# Autumn sown wheat requires different fungicide inputs under irrigated and dryland conditions

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## Abstract

This paper summarizes two seasons of fungicide programme by cultivar resistance trials in autumn sown wheat for the control of septoria tritici blotch (STB) caused by the fungal pathogen *Zymoseptoria tritici* under irrigated and dryland conditions in Canterbury. Variation in STB development between seasons, driven by rainfall and infection events, resulted in different optimum fungicide programmes depending on disease pressure. In 2016-17, a high disease pressure season, a four spray fungicide programme was optimal under irrigation regardless of cultivar resistance to STB with a margin over fungicide cost (MOFC) up to $1519/ha. In dryland conditions a two spray programme produced the greatest net returns of up to $990/ha. Under low disease pressure conditions in 2017-18, the highest irrigated yields and a MOFC of up to $454/ha were achieved with a three spray programme. Drought conditions in 2017-18 resulted in lower dryland yields and negative MOFC. To optimise disease control with economic returns farmers should consider an integrated disease management approach taking into account, time of sowing, rainfall and irrigation.

***Additional keywords:*** septoria, irrigation, disease pressure, yield response, margin over fungicide cost

## Introduction

Septoria tritici blotch (STB) caused by *Zymoseptoria tritici* is can cause major yield loss of autumn sown wheat, particularly when the top three leaves in the canopy are affected (Thomas *et al.*, 1989; Robert *et al.*, 2018). Spring-summer infection is spread by asexual fruiting bodies (pycnidiospores) when the plant is going through stem extension, and is aided by high relative humidity (Hess and Shaner, 1987) and rain splash (Shaw and Royal, 1993), although any crop wetness, such as dew, or irrigation can spread spores and even leaf to leaf contact by wind movement can result in spread in dry weather (AHDB, 2012).

Internationally, yield losses to STB of up to 60% have been recorded in epidemic years (Raman and Milgate, 2012; FAR, 2017a). Typically annual losses range from 5-25%, with major variation from year to year caused by disease pressure and cultivar susceptibility (Jørgensen *et al.*, 2008; Fones and Gurr, 2015).

Farmers need to consider using an integrated approach using crop rotation, stubble management, time of sowing, cultivar resistance and an understanding of weather conditions from the start of stem extension to the end of anthesis (Raman and Milgate, 2012; FAR, 2016a). This is important for many farmers operating in a dryland, lower yielding environment, as an intensive fungicide programme can be uneconomic (Raman and Milgate, 2012; FAR 2016a).

The objective of this experiment was to determine appropriate fungicide programmes to maximise the margin over fungicide cost for farmers in both irrigated and dryland conditions. This information will contribute to a cereal disease management strategy for New Zealand cropping farmers.

## Materials and Methods

Two trials in adjacent areas, one under irrigated and one under dryland conditions were conducted at FAR's Chertsey Arable Research site (43°47'32"S; 171°51'49"E) in the 2016-17 and 2017-18 seasons. The previous cropping history for both trials was pasture. The soil type was a Chertsey shallow silt loam (Kear *et al.* 1967). This soil type is stony and free draining. A weather station was on site and recorded continuous temperature, relative humidity, rainfall and leaf wetness.

Individual plots (10 m x 1.65 m) were drilled with a belted cone plot drill on 14th April 2016 and 21st April 2017. The experimental design was a split plot design with four replicates with the fungicide programme (Table 1) as main plots and cultivar as sub-plots. Cultivars were selected based on their genetic resistance to STB, with Excede (mostly susceptible), Starfire (moderately resistant) and Inferno (mostly resistant) in Year 1 (FAR, 2016b). The cv. Wakanui (moderately resistant) replaced Starfire in Year 2 due to the increased susceptibility of Starfire to STB (increased from moderately resistant to moderately susceptible) in the 2016-17 season (FAR, 2017b).

