Interaction between fungicide program and in-crop nitrogen timing for the control of yellow leaf spot (YLS) in mid-May sown wheat

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Key points

- The level of yellow leaf spot (YLS — *Pyrenophora tritici repentis*) control achieved with fungicides applied at either first node (GS31) or third node (GS33) in a susceptible wheat-on-wheat situation (cv EGA Gregory) was between 25–50% in most assessments.
- This relatively poor level of disease control has been consistent across the four years of research.
- There was no significant yield response to fungicide application during 2016, but there was a trend for small yield gains where fungicide was applied at first node (GS31), or third node (GS33) or applied twice at first node (GS31) and third node (GS33).
- These small (0.15–0.25t/ha) yield increases have been common across the four years of trials, either from a single later spray at third node (GS33) or from two sprays where a third node (GS33) application was preceded with a tillering (GS23) or first node (GS31) spray.
- A single YLS fungicide application at tillering (GS23), carried out as part of a weed control spray, did not generally prove to be economical.
- Nitrogen (N) applied at tillering (GS23) or first node (GS31) has not produced statistical yield differences, but delaying the main nitrogen dose until third node (GS33) reduced yield by and average of 0.5t/ha compared with the first node (GS31) timing during 2016.
- There were no significant differences in YLS severity due to fungicide product — Tilt® (propiconazole) and Prosaro® (prothioconazole and tebuconazole) — or nitrogen timing.

Location: Coreen, NSW
Sowing date: 12 May 2016
Rotation: Second wheat
Variety: EGA Gregory
Stubble: EGA Gregory unburnt
Rainfall:
GSR: 567mm (April – October)
Summer rainfall: 80mm

Method

The trial examined the influence of two nitrogen timings: 40kg N/ha applied at first node (GS31) or third node (GS33) (Table 1) and four fungicide strategies (untreated, fungicide at first node — 12 August, third node — 5 September and fungicide at both timings) on levels of yellow leaf spot (YLS — *Pyrenophora tritici repentis*) as part of the Riverine Plains Inc *Maintaining Profitable Farming Systems with Retained Stubble in the Riverine Plains Region* project.

The trial was set up in a block of commercial wheat (cv Gregory) in a wheat-on-wheat rotation position as a balanced split–split plot design, with nitrogen timing as the main plot (Table 1), fungicide timing as the sub plot and fungicide product as the sub-sub plot, replicated four times. During spring 2016 the trial was badly affected by waterlogging, making yield data more variable.

For each of the nitrogen strategies, two fungicides were evaluated at their full rates at both timings: Tilt (0.5L/ha) and Prosaro (0.3L/ha). A full list of nitrogen and fungicide treatments is presented in Table 2.

Data has been statistically analysed using analysis of variance (ANOVA), with means separated using the unrestricted least significant difference (LSD) procedure.

TABLE 1 Nitrogen application rates and timings

	12 May 2015 (sowing)	12 August 2016 (GS31)	6 September 2016 (GS33)	Total nitrogen applied
	(kg N/ha)			
Tillering timing	6	40	Nil	46
First node timing	6	Nil	40	46

There were no restrictions on the uptake of nitrogen, although several transient waterlogging events are likely to have resulted in nitrogen being lost as nitrous oxide (N_2O).

TABLE 2 Treatment list

Treatment		Active ingredient (g/ha ai)	Fungicide timing (mL/ha)		Nitrogen timing (kg N/ha)	
			GS31 12 Aug	GS33 6 Sep	GS31 12 Aug	GS33 6 Sep
1	Untreated				40	
2	Untreated					40
3	Prosaro	Prothioconazole (63) and tebuconazole (63)	300		40	
4	Prosaro	Prothioconazole (63) and tebuconazole (63)	300			40
5	Prosaro	Prothioconazole (63) and tebuconazole (63)		300	40	
6	Prosaro	Prothioconazole (63) and tebuconazole (63)		300		40
7	Prosaro	Prothioconazole (126) and tebuconazole (126)	300	300	40	
8	Prosaro	Prothioconazole (126) and tebuconazole (126)	300	300		40
9	Untreated[#]				40	
10	Untreated[#]					40
11	Tilt	Propiconazole (250)	500		40	
12	Tilt	Propiconazole (250)	500			40
13	Tilt	Propiconazole (250)		500	40	
14	Tilt	Propiconazole (250)		500		40
15	Tilt	Propiconazole (500)	500	500	40	
16	Tilt	Propiconazole (500)	500	500		40

[#]The trial is a balance split–split plot design; hence the replication of the 40kg N/ha at GS22 untreated with fungicide and 40kg N/ha at GS31 untreated with fungicide treatments (9 and 10).

