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Efficacy of two and three-spray programmes with new strobilurin fungicides in winter wheat

by

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CONTENTS

Abstract

Fungicide programmes were compared in two experiments a year for three years, one in a susceptible variety to *Septoria tritici* (Consort) and one in a less susceptible variety to *S. tritici* (Deben) at Manor Farm, Morley St Botolph, Norfolk on a sandy loam soil. In all three seasons *S. tritici* was the predominant foliar disease. The occurrence of the mutation in isolates that confer resistance of *S. tritici* to strobilurins increased rapidly during the period when the experiments were carried out, from a relatively low level at the beginning of the 2002 growing season to a very high level at the end of the 2004 growing season. Due to the changing background of fungicide resistance, the conclusions drawn reflect only the individual years and the location in which the experiments were done:

- Cultivars susceptible to *S. tritici* required a three-spray programme to provide a reliable and economic level of disease control. Changes in resistance to the strobilurins over the time period of the project may have influenced the number of sprays required in the less susceptible variety.
- In less disease susceptible varieties in particular, there was some flexibility in the timing of the second fungicide application (T2 - typically at full flag leaf emergence) within a two or three-spray programme. The degree of flexibility was governed by the dose of fungicides at the first application (T1 – typically at final leaf three emergence). Disease pressure late in the season and fungicide dose also appeared to be influenced by the level of resistance to the strobilurins.
- There was a possible advantage in delaying T2 to early ear emergence where it contained a strobilurin, even when a third fungicide application (T3 – typically at mid-anthesis) not containing a strobilurin was applied. This was recorded in Consort in 2002, despite a slight reduction in disease control, when resistance to the strobilurins was not of great significance but did not occur in 2003, when resistance was more significant. However, it was still recorded in Deben in 2003 (there was insufficient disease in Deben in 2004 to base any conclusion).
- If T2 is delayed to ear emergence the benefit of a T3 application is not necessarily diminished and may be enhanced, particularly if the T3 is strobilurin based and the T2 does not include a strobilurin.
- With increasing resistance to strobilurins throughout the project the emphasis of their value appeared to change from *S. tritici* control and ear disease control plus some "physiological" benefits to ear disease control and "physiological" benefits. This suggests that if there is a role for strobilurins on future wheat crops they should be applied at the later timings within the fungicide strategy, particularly at T3.

Summary

Objectives

- To measure the cost and flexibility of a two spray programme in a disease susceptible variety of wheat and to determine the initial dose necessary to provide such flexibility.

- To measure the cost and flexibility of a two-spray and one-spray programme in a disease tolerant variety.

- To compare the cost effectiveness and flexibility of strategies involving a reduced number of spray applications with three-spray programmes.

Materials and methods

Two experiments were conducted in each growing season from 2002 to 2004 at Morley St Botolph, Wymondham, Norfolk. In each year one experiment was conducted on the cultivar Consort which is relatively susceptible to *Septoria tritici* (HGCA/CEL Recommended List rating 4) and brown rust, (Recommended List rating 4) and the other was conducted on the cultivar Deben, which is more tolerant to *S. tritici* (Recommended List rating 6) and brown rust (HGCA/CEL Recommended List rating 5). Crops were drilled as first wheats from late September to mid-October to minimise the potential impact of eyespot and take-all (*Gaeumannomyces graminis*).

Foliar treatments were applied in accordance with the treatment list which was adapted each season according to results in the previous year and in response to the rapid advancement of *S. tritici* resistance to strobilurins.

In 2004 the impact of resistance to strobilurins on fungicide strategy in both disease susceptible and less disease susceptible programmes was tested and the most appropriate timing for a single strobilurin application within a two-spray programme on disease tolerant varieties was evaluated. Treatments were also designed to evaluate the most appropriate T2 timing (the second fungicide

application, typically at full flag leaf emergence, GS 39) when using the newer generation of strobilurins, particularly in a programme using a single application of strobilurin on disease susceptible varieties. In both susceptible and less susceptible varieties the role of chlorothalonil within fungicide strategies was also evaluated.

Foliar fungicide applications were timed as closely as possible to protocol guidelines. All other agrochemical and fertiliser inputs were applied in accordance with Good Agricultural Practice. All experiments were conducted as a randomised block design with three replicates.

At each assessment disease and or green leaf area was recorded as percentage infection on each individual leaf layer on a whole plot basis. Each season assessments were carried out across the whole experimental area to establish base levels of disease just prior to the first fungicide application. In all years disease and green leaf area assessments of final leaves 1 to 3 in all plots were scheduled at GS 75 (milky ripe). From GS 75, weekly green leaf area assessment of the top three leaves was carried out until all upper leaves had senesced. The plots were harvested and yields (t/ha at 85% dm) and specific weights (kg/hl at 85%dm) were calculated. Data were analysed using analysis of variance (ANOVA).

Key results and conclusions

Consort (cultivar susceptible *S. tritici*)

In all three years, three-spray programmes gave the most reliable margins. However, in 2002, when resistance was at a low level, some two spray treatments gave similar margins to a three spray strategy, despite relatively high disease pressure from *S. tritici* throughout the season. In 2003 and 2004, disease pressure was lower and comparisons between two and three-spray programmes were less clear. In these years the best two-spray programmes based on strobilurin/triazole mixtures gave yields that were not significantly different to the three-spray programmes, particularly in 2003 when disease pressure developed late rather than early in the season. However, in all three years predicting optimum doses in a two spray strategy and achieving the optimum T2 timing to obtain margins similar to a three spray strategy would have been difficult if not impossible to achieve in practice.

In 2002 strobilurins applied at T1 (the first fungicide application, typically at the emergence of final leaf three at the second node detectable stage, GS 32) and T3 (the final fungicide application, typically at mid-anthesis, GS 65) gave the best yields and margin over fungicide costs, data also suggests that these timings were perhaps the most reliable in 2003. However, in 2004 programmes including strobilurins at T2 and T3 appeared to be more reliable. This does not reflect disease development in that season (i.e. relatively high pressure early in the season) but may reflect the changing role of strobilurins from leaf and ear disease control plus green leaf retention to ear disease control and green leaf retention as *S. tritici* resistance to strobilurins developed. This result is also reflected in the findings of HGCA project 2533 (Project Report 385 - Disease control programmes using triazole and strobilurin fungicides on winter wheat). There were no one-strobilurin based programmes on Consort in either project.

In 2002, there was a financial advantage in delaying the T2 strobilurin-based application from GS 39 to half ear emergence (GS 55), where they generally maintained green leaf despite poorer disease control in both two and three-spray programmes. This may have been due to application of strobilurin onto the ear (no strobilurin was included in the T3 application) or a physiological effect from the later application of the strobilurin. This effect was not consistently noted in 2003 and 2004 particularly with programmes containing the lower doses of strobilurin. This may have been due to the building resistance to strobilurins and hence more of a penalty from *S. tritici* control from delayed application. The data suggest that this is a consequence of the physiological benefits from the strobilurins (plus some control of ear diseases) which are more likely to occur once the ear is emerging particularly as there is no benefit from their application for the control of *S. tritici*, due to resistance.

The higher doses of fungicide used at T1 (particularly with chlorothalonil) gave more flexibility in the T2 timing and hence reduced the impact of delayed T2 application.

T3 applications tended to be more cost-effective where T2 was delayed beyond GS 39. This occurred particularly in 2002 and 2004. This is counter-intuitive as there would be an assumption that delaying T2 would reduce the value of the T3.

These results must be treated with care as there is a widespread, high level of resistance of *S. tritici* to strobilurins and also an increasing shift in the resistance of *S. tritici* to triazoles.

Deben (cultivar less susceptible to *S. tritici*)

The variety Deben is less susceptible to *S. tritici* compared with Consort and was also sown later, - hence, disease (*S. tritici*) pressure was significantly less than in the Consort experiments.

Single sprays were tested in 2002 when *S. tritici* pressure was relatively high throughout the season. There were no significant differences between dose or timing of a single strobilurin-based application, however, there was a consistent trend suggesting that the higher the dose the later the single application could be made to optimise returns. Yields were significantly higher when the same dose was split between two applications. There also appeared to be more consistency in the choice of dose and flexibility of timing in a two-spray programme to optimise returns than in Consort in the same year. There was no yield advantage to a three-spray programme.

2003 was a lower disease year with the greatest pressure from *S. tritici* occurring late in the season. There were very few significant yield differences between any of the treatments and any differences were small. However, the data suggest that three-spray programmes based on a T1 of triazole + chlorothalonil provided similar margins to a two spray strategy where each application was based on strobilurin. The main messages from the results this year was the wide degree of flexibility in the timing of the T2 spray within a three-spray programme. There appeared to be an advantage to applying a strobilurin based T2 at or after ear emergence where T3 did not include a strobilurin but this advantage was not so obvious where T3 included a strobilurin.

Three-spray strategies with a single strobilurin timing were compared in 2003 and 2004. In 2003, a strobilurin-based treatment at T2 provided a significant yield advantage when delayed from GS 39 to GS 55; however, this later treatment only produced a similar yield to where a single strobilurin was applied at T3. This also indicates that the benefit from the strobilurin occurred when applied to the ear.

In 2004, there were no significant responses to fungicides in this experiment and hence no clear conclusions.

Conclusions

In all years *S. tritici* was the predominant foliar disease. In 2002 *S. tritici* pressure was relatively high throughout the season, in 2003, high septoria pressure occurred relatively late in the season in contrast to 2004 when disease pressure was relatively high early in the season and then continued to develop more steadily.

Cultivars susceptible to *S. tritici* (e.g. Consort) usually required a three-spray programme except in locations and or seasons where there was very low disease pressure and/or rapid loss of green leaf at the end of the season. Hence, in many situations a deliberately stretched, two-spray programme would not have been advisable on a disease susceptible variety, even where there was no *S. tritici* resistance to the strobilurins.

Varieties less susceptible to *S. tritici* (e.g. Deben) only required a two-spray programme based on strobilurins when resistance of *S. tritici* to their mode of action was not significantly reducing their efficacy. However, with high resistance to strobilurins a three-spray programme, based on triazole +/- chlorothalonil at T1 (1st fungicide application) and T2 (2nd fungicide application) and a strobilurin at T3 may be more robust where the weather is conducive to late-season development of *S. tritici*.

There is some flexibility in the timing of T2 within a three-spray programme. The degree of flexibility is governed by disease pressure from the flag leaf stage onwards, fungicide dose and disease susceptibility of the variety and also appeared to be influenced by the level of resistance to the strobilurins. “Sufficient” doses of triazole and chlorothalonil are required at T1 to give flexibility in the timing of T2. In less susceptible varieties there is more flexibility in the timing of the second application, with a large application window for optimum results. This is because the impact of the lower disease control on yield was less than the possible benefits from ear disease control and green leaf retention.

In Deben in 2003, a single strobilurin based treatment at T2 in a three-spray programme provided a significant yield advantage when delayed from GS 39 to GS 55; however, this later treatment only produced a similar yield to where a single strobilurin was applied at T3. This also indicates that the benefit from the strobilurin occurred when applied to the ear.

If T2 is delayed until ear emergence the benefit of a T3 application is not necessarily diminished and may be enhanced, particularly if the T3 is strobilurin based and the T2 does not include a strobilurin. This may be because the T3 compensates for poorer disease control as a result of the delayed T2. Therefore, growers should not justify delaying T2 (until GS 55) whilst hoping that a T3 application can be avoided.

In situations with low to moderate disease pressure flexibility in the timing of T2 can be used to prioritise high demands on labour and machinery. A more cautious approach should be taken when growing a more susceptible variety in regions and seasons where disease pressure is greater.

Changes in the susceptibility of *S. tritici* to the triazoles may reduce the flexibility of the T2 timing.

Detailed technical report

1. Introduction

HGCA Project Report 281 (Exploiting new fungicides to reduce fixed costs) suggested that on cultivars which are less susceptible to *Septoria tritici* e.g. Claire the 'first generation' of strobilurin fungicides enabled a reduction in the number of fungicide sprays within a programme from three to two. However, on *S. tritici* susceptible varieties, such as Consort a three-spray policy including two strobilurin applications was required.

At the conception of this project 'second generation' strobilurins, such as pyraclostrobin, held significant eradicant and persistent properties providing a prolonged period of protection against disease. This project was designed to investigate whether a two-spray policy in less susceptible varieties would be more robust and whether a two-spray policy in susceptible varieties may be a possibility using pyraclostrobin.

With such an approach there are issues relating to the cost, flexibility and robustness of the programmes, this project aimed to examine the cost effectiveness of a flexible approach as this may be of great significance in an industry that is attempting to minimise labour and machinery costs.

Since the beginning of this project there has been a rapid rise in *S. tritici* resistance to strobilurins, this resistance is now frequent and widespread throughout the United Kingdom. In response to *S. tritici* resistance to strobilurins in 2003 and 2004 the strobilurin based treatments were supplemented by additional triazole and/or chlorothalonil to compensate for the expected poorer control of *S. tritici*.

2. Materials and methods

2.1 Sites

Two experiments were conducted in each growing season from 2002 to 2004 at Manor Farm, Morley St Botolph, Wymondham, Norfolk. In each year one experiment was conducted on the cultivar Consort which is relatively susceptible to *S. tritici* (HGCA/CEL Recommended List rating 4) and brown rust (*Puccinia recondita*), (HGCA/CEL Recommended List rating 4) and the other was conducted on the cultivar Deben which is less susceptible to *S. tritici* (Recommended List rating 6) and brown rust (HGCA/CEL Recommended List rating 5).

