Raider) up to 56% (Vixen).
- The remaining 6 varieties with an East Coast disease rating of MS or better, yielded no different between the treated or untreated treatments.
- Five varieties had increased screenings when untreated. Vixen screenings increased from 1.8% to 15%. All other varieties' screenings were very low and would not have changed the binned grade at delivery.

Manildra 2024

- Manildra received close to average rainfall GSR (317 mm).

- Conditions were conducive to disease development. Yr, YLS and STB was observed in the untreated plots in some varieties.
- The site average yield in the treated plots was 4.69 t/ha.
- Eleven varieties suffered a yield reduction when untreated. Reduction ranged from 7% (LRPB Reliant) to ~79% (Vixen).
- Longsword was the only variety at this site to have no yield reduction when untreated.
- Six varieties had increased screenings when untreated. Catapult and Vixen had very high screenings of 20% and 16.9%, an increase of 18% and 15%, respectively, over the treated plots. Screenings were less than 5% in all the treated plots.

Discussion

The yield response in these trials was closely related to rainfall but not entirely. Sites at Gilgandra and Wellington in 2023 showed no yield reduction in any variety when untreated, even in the Yr highly susceptible varieties such as Vixen. This was despite moderate yields of 2.6 to 2.9 t/ha. At West Wyalong in 2023, Vixen was the only variety to show a yield decline (15%) when untreated despite the site receiving the lowest rainfall and average yield of any site.

The sites with the most in-crop rainfall had the highest yields but were also where varieties with lower Yr resistance exhibited the greatest yield losses, but the extent depended on the site.

At Manildra in 2024 all varieties (except for Longsword) suffered yield loss, the level of impact declining as varietal resistance increased. Varieties with a MR rating (East Coast) or better for Yr (e.g. LRPB Lancer, LRPB Raider, and LRPB Reliant) would not be expected to suffer an economic loss yet yield losses of up to ~0.5 t/ha occurred. Such impacts may be best considered as evidence of the high disease pressure at this site driven by conducive weather and high inoculum loads. The presence of other diseases such as STB and YLS would have also contributed to the yield reduction in the more Yr resistant varieties. Once available the results from the qPCR will both identify and quantify the range of pathogen levels present, and if confirmed, remind growers that Yr is not the only foliar fungal disease that can reduce wheat yield.

When looking at the range of yields across all the trials the level of impact increases with decreased Yr resistance (Figure 2), indicating Yr was most likely the major driver in yield loss in these field experiments.

