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Application timing of recent fungicides used in winter barley disease control programmes

by

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Abstract

A 3-year study was undertaken to determine the influence of recently-introduced fungicides on the traditional timings employed for winter barley disease control. Previous advice had been to apply a T1 spray at GS30-31, followed 3-4 weeks later by a T2 spray, when using programmes based on fungicides with good eradicant activity (triazoles and morpholines).

However, the first new products (strobilurins and cyprodinil) were most effective as protectants. The ability to apply these slightly earlier would increase flexibility, but control of established disease could be jeopardised if applied too late. There was also evidence that the T2 spray, previously seen as less critical than T1, might take on new significance with the greening effects of strobilurins, and that a T3 spray might even be justified.

Field trials were established, starting in autumn 2001, at four sites in England. Their geographic spread and chosen varieties were targeted to represent key foliar disease scenarios. These were rhynchosporium (Hants.), brown rust (Glos.), brown rust and rhynchosporium (Lincs.), and net blotch and rhynchosporium (Norfolk). 21 fungicide treatments were examined, involving one, two or three-spray programmes at a range of timings. Single or first (T1) sprays were based on Acanto (picoxystrobin). Second (T2) sprays were based on Amistar (azoxystrobin). For all treatments applied up to GS49, Opus (epoxiconazole) + Corbel (fenpropimorph), or Unix (cyprodinil), were evaluated as alternative partners. Foliar disease and green leaf area were assessed, and trials were taken to yield. Samples were analysed for physical grain quality, and margins were calculated.

Single sprays gave larger yield increases at T2 than at T1. Two-sprays always gave a benefit compared to T1 only, but were not always better than T2 only. Two-sprays were more effective at controlling rhynchosporium, but under varying disease pressure, T2 applications were the most crucial for protecting green leaf. However, the three seasons were not characterised by high disease pressure prior to T1. Within a 14 day window, timing of the T1 spray had no consistent effect on yield. It was also not critical whether it was leaf 3 or 4 emerging at the time of application. Similarly, timing of the T2 spray rarely had a significant impact on green leaf retention or yield. However, there was sometimes an advantage to spraying at GS39-49 where rhynchosporium was the main disease, or spraying at GS49-59 where brown rust was dominant. Despite some improvements in disease control, there were no significant yield benefits or increases in margin as a result of applying a T3 spray.

Whilst the pattern of disease resulting from seasonal or regional weather will always determine which timings are most beneficial, fungicide sprays at T2 are at least as important as at T1 in winter barley. Linked to this, yield responses have been higher with brown rust or net blotch than for an equal incidence of rhynchosporium. With strobilurin fungicides, there is flexibility in the timing of the T1 and T2 sprays, and the interval between them, whether a protectant or eradicant partner is used. However, it was rarely of benefit to delay the T1 or T2 spray where a protectant partner was used, even though few trials had a high requirement for eradication.

Summary

Project Overall Aim

To determine the influence of recently-introduced fungicides on the traditional timings employed for winter barley disease control, in order to establish new management guidelines for the crop.

Introduction

The introduction in 1997 of two new fungicide types, strobilurins and cyprodinil, had significant implications for foliar disease control in barley. A particular feature of these was the duration and level of the protection that they offered, and it quickly became apparent that the existing guidelines for optimum application timing might no longer be appropriate. Historically, the T1 fungicide had been seen as the key spray timing for winter barley, with the T2 fungicide often omitted where disease control following the T1 application had been good. However, there were indications that the use of a strobilurin as part of the T2 spray was leading to improved control of brown rust and net blotch, often the dominant diseases at that timing, and as a result green leaf area was being better protected and yields were benefiting more from an application at this timing.

Not only was there potential to re-define the relative importance of the different spray timings, the growth stages at which at the T1 and T2 treatments needed to be applied could also be modified. Previous advice had been to apply the T1 spray at GS30-31, followed 3-4 weeks later by the T2 spray (if needed). However, this assumed the use of spray programmes based mainly on fungicides with good eradicant activity (triazoles and morpholines) whereas the first new generation products had particular strengths as protectants. This might jeopardise the control of established disease, if applied too late. At the same time, application of the T1 or T2 sprays slightly earlier than before could have advantages, for example when tank-mixing with other inputs.

For winter wheat, it had long been recognised that the optimum timing for the T1 spray was dependent on leaf emergence, not on growth stage. For winter barley, it was unclear whether the leaf that was emerging when the T1 spray was applied was critical, and whether the choice of eradicant or protectant partner at T1 had an effect on this. With the awns also contributing significantly to yield in winter barley, it was also uncertain whether applying the T2 spray before they had emerged would compromise disease control and yield, or application well after the awns had emerged would be less effective even when using an eradicant partner.

A series of trials were therefore established, starting in autumn 2001, with a wide geographic spread of sites in England, and utilising a different variety at each site to reflect the main disease pressures likely to be experienced at that location. The specific objectives of the three year project were as follows:

To determine the relative contributions of the T1 and T2 sprays in winter barley, when using strobilurins.

To examine the effect of application timing of the T1 and T2 sprays.
To identify whether response to the T1 spray is dependent on the leaf emerging at the time of application.
To establish the degree of flexibility in the T1 – T2 spray interval, when using strobilurins.
To investigate how choice of partner, either eradicant (Opus + Corbel) or protectant (Unix) influences this.
To evaluate the benefit of a third (T3) spray application in winter barley.

Methods

Field trials were established at four locations in England in three successive seasons from 2001/02 to 2003/04. At each location, a different variety of winter barley was sown, in order to target different foliar diseases.
Andover, Hampshire Variety: Sumo Disease: rhynchosporium
Caythorpe, Lincolnshire Variety: Carat Diseases: brown rust, rhynchosporium
Cirencester, Gloucestershire: Variety: Siberia Diseases: brown rust, net blotch
Morley, Norfolk Variety: Pearl Diseases: net blotch, rhynchosporium

21 fungicide treatments, involving one, two or three-sprays at a range of timings, were compared with an untreated. Treatments consisted mainly of two-spray programmes, with the first spray at one of three timings (GS30, 30 + 7 days, or 30 + 14 days), followed by a second also at one of three timings (GS39, GS49, GS59), giving nine combinations. Single spray treatments at GS30 + 7 days or GS49, and three-spray programmes with applications at GS30, GS39 and GS59, were also examined. Single sprays, and the first spray of all two- and three-spray programmes, were based on a half dose of Acanto (picoxystrobin). The second spray of two- or three-spray programmes was based on a half dose of Amistar (azoxystrobin). For single and two-spray treatments, Opus (epoxiconazole) + Corbel (fenpropimorph) and Unix (cyprodinil) were evaluated as alternative partners (Unix not at GS59). Where applied, third sprays were either Amistar + Opus or Opus alone. To summarise, fungicide products and doses (l/ha or kg/ha) used were:

First spray (T1) Acanto 0.5 + Opus 0.25 + Corbel 0.25 or Acanto 0.5 + Unix 0.4kg
Second spray (T2) Amistar 0.5 + Opus 0.25 + Corbel 0.25 or Amistar 0.5 + Unix 0.4kg
Third spray (T3) Amistar 0.25 + Opus 0.25 or Opus 0.5

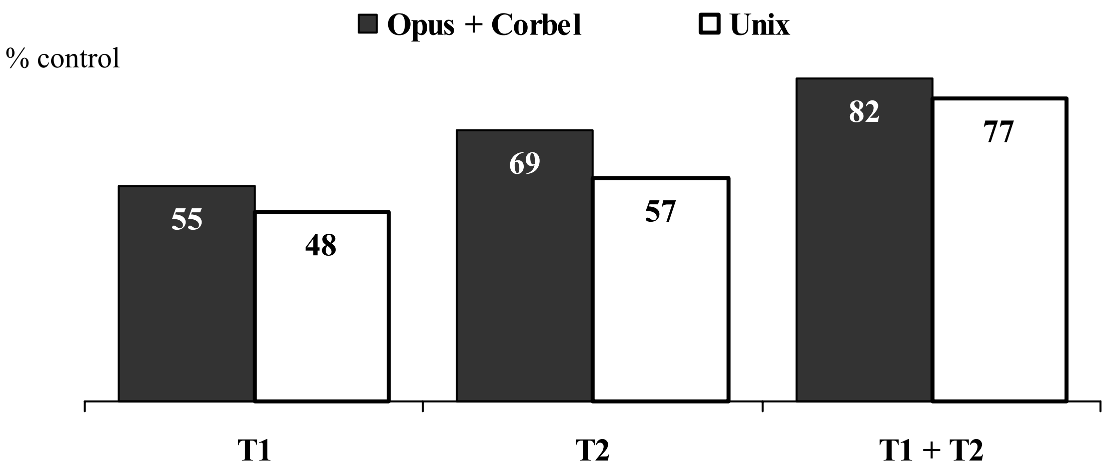
Foliar disease levels and green leaf area were assessed at key stages, and growth stages and leaf emergence recorded. Trials were taken to yield, and grain samples analysed for physical grain quality. Margins (output value less fungicide and applications costs) were then calculated, based on feed grain valued at £60/t, and fungicide costs per litre of Acanto £30, Amistar £26, Opus £24, Corbel £18, Unix £26.25 (per kg) and a spray application cost of £6/ha (per pass). This gave total treatment costs of £31.50/ha at T1 (or for single spray programmes), £29.50 at T2, and £61.00/ha for two-spray programmes.

Results

The relative contributions of the T1 and T2 spray timings

Single T1 sprays of Acanto applied with Opus/Corbel or Unix were compared with the same single sprays at T2, and a two-spray sequence (replacing Acanto with Amistar at T2). Two-sprays were more effective overall at controlling rhynchosporium. In 2003, T1 sprays were less effective on leaves 1 or 2, but in 2004 T2 sprays were less effective on leaves 3 or 4. Opus/Corbel was slightly more effective as a partner than Unix, although the largest differences were with single T2 sprays (where the need for eradication would have been greatest).

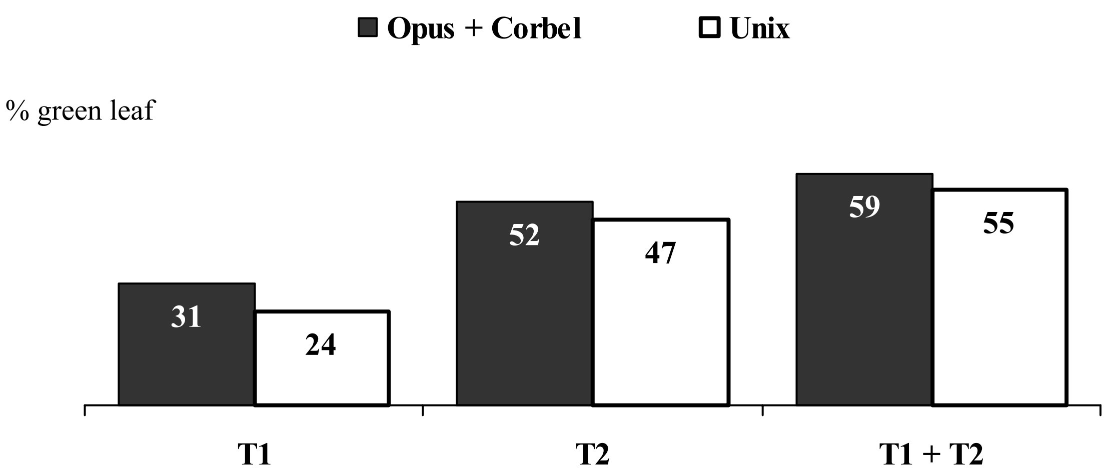
Figure 1. The effect of T1 and T2 spray applications on rhynchosporium control



Mean of 3 trials, 2002-2004, and two leaf layers

Under varying disease pressures from brown rust, rhynchosporium and net blotch, single sprays at T2 were consistently more effective at protecting green area on leaf 2 than single sprays at T1. Two-spray sequences always gave a benefit compared to single sprays at T1, but not always compared to single sprays at T2.

Figure 2. The effect of T1 and T2 spray applications on retention of green leaf area



Mean of 6 trials, 2002-2004, leaf 2

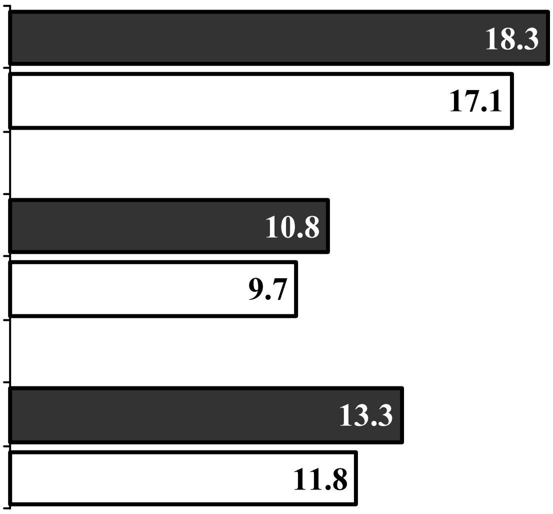
In nine out of twelve trials, single sprays at T1 ranked below single sprays at T2 in grain yield for both partners. In only one trial, where brown rust developed relatively early, did single sprays at T1 rank above single sprays at T2. Four trials showed a significant advantage to applying a T1 spray in addition to a T2, most notably in the trial where brown rust developed early.

Figure 3. Yield response over untreated with T1, T2 or T1 + T2 spray applications

T1 (GS30 +7) + T2 (GS49)
Acanto/Amistar + Opus + Corbel **(10.7 – 32.0)**
Acanto/Amistar + Unix **(6.9 – 29.6)**

T1 (GS30 + 7 days) only
Acanto + Opus + Corbel **(3.8 – 29.2)**
Acanto + Unix **(1.2 – 23.7)**

T2 (GS49) only
Acanto + Opus + Corbel **(7.8 – 25.5)**
Acanto + Unix **(2.4 – 17.0)**



Mean % yield increase over untreated (range)

Mean of 12 trials, 2002-2004

In more than 70% of comparisons, highest margins were obtained with single sprays at T2, compared to 20% where margins were highest with two sprays, and less than 10% with a single spray at T1. Only in 2004 did choice of partner (Opus + Corbel or Unix) affect which trials gave an economic benefit from a T1 spray in addition to a T2 spray, and which did not, and this was not consistent between the four trials.

