Stripe Rust Management in Wheat

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GRDC Grains Research & Development Corporation

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Managing Stripe Rust in Wheat

Take Home Message

- Grow resistant varieties.
- If growing a wheat variety with a stripe rust rating of 1-5 use a preventative strategy.
- Application timing is more important than product choice.

History

Stripe rust was not a serious economic concern to the wheat industry for most of the 1990's due to the use of resistant varieties. However, by 2003 it had developed into a significant issue, particularly as new pathotypes evolved. Even in the dry years of 2003 and 2004, stripe rust cost growers significant income.

The management of the current stripe rust epidemic differs to that of the 1980's for a number of reasons:

- farming systems have changed
- higher potential yields
- dramatic reduction in the cost of fungicides, and
- an increased ability to cover large areas of crop

Trial work conducted in the medium to high rainfall zone over the last three years (on varieties rated 1-5 for stripe rust) has been aimed at tailoring management packages for growers in the wake of this current stripe rust epidemic. This research has enabled the development of successful management strategies to deal with not only the 2006 season, but any future stripe rust outbreaks.

Table 1 lists the current main wheat varieties grown in southern NSW. The table highlights the current stripe rust resistance ratings and how those ratings have changed since 2002.

Before exploring specific stripe rust management options it is important to understand the key areas that contribute to the development of a management plan.

Table 1: Stripe Rust Resistance Ratings of Wheat

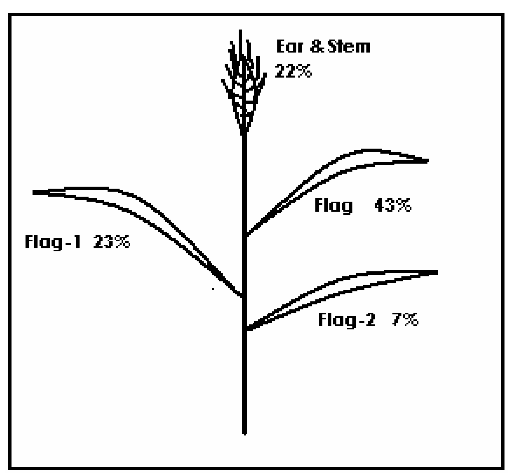
Variety	H45 Strain 2002	WA Strain 2003	Stripe Rust Rating 2006
Braewood	7	7	8 (6)*
Carinya	-	-	8 (6)*
Chara	7	4	3
Diamondbird	7	4	3
Drysdale	6	5	3
EGA Wedgetail	7	6	5
Ellison	-	-	8 (5*)
H 45	3	1	1
H 46	-	-	5
Janz	7	5	5
Lang	7	5	5
Marombi	7	7	8 (5)*
Strzelecki	7	7	8
Sunstate	8	8	8 (7)*
Ventura	-	-	8 (7)*

Source: NSW DPI (* the figures in brackets indicate the reaction to the Yr17 pathotype)

1. What are we trying to protect?

It is important to understand which plant structures (leaves, stem and ear) contribute most to yield and to determine when growing conditions (soil, water) will allow any fungicide benefit to be expressed. Based on European studies, the top three leaves of the wheat plant contribute approximately 70-75% to yield (figure 1). Whilst this may vary due to seasonal conditions, any management strategy in the medium-high rainfall environment should be targeted at keeping the top three leaves disease free, particularly the flag leaf.

Figure 1. Leaf Contribution to Grain Yield
(Source: HGCA 2000 UK)