In 2002 *S. tritici* pressure was relatively high from early spring, increasing in severity as the season progressed; traces of brown rust were seen in the untreated Consort from mid July. In early July, *S. tritici* was affecting 23.3, 50.0 and 71.7% of the area of final leaves 1, 2 and 3 respectively of untreated crop. In 2003 *S. tritici* symptoms were visible from early spring but the disease spread relatively slowly in the following dry conditions. Despite this slow start, rain during the spring encouraged disease development and by early July levels of disease in the untreated Consort were moderate to high with *S. tritici* affecting 3.7, 17.3 and 71.7% of the area of leaves 1, 2 and 3 respectively of untreated crop. During 2004, Septoria pressure was relatively high in early spring and then proceeded to develop more steadily reaching 9.3%, 36.7% and 46.7% on the flag (leaf 1), final leaf 2 and leaf 3 respectively on the untreated Consort in late June.

The variety Deben is less susceptible to *S. tritici* compared with Consort and was sown later, hence, disease (*S. tritici*) pressure was significantly less than in the Consort experiments.

Crops were drilled as first wheats from late September to mid October to minimise the potential impact of eyespot and take-all (*Gaeumannomyces graminis*). All experiments were conducted on a medium sandy, loam over chalky boulder clay (Ashley series).

2.2 Experimental design

A randomised block design incorporating between 24 and 26 treatments with three replicates was used for all experiments.

2.3 Data handling

Disease, green leaf area, yield and grain quality data was collected either manually or directly onto hand held computers. After collection all data was transferred to the statistical package Advanced Research Manager (ARM).

Table 1. Summary of site information, cultivar Consort

Site	**2002**	**2003**	**2004**
Drilling date	1 October 2001	25 September 2002	30 September 2003
Previous crop	Peas	Peas	Set aside

Table 2. Summary of site information, cultivar Deben

Site	**2002**	**2003**	**2004**
Drilling date	9 October 2001	4 October 2002	24 October 2003
Previous crop	Sugar beet	Peas	Sugar beet

2.4 Statistical analysis

Data was analysed in ARM using analysis of variance (ANOVA) with LSD's quoted at P=0.05.

2.5 Fungicide treatments

Sprays were applied in a water volume of 200 l/ha using hand-held, pressurised plot spraying equipment fitted with flat fan nozzles, selected to produce a medium spray quality at 200-300 kPa pressure.

Details of fungicide treatments in each season are shown in the Tables 3-9. Treatment applications were timed as closely as possible to protocol guidelines, actual dates and growth stages are shown in the results tables.

With the exception of single applications on the less susceptible cultivar Deben all treatments began when the second node was detected (whilst leaf 3 was emerging) i.e. ZGS 32 (T1). This was followed by a second application at either full flag leaf emergence i.e. ZGS 39 or approximately 10 days following full flag leaf emergence or at half ear emergence i.e. GS 55. The second application was stretched between treatments to test the persistence of the first application and the curative activity of the second application. Three-spray programmes were completed with a follow up application at mid anthesis i.e. ZGS 65 (T3).

Foliar treatments were applied in accordance with the treatment list which was adapted each season according to results in the previous year and in response to the rapid advancement of *S. tritici* resistance to strobilurins. Treatments for each season are shown in the Tables 3-9 below.

In 2004 the impact of resistance to strobilurins on fungicide strategy in both disease susceptible and less disease susceptible programmes was tested and the most appropriate timing for a single strobilurin application within a two-spray programme on less disease susceptible varieties was evaluated. Treatments were also designed to evaluate the most appropriate T2 timing when using the newer generation of strobilurins, particularly in a programme using a single application of strobilurin on disease susceptible varieties. In both susceptible and tolerant varieties the role of chlorothalonil within fungicide strategies was also evaluated.

2.6 Maintenance applications

All other agrochemical and fertiliser inputs were applied in accordance with Good Agricultural Practice.

2.7 Assessment of foliar disease and green leaf area

At each assessment disease and or green leaf area was recorded as percentage infection on each individual leaf layer on a whole plot basis. Each season assessments were carried out across the whole experimental area to establish base levels of disease just prior to the first fungicide application. In all years disease and green leaf area assessment of final leaves 1 to 3 in all plots were scheduled at GS 75 (grain milky ripe). From GS 75, weekly green leaf area assessments of the top three leaves were carried out until all upper leaves had senesced.

2.8 Yield assessments

The plots were harvested using a Sampo 2010 combine which was modified for plot work and used electronic weighing device (Novatech M864 Loadmeter). Experiments were harvested by replicate.

Moisture content and grain specific weight were determined using a Foss Infratec 1241 grain analyser. Grain yield and specific grain weights were determined at 85% dry matter.

Table 3. Treatments on Consort in 2002

	Treatments product and dose (l/ha)				
	GS 32	GS 39	GS 39 + 10 days	GS 55	GS 65
1	Opera 0.375	Opera 0.75	-	-	Folicur 0.5
2	Opera 0.375	-	Opera 0.75	-	Folicur 0.5
3	Opera 0.375	Opera 0.75	-	-	-
4	Opera 0.375	-	Opera 0.75	-	-
5	Opera 0.375	-	-	Opera 0.75	-
6	Opera 0.375	Opera 1.125	-	-	Folicur 0.5
7	Opera 0.375	-	Opera 1.125	-	Folicur 0.5
8	Opera 0.375	Opera 1.125	-	-	-
9	Opera 0.375	-	Opera 1.125	-	-
10	Opera 0.375	-	-	Opera 1.125	-
11	Opera 0.75	Opera 0.75	-	-	Folicur 0.5
12	Opera 0.75	-	Opera 0.75	-	Folicur 0.5
13	Opera 0.75	Opera 0.75	-	-	-
14	Opera 0.75	-	Opera 0.75	-	-
15	Opera 0.75	-	-	Opera 0.75	-
16	Opera 0.75	Opera 1.125	-	-	Folicur 0.5
17	Opera 0.75	-	Opera 1.125	-	Folicur 0.5
18	Opera 0.75	Opera 1.125	-	-	-
19	Opera 0.75	-	Opera 1.125	-	-
20	Opera 0.75	-	-	Opera 1.125	-
21	Opus 0.3 + Bravo 1.0	Twist 1.0 + Opus 0.3	-	-	Amistar 0.25 + Folicur 0.25
22	Opus 0.3 + Bravo 1.0	Opera 0.75	-	-	Amistar 0.25 + Folicur 0.25
23	Opera 0.375	Opus 0.75 + Bravo 1.0	-	-	Amistar 0.25 + Folicur 0.25
24	-	Opera 1.5	-	-	-
25	-	Twist 2.0 + Opus 0.6	-	-	-
26	Untreated	-	-	-	-

Table 4. Treatments on Consort in 2003

	Treatments product and dose (l/ha)				
	GS 32	GS 39	GS 39 + 10 days	GS 55	GS 65
1	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.1	-	-	Folicur 0.5
2	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.1	-	Folicur 0.5
3	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.1	-	-	-
4	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.1	-	-
5	Opera 0.375 + Opus 0.25	-	-	Opera 0.75 + Opus 0.1	-
6	Opera 0.375 + Opus 0.25	Opera 1.125	-	-	Folicur 0.5
7	Opera 0.375 + Opus 0.25	-	Opera 1.125	-	Folicur 0.5
8	Opera 0.375 + Opus 0.25	Opera 1.125	-	-	-
9	Opera 0.375 + Opus 0.25	-	Opera 1.125	-	-
10	Opera 0.375 + Opus 0.25	-	-	Opera 1.125	-
11	Opera 0.75 + Opus 0.1	Opera 0.75 + Opus 0.1	-	-	Folicur 0.5
12	Opera 0.75 + Opus 0.1	-	Opera 0.75 + Opus 0.1	-	Folicur 0.5
13	Opera 0.75 + Opus 0.1	Opera 0.75 + Opus 0.1	-	-	-
14	Opera 0.75 + Opus 0.1	-	Opera 0.75 + Opus 0.1	-	-
15	Opera 0.75 + Opus 0.1	-	-	Opera 0.75 + Opus 0.1	-
16	Opera 0.75 + Opus 0.1	Opera 1.125	-	-	Folicur 0.5
17	Opera 0.75 + Opus 0.1	-	Opera 1.125	-	Folicur 0.5
18	Opera 0.75 + Opus 0.1	Opera 1.125	-	-	-

19	Opera 0.75 + Opus 0.1	-	Opera 1.125	-	-
20	Opera 0.75 + Opus 0.1	-	-	Opera 1.125	-
21	Opus 0.3 + Bravo 1.0	Twist 1.0 + Opus 0.4	-	-	Amistar 0.25 + Folicur 0.25
22	Opus 0.3 + Bravo 1.0	Opera 0.75 + Opus 0.1	-	-	Amistar 0.25 + Folicur 0.25
23	Opera 0.375 + Opus 0.25	Opus 0.75 + Bravo 1.0	-	-	Amistar 0.25 + Folicur 0.25
24	Opera 0.375 + Opus 0.25	-	Opus 0.75 + Bravo 1.0	-	Amistar 0.25 + Folicur 0.25
25	Opera 0.375 + Opus 0.25	-	-	Opus 0.75 + Bravo 1.0	Amistar 0.25 + Folicur 0.25
26	Untreated	-	-	-	-

Table 5. Treatments on Consort in 2004

	Treatments product and dose (l/ha)				
	GS 32	GS 39	GS 39 + 10 days	GS 55	GS 65
1	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.2	-	-	Folicur 0.5
2	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.2	-	Folicur 0.5
3	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.2	-	-	-
4	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.2	-	-
5	Opera 0.375 + Opus0.25	-	-	Opera 0.75 + Opus 0.2	-
6	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.45+	-	-	Folicur 0.5
7	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.45+	-	Folicur 0.5
8	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.45+	-	-	-
9	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.45+	-	-
10	Opera 0.375 + Opus 0.25	-	-	Opera 0.75 + Opus 0.45+	-
11	Opera 0.375 + Opus 0.25 + Bravo 1.0	Opera 0.75 + Opus 0.2	-	-	Folicur 0.5
12	Opera 0.375 + Opus 0.25 + Bravo 1.0	-	Opera 0.75 + Opus 0.2	-	Folicur 0.5
13	Opera 0.75 + Opus 0.1	Opera 0.75 + Opus 0.2	-	-	-
14	Opera 0.75 + Opus 0.1	-	Opera 0.75 + Opus 0.2	-	-
15	Opera 0.75 + Opus 0.1	-	-	Opera 0.75 + Opus 0.2	-
16	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.2 + Bravo 1.0	-	-	Folicur 0.5
17	Opera 0.375 + Opus0.25	-	Opera 0.75 + Opus 0.2 + Bravo 1.0	-	Folicur 0.5

18	Opera 0.75 + Opus 0.1	Opera 0.75 + Opus 0.45+	-	-	-
19	Opera 0.75 + Opus 0.1	-	Opera 0.75 + Opus 0.45+	-	-
20	Opera 0.75 + Opus 0.1	-	-	Opera 0.75 + Opus 0.45+	-
21	Opus 0.4 + Bravo 1.0	Opera 0.75 + Opus 0.45+	-	-	Amistar 0.25 + Folicur 0.25
22	Opus 0.4 + Bravo 1.0	-	Opera 0.75 + Opus 0.45+	-	Amistar 0.25 + Folicur 0.25
23	Opera 0.375 + Opus 0.25	Opus 0.75 + Bravo 1.0	-	-	Amistar 0.25 + Folicur 0.25
24	Opera 0.375 + Opus 0.25	-	Opus 0.75 + Bravo 1.0	-	Amistar 0.25 + Folicur 0.25
25	Opera 0.375 + Opus 0.25	-	-	Opus 0.75 + Bravo 1.0	Amistar 0.25 + Folicur 0.25
26	Untreated	-	-	-	-

Table 6. Treatments on Deben in 2002

	Treatments product and dose (l/ha)				
	GS 32	GS 39	GS 39 + 10 days	GS 55	GS 65
1	Opera 1.5	-	-	-	-
2	-	Opera 1.5	-	-	-
3	-	-	Opera 1.5	-	-
4	-	-	-	Opera 1.5	-
5	Opera 1.125	-	-	-	-
6	-	Opera 1.125	-	-	-
7	-	-	Opera 1.125	-	-
8	-	-	-	Opera 1.125	-
9	Opera 0.75	-	-	-	-
10	-	Opera 0.75	-	-	-
11	-	-	Opera 0.75	-	-
12	-	-	-	Opera 0.75	-
13	Opera 0.75	-	Opera 0.75	-	-
14	Opera 0.75	-	-	Opera 0.75	-
15	Opera 0.375	-	Opera 0.75	-	-
16	Opera 0.375	-	-	Opera 0.75	-
17	Opera 0.375		Opera 0.375	-	-
18	Opera 0.375	-	-	Opera 0.375	-
19	Opera 0.375	Opera 0.375	-	-	Folicur 0.5
20	Opera 0.375	Opera 0.75	-	-	Folicur 0.5
21	Opus 0.25 + Bravo 1.0	Mantra 0.75	-	-	Amistar 0.25 + Folicur 0.25
22	Opus 0.15 + Bravo 0.6	Mantra 0.5	-	-	Amistar 0.25 + Folicur 0.25
23	Opus 0.25 + Bravo 1.0	Opera 0.75	-	-	Amistar 0.25 + Folicur 0.25
24	Untreated	-	-	-	-