Table 1. Spray timings producing the highest margins (output value less treatment cost)

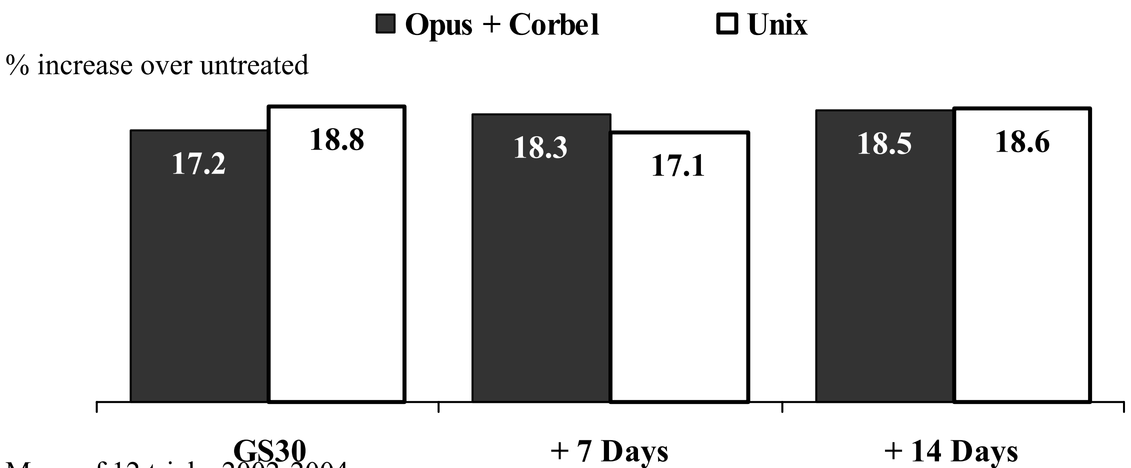
Location	**2002**		**2003**		**2004**	
	Opus + Corbel	Unix	Opus + Corbel	Unix	Opus + Corbel	Unix
Hants.	**T2**	**T2**	**T2**	**T2**	**T2**	**T1+T2**
Lincs.	**T1**	**T1**	**T2**	**T2**	**T2**	**T2**
Glos.	**T1+T2**	**T1+T2**	**T2**	**T2**	**T1+T2**	**T2**
Norfolk	**T2**	**T2**	**T2**	**T2**	**T1+T2**	**T2**

12 trials, 2002-2004

The degree of flexibility in the T1 spray timing

The performance of T1 sprays was compared when applied at either GS30, about 7 days later at GS30-31 or 14 days later at GS31-32, all followed by a T2 spray at GS49. The earliest T1 timing gave the poorest control of rhynchosporium, although differences were often small. T1 timing had little or no effect on the control of brown rust with Opus + Corbel as partner, but with Unix control was more variable. None of the T1 timings consistently gave the highest yields, and there was little difference in mean yield response over untreated.

Figure 4. The effect of T1 timing on yield response over untreated (T2 at GS49)

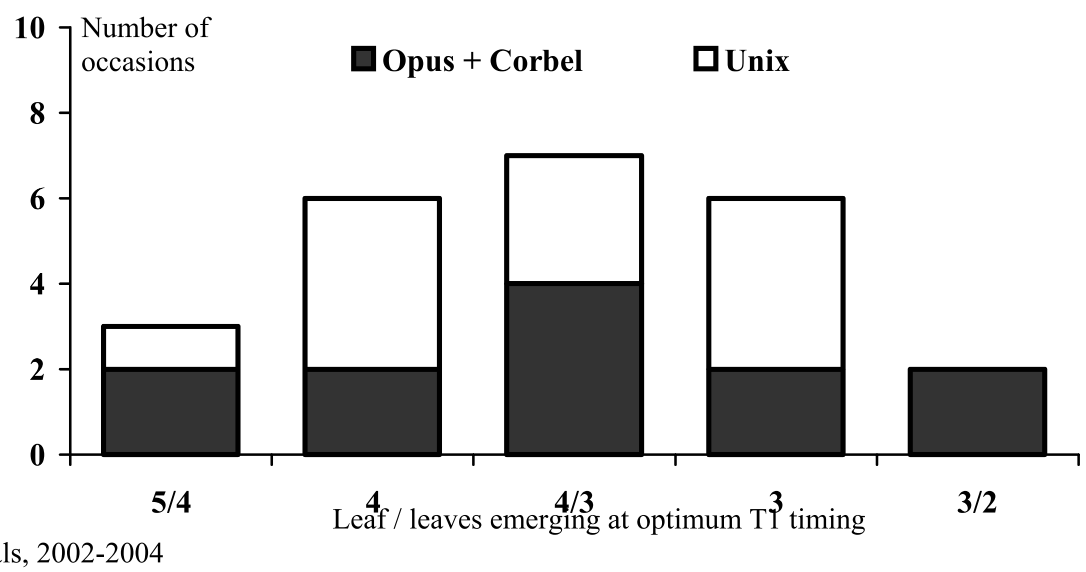


Mean of 12 trials, 2002-2004

The importance of leaf emergence in determining the optimum T1 timing

Figure 5 shows the leaves emerging at the optimum T1 timing, for both the Opus + Corbel and Unix partners. With one exception the Unix optimum always coincided with the emergence of leaf 3 and/or leaf 4. For Opus + Corbel, there was little disadvantage to applications that coincided with the emergence of leaf 5 or leaf 2.

Figure 5. Leaf / leaves emerging at optimum T1 timing for yield

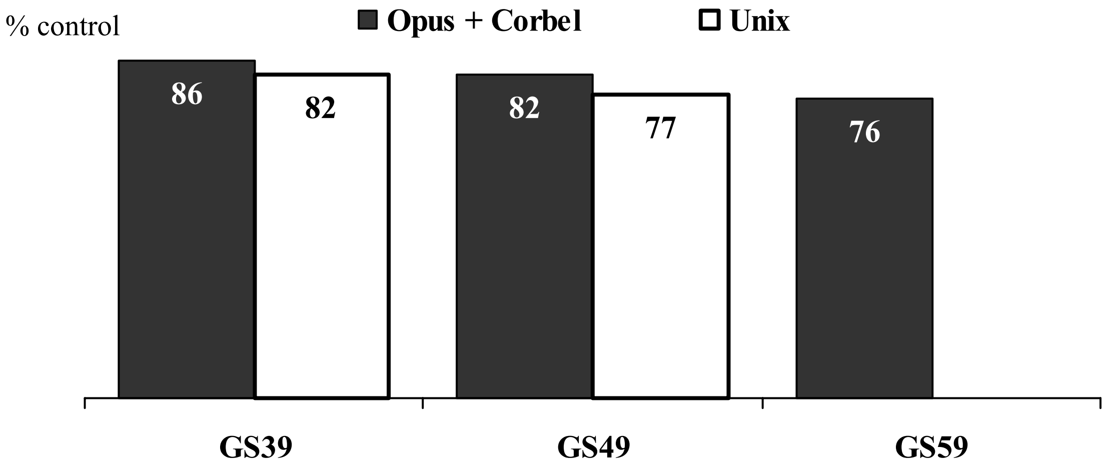


12 trials, 2002-2004

The degree of flexibility in the T2 spray timing

The performance of T2 sprays was compared when applied at either GS39 (flag leaf emergence), GS49 (awn emergence) or GS59 (ear emergence), all preceded by a T1 spray at GS30 + 7 days. Unix is not approved for use beyond GS49. The earliest T2 timing tended to give the best control of rhynchosporium for both partners, although differences were rarely significant. For Opus + Corbel, timing had little impact on brown rust control even on leaf 4, but with Unix GS39 was more effective than GS49 in the latter case. Under varying disease pressure, timing had no consistent effect on the amount of green area retained on leaf 2.

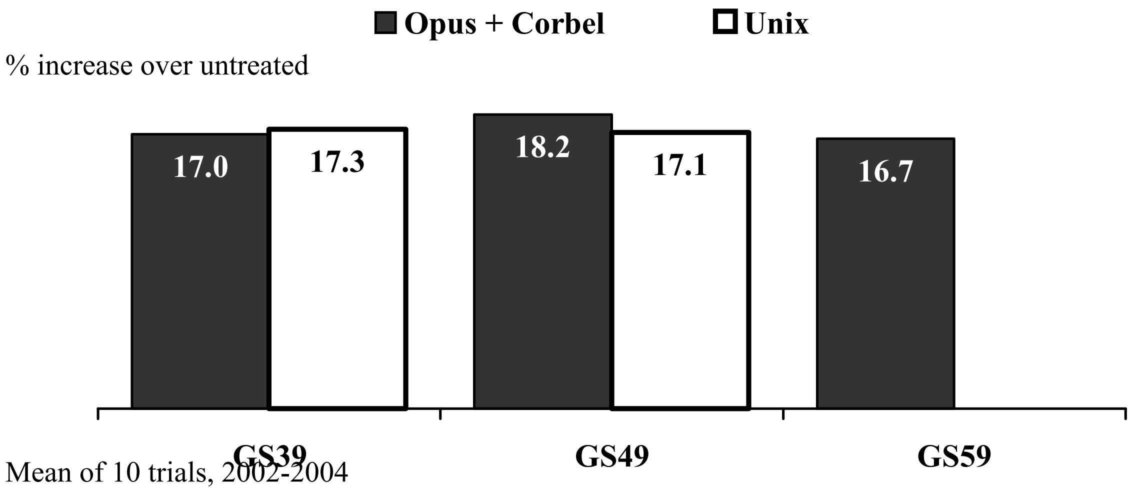
Figure 6. Effect of T2 spray timing on rhynchosporium control



Mean of 3 trials, 2002-2004, and two leaf layers

None of the T2 timings consistently gave the highest yield increases, and differences were rarely significant. Where rhynchosporium was the main disease, delaying the T2 until GS59 was detrimental in 2002 and 2003, but not in 2004. Where brown rust or net blotch were dominant, GS39 was generally the least effective timing. T2 timing had no effect on thousand grain weight or specific weight, other than that reflected in yield.

Figure 7. The effect of T2 timing on yield response over untreated (T1 at GS30 + 7 days)



Mean of 10 trials, 2002-2004

The degree of flexibility in interval between the T1 and T2 sprays

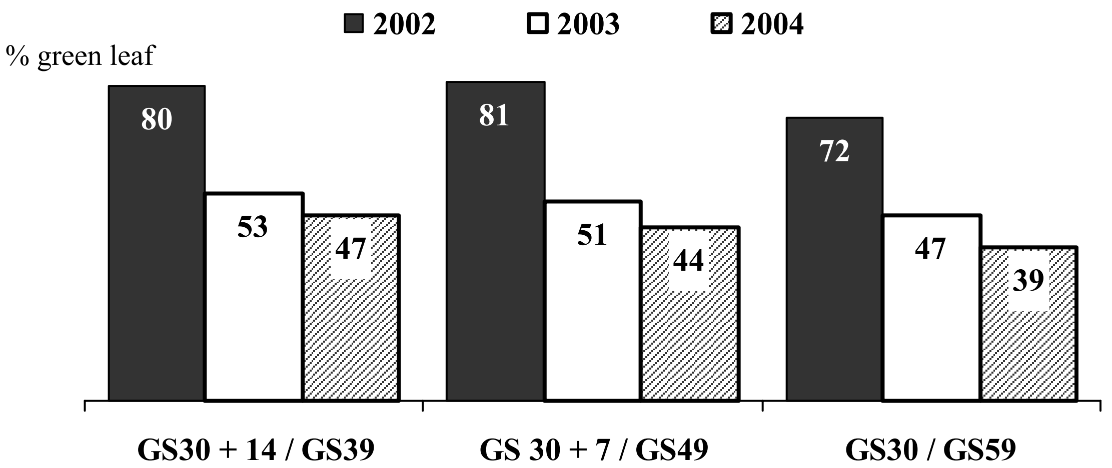
The combination of three T1 and three T2 spray timings gave nine possible T1-T2 intervals (when using Opus + Corbel as the partner). The smallest, largest and mean number of days between the T1 and T2 sprays for the shortest, longest and middle intervals is shown in Table 2. The shortest interval averaged 3 weeks (range 1-4 weeks), the middle interval 5 weeks and the longest interval 7½ weeks (range 6-9 weeks).

Table 2. Shortest, longest and mean intervals between T1 and T2 spray timings

T1 and T2 Spray Timings	Interval between T1 and T2 spray timings (no. of days)		
	Smallest	Largest	Mean
T1 GS30 + 14 days fb T2 GS39	8	28	20.4
T1 GS30 + 7 days fb T2 GS49	21	42	34.5
T1 GS30 fb T2 GS59	41	62	52.2

The longest interval tended to give inferior control of rhynchosporium, and under varying disease pressure was also less effective at retaining green area on leaf 2, especially in 2002.

