Hyper-yielding crops: disease management and germplasm interactions

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The following article is based on results from the southern NSW hyper-yielding crops research program, which is a national GRDC investment taking place across the higher yielding regions of southern Australia. The research is taking place at Wallendbeen, NSW, at an altitude of 540m, which naturally creates a generally cooler, longer-season environment for growing high-yielding crops. At this altitude, disease infection can be delayed until later in the season compared with lower altitudes in the Riverine Plains region. Please note these are first-year results.

Key points

- In seasons that favour higher yield potential, disease management is one of the most important management factors for growing high-yielding cereal crops.
- Irrespective of the fungicide strategy applied in this trial, the feed winter wheats RGT Accroc and Anapurna significantly out-yielded all other cultivars and achieved more than 10t/ha with fungicide input.
- There was a significant interaction between cultivar and fungicide management strategy, with the stripe-rust-susceptible cultivars, LRPB Trojan and DS Bennett, yielding an additional 5.27t/ha and 3.07t/ha, respectively, when fungicide was applied at flag leaf emergence (GS39). This compared to a response of less than 1t/ha with most other less susceptible cultivars.
- Septoria tritici blotch (STB) was the principal disease observed in untreated crops of Scepter and Beckom, while stripe rust was the main disease in LRPB Trojan, DS Bennett, Coolah, RGT Accroc and Catapult. Other cultivars were subject to low levels of both stripe rust and STB disease pressure.
- LRPB Trojan, Catapult, Coolah and DS Bennett yielded significantly more when four units of fungicide were applied (seed treatment and three foliar fungicides), compared with a single spray at flag leaf emergence (GS39).
- Where genetic resistance in a wheat cultivar is not sufficient to enable fungicide decisions to be delayed until flag leaf emergence (GS39), look to target the following key timings for fungicide intervention: first node (GS31), flag leaf emergence (GS39), with an optional third application at head emergence (GS59).
- Avoid repeated use of the same fungicide active ingredients. In the case of the newer Group 11 strobilurins (QoIs) and Group 7 succinate dehydrogenase inhibitors (SDHIs), restrict application (where possible) to just one per season in order to slow and prevent the selection of resistant strains.

Aim

This trial aims to develop profitable and sustainable approaches to disease management for high yielding wheat varieties grown in regions with higher yielding potential.

Method

During 2020, a replicated small plot trial was established at the NSW Hyper-yielding crops research site at Wallendbeen, New South Wales, as part of the national GRDC funded Hyper-yielding crops (HYC) project, led by FAR Australia.

This trial, sown 21 April, 2020, assessed the performance of 10 wheat cultivars (five of which were sown across all HYC sites nationally, with the remaining five cultivars selected specifically for their adaptation to the region). Both winter and spring germplasm was evaluated, with cultivars having a variety of disease ratings to fully assess the yield potential of these cultivars under different disease management strategies (Table 1).

Each cultivar was exposed to three different levels of disease management: an untreated control, a single fungicide spray and a full fungicide control package, with details of each treatment presented in Table 2. Other than fungicide application, all other management applications were standardised across the trial to maximise yield potential as per the seasonal conditions.

Sowing date: 21 April, 2020
Harvested: 14 December, 2020
Rotation position: First cereal after canola (2019)
Rainfall: GSR 587mm (April – October)
Soil mineral nitrogen: (10 June, 2020)
0–60cm: 68.5kg N/ha

Outline of Wallendbeen trial, 8 October 2020, white star denotes first plot.

TABLE 1 Cultivar, type and disease ratings of wheat cultivars sown at Wallendbeen, NSW, 2020

Cultivar	Type	Disease rating		
		Stripe rust	Septoria tritici blotch	Yellow leaf spot
LRPB Trojan	Mid – slow spring	S-VS	MS	MS-S
Scepter	Mid spring	MS-S	S	MR-MS
LRPB Nighthawk	Slow spring	MR	MS-S	MR-MS
Anapurna	Slow winter	R-MR	MR-MS	MR-MS
RGT Accroc	Slow winter	R-MR	MR-MS	MR-MS
Beckom	Mid spring	MR-MS	S	MS-S
Catapult	Mid – slow spring	MR-MS/S-VS	MS-S	MR-MS
EGA Gregory*	Mid – slow spring	MR	MS-S	S
Coolah*	Mid – slow spring	R-MR	MS-S	MS-S
DS Bennett	Mid winter	S	MS-S	MR-MS

Note: The first five cultivars listed were standard to all sites across the HYC project nationally, with the remaining five cultivars chosen for their adaptation to the region.