As outlined, the commercially-sown crop of EGA Gregory was badly affected by waterlogging, particularly through September, which reduced both the plant and tiller population to 75 plants/m^2 and 153 tillers/m^2 when assessed at the two-leaf stage (GS12) 31 May and at the first node stage (GS31) on 12 August, respectively.

Results

i) Disease assessment data

At the first fungicide application timing at first node (GS31) there was a high level of disease incidence on the top two newly-emerged leaves (flag-5 and flag-6) with the newest emerging leaf (flag-4) showing no infection (Table 3).

When assessed at third node (GS33), before the second fungicide application timing, there was little evidence of earlier treatment effects except on flag-4, which was the newest emerged leaf at the first node (GS31) application (Table 4). On this leaf, YLS severity was reduced from about 60% to 47%, which is equivalent to less than 25% control.

TABLE 3 Yellow leaf spot severity and incidence assessed 12 August 2016, first node (GS31), on the newest fully-emerged infected leaves (flag-5 and flag-6)

GS31	YLS (%)	
	Flag-5	Flag-6
Disease severity	1.9	31.1
Disease incidence	66.7	100

There was no difference in fungicide performance applied at first node (GS31).

At 50% ear emergence, the impact of the first node (GS31) spray and later spray at third node (GS33) was evident in the YLS infection levels recorded on the flag leaf and flag-1 however, spraying gave less than 50% control (Figure 1).

The double-spray approach was significantly better than the single first node (GS31) spray on flag-1, but control was still short of 50% and severity differences were small (Table 5).

Fungicide application significantly improved green leaf retention (GLR) with the later spray and double sprays giving about 60% GLR compared with 36% in the untreated control.

The first node (GS31) spray improved GLR, but the improvement was not statistically significant (Table 5). No differences in product performance were recorded at this assessment. There also was no evidence the two different fungicides interacted with application timings differently, with the later spray and double-spray programs giving the best results, irrespective of product tested.

Disease assessments at flowering (GS61) showed significant effects from fungicides, which were similar to those recorded two weeks earlier. There were no effects of fungicide product or nitrogen timing on YLS or GLR (Table 6 and Figure 2).

TABLE 4 Yellow leaf spot severity (% leaf area infected) and incidence (% of leaves infected) assessed 6 September 2016, third node (GS33), on the second newest fully-emerged leaf (flag-2, flag-3 and flag-4)

	YLS (%)					
	Flag-2		Flag-3		Flag-4	
Nitrogen timing	Severity	Incidence	Severity	Incidence	Severity	Incidence
GS31	1.8[a]	95.0[a]	10.2[a]	100[a]	48.9[a]	100[a]
GS33	2.0[a]	92.4[a]	12.0[a]	100[a]	53.9[a]	100[a]
Mean	**1.9**	**93.7**	**11.1**	**100**	**51.4**	**100**
LSD	0.3	4.8	2.6	–	6.4	–
Fungicide timing						
Untreated control	2.0[a]	94.2[a]	12.2[a]	100[a]	60.6[a]	100[a]
GS31	2.0[a]	94.8[a]	11.9[a]	100[a]	46.9[b]	100[a]
LSD	0.4	6.8	3.7	–	9.1	–
Product						
Prosaro	1.9[a]	92.8[a]	11.0[a]	100[a]	52.8[a]	100[a]
Tilt	2.0[a]	94.6[a]	11.2[a]	100[a]	50.1[a]	100[a]
LSD	0.3	4.8	2.6	–	6.4	–

Note: The newest emerged leaf (flag-1) had no disease as very newly emerged.
Figures followed by different letters are regarded as statistically significant.

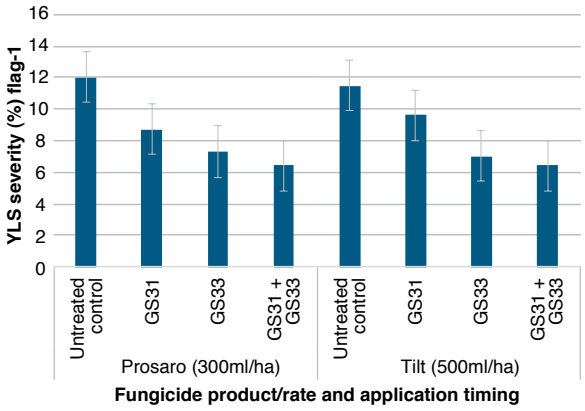

FIGURE 1 Interaction between fungicide application timing* and product on YLS severity (flag-1), assessed 50% head emergence (GS55), 29 September 2016

*Mean of two nitrogen application timings

The error bars are a measure of LSD 3.2%. The interaction was not significant.