**Table 1:** Fungicide treatments expressed in g a.i/ha and application dates.

| | 28 Sep 2016<br>27 Sep 2017<br>GS30-31 | 17 Oct 2016<br>13 Oct 2017<br>GS32 | 9 Nov 2016<br>3 Nov 2017<br>GS39 | 24 Nov 2016<br>28 Nov 2017<br>GS65 |
|---|---|---|---|---|
| Untreated | Nil | | | |
| 2 Spray | | BX 52.5/ PT 150 | FP 62.5 /EP 62.5 + EP 31.3 | |
| 3 Spray | | BX 52.5/ PT 150 | FP 62.5 /EP 62.5 + EP 31.3 | EP 62.5 + PY 100 |
| 4 Spray | EP 125 | BX 52.5/ PT 150 | FP 62.5 /EP 62.5 + EP 31.3 | EP 62.5 + PY 100 |

EP = epoxixonazole, BX = bixafen, PT = prothioconazile, FP = fluxapyroxad, PY = pyraclostrobin

Irrigation was applied by overhead sprinklers with a total of 225 mm in seven applications and 305 mm in nine applications to the irrigated trials in 2016-17 and 2017-18 respectively. The trial area received 126 mm (2016-17) and 44 mm (2017-18) of rainfall between the start of stem extension (GS 30) and anthesis (GS 65). Foliar fungicide treatments were applied using a backpack type plot sprayer with a 1.65 m hand held boom equipped with four 110015 and two 6501 flat fan nozzles applying 180 L water/ha at a pressure of 210 kPA.

In all trials, disease assessments were carried out at growth stage (GS) 30 (Zadoks *et al.* 1974), where 30 plants were randomly selected from across the trial area. Visual disease assessments were made based on the percentage of leaf area affected with STB on the three newest leaves on the main stem (James, 1971). Subsequent assessments were carried out at GS 32 (untreated and four spray programme only), GS 39, 65, 75-80 and GS 75-80 + 21 days (all treatments). At each assessment timing 10 main stems were randomly selected per plot and the percent disease infection was recorded on the top three leaves.

Thermal time (°Cd) was calculated as the sum of mean daily temperature, with a base temperature of 0°C. Margin over fungicide cost was calculated as (treatment yield x wheat price \$/t – (fungicide cost + application cost)) – (control yield x wheat price \$/t). The average price of wheat was \$340/t. An allowance of \$15/ha per fungicide application was included. All values were calculated excluding GST.

Plots were harvested using a Sampo® small plot combine at approximately 14% moisture content. The dryland and irrigated trials were harvested on the 27th January and 3rd February in 2017 and 9th January and 25th January in 2018 respectively. Statistical analysis was completed with Genstat® (18th edition VSN International Ltd, UK) using analysis of variance (ANOVA). Non-linear polynomial quadratic and sigmoid regression were used to fit disease progress curves. Where significant effects were observed ($P<0.05$), differences were compared using least significant difference (LSD) procedure ($P=0.05$).

## Results

### Disease progression

Disease progress in control treatments is summarised in Figure 1. The data shows contrasting STB development across two trial seasons. When disease severity was plotted against thermal time from the start of stem extension (GS 30), it increased earlier in 2016 than 2017. In 2016-17, there was a total of 126 mm of rainfall, 667 hours of RH >85%, and 23 infection risk periods (24 hours of consecutive leaf wetness) between the start of stem extension (GS 30) and anthesis (GS 65). These conditions led to high disease pressure and rapid STB development that was similar under both irrigated and dryland conditions. STB infection in untreated plots reached a maximum of 100% on the top two leaves 1133 °Cd after the start of stem extension (GS 30) for mostly susceptible (MS) Excede and moderately resistant (MR) Starfire (Figure 1a-d). The mostly resistant (MRR) cultivar Inferno had significantly less disease than Excede and Starfire in both trials.