Figure 8. The effect of T1 - T2 spray interval on retention of green leaf area



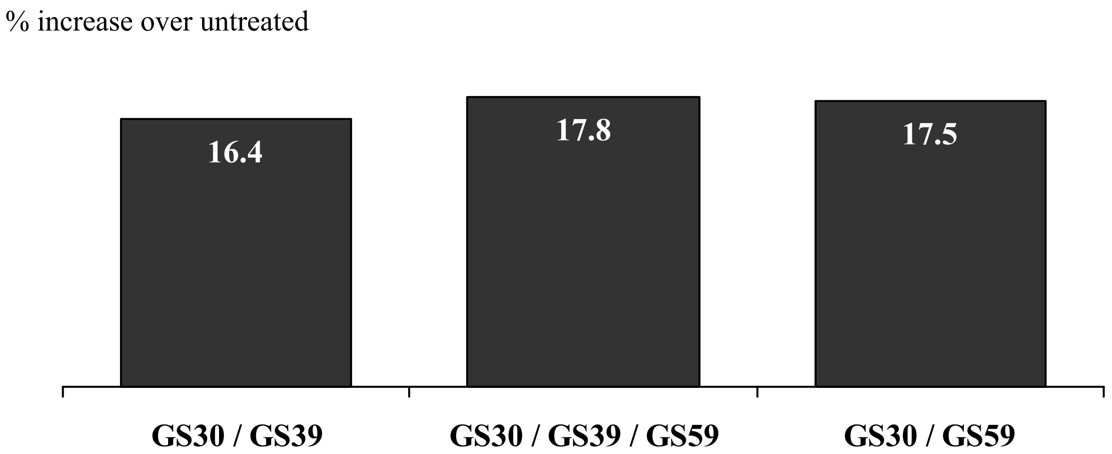
Mean of 2 trials per year, leaf 2

The length of the spray interval had a significant effect on the yield response to fungicide in only one out of ten trials, and there was generally no meaningful relationship between the interval length and the effectiveness of the corresponding treatment at increasing yield. Where there was an indication of an advantage to a specific interval it was often the middle one (GS30 + 7 days followed by GS49). Where there was an indication of a disadvantage to a specific interval, this was often the shortest one (GS30 + 14 days followed by GS39).

The benefit from a T3 spray application

The effect of a 'T3' fungicide spray (Opus 0.5 l/ha) applied in addition to T1 and T2 sprays at GS30 and GS39 respectively, was compared against two-spray sequences at GS30 and GS39 or GS30 and GS59 only. In 2002 the control of rhynchosporium was increased with a T3 spray, but not in the following two years. Small improvements were also obtained in brown rust and net blotch control in individual trials. In three out of ten trials there was a yield benefit from a third fungicide spray, but none of the differences were significant. In other cases, the three-spray treatment was no better than the most effective of the two-spray programmes.

Figure 9. The effect of a third fungicide spray on yield response over untreated



Mean of 10 trials, 2002-2004

There were no situations where three sprays gave a higher margin than the most effective two-spray programme, and often three sprays gave a lower margin. In a few trials there was an increase in thousand grain weight, but there was no consistent improvement in specific weight.

In one trial in Lincolnshire in 2004 under moderate rhynchosporium pressure there were consistent indications of improvements (not significant) in the retention of green area, thousand grain weight and yield with a third fungicide compared to either of the two-spray programmes. However, there were no differences in margin.

Table 3. The effect of a third fungicide spray in Lincolnshire in 2004

T1 and T2 Spray Timings	Fungicide Programme			LSD
	GS30/GS39	GS30/GS39/GS59	GS30/GS59	
% green area leaf 2	55	72	47	22
% yield increase	12.7	16.4	12.7	4.7
TGW (g)	44.5	46.4	44.7	NS
Margin (£/ha)	496	496	496	

Conclusions and Implications

Fungicide applications at the T2 timing in winter barley are at least as important as at T1, regardless of the diseases that are present, or the choice of eradicant or protectant partner to a strobilurin.

However, the pattern of disease development that results from seasonal and regional weather factors will determine which of the timings is the most beneficial in a given situation. The three seasons within which these trials were conducted were not characterised by high disease pressure in the period leading up to T1. Where, for example, rhynchosporium is very active early in the season, fungicides applied at T1 and possibly earlier (at T0) may be more important.

Yield responses to fungicide have been larger where brown rust (and net blotch) are the main diseases than where similar or higher levels of rhynchosporium have been present.

This partly explains why T2 fungicides have tended to contribute slightly more than half of the yield response (brown rust and net blotch tend to be more prevalent at that stage). Note that to some extent this may reflect the fact that fungicide programmes such as those evaluated here have often been less successful at controlling rhynchosporium than brown rust, and the recent approval of fungicides containing prothioconazole (Proline or Fandango) may help to improve this.

Programmes based on two half-rate strobilurin sprays have shown a high degree of flexibility in timing, with application windows of 2 weeks or more (and spray intervals varying by up to four weeks) having relatively little impact on yield.

This is in stark contrast to winter wheat, where the effective control of septoria in particular is often very dependent on timing. Where spray days or spraying capacity are limited, the use of fungicide programmes that allow considerable flexibility in their application timings is likely to be of benefit. However, intervals of less than 3 weeks or more than 7 weeks should still be avoided.

Unlike in wheat, the efficacy of, and optimum timing for, the T1 spray in winter barley is not closely related to the emergence of a particular leaf layer.

Whilst in winter wheat the T1 fungicide should be applied when leaf 3 is emerging rather than leaf 4, on winter barley which of these two leaves is emerging is less critical. Applications can therefore be timed effectively by growth stages. With a ‘flexible’ (eradicant) partner added to strobilurin, applications as early as when leaf 5 is still emerging on some plants, or as late as when leaf 2 has started to emerge, may be equally effective.

Timing of the T2 spray has had no consistent impact on yield, regardless of the diseases present, but GS49 (awn emergence) remains the best compromise.

There is some evidence that the T2 application should be earlier (GS39) than GS49 rather than later (GS59) where rhynchosporium is still active. Where brown rust (or net blotch) are increasing at T2, if an eradicant partner is included application earlier than GS49 may be disadvantageous.

Choice of strobilurin partner (either protectant as with Unix or eradicant as with Opus + Corbel) has had no consistent effect on yield, but in situations where delaying the T1 or T2 spray has been beneficial with Opus + Corbel as the partner, this has not generally been the case with Unix.

Use of a mainly protectant partner with a strobilurin might be expected to be more limiting to the flexibility in timing of the T1 and T2 sprays, especially where brown rust was the main disease present. Whilst there were some situations where this was true, overall the choice of partner made little difference. However it should be noted that the patterns of weather and disease development over the three years of the project did not generally result in a high requirement for disease eradication at any of the T1 or T2 timings.

Application of a third fungicide spray at the 'T3' timing is unlikely to be justified on winter barley, in either rhynchosporium or brown rust dominated situations.

When this project first started, application of a third strobilurin-based fungicide spray at T3 offered potential to improve yields and grain quality through extending the green area duration of the crop canopy. Since then, resistance concerns have led to the use of strobilurins in cereals being limited to two applications. Despite occasional improvements in disease control or yield compared to the most effective two-spray programmes, neither strobilurin nor triazole based T3 sprays have been shown to be cost-effective here.

The influence of recently-introduced fungicides on application timings used in winter barley disease control programmes

Project Overall Aim

To determine the influence of recently-introduced fungicides on the traditional timings employed for winter barley disease control, with a view to establishing new management guidelines for the crop.

1. Introduction

The introduction of two new groups of fungicides in the late 1990s heralded the start of a new era in crop protection in cereals. In many ways, their impact on disease control in barley was even greater than in wheat. The strobilurin group provided a much needed addition to triazoles and morpholines, for improving the control of rhynchosporium, net blotch and brown rust. Cyprodinil likewise was a vital alternative protectant partner against rhynchosporium, net blotch and mildew, in addition to controlling eyespot. A particular feature of these new fungicides was the duration and level of the protection that they offered, and it quickly became apparent that the existing guidelines for optimum application timing might no longer be appropriate.

Historically, the T1 fungicide, had been seen as the key spray timing for winter barley, with the T2 fungicide often omitted where disease control following the T1 application had been good. However, there was evidence from other work (ARC, 2000) that the use of Amistar (azoxystrobin) as part of the T2 spray was leading to improved control of brown rust and net blotch, often the dominant diseases at that timing, and as a result green leaf area was being better protected and yields were benefiting more from an application at this timing. There was also a suggestion that there might be an advantage to a later third spray, equivalent to a T3 spray in wheat, due to the ability to maintain green leaf area for longer.

Not only was there potential to re-define the relative importance of the different spray timings, the growth stages at which at the T1 and T2 treatments needed to be applied could also be modified. Best advice previously had been to apply the T1 spray at GS30-31, followed 3-4 weeks later by the T2 spray (if needed). However, this assumed the use of spray programmes based mainly on fungicides with good eradicant activity (triazoles and morpholines) whereas the first new generation products had particular strengths as protectants. A mix of strobilurin + cyprodinil would potentially have relatively eradicant activity, which might jeopardise the control of diseases once established, if applied too late. At the same time, the ability to apply the T1 and T2 sprays slightly earlier than before could have advantages, for example allowing the fungicides to be tank-mixed with PGR applications that were often targeted at about GS30 and GS39.

For winter wheat, it had long been recognised that the optimum timing for the T1 spray was dependent, not on growth stage, but on leaf emergence. With leaf 3 contributing more to yield (and more reliably) than leaf 4, application prior to the emergence of leaf 3 was generally found to be disadvantageous to yield. For winter barley, it was unclear whether the leaf that was emerging when the T1 spray was applied was critical, and again whether the choice of partner to the strobilurin at T1 (eradicant triazole or protectant cyprodinil) had an effect on this. With the awns also contributing a significant proportion of the yield in winter barley, it was also uncertain whether applying the T2 spray before they had emerged (at GS39, full flag leaf emergence) would compromise disease control and yield, or application well after the awns had emerged (at GS59, full ear emergence) would be less effective even when using an eradicant partner (Unix is not approved for use after GS49, awns emerged).

A series of trials were therefore established, starting in autumn 2001, with a wide geographic spread of sites in England, and utilising a different variety at each site to reflect the main disease pressures likely to be experienced in that location. The specific objectives of the work, conducted over a three-year period, were as follows:

- To determine the relative contributions of the T1 and T2 sprays in winter barley, when using strobilurin fungicides at both timings.
- To examine the effect of application timing of the T1 and T2 sprays.
- To identify whether the response to the T1 spray is dependent on the leaf that is emerging at the time of application.
- To establish the degree of flexibility in the T1 – T2 spray interval, when using strobilurin fungicides at both timings.
- To investigate how the choice of partner to the strobilurins, either eradicant (Opus + Corbel) or mainly protectant (Unix) influences the above.
- To evaluate the benefit of a third (T3) spray application in winter barley.

2. Materials and Methods

2.1 Overview

Field trials were established at four locations in England in three successive seasons from 2001/02 to 2003/04. At each location, a different variety of winter barley was sown, in order to target different foliar diseases. In each trial, 21 fungicide treatments, involving one, two and three-spray programmes at a range of application timings from GS30 (ear at 1cm) to GS59 (ears fully emerged), were compared with an untreated. The treatments were based on a half dose of strobilurin (mainly Acanto at T1 and Amistar at T2) partnered either by Opus + Corbel or Unix. Foliar disease levels were assessed at key stages, and growth stages and leaf emergence recorded. Trials were taken to yield, and grain sampled and analysed for grain quality. Margins (defined as output value less fungicide and applications costs) were then calculated, using standard prices.

2.2 Site locations, soil types, varieties and target diseases

Site characteristics for the four locations were:

Andover, Hampshire	Soil type:	Andover series chalkland soil
	Average annual rainfall:	735 mm
	Variety:	Sumo
	Target Disease:	Rhynchosporium
Caythorpe, Lincolnshire	Soil type:	Elmton 1 series brashy fine loam over limestone
	Average annual rainfall:	590 mm
	Variety:	Carat
	Target Diseases:	Brown rust, rhynchosporium
Cirencester, Gloucestershire	Soil type:	Elmton 1 series brashy fine loam over limestone
	Average annual rainfall:	770 mm
	Variety:	Siberia
	Target Diseases:	Brown rust, net blotch,
Morley, Norfolk	Soil type:	Ashley series sandy loam over chalky clay
	Average annual rainfall:	635 mm
	Variety:	Pearl
	Target Diseases:	Net blotch, rhynchosporium

Full site details, and overall inputs, are shown in Appendix D (section 7.4).

2.3 Fungicide treatments

The fungicide treatments that were evaluated consisted mainly of two-spray programmes, with the first spray at one of three timings (GS30, GS30 + 7 days, or GS30 + 14 days), followed by the second spray at one of three timings (GS39, GS49, GS59), giving nine combinations. Single spray treatments at either GS30 + 7 days or GS49, and three-spray programmes with applications at GS30, GS39 and GS59, were also examined. Single spray treatments, and the first spray of all two- and three-spray programmes, were all based on a half dose (0.5 l/ha) of Acanto (picoxystrobin). The second spray of all two- and three-spray programmes was based on a half dose (0.5 l/ha) of Amistar (azoxystrobin). For all single spray and two-spray treatments with applications up to and including GS49, both Opus (epoxiconazole) + Corbel (fenpropimorph) and Unix (cyprodinil) were evaluated as partners to the Acanto or Amistar. Unix is not approved for application to barley after GS49. The third spray of the three-spray programmes was either Amistar + Opus or Opus alone. In all, 21 different programmes were compared with a fully untreated.

To summarise, fungicide products and doses (l/ha or kg/ha) applied were:

First spray (T1)	Acanto 0.5 + Opus 0.25 + Corbel 0.25
	Acanto 0.5 + Unix 0.4kg
Second spray (T2)	Amistar 0.5 + Opus 0.25 + Corbel 0.25
	Amistar 0.5 + Unix 0.4kg
Third spray (T3)	Amistar 0.25 + Opus 0.25
	Opus 0.5

The full treatment matrix is shown in table 2.2.

All treatments were applied in 200 l/ha water as a medium spray, using AZO plot spraying equipment fitted with conventional flat fan nozzles.