Table 7. Treatments on Deben in 2003

	Treatments product and dose (l/ha)				
	GS 32	GS 39	GS 39 + 10 days	GS 55	GS 65
1.	Opera 1.5	-	-	-	-
2.	-	Opera 1.5	-	-	-
3.	-	-	Opera 1.5	-	-
4.	-	-	-	Opera 1.5	-
5.	-	-	-	-	Opera 1.5
6	Opera 0.75 + Opus 0.1	Opera 0.75 + Opus 0.1	-	-	-
7.	Opera 0.75 + Opus 0.1	-	Opera 0.75 + Opus 0.1	-	-
8.	Opera 0.75 + Opus 0.1	-	-	Opera 0.75 + Opus 0.1	-
9.	Opera 0.75 + Opus 0.1	-	-	-	Opera 0.75 + Opus 0.1
10.	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.1	-	-	-
11.	Opera 0.375 + Opus 0.25	-	Opera 0.75 + Opus 0.1		
12.	Opera 0.375 + Opus 0.25	-	-	Opera 0.75 + Opus 0.1	-
13.	Opera 0.375 + Opus 0.25	-	-	-	Opera 0.75 + Opus 0.1
14.	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.1	-	-	Folicur 0.5
15.	Opera 0.375 + Opus 0.25	-	-	Opera 0.75 + Opus 0.1	Folicur 0.5
16.	Opera 0.75 + Opus 0.1	Opus 0.5 + Bravo 1.0	-	-	Folicur 0.5
17.	Opera 0.75 + Opus 0.1	-	-	Opus 0.5 + Bravo 1.0	Folicur 0.5
18.	Opus 0.25 + Bravo 1.0	Opera 0.75 + Opus 0.1	-	-	Folicur 0.5
19.	Opus 0.25 + Bravo 1.0	-	-	Opera 0.75 + Opus 0.1	Folicur 0.5
20.	Opus 0.25 + Bravo 1.0	Opus 0.5 + Bravo 1.0	-	-	Amistar 0.25 + Folicur 0.25

21.	Opus 0.25 + Bravo 1.0	-	-	Opus 0.5 + Bravo 1.0	Amistar 0.25 + Folicur 0.25
22.	Opus 0.25 + Bravo 1.0	Opera 0.75 + Opus 0.1	-	-	Amistar 0.25 + Folicur 0.25
23.	Opus 0.25 + Bravo 1.0	-	-	Opera 0.75 + Opus 0.1	Amistar 0.25 + Folicur 0.25
24.	Opera 0.375 + Opus 0.25	Opera 0.75 + Opus 0.1	-	-	Amistar 0.25 + Folicur 0.25
25.	Opera 0.375 + Opus 0.25	-	-	Opera 0.75 + Opus 0.1	Amistar 0.25 + Folicur 0.25
26.	Untreated	-	-	-	-

Table 8. Treatments on Deben in 2003

	Treatments product and dose (l/ha)				
	GS 32	GS 39	GS 39 + 10 days	GS 55	GS 65
1	Opera 1.5	-	-	-	-
2	-	Opera 1.5	-	-	-
3	-	Opera 1.5 + Bravo 1.0	-	-	-
4	-	-	Opera 1.5	-	-
5	-	-	-	Opera 1.5	-
6	-	-	-	Opera 1.5 + Bravo 1.0	-
7	Opera 0.75	Opera 0.75 + Opus 0.2	-	-	-
8	Opera 0.75	-	Opera 0.75 + Opus 0.2	-	-
9	Opera 0.75	-	-	Opera 0.75 + Opus 0.2	-
10	Opera 0.75	-	-	-	Opera 0.75 + Opus 0.2
11	Opera 0.375 + Opus 0.15	Opera 0.75 + Opus 0.2	-	-	-
12	Opera 0.375 + Opus 0.15 + Bravo 1.0	Opera 0.75 + Opus 0.2	-	-	-
13	Opera 0.375 + Opus 0.15	-	Opera 0.75 + Opus 0.2	-	-
14	Opera 0.375 + Opus0.15	-	-	Opera 0.75 + Opus 0.2	-
15	Opera 0.375 + Opus 0.15 + Bravo 1.0	-	-	Opera 0.75 + Opus 0.2	-
16	Opera 0.375 + Opus 0.15	-	-	-	Opera 0.75 + Opus 0.2
17	Opera 0.375 + Opus 0.15	Opera 0.75 + Opus 0.2	-	-	Folicur 0.5
18	Opera 0.375 + Opus 0.15	-	-	Opera 0.75 + Opus 0.2	Folicur 0.5
19	Opus 0.3 + Bravo 1.0	Opera 0.75 + Opus 0.2	-	-	Folicur 0.5
20	Opus 0.3 + Bravo 1.0	-	-	Opera 0.75 + Opus 0.2	Folicur 0.5
21	Opus 0.3 + Bravo 1.0	Opera 0.75 + Opus 0.2	-	-	Amistar 0.25 + Folicur 0.25
22	Opus 0.3 + Bravo 1.0	-	-	Opera 0.75 + Opus 0.2	Amistar 0.25 + Folicur 0.25

23	Opera 0.375 + Opus 0.15	Opus 0.5 + Bravo 1.0	-	-	Amistar 0.25 + Folicur 0.25
24	Opera 0.375 + Opus 0.15	-	-	Opus 0.5 + Bravo 1.0	Amistar 0.25 + Folicur 0.25
25	Opus 0.3 + Bravo 1.0	-	-	Opus 0.5 + Bravo 1.0	-
26	Untreated	-	-	-	-

Table 9. Active ingredients of commercial products used

Product	Active ingredients (ai)	g ai/l	Formulation
Amistar	azoxystrobin	250	SC
Bravo	chlorothalonil	500	SC
Folicur	tebuconazole	250	EW
Opera	epoxiconazole + pyraclostrobin	50:133	SE
Opus	epoxiconazole	125	SC

3. Results

3.1 Consort (cultivar susceptible to *S. tritici*)

<u>2002: Tables 10-11 + Appendix Tables 22-23</u>

S. tritici resistance to strobilurins was at a low level. *S. tritici* was present from early spring, increasing in severity as the season progressed. Traces of brown rust were seen only on the untreated crop in mid July. When assessed on 9 July, *S. tritici* was affecting 23.3, 50.0 and 71.7% of the area of final leaves 1, 2 and 3 respectively of untreated crop. All treatments significantly reduced disease to similar levels on final leaf 1 (0.1 to 0.8% disease) but greater differences were seen on final leaf 2 (0.6 to 9.7% disease) and more particularly on final leaf 3 where disease levels ranged from 8.3% to 38.3%.

Where no fungicide was applied, the crop produced a yield of 7.68 t/ha. All the treatments significantly increased yield, with responses ranging from 2.78 t/ha, a single application of Twist + Opus (2.0 + 0.6 l/ha) on 20 May (Treatment 25) to 3.73 t/ha, a three-spray programme of Opera (0.75) on 24 April (GS 32), Opera (1.125) on 20 May (GS 39-41) and Folicur (0.5) on 11 June (GS 65), (Treatment 17). The greatest margin over fungicide and application costs (£182.30/ha at a grain price of 65 £/ha) was from a three-spray programme of Opera (0.375 l/ha) on 24 April (GS 32), Opus + Bravo (0.75 + 1.0) on 20 May (GS 39-41) and Amistar + Folicur (0.25 + 0.25) on 11 June (GS 65), (Treatment 23). However, this was not significantly differently different to some two-spray programmes.

Generally a two-spray strategy was not as profitable as a three-spray strategy, however, despite relatively high disease levels throughout the season some two spray treatments gave similar margins to a three spray strategy. The most economic two-spray programmes were those with the second spray delayed until at least GS 55. T3 applications tended to be more cost-effective where T2 was delayed beyond GS 39.

<u>2003: Tables 12-13 + Appendix Table 24</u>

S. tritici symptoms were visible from early spring but the disease spread relatively slowly in the dry conditions. Despite this slow start, rain during the spring encouraged disease development and by early July levels of disease in the untreated Consort were moderate to high with *S. tritici* affecting 3.7, 17.3 and 71.7% of the area of leaves 1, 2 and 3 respectively of untreated crop. All treatments significantly reduced disease to similar levels on final leaf 1 (0.1 to 0.2% disease) and final leaf 2 (0.3 to 2.5% disease). However on final leaf 3 there were greater treatment effects, with disease levels ranging from 3.7% to 23.7%. Where no fungicide was applied, the crop produced a yield of 9.87 t/ha. All the treatments significantly increased yield, with responses ranging from 1.16 (Treatment 2) to 1.61 t/ha (Treatment 24), with no real difference between many of the programmes. The greatest margin over fungicide and application costs (£40.05/ha at a grain price of 65 £/ha) was from a two-spray programme of Opera + Opus (0.375 + 0.25 l/ha) on 23 April (GS 32) followed by Opera (1.125 l/ha) on 4 June (GS 59-61), (Treatment 10) but some three-spray programmes gave similar margins.

<u>2004: Tables 14-15 + Appendix Tables 25-26</u>

S. tritici resistance to strobilurins was at a high level. In early spring disease pressure was relatively high and then continued to develop more steadily reaching 9.3%, 36.7% and 46.7% on the flag (final leaf 1), final leaf 2 and 3 respectively of the untreated crop on 28 June.

The untreated crop produced a yield of 7.25 t/ha. All treatments significantly improved yield compared with the untreated crop with yield responses ranging from 1.29 (Treatment 2) to 2.33 t/ha (Treatment 17). The highest yields came from programmes that contained the higher doses of fungicides (particularly the triazoles) and also received chlorothalonil at T1. A three-spray programme of Opus 0.4 + Bravo 1.0 l/ha at GS 32 followed by Opera 0.75 l/ha + Opus 0.45 l/ha at GS 39-41 followed by Amistar 0.25 l/ha + Folicur 0.25 l/ha at GS 69 (Treatment 17) gave the greatest margin over fungicide costs of 97.15 £/ha at a grain price of 75 £/ha.

In 2003, a strobilurin based treatment at T2 provided a significant yield advantage when delayed from GS 39 to GS 55; however, this later treatment only produced a similar yield to where a single strobilurin was applied at T3. This also indicates that the benefit from the strobilurin occurred when applied to the ear.

Table 10. Consort, the effect of treatment on *S. tritici* at milky ripe (% leaf area), 9 July 2002

	GS 32 24 April	GS 39-41 20 May	GS 55 T2 + 11 days 31 May	GS 61 6 June	GS 65 11 June	Leaf 2	Leaf 3
1	A	B	-	-	J	1.7	21.0
2	A	-	B	-	J	6.0	31.7
3	A	B	-	-	-	3.0	21.7
4	A	-	B	-	-	1.7	22.7
5	A	-	-	B	-	9.7	36.0
6	A	C	-	-	J	0.5	10.0
7	A	-	C	-	J	2.8	24.3
8	A	C	-	-	-	1.2	11.0
9	A	-	C	-	-	2.0	22.7
10	A	-	-	C	-	5.3	30.3
11	B	B	-	-	J	0.8	11.0
12	B	-	B	-	J	4.0	23.3
13	B	B	-	-	-	2.5	12.3
14	B	-	B	-	-	6.3	17.7
15	B	-	-	B	-	5.7	26.0
16	B	C	-	-	J	0.4	10.0
17	B	-	C	-	J	0.8	14.3
18	B	C	-	-	-	1.2	8.3
19	B	-	C	-	-	1.0	10.3
20	B	-	-	C	-	3.0	21.0
21	E	G	-	-	K	2.3	25.0
22	E	B	-	-	K	1.3	19.3
23	A	F	-	-	K	0.6	12.3
24	-	D	-	-	-	3.0	38.3
25	-	H	-	-	-	1.0	35.0
26	Untreated	-	-	-	-	50.0	71.7
	LSD (P=0.05)					3.03	8.96
	SE per plot (50 df) ±					1.84	5.43
	CV (%)					40.6	24.0

A = Opera (0.375 l/ha)

B = Opera (0.75 l/ha)

C = Opera (1.125 l/ha)

D = Opera (1.5 l/ha)

E = Opus + Bravo (0.3 + 1.0 l/ha)

F = Opus + Bravo (0.75 + 1.0 l/ha)

G = Twist + Opus (1.0 + 0.3 l/ha)

H = Twist + Opus (2.0 + 0.6 l/ha)

J = Folicur (0.5 l/ha)

K = Amistar + Folicur (0.25 + 0.25 l/ha)

Table 11. The effect of treatment on grain yield (t/ha at 85%), Consort 2002

	GS 32 24 April	GS 39-41 20 May	GS 55 T2 + 11 days 31 May	GS 61 6 June	GS 65 11 June	Grain yield (t/ha at 85% dm)	*Margin (£/ha)
1	A	B	-	-	J	10.95	148.30
2	A	-	B	-	J	11.36	174.95
3	A	B	-	-	-	10.58	138.25
4	A	-	B	-	-	10.87	157.10
5	A	-	-	B	-	11.01	166.20
6	A	C	-	-	J	11.32	159.60
7	A	-	C	-	J	11.37	162.85
8	A	C	-	-	-	10.93	148.25
9	A	-	C	-	-	10.96	150.20
10	A	-	-	C	-	11.04	155.40
11	B	B	-	-	J	10.96	136.20
12	B	-	B	-	J	11.06	142.70
13	B	B	-	-	-	10.87	144.35
14	B	-	B	-	-	11.23	167.75
15	B	-	-	B	-	10.97	150.85
16	B	C	-	-	J	10.93	121.50
17	B	-	C	-	J	11.41	152.70
18	B	C	-	-	-	11.14	149.15
19	B	-	C	-	-	10.82	128.35
20	B	-	-	C	-	11.11	147.20
21	E	G	-	-	K	11.25	172.80
22	E	B	-	-	K	11.21	166.20
23	A	F	-	-	K	11.40	182.30
24	-	D	-	-	-	10.68	138.00
25	-	H	-	-	-	10.46	131.70
26	Untreated	-	-	-	-	7.68	
	LSD (P=0.05)					0.376	-
	SE per plot (50 df) ±					0.228	-
	CV (%)					2.1	-

A = Opera (0.375 l/ha)

B = Opera (0.75 l/ha)

C = Opera (1.125 l/ha)

D = Opera (1.5 l/ha)

E = Opus + Bravo (0.3 + 1.0 l/ha)

F = Opus + Bravo (0.75 + 1.0 l/ha)

G = Twist + Opus (1.0 + 0.3 l/ha)

H = Twist + Opus (2.0 + 0.6 l/ha)

J = Folicur (0.5 l/ha)

K = Amistar + Foliciur (0.25 + 0.25 l/ha)

*Margin = margin over fungicide costs. Margin based on Consort £65/t and application costs of £6/ha.

