

2.2.3 To evaluate the cost effectiveness of strobilurin based fungicides on barley in the different climatic regions of southern Australia

Nick Poole¹ & Peter Burgess²

¹Foundation for Arable Research (FAR), ²Kalyx Agriculture, WA

The following trial is part of a GRDC funded project (SFS 00015) on disease management in cereals taking place in southern Australia, principally in the high rainfall zone. It is a joint project linking Australian farming groups (lead group Southern Farming Systems) with the New Zealand organisation Foundation for Arable Research (FAR).

Summary:

In a barley trial where the principal diseases were leaf rust (*Puccinia hordei*) and powdery mildew (*Blumeria graminis*), foliar fungicide application increased yield by between 0.36 – 1.75 t/ha, taking the untreated yield from 2.79 t/ha to a maximum of 4.54 t/ha.

The trial, in the cultivar Baudin, compared three fungicides products applied at three rates. The products and rates were: Tilt Xtra (cyproconazole & propiconazole) 125, 250 & 500ml/ha, Opus (epoxiconazole) 125, 250 & 500ml/ha and the strobilurin/triazole based fungicide Amistar Xtra (cyproconazole & azoxystrobin). Each product rate combination was applied as a single spray applied at GS33 (third node – flag leaf minus 1 emergence) and as a two spray programme with treatments applied at GS30 (start of stem elongation) and GS49 (first awns emerging).

Despite overall treatment with Impact 400ml/ha (flutriafol) in furrow at sowing, leaf rust and mildew were evident on the older leaves at the GS30 application, though infection on newer leaves, flag minus 3 (F-3) and flag minus 4 (F-4) levels was less than 1.5%. Disease levels in the untreated continued to build up through stem elongation, mildew being dominant until awn emergence with leaf rust being dominant post ear emergence. At late ear emergence F-1 was 45% infected with leaf rust in the untreated plots.

There were significant differences in resultant yield due to fungicide treatment, which correlated very strongly with green leaf retention during grain fill on the top leaves of the crop canopy, flag -1 $r^2 = 0.93$ and flag-2 $r^2 = 0.81$. The highest fungicide rates tested invariably gave the highest yields but the advantage over the intermediate rates was not significant and frequently it was the intermediate rates that gave the optimum margins. In terms of product performance, at the rates tested Amistar Xtra (the strobilurin based fungicide) was superior to Tilt Xtra, which in turn was superior to Opus in terms of yield and margin. The strobilurin based treatment Amistar Xtra showed greater yield superiority over the triazole treatments (Tilt Xtra and Opus) when applied as a single spray, however overall even with Amistar Xtra, 2 spray approaches gave better results than single spray applications. From a technical standpoint it should be emphasised that both Tilt Xtra and Amistar Xtra are mixtures of two active ingredients, a feature that might confer an advantage when applied at lower rates (provided of course that both active ingredient are effective against the target disease and available at a cost effective price). Since Amistar Xtra and Tilt Xtra

were more cost effective than Opus in this experiment it would indicate that both products mixtures were relatively strong against leaf rust.

Two sprays were more cost effective than one spray, in part because two sprays applied more active ingredient and gave better disease control and green leaf retention. However even where the same amount of active ingredient was applied, there was a tendency for two sprays to be more cost effective than one spray, though this was not always based on statistically significant yield differences. Despite the significant yield advantage of Amistar Xtra in both one and two spray programmes over Opus and Tilt Xtra, its margins were reduced by the product's higher cost, such that Tilt Xtra 250ml/ha applied twice gave the best margin in the trial.

Many of the treatment trends established for yield related to grain quality, this was particularly the case with screenings, which were lower at higher application rates, with products that gave better disease control and with two sprays as opposed to one application.

Trial Details:

Location: Farmers Rd, Munglinup, WA (Protocol 7 of GRDC project SFS 00015)

Trial Size: 19 treatments x 4 reps, **Plot size:** 2.2m x 15 m

Soil Type: Sandy loam, **Rotation Position:** Canola 2005, Barley 2004,

Sown: 1st May 2006 with Farm DBS system (seedbed moist and friable)

Sowing Rate: 65 kg/ha with Impact on fertiliser 400ml/ha over trial area

Cultivar: Baudin (susceptible)

Treatment List and application timings:

The treatment list of foliar applied fungicides was based on 3 primary timings GS30-31 (start of stem elongation – first node), GS33 (3rd node – Flag minus 1 emergence) and GS49 (1st awns emerging).

Table 1. Fungicide timing, rates and application date details

GS33 (Flag minus 1 emergence) – 4th August 2006

1 Spray approach

1. Tilt Xtra 125ml/ha
2. Tilt Xtra 250ml/ha
3. Tilt Xtra 500ml/ha
4. Opus 125 ml/ha
5. Opus 250 ml/ha
6. Opus 500ml/ha
7. Amistar Xtra 200 ml/ha
8. Amistar Xtra 400 ml/ha
9. Amistar Xtra 800 ml/ha

GS30-31 (leaf 4 emergence) – 18th July

2 Spray approaches

10. Tilt Xtra 125ml/ha
11. Tilt Xtra 250ml/ha

GS49 (First awns emerging) – 17th August

- Tilt Xtra 125ml/ha
- Tilt Xtra 250ml/ha

- | | |
|----------------------------|------------------------|
| 12. Tilt Xtra 500ml/ha | Tilt Xtra 500ml/ha |
| 13. Opus 125 ml/ha | Opus 125 ml/ha |
| 14. Opus 250 ml/ha | Opus 250 ml/ha |
| 15. Opus 500ml/ha | Opus 500ml/ha |
| 16. Amistar Xtra 200 ml/ha | Amistar Xtra 200 ml/ha |
| 17. Amistar Xtra 400 ml/ha | Amistar Xtra 400 ml/ha |
| 18. Amistar Xtra 800 ml/ha | Amistar Xtra 800 ml/ha |

19. Untreated

Seed treatment: Raxil

Guide to Formulation:

Tilt Xtra – 330 EC at 500ml/ha = cyproconazole 40g ai/ha + propiconazole 125g ai/ha
 Amistar Xtra 280 SC at 400 ml/ha = 80g/ha azoxystrobin ai + cyproconazole 32 g/ha ai
 Opus 125SC at 250ml/ha = 31.25g/ha epoxiconazole ai

Application rate: 60 l/ha

Date disease first visible: Early tillering (June) - mildew

Date of disease assessments: July 18th, 4th August, 16th August, 30th August and 12th September with a lodging assessment 9th November (date of harvest).