Table 2.1. Active ingredients and formulations of the fungicides used

Product	Active Ingredient	Formulation	Maximum Single Dose
Acanto	250 g/l picoxystrobin	SC	1.0 l/ha
Amistar	250 g/l azoxystrobin	SC	1.0 l/ha
Corbel	750 g/l fenpropimorph	EC	1.0 l/ha
Opus	125 g/l epoxiconazole	SC	1.0 l/ha
Unix	75% w/w cyprodinil	WG	0.67 kg/ha

Table 2.2. Fungicide treatment table showing products applied and application timings

Treat. No.	T1 GS30	T1 30 + 7 days	T1 30 + 14 days	T2 GS39	T2 GS49	T2 GS59
1	Acanto + Opus/Corbel	-	-	Amistar + Opus/Corbel	-	-
2	Acanto + Unix	-	-	Amistar + Unix	-	-
3	-	Acanto + Opus/Corbel	-	Amistar + Opus/Corbel	-	-
4	-	Acanto + Unix	-	Amistar + Unix	-	-
5	-	-	Acanto + Opus/Corbel	Amistar + Opus/Corbel	-	-
6	-	-	Acanto + Unix	Amistar + Unix	-	-
7	Acanto + Opus/Corbel	-	-	-	Amistar + Opus/Corbel	-
8	Acanto + Unix	-	-	-	Amistar + Unix	-
9	-	Acanto + Opus/Corbel	-	-	Amistar + Opus/Corbel	-
10	-	Acanto + Unix	-	-	Amistar + Unix	-
11	-	-	Acanto + Opus/Corbel	-	Amistar + Opus/Corbel	-
12	-	-	Acanto + Unix	-	Amistar + Unix	-
13	Acanto + Opus/Corbel	-	-	-	-	Amistar + Opus/Corbel
14	-	Acanto + Opus/Corbel	-	-	-	Amistar + Opus/Corbel
15	-	-	Acanto + Opus/Corbel	-	-	Amistar + Opus/Corbel
16	-	Acanto + Opus/Corbel	-	-	-	-
17	-	Acanto + Unix	-	-	-	-
18	-	-	-	-	Acanto + Opus/Corbel	-
19	-	-	-	-	Acanto + Unix	-
20	Acanto + Opus/Corbel	-	-	Amistar + Opus/Corbel	-	Amistar + Opus*
21	Acanto + Opus/Corbel	-	-	Amistar + Opus/Corbel	-	Opus*
22	untreated	-	-	untreated	-	-

* Applied as ‘T3’ sprays

2.4 Trial design

Treatments were applied to small plots measuring 12m long (10m harvested) x 2.1 m wide, in a randomised block design with 4 replicates.

2.5 Assessments and data analysis

The assessments and monitoring conducted during the three seasons consisted of:

- Grain yield, specific weight and thousand grain weight
- Date and growth stage for each fungicide application timing
- Leaf emergence (number and %) for each of the T1 application timings
- Foliar disease (% infection) at each application timing (for appropriate treatments)
- Full assessment of foliar diseases and green leaf area at GS71-75
- Rainfall pattern
- Margins over treatment cost

Trials were harvested using Sampo 2010 or Claas Dominator plot combines fitted with weighing systems. Disease and green leaf area assessments were based on the mean % leaf area affected of 10 leaves per plot for each leaf layer. Leaf emergence was recorded by tagging and recording the uppermost emerging leaf on 30 plants per trial at weekly intervals from GS30 until GS39, and subsequent conversion of the data to eventual leaf numbers.

2.6 Margin calculations

Margins, defined in this case as output value less fungicide and application costs, were calculated as follows:
Grain value £60/t (all varieties assumed to be at feed price).
Acanto £30/litre
Amistar £26/litre
Unix £26.25/kg
Opus £24/litre
Corbel £18/litre
Application Cost £6/ha
This gave a total cost for the main applications as follows:

Treatment (l or kg/ha)	**Treatment cost including application (£/ha)**
T1 Acanto 0.5 + Opus 0.25 + Corbel 0.25	31.50
T1 Acanto 0.5 + Unix 0.4kg	31.50
T2 Amistar 0.5 + Opus 0.25 + Corbel 0.25	29.50
T2 Amistar 0.5 + Unix 0.4kg	29.50
T1 + T2	61.00
T1 + T2 + Opus T3	79.00

3.0 Results

The results from the twelve trials are presented in six sections, relating to the specific objectives of the project:
1. The relative contributions of the T1 and T2 spray timings
2. The degree of flexibility in the T1 spray timing
3. The importance of leaf emergence in determining the optimum T1 timing
4. The degree of flexibility in the T2 spray timing
5. The degree of flexibility in the T1 – T2 spray interval
6. The benefit from a T3 spray application

Within each section, the effects of choice of protectant (Unix) versus eradicant (Opus + Corbel) partner to the strobilurins are considered, and the following results are included:

- Disease levels and Green leaf area
  These are illustrated using data from the following trial locations and seasons:
  Rhynchosporium: Hampshire, 2002, 2003 and 2004
  Brown rust: Lincolnshire 2003 and Gloucestershire 2003 and 2004
  Net blotch: Norfolk 2004
  Green leaf area: Lincolnshire and Norfolk 2002, 2003 and 2004
- Grain Yield (presented as the % increase in yield obtained with that treatment compared to the untreated)
- Grain Quality (specific weight and thousand grain weight)
- Margin (output value less fungicide and application cost)

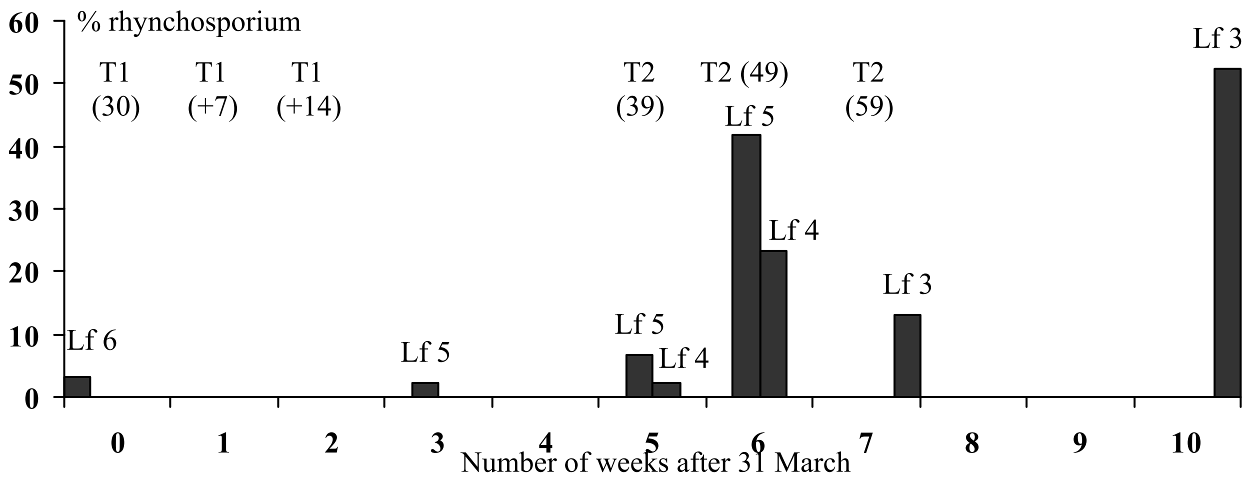
Full results tables for each trial by site and year are shown in Tables 7.1 to 7.12 in appendix C (section 7.3).

Rainfall Pattern and Background Disease Pressure
Monthly rainfall for each location, from September through to July/August, is shown in Figures 7.1 to 7.12 in Appendix E (section 7.5). Both the 2002 and 2003 springs were characterised by relatively dry weather in March and early April. Wetter weather followed in late April and May, especially in 2002. In 2004, April itself was wettest, with May particularly dry.

The disease pressure encountered in each of the trials varied with location and season. As expected, in Hampshire rhynchosporium was dominant, with moderately high or high levels present in all three years. In Gloucestershire, brown rust was the major disease present, at moderate or high levels. At the other two locations, disease pressure tended to be a mix of brown rust and rhynchosporium, sometimes only at low levels, with the exception of Norfolk in 2004 when net blotch was present at moderately high levels.
Disease progress onto successive leaf layers in untreated plots (and relative to the six fungicide application timings) are shown for four of the trials as follows: rhynchosporium in Hampshire 2004 (Figure 3.1), brown rust

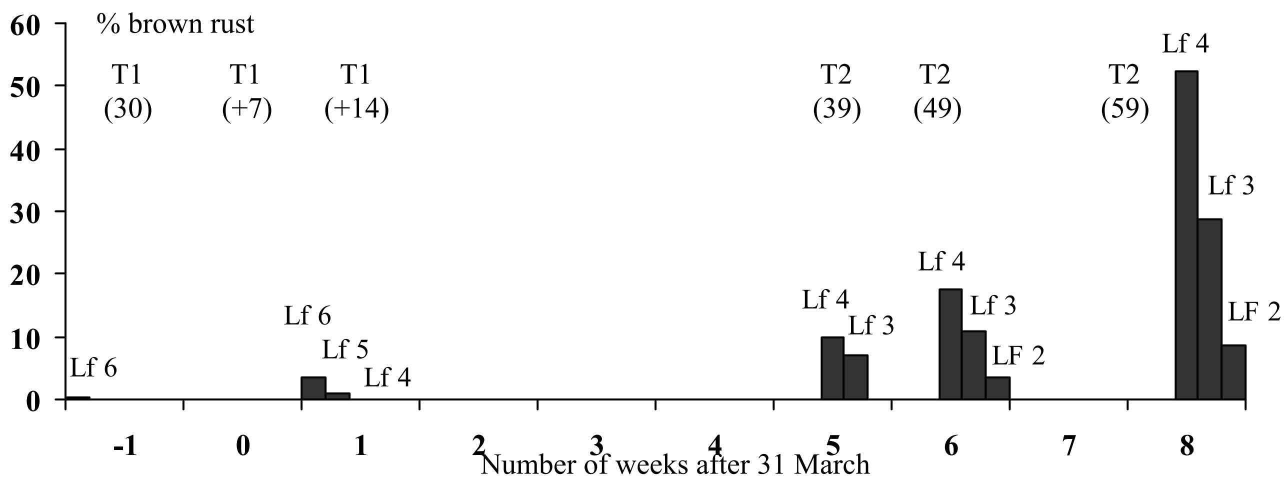
in Lincolnshire in 2002 (Figure 3.2), net blotch in Norfolk in 2004 (Figure 3.3) and brown rust and rhynchosporium in Lincolnshire in 2003 (Figure 3.4).

Figure 3.1 Development of rhynchosporium in Hampshire in 2004 (untreated)



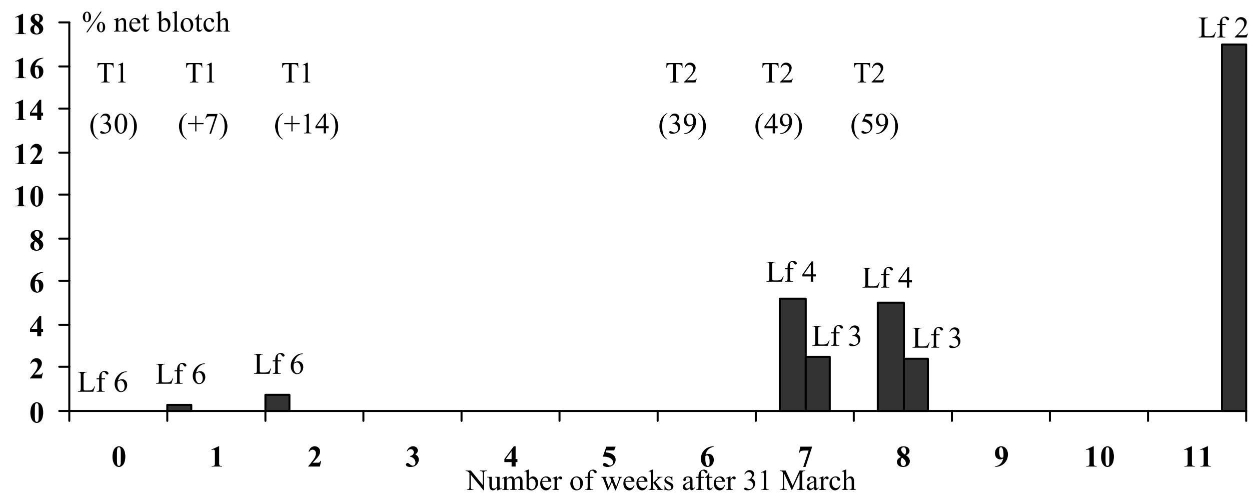
With low rainfall in February, disease pressure at T1 was low. At the first T2 timing, disease was restricted to low levels of rhynchosporium on leaves 4 and 5, but by GS49 incidence had increased substantially on lower leaves. By the third T2 timing, rhynchosporium was evident on leaf 3. Levels on this leaf were high by the end of the season, although dry weather in May and June resulted in little disease developing on the top two leaves.