Table 12. Consort, the effect of treatment on *S. tritici* at milky ripe (% leaf area), 4 July 2003

	GS 31-32 23 April	GS 39-41 21 May	GS 45-51 T2 + 9 days 30 May	GS 59-61 4 June	GS 69 16 June	Leaf 2	Leaf 3
1	A	B	-	-	G	1.7	11.3
2	A	-	B	-	G	2.1	14.0
3	A	B	-	-	-	1.8	12.3
4	A	-	B	-	-	1.0	12.3
5	A	-	-	B	-	1.6	23.7
6	A	C	-	-	G	1.3	10.7
7	A	-	C	-	G	0.9	9.7
8	A	C	-	-	-	1.2	12.0
9	A	-	C	-	-	1.1	10.7
10	A	-	-	C	-	2.2	14.3
11	B	B	-	-	G	2.0	17.7
12	B	-	B	-	G	1.3	10.7
13	B	B	-	-	-	2.0	18.3
14	B	-	B	-	-	1.2	14.3
15	B	-	-	B	-	1.8	16.7
16	B	C	-	-	G	1.3	9.0
17	B	-	C	-	G	1.0	7.7
18	B	C	-	-	-	0.7	9.0
19	B	-	C	-	-	1.2	10.0
20	B	-	-	C	-	2.5	17.7
21	D	F	-	-	H	1.1	6.7
22	D	B	-	-	H	1.4	5.3
23	A	E	-	-	H	0.3	3.7
24	A	-	E	-	H	0.4	4.3
25	A	-	-	E	H	1.0	10.0
26	Untreated	-	-	-	-	17.3	71.7
	LSD (P=0.05)					6.80	6.83
	SE per plot (50 df) ±					4.12	4.14
	CV (%)					4.3	29.6

A = Opera 0.375 l/ha + Opus 0.25 l/ha

B = Opera 0.75 l/ha + Opus 0.1 l/ha

C = Opera 1.125 l/ha

D = Opus 0.3 l/ha + Bravo 1.0 l/ha

E = Opus 0.75 l/ha + Bravo 1.0 l/ha

F = Twist 1.0 l/ha + Opus 0.4 l/ha

G = Folicur 0.5 l/ha

H = Amistar 0.25 l/ha + Folicur 0.25 l/ha

Table 13. The effect of treatment on grain yield (t/ha at 85%), Consort 2003

	GS 31-32 23 April	GS 39-41 21 May	GS 45-51 T2 + 9 days 30 May	GS 59-61 4 June	GS 69 16 June	Grain yield (t/ha at 85% dm)	*Margin (£/ha)
1	A	B	-	-	G	11.14	15.80
2	A	-	B	-	G	11.03	8.65
3	A	B	-	-	-	11.14	29.80
4	A	-	B	-	-	11.28	38.90
5	A	-	-	B	-	10.98	19.40
6	A	C	-	-	G	11.20	10.45
7	A	-	C	-	G	11.29	16.30
8	A	C	-	-	-	11.22	25.75
9	A	-	C	-	-	11.27	29.00
10	A	-	-	C	-	11.44	40.05
11	B	B	-	-	G	11.30	17.95
12	B	-	B	-	G	11.22	12.75
13	B	B	-	-	-	11.17	23.50
14	B	-	B	-	-	11.17	23.50
15	B	-	-	B	-	11.13	20.90
16	B	C	-	-	G	11.25	5.45
17	B	-	C	-	G	11.37	13.25
18	B	C	-	-	-	11.32	24.00
19	B	-	C	-	-	11.35	25.95
20	B	-	-	C	-	11.21	6.10
21	D	F	-	-	H	11.21	25.95
22	D	B	-	-	H	11.37	35.25
23	A	E	-	-	H	11.46	33.85
24	A	-	E	-	H	11.48	35.15
25	A	-	-	E	H	11.33	36.15
26	Untreated	-	-	-	-	9.87	-
	LSD (P=0.05)					0.397	-
	SE per plot (50 df) ±					0.241	-
	CV (%)					2.2	-

A = Opera 0.375 l/ha + Opus 0.25 l/ha
B = Opera 0.75 l/ha + Opus 0.1 l/ha
C = Opera 1.125 l/ha
D = Opus 0.3 l/ha + Bravo 1.0 l/ha
E = Opus 0.75 l/ha + Bravo 1.0 l/ha
F = Twist 1.0 l/ha + Opus 0.4 l/ha
G = Folicur 0.5 l/ha
H = Amistar 0.25 l/ha + Folicur 0.25 l/ha

*Margin = margin over fungicide costs. Margin based on Consort £65/t and application costs of £6/ha.

Table 14. Consort, the effect of treatment on *S. tritici* at milky ripe (% leaf area), 28 June 2004

	GS 32 26 April	GS 39-41 24 May	GS 55 T2 + 10 days 3 June	GS 69 10 June	Leaf 1	Leaf 2	Leaf 3
1	A	E	-	H	0.0	13.3	45.0
2	A	-	E	H	0.0	17.0	41.7
3	A	E	-	-	0.0	11.0	43.3
4	A	-	E2	-	0.3	12.0	43.3
5	A	F	-	H	0.2	11.7	45.0
6	A	-	F	H	0.1	13.3	45.0
7	A	F	-	-	0.0	8.3	43.3
8	A	-	F	-	0.0	12.0	45.0
9	B	E	-	H	0.0	5.7	35.0
10	B	-	E	H	0.2	7.7	35.0
11	C	E	-	-	0.0	10.7	43.3
12	C	-	E	-	0.0	12.3	38.3
13	A	G	-	H	0.0	9.0	40.0
14	A	-	G	H	0.0	8.0	43.3
15	C	F	-	-	0.2	11.3	38.3
16	C	-	F	-	0.3	10.3	40.0
17	D	F	-	I	0.0	5.7	35.0
18	D	-	F	I	0.0	10.7	41.7
19	A	C0	-	I	0.0	9.0	40.0
20	A	-	C	I	0.2	9.7	45.0
21	Untreated	-	-	-	9.3	36.7	46.7
	LSD (P=0.05)				0.89	5.55	6.56
	SE per plot (40 df) ±				0.54	3.37	3.98
	CV (%)				103.2	28.8	9.6

A = Opera 0.375 l/ha + Opus 0.25 l/ha

B = Opera 0.375 l/ha + Opus 0.25 l/ha + Bravo 1.0 l/ha

C = Opera 0.75 l/ha + Opus 0.1 l/ha

D = Opus 0.4 l/ha + Bravo 1.0 l/haI

E = Opera 0.75 l/ha + Opus 0.2 l/ha

F = Opera 0.75 l/ha + Opus 0.45 l/ha

G = Opera 0.75 l/ha + Opus 0.2 l/ha + Bravo 1.0 l/ha

H = Folicur 0.5 l/ha

I = Amistar 0.25 l/ha + Folicur 0.25 l/ha

The amount of triazole applied at T1 and T2 has been balanced between treatments.

Table 15. The effect of treatment on grain yield (t/ha at 85%), Consort 2004

	GS 32 26 April	GS 39-41 24 May	GS 55 T2 + 10 days 3 June	GS 69 10 June	Grain yield (t/ha at 85% dm)	* Margin (£/ha)	** Margin (£/ha)
1	A	E	-	H	8.81	41.03	9.81
2	A	-	E	H	8.54	21.15	-4.77
3	A	E	-	-	8.79	54.53	23.71
4	A	-	E	-	8.80	55.13	24.15
5	A	F	-	H	8.74	29.93	0.06
6	A	-	F	H	9.04	52.28	16.46
7	A	F	-	-	9.04	67.28	31.46
8	A	-	F	-	8.80	49.05	18.09
9	B	E	-	H	9.22	68.63	29.24
10	B	-	E	H	9.31	75.83	34.53
11	C	E	-	-	8.74	42.00	12.08
12	C	-	E	-	8.56	27.97	1.79
13	A	G	-	H	8.90	44.63	11.65
14	A	-	G	H	9.08	55.28	19.46
15	C	F	-	-	9.02	56.63	21.21
16	C	-	F	-	8.96	52.35	18.07
17	D	F	-	I	9.58	97.15	50.47
18	D	-	F	I	9.35	80.13	37.99
19	A	C0	-	I	9.29	77.13	36.23
20	A	-	C	I	8.91	48.18	15.00
21	Untreated	-	-	-	7.25	0.00	0.00
	LSD (P=0.05)				0.437	-	-
	SE per plot (40 df) ±				0.265	-	-
	CV (%)				3.0	-	-

A = Opera 0.375 l/ha + Opus 0.25 l/ha
B = Opera 0.375 l/ha + Opus 0.25 l/ha + Bravo 1.0 l/ha
C = Opera 0.75 l/ha + Opus 0.1 l/ha
D = Opus 0.4 l/ha + Bravo 1.0 l/ha
E = Opera 0.75 l/ha + Opus 0.2 l/ha
F = Opera 0.75 l/ha + Opus 0.45 l/ha
G = Opera 0.75 l/ha + Opus 0.2 l/ha + Br 1.0 l/ha
H = Folicur 0.5 l/ha
I = Amistar 0.25 l/ha + Folicur 0.25 l/ha

The amount of triazole applied at T1 and T2 has been balanced between treatments.

Margin over fungicide costs based are based on grain prices of *£75/t and **£55/t and application costs of £6/ha.

3.2 Deben (cultivar less susceptible to *S. tritici*)

<u>2002: Tables 16-17 + Appendix Tables 27-28</u>

S. tritici resistance to strobilurins was at a low level. *S. tritici* was present from early spring, increasing in severity as the season progressed. When assessed on 9 July, *S. tritici* was affecting 11.0, 33.3 and 71.7% of the area of final leaves 1, 2 and 3 respectively of untreated crop. All treatments significantly reduced disease levels, with the poorest control generally from a single application of Opera (at any dose) at GS 32 (final leaves 1 and 2) or when applied in late May or early June (final leaf 3).

Where no fungicide was applied, the crop produced a yield of 8.43 t/ha. All the treatments significantly increased yield, with responses ranging from 1.56 t/ha, a single application of Opera (1.5 l/ha) applied on 25 April (GS 32), (Treatment 1) to 2.45 t/ha, a two-spray programme of Opera (0.375 l/ha) on 25 April followed by Opera (0.75) on 31 May (GS 55), (Treatment 15). This treatment also gave the greatest margin over fungicide costs (£108.87/ha at a grain price of 65 £/ha). However, there were only small and statistically insignificant differences between many of the two and three-spray programmes.

There were no significant differences between dose or timing of a single strobilurin based application, however, there was a consistent trend suggesting that the higher the dose the later the single application could be made to optimise returns. Yields were significantly higher when the same dose was split between two applications. There was little difference in yield between treatments where T2 was stretched from GS 39 to GS 55 or GS 61 (i.e. flag leaf to early anthesis). There was no yield advantage to a three-spray programme.

<u>2003: Tables 18-19 + Appendix Table 29</u>

S. tritici symptoms were visible from early spring but the disease spread relatively slowly in the dry conditions. Despite this slow start, rain during the spring encouraged disease development and when assessed on 3 July, *S. tritici* was affecting 0.5, 2.7 and 8.3% of the area of final leaves 1, 2 and 3 respectively of untreated crop. Most treatments gave good disease control, with the poorest control from a single application of Opera at GS 32 (final leaves 1 and 2) or GS 69 (final leaf 3).

Where no fungicide was applied, the crop produced a yield of 10.04 t/ha. All the treatments significantly increased yield, with responses ranging from 0.56 (Treatment 1) to 1.37 t/ha

(Treatment 24), with only small differences between many of the programmes. The greatest margin over fungicide and application costs (£32.45/ha at a grain price of £65/ha) was from a three-spray programme of Opus + Bravo (0.25 + 1.0 l/ha) on 30 April (GS 32), Opus + Bravo (0.5 + 1.0) on 21 May (GS 39) and Amistar + Folicur (0.25 + 0.25) on 16 June (GS 69), (Treatment 20) but differences in yield from some two-spray programmes were statistically insignificant.

However, the data suggest that three-spray programmes based on a T1 of triazole + chlorothalonil provided similar margins to a two spray strategy where each application was based on strobilurin. There was a wide degree of flexibility in the timing of the T2 spray within a three-spray programme. Again, there appeared to be an advantage to applying a strobilurin based T2 at or after ear emergence where T3 did not include a strobilurin; this advantage was not obvious where T3 included a strobilurin.

2004: Tables 20-21 + Appendix Tables 30-31

S. tritici developed slowly on the crop reaching 0.8%, 4.4% and 9.4% on the flag (final leaf 1), final leaf 2 and final 3 respectively of the untreated crop on 2 July.

The untreated crop produced a yield of 9.23 t/ha. There were no significant differences in yield between the treatments and compared with the untreated crop. All margin over fungicide costs were negative when calculated using a grain price of 75 £/t and hence there are no clear conclusions or trends.

