Tebuconazole significantly reduces wheat yield under terminal spring drought

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Aim

The original aim of this experiment was to test whether application of foliar fungicide to crops moderately resistant/moderately susceptible to stripe rust with infection detected at GS39-45 and of average yield potential (1.5-2.5t/ha) results in a profitable yield response. However, the experiment was side-tracked by a somewhat surprising result.

Take home messages

- *In this experiment foliar application of tebuconazole at label rates to a wheat crop (cv. Yitpi) at GS38-49 resulted in a significant yield loss (0.43t/ha or a 43 percent decrease relative to the control)*
- *This is the first time such a difference has been recorded in fungicide trials conducted by BCG and FAR in the Mallee. All previous studies have at worst shown no yield response to application of tebuconazole. Much smaller yield losses (5-10 percent) have been recorded in response to application of faster-moving azoles in higher-yielding environments in the presence of drought and absence of disease*
- *In the Mallee, foliar applications of tebuconazole to wheat should be avoid if strip rust has not been detected or has only been found in low levels by flag leaf emergence in moderately resistant/ moderately susceptible crops, particularly if stored soil water is limited ie. if decile 1-3 seasons*

Method

Localised hot-spots and a low overall infection of stripe rust was detected in a 96ha paddock of wheat (cv. Yitpi) in early September 2008. The crop was growing on long fallow from 2007. Yield potential at that time was visually assessed to be around 2.0-3.0t/ha and calculated using Yield Prophet® to be between 1.3 and 4.2t/ha, with a 50 percent probability of achieving 2.1t/ha. The managers of the paddock decided to prevent further infection of stripe rust by applying a foliar fungicide. As Yitpi is also rated as 'susceptible' to stem rust, the triazole fungicide tebuconazole was selected as it also offers protection against this pathogen.

Tebuconazole (trade name Hornet®) was applied at 145ml/ha to the crop using a Case Patriot SPX4410 with Wilga SR110-04 nozzles on 17 September 2008 (GS38-49, emergence of the crop was staggered do to marginal seed-bed moisture at sowing). Swaths of 27.4 x 200m in length were systematically left untreated and paired to an adjacent treated area. An initial assessment of site infection of stripe rust (infection only, no consideration of chlorosis from adult plant resistance) was made at time of application. Disease level for each plot was assessed on 3 October 2008, 16 days after fungicide application when the crop was at GS61. Grain yield was measured using a commercial harvester and weigh bin on 2 December 2008 following crop maturity. For the control, two header swathes of 9.2m were taken from each plot, avoiding the wheel tracks from the spray operation. For the tebuconazole treatment, two header swathes were taken, one either side of the adjacent control plot.

A two-tailed Student's t-test assuming equal variance was used to test for significant differences between disease levels and harvest results for the two treatments.

The growth of the crop was simulated using APSIM 6.1 (www.apsim.info) parameterised using measurements of soil water and nitrogen made by the growers on 18 April 2008.

Location: Normanville (23 km east of Quambatook)

Replicates: 4

Sowing date: 25 May

Seeding density: 168 plants/m²

Crop type: Yitpi

Seeding equipment: Gason 'Trashmaster' with narrow points on 203mm row-spacing and prickle chain

Results

There was 37mm of plant available water and 122kg/ha of nitrate measured in the top 0.6m of soil at the site on 18 April 2008. From 1 April to 31 October, 142mm of rain was recorded at the grower's rain gauge located 3km west of the site, only 8mm of which fell after 17 September when the tebuconazole treatment was applied.

Initial site assessment prior to application of fungicide showed that 14 percent of main stems were infected with stripe rust. Infected plants typically had between one to five percent of flag-2 leaf tissue affected by the disease.

There were no significant differences (P>0.05) in the number of infected plants or amount of infected leaf tissue between the control and treatments when assessed 16 days following fungicide application (3 October, GS61). Across the site an average of 21 percent of main stems were infected, with infections only ever found on one leaf per plant, which varied from flag to flag-3. The mean area of each leaf that was affected by stripe rust was two percent.

The crop sprayed with tebuconazole yielded significantly less than the control (P<0.05, Table 1). There was no significant difference in grain protein or screenings between the two treatments (P>0.05, Table 1).