NB: Flag-1 = leaf 2. Flag-2 = leaf 3

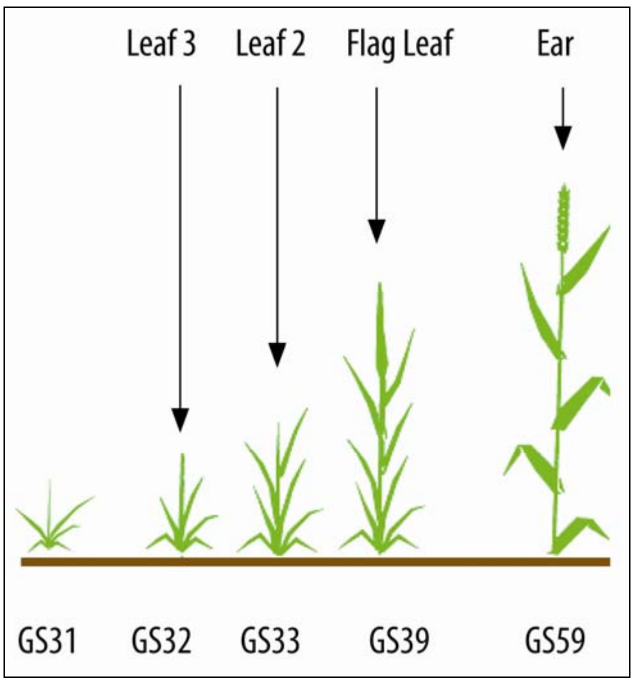
When do these important leaves emerge?

Since foliar fungicides only protect the leaves that are emerged at application it is important to identify when the top 3 leaves emerge in order to protect them from disease.

The start of stem elongation is particularly important for decisions on fungicide application, since it marks the emergence of the first of the important yield contributing leaves.

Full emergence of the first important leaf (leaf 3 or flag -2) approximately coincides with the 2nd node stage on the main stem (GS32). Full flag leaf emergence on the main stem is referred to as GS39. Protection at the flag leaf stage (GS39) provides the greatest yield response and is, therefore the most important leaf to keep disease free.

Figure 2. Wheat plants and leaf emergence.



In order to correctly identify these growth stages more precisely, main stems of the cereal plants are cut longitudinally and the position of nodes (joints in the stem) and the length of internodes (cavity in the stem between nodes) is measured with a ruler.

The following photo is of a wheat plant at GS30. The tip of the developing ear is 1cm or more from the base of the stem where the lowest leaves attach to the shoot apex.

Figure 3. Photo of wheat plant at GS 30

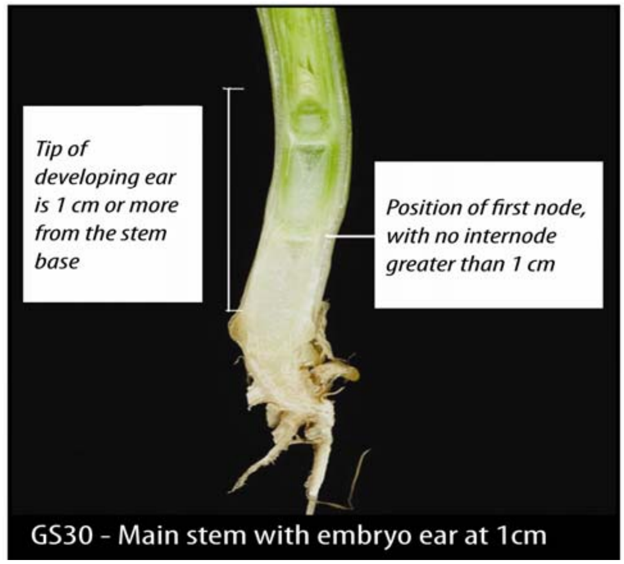
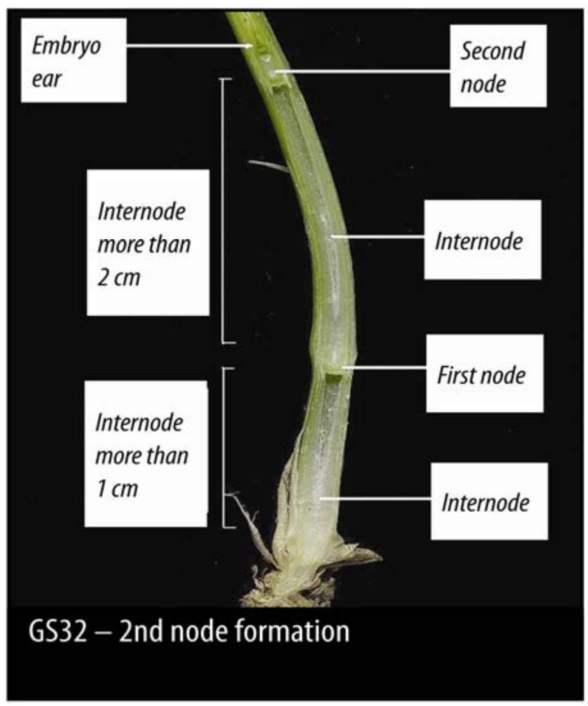


Figure 4. Photo of wheat stem cut longitudinally.