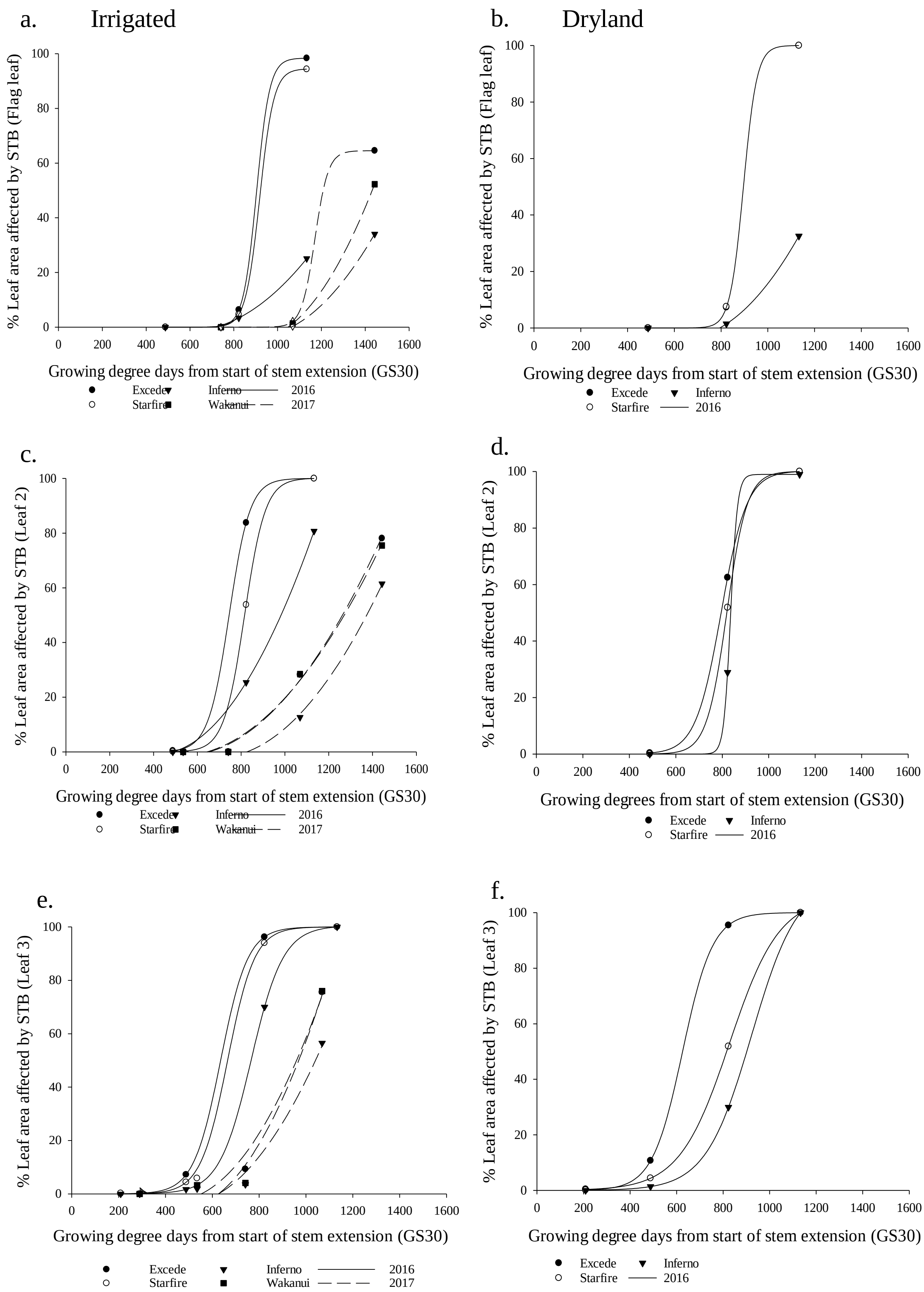


**Figure 1:** The development of untreated Septoria tritici blotch infection (%leaf area affected) against thermal time since the start of stem extension on (a-b) the flag leaf, (c-d) leaf 2 and (e-f) leaf 3.

On leaf three, >90% infection by STB was observed by 823 °Cd post GS 30 for Excede and Starfire. In contrast, Inferno had 70% infection (Figure 1c). Use of a four spray programme reduced STB severity compared to two and three spray programmes for irrigated Excede and Starfire, but not Inferno, with no differences between fungicide programmes (Figure 2a). Under dryland conditions differences between fungicide programmes were variable (Figure 2b).

In 2017-18, weather conditions were not conducive to the development of STB with 44 mm of rainfall, 556 hours of RH >85% and 3 leaf wetness infection risk periods between the start of stem extension and anthesis. It took 1443°Cd after GS 30 for disease to reach 65, 52 and 34% leaf area affected by STB for untreated Excede, Wakanui and Inferno on the flag leaf and 78, 75 and 62% on leaf two in the irrigated trial (Figure 1a-d). Under dryland conditions disease reached 12, 11 and 7% leaf area affected by STB on the flag leaf for Excede, Wakanui and Inferno and 19, 23 and 18% on leaf two respectively. Severe drought stress resulted in early senescence in the 2017-18 dryland trial. The final disease assessment on leaf 3 was conducted 1069 °Cd after the start of stem elongation with 75, 76 and 56% and 12, 7 and 6% for irrigated and dryland Excede, Wakanui and Inferno respectively. Despite low incidence of disease, all fungicide programmes reduced STB severity compared to the untreated ($P<0.001$). In both trials there were minimal disease incidence differences between two, three and four spray programmes (Figure 3).