Table 16. Deben, the effect of treatment on *S. tritici* at milky ripe (% leaf area), 9 July 2002

	GS 32 25 April	GS 45-47 25 May	GS 55 T2 + 6 days 31 May	GS 59-61 06 June	GS 65 11 June	Leaf 2	Leaf 3
1	A	-	-	-	-	9.7	20.7
2	-	A	-	-	-	6.0	40.0
3	-	-	A	-	-	2.3	35.0
4	-	-	-	A	-	2.0	45.0
5	B	-	-	-	-	11.7	27.0
6	-	B	-	-	-	5.0	43.3
7	-	-	B	-	-	3.3	45.0
8	-	-	-	B	-	4.0	45.0
9	C	-	-	-	-	11.0	26.0
10	-	C	-	-	-	6.3	43.3
11	-	-	C	-	-	3.3	53.3
12	-	-	-	C	-	4.3	46.7
13	C	-	C	-	-	1.2	14.3
14	C	-	-	C	-	0.8	10.7
15	D	-	C	-	-	1.5	11.0
16	D	-	-	C	-	1.8	14.3
17	D		D	-	-	1.3	22.3
18	D	-	-	D	-	2.3	24.3
19	D	D	-	-	I	3.0	21.0
20	D	C	-	-	I	1.3	14.0
21	E	G	-	-	J	1.5	29.3
22	F	H	-	-	J	5.3	33.3
23	E	C	-	-	J	1.8	17.7
24	Untreated	-	-	-	-	33.3	71.7
	LSD (P=0.05)					4.18	11.02
	SE per plot (46 df) ±					2.53	6.68
	CV (%)					48.8	21.3

A = Opera 1.5 l/ha

B = Opera 1.125 l/ha

C= Opera 0.75 l/ha

D = Opera 0.375 l/ha

E = Opus 0.25 l/ha + Bravo 1.0 l/ha

F = Opus 0.15 l/ha + Bravo 0.6 l/ha

G = Mantra 0.75 l/ha

H = Mantra 0.5 l/ha

I = Folicur 0.5 l/ha

J = Amistar 0.25 l/ha + Folicur 0.25 l/ha

Table 17. The effect of treatment on grain yield (t/ha at 85%), Deben, 2002

	GS 32 25 April	GS 45-47 25 May	GS 55 T2 + 6 days 31 May	GS 59-61 06 June	GS 65 11 June	Grain yield (t/ha at 85% dm)	*Margin (£/ha)
1	A	-	-	-	-	9.99	44.34
2	-	A	-	-	-	10.30	64.81
3	-	-	A	-	-	10.31	65.27
4	-	-	-	A	-	10.49	76.90
5	B	-	-	-	-	10.14	66.64
6	-	B	-	-	-	10.22	71.84
7	-	-	B	-	-	10.45	86.86
8	-	-	-	B	-	10.29	76.52
9	C	-	-	-	-	10.03	72.70
10	-	C	-	-	-	10.34	92.39
11	-	-	C	-	-	10.14	79.85
12	-	-	-	C	-	10.10	77.05
13	C	-	C	-	-	10.82	92.35
14	C	-	-	C	-	10.80	90.99
15	D	-	C	-	-	10.88	108.87
16	D	-	-	C	-	10.79	103.35
17	D		D	-	-	10.54	99.39
18	D	-	-	D	-	10.65	106.87
19	D	D	-	-	I	10.62	90.92
20	D	C	-	-	I	10.75	86.29
21	E	G	-	-	J	10.61	79.88
22	F	H	-	-	J	10.35	75.01
23	E	C	-	-	J	10.71	86.15
24	Untreated	-	-	-	-	8.43	-
	LSD (P=0.05)					0.374	-
	SE per plot (46 df) ±					0.227	-
	CV (%)					2.2	-

A = Opera 1.5 l/ha
B = Opera 1.125 l/ha
C= Opera 0.75 l/ha
D = Opera 0.375 l/ha
E = Opus 0.25 l/ha + Bravo 1.0 l/ha
F = Opus 0.15 l/ha + Bravo 0.6 l/ha
G = Mantra 0.75 l/ha
H = Mantra 0.5 l/ha
I = Folicur 0.5 l/ha
J = Amistar 0.25 l/ha + Folicur 0.25 l/ha

*Margin = margin over fungicide costs. Margin based on Deben at £65/t and application costs of £6/ha.

Table 18. Deben, the effect of treatment on *S. tritici* at milky ripe (% leaf area), 3 July 2003

	GS 32 30 April	GS 39 21 May	GS 45-51 T2 + 9 days 30 May	GS 61-65 05 June	GS 69 16 June	Leaf 2	Leaf 3
1	A	-	-	-	-	1.7	4.0
2	-	A	-	-	-	0.2	1.2
3	-	-	A	-	-	0.2	3.0
4	-	-	-	A	-	0.6	3.7
5	-	-	-	-	A	0.9	5.0
6	B	B	-	-	-	0.2	0.5
7	B	-	B	-	-	0.2	0.8
8	B	-	-	B	-	0.5	1.1
9	B	-	-	-	B	0.9	3.3
10	C	B	-	-	-	0.2	0.4
11	C	-	B			0.2	0.8
12	C	-	-	B	-	0.4	0.9
13	C	-	-	-	B	0.8	2.7
14	C	B	-	-	F	0.2	0.8
15	C	-	-	B	F	0.2	1.3
16	B	E	-	-	F	0.0	0.2
17	B	-	-	E	F	0.3	0.6
18	D	B	-	-	F	0.2	0.2
19	D	-	-	B	F	0.2	0.5
20	D	E	-	-	G	0.1	0.3
21	D	-	-	E	G	0.3	0.7
22	D	B	-	-	G	0.1	0.5
23	D	-	-	B	G	0.3	0.6
24	C	B	-	-	G	0.1	0.8
25	C	-	-	B	G	0.4	1.6
26	Untreated	-	-	-	-	2.7	8.3
	LSD (P=0.05)-					0.44	1.38
	SE per plot (50 df) ±					0.27	0.84
	CV (%)					56.7	49.5

A = Opera 1.5 l/ha

B = Opera 0.75 l/ha + Opus 0.1 l/ha

C= Opera 0.375 l/ha + Opus 0.25 l/ha

D = Opus 0.25 l/ha + Bravo 1.0 l/ha

E = Opus 0.5 l/ha + Bravo 1.0 l/ha

F = Folicur 0.5 l/ha

G = Amistar 0.25 l/ha + Folicur 0.25 l/ha

Table 19. The effect of treatment on grain yield (t/ha at 85%), Deben, 2003

	GS 32 30 April	GS 39 21 May	GS 45-51 T2 + 9 days 30 May	GS 61-65 05 June	GS 69 16 June	Grain yield (t/ha at 85% dm)	*Margin (£/ha)
1	A	-	-	-	-	10.60	-14.60
2	-	A	-	-	-	11.02	12.70
3	-	-	A	-	-	11.03	13.35
4	-	-	-	A	-	11.24	27.00
5	-	-	-	-	A	11.06	15.30
6	B	B	-	-	-	11.18	13.10
7	B	-	B	-	-	11.06	5.30
8	B	-	-	B	-	11.09	7.25
9	B	-	-	-	B	11.31	21.55
10	C	B	-	-	-	11.08	14.85
11	C	-	B			11.04	12.25
12	C	-	-	B	-	11.21	23.30
13	C	-	-	-	B	11.19	22.00
14	C	B	-	-	F	10.95	7.60
15	C	-	-	B	F	11.36	19.05
16	B	E	-	-	F	11.27	16.54
17	B	-	-	E	F	11.07	3.45
18	D	B	-	-	F	10.97	0.95
19	D	-	-	B	F	11.37	26.95
20	D	E	-	-	G	11.32	32.45
21	D	-	-	E	G	11.30	31.15
22	D	B	-	-	G	11.36	23.55
23	D	-	-	B	G	11.30	19.65
24	C	B	-	-	G	11.41	19.55
25	C	-	-	B	G	11.40	18.90
26	Untreated	-	-	-	-	10.04	-
	LSD (P=0.05)-					0.379	-
	SE per plot (50 df) ±					0.230	-
	CV (%)					2.1	-

A = Opera 1.5 l/ha
B = Opera 0.75 l/ha + Opus s0.1 l/ha
C= Opera 0.375 l/ha + Opus 0.25 l/ha
D = Opus 0.25 l/ha + Bravo 1.0 l/ha
E = Opus 0.5 l/ha + Bravo 1.0 l/ha
F = Folicur 0.5 l/ha
G = Amistar 0.25 l/ha + Folicur 0.25 l/ha

*Margin = Margin over fungicide costs. Margin based on Deben £65/t and application costs of £6/ha.

Table 20. Deben, the effect of treatment on *S. tritici* at milky ripe (% leaf area), 2 July 2004

	GS 32-33 11 May	GS 39 24 May	GS 47 3 June	GS 57 T2 + 15 days 8 June	GS 69 15 June	Leaf 1	Leaf 2	Leaf 3
1	A					0.1	1.0	2.5
2		A				0.0	0.5	4.7
3		B				0.0	1.4	7.0
4			A			0.0	0.5	3.8
5				A		0.0	1.8	6.0
6				B		0.1	2.9	6.3
7	C	G				0.0	0.4	4.0
8	C		G			0.0	0.6	2.9
9	C			G		0.0	0.8	3.1
10	C				G	0.0	1.0	4.5
11	D	G				0.0	0.5	2.4
12	E	G				0.0	0.3	2.8
13	D		G			0.0	0.5	5.0
14	D			G		0.0	1.4	6.4
15	E			G		0.0	1.2	5.4
16	D				G	0.0	0.8	3.5
17	D	G			I	0.0	0.4	3.7
18	D			G	I	0.0	0.6	4.8
19	F	G			I	0.0	0.2	2.2
20	F			G	I	0.0	0.4	2.8
21	F	G			J	0.0	0.2	1.6
22	F			G	J	0.0	0.5	4.2
23	D	H			J	0.0	0.2	1.4
24	D			H	J	0.0	0.5	2.9
25	F			H		0.0	0.8	1.7
26	Untreated					0.8	4.4	9.4
	LSD					0.43 (NS)	2.16 (NS)	4.37 (NS)
	SE per plot (50 df) ±					0.21	1.05	2.12
	CV (%)					487.4	118.0	52.9

A = Opera 1.5 l/ha

B = Opera 1.5 l/ha + Bravo 1.0 l/ha

C = Opera 0.75 l/ha

D = Opera 0.375 l/ha + Opus 0.15 l/ha

E= Opera 0.375 l/ha + Opus 0.15 l/ha + Bravo 1.0 l/ha

F = Opus 0.3 l/ha + Bravo 1.0 l/ha

G = Opera 0.75 l/ha + Opus 0.2 l/ha

H = Opus 0.5 l/ha + Bravo 1.0 l/ha

I = Folicur 0.5 l/ha

J = Amistar 0.25 l/ha + Folicur 0.25 l/ha

Table 21. The effect of treatment on grain yield (t/ha at 85%), Deben 2004

	GS 32-33 11 May	GS 39 24 May	GS 47 3 June	GS 57 T2 + 15 days 8 June	GS 69 15 June	Grain yield (t/ha at 85% dm)	* Margin (£/ha)	** Margin (£/ha)
1	A					9.68	-23.10	-32.14
2		A				9.14	-63.53	-61.79
3		B				9.50	-39.45	-44.93
4			A			9.28	-53.10	-54.14
5				A		9.51	-36.00	-41.60
6				B		9.23	-59.74	-59.81
7	C	G				9.20	-69.90	-69.34
8	C		G			9.10	-77.36	-74.81
9	C			G		9.60	-40.05	-47.45
10	C				G	9.19	-71.18	-70.28
11	D	G				9.46	-41.78	-46.28
12	E	G				9.47	-44.03	-48.73
13	D		G			9.68	-25.28	-34.18
14	D			G		9.64	-28.12	-36.26
15	E			G		9.60	-34.01	-41.38
16	D				G	9.50	-40.76	-45.53
17	D	G			I	9.59	-46.65	-53.85
18	D			G	I	9.51	-52.46	-58.11
19	F	G			I	9.63	-37.88	-45.78
20	F			G	I	9.67	-34.73	-43.47
21	F	G			J	9.71	-33.76	-43.29
22	F			G	J	9.50	-48.99	-54.46
23	D	H			J	9.49	-41.15	-46.27
24	D			H	J	9.52	-38.34	-44.21
25	F			H		9.13	-44.89	-42.84
26	Untreate d					9.23	0.00	0.00
	LSD					0.519 (NS)	-	-
	SE per plot (50 df) ±					0.252	-	-
	CV (%)					2.7	-	-

A = Opera 1.5 l/ha
B = Opera 1.5 l/ha + Bravo 1.0 l/ha
C = Opera 0.75 l/ha
D = Opera 0.375 l/ha + Opus 0.15 l/ha
E= Opera 0.375 l/ha + Opus 0.15 l/ha + Bravo 1.0 l/ha
F = Opus 0.3 l/ha + Bravo 1.0 l/ha
G = Opera 0.75 l/ha + Opus 0.2 l/ha
H = Ous 0.5 l/ha + Bravo 1.0 l/ha
I = Folicur 0.5 l/ha
J = Amistar 0.25 l/ha + Folicur 0.25 l/ha

Margin over fungicide costs based are based on grain prices of *£75/t and **£55/t and application costs of £6/ha.