The photo above demonstrates a wheat plant at GS32. This is when the second node can be detected and is separated from the first node (situated below it) by an interode that exceeds 2cm.

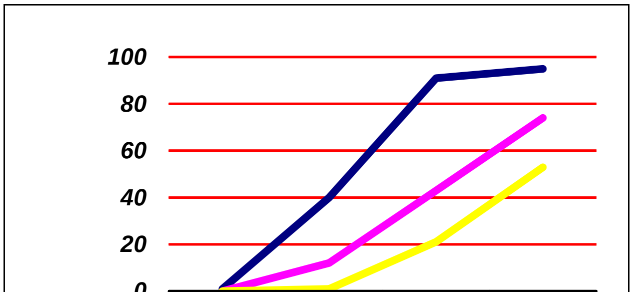
2. Onset of Infection & Rate of Spread of Stripe Rust

The biology and ecology of stripe rust is very well understood. We know the seasonal conditions that trigger both the development and spread of the disease.

Over the last four-five years the onset of stripe rust has commonly occurred between GS32 & GS39. In these years, peak stripe rust activity occurred just prior to GS39 and up to GS59. Stripe rust activity is relative to temperature and moisture and will vary due to seasonal conditions. Typically wheat sown on time will take approximately 3-4 weeks to develop from GS32 to GS39 (this can be as little as 2 weeks with late sown crops), and from three to five weeks to develop from GS39 to GS59.

The time between when the disease spores land on the leaf and when you can see disease symptoms is called the latent period or latent phase. This period is temperature and moisture driven and is typically 7-10 days at (20 degrees C) GS 39. This means that whilst a leaf may look healthy, the disease can already be developing within the leaf and causing damage. Uncertainty of seasonal conditions and not knowing the level of latent infection are the reasons the rate and spread of infection is difficult to predict.

Figure 5. % Infection Rate (LAI %) 2005 (Diamondbird)



	GS33	GS39	GS53	GS65
Leaf 3	1	40	91	95
Leaf 2	0	12	43	74
Flag	0	1	21	53

* Flag not emerged at GS33

The above average rainfall and mild spring temperatures in 2005 were conducive to the rapid development and spread of stripe rust resulting in unprecedented infection levels. By comparison in 2004 infection levels were much lower under drier spring conditions. Figure 5 shows the percentage of leaf area infected at growth stages GS33 (emergence of leaf 2), GS39 (flag leaf emergence) and GS65 (full flowering) and illustrates the very rapid rise in 2005 infection levels. In 2005 flag leaf infection developed from 1% to 21% in 9 days, while leaf 3 went from 40% to 91% in the same period. By comparison in 2004 the infection rate on the flag leaf went from 0 to 2% in 14 days, whilst leaf 3 went from 1% to 9% in the same period.

3. How do foliar fungicides work?

All fungicides work more effectively when applied before the disease becomes established in the leaves you are trying to protect. In order to time foliar fungicides correctly we need to appreciate how these fungicides work in terms of movement and control of the pathogen. In general terms foliar fungicide activity can be described in one of two ways.

Protectant activity – This is where the plant foliage is protected after the spray date by inhibiting fungal spores developing on the plant tissue.

Curative activity – This is where the fungicide is able to cure the existing disease infection, usually through systemic activity and before the disease is expressed on the leaf. A fungicide with curative activity can prevent expression of the fungus even if part way through its latent period. This activity is referred to as *kickback activity* as it controls disease after the date of infection. Different fungicides have differing levels of curative activity (expressed in days or degree C days). Kickback is limited to approximately 10 days maximum depending on temperature, rate and product.

Cereal foliar fungicides do not move down the plant, movement in the leaves and stem is upwards towards the leaf tip via the water carrying xylem vessels.