Results:

i) Disease assessments

Despite at sowing treatment with Impact in furrow on the fertiliser (400ml/ha), older leaves were heavily infected with both mildew (*Blumeria graminis*) and leaf rust (*Puccinia hordei*) at the application of the first fungicide at GS30-31. By tagging those leaves present at GS30-31 assessment it was possible to identify disease levels relative to the leaf position in the final canopy (Table 2).

Table 2. Disease levels (% mildew infection (Mil) & % leaf rust (L.r) infection) assessed at application of the GS30 fungicide – July 17th

Treatment	Flag minus 3		Flag minus 4		Flag minus 5		Flag minus 6	
	% L.r	% Mil.						
Untreated control*	0.0	0.3	1.0	1.4	2.1	3.5	30.5	15.0

* Untreated control did receive Impact (*flutriafol*) at sowing.

At the time of first fungicide application though mildew and leaf rust infections were established in the crop, the levels were not high on the first of the yield bearing leaves, flag – 3.

As the crop developed through stem elongation the levels of both mildew and leaf rust increased in the untreated crop, by GS33 when the second fungicide was applied, mildew was the slightly more dominant disease. The fungicide applications 18 days earlier had controlled the disease with the exception of the lowest rate treatments, though even these had kept disease levels at 2% infection or below (table 2.). There were also low levels of spot form of net blotch (SFNB) – *Pyrenophora teres f. maculate* present at this assessment.

Table 2. Influence of fungicide treatment at GS30 on % mildew infection (Mil), % leaf rust (L.r) infection & % SFNB infection assessed at GS33 18 days after application – assessed August 4th

Treatment (GS30)	ml/ha	Flag minus 2			Flag minus 3		
		Mil.	L.r.	SFNB	Mil.	L.r.	SFNB
Tilt Xtra 330 EC	125	0.3	0.4	0.3	0.9	1.0	1.2
Tilt Xtra 330 EC	250	0.0	0.0	0.1	0.3	0.2	0.7
Tilt Xtra 330 EC	500	0.0	0.0	0.0	0.0	0.0	0.0
Opus 125 SC	125	0.0	0.0	0.1	0	1.2	1.2
Opus 125 SC	250	0.0	0.0	0.0	0.0	0.0	0.0
Opus 125 SC	500	0.0	0.0	0.0	0.0	0.0	0.0
Amistar Xtra 280SC	100	0.0	0.1	0.1	0.1	2.1	1.0
Amistar Xtra 280SC	200	0.0	0.0	0.0	0.0	0.0	0.0
Amistar Xtra 280SC	400	0.0	0.0	0.0	0.0	0.0	0.0
Untreated		1.9	1.5	1.6	11.5	3.7	5.6
LSD - % infection		0.3	0.7	1.0	0.6	0.3	0.6

On 16th August 31 days after GS30 applications (and at the same time as the GS49 fungicide applications were applied) disease levels were still relatively low in the top three leaves of the canopy with most fungicide treated crops showing this than 1% mildew and rust infection (Table 3).

Table 3. Influence of fungicide treatment at GS30 on levels % mildew infection (Mil) & % leaf rust (L.r) infection 31 days after application – assessed August 16th

Treatment (GS30)	ml/ha	Flag		Flag minus 1		Flag minus 2	
		Mil.	L.r.	Mil.	L.r.	Mil.	L.r.
Tilt Xtra 330 EC	125	0.0	0.2	0.1	0.6	0.4	0.8
Tilt Xtra 330 EC	250	0.0	0.1	0.1	0.8	0.2	0.6
Tilt Xtra 330 EC	500	0.0	0.1	0.0	0.9	0.0	0.5
Opus 125 SC	125	0.0	0.1	0.3	0.9	0.9	1.0
Opus 125 SC	250	0.0	0.1	0.3	0.7	0.6	0.8
Opus 125 SC	500	0.0	0.1	0.2	0.7	0.2	0.7
Amistar Xtra 280SC	100	0.0	0.1	0.5	0.7	1.4	0.6
Amistar Xtra 280SC	200	0.0	0.0	0.1	0.5	0.5	0.3
Amistar Xtra 280SC	400	0.0	0.1	0.2	0.2	0.3	0.0
Untreated		0.0	0.2	0.7	1.1	3.6	1.3
LSD - % infection		0.0	0.2	0.5	0.3	0.9	0.5

By 70-80% ear emergence (GS57) leaf rust had developed strongly on the top 3 leaves, reaching almost 50% infection on flag minus 1 (F-1), the worst infected leaf in the canopy at this stage. Powdery mildew levels had also built up in the untreated increasing to 13% on F-1. At this stage there were clear differences in fungicide performance due to both fungicide rate and timing. At the lowest rates tested the differences were most pronounced (figure 1).