Figure 3.2 Development of brown rust in Lincolnshire in 2002 (untreated)



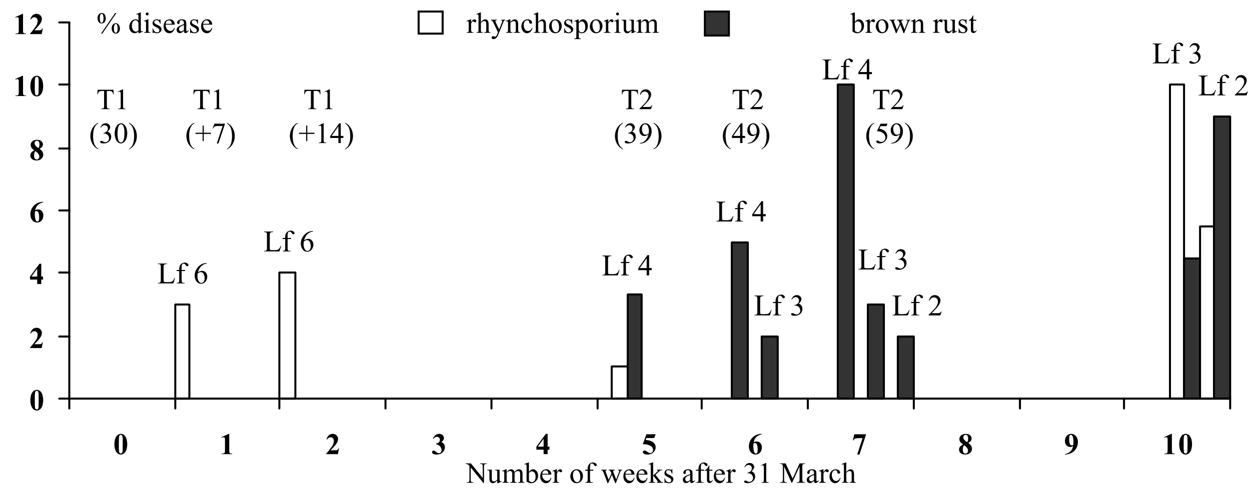
At the first T1 timing disease was at very low levels even on leaf 6. However, by the third T1 timing brown rust had begun to develop on leaves 5 and 4, albeit still at low levels. At the first T2 timing, brown rust was present at moderate levels on leaves 3 and 4. These had increased slightly by GS49, with disease appearing on leaf 2. With wetter weather in May disease had increased substantially on leaves 2-4 by shortly after GS59.

Figure 3.3 Development of net blotch in Norfolk in 2004



Net blotch remained at very low levels throughout the T1 period, but by T2 had begun to increase, having reached leaf 4 and leaf 3. However, significant levels of the disease did not develop until after the final T2 spray timing, with the highest incidence recorded on leaf 2 at the end of the season.

Figure 3.4 Disease development in Lincolnshire in 2003 (untreated)



The main disease threat alternated between rhynchosporium and brown rust as the season progressed. At T1, rhynchosporium was the main disease present on leaf 6. By GS39, brown rust was present and at higher levels on leaf 4 than rhynchosporium. Brown rust then spread rapidly during the T2 window, spreading up to leaf 2. By the end of the season, rhynchosporium (on leaf 3) and brown rust (on leaf 2) were both at moderate levels.

In Table 3.1 the twelve trials are shown in order of increasing average yield response to fungicide treatment. The results indicate that disease severity was less important than the specific main disease that was present, in determining the response. Yield increases tended to be greater where brown rust was the major pathogen than where rhynchosporium was dominant, even though some of the highest disease levels obtained in any of the trials were in the three Hampshire trials that were mainly affected by rhynchosporium.

Table 3.1 The effect of disease(s) present, and their severity, on the mean yield response to fungicide

Location and year	**Main disease**	**Severity**	**Secondary disease**	**Severity**	**Mean % increase in yield over untreated**
Hants. 03	rhyncho	mod-high	b rust	moderate	7
Hants. 04	rhyncho	mod-high			12
Norfolk 03	b rust	moderate	rhyncho	low	12
Lincs. 04	rhyncho	moderate	b rust	low	14
Hants. 02	rhyncho	high			15
Lincs. 03	b rust	moderate	rhyncho	low	16
Norfolk 02	b rust	moderate	rhyncho	moderate	16
Glos. 02	b rust	moderate	net blotch	low	16
Glos. 03	b rust	high			18
Glos. 04	b rust	mod-high			20
Norfolk 04	net blotch	mod-high	rhyncho	moderate	20
Lincs. 02	b rust	high			30

3.1 The Relative Contributions of the T1 and T2 Spray Timings

The effect of single sprays of Acanto + Opus/Corbel or Unix at T1 was compared with single sprays at T2, and also a two-spray sequence at T1 and T2 (but replacing Acanto with Amistar at the T2 timing). Their impact on disease control, yield, grain quality and margin were assessed.

3.1.1 Disease levels and green leaf area

In 2002 there was no consistent advantage to one or other single spray timing in the control of rhynchosporium on the top two leaves (Table 3.2). However, in 2003 single sprays at T1 were less effective, and with Unix as the partner there was a benefit from two sprays compared to one. In 2004, when assessed on slightly lower leaves, single sprays at T1 were more effective than at T2, and there was no advantage to two sprays.

Overall, Opus + Corbel as partner gave slightly better control of rhynchosporium than Unix, although this difference was greatest with single sprays at T2 (where there would have been the greatest eradication need).

Table 3.2 Control of rhynchosporium with single vs two sprays (Hampshire)

Trial year	Leaf assessed	Opus + Corbel partner			Unix partner		
		% control of rhynchosporium					
		T1 only	T2 only	T1 + T2	T1 only	T2 only	T1 + T2
02	2	51	35	70	24	54	58
02	1	62	64	71	49	66	61
02	Mean	56	50	71	37	60	60
03	2	13	93	84	13	59	77
03	1	36	93	91	35	72	92
03	Mean	25	93	88	24	65	85
04	4	89	67	84	89	25	79
04	3	76	64	91	80	68	93
04	Mean	83	65	88	85	46	86
Mean	Mean	55	69	82	48	57	77

In 2003, single sprays applied at the T2 timing were more effective at controlling brown rust on the top two leaves (Table 3.3). Unix was a less effective partner than Opus + Corbel, especially when applied at T1 only. In most cases, a two-spray sequence was more effective than a single spray at either timing. In 2004, a single spray at the T1 timing gave better control on leaf 4 than at T2, and there was no advantage to a two-spray sequence. Opus + Corbel was again more effective as a partner than Unix, in this case most notably at T2.

Table 3.3 Control of brown rust with single vs two sprays (Lincolnshire and Gloucestershire)

Trial Year	Leaf assessed	Opus + Corbel partner			Unix partner		
		% control of brown rust					
		T1 only	T2 only	T1 + T2	T1 only	T2 only	T1 + T2
Lincs. 03	2	83	91	97	61	74	89
Glos. 03	2	69	87	95	20	74	58
Glos. 03	1	69	83	92	45	67	79
03	Mean	74	87	95	42	72	75
Glos. 04	4	98	86	99	90	58	78
Mean	Mean	80	87	96	54	68	76

Control of net blotch in 2004 on the top two leaves was better with single sprays applied at T2 than at T1 (Table 3.4). Opus + Corbel was generally a more effective partner than Unix when applied as single sprays, but not when applied as a two-spray programme.

Table 3.4 Control of net blotch with single vs two sprays (Norfolk)

Trial Year	Leaf assessed	Opus + Corbel partner			Unix partner		
		% control of net blotch					
		T1 only	T2 only	T1 + T2	T1 only	T2 only	T1 + T2
04	2	64	77	84	55	68	84
04	1	78	94	95	66	92	98
04	Mean	71	86	90	61	80	91

Single sprays at T2 were consistently more effective at protecting green area on leaf 2 than single sprays at T1 (Table 3.5). Two-spray programmes always gave a benefit compared to single sprays at T1, but were not always of benefit compared to single sprays at T2. There were no consistent differences between the Opus + Corbel and Unix partners, but overall Opus + Corbel had an advantage over Unix in the majority of cases.

Table 3.5 Green leaf area on leaf 2 with single vs two sprays (Norfolk and Lincolnshire)

Trial year	Opus + Corbel partner			Unix partner		
	% green leaf area					
	T1 only	T2 only	T1 + T2	T1 only	T2 only	T1 + T2
Lincs. 02	45	51	71	26	30	64
Norfolk 02	63	89	90	55	89	95
02 Mean	54	70	81	41	60	80
Lincs. 03	25	58	69	14	25	31
Norfolk 03	13	39	34	18	67	55
03 Mean	19	48	51	16	46	43
Lincs. 04	25	50	53	23	27	32
Norfolk 04	17	24	34	9	44	52
04 Mean	21	37	44	16	35	42
Mean	31	52	59	24	47	55

3.1.2 Grain Yield

In nine out of twelve trials, single sprays at T1 ranked below single sprays at T2 in grain yield for both the Unix and the Opus + Corbel partners. However only two of these differences, both with Unix as partner, were significant (underlined). In only one trial did the yield of single sprays at T1 rank higher than single sprays at T2, and again the difference was only significant with Unix as partner. This trial (Lincolnshire 2002) developed brown rust relatively early in the season.

Two-spray programmes gave a significant yield advantage over single sprays at T1 in nine out of twelve trials with Opus + Corbel as partner, but only seven trials with Unix. Compared to single sprays at T2, two sprays only gave a significant advantage in three out of twelve trials with Opus + Corbel, or four trials with Unix as partner. With the exception of the brown rust trial mentioned above, there was no particular pattern to the trials which benefited significantly from a T1 over and above a T2 application.

Table 3.6 The relative contributions of the T1 and T2 spray timings to grain yield

Location and year	Main disease(s)	Opus + Corbel partner: % increase in yield over untreated			Unix partner: % increase in yield over untreated			LSD (5%)
		T1 only	T2 only	T1 + T2	T1 only	T2 only	T1 + T2	
Hants. 02	rhyncho	6.9	10.5	14.9	6.8	12.4	16.2	6.6
Hants. 03	rhyncho b rust	3.8	9.5	10.7	1.2	2.4	6.9	6.9
Hants. 04	rhyncho	5.7	13.4	15.4	2.4	4.9	15.2	9.2
Lincs. 02	b rust	29.2	25.5	32.0	23.7	<u>14.8</u>	29.6	5.7
Lincs. 03	b rust rhyncho	11.8	13.5	16.0	10.3	11.4	15.5	6.2
Lincs. 04	rhyncho b rust	8.3	11.4	15.0	<u>7.5</u>	14.7	15.0	4.7
Glos. 02	b rust net blotch	11.0	12.8	19.0	9.4	7.9	16.2	7.2
Glos. 03	b rust	9.5	12.8	19.0	12.7	15.7	18.1	8.9
Glos. 04	b rust	14.9	17.5	27.5	15.8	16.3	19.3	7.7
Norfolk 02	b rust rhyncho	9.3	14.0	13.4	<u>6.8</u>	13.1	15.0	5.5
Norfolk 03	b rust rhyncho	3.8	7.8	12.3	9.0	11.1	17.6	5.6
Norfolk 04	net blotch rhyncho	15.4	10.7	24.7	10.8	17.0	21.2	6.8
Mean		10.8	13.3	18.3	9.7	11.8	17.1	

3.1.3 Grain Quality

Single sprays at T1 consistently resulted in lower specific weights compared to single sprays at T2 or two-spray programmes (Table 3.7). However, two-sprays generally had no specific weight advantage compared to single sprays at T2. Effects on thousand grain weight were less consistent, but there was a penalty to single sprays more often when applied at T1 than at T2.

Table 3.7 Grain quality comparison for single vs two sprays (mean of Opus + Corbel and Unix)

Location and year	Main disease(s)	Specific weight (kg/hl)			Thousand grain weight (g)		
		T1	T2	T1+T2	T1	T2	T1+T2
Hants. 02	rhyncho	61.1	61.7	61.5	45.5	45.6	45.9
Hants. 03	rhyncho b rust	60.0	61.0	60.8	50.8	53.3	52.0
Hants. 04	rhyncho	62.6	63.4	62.6	55.5	55.9	56.6
Lincs. 02	b rust	68.6	69.1	69.7	41.6	39.6	40.2
Lincs. 03	b rust rhyncho	69.3	69.7	69.2	49.4	50.0	51.1
Lincs. 04	rhyncho b rust	66.1	67.3	66.6	45.0	45.2	45.2
Glos. 02	b rust net blotch	55.4	57.6	58.1	39.3	42.9	41.6
Glos. 03	b rust	57.2	59.0	59.2	42.1	44.1	43.6
Glos. 04	b rust	54.8	55.5	55.6	36.7	37.9	38.3
Norfolk 02	b rust rhyncho	66.5	67.7	67.4	44.5	46.7	46.8
Norfolk 03	b rust rhyncho	67.7	69.2	69.1	48.4	50.4	50.9
Norfolk 04	net blotch rhyncho	65.6	66.6	67.3	46.9	48.3	49.0
Mean		62.9	64.0	63.9	45.5	46.7	46.8

3.1.4 Margin (Output less fungicide and application costs)

In over 70% of comparisons, highest margins (underlined) were obtained with a single spray at T2, compared to 20% where margins were highest with two sprays, and less than 10% with a single spray at T1 (Table 3.8). However, there were some differences (all in 2004) between the two partners as to which trials gave a cost-effective benefit to a T1 spray prior to a T2, and which did not.

Table 3.8 Margin comparison for single vs two sprays

Location and year	Main disease(s)	Opus + Corbel partner			Unix partner		
		Margin (£/ha) with sprays applied at:					
		T1 only	T2 only	T1+T2	T1 only	T2 only	T1+T2
Hants. 02	rhyncho	282	<u>292</u>	276	281	<u>297</u>	279
Hants. 03	rhyncho b rust	377	<u>399</u>	374	366	<u>371</u>	359
Hants. 04	rhyncho	445	<u>480</u>	459	430	441	<u>458</u>
Lincs. 02	b rust	<u>482</u>	467	463	<u>460</u>	425	454
Lincs. 03	b rust rhyncho	446	<u>453</u>	434	439	<u>444</u>	432
Lincs. 04	rhyncho b rust	504	<u>519</u>	508	500	<u>536</u>	508
Glos. 02	b rust net blotch	592	602	<u>607</u>	583	575	<u>592</u>
Glos. 03	b rust	383	<u>396</u>	390	395	<u>407</u>	386
Glos. 04	b rust	413	423	<u>432</u>	416	<u>418</u>	400
Norfolk 02	b rust rhyncho	424	<u>444</u>	412	414	<u>440</u>	419
Norfolk 03	b rust rhyncho	425	<u>443</u>	433	448	<u>457</u>	456
Norfolk 04	net blotch rhyncho	436	417	<u>444</u>	417	<u>443</u>	430
Mean		434	444	436	429	438	431

3.2 The Degree of Flexibility in the T1 Spray Timing

The performance of T1 sprays applied either at GS30, approximately 7 days later, or 14 days later, was examined by comparing disease control and protection of green leaf area, and yield. In all of the comparisons shown in this section, a T2 follow-up spray was applied at GS49. Grain quality was not influenced by the T1 spray, so is not considered here. Also, the cost of the T1 sprays was the same regardless of application timing, so margins have not been presented separately.