Foliar fungicides applied to plants do not protect un-emerged leaves or the base of part emerged leaves, other than reducing inoculum levels on lower leaves.

Movement in these xylem vessels is the same for triazole fungicides applied to the leaf or applied as a seed treatment. However, the movement of active ingredient from the stem base into new tissue i.e. from in-furrow or treated seed is less constrained than applying fungicide to the leaf (since foliar applied product cannot move back down the leaf).

What is the difference between the triazoles and strobilurins?

Different fungicide groups have different modes of action to kill the fungus.

Strobilurins are extremely effective protectants but poor curative fungicides. They have the ability to control disease and keep the crop greener for longer, provided there is sufficient soil moisture and plants are not subjected to excessive temperatures.

Triazoles are, in contrast, better curative products with variable protection characteristics depending on how long sufficient concentration can be maintained within the leaves (remembering that once inside the leaf the fungicide starts to move away from the point of contact with the plant).

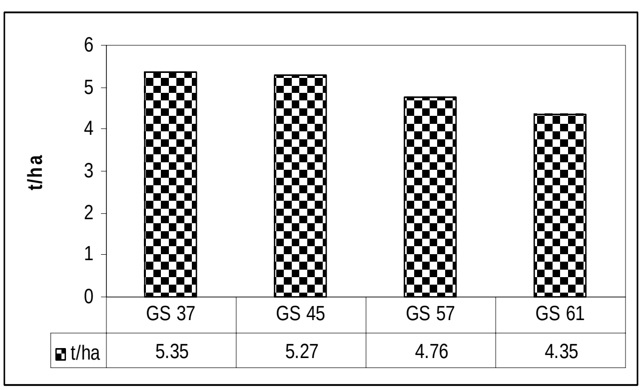
The majority of registered products available for stripe rust control in Australia are triazole fungicides. It is only in the last two years that strobilurin fungicides have become available. For cereals, strobilurins are currently only available in a mix with a curative triazole fungicide.

4. Application Timing & Treatment Options

There has been much debate in the industry since 2002 on how to effectively manage stripe rust epidemics. Previous strategies have been based around observing a critical threshold of infection then taking action. With the current stripe rust epidemic our ability to predict the onset of disease infection and rate of spread has been poor. Subsequently the wait and see approach has been ineffective in many cases.

Recent research trials have looked extensively at product rate, product choice and application timing under varying disease pressure and across a range of varietal tolerances. This research strongly suggests that a timely preventative strategy is the most appropriate way to manage stripe rust, both agronomically and economically when growing varieties with a stripe rust rating of 1-5.

Figure 6: Effect of Timing on Yield – H45 2003



(LSD = 0.18 t/ha, Untreated = 3.95 t/ha, cv 7.44%)

For any preventative strategy to work, application timing is critical. Figure 6 demonstrates that in 2003 in the high rainfall zone, in a below average rainfall year, stripe rust cost growers 40kg/ha for every day that spraying was delayed after flag leaf emergence. This yield loss equates to $6.00/ha/day (wheat valued at $150/tonne). This occurred when a single fungicide was used and when stripe rust was present prior to flag leaf emergence (GS39).

In order to achieve the correct application timing, we need to understand the expected disease onset and the expected length of protection from any of the fungicides. Foliar fungicides at standard use rates give between 2-4 weeks protection. The higher the disease pressure the shorter the protection period.

Subsequent trial work over 2003-2005 focused on getting the application timing correct to achieve a reliable strategy that will economically manage stripe rust damage across a range of seasons and disease pressure, relative to varietal tolerance.