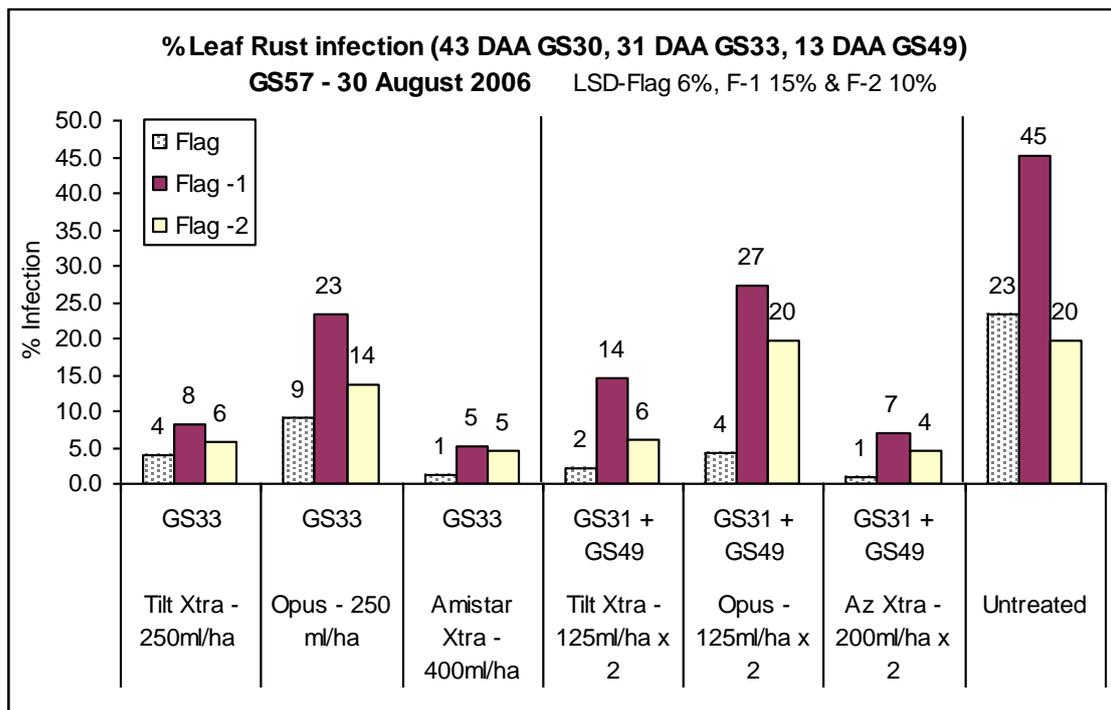


Figure 1. Influence of fungicide product in single and two spray programmes (equivalent rates tested) on % leaf rust infection recorded GS57 30th August.

Comparing identical levels of active ingredient there was little difference between one spray and two sprays when assessed at ear emergence. All products gave significantly better disease control on the top two leaves of the plant in comparison to untreated plots. Amistar Xtra gave superior disease control to Opus at GS57, though the advantage over Tilt Xtra was not statistically significant.

If all treatments were compared on F-1, there was a clear indication that the lowest rates experimented upon were inferior, though note that the inferiority is more pronounced (and significant with Tilt Xtra and Amistar Xtra) when comparing the single sprays at GS33 (figure 2).

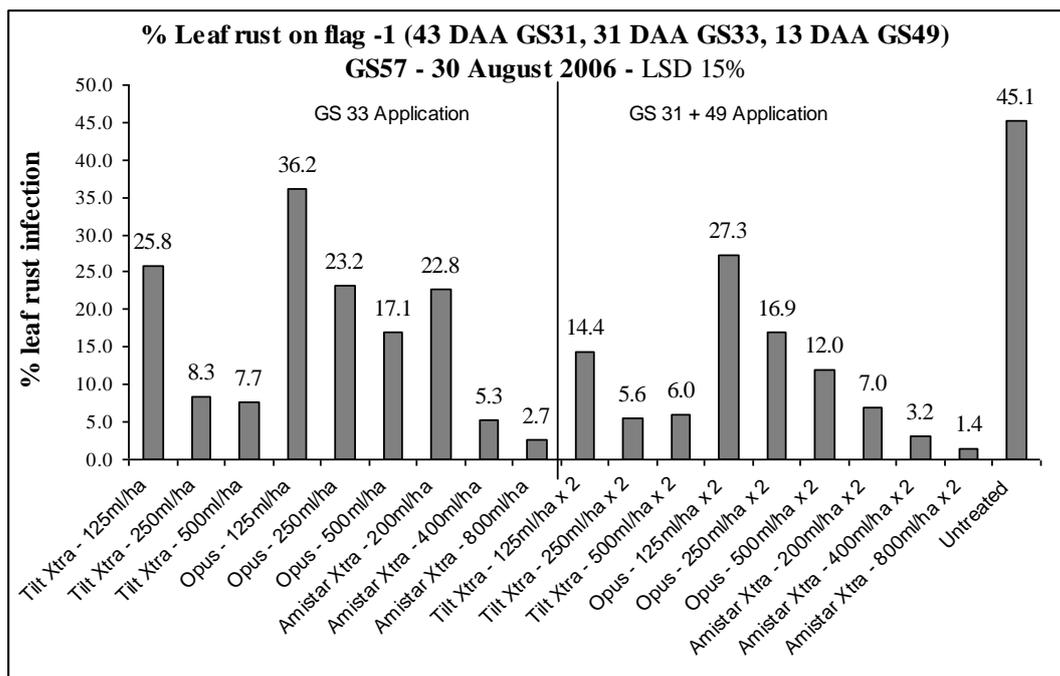


Figure 2. Influence of fungicide product and rate in single and two spray programmes on % leaf rust infection recorded GS57 30th August.

At the end of flowering/early grain-fill (GS69/71) on the 12th September active infection pressure had reduced in the untreated. Similar disease control patterns to those observed in late August were recorded, though there was there a greater tendency for the two spray programmes to be superior and for the greater persistence of Amistar Xtra to be displayed.

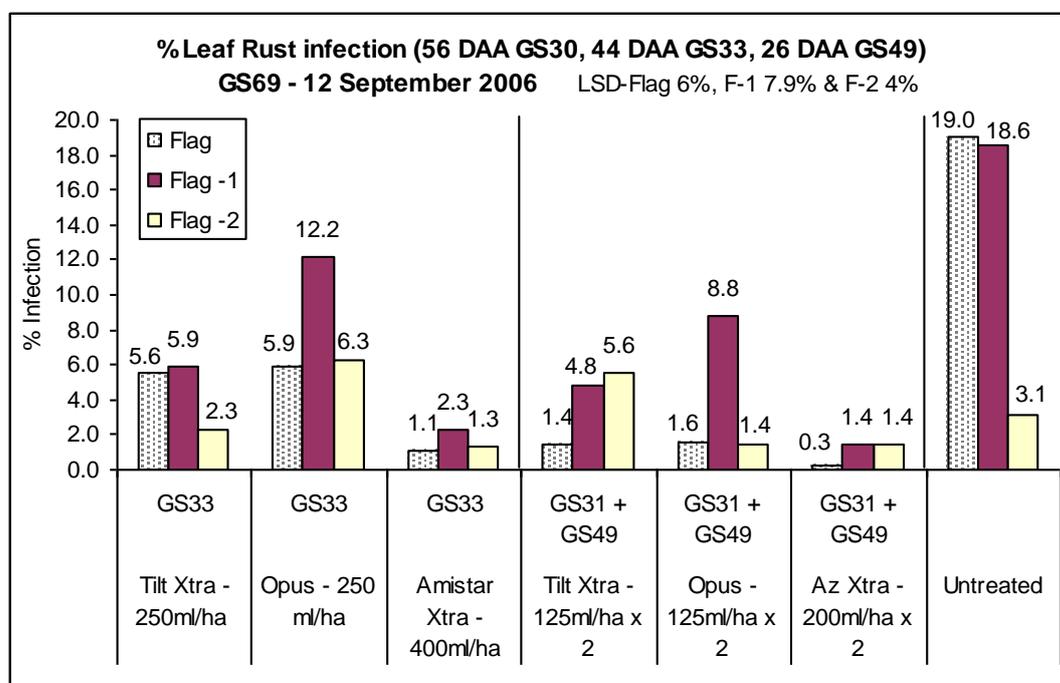


Figure 3. Influence of fungicide product in single and two spray programmes (equivalent rates tested) on % leaf rust infection recorded GS69 - 12th September.