VS = Very susceptible, S = Susceptible MS = Moderately susceptible, MR = Moderately resistant, R = Resistant.

Ratings from most recent data source: Cereal disease guide Victoria 2021.

* Rating from Winter crop variety sowing guide NSW 2020.

TABLE 2 Fungicide treatment of wheat cultivar trials sown at Wallendbeen, NSW, 2020

Crop stage	Unsprayed	Single spray	Three spray (complete control)
Seed treatment	Vibrance/Gaucho	Vibrance/Gaucho	Vibrance/Gaucho + Systiva
GS31	–	–	Prosaro 300ml
GS39	–	Amistar Xtra 800ml	Amistar Xtra 800ml
GS 59–61	–	–	Opus 500ml

Note: All fungicide treatments received a seed dressing for smuts/bunts and insecticide as Gaucho.

Results

i. Phenology

For the spring cultivars, there was little difference in the time to reach the start of stem elongation (first node — GS31) with the fastest spring Scepter and Beckom being the earliest varieties to reach GS31 (12 July). The winter varieties reached GS31 significantly later, with the earliest being RGT Accroc and DS Bennett on 11 August, followed by Anapurna on 15 August.

Similarly, the spring-type varieties started to flower at about the same time (25 September), while the winter varieties started flowering much later. RGT Accroc was the first winter type to start flowering (12 October) and DS Bennett was the last (17 October).

The slow spring cultivar, LRPB Nighthawk, has a greater photoperiod requirement than the other spring cultivars and had the longest time period between stem elongation (GS31) and flowering (GS61) at 87 days (Figure 1). LRPB Nighthawk started stem elongation at the same time as the spring-type varieties (15 July) but began flowering at a similar time to the winter varieties (10 October) (Table 3).

TABLE 3 Approximate dates of critical growth stages of stem elongation (GS31) and start of flowering (GS61) in wheat cultivars sown at Wallendbeen, NSW, 2020

Cultivar	GS31	GS61
Scepter	12 July	25 September
Beckom	12 July	25 September
LRPB Trojan	15 July	25 September
LRPB Nighthawk	15 July	10 October
Catapult	15 July	25 September
EGA Gregory	15 July	25 September
Coolah	15 July	25 September
RGT Accroc	11 August	12 October
DS Bennett	11 August	17 October
Anapurna	15 August	15 October

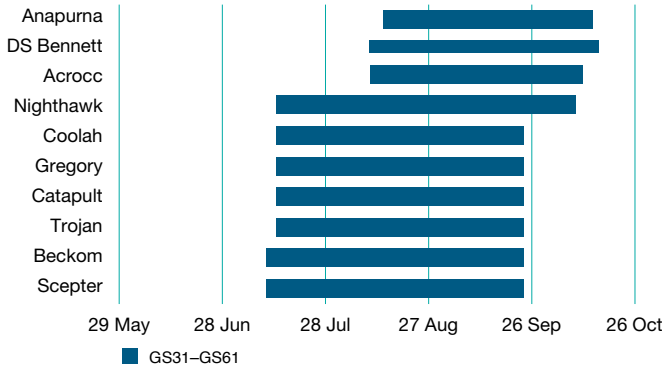

FIGURE 1 Duration of the development period between first node (GS31) and flowering (GS61) (calendar days) in wheat cultivars sown at Wallendbeen, NSW, 2020

ii. Disease assessment

The 2020 growing season generated high disease pressure across a number of susceptible varieties. Full disease assessments were conducted after flag leaf emergence (GS39) and during grain fill (GS75–80), however only the results from the grain fill assessment are presented here.