Table 1. Mean grain yield and quality parameters for the tebuconazole treatment and control.

Treatment	Yield t/ha	Protein %	Screenings (%)
1. Control	0.99	15.3	0.41
2. Tebuconazole (145 ml/ha)	0.56	15.6	0.48
P value	**0.01 (significant)**	**0.35 (not significant)**	**0.38 (not significant)**

There were no significant differences (P>0.05) in grain number per head, grain weight per head or mean grain weight between the fungicide treatment and the control.

Final attainable grain yield simulated by APSIM was 1.30t/ha. The soil water stress index calculated by APSIM, which is the proportion by which potential photosynthesis has been reduced by water stress, shows that the crop became stressed toward the end of August, and was experiencing consistently high levels of stress from around the time of fungicide application until crop maturity (Figure 1).

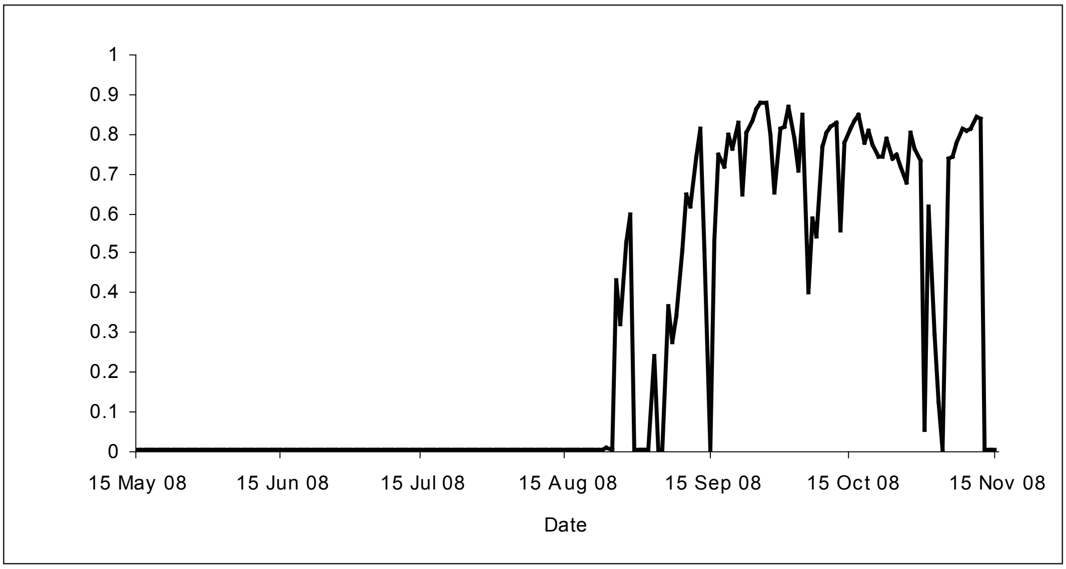

Figure 1. Crop soil water stress index for photosynthesis calculated for the site by APSIM 6.1. The stress value is the proportion by which potential photosynthesis has been reduced by water stress.

Interpretation

The reduction in yield in response to tebuconazole applied at label rates recorded in this experiment is of concern, particularly given the amount of fungicides applied in the Mallee in 2008 that have tebuconazole as an active ingredient (eg. Hornet® previously known as Foliclur®, Folicur®). This result is supported by many growers in the Normanville and Quambatook regions anecdotally observing negative visual and yield responses in wheat crops sprayed with tebuconazole in 2008. However, this is the first case in which such a large yield reduction in wheat has been recorded. Previous fungicide experiments conducted by BCG and FAR in the Mallee (eg. BCG and Poole 2005) have, at worse, only shown no yield response following application of tebuconazole.

Reduction in photosynthetic leaf area and consequently, transpiration, due to stripe rust infection is one mechanism that has been proposed to explain yield losses in response to fungicide application. In theory, crops with less photosynthetic leaf area due to stripe rust infection would transpire at a reduced rate, thus preserving more soil water for grain filling and increasing yield relative to crops in which stripe rust is controlled. However, this is unlikely to be the mechanism that is at play in this experiment, as there were no differences in infection level between the treatment and the control, and the amount of leaf area affected by the disease (two percent of infected leaf) could not explain such a drastic reduction in yield. Toxicity of the active ingredient of the fungicide itself is a more plausible explanation.