Since green leaf area during grain fill is frequently correlated to the yield response all fungicide treatments were assessed for green leaf retention on the top three leaves. These assessments also carried out on 12th September revealed significantly more green leaf retention on the flag leaf & F-1 with the two spray approach than the single spray at GS33. Amistar Xtra gave superior green leaf retention to Tilt Xtra on the oldest of the top three leaves and both products were superior to Opus (Figure 4a & 4c). It also revealed a significant advantage to increased fungicide rate (Figure 4b).

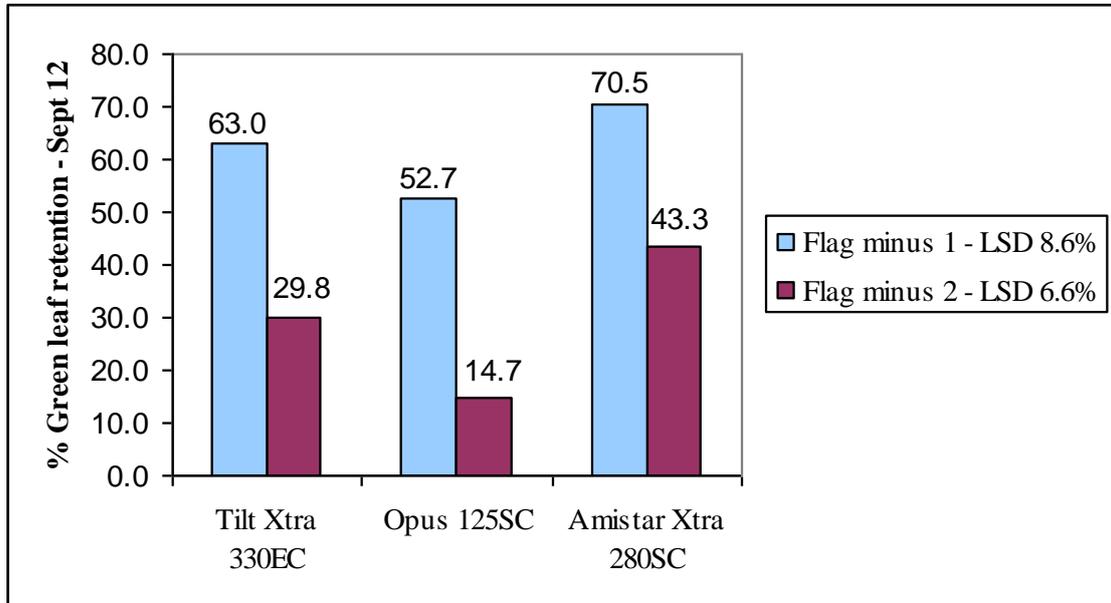


Figure 4a. Influence of fungicide product (mean of all rates and timings) on % green leaf area recorded GS69/71 – 12th September.

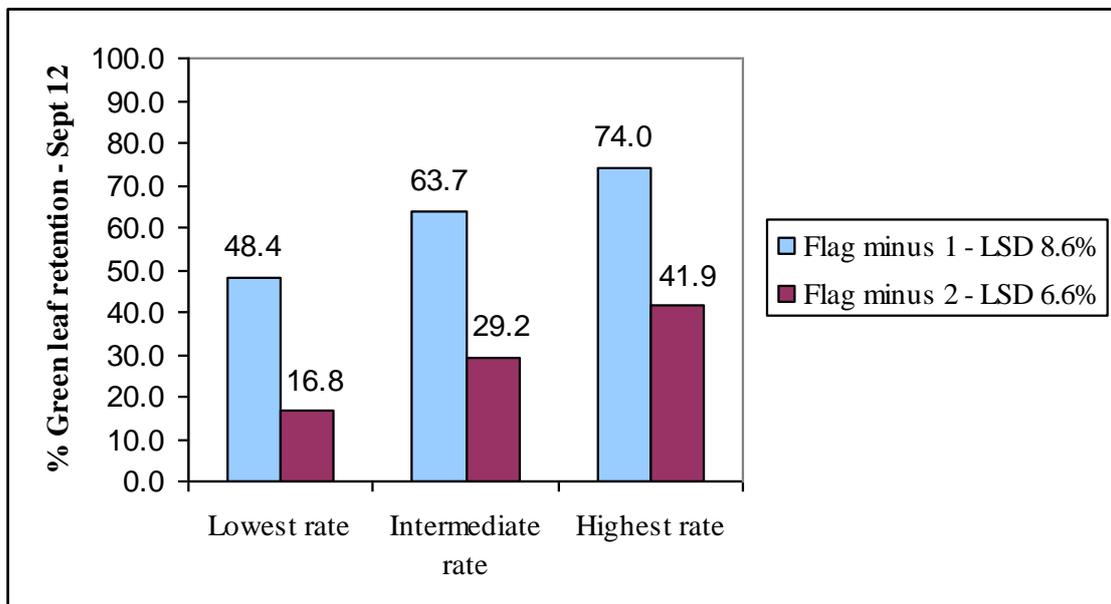


Figure 4b. Influence of fungicide rate (mean of all products and timings) on % green leaf area recorded GS69/71 – 12th September.