## Grain yield

Under high disease pressure conditions in 2016-17 the highest yields were achieved with a four spray programme with 11.4, 11.5 and 12.2 t/ha under irrigation and 10.3, 9.8 and 10.1 t/ha under dryland conditions for the cultivars Excede, Starfire and Inferno respectively (Figure 2c-d). Four spray programme yields were significantly higher than two and three spray programmes for all cultivars under irrigation but with only Inferno under dryland conditions. Calculation of margin over fungicide cost (MOFC) generated a positive return to all fungicide programmes. The best economic response under irrigation was with a four spray programme with $1519, $1416 and $1074/ha for Excede, Starfire and Inferno. Under dryland conditions, the highest net return was with a two spray programme with $990, $758 and $370/ha for Excede, Starfire and Inferno respectively. Under high disease pressure and irrigation, all cultivars required the maximum number of fungicide applications, regardless of cultivar resistance rating.

In the low disease pressure 2017-18 season, the highest irrigated yields were 10.7, 10.7 and 10.8 t/ha for Excede, Wakanui and Inferno, while drought stress limited dryland yields to 5.1, 5.4 and 4.8 t/ha for Excede, Wakanui and Inferno respectively (Figure 3c-d). All fungicide programmes increased yield ($P<0.001$) relative to the untreated under irrigation, but there were no significant yield differences between two, three and four spray programmes. Under dryland conditions, the application of fungicide did not significantly increase yield. With irrigation the highest net returns were $454 and $252/ha for Excede and Inferno with a three spray programme and $298/ha for Wakanui with a two spray programme. Under dryland conditions all of the fungicide programmes