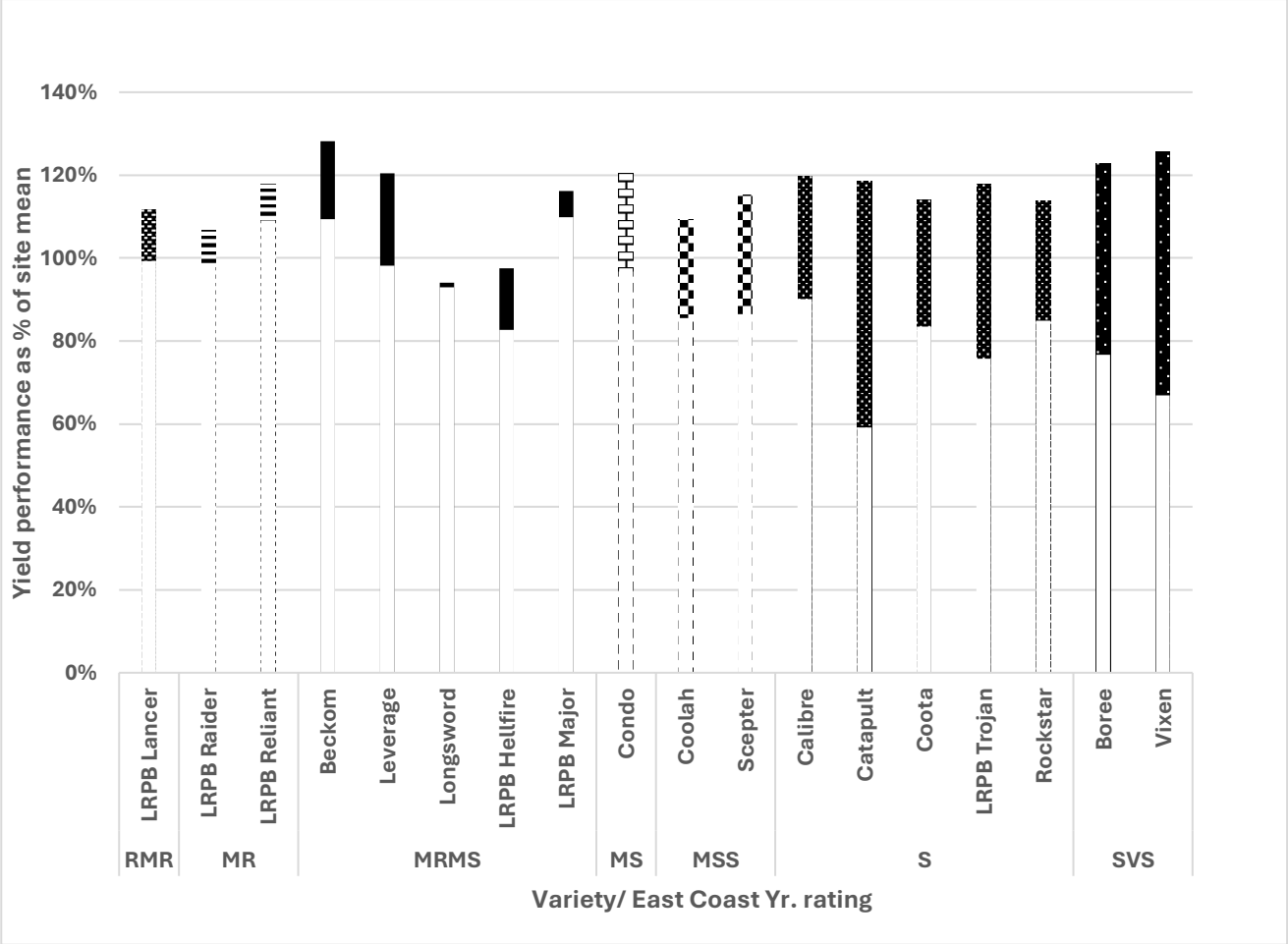

Figure 2. Variation in varietal yield performance as a percentage of site mean including both treated and untreated outcomes from 9 sites over 2 years.

Ⓑ *The above varieties protected under the Plant Breeders Rights Act 1994.*

Figure 2 illustrates the relative varietal yield performance of both treated and untreated means, over all the trial sites as a percentage of the site mean yield.

The lowest yield of the RMR rated LRPB LancerⒷ was 99% of the site mean but as high as 112% and so showed only 12% yield variation. This can be compared to VixenⒷ (SVS rating), which has achieved yields as high as 126% and as low as 67% of the site mean yield with a variation of 59%.

The varieties with above average yields included LRPB LancerⒷ, LRPB ReliantⒷ, BeckomⒷ and LRPB MajorⒷ, all having a relatively small range of variability in response to foliar disease control and site/year. These have a Yr rating of MRMS or better. BoreeⒷ and VixenⒷ, with a SVS rating have outyield almost every other variety when treated for foliar diseases (upper limit) but the downside risk (lower limit) is also far greater when left untreated. The yield reduction levels are often more than double that of the more resistant wheat varieties.

Growers and advisors have chosen wheat varieties based on high yield potentials, and these trials have confirmed that this can be a good strategy, if leaf diseases can be managed. The downside risk or potential yield loss when disease control may not be possible or timely is often not fully understood or considered when making varietal choices. It could be argued that there

is little current empirical data available to help growers to quantify yield loss to manageable foliar diseases like Yr when considering wheat varieties.

National rust rating systems (Figure 3), speak generally in terms of responsiveness to management options so it is not surprising growers have little understanding of the downside risk to these varieties. What does a rating of MS versus SVS mean in terms of yield penalty?

Rusts and foliar diseases

A standard disease resistance rating system has been adopted for all crops in all states across Australia. This document helps to explain the values and their implications for growers and advisers.

Standard disease ratings		
Rating	**Alpha code**	**Numeric code**
Resistant	R	9
Resistant – Moderately Resistant	R-MR	8
Moderately Resistant	MR	7
Moderately Resistant – Moderately Susceptible	MR-MS	6
Moderately Susceptible	MS	5
Moderately Susceptible – Susceptible	MS-S	4
Susceptible	S	3
Susceptible – Very Susceptible	S-VS	2
Very Susceptible	VS	1