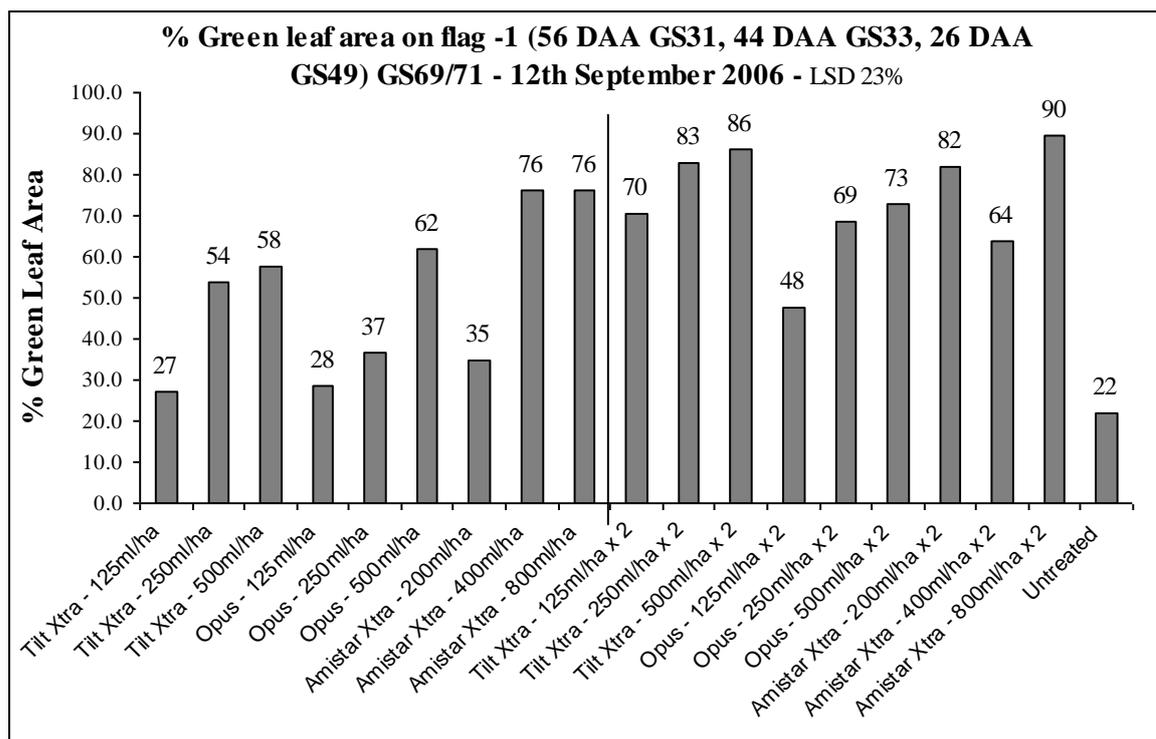


Figure 4c. Influence of fungicide product and rate in single and two spray programmes on % green leaf area recorded GS69/71.

ii) Yield and Quality data

The trial was harvested on the 9th November. Yields are outlined in figure 5-8.

a) Influence of fungicide timing on yield t/ha

Irrespective of fungicide programme there was a significant yield response to fungicide application (figure 5). Two spray programmes were superior to single spray programmes (0.43 t/ha), in part due to the higher rates employed in the two spray programmes, however there was also evidence that two sprays were superior to one spray even where active ingredient rates were equivalent.

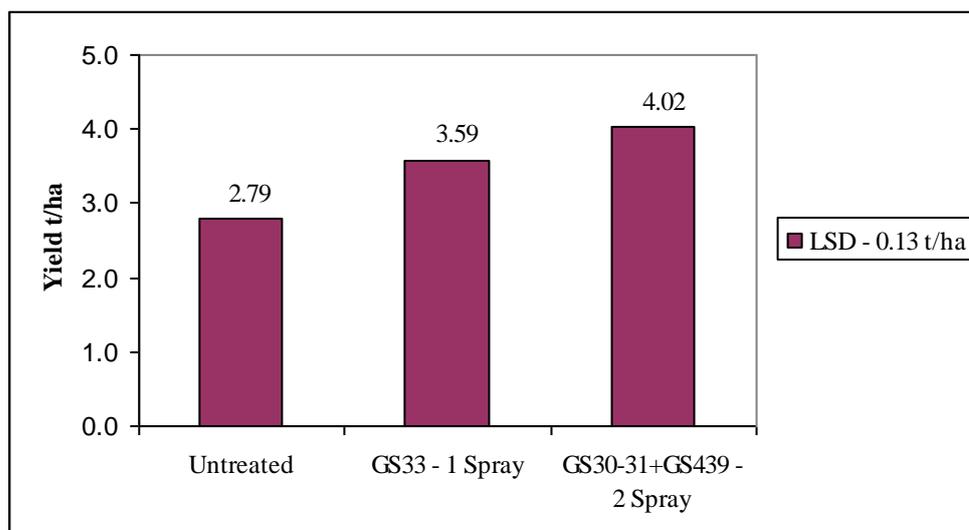


Figure 5. Influence of fungicide timing on Baudin yield t/ha (mean of all products and rates)

b) Influence of fungicide rate on yield t/ha

Taking the three rates of each product experimented upon and meaning them together revealed that both the intermediate rate and the highest rate of those tested produced significantly more yield than the lowest rate tested. There was no significant interaction between rate and timing.

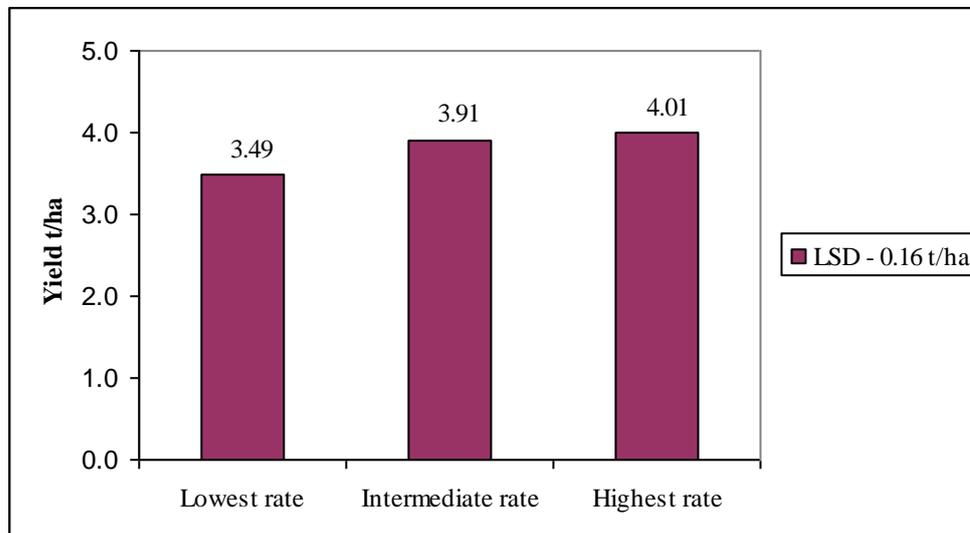


Figure 6. Influence of fungicide rate on Baudin yield t/ha (mean of all products and timings)

c) Influence of fungicide product on yield t/ha

Amistar Xtra significantly outyielded Tilt Xtra by 0.21 t/ha and Opus by 0.47 t/ha if all rates and timings were averaged.