3.2.1 Disease levels and green leaf area

Regardless of partner, the earliest T1 timing (GS30) tended to give poorer control of rhynchosporium than either the middle or later T1 timing, although differences were often small and not significant (Table 3.9). With Unix, the later T1 timing gave slightly inferior disease control in 2002 and 2004, but this was not the case with the more eradicant Opus + Corbel partner.

Table 3.9 The effect of T1 timing on the control of rhynchosporium (Hampshire, T2 at GS49)

Trial Year	Leaf assessed	Opus +Corbel partner			Unix partner		
		% control of rhynchosporium, T1 applied at:					
		GS30	+ 7 days	+ 14 days	GS30	+ 7 days	+ 14 days
02	2	60	70	69	30	58	39
02	1	72	71	79	47	61	58
02	Mean	66	71	74	39	60	48
03	2	66	84	90	70	77	91
03	1	87	91	98	95	92	95
03	Mean	78	88	94	83	85	93
04	4	86	84	83	70	79	74
04	3	88	91	91	80	93	87
04	Mean	87	88	87	75	86	81
Mean	Mean	76	82	85	65	77	74

With Opus + Corbel as the partner, timing of the T1 sprays had little or no effect on the control of brown rust, either on the top two leaves in 2003 or on leaf 4 in 2004 (Table 3.10). With Unix, there was more variation in control with the T1 timing (and Unix was generally inferior to Opus + Corbel), but no particular timing was consistently the most effective. Timing of the T1 spray had relatively little effect on the control of net blotch on the top two leaves in Norfolk in 2004.

Table 3.10 The effect of T1 timing on the control of brown rust (Lincs. and Glos., T2 at GS49)

Trial Year	Leaf assessed	Opus +Corbel partner			Unix partner		
		% control of brown rust, T1 applied at:					
		GS30	+ 7 days	+ 14 days	GS30	+ 7 days	+ 14 days
Lincs. 03	2	94	97	97	89	89	89
Glos. 03	2	95	95	92	73	58	77
Glos. 03	1	93	92	95	82	79	69
03	Mean	94	95	95	81	75	78
Glos. 04	4	100	99	99	97	78	93
Mean	Mean	95	96	96	85	76	82

Timing of the T1 spray had no consistent effect on the amount of green leaf area retained, whether Opus + Corbel or Unix were used as partner (Table 3.11). For all three seasons in Lincolnshire, Opus + Corbel was the more effective partner at preserving green area on leaf 2. In Norfolk, Unix was more effective. This undoubtedly reflects differences in the main disease pressures between the two locations.

Table 3.11 The effect of T1 timing on green leaf area on leaf 2 (Norfolk and Lincs., T2 at GS49)

Trial year	Opus + Corbel partner			Unix partner		
	% green leaf area					
	GS30	+ 7 days	+ 14 days	GS30	+ 7 days	+ 14 days
Lincs. 02	58	71	64	43	64	59
Norfolk 02	91	90	90	96	95	95
02 Mean	75	81	77	70	80	77
Lincs. 03	73	69	64	31	31	45
Norfolk 03	41	34	33	66	55	63
03 Mean	57	51	48	49	43	54
Lincs. 04	55	53	52	23	32	45
Norfolk 04	40	34	36	46	52	39
04 Mean	48	44	44	34	42	42
Mean	60	59	56	51	55	58

3.2.2 Grain Yield

None of the T1 spray timings consistently gave the highest yields, regardless of the partner used (Table 3.12), and there was little difference in the mean yield response over untreated for each of the timings across the twelve trials. Where one timing was significantly better than one or both of the other two timings (underlined), this was sometimes the earliest timing (GS30) and sometimes the later timing (GS30 + 14 days). This did not appear to be dependent on the partner used, or the disease pressure. There was only one trial (Glos. 02) where the earliest timing was significantly better when Unix was used as partner, and the later timing when Opus + Corbel was used (this might have been expected to have been the case more frequently with Unix being a mainly protectant partner and Opus + Corbel having more eradicant activity).

Table 3.12 The effect of T1 timing on yield response (T2 at GS49)

Location and year	Main disease(s)	Opus + Corbel partner			Unix partner			LSD (5%)
		% increase in yield over untreated, T1 applied at						
		GS30	+7 days	+14 days	GS30	+7 days	+14 days	
Hants. 02	rhyncho	16.1	14.9	16.1	16.3	16.2	14.9	6.6
Hants. 03	rhyncho b rust	9.5	10.7	8.5	8.1	6.9	8.7	6.9
Hants. 04	rhyncho	15.3	15.4	14.2	12.8	15.2	13.3	9.2
Lincs. 02	b rust	32.6	32.0	32.6	26.6	29.6	32.3	5.7
Lincs. 03	b rust rhyncho	12.5	16.0	15.9	18.1	15.5	17.2	6.2
Lincs. 04	rhyncho b rust	15.7	15.0	14.1	13.0	15.0	16.1	4.7
Glos. 02	b rust net blotch	20.3	19.0	29.8	23.8	16.2	18.4	7.2
Glos. 03	b rust	14.3	19.0	24.2	21.6	18.1	20.1	8.9
Glos. 04	b rust	21.9	27.5	20.0	25.0	19.3	23.6	7.7
Norfolk 02	b rust rhyncho	19.9	13.4	16.7	19.1	15.0	14.8	5.5
Norfolk 03	b rust rhyncho	9.5	12.3	10.5	15.1	17.6	17.5	5.6
Norfolk 04	net blotch rhyncho	19.0	24.7	19.6	26.1	21.2	26.5	6.8
Mean		17.2	18.3	18.5	18.8	17.1	18.6	

3.3 The importance of leaf emergence in determining the optimum T1 timing

In Table 3.13 the twelve trials are shown in order of increasing leaf emergence stage when the T1 sprays were applied. In the most backward (Norfolk 2003), at the earliest T1 timing (GS30) leaf 5 was half emerged, and at the later timing (GS30 + 14 days) leaf 4 was half emerged. In the most forward, leaf 3 was part emerged at the earliest timing, and leaf 2 was starting to emerge at the later timing. If optimum T1 timing was associated with the emergence of a particular leaf, then the stage at which the highest yield response was obtained might have been expected to have shown a shift from the earliest to the later timing (or vice versa) when moving down the table. With Opus + Corbel as partner, there was no trend to suggest that the optimum T1 timing was later in trials were leaf emergence was more backward, or earlier in trials where emergence was more advanced. With Unix as partner there was some indication that the optimum T1 timing was closer to GS30 in more forward trials, or 7-14 days later in more backward trials, but there was still no clear link to the emergence of a particular leaf

Table 3.13 The effect of T1 timing relative to leaf emergence on yield response

Location and year	Leaf emergence score when T1 spray applied at			Opus + Corbel partner			Unix partner		
				% yield increase over untreated					
	GS30	+7 day	+14 day	GS30	+7 day	+14 day	GS30	+7 day	+14 day
Norfolk 03	5.00	4.50	4.00	9.5	12.3	10.5	15.1	17.6	17.5
Lincs. 04	4.50	4.00	3.50	15.7	15.0	14.1	13.0	15.0	16.1
Norfolk 04	4.50	3.50	3.00	19.0	24.7	19.6	26.1	21.2	26.5
Hants. 04	4.25	3.75	3.25	15.3	15.4	14.2	12.8	15.2	13.3
Lincs. 02	4.00	3.50	3.00	32.6	32.0	32.6	26.6	29.6	32.3
Hants. 03	4.00	3.50	3.00	9.5	10.7	8.5	8.1	6.9	8.7
Lincs. 03	4.00	3.50	3.00	12.5	16.0	15.9	18.1	15.5	17.2
Norfolk 02	4.00	3.25	3.00	19.9	13.4	16.7	19.1	15.0	14.8
Glos. 02	4.00	3.00	2.50	20.3	19.0	29.8	23.8	16.2	18.4
Hants. 02	3.50	3.25	3.00	16.1	14.9	16.1	16.3	16.2	14.9
Glos. 04	3.50	3.00	2.50	21.9	27.5	20.0	25.0	19.3	23.6
Glos. 03	3.25	3.00	2.50	14.3	19.0	24.2	21.6	18.1	20.1
Mean	4.04	3.48	3.02	17.2	18.3	18.5	18.8	17.1	18.6

Key to leaf emergence scores

2.50 = Leaf 3 90% emerged - leaf 2 10% emerged

3.00 = Leaf 3 50% emerged

3.50 = Leaf 4 90% emerged - leaf 3 10% emerged

4.00 = Leaf 4 50% emerged

4.50 = Leaf 5 90% emerged - leaf 4 10% emerged

5.00 = Leaf 5 50% emerged

3.4 The Degree of Flexibility in the T2 Spray Timing

The performance of T2 sprays applied either at GS39, GS49 or GS59, was examined by comparing disease control and protection of green leaf area, yield response and grain quality. In all of the comparisons in this section, a preceding T1 spray was applied at the middle T1 timing (GS30 + 7 days). The cost of the T2 sprays was the same regardless of application timing, so margins have not been presented separately.

3.4.1 Disease levels and green leaf area

The earliest T2 timing (GS39) tended to give the best control of rhynchosporium regardless of partner, although differences were often small and not significant (Table 3.14). With Opus + Corbel, there was either little difference between the GS49 and GS59 timings, or GS59 was inferior.

Table 3.14 The effect of T2 timing on the control of rhynchosporium (Hampshire, T1 at GS30 + 7 days)

Trial Year	Leaf assessed	Opus + Corbel partner			Unix partner		
		% control of rhynchosporium, T2 applied at:					
		GS39	GS49	GS59	GS39	GS49	GS59
02	2	73	70	64	67	58	n/a
02	1	75	71	71	58	61	n/a
02	Mean	74	71	68	62	60	n/a
03	2	92	84	51	91	77	n/a
03	1	98	91	90	96	92	n/a
03	Mean	95	88	71	94	85	n/a
04	4	93	84	87	92	79	n/a
04	3	86	91	90	87	93	n/a
04	Mean	90	88	89	90	86	n/a
Mean	Mean	86	82	76	82	77	n/a

With Opus + Corbel as the partner, timing of the T2 spray had little impact on brown rust control when assessed on leaf 2 or leaf 4 (Table 3.15). However, with Unix as partner there was an indication of a reduction in control on leaf 4 when the T2 was applied at GS49 rather than at GS39.

Table 3.15 The effect of T2 timing on the control of brown rust (Lincs. and Glos., T1 at GS30 + 7 days)

Trial year	Leaf assessed	Opus + Corbel partner			Unix partner		
		% control of brown rust, T2 applied at:					
		GS39	GS49	GS59	GS39	GS49	GS59
Lincs. 03	2	97	97	97	91	89	n/a
Glos. 04	4	100	99	99	96	78	n/a
Mean	Mean	98	98	98	94	84	n/a

In 2004, differences between the T2 timings in the control of net blotch were small, however GS49 was marginally the most effective where Opus + Corbel was used (Table 3.16).

Table 3.16 The effect of T2 timing on the control of net blotch (Norfolk, T1 at GS30 + 7 days)

Trial Year	Leaf assessed	Opus +Corbel partner			Unix partner		
		% control of net blotch, T2 applied at:					
		GS39	GS49	GS59	GS39	GS49	GS59
04	2	81	84	81	84	84	n/a
04	1	87	95	92	94	98	n/a
04	Mean	84	90	87	89	91	n/a

Timing of the T2 spray had no consistent effect on the amount of green area retained on leaf 2, regardless of the partner (Table 3.17). The results again highlight that in two out of three years Opus + Corbel was a more effective partner than Unix in Lincolnshire, whereas the opposite was generally the case in Norfolk.

Table 3.17 The effect of T2 timing on green area on leaf 2 (Norfolk and Lincs., T1 at GS30 + 7 days)

Trial year	Opus + Corbel partner			Unix partner		
	% green leaf area					
	GS39	GS49	GS59	GS39	GS49	GS59
Lincs. 02	68	71	63	75	64	n/a
Norfolk 02	89	90	94	96	95	n/a
02 Mean	79	81	78	85	80	n/a
Lincs. 03	60	69	51	39	31	n/a
Norfolk 03	45	34	30	45	55	n/a
03 Mean	53	51	41	42	43	n/a
Lincs. 04	57	53	58	22	32	n/a
Norfolk 04	47	34	38	35	52	n/a
04 Mean	52	44	48	28	42	n/a
Mean	61	59	56	52	55	n/a

3.4.2 Grain Yield

None of the T2 timings consistently gave the highest yield increases, and differences were rarely significant (Table 3.18). In 2002 and 2003 delaying the T2 spray until GS59 appears to have been detrimental where rhynchosporium was dominant, but this was not the case in 2004. Similarly, where brown rust or net blotch were the main diseases present, GS39 was generally the least effective T2 timing. Overall, the middle T2 timing at GS49 produced the highest mean yield increase over untreated when using Opus + Corbel as partner.