4. Discussion

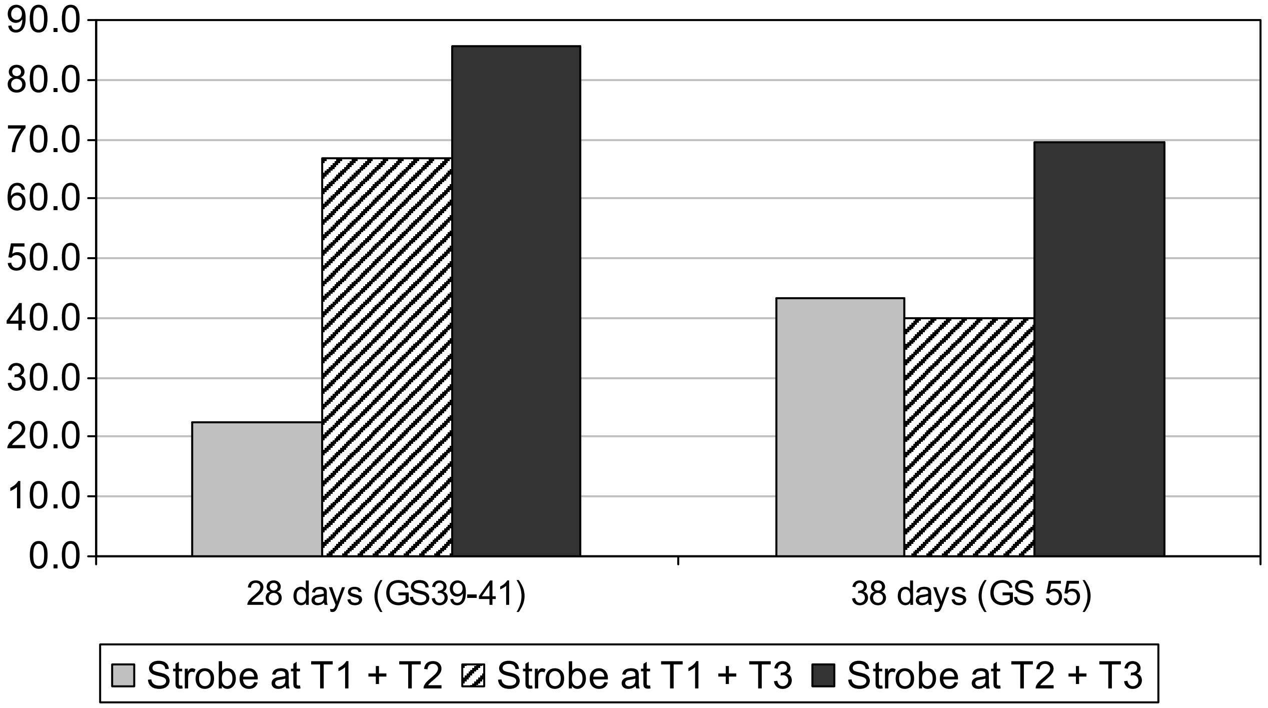
S. tritici resistance to strobilurins has increased rapidly and high levels of resistance are widespread across the UK. In 2002 this resistance was at relatively low levels and strobilurins gave effective control of *S. tritici.* At the beginning of the 2004 season this resistance was "high" at the experiment sites, (Source: analysis by Syngenta). In all years *S. tritici* was the predominant foliar disease. In 2002 *S. tritici* pressure was relatively high throughout the season, in 2003, high septoria pressure occurred relatively late in the season in contrast to 2004 when disease pressure was relatively high early in the season and then continued to develop more steadily.

4.1 Disease susceptible varieties (e.g. Consort)

In all three years, three-spray programmes gave the most reliable margins. However, in 2002, when resistance was at a low level, some two-spray treatments gave similar margins to a three spray strategy, despite relatively high disease pressure from *S. tritici* throughout the season. In 2003 and 2004, disease pressure was lower and comparisons between two and three-spray programmes were less clear. In these years the best two-spray programmes based on Opera gave yields that were not significantly different to the three-spray programmes, particularly in 2003 when disease pressure developed late rather than early in the season. However, in all three years predicting optimum doses in a two spray strategy and achieving the optimum T2 timing to obtain margins similar to a three spray strategy would have been difficult if not impossible to achieve in practice.

In 2002 strobilurins applied at T1 and T3 gave the best yields and margin over fungicide costs, data also suggests that these timings were perhaps the most reliable in 2003. However, in 2004 programmes including strobilurins at T2 and T3 appeared to be more reliable (Figure 1). This does not reflect disease development in that season (i.e. relatively high pressure early in the season) and hence may indicate a changing role of strobilurins from leaf and ear disease control plus green leaf retention to ear disease control and green leaf retention as *S. tritici* resistance to strobilurins developed. This result is also reflected in HGCA project 2533 (Project Report 385 - Disease control programmes using triazole and strobilurin fungicides on winter wheat). There were no one strobilurin-based programmes on Consort in either project.

Figure 1. The effect of strobilurin timing (at GS 39 or GS 55) within three-spray programmes Consort, 2004. Margin response over untreated (£/ha), (margin based on grain at £70/t, and each application cost at £6/ha). The strobilurin applied as Opera (pyraclostrobin). The amount of triazole in each treatment was adjusted to deliver the equivalent of 0.4 l/ha Opus at T1 followed by 0.75 l/ha Opus at T2. Amistar 0.25 l/ha + Folicur 0.25 l/ha applied at T3



In 2002, there was a financial advantage in delaying the T2 strobilurin based application from GS 39 (full flag leaf emergence) to GS 55 (half ear emergence), despite poorer disease control in both two and three-spray programmes. This may have been due to application of strobilurin onto the ear (no strobilurin was included in the T3 application) or a physiological effect from the later application of the strobilurin. The data suggests that this is a consequence of the physiological benefits from the strobilurins (plus some control of ear diseases) which are more likely to occur once the ear is emerging particularly where there is no benefit from their application for the control of leaf diseases. This effect was not consistently noted in 2003 and 2004, particularly with programmes containing the lower doses of strobilurin.

The higher doses of fungicide used at T1 (particularly with chlorothalonil) gave more flexibility in the T2 timing and hence reduced the impact of delayed T2 application, (Figures 2, 3 and 4). The addition of chlorothalonil (Bravo) at T1 gave a yield and margin boost when a less robust dose of triazole (equivalent to Opus 0.5 l/ha) was applied at T2, this effect was significant when T2 was delayed until half ear emergence (GS 55). The benefit of the addition of chlorothalonil was most pronounced when chlorothalonil was applied at T1 in a more protectant situation where leaf 3 was emerging. When the application of T2 was stretched to half ear emergence (GS 55) chlorothalonil did not interfere with the curative activity of the triazole (Figure 3).

Figure 2. The effect of triazole dose at T2 in "well timed" (28 days between T1 and T2) and stretched (38 days between T1 and T2) two-spray programmes Consort, 2004. Margin response over untreated (£/ha), (margin based on grain at £70/t, and each application cost at £6/ha). All treatments were followed by Folicur 0.5 l/ha at T3 at GS 65 (mid anthesis).

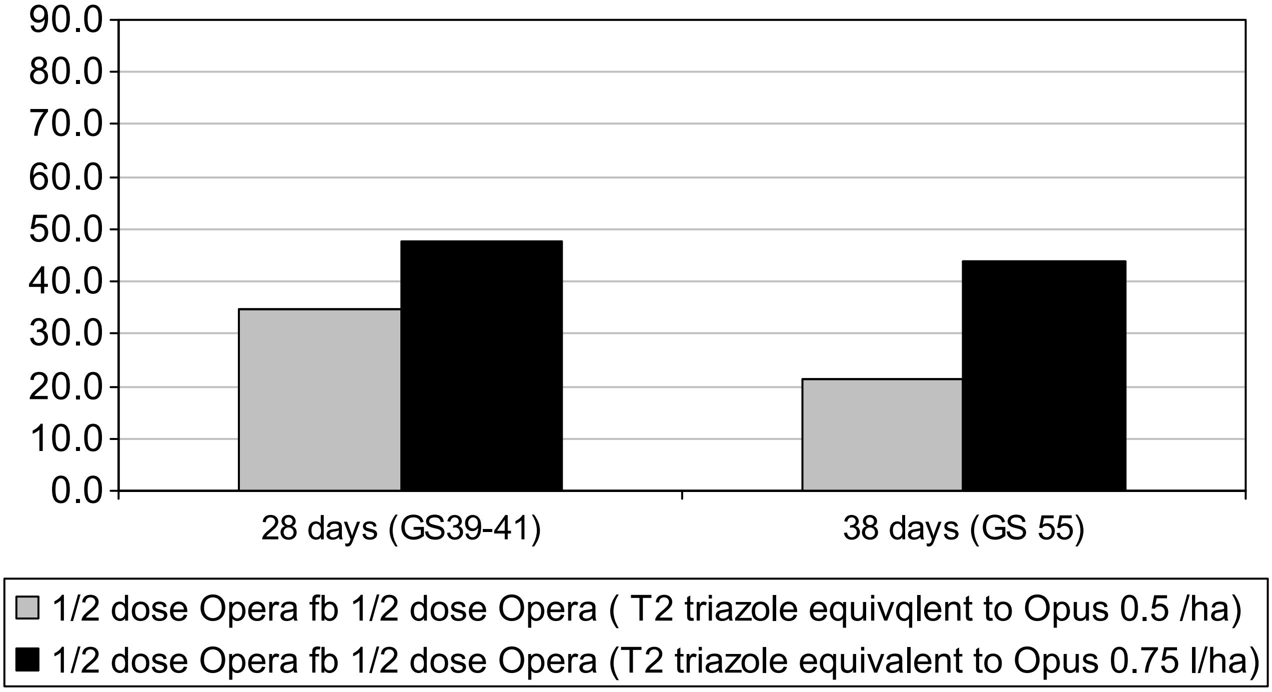
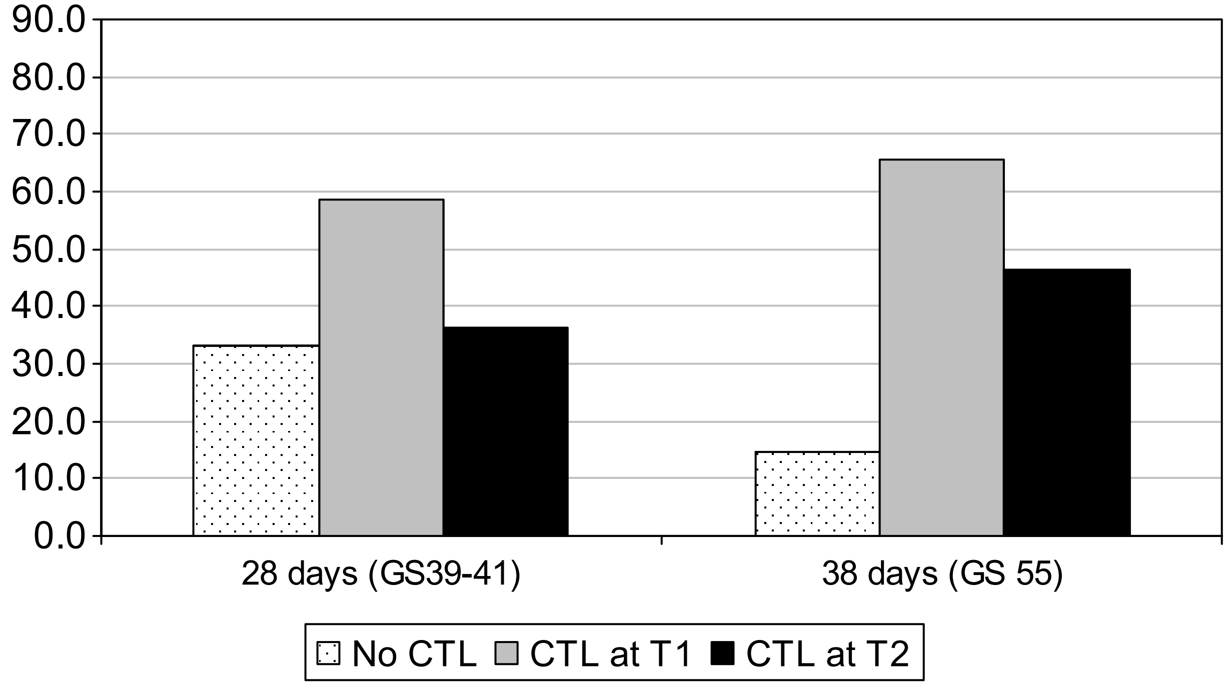
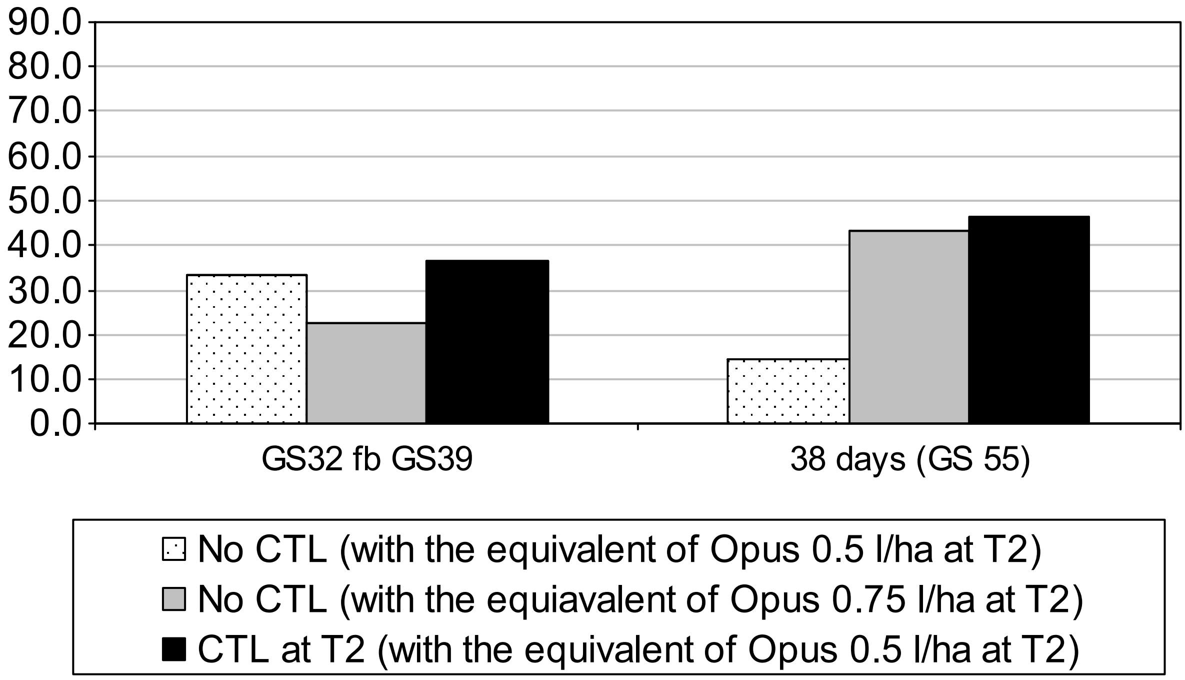


Figure 3. The benefit of the addition of chlorothalonil (CTL) to Opera 0.375 l/ha + Opus 0.25 l/ha at T1 and Opera 0.75 l/ha + Opus 0.2 l/ha at T2 in three-spray programmes, Consort, 2004. Margin response over untreated (£/ha), (margin based on grain at £70/t, and each application cost at £6/ha). All treatments were followed by Folicur 0.5 l/ha at T3 at GS 65 (mid anthesis)



Both the higher dose of triazole and the addition of chlorothalonil were more beneficial in a stretch situation (Figure 4).