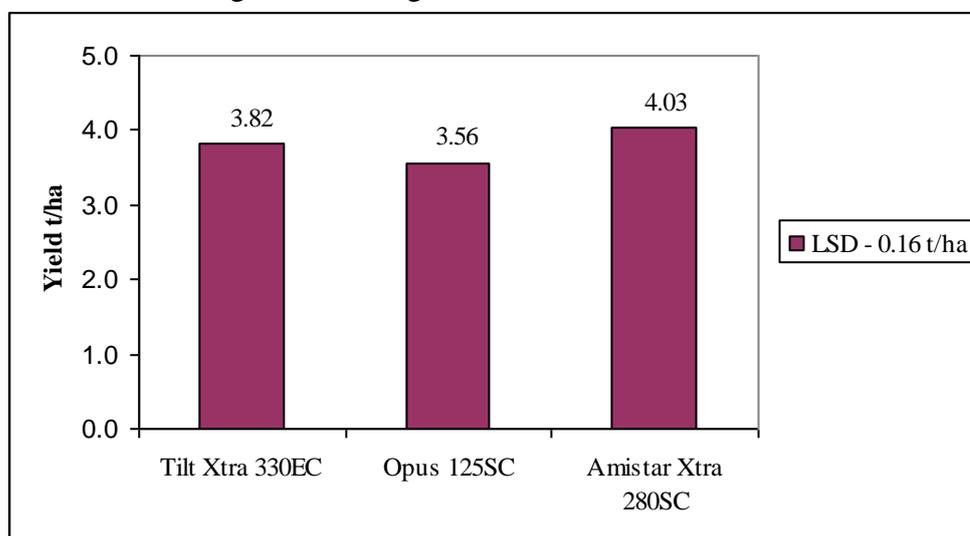


Figure 7. Influence of fungicide product on Baudin yield t/ha (mean of all rates and timings)

d) Interaction of product, rate and timing

Examining all the products, rates and fungicide timings fungicide application increased yield by between 0.36 – 1.75 t/ha depending on treatment (figure 8). The highest yields were produced by the highest rates of Amistar Xtra in both and two spray programmes, though two sprays were superior.

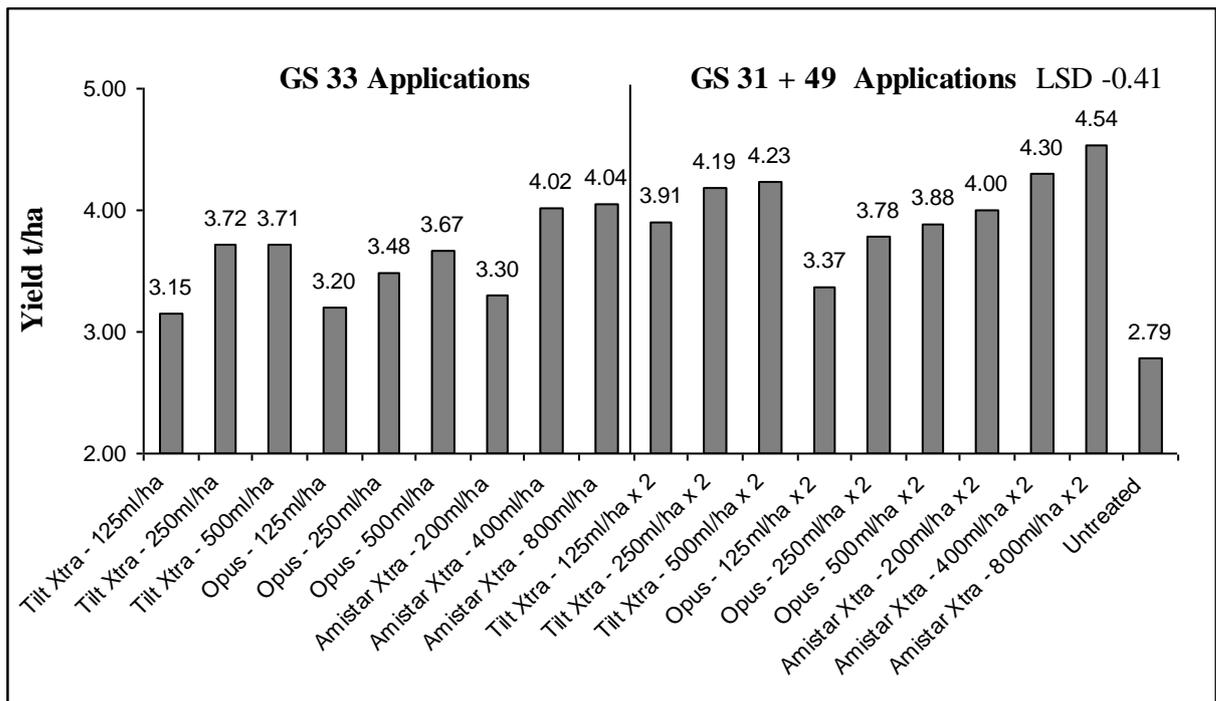


Figure 8. Influence of three fungicide products applied at three rates in one and two spray programmes on Baudin yield (t/ha)

Overall it was the highest rates of active ingredient that produced the highest yields i.e. the higher rate two spray programmes, however comparing the same rates of active ingredient applied in single and two sprays revealed a trend in favour of two sprays (figure 9).