The best disease control from fungicide strategies on the flag leaf were in the range of 30–40% and on flag-1 it was approximately 50%.

On flag-1 the disease control achieved with the later spray and double-spray programs was superior to the earlier first node (GS31) spray (mean of both nitrogen timings). There was no difference between the double-spray program and the single application at third node (GS33) on either disease severity or GLR.

Despite differences in YLS severity, and high levels of disease in the canopy, levels of the disease on the flag leaf were only moderate and there were no differences in crop canopy greenness (measured as crop reflectance with the Greenseeker®) in this trial at any of the three assessment timings (Table 7).

Yellow leaf spot damage in the canopy at the start of flowering (GS61)

TABLE 5 Yellow leaf spot severity and incidence assessed 29 September 2016, 50% ear emergence (GS55), on the flag leaf and flag-1, and green leaf retention (GLR) on flag-2

	YLS (%)				GLR (%)
GS55	Flag		Flag-1		Flag-2
Nitrogen timing	Severity	Incidence	Severity	Incidence	GLR
GS31	1.7[a]	82.9[a]	9.6[a]	100.0[a]	49.0[a]
GS33	1.2[b]	76.7[a]	7.6[b]	99.6[a]	50.4[a]
Mean	**1.4**	**79.8**	**8.6**	**99.8**	**49.7**
LSD	0.3	7.1	1.6	0.9	6.9
Fungicide timing					
Untreated control	1.9[a]	89.2[a]	11.8[a]	100.0[a]	36.4[b]
GS31	1.4[b]	84.2[ab]	9.1[b]	100.0[a]	43.8[b]
GS33	1.2[b]	77.5[bc]	7.1[bc]	100.0[a]	57.4[a]
GS31 and 33	1.2[b]	68.3[c]	6.4[c]	99.2[a]	61.2[a]
LSD	0.4	10.1	2.3	1.2	9.8
Product					
Prosaro	1.4[a]	77.9[a]	8.6[a]	99.6[a]	51.2[a]
Tilt	1.5[a]	81.7[a]	8.6[a]	100.0[a]	48.2[a]
LSD	0.3	7.1	1.6	0.9	6.9

Figures followed by different letters are regarded as statistically significant.

TABLE 6 Yellow leaf spot severity and incidence assessed 14 October 2016, start of flowering (GS61), on the flag leaf and flag-1 and green leaf retention (GLR) on flag-1

	YLS (%)				GLR (%)
Treatment	Flag		Flag-1		Flag-1
Nitrogen timing	Severity	Incidence	Severity	Incidence	GLR
GS31	7.2[a]	100[a]	40.2[a]	100[a]	59.8[a]
GS33	7.4[a]	100[a]	41.3[a]	100[a]	55.6[a]
Mean	**7.3**	**100**	**40.7**	**100**	**57.7**
LSD	0.9	–	2	–	10.1
Fungicide timing					
Untreated control	9.9[a]	100[a]	62.6[a]	100[a]	37.4[b]
GS31	7.1[b]	100[a]	42[b]	100[a]	58.1[a]
GS33	5.9[b]	100[a]	29.7[c]	100[a]	64.2[a]
GS31+33	6.2[b]	100[a]	28.7[c]	100[a]	71.3[a]
LSD	1.3	–	10.1	–	14.3
Product					
Prosaro	7.5[a]	100[a]	42.4[a]	100[a]	54.5[a]
Tilt	7.1[a]	100[a]	39.1[a]	100[a]	60.9[a]
LSD	0.9	–	7.12	–	10.1

Figures followed by different letters are regarded as statistically significant.