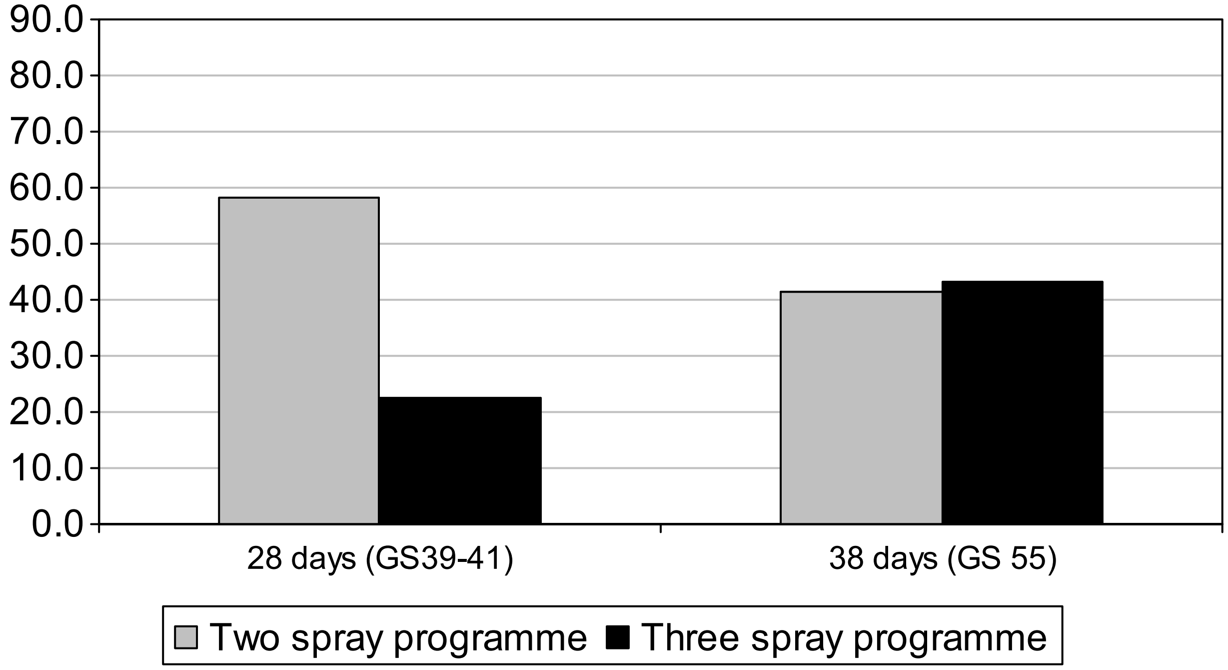
Figure 4. The benefit of the addition of chlorothalonil at T2 compared with a more robust dose of triazole, Consort, 2004. Margin response over untreated (£/ha), (margin based on grain at £70/t, and each application cost at £6/ha). All treatments were followed by Folicur 0.5 l/ha at T3 at GS 65 (mid anthesis)



T3 applications tended to be more cost-effective where T2 was delayed beyond GS 39 (Figure 5). This occurred particularly in 2002 and 2004 and is associated with helping to reduce the impact of the poorer disease control that occurs with a delayed T2. This is counter-intuitive as there would be an assumption that delaying T2 would reduce the value of the T3. Because of this growers should not justify delaying T2 (until GS 55) solely to anticipate that a T3 application can be avoided.

These results must be treated with care as there is an increasing shift in the resistance of *S. tritici* to triazoles.

Figure 5. The benefit of a T3 application on Consort in "well timed" (28 days between T1 and T2) and 'stretch' (38 days between T1 and T2) programmes, 2004. Quarter dose of Opera (0.375 l/ha) at T1 followed by half dose Opera (0.75 l/ha) with three quarter dose triazole (Opus 0.75 l/ha) at T2. Margin response over untreated (£/ha), (margin based on grain at £70/t, and each application cost at £6/ha)



4.2 Less disease susceptible varieties (e.g. Deben)

The variety Deben is less susceptible to *S. tritici* compared with Consort and was sown later, hence, disease (*S. tritici*) pressure was significantly less than in the Consort experiments.

Single sprays were tested in 2002 when *S. tritici* pressure was relatively high throughout the season. There were no significant differences between dose or timing of a single strobilurin based application, however, there was a consistent trend suggesting that the higher the dose the later the single application could be made to optimise returns. Yields were significantly higher when the same dose was split between two applications. There also appeared to be more consistency in the choice of dose and flexibility of timing in a two-spray programme to optimise returns than in Consort in the same year. There was no yield advantage to a three-spray programme.

2003 was a lower disease year with the greatest pressure from *S. tritici* occurring late in the season. There were very few significant yield differences between any of the treatments and any differences were small. However, the data suggest that three-spray programmes based on a T1 of triazole + chlorothalonil provided similar margins to a two spray strategy where each application was based on strobilurin. The main messages from the results this year was the wide degree of flexibility in the timing of the T2 spray within a three-spray programme. Again, there appeared to be an advantage to applying a strobilurin based T2 at or after ear emergence where T3 did not include a strobilurin; this advantage was not obvious where T3 included a strobilurin.

In 2004 there were no significant responses to fungicides on varieties less susceptible to *S. tritici* and hence no clear conclusions. There were no obvious trends to suggest the most appropriate timing of strobilurins within a three-spray programme.

5. Implications

Cultivars susceptible to *S. tritici* (e.g. Consort) usually require a three-spray programme except in locations and or seasons where there is very low disease pressure and/or rapid loss of green leaf at the end of the season. Hence in most seasons a deliberately stretched, two-spray programme would not be advised on varieties susceptible to *S. tritici* and possibly brown rust.

Varieties less susceptible to *S. tritici* (e.g. Deben) only required a two-spray programme based on strobilurins when resistance of *S. tritici* to their mode of action was not significantly reducing their efficacy. However, with high resistance to strobilurins a three-spray programme, based on triazole +/- chlorothalonil at T1 (1^{st} fungicide application) and T2 (2^{nd} fungicide application) and a strobilurin + triazole at T3 may be more robust where the weather is conducive to late season development of *S. tritici*.

There is some flexibility in the timing of T2 within a three-spray programme. The degree of flexibility is governed by disease pressure from the flag leaf stage onwards, fungicide dose, disease susceptibility of the variety and the level of resistance to fungicides. "Sufficient" doses of triazole and chlorothalonil are required to give flexibility in the timing of T2. In less susceptible varieties there is a lot of flexibility in the timing of a second application that contains a strobilurin (particularly if T3 does not contain a strobilurin). This may be because the impact on yield from lower disease control is less than that from the benefits of some control of ear diseases and the prolonged green leaf retention that may occur from the later application.

If T2 is delayed to ear emergence the benefit of a T3 application is not necessarily diminished and may be enhanced, particularly if the T3 contains a strobilurin and the T2 does not include a strobilurin. This may be because the triazole the T3 compensates for poorer disease control as a result of the delayed T2. Therefore, growers should not justify delaying T2 (until GS 55) in anticipation that a T3 application can be avoided.

In situations with low to moderate disease pressure flexibility in the timing of T2 can be used to prioritise demands on labour and machinery. A more cautious approach should be taken when growing a more susceptible variety in regions and seasons where disease pressure is greater.

On Deben in 2003, a single strobilurin based treatment in a three-spray programme at T2 provided a significant yield advantage when delayed from GS 39 to GS 55; however, this later treatment only produced a similar yield to where a single strobilurin was applied at T3. This also indicates that the benefit from the strobilurin occurred when applied to the ear.

With increasing resistance to strobilurins throughout the project the emphasis of their value appeared to change from *S. tritici* control and ear disease control plus some "physiological" benefits to ear disease control and "physiological" benefits. This suggests that if there is a role for strobilurins on future wheat crops they should be applied at the later timings within the fungicide strategy, particularly at T3.

6. Acknowledgements

The author would like to thank all members of the field team at TAG Eastern Region involved in the conduct of these experiments.

7. Appendix

Table 22. The effect of treatment on *S. tritici* and green leaf area (% leaf area), Consort 2002

Treatment No.	Septoria Leaf 1 9 July	GLA Leaf 1 9 July	GLA Leaf 2 9 July	GLA Leaf 3 9 July	GLA Leaf 1-3 16 July	GLA Leaf 1-3 23 July	GLA Leaf 1-3 30 July
1	0.3	90.0	90.7	50.0	59.7	14.0	0.3
2	0.1	90.0	83.3	33.3	55.0	21.3	0.3
3	0.8	88.7	86.7	48.3	53.3	7.7	-
4	0.1	90.0	90.0	49.3	60.7	20.0	0.7
5	0.2	90.0	76.7	28.3	56.7	17.0	1.0
6	0.1	90.0	92.7	70.0	59.3	20.7	0.3
7	0.1	90.0	88.3	46.7	58.7	17.7	-
8	0.2	90.0	92.0	61.7	57.0	12.0	0.0
9	0.1	90.0	91.0	48.3	58.0	20.7	-
10	0.2	90.0	87.7	33.3	56.3	20.0	0.7
11	0.1	90.0	94.0	71.7	59.7	16.0	0.3
12	0.1	90.0	87.7	51.7	58.0	20.7	1.0
13	0.8	89.0	90.0	58.3	53.3	5.3	-
14	0.4	89.7	81.0	51.7	57.3	18.7	0.3
15	0.2	89.3	82.7	43.3	56.0	20.0	0.7
16	0.1	90.0	92.3	73.3	62.0	20.7	1.3
17	0.1	90.0	93.0	55.0	58.0	20.3	1.0
18	0.5	89.3	92.0	70.0	54.7	10.3	-
19	0.1	90.0	92.3	65.0	65.3	23.0	0.7
20	0.1	90.0	87.7	56.7	60.0	19.7	1.3
21	0.1	90.0	90.7	48.3	65.0	20.7	1.7
22	0.2	90.0	91.7	61.7	58.3	18.3	0.3
23	0.1	90.7	94.3	70.0	61.7	21.7	1.3
24	0.2	90.0	90.0	30.0	55.3	12.7	-
25	0.1	90.0	92.3	21.7	61.3	24.0	0.7
26	23.3	41.7	1.7	0.0	6.0	1.7	-
LSD (P=0.05)	2.47	8.93	6.31	16.47	5.92	5.21	0.97
SE per plot 50 df) ±	1.50	5.41	3.82	9.98	3.59	3.16	0.59
CV (%)	135.0	6.2	4.5	20.0	6.4	18.5	107.0

Table 23. The effect of treatment on specific grain weight (kg/hl at 85% dm), Consort 2002

Treatment No.					Specific grain weight
1					77.7
2					78.6
3					77.4
4					78.6
5					78.5
6					78.5
7					78.5
8					77.8
9					78.0
10					78.9
11					78.1
12					78.3
13					77.5
14					78.5
15					78.9
16					78.5
17					78.9
18					77.8
19					78.4
20					79.0
21					78.7
22					79.0
23					79.2
24					77.8
25					77.7
26					71.6
LSD (P=0.05)					0.99
SE per plot 50 df) ±					0.60
CV (%)					0.8

Table 24. The effect of treatment on *S. tritici* and green leaf area (% leaf area) and specific grain weight (kg/hl at 85% dm), Consort 2003

Treatment No.	Septoria Leaf 1 4 July	GLA Leaf 1 4 July	GLA Leaf 2 4 July	GLA Leaf 3 4 July	GLA Leaf 1-3 8 July	GLA Leaf 1-3 15 July	Specific grain weight
1	0.1	95.0	96.3	51.7	95.0	33.3	79.7
2	0.1	95.0	94.7	46.7	94.7	30.0	80.1
3	0.2	94.7	96.0	46.7	94.7	34.7	78.9
4	0.1	95.0	96.7	48.3	95.3	32.7	79.2
5	0.2	95.0	95.7	26.7	90.7	26.7	79.6
6	0.1	95.0	96.7	50.0	92.3	30.0	79.5
7	0.1	95.0	97.0	55.0	95.3	35.3	79.7
8	0.1	95.0	97.0	46.7	97.3	32.7	79.4
9	0.1	95.0	96.7	53.3	92.7	40.0	79.6
10	0.1	95.0	95.7	45.0	92.3	32.7	80.1
11	0.1	95.0	96.0	45.0	95.7	42.7	79.7
12	0.1	94.7	97.0	53.3	96.3	33.3	80.1
13	0.2	94.7	95.7	43.3	93.3	34.3	78.9
14	0.1	95.0	96.3	46.0	91.3	35.0	79.7
15	0.2	95.0	96.7	39.0	90.3	31.7	80.3
16	0.1	95.0	96.7	57.7	65.3	31.0	79.5
17	0.1	95.0	96.7	58.3	93.7	35.3	79.9
18	0.1	95.0	97.3	58.3	96.0	35.7	78.7
19	0.1	95.0	96.7	50.0	92.3	34.7	79.7
20	0.2	95.0	95.7	40.0	91.7	33.7	79.8
21	0.1	95.0	96.7	58.3	96.3	41.0	79.1
22	0.1	95.0	97.0	56.7	95.0	40.0	79.5
23	0.1	95.0	98.0	71.7	97.7	48.3	79.9
24	0.1	95.0	97.7	66.7	97.3	42.0	80.1
25	0.1	95.0	96.7	50.0	94.7	46.3	80.5
26	3.7	90.0	63.3	2.7	75.0	9.0	76.8
LSD (P=0.05)	0.38	0.33	6.80	13.59	3.97	9.23	0.65
SE per plot 50 df) ±	0.23	0.20	4.12	8.24	2.41	5.60	0.39
CV (%)	87.5	0.2	4.3	16.9	2.6	16.1	0.5