As outlined previously, in the medium to high rainfall environment the aim of a preventative strategy is to keep the top three leaves disease free, particularly the flag leaf. These preventative options will typically be focused on one of the four following options to achieve this:

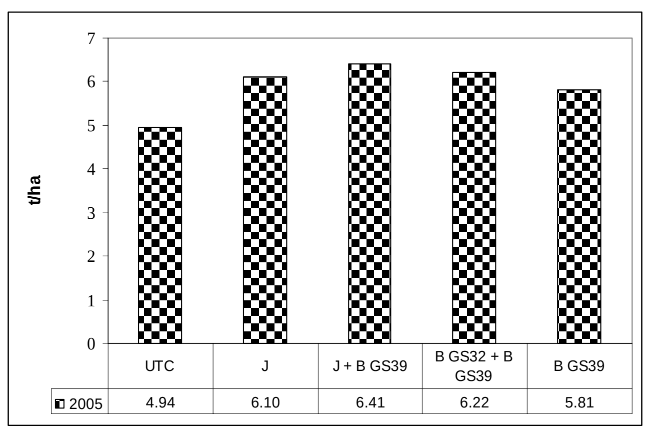
1. One single up front treatment of Jockey® or Impact®

2. One in-crop foliar spray at GS39 (flag leaf emergence)

3. A foliar fungicide application at GS32 (when leaf three has emerged) then a second application at GS39 once the flag has fully emerged.

4. An appropriate at sowing fungicide, Jockey® or Impact®, can be used in lieu of a GS32 foliar fungicide and followed up with a GS39 application.

Figure 7. Comparison of Fungicide Strategies on Yield (t/ha) in Young 2005. Variety Diamondbird



(LSD = 0.68 t/ha, cv 7.94%. J = Jockey, B = Bayleton @ 0.5 L/ha GS32 and GS39)

Figure 7 shows that all strategies employed gave a significant yield response when compared to the untreated. There was no significant difference between any of the strategies employed.

5. Stripe Rust Management Plan

Which strategy you decide to use is based on one of the four treatment options previously listed. Deciding which one is the most appropriate to use is influenced by the following factors:

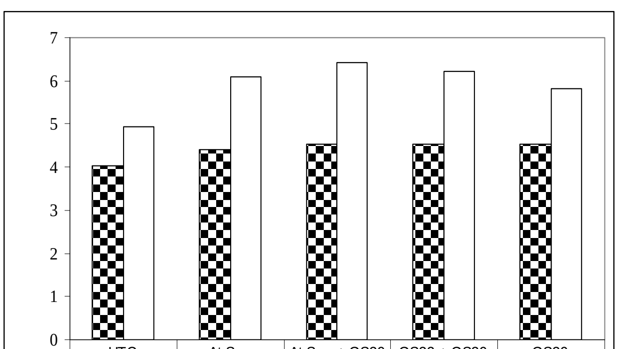
- Varietal choice & stripe rust rating
- Seasonal conditions & yield potential
- Crop rotation (take-all risk)
- Sowing time
- Fungicide strategy
- Ability to spray on time
- Profitability

Combining the preventative treatment options with these factors make up the Stripe Rust Management Plan. The options used will also be influenced by each growers perceived risk relative to their varietal tolerance and past history of experience in dealing with these serious disease outbreaks.

Figure 8 demonstrates the comparison of up front and/or in crop strategies on Diamondbird (rated 4, then 3) for both 2004 and 2005. In 2004 all treatments were significantly better than the untreated control. There were no significant differences between any of the strategies employed. However, a single GS39 foliar spray in 2004 was the most economic strategy. In 2005, the application of a foliar spray at GS32 and GS39, was the most economic strategy.

All strategies employed in both years gave a significant economic yield response compared to the untreated control.

Figure 8. Comparison of Fungicide Strategies on Yield (t/ha) in Young 2004 and 2005. Variety Diamondbird

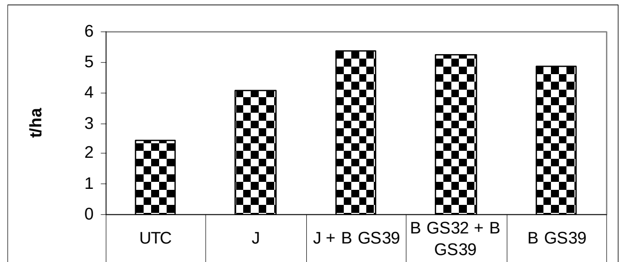


	UTC	At Sow	At Sow + GS39	GS32 + GS39	GS39
2004	4.02	4.41	4.54	4.54	4.54
2005	4.94	6.10	6.41	6.22	5.81