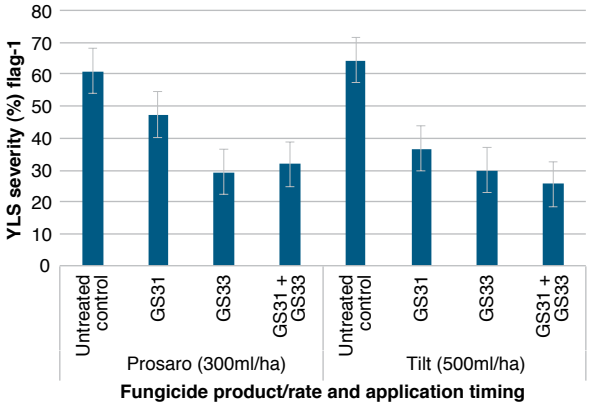

FIGURE 2 Interaction between fungicide application timing* and product on YLS severity (flag-1), assessed start of flowering (GS61), 14 October 2016

*Mean of two nitrogen application timings

The error bars are a measure of LSD 14.2%

ii) Yield and quality results

Influence of nitrogen timing

The earlier timing of applying nitrogen at first node (GS31) resulted in significantly more yield than with the later nitrogen timing at third node (GS33) (Table 8). The 0.52t/ha yield increase when nitrogen was applied at first node (GS31) reduced grain protein by 0.5%, but there was no difference between the two nitrogen timings in terms of test weight or screenings.

TABLE 7 Normalised difference vegetation index (NDVI) 6 September 2016, third node (GS33), 29 September 2016, 50% head emergence (GS55) and 14 October 2016 start of flowering (GS61)

Treatment	NDVI		
Nitrogen timing	**GS33**	**GS55**	**GS65**
GS22	0.69[a]	0.65[a]	0.57[a]
GS31	0.68[a]	0.64[a]	0.57[a]
Mean	**0.68**	**0.65**	**0.57**
LSD	0.03	0.03	0.03
Fungicide timing			
Untreated control	0.69[a]	0.65[ab]	0.59[a]
GS23	0.66[a]	0.62[b]	0.56[a]
GS33	0.68[a]	0.65[ab]	0.57[a]
GS23+33	0.70[a]	0.66[b]	0.59[a]
LSD	0.04	0.04	0.04
Product			
Prosaro	0.69[a]	0.65[a]	0.58[a]
Tilt	0.68[a]	0.64[a]	0.57[a]
LSD	0.03	0.03	0.03

Figures followed by different letters are regarded as statistically significant.

Influence of fungicide timing and product

Waterlogging resulted in a thin crop, which was low yielding, and there were no significant differences in yield as a result of fungicide treatment, although in common with previous years there was a trend for yield effects to be positive (0.1–0.17t/ha). Fungicide application did give small improvements in test weight, which was statistically significant when applied at first node (GS31).

There were no yield or quality differences measured between Tilt and Prosaro (Figure 3). In this trial both products partially controlled YLS, rarely giving more than 50% control, a result similar to 2014 and 2015.

Commercial implications

This research trial has been run for four years using susceptible and moderately susceptible wheat cultivars. In a wheat-on-wheat situation, YLS has been the principal disease causing infection. The most severe infection was noted during 2016.

The influence of fungicide treatment against this disease has been consistent over the four years of work. Using either Prosaro (tebuconazole/prothioconazole) or Tilt (propiconazole) disease control has rarely exceeded 50% and has more typically been in the range of 25–50%. This level of disease control is poor relative to traditional control levels observed with fungicides against other diseases. Despite this there were small, but consistent, positive yield effects across the four years (maximum response to fungicide during 2013 was 0.25t/ha, during 2014 was 0.21t/ha, during 2015 was 0.4t/ha and during 2016 was 0.17t/ha). These small yield effects were seen in response to two applications of fungicide and later spray timings during stem elongation, or third node (GS33).

Foliar fungicides applied at tillering (GS23) during 2014–16 gave poor disease control and were rarely, if ever, economic. In all years, although the rotation and cultivar have favoured the disease, the yields of the trials have still been in the 2–4t/ha range. The early control of YLS up to the start of stem elongation (GS30) has been greater with stubble management practices such as burning than that observed with foliar fungicides. It was also noticeable that in the large block stubble management trials a switch to the more resistant cultivar Corack has controlled YLS such that differences in YLS control as a result of stubble management treatment have not been observed.

TABLE 8 Yield, protein, test weight and screenings at harvest (GS99), 9 December 2016

Treatment	Grain yield and quality			
Nitrogen timing	**Yield (t/ha)**	**Protein (%)**	**Test weight (kg/hL)**	**Screenings (%)**
GS31	3.78[a]	8.8[b]	82.3[a]	2.5[a]
GS33	3.26[b]	9.3[a]	81.9[a]	2.4[a]
Mean	**3.52**	**9.0**	**82.1**	**2.5**
LSD	0.18	0.2	0.5	0.3
Fungicide timing				
Untreated control	3.42[a]	9.2[a]	81.6[b]	2.4[a]
GS31	3.52[a]	9.0[a]	82.4[a]	2.6[a]
GS33	3.55[a]	9.0[a]	82.2[ab]	2.4[a]
GS31+33	3.59[a]	8.9[a]	82.2[ab]	2.4[a]
LSD	0.25	0.3	0.7	0.4
Product				
Prosaro	3.54[a]	9.1[a]	82.1[a]	2.4[a]
Tilt	3.50[a]	9.0[a]	82.1[a]	2.5[a]
LSD	0.18	0.2	0.5	0.3

Figures followed by different letters are regarded as statistically significant.