Table 25. The effect of treatment on green leaf area (% leaf area), Consort 2004

Treatment No.	GLA Leaf 1 28 June	GLA Leaf 2 28 June	GLA Leaf 3 28 June	GLA Leaf 1 5 July	GLA Leaf 2 5 July	GLA Leaf 1 12 July	GLA Leaf 2 12 July
1	93.0	75.0	0.3	85.0	69.0	43.3	21.7
2	94.3	61.7	0.0	84.0	56.0	46.7	8.3
3	94.0	73.3	0.0	74.0	60.0	36.7	5.0
4	93.7	70.0	0.0	75.0	47.0	35.0	5.3
5	89.0	70.0	0.0	70.0	56.0	45.0	14.3
6	95.0	70.0	0.3	82.0	63.0	43.3	15.0
7	94.7	76.7	0.3	82.0	70.0	55.0	18.3
8	94.7	75.0	0.0	77.0	49.0	41.7	7.0
9	94.3	86.0	3.0	83.0	74.0	53.3	36.7
10	94.7	80.0	3.3	88.0	75.0	48.3	26.7
11	94.0	75.0	0.3	88.0	68.0	55.0	10.0
12	94.7	75.0	0.3	82.0	57.0	43.3	12.3
13	94.0	76.7	0.7	84.0	72.0	58.3	23.3
14	94.7	78.3	0.0	89.0	78.0	60.0	36.7
15	94.7	79.3	0.3	86.0	73.0	60.0	33.3
16	94.3	75.0	0.0	85.0	59.0	63.3	11.7
17	95.0	84.3	1.7	88.0	77.0	63.3	35.0
18	94.3	76.7	1.0	87.0	71.0	56.7	35.0
19	95.0	78.3	0.3	84.0	77.0	51.7	30.0
20	95.0	75.0	0.0	83.0	67.0	60.0	26.7
21	78.3	23.3	0.0	62.0	3.0	4.0	0.0
LSD (P=0.05)	4.23	11.13	1.74	16.5 (NS)	15.70	22.3	13.9
SE per plot 40 df) ±	2.56	6.75	1.06	10.0	9.50	13.5	8.4
CV (%)	2.8	9.2	184.7	12.2	15.2	27.7	43.0

Table 26. The effect of treatment on green leaf area (% leaf area) and specific grain weight (kg/hl at 85% dm), Consort 2004

Treatment No.						GLA Leaf 1 19 July	Specific grain weight
1						8.7	69.3
2						7.3	68.9
3						14.3	70.7
4						12.7	70.2
5						13.3	70.2
6						18.3	69.2
7						21.0	70.3
8						26.7	70.3
9						23.3	69.8
10						43.3	69.5
11						7.3	68.7
12						6.0	68.8
13						18.3	69.7
14						29.0	69.2
15						43.3	69.8
16						20.7	69.0
17						48.3	70.1
18						41.7	69.5
19						53.3	70.5
20						25.0	70.1
21						0.0	65.6
LSD (P=0.05)						18.4	1.51
SE per plot 40 df) ±						11.1	0.92
CV (%)						48.5	1.3

Table 27. The effect of treatment on *S. tritici* and green leaf area (% leaf area), Deben 2002

Treatment No.	Septoria Leaf 1 9 July	GLA Leaf 1 9 July	GLA Leaf 2 9 July	GLA Leaf 3 9 July	GLA Leaf 1-3 16 July	GLA Leaf 1-3 23 July	GLA Leaf 1-3 30 July
1	3.3	85.0	75.0	28.3	36.7	4.7	0.0
2	0.4	94.3	87.7	16.7	58.7	14.7	0.7
3	0.2	94.7	93.3	10.0	64.0	13.3	1.0
4	0.2	95.0	93.3	6.7	61.7	16.0	1.7
5	3.3	87.7	75.0	20.0	35.3	6.0	0.0
6	0.8	92.7	89.3	6.7	51.0	10.7	0.0
7	0.2	95.0	90.0	10.0	60.0	14.3	1.0
8	0.2	95.0	89.7	7.3	61.0	12.7	2.0
9	2.2	90.7	75.0	21.7	37.7	7.0	0.0
10	0.3	93.7	88.7	12.7	60.0	12.0	0.3
11	0.2	95.0	93.0	4.0	59.0	13.3	1.0
12	0.2	95.0	90.7	8.3	60.0	15.3	1.3
13	0.2	95.0	93.7	38.3	61.3	13.7	1.3
14	0.2	95.0	95.3	60.0	62.3	14.7	2.0
15	0.2	95.0	94.3	46.7	62.0	15.3	1.3
16	0.2	95.0	94.3	50.0	61.7	13.3	1.7
17	0.2	95.0	94.7	34.0	62.7	13.0	0.7
18	0.4	94..0	91.7	33.3	62.0	10.7	1.3
19	0.4	94.3	92.3	33.3	60.3	11.3	1.0
20	0.2	95.0	94.0	38.3	60.7	13.3	1.0
21	0.2	95.0	94.3	18.3	61.3	14.7	1.3
22	0.2	94.7	87.7	23.3	61.3	13.3	1.3
23	0.2	95.0	93.7	28.3	60.3	14.7	1.7
24	11.0	68.3	25.0	0.3	14.8	0.0	0.0
LSD (P=0.05)	1.55	3.35	8.52	16.3	9.62	4.74	0.90
SE per plot 46 df) ±	0.94	2.03	5.16	9.88	5.83	2.87	0.55
CV (%)	89.6	2.2	5.9	42.6	10.5	23.9	55.6

Table 28. The effect of treatment on specific grain weight (kg/hl at 85% dm), Deben 2002

Treatment No.							Specific grain weight
1							71.2
2							72.1
3							72.9
4							73.4
5							71.5
6							71.9
7							72.6
8							73.1
9							71.3
10							72.0
11							72.2
12							72.4
13							73.1
14							73.2
15							73.1
16							73.3
17							72.5
18							72.9
19							72.1
20							72.9
21							73.3
22							73.1
23							73.3
24							68.8
LSD (P=0.05)							0.71
SE per plot 46 df) ±							0.43
CV (%)							0.6

Table 29. The effect of treatment on *S. tritici* and green leaf area (% leaf area) and specific grain weight (kg/hl at 85% dm), Deben 2003

Treatment No.	Septoria Leaf 1 3 July	GLA Leaf 1 3July	GLA Leaf 2 3July	GLA Leaf 3 3 July	GLA Leaf 1-3 8 July	GLA Leaf 1-3 16 July	Specific grain weight
1	0.87	93.0	94.0	71.7	81.7	15.7	74.3
2	0.07	95.0	97.3	85.0	98.0	30.0	75.4
3	0.04	95.7	97.0	75.0	97.7	36.7	76.1
4	0.20	94.7	96.3	81.7	96.3	36.0	76.8
5	0.30	94.7	95.7	71.7	95.0	28.3	77.4
6	0.13	95.0	97.0	85.0	98.7	35.7	75.3
7	0.03	95.3	97.0	80.0	97.7	35.7	75.4
8	0.13	94.7	96.3	85.0	96.0	33.3	76.4
9	0.37	94.3	95.7	76.7	92.0	30.0	76.5
10	0.10	95.0	97.0	86.7	96.7	30.3	75.1
11	0.04	95.3	97.0	83.3	98.3	32.3	75.6
12	0.07	95.3	96.3	86.7	97.0	31.0	76.6
13	0.10	95.0	96.0	76.7	92.7	26.7	76.6
14	0.04	95.7	97.0	83.3	96.3	36.7	75.7
15	0.04	95.3	96.3	80.0	97.7	35.0	76.0
16	0.03	95.7	98.0	90.7	98.7	37.7	75.7
17	0.03	95.7	96.7	85.0	97.0	35.7	75.5
18	0.01	95.3	97.0	88.3	97.0	36.0	75.9
19	0.10	95.3	97.0	86.7	98.7	37.3	76.7
20	0.00	96.0	98.0	90.0	98.3	40.7	76.2
21	0.04	95.3	97.0	85.0	97.7	35.7	76.3
22	0.01	95.7	97.3	85.0	98.7	38.3	76.2
23	0.10	95.0	96.7	86.7	96.7	29.3	76.7
24	0.17	95.3	97.3	86.0	98.0	33.0	76.5
25	0.14	95.0	96.7	78.3	96.7	31.7	76.7
26	0.50	93.3	93.7	66.7	78.7	7.3	73.5
LSD (P=0.05)	0.211	0.90	1.11	8.16	3.47	7.87	0.76
SE per plot 50 df) ±	0.128	0.54	0.67	4.94	2.10	4.77	0.46
CV (%)	90.9	0.6	0.7	6.0	2.2	14.8	0.6

Table 30. The effect of treatment on green leaf area (% leaf area), Deben 2004

Treatment No.	GLA Leaf 1 2 July	GLA Leaf 2 2 July	GLA Leaf 3 2 July	GLA Leaf 1 12 July	GLA Leaf 2 12 July	GLA Leaf 3 12 July	GLA Leaf 1 20 July
1	95.0	94.0	58.0	82.0	53.0	3.0	42.0
2	95.0	96.0	48.0	80.0	51.0	4.0	39.0
3	96.0	95.0	51.0	80.0	54.0	6.0	46.0
4	95.0	96.0	53.0	77.0	56.0	9.0	40.0
5	94.0	93.0	44.0	81.0	51.0	3.0	42.0
6	95.0	92.0	45.0	82.0	50.0	6.0	45.0
7	95.0	95.0	54.0	80.0	63.0	4.0	43.
8	95.0	96.0	53.0	82.0	45.0	3.0	43.0
9	95.0	94.0	51.0	81.0	56.0	7.0	43.0
10	94.0	93.0	46.0	79.0	52.0	3.0	37.0
11	95.0	97.0	59.0	81.0	58.0	5.0	41.0
12	95.0	97.0	64.0	81.0	60.0	11.0	43..0
13	95.0	98.0	56.0	79.0	58.0	6.0	47.0
14	94.0	94.0	50.0	84.0	57.0	5.0	47.0
15	95.0	94.0	50.0	81.0	60.0	4.0	46.0
16	94.0	94.0	51.0	78.0	48.0	4.0	40.0
17	96.0	97.0	50.0	81.0	62.0	7.0	44.0
18	95.0	92.0	55.0	81.0	58.0	7.0	42.0
19	96.0	98.0	61.0	79.0	61.0	10.0	41.0
20	93.0	96.0	55.0	82.0	64.0	8.0	48.0
21	95.0	97.0	63.0	83.0	62.0	8.0	38.0
22	94.0	96.0	54.0	81.0	55.0	7.0	44.0
23	95.0	96.0	54.0	80.0	58.0	9.0	40.0
24	96.0	96.0	55.0	82.0	58.0	3.0	38.0
25	94.0	97.0	55.0	77.0	54.0	4.0	35.0
26	94.0	89.0	44.0	73.0	46.0	3.0	34.0
LSD (P=0.05)	1.80	3.8	12.4	7.1	14.5	5.3	12.0
SE per plot 50 df) ±	0.9	1.9	6.0	3.5	7.0	2.6	5.8
CV (%)	0.9	2.0	11.4	4.3	12.7	48.2	18.7

Table 31. The effect of treatment on *S. tritici* and green leaf area (% leaf area) and specific grain weight (kg/hl at 85% dm), Deben 2004

Treatment No.				GLA Leaf 2 20 July	GLA Leaf 1 26 July	GLA Leaf 2 26 July	Specific grain weight
1				6.0	16.0	2.0	71.0
2				7.0	14.0	2.0	71.4
3				9.0	20.0	2.0	71.6
4				10.0	17.0	3.0	71.3
5				9.0	17.0	2.0	71.5
6				9.0	18.0	3.0	71.5
7				8.0	17.0	3.0	71.1
8				8.0	21.0	3.0	70.5
9				12.0	23.0	4.0	72.0
10				7.0	14.0	2.0	71.1
11				13.0	19.0	4.0	71.5
12				11.0	20.0	3.0	71.0
13				10.0	16.0	2.0	71.2
14				8.0	20.0	2.0	71.1
15				8.0	18.0	2.0	72.1
16				7.0	19.0	2.0	71.4
17				9.0	22.0	3.0	71.5
18				7.0	21.0	2.0	71.4
19				10.0	20.0	2.0	71.6
20				14.0	20.0	3.0	71.7
21				11.0	21.0	5.0	71.7
22				10.0	16.0	3.0	71.4
23				9.0	15.0	2.0	71.0
24				6.0	17.0	3.0	71.3
25				5.0	17.0	3.0	70.8
26				8.0	12.0	2.0	71.7
LSD (P=0.05)				5.6	6.8	1.6	1.08
SE per plot 50 df) ±				2.7	3.3	0.8	0.52
CV (%)				31.3	18.7	32.6	0.7