Table 3.18 The effect of T2 timing on yield response (T1 at GS30 + 7 days)

Location and year	Main disease(s)	Opus + Corbel partner			Unix partner			LSD (5%)
		% increase in yield over untreated, T2 applied at						
		GS39	GS49	GS59	GS39	GS49	GS59	
Hants. 02	rhyncho	16.7	14.9	11.7	19.4	16.2	n/a	6.6
Hants. 03	rhyncho b rust	9.8	10.7	4.1	5.5	6.9	n/a	6.9
Hants. 04	rhyncho	12.8	15.4	16.5	12.6	15.2	n/a	9.2
Lincs. 02	b rust	30.8	32.0	32.5	32.2	29.6	n/a	5.7
Lincs. 03	b rust rhyncho	11.1	16.0	<u>19.7</u>	18.4	15.5	n/a	6.2
Lincs. 04	rhyncho b rust	15.2	15.0	15.5	14.7	15.0	n/a	4.7
Glos. 04	b rust	22.7	<u>27.5</u>	17.2	15.7	19.3	n/a	7.7
Norfolk 02	b rust rhyncho	17.4	13.4	17.1	20.4	15.0	n/a	5.5
Norfolk 03	b rust rhyncho	12.1	12.3	13.0	10.9	<u>17.6</u>	n/a	5.6
Norfolk 04	net blotch rhyncho	21.3	24.7	19.6	23.4	21.2	n/a	6.8
Mean		17.0	18.2	16.7	17.3	17.1	n/a	

3.4.3 Grain Quality

Differences in grain specific weight resulting from applications at the different T2 timings were mostly small, and there was no consistent advantage to any of the three timings, when using Opus + Corbel as partner (Table 3.19). The optimum T2 timing for specific weight in each of the trials however quite closely reflected the optimum timing for yield. Thousand grain weights likewise showed no particular advantage to one timing compared to the other two.

Table 3.19 The effect of T2 timing on grain quality (T1 at GS30 + 7 days, Opus + Corbel partner)

Location and year	Main disease(s)	Specific Weight (kg/hl)			Thousand Grain Weight (g)		
		GS39	GS49	GS59	GS39	GS49	GS59
Hants. 02	rhyncho	62.5	61.5	61.7	46.9	45.8	45.9
Hants. 03	rhyncho b rust	60.9	61.1	60.5	52.8	53.6	52.8
Hants. 04	rhyncho	62.9	62.5	63.7	57.6	56.4	57.2
Lincs. 02	b rust	69.5	69.8	70.0	41.5	41.5	38.6
Lincs. 03	b rust rhyncho	68.8	69.4	69.3	49.3	50.3	51.0
Lincs. 04	rhyncho b rust	66.6	66.4	66.9	44.0	45.5	45.7
Glos. 04	b rust	54.9	56.3	56.4	37.1	38.8	38.8
Norfolk 02	b rust rhyncho	68.0	67.3	68.0	47.2	46.0	46.2
Norfolk 03	b rust rhyncho	68.5	69.3	69.2	49.3	52.0	49.2
Norfolk 04	net blotch rhyncho	66.8	66.9	67.2	47.7	47.3	49.8
Mean		64.9	65.1	65.3	47.3	47.7	47.5

3.5 The Degree of Flexibility in the T1 – T2 Spray Interval

The combination of three T1 spray timings and three T2 spray timings examined in the trials gave nine possible T1 - T2 spray intervals. The shortest of these (the later of the three T1 timings followed by the earliest of the three T2 timings, the longest of these (the earliest of the three T1 timings followed by the later of the three T2 timings) and the 'middle' interval (middle timings at T1 and T2) are shown in table 3.20. The lengths of these intervals varied considerably from trial to trial. This was dependent on the location/variety and the season (which affected both speed of development and also the opportunities for application of treatments). The shortest interval ranged from 1-4 weeks, with an average of 3 weeks, and the longest from 6-9 weeks, with an average of 7½ weeks.

Table 3.20 Shortest, average and longest intervals between the T1 and T2 spray timings

Location and year	Main disease(s)	Interval (number of days) between spray timings		
		GS30 +14 / GS39	GS30 +7 / GS49	GS30 / GS59
Hants. 02	rhyncho	23	36	51
Hants. 03	rhyncho b rust	22	36	55
Hants. 04	rhyncho	16	35	47
Lincs. 02	b rust	28	42	58
Lincs. 03	b rust rhyncho	19	32	49
Lincs. 04	rhyncho b rust	22	36	56
Glos. 04	b rust	10	21	41
Norfolk 02	b rust rhyncho	21	33	53
Norfolk 03	b rust rhyncho	26	40	62
Norfolk 04	net blotch rhyncho	17	34	50
Mean		20.4	34.5	52.2

3.5.1 Disease levels and green leaf area

There were no consistent differences in rhynchosporium control between the shortest and middle intervals, but the longest interval gave inferior control of rhynchosporium, especially on leaf 2 in 2003 (Table 3.21).

Table 3.21 The effect of T1-T2 spray interval on control of rhynchosporium (Hampshire, Opus + Corbel)

Trial year	Leaf assessed	% control of rhynchosporium		
		GS30 +14 / GS39	GS30 +7 / GS49	GS30 / GS59
02	2	70	70	64
02	1	63	71	69
02	Mean	66	71	67
03	2	92	84	49
03	1	95	91	86
03	Mean	94	88	67
04	4	90	84	81
04	3	83	91	88
04	Mean	87	88	84
Mean	Mean	82	82	73

The length of spray interval had very little effect on the control of brown rust in Lincolnshire in 2003 or Gloucestershire in 2004, or on the control of net blotch in Norfolk in 2004. Differences in the amount of green leaf area retained were relatively small, but the longest interval (GS30 - GS59) tended to be the least effective, but with little or no disadvantage to the shortest interval (Table 3.22).

Table 3.22 The effect of T1-T2 spray interval on green leaf area (Norfolk and Lincs., Opus + Corbel)

Trial year	% green leaf area		
	GS30 +14 / GS39	GS30 +7 / GS49	GS30 / GS59
Lincs. 02	71	71	59
Norfolk 02	89	90	86
02 Mean	80	81	72
Lincs. 03	65	69	59
Norfolk 03	41	34	35
03 Mean	53	51	47
Lincs. 04	57	53	47
Norfolk 04	38	34	32
04 Mean	47	44	39
Mean	60	59	53

3.5.2 Grain yield

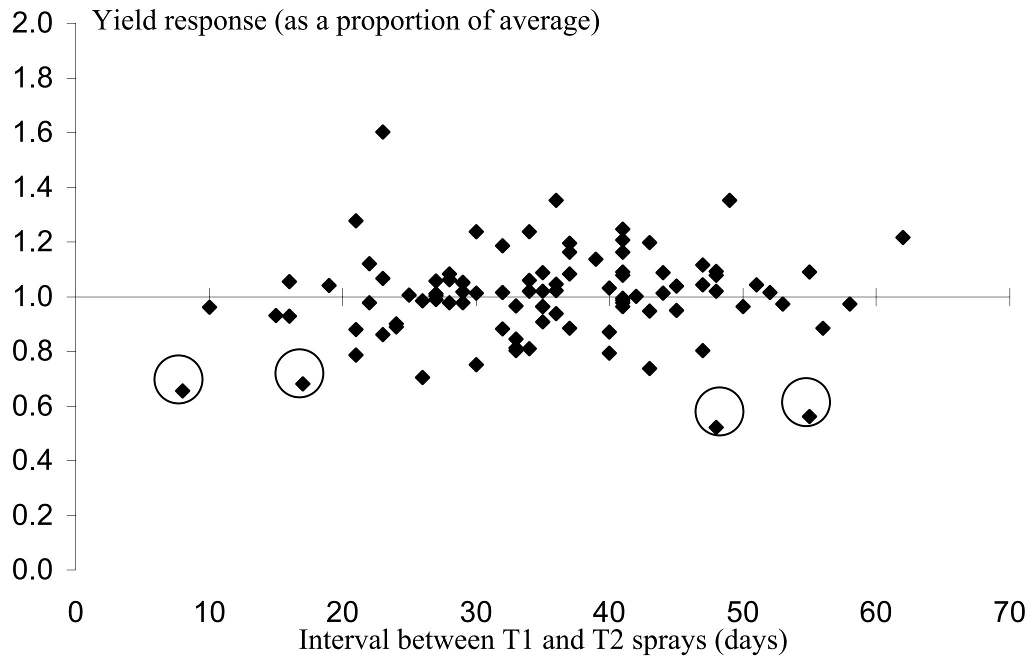
The length of spray interval only had a significant effect on the yield response to fungicide in one trial, but where there was any advantage to a specific interval it was often the middle one (Table 3.23). Where one specific interval showed a disadvantage, this was often the shortest interval.

Table 3.23 The effect of T1-T2 spray interval on yield response (Opus + Corbel)

Location and year	Main disease(s)	% Yield increase over untreated			LSD (5%)
		GS30 +14 / GS39	GS30 +7 / GS49	GS30 / GS59	
Hants. 02	rhyncho	13.7	14.9	16.6	6.6
Hants. 03	rhyncho b rust	8.9	10.7	4.4	6.9
Hants. 04	rhyncho	13.2	15.4	15.8	9.2
Lincs. 02	b rust	34.0	32.0	31.1	5.7
Lincs. 03	b rust rhyncho	16.5	16.0	21.4	6.2
Lincs. 04	rhyncho b rust	14.1	15.0	12.7	4.7
Glos. 04	b rust	20.7	27.5	23.4	7.7
Norfolk 02	b rust rhyncho	14.5	13.4	16.1	5.5
Norfolk 03	b rust rhyncho	11.7	12.3	14.5	5.6
Norfolk 04	net blotch rhyncho	13.6	24.7	19.3	6.8
Mean		16.1	18.2	17.5	

For figures 3.1 and 3.2, yield responses have been converted to a proportion of the average yield response to fungicide in that trial (*i.e.* <1.0 means the yield response to that programme was less than the average in that trial, >1.0 means the yield response was above the average in that trial). The converted yield responses (for the Opus + Corbel partner only) for each of the nine possible spray intervals, and in each of the 11 trials (excluding Glos. 03) have then been plotted against the corresponding T1 – T2 spray interval (in days).

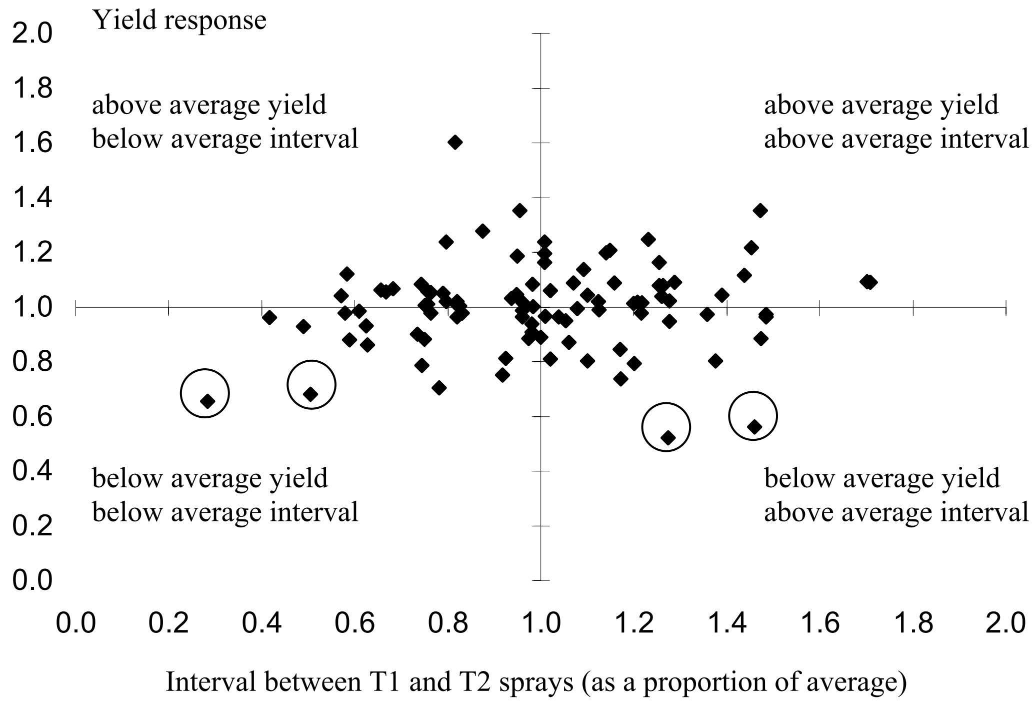
Figure 3.1 The relationship between yield response to fungicide and interval between sprays



There was no meaningful relationship between the length of the interval between sprays, and the effectiveness of the corresponding treatment at increasing yield. However, four of the outlying points (circled), representing treatments that gave poor yield responses, had spray intervals of less than 20 days or more than 45 days.

For figures 3.2, the interval between the T1 and T2 sprays has also been converted to a proportion of the average spray interval in that trial (*i.e.* <1.0 means that the spray interval for that programme was less than the average in that trial, >1.0 means that the spray interval was above the average in that trial). The converted yield responses (for the Opus + Corbel partner only) for each of the nine possible spray intervals, and in each of the 11 trials (excluding Glos. 03) have then been plotted against the corresponding converted spray interval.

Figure 3.2 The relationship between yield response to fungicide and interval between sprays



Again there was no relationship between the length of the interval between sprays, and the effectiveness of the corresponding treatment at increasing yield, but the same four outlying points (circled) are highlighted.

3.6 The Benefit from a T3 Spray Application

The impact of a third 'T3' fungicide spray (Opus 0.5 l/ha) on disease control, protection of green leaf area, yield, grain quality and margin was evaluated on winter barley. Comparisons were made between a three-spray programme with applications at GS30, GS39 and GS59, and two-spray programmes with applications at GS30 followed by either GS39 or GS59.

3.6.1 Disease levels and green leaf area

In 2003 and 2004, the application of a third spray at GS59 did not improve the control of rhynchosporium compared to a GS30 / GS39 two-spray programme only (Table 3.24). A two-spray programme where the second spray was applied at GS59 was less effective than where the second spray was applied at GS39, although note that in 2004 it was leaves 3 and 4 that were assessed. In 2002, there was a benefit from a third spray, especially on leaf 2, compared to either of the two-spray programmes.