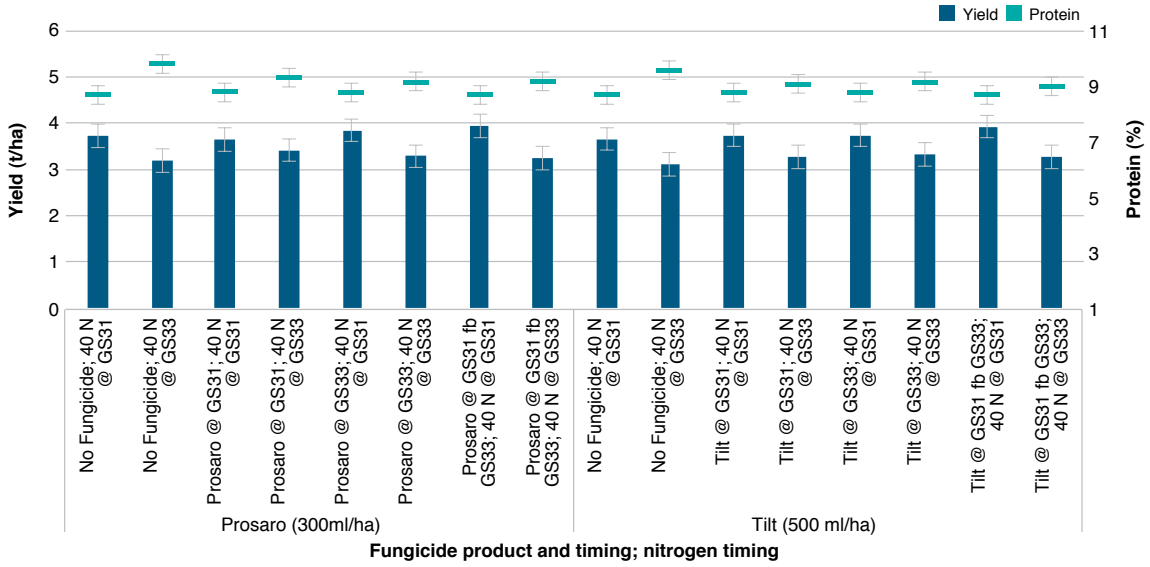

FIGURE 3 Influence of nitrogen timing and fungicide strategy on yield and protein, 9 December 2016
*The error bars are a measure of LSD – yield 0.5 t/ha and 0.7% protein.

Application details:

T1 Application 12 August 2016

Application description		Application equipment	
Application date	12 August 2016	**Nozzle brand**	Air mix
Actual growth stage at application	GS31	**Nozzle type**	Air induction
Crop height (cm)	18	**Nozzle size**	11001
Method/equipment used	FAR hand boom	**Nozzle spacing (cm)**	50
Soil moisture	Moist	**Boom height above crop (cm)**	50
Air temperature (°C)	9.7	**Operating pressure (kPa)**	200
Cloud cover (%)	100	**Ground speed (km/h)**	4.32
Relative humidity (%)	80.2	**Spray volume (L/ha)**	100
Wind velocity (km/h) (start/finish)	3.2–5.8		
Wind direction (start/ finish)	N		
Dew presence (Y/N)	N		
Crop cover (%)	50		

T2 Application 6 September 2016

Application description		Application equipment	
Application date	6 September 2016	**Nozzle brand**	Air mix
Actual growth stage at application	GS33	**Nozzle type**	Air induction
Crop height (cm)	40	**Nozzle size**	11001
Method/equipment used	FAR hand boom	**Nozzle spacing (cm)**	50
Soil moisture	Damp	**Boom height above crop (cm)**	50
Air temperature (°C)	15	**Operating pressure (kPa)**	300
Cloud cover (%)	50	**Ground speed (km/h)**	4.8
Relative humidity (%)	85	**Spray volume (L/ha)**	100
Wind velocity (km/h) (start/finish)	2.5–2.7		
Wind direction (start/ finish)	SW		
Dew presence (Y/N)	SW		
Crop cover (%)	85		

Acknowledgements

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