There were significant levels of stripe rust in the unsprayed treatments. The highest levels of stripe rust were observed in LRPB Trojan, DS Bennett and Catapult, with lower disease levels observed in Coolah, RGT Accroc, and Scepter (Figure 2). LRPB Trojan had the highest levels of infection with 80 per cent of the flag leaf and 68 per cent of the flag-1 infected by stripe rust. In varieties that were significantly infected by stripe rust, a single fungicide application at GS39 significantly reduced the levels of infection and provided over 90 per cent control in all varieties except Catapult (which provided 78 per cent control of stripe rust). The application of three in-crop fungicide sprays as part of the complete control treatment provided 100 per cent control in Scepter and RGT Accroc and over 97 per cent control in all other varieties.

Septoria tritici blotch, caused by the pathogen *Zymoseptoria tritici*, was much less prevalent at the site, with only Scepter showing high levels of infection (Figure 3) at 15 per cent of the leaf area of the flag leaf and 28 per cent of the flag-1 leaf area affected. Yellow leaf spot, leaf rust and wheat powdery mildew also were present at the site at low levels.

Untreated, single spray and multiple fungicide control treatments in Coolah wheat at GS75–80 (3 November, 2020).

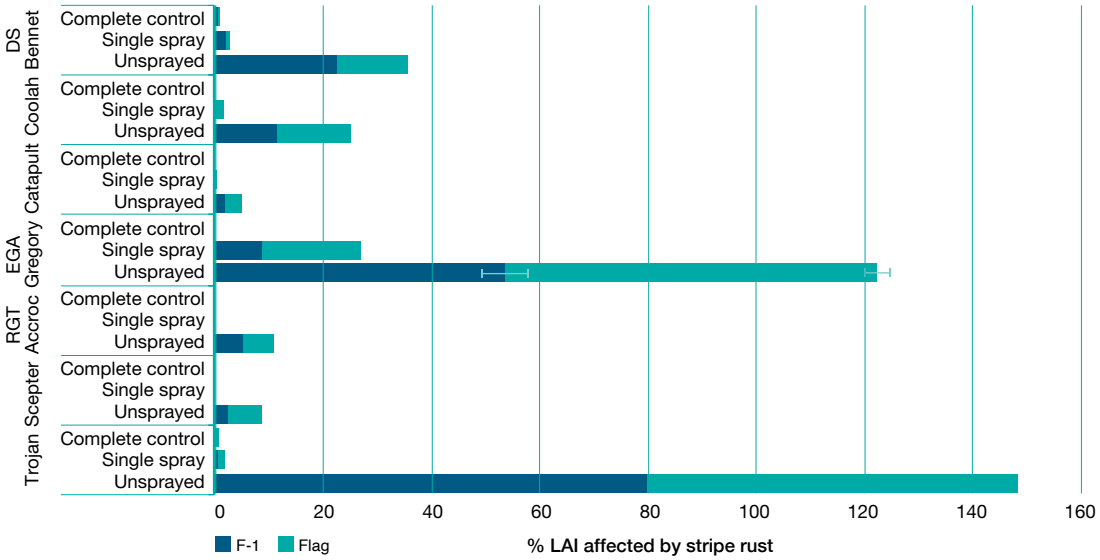

FIGURE 2 Stripe rust infection at grain fill (GS75–80), 3 November, in wheat cultivars sown at Wallendbeen, NSW, 2020

Note: This figure only shows varieties with significant infection levels. F-1 P= <0.001, LSD= 8.4. Flag P=<0.001, LSD= 4.6. Error bars represent LSD.