(2004: LSD = 0.36, cv 5.49% ; 2005: LSD = 0.68, cv 7.94%. J = Jockey, B = Bayleton @ 0.5 L/ha GS32 and GS39)

Yields for the trial at Young in 2005 ranged from 4.94 t/ha for the untreated control to 6.62 t/ha for the highest yielding treatment. This equates to a difference of $252/ha (wheat at $150/t del. local silo). Nett of treatment and application costs the economic difference is $222/ha compared to the untreated control. The lowest yielding of the preventative options was a single GS39 spray which yielded 5.65t/ha. Nett of costs this was still $89/ha better than the control.

Figure 9. Comparison of Fungicide Strategies on Yield (t/ha) Junee 2005. Variety H45



	UTC	J	J + B GS39	B GS32 + B GS39	B GS39
t/ha	2.45	4.08	5.39	5.26	4.88

(LSD = 0.50, cv = 7.27, J = Jockey, B = Bayleton @ 0.5 L/ha GS32 and 1.0 L/ha GS39)

Figure 9 demonstrates a different result but on the variety H45 (rated 1). All strategies gave a significant economic yield response relative to the untreated. However, those strategies which employed the combination of upfront and GS39 sprays were significantly superior to the upfront only or GS39 only strategy.

The approximate cost of the standard triazole fungicides listed in these trials range from $3.00/ha to $12.00/ha at their equivalent use rates (Bayleton®, Tilt® and Folicur®). The at sowing treatments costs are approximately $16/ha for Impact ® and $3.00/10 kg of seed for Jockey ®. Any application costs needs to be in addition to these figures.

Appendix *1* lists in detail some of the stripe trial results that have been conducted since 2003. The 2005 trials at Young and Junee have been costed out to further highlight the yield and economic result of forward planning.

Which strategy you decide to use is based on the combination of factors that have been discussed thus far. In assessing what is the most appropriate option for each region and grower, a few key points should be noted when considering these strategies:

- In the three years of these trials, all preventative treatments listed were significantly better than the control tested on varieties rated 1 – 5.

- Treatment options will vary in their yield response relative to season, disease pressure and timing of the disease infection.

- The lower the varietal rating the greater potential for yield response to the preventative treatments.

- The lower the varietal rating the more rapid is the disease infection in any given year

- The 2005 early infection meant yield was lost due to disease in the two leaves below the flag (leaf 2, and leaf 3). Thus to maximise profitability it was important to put in place protection before flag leaf emergence. This can be achieved, either by employing the best up front options (Jockey®/Impact®), or by adopting a pre GS39 foliar spray timed to coincide with the emergence of leaf 3 at GS32. Which of these options is adopted depends on how the grower is equipped to carry out GS32 sprays.

- Jockey® and Impact® are more appropriate where the grower is not equipped with the ability to spray early in the spring either due to wet ground conditions or lack of equipment or access to timely spray contracting services, or there is a risk of take-all.

- Length of protection for either Jockey® or Impact ® is influenced by sowing time.

- A single upfront treatment of either Jockey® or Impact® may not provide enough protection in the medium to high rainfall zone in most situations.

- From an agronomic standpoint, the upfront options are most attractive where susceptible varieties are grown under shorter season conditions and where lower disease pressure has occurred, in which case the initial control measure may potentially protect the crop for the whole season.

- However, if growers and advisors are equipped with the knowledge of growth stages and ability to spray in crop, foliar fungicide strategies give a more flexible approach to protect the crop, since decisions are made later in the season when disease pressure can be more accurately determined. In medium and high rainfall areas the value ($/ha) of a single in crop (GS 39) spray for stripe rust control in varieties rated 3-5 was greater than the best up front options (Jockey® or Impact® in Furrow)

- In low rainfall areas and shorter seasons the overall response to fungicides is reduced, along with the clear advantage of foliar fungicides over up front options

- If the crop is under disease pressure, the longer the spray is delayed after leaf emergence the more difficult it will be to control the disease in that leaf, since the curative activity of most systemic fungicides is little more than 7-10 days.

- Under moderate disease infection with low rated varieties, stripe rust protection prior to GS39 can be critical.