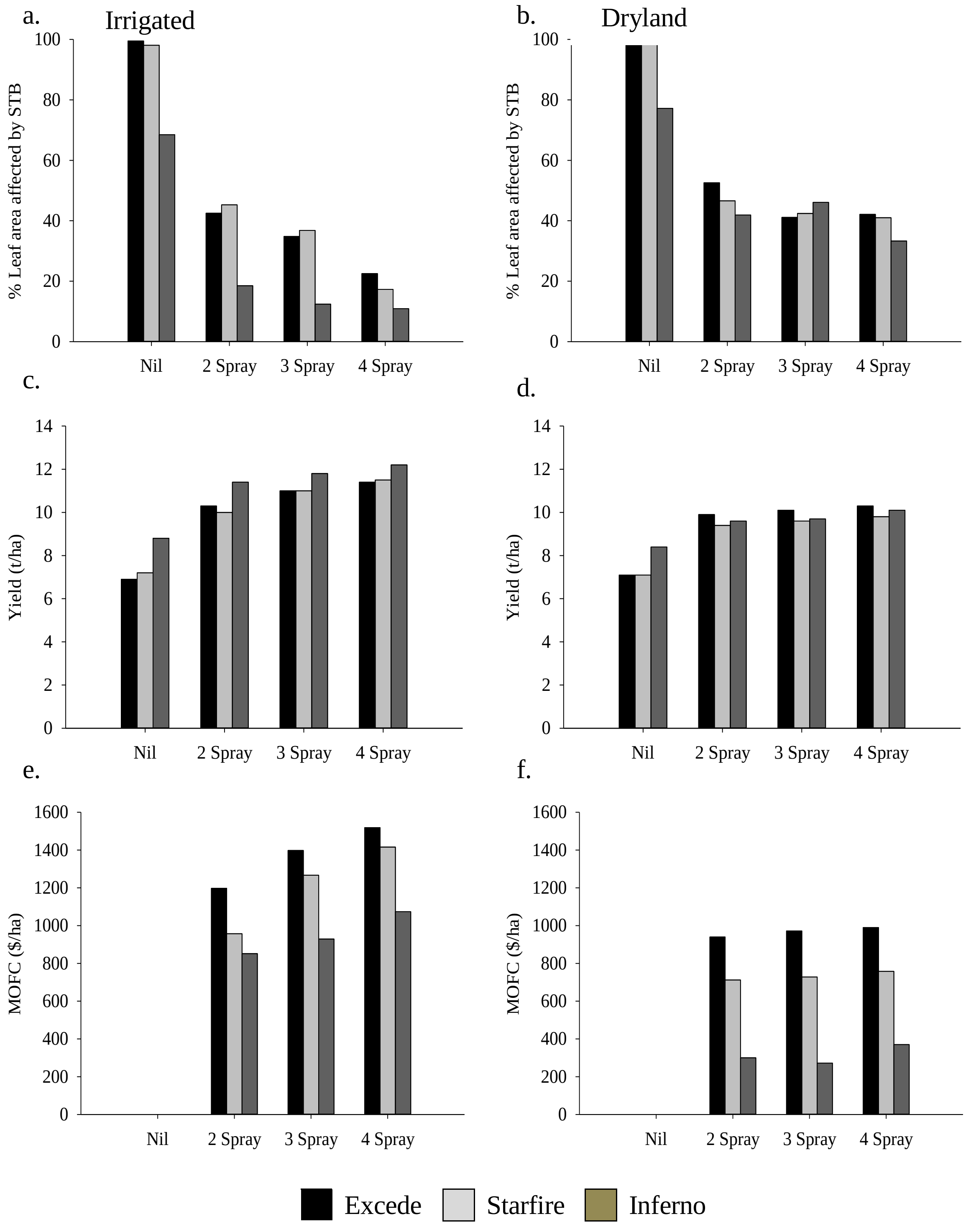


**Figure 2:** The effect of fungicide programme on mean % leaf area affected (top three leaves) by STB at GS 75-80, (a-b), yield (t/ha) (c-d) and margin over fungicide cost (MOFC, $/ha) (e-f) of autumn sown wheat at Chertsey 2016-17.