Rating	Management option description	For growers: what do I see?	For growers: what do I do?
Resistant (R)	Disease may be found but will be at such a level that no economic management is required, even in instances of high disease pressure.	Trace levels of disease may be found.	No economic management decisions required.
Moderately Resistant (MR)	Disease may be observed but no economic management decisions will be required. Preventative sprays not necessary but disease should be monitored. Management of seed quality may be required.	The disease may be observed at very low levels.	No economic management decisions required. Monitor crops for disease development.
Moderately Susceptible (MS)	In the presence of inoculum and in seasons conducive to disease, the disease will be seen more readily when inspecting the crop. If the disease appears early in the season, then an economic management decision (preventative spray) may be appropriate. Later occurrence of the disease may not require any action. Management of seed quality will be required.	In the presence of inoculum, the disease will be seen more readily when inspecting the crop.	Monitor crops for disease development. In the presence of inoculum and in seasons conducive to disease, an economic management decision may be appropriate (e.g. preventative spray). Later occurrence of the disease may not require any action.
Susceptible (S)	The disease will be easily found in the crop. Management decisions will be required to reduce yield loss and will most probably be economic to do so. Management of seed quality will be required.	In the presence of inoculum, the disease will often be easily found in the crop. The disease will be observed readily in the crop.	Management decisions will be required to reduce yield loss and will most probably be economic to do so.

Figure 3. Rust rating system
(Source https://nvt.grdc.com.au/__data/assets/pdf_file/0032/447098/NVT-disease-ratings_June-2021.pdf)

A recent social media survey undertaken by Brill Ag showed 74% of survey respondents would accept a 0.5 t/ha yield penalty to avoid fungicide use even when economically justifiable. Could this be extrapolated to suggest growers would be willing to accept lower yields (reward) to grow a variety with a lower risk of yield loss when spraying is not possible? (e.g. in very wet seasons where trafficability can be an issue).

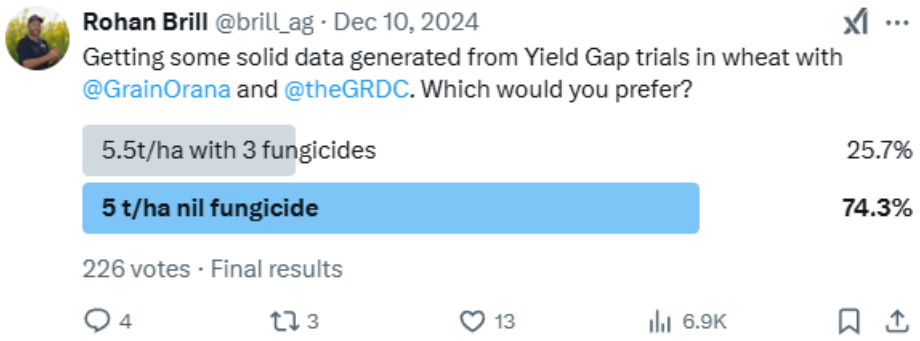

Figure 4. X survey on preference of yield vs fungicide application

This research has highlighted the significant risk that susceptible wheat varieties carry with yield losses of more than 60% in several cases, albeit with no leaf disease control. Though, growers may be delayed or prevented from applying one or 2 foliar fungicides, very rarely would they be prevented from providing any control. However, the yield impact of missing one key timing in a SVS variety is more substantial than in more resistant varieties. This work has also shown that wheat varieties with moderate resistance (MRMS or better) are relatively resilient and if growers were unable to apply any fungicides the downside is a yield loss of <10%.

Additionally benefits to growing more resistant varieties, aside from mitigating risk, include:

- time can be spent on other farming activities.
- lower fungicide input costs
- reduction in risk to the breakdown of genetic resistance
- reduction in the risk that fungal pathogens develop resistance to fungicides.

Conclusions

Growing wheat varieties with higher disease susceptibility because it has the highest yield potential introduces a significant risk to growers in circumstances when control is hindered or not possible. Many growers may not appreciate the exceptionally large downside risk to yield and quality when spraying does not occur.

There are varieties available with high yield potential and with better disease resistance that carry much less risk when leaf disease control is not possible. Yields in these varieties may vary as little as 10% even when leaf disease levels are high, in contrast, susceptible wheat varieties may incur yield losses up to 60% when untreated.

Growers can also save time and money on control programs. This, combined with the improved stewardship afforded to the industry through less reliance on fungicides and less potential for shifts in pathogen virulence, could suggest that the **risks can sometimes exceed the rewards for growing more susceptible wheat varieties.** This of course is up to the individual's attitude to risk and the capacity available to them to spray large areas of crop with foliar fungicides, although economically justifiable, when they could be doing other things.

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Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

GOA would also like to acknowledge the valuable collaboration with Rohan Brill of Brill Ag in undertaking this work.

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Date published

February 2025