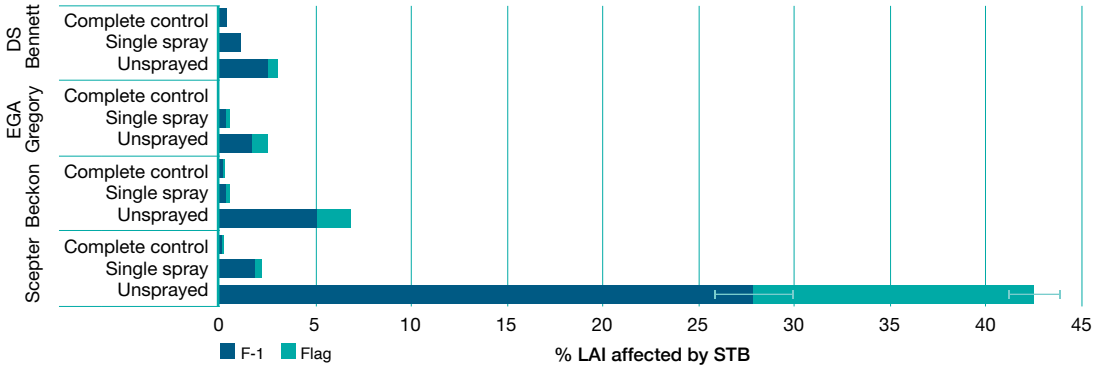

FIGURE 3 Septoria tritici blotch infection at grain fill (GS75–80), 3 November, in wheat cultivars sown at Wallendbeen, NSW, 2020

Note: This figure only shows varieties with significant infection levels. F-1 P= <0.001, LSD= 2.6. Flag P=<0.001, LSD= 4.2. Error bars represent LSD.

iii. Normalised difference vegetative index (NDVI)

Crop reflectance measurements taken with a Greenseeker™ and recorded as NDVI showed differences in crop canopy greenness that can mostly be attributed to the presence of disease (Figure 4). When measured on 23 September and 1 November, the untreated LRPB Trojan plots had significantly lower NDVI than all other treatments as a result of high levels of stripe rust infection. On 1 November, the disease-susceptible varieties LRPB Trojan, DS Bennett (Stripe rust susceptible, Figure 2) and Scepter (STB susceptible, Figure 3) had significantly lower NDVI values in the untreated plots when compared to the complete control plots. However, Anapurna, with its improved disease resistance, showed no significant difference in NDVI value between the untreated and complete control plots, highlighting the value of genetic resistance in maintaining green leaf area.

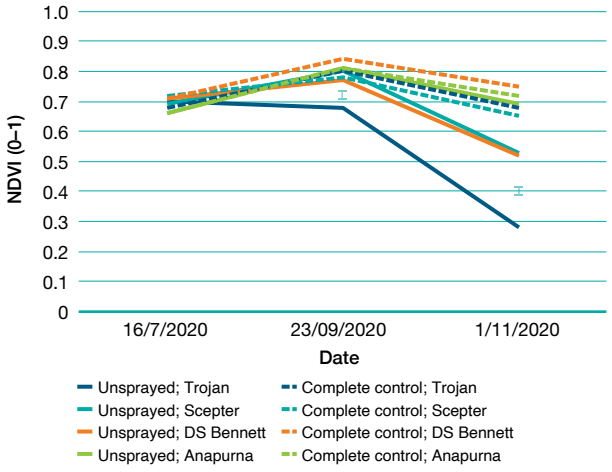

FIGURE 4 NDVI readings (0–1 scale) of the unsprayed and complete control treatments on 16 July, 23 September and 1 November in selected wheat cultivars sown at Wallendbeen, NSW, 2020

Error bars represent LSD where P<0.05.

iv. Lodging index

Lodging index scores were calculated by assessing the percentage of the plot lodged multiplied by the severity of the lodging. Lodging was assessed pre-harvest (9 December) and was accompanied by a measure of crop height, assessed at the same time. The most susceptible variety to lodging, EGA Gregory, gave the highest lodging score, while the more resistant LRPB Nighthawk was relatively unaffected (Figure 5).

v. Grain yield and quality

The trial was harvested on 14 December 2020 with an average yield of 8.2t/ha. The highest yields were recorded in the complete control treatments for RGT Accroc (10.8t/ha) and Anapurna (10.5t/ha). As a result of high disease pressure at the site, there was a significant interaction for grain yield between fungicide management strategy and cultivar (Table 4). All varieties showed a yield response to a single flag leaf spray compared with the unsprayed control. However, only four varieties gave a significant yield response to the multiple fungicide applications in the complete control treatment compared with the single fungicide application.

Grain protein varied significantly between varieties. EGA Gregory and Scepter had the highest proteins of 11.9 per cent and 11.8 per cent respectively, while RGT Accroc and DS Bennett had the lowest proteins with 10.3 per cent and 10.4 per cent respectively.