Tebuconazole is notable among most other foliar fungicides in that it is toxic to plants (phytotoxic) at rates normally required to provide adequate control against fungal diseases (Pederson 2007). Tebuconazole phytotoxicity has been recorded at higher use rates in many crop species including soy beans, cocoa, winter grass and rock melons (Holderness 1990 and Vawdrey 1994). In most of these published cases, symptoms have included obvious death of leaf tissue. There were no obvious visual differences between the control and tebuconazole treatment in this experiment. However, Pederson (2007) notes that symptoms of tebuconazole phytotoxicity may affect all or only parts of the plant (including roots), and can include only a subtle growth reduction.

The phytotoxic effects of tebuconazole appear to be exacerbated when applied to plants under drought stress (Pederson 2007). The wheat crop in this experiment was visibly drought-stressed from shortly after fungicide application to crop maturity, an observation supported by the APSIM output in Figure 1. High temperatures and the addition of crop oils to fungicide tank mixes are also thought to increase plant susceptibility, although no crop oils were used in this experiment. Phototoxic effects have also been shown to be variety dependent in *Poa annua* (winter grass) and soy beans.

Very little is known about phytotoxicity of tebuconazole in wheat. Smaller yield reductions (5-10 percent) than that observed in this study have been recorded in wheat in response to applications of other fast-moving azole fungicides, which is thought to be the result of leaf tipping in the absence of disease and presence of drought (N Poole, unpublished data).

Application

Given the findings of this experiment and the high temperatures and terminal drought conditions that are often a feature of spring in the Mallee, it is recommended that caution should be exercised when considering foliar fungicides in wheat.

Recommendations to apply fungicide to control stripe rust in the Mallee are often made to prevent the need for further crop monitoring and 'worry', the rationale being that if fungicide is applied and not needed, the error results in only a relatively low cost per hectare. If, on the other hand, fungicide is not applied when it should have been (eg. subsequent wet spring with high inoculation pressure and susceptible varieties), it is perceived that the consequent financial loss would be much greater. The results from this experiment show the losses could be more than the cost of funcicide per hectare, however further work is require to validate this. Tebuconazole is often chosen for its activity on stem rust, but with continued dry spring conditions ill-suited to the spread of this pathogen, and the release of cultivars adapted to the Mallee that have good resistance (eg. Correll, Young), its usefulness in the future may be limited.

Further to this, positive yield responses to any kind of foliar fungicide are rarely seen in the Mallee and growers and their advisors could question the role that they currently play in our farming systems. Based on all evidence accumulated to date, a simple rule of thumb would be that foliar fungicides should not be applied in the Mallee if stripe rust has not been detected or has only been found in low levels by flag leaf emergence in moderately resistant/moderately susceptible crops, particularly if stored soil water is limited, ie. in decile 1-3 seasons.

There is scope for further research to see if the results observed in this study can be repeated with both tebuconazole and other azole fungicides, and a mechanism of yield loss determined. A review of previous foliar fungicide experiments in low rainfall environments to determine if this is an isolated incident would also be of value.

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References

BCG, Poole N (2005) Fungicide strategies in wheat. BCG-WFS 2004/05 Wimmera and Mallee crop and pasture production manual – members only edition, pp 156-61.

Holderness M (1990) Control of vascular-streak dieback of cocoa with triazole fungicides and the problem of phytotoxicity. Plant Pathology **39** 286-293.

Pederson M (2007) Method of reducing phytotoxicity on plants susceptible to triazole fungicides. World Intellectual Property Organisation Publication Number WO/2007/028388 www.wipo.int/pctdb/en/wo.jsp?IA=DK2006000484&DISPLAY=DESC

Vawdrey LL (1994) Evaluation of fungicides and cultivars for control of gummy stem blight of rockmelon caused by *Didymella bryoniae*. Australian Journal of Experimental Agriculture **34** 1191 – 1195.