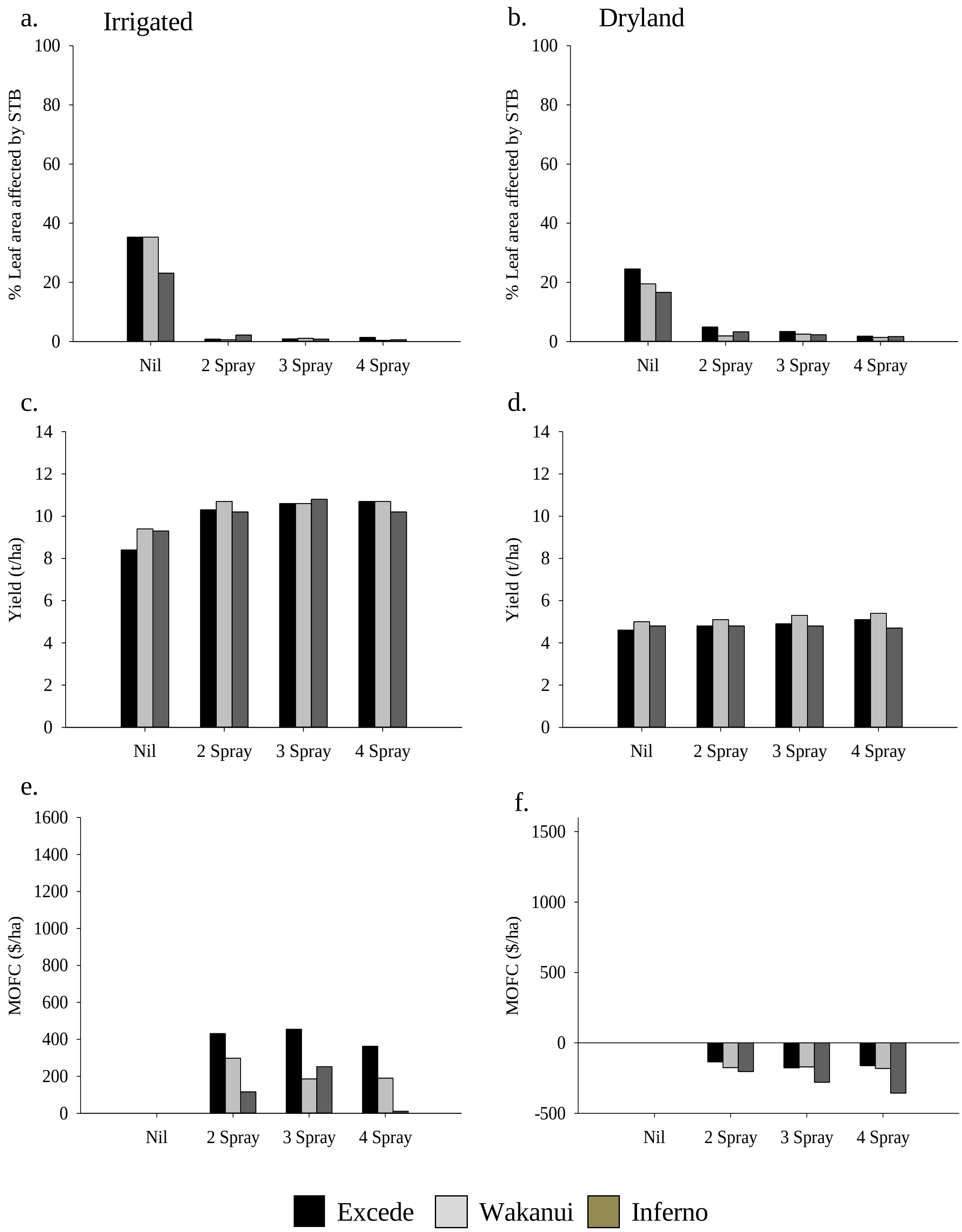


**Figure 3:** The effect of fungicide programme on mean % leaf area affected (top three leaves) by STB at GS 75-80, (a-b), yield (t/ha) (c-d) and margin over fungicide cost (MOFC, $/ha) (e-f) of autumn sown wheat at Chertsey 2017-18.

were uneconomic with losses of $135-162/ha for Excede, $176-182/ha for Wakanui and $204-357/ha for Inferno.

## Discussion

Septoria tritici blotch is a major fungal plant disease of wheat in New Zealand (Marroni *et al.,* 2006). The economic impact varies from year to year and between cultivars creating challenges for farmers to effectively control disease in a given field in a given season. A farmer may sow early to chase potentially higher yields (Craigie *et al.,* 2015). In such a crop, the risk of STB development is increased as early planted crops are more likely to be exposed to sufficient rainfall and humidity to encourage disease spread (Fones and Gurr, 2015), especially if under irrigation. A farmer in this high disease pressure scenario may wish to consider a more intensive fungicide programme than a farmer operating in low-moderate disease pressure conditions or a lower yielding dryland environment (Raman and Milgate, 2012; FAR, 2016a).

The variability of STB infection was highlighted over three seasons of FAR trials. During 2014-15 and 2015-16, trials were conducted on both disease resistant and susceptible cultivars, under irrigated and dryland conditions as well as early and later sowings. Results from these low disease pressure seasons showed lower yield responses to controlling disease and in some cases, response to disease control was uneconomic (FAR, 2016a). In trials run in 2016-17, a high disease pressure season, the average yield response to fungicide of 4.4 t/ha compared to 1.8 t/ha for the previous two seasons (FAR, 2017a).

The present study showed that under high disease pressure in 2016-17, the highest yield and MOFC was generated with the most intensive four spray fungicide programme under irrigation, regardless of cultivar. Under high disease pressure in dryland conditions, although a three spray programme yielded higher, the two spray programme was the most economic. Under low-moderate disease pressure in 2017-18, a three spray programme produced the highest net returns under irrigation, while response to disease control was uneconomic under dryland conditions. The rate of disease progress under high and low disease pressure seasons was modelled by Robert *et al.* (2018), who found that when disease was plotted against thermal time from sowing, disease progressed much earlier in wet seasons than dry seasons, by up to 300-400 °Cd depending on leaf level. Like the current study, disease progress was driven by regular rainfall and infection events and resulted in fast, regular disease progress.

Data from the UK suggests that greater cultivar resistance makes the choice of the fungicide programme less critical (Young *et al.,* 2018). The present study showed that, like Jørgensen *et al.* (2008), the difference between optimal fungicide input in resistant or susceptible cultivars was relatively small. Like both Jørgensen *et al.* (2008) and Young *et al.* (2018), data showed less yield loss with resistant cultivars compared to susceptible cultivars. This has implications for growers, in that use of a more resistant cultivar can reduce potential losses if fungicide timing is not optimal due to a lack of spray windows (Young *et al.,* 2018).

The present study showed that variation in STB development between seasons resulted in different optimum fungicide programmes for high and low disease pressure conditions. Even after taking rainfall and cultivar resistance into account, irrigated autumn sown wheat required a more intensive fungicide programme than under dryland conditions. An integrated approach to disease management is important for farmers to realise optimal disease control and economic returns.

## Acknowledgements

The authors thank the New Zealand Arable team for trial management and harvest and FAR (Foundation for Arable Research) for funding the research.

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