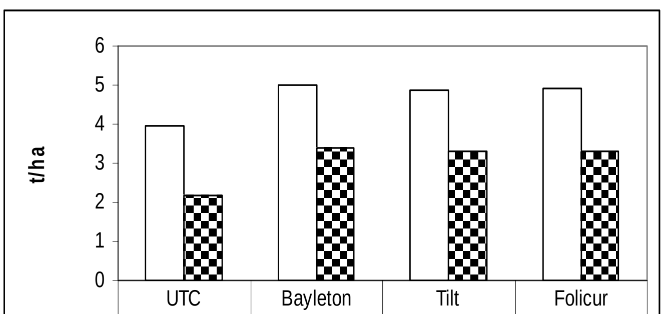
6. Product Comparison

There is mixed opinion regarding the most appropriate product to use for a preventative strategy. Results from 2003 and 2004 (on varieties rated 3-4) comparing fungicides shows little difference between the fungicides tested (refer Figure 10). The choice of product should be based on existing infection levels, varietal rating, seasonal conditions, length of protection required, and cost of product against expected yield and response.

There are significant differences between products relative to their length of protection and curative activity. Product choice becomes more important under higher disease pressure and when protecting very susceptible varieties. This choice is also influenced by cost per hectare and this factor is part of the decision making process when developing a management strategy.

Correct application timing is however still more important than product choice. Timing should be the focus of your management strategy.

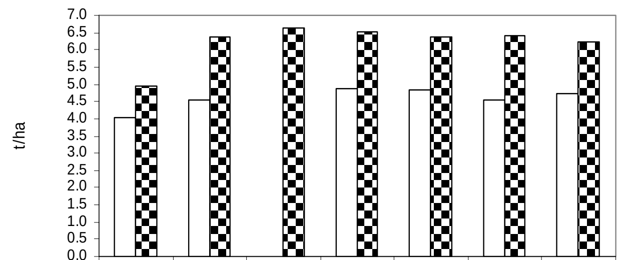
Figure 10. Comparison of Fungicide on Yield (t/ha)



	UTC	Bayleton	Tilt	Folicur
2003	3.95	4.99	4.89	4.93
2004	2.16	3.41	3.3	3.32

(UTC = Untreated control, Rates of product were Bayleton 1 L/ha, Tilt 250 mL/ha, and Folicur 145 mL/ha, LSD 2003 = 0.18, 2004 = 0.23)

Figure 11. Comparison of Combination Fungicides in Young 2004 and 2005. Variety Diamondbird



	UTC	B32 B39	B32 F39	B32 O39	J O39	J B39	I B39
2004	4.02	4.54	0	4.87	4.83	4.54	4.72
2005	4.94	6.37	6.62	6.53	6.38	6.41	6.23

(LSD: 2004 =0.36; 2005 = 0.68)
(B = Bayleton 500 mL/ha, F = Folicur 145 mL/ha, O = Opus 250 mL/ha, I = Impact and J =Jockey)

Figure 11 lists the detailed data for some of the common combination treatments at Young in 2004 and 2005. These are either at-sowing or GS32 treatments followed by a GS39 treatment. The focus for these results are the comparisons between treatments at GS39. Whilst there were minor yield differences, none were significantly different to each other in both years.

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2. FarmLink Research & Chandlers Landmark