TABLE 4 The effect of fungicide management and cultivar on grain yield at harvest, 14 December in wheat cultivars sown at Wallendbeen, NSW, 2020

	Fungicide management			
	Unsprayed	Single spray	Three-spray (complete control)	Mean
Cultivar	Yield (t/ha)	Yield (t/ha)	Yield (t/ha)	Yield (t/ha)
LRPB Trojan	2.28^{n}	7.55^{hij}	8.13^{efg}	**5.98**
Scepter	7.07^{kl}	8.60^{d}	8.55^{de}	**8.07**
LRPB Nighthawk	7.98^{gh}	8.47^{def}	8.54^{de}	**8.33**
Anapurna	9.69^{c}	10.22^{b}	10.46^{ab}	**10.12**
RGT Accroc	9.72^{c}	10.86^{a}	10.83^{a}	**10.47**
Beckom	7.75^{ghi}	8.46^{def}	8.66^{d}	**8.29**
Catapult	6.06^{m}	7.84^{ghi}	8.46^{def}	**7.45**
EGA Gregory	6.75^{l}	7.15^{jkl}	7.40^{ijk}	**7.10**
Coolah	7.26^{ijk}	8.07^{fg}	8.75^{d}	**8.03**
DS Bennett	5.68^{m}	8.75^{d}	9.48^{c}	**7.97**
Mean	**7.02**	**8.60**	**8.93**	
LSD Cultivar p = 0.05				
LSD Management p=0.05				
LSD Cultivar x management P=0.05				

Figures followed by different letters are regarded as statistically significant.

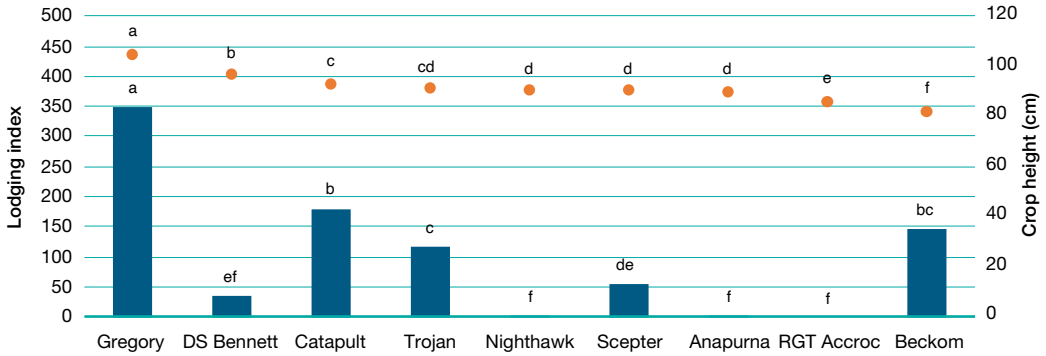

FIGURE 5 Lodging index (0–500 scale) and crop height at crop maturity in wheat cultivars sown at Wallendbeen, NSW, 2020

Lodging P= <0.001, LSD= 35. Crop height P= <0.001, LSD= 2.2.
Points labelled with different letters are considered to be statistically different.

Untreated LRPB Trojan vs untreated Anapurna pre harvest (9 December, 2020).

Conclusion

The first year of Hyper Yielding Crops research reaffirms that in seasons that favour higher yield potential, disease management is one of the most important management factors in growing high-yielding cereal crops.

Stripe rust infection in untreated LRPB Trojan (22 September, 2020).

The Wallendbeen site had high yield potential (greater than 10t/ha) during the 2020 season and the ability to achieve high yields depended on disease control. Disease pressure was high, with disease management strategies increasing yield by up to 5.27t/ha in the most susceptible cultivars. This compares to yield responses of less than 1t/ha for the more disease-resistant cultivars and highlights the critical importance of genetic resistance to disease.

In a season with higher yield potential and higher disease pressure (primarily stripe rust pathotypes 198 E16 A+ J+ T+ 17+, septoria tritici blotch and lower levels of leaf rust, powdery mildew and yellow leaf spot), all wheat cultivars gave a significant yield response to fungicide application. Where cultivars had greater genetic resistance there was no statistical yield difference between a single application of fungicide at flag leaf (GS39) (based on a full rate azoxystrobin/epoxiconazole mixture [Radial® 840mL/ha]) and the application of Systiva and three in-crop fungicide sprays.

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