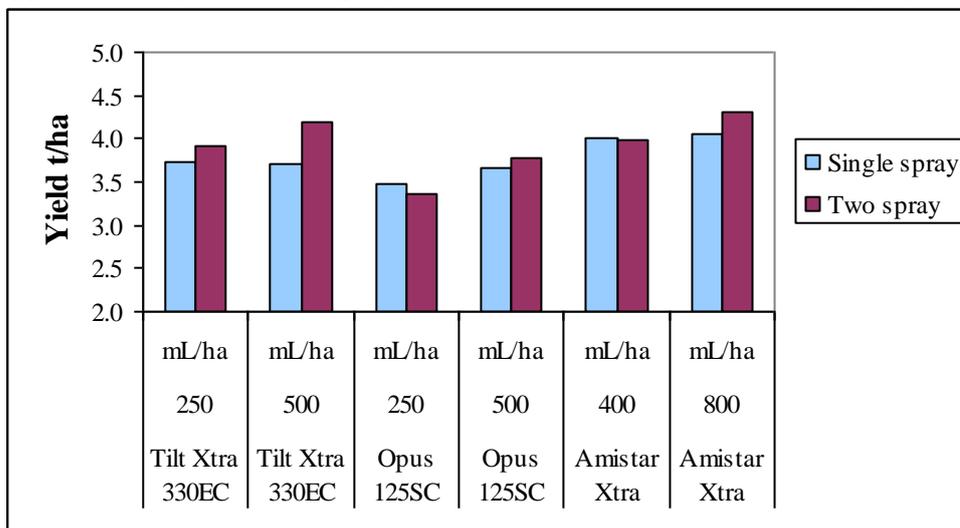


Figure 9. Influence of three fungicide products when applied at the same rate of active ingredient in one and two spray programmes.

e) Correlation between green leaf retention at early grain fill and final yield

Harvested yield showed an excellent correlation with green leaf retention scores on flag minus 1 ($r^2 = 0.93$) and flag minus 2 ($r^2 = 0.81$) recorded at the start of grain fill (figure 9).

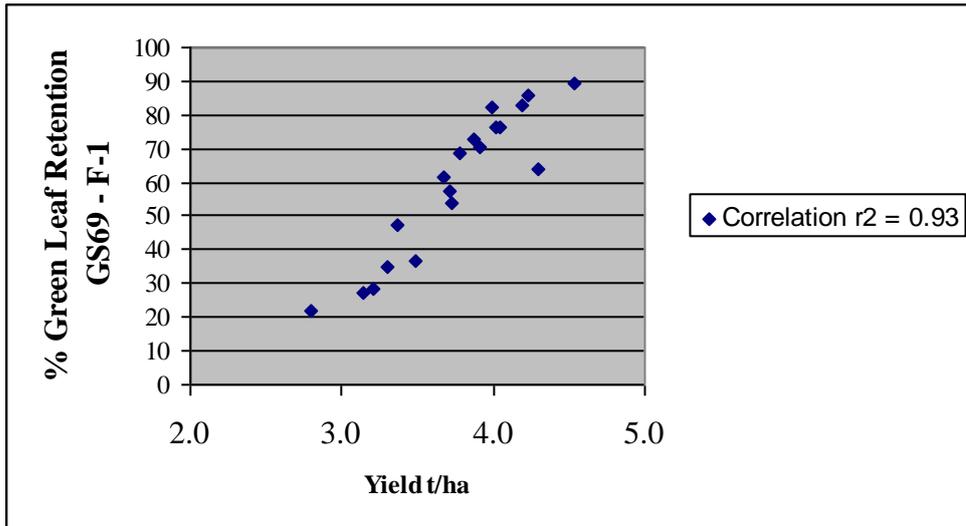


Figure 9. Correlation between green leaf retention on flag – 1 at late flowering and final harvested yield.

f) Influence of fungicide application on grain quality

The influence of fungicide application was particularly evident on % screenings, which were high in this trial (figure 10.). Though not all treatments were assessed for thousand seed weight (TSW), it is clear from assessment of the Amistar Xtra plots that seed weight was an important component of the improved screening levels (TSW of Amistar Xtra 400 ml/ha, 1 spray – 29.5g, same active ingredient 2 spray - 31.6g & untreated 24.3g).

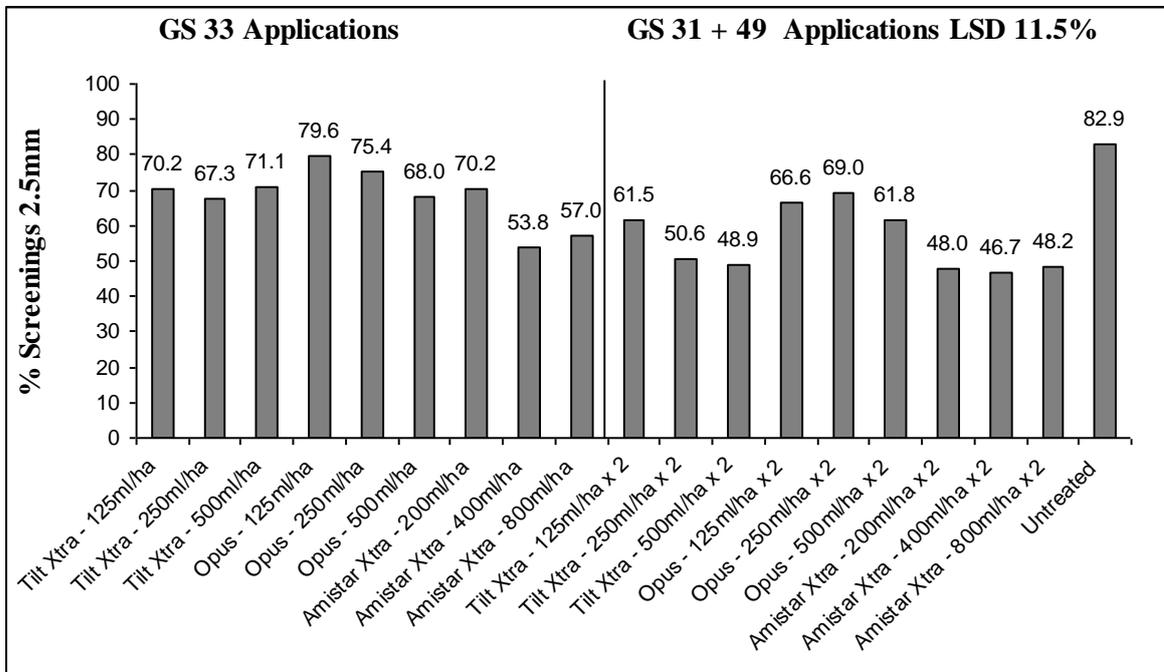


Figure 10. Influence of fungicide treatment on % screenings (2.2mm)

Conclusions:

Under leaf rust pressure during the principal phase of stem elongation and early grain fill, all fungicide treatments gave a cost effective return on investment, which ranged from 3:1 (3\$ return for each \$ spent) to 17:1. The lowest returns were generated from applying the lowest fungicide rates as single sprays at GS33, despite individual disease levels being below 2% on flag minus 2 at this application timing (figure 11).