Appendix 1: Stripe Rust Trial Summary 2003 - 2005

No.	Treatment	Rate/ha or /100kg seed	GS39 Applic.	Rate/ha	2005										2005			2004			2003
					Young[1]					Junee[2]					Harden[3]				Young[1]		
	Sowing date Site				Di'bird t/ha 17-Jun Young	Wheat Del. Silo $/ha ($150/t)	Cost of Treat. $/ha	Appl. Costs $/ha	Nett Return $/ha	H45 t/ha 15-Jun Junee	Wheat Del. Silo $/ha ($150/t)	Cost of Treat. $/ha	Appl. Costs $/ha	Nett Return $/ha	H45 t/ha 27-Jun Wombat	Drys t/ha 27-Jun Wombat	Ventura t/ha 27-Jun Wombat	H45 t/ha 6-Jun Wombat	Dim,bird t/ha 24-Jun Young	H45 t/ha 6-Jul Young	H45 t/ha 20-Jun Young
	% Flag LAI: 28 DA GS39				**53%**					**82%**					**99%**	**53%**	**0.10%**	**37%**	**2%**	**45%**	**10%**
1	Untreated				4.94	741.00	0.00	0.00	741.00	2.45	367.50	0.00	0.00	367.50	1.24	4.59	7.02	3.86	4.02	2.16	3.95
	Sowing Only																				
2	Baytan	100 ml								3.12	468.00	7.00	3.00	458.00							
3	Jockey	450 ml			6.10	915.00	22.00	3.00	890.00	4.08	612.00	22.00	3.00	587.00	3.69	5.78	6.86	5.61	4.41		
4	Impact	400 ml			6.11	916.50	20.00	3.00	893.50	4.86	729.00	20.00	3.00	706.00	3.36	5.90	7.09	4.01	4.47		
	Sowing + Foliar																				
5	Impact	400 ml	Bayleton	500 ml	6.23	934.50	23.00	15.00	896.50	5.61	841.50	23.00	15.00	803.50					4.72		
6	Jockey	450 ml	Bayleton	500 ml	6.41	961.50	25.00	15.00	921.50	5.39	808.50	25.00	15.00	768.50					4.54		
7	Jockey	450 ml	Opus	250 ml	6.38	957.00	37.00	15.00	905.00						5.96	7.10	6.72		4.83		
8	Impact	400 ml	Opus	250 ml											5.85	7.10	7.08				
9	Jockey	450 ml	Folicur	145 ml														5.80			
10	Impact	400 ml	Folicur	145 ml														6.08			
	Foliar Only GS32 & GS39																				
11	Bayleton	500 ml	Bayleton	500 ml	6.22	933.00	6.00	15.00	912.00										4.54		
12	Bayleton	500 ml	Bayleton	1000 ml	6.37	955.50	9.00	15.00	931.50	5.16	774.00	9.00	15.00	750.00							
13	Bayleton	500 ml	Tilt	250 ml	6.16	924.00	12.00	15.00	897.00												
14	Bayleton	500 ml	Folicur	145 ml	6.62	993.00	15.00	15.00	963.00												
15	Bayleton	500 ml	Opus	250 ml	6.53	979.50	18.00	15.00	946.50						5.63	6.93	7.19		4.87		
16	Bayleton	500 ml	AXtra	400 ml	6.32	948.00	38.00	15.00	895.00										4.98		
17	Tilt Xtra	250 ml	AXtra	400 ml	6.63	994.50	47.00	15.00	932.50												
	Foliar Only GS39																				
18			Bayleton	500 ml	5.81	871.50	3.00	12.00	856.50	4.88	732.00	3.00	12.00	717.00					4.54	3.26	
19			Bayleton	1000 ml	5.65	847.50	6.00	12.00	829.50	5.05	757.50	6.00	12.00	739.50						3.41	5.31
20			Tilt	250 ml						5.35	802.50	10.00	12.00	780.50						3.30	5.19
21			Folicur	145 ml						5.07	760.50	12.00	12.00	736.50				5.86		3.32	5.32
22			Opus	250 ml	5.68	852.00	15.00	12.00	825.00	5.50	825.00	15.00	12.00	798.00	4.71	6.78	7.20	6.07	4.63		
23			AXtra																4.65		
	Foliar Only GS32, GS39 & GS65																				
24		500 ml	Bay x 2	500 ml	6.06	909.00	9.00	27.00	873.00	5.73	859.50	9.00	27.00	823.50					4.90		
LSD					0.68				102.00	0.50				75.30	0.36	0.24	0.27	0.30	0.36	0.23	0.18
CV					7.94					7.27					5.63	2.57	2.59	3.78	5.49	4.72	

[1] Conducted by Chris Duff & Tim Condon formerly Chandlers Landmark & Peter Hamblin Agritech NSW
[2] Conducted by FarmLink
[3] Conducted by Nick Poole, Foundation for Arable Research (FAR) NZ.