Table 3.24 The effect of a T3 spray on the control of rhynchosporium (Hampshire, Opus)

Trial year	Leaf assessed	% control of rhynchosporium		
		GS30/39	GS30/39/59	GS30/59
02	2	65	82	64
02	1	76	82	69
02	Mean	70	82	67
03	2	94	73	49
03	1	98	85	86
03	Mean	96	79	67
04	4	96	92	81
04	3	92	87	88
04	Mean	94	89	84
Mean	Mean	87	83	73

Complete control of brown rust was obtained with the three-spray programme on leaf 2 in Lincolnshire and leaf 4 in Gloucestershire, but in the latter case the same was true with the two-spray programmes (Table 3.25).

Table 3.25 The effect of a T3 spray on the control of brown rust (Lincs. and Glos., Opus)

Trial year	Leaf assessed	% control of brown rust		
		GS30/39	GS30/39/59	GS30/59
Lincs. 03	2	97	100	94
Glos. 04	4	100	100	100
Mean	Mean	98	100	97

There was a very small benefit from a third fungicide spray in the control of net blotch in 2004, particularly on leaf 2, compared to either of the two-spray programmes (Table 3.26).

Table 3.26 The effect of a T3 spray on the control of net blotch (Norfolk, Opus)

Trial Year	Leaf assessed	% control of net blotch		
		GS30/39	GS30/39/59	GS30/59
04	2	80	85	81
04	1	93	96	95
04	Mean	87	91	88

Only in one case (Lincolnshire 2004) did three-sprays result in better protection of green leaf area than the most effective of the two-spray programmes (Table 3.27). However, as the most-effective of the two-spray programmes varied between GS30/GS39 and GS30/GS59, three sprays had a slight advantage overall.

Table 3.27 The effect of a T3 spray on green leaf area (Norfolk and Lincs., Opus)

Trial year	% green leaf area		
	GS30/39	GS30/39/59	GS30/59
Lincs. 02	68	70	59
Norfolk 02	92	92	86
02 Mean	80	81	72
Lincs. 03	69	68	59
Norfolk 03	33	26	35
03 Mean	51	47	47
Lincs. 04	55	72	47
Norfolk 04	27	31	32
04 Mean	41	51	39
Mean	57	60	53

3.6.2 Grain yield

In three out of the ten trials, there was an indication of a yield benefit from a third T3 fungicide spray, but none of the differences were significant (Table 3.28). There were no consistent site, seasonal or disease factors that were associated with this. In other cases, the three-spray treatment was no better than the most-effective of the comparison two-spray programmes. In Lincolnshire in 2003, the GS30/GS39 two-spray programme gave a significantly smaller yield response over untreated than the GS30/GS59 two-spray programme, but generally neither had a consistent advantage.

Table 3.28 The effect of a T3 spray on yield response (Opus)

Location and year	Main disease(s)	% yield increase over untreated			LSD (5%)
		GS30/39	GS30/39/59	GS30/59	
Hants. 02	Rhyncho	18.5	15.9	16.6	6.6
Hants. 03	Rhyncho b rust	8.5	8.9	4.4	6.9
Hants. 04	Rhyncho	10.7	17.3	15.8	9.2
Lincs. 02	b rust	31.6	31.1	31.1	5.7
Lincs. 03	b rust Rhyncho	12.8	16.3	21.4	6.2
Lincs. 04	Rhyncho b rust	12.7	16.4	12.7	4.7
Glos. 04	b rust	19.1	21.9	23.4	7.7
Norfolk 02	b rust Rhyncho	15.0	18.1	16.1	5.5
Norfolk 03	b rust Rhyncho	11.5	9.3	14.5	5.6
Norfolk 04	net blotch Rhyncho	23.7	23.0	19.3	6.8
Mean		16.4	17.8	17.5	

3.6.3 Grain Quality

Application of a third fungicide spray at GS59 had little effect on grain quality, with no consistent improvement in specific weight or thousand grain weight (Table 3.29). However, in a few trials there was an increase in thousand grain weight compared to a two-spray programme, notably in Lincolnshire and in particular in 2002 compared to a GS30/GS39 sequence.

3.6.4 Margin (output less fungicide and applications costs)

There were no situations where three-sprays gave a higher margin than the most effective two-spray programme, and often three sprays gave a lower margin (Table 3.30). Overall the GS30/GS59 two-spray programme was most the cost-effective, but there was no consistent advantage over a GS30/GS39 sequence.

Table 3.29 The effect of a T3 spray on grain quality (Opus)

Location and Year	Main Disease(s)	Specific Weight (kg/hl)			Thousand Grain Weight (g)		
		30/39	30/39/59	30/59	30/39	30/39/59	30/59
Hants. 02	rhyncho	61.9	61.3	62.1	45.8	45.9	46.6
Hants. 03	rhyncho b rust	60.6	59.3	60.2	51.8	53.0	52.0
Hants. 04	rhyncho	62.9	63.4	63.1	57.5	57.6	57.7
Lincs. 02	b rust	68.8	69.5	69.8	35.4	43.8	41.7
Lincs. 03	b rust rhyncho	68.7	69.6	69.5	50.5	51.3	52.8
Lincs. 04	rhyncho b rust	66.2	66.8	66.3	44.5	46.4	44.7
Glos. 04	b rust	56.1	56.1	56.6	38.5	38.8	40.1
Norfolk 02	b rust rhyncho	67.1	67.9	68.0	46.7	45.5	46.1
Norfolk 03	b rust rhyncho	68.6	68.9	69.1	49.3	50.9	49.5
Norfolk 04	net blotch rhyncho	66.2	67.1	66.1	47.4	47.1	46.4
Mean		64.7	65.0	65.1	46.7	48.0	47.8

Table 3.30 The effect of a T3 spray on margin (Opus)

Location and Year	Main Disease(s)	Margin (£/ha)		
		GS30/39	GS30/39/59	GS30/59
Hants. 02	rhyncho	286	261	280
Hants. 03	rhyncho b rust	366	349	349
Hants. 04	rhyncho	438	450	461
Lincs. 02	b rust	462	442	460
Lincs. 03	b rust rhyncho	420	417	457
Lincs. 04	rhyncho b rust	496	496	496
Glos. 04	b rust	399	392	416
Norfolk 02	b rust rhyncho	419	413	423
Norfolk 03	b rust rhyncho	429	402	442
Norfolk 04	net blotch rhyncho	440	419	422
Mean		415	404	421

4. Discussion

Rainfall pattern, and its impact on disease development, will inevitably affect both the optimum timing for fungicide applications, and also the magnitude of any reduction in yield or disease control resulting from applications that are less well timed. All three of the seasons in which the trials took place were characterised by relatively dry weather in March, such that when T1 sprays were applied at the end of the month or in early April the amounts of disease established in the crop tended not to be high. Wetter weather was experienced close to the T2 spray timings, notably in May 2002 in the south and west of England, and in April 2004 in the south and east. As a consequence, it was at these later timings that disease levels tended to be increasing most rapidly, regardless of the disease present, and this will have strongly influenced the trials. However, it must be assumed that there is an equal chance of similar weather being experienced in future seasons, so the results are unlikely to be atypical for these areas. In some parts of the UK, for example in Scotland, the weather pattern and resulting disease development could be quite different in a typical spring, and this might place much greater emphasis on the earlier application timings, especially for the control of rhynchosporium. Hence any extrapolation of these results outside of the situations encountered in these trials should be done with caution.

In the trials, there was a clear tendency for larger yield responses to fungicide to be obtained where brown rust or net blotch were dominant, than for comparable levels of rhynchosporium. However, as a consequence of the weather patterns, the three diseases were often developing most rapidly at similar crop stages, whereas in situations where, for example, rhynchosporium develops more rapidly prior to the T1 timing and brown rust not until the T2 timing, the yield penalty from poor control of rhynchosporium could well be greater. In addition, the levels of brown rust control achieved tended to be greater than for rhynchosporium, especially with the Opus + Corbel partner. The recent approval of prothioconazole, and the improvement in rhynchosporium control that this is expected to bring, could well lead to better yield responses where this disease is dominant.

As much of the disease development that took place occurred in late April and May rather than in March and early April, the better responses to fungicides applied at T2 rather than at T1 might have been anticipated. The highest recorded disease levels (and most significant differences between treatments) tended to be on leaves 1 and 2, where T2 sprays would have been expected to have had the most impact. It is notable that in Hampshire in 2004, where rhynchosporium was mainly present on leaves 3 and 4, a single T2 spray was slightly less effective (both in controlling the disease on leaf 4 and in protecting yield) than two-sprays where the partner to the strobilurin was eradicant (Opus + Corbel), but significantly less effective where the partner was protectant (Unix). It would be therefore wrong to conclude that a T2 spray will always be of more benefit than a T1, but the potential penalties as a result of applying just a T1 spray and not following up with a T2 are clear.

With spraying capacity often stretched to the limit on farms, yield penalties or increased chemical costs can easily be incurred as a result of an inability to apply fungicides to winter wheat within a relatively narrow period around the optimum timings. This reflects the major contribution to final yield made by the top three leaves, with the two key applications in wheat, at T1 and T2, targeted specifically at the emergence of leaf 3 and the flag leaf respectively. Where winter barley is being grown, the possibility of flexible spray timings could have real advantages (for example enabling a reduction in passes through the crop by tank-mixing inputs, or allowing applications to wheat or other crops to be given priority).

For barley, leaf 3 will typically contribute more to yield than the flag leaf, with the awns responsible for a larger proportion still. The results obtained here indicate that application of the T1 spray at about GS31 (when leaf 3 and/or leaf 4 might be emerging), and the T2 spray at GS49 (when the awns have just emerged) represent the likely optimum timings. However, in the majority of cases applications earlier or later than the optimum had little or no effect on disease control, or on yield, even where the more protectant combination of strobilurin + Unix was used. In the few situations where disease control or yields were compromised, this was generally the result of:

- Applying T1 sprays too early or T2 sprays too late where rhynchosporium was the main disease. This might be less of a problem in future with the availability of Proline as a partner to the strobilurins.
- Applying T2 sprays too early where brown rust or net blotch were the major late season threats (especially with the eradicant Opus + Corbel partner).
- Applying T2 sprays too late when targeting established brown rust on lower leaves with a protectant (Unix) partner to the strobilurin.

Therefore, whilst strobilurin-based fungicides are well suited as the basis of protectant fungicide programmes, with applications timed at the start of the T1 and T2 spray windows, they can be just as effective when applied later, provided that they are mixed with an appropriate eradicant partner where disease is established.

The fact that the yield response over untreated was reduced by only 3% (from 34% to 31%) when the interval between sprays was stretched from 4 to 8 weeks under relatively high brown rust pressure in Lincolnshire in 2002 clearly illustrates the flexibility that can be introduced where the fungicides used are highly effective against the disease (in this case Acanto/Amistar + Opus + Corbel for brown rust). However, it is worth noting that there were some examples where spray intervals of less than three weeks or more than six weeks resulted in poorer than average yield responses to fungicide.

Application of a third fungicide spray at GS59, equivalent to the 'T3' in wheat, sometimes gave a marginal improvement in disease control, but interestingly the greatest benefit was in the control of rhynchosporium (in 2002), where two-spray programmes typically gave only 65-75% control compared to over 80% with three sprays. The presumption might have been that high brown rust pressure would have been most likely to result in a benefit from a T3 spray. However, two-spray programmes with Opus + Corbel as partner invariably gave 90-95% control of brown rust, such that there was little work for the T3 spray to do. In the Lincolnshire trials, which were affected by brown rust and rhynchosporium, only when the latter was the main disease (in 2004) was there an increase in green leaf protection as a result of applying a third fungicide spray. There was a small yield advantage with the additional spray in a few cases, but this was never cost-effective, and surprisingly there was no consistent specific weight improvement either. Although only the effects of the straight Opus T3 spray were presented in detail, there is no evidence from the results that a third spray of strobilurin would have had any greater impact.

This project did not examine the impact of a 'third' spray applied prior to the two main applications i.e. at the 'T0' timing (prior to GS30) rather than at T3. However, results from other trials have previously shown that such treatments can often be of benefit to disease control, and sometimes yield, where net blotch and/or rhynchosporium pressure are high at that early stage of growth.

5. Conclusions and Implications

- Fungicide applications at the T2 timing in winter barley are at least as important as at T1, regardless of the diseases that are present, or the choice of eradicant or protectant partner to a strobilurin.

However, the pattern of disease development that results from seasonal and regional weather factors will determine which of the timings is the most beneficial in a given situation. The three seasons within which these trials were conducted were not characterised by high disease pressure in the period leading up to T1. Where, for example, rhynchosporium is very active early in the season, fungicides applied at T1 and possibly earlier (at T0) may be more important.

- Yield responses to fungicide have been larger where brown rust (and net blotch) are the main diseases than where similar or higher levels of rhynchosporium have been present.

This partly explains why T2 fungicides have tended to contribute slightly more than half of the yield response (brown rust and net blotch tend to be more prevalent at that stage). Note that to some extent this may reflect the fact that fungicide programmes such as those evaluated here have often been less successful at controlling rhynchosporium than brown rust, and the recent approval of fungicides containing prothioconazole (Proline or Fandango) may help to improve this.

- Programmes based on two half-rate strobilurin sprays have shown a high degree of flexibility in timing, with application windows of 2 weeks or more (and spray intervals varying by up to four weeks) having relatively little impact on yield.

This is in stark contrast to winter wheat, where the effective control of septoria in particular is often very dependent on timing. Where spray days or spraying capacity are limited, the use of fungicide programmes that allow considerable flexibility in their application timings is likely to be of benefit. However, intervals of less than 3 weeks or more than 7 weeks should still be avoided.

- Unlike in wheat, the efficacy of, and optimum timing for, the T1 spray in winter barley is not closely related to the emergence of a particular leaf layer.

Whilst in winter wheat the T1 fungicide should be applied when leaf 3 is emerging rather than leaf 4, on winter barley it is less critical which of these two leaves is emerging. Applications can therefore be timed effectively by growth stages. With a ‘flexible’ (eradicant) partner added to strobilurin, applications as early as when leaf 5 is still emerging on some plants, or as late as when leaf 2 has started to emerge, may be equally effective