Two spray programmes applied at GS30-31 (start of stem elongation) and GS49 (first awn emergence) produced consistently better margins than single sprays, despite the higher cost of the programme, however comparing the same rates of active ingredient applied as one and two spray programmes also revealed a similar advantage to two spray timings over one. This margin advantage related to higher yields as a result of better green leaf retention and was achieved despite higher application costs.

In terms of product performance, despite the significant yield advantage of Amistar Xtra in both one and two spray programmes over Opus and Tilt Xtra, its margins were reduced by the products higher cost, such that Tilt Xtra 250ml/ha applied twice gave better margins than the equivalent Amistar Xtra 400ml/ha two spray programme. When the products were applied as single sprays, though overall these applications were inferior to two sprays, Amistar Xtra margins were superior to Tilt Xtra and Opus, indicating that the greater persistence of the strobilurin based product was more evident with a single spray programme.

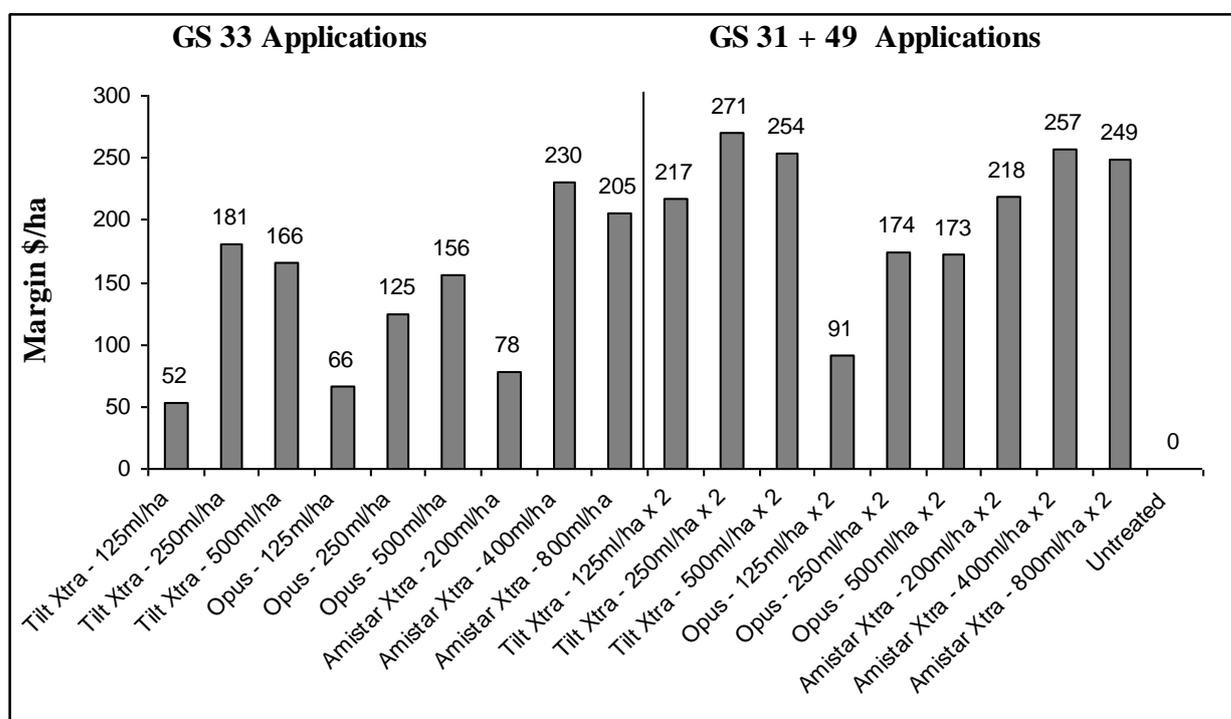


Figure 11. Margin (\$/ha) after the deduction of chemical costs, application costs and wheeling damage associated with fungicide applications after GS31.

Notes: Amistar Xtra 400ml/ha has been costed at \$32/ha with Opus & Tilt Xtra at 250 ml/ha costed at \$12.50/ha. Wheeling damage from foliar sprays after GS30 based on 2.5% yield loss with \$7.50/ha application cost for foliar sprays.
Feed barley based on farm gate price \$240/tonne

Appendix:

Maximum and minimum monthly temperature means (⁰C) & monthly rainfall for trial site (mm) Jan – Dec 2006 (recorded at Munglinup, WA)

	Rainfall (mm)		Temperature ⁰ C	
	2006	Average	Minimum mean	Maximum mean
January	124.4	28.9	14.1	27.8
February	29.6	35.1	14.8	27.2
March	68.8	28.7	13.5	25.7
April	70.2	31.7	11.7	23.3
May	23.8	52.2	9.3	19.4
June	24.0	50.0	7.6	17.0
July	71.2	63.8	6.8	16.1
August	28.2	59.7	6.8	16.8
September	38.6	53.4	7.5	19.0
October	4.8	44.8	8.6	21.4
November	25.6	38.7	10.9	24.1
December	2.0	27.7	12.8	26.4
Total	511.2	514.7		

Acknowledgements:

I would like to acknowledge all the input of our co-workers on project SFS 00015 but in particular for work relevant to this trial, Peter Burgess and all the team at Kalyx Agriculture, and the host farmer Mr Andrew Bott.

Contact Details:

Nick Poole (poolen@far.org.nz)
Foundation for Arable Research,
PO Box 80,
Lincoln, Canterbury,
New Zealand
e-mail: poolen@far.org.nz
Tel: 001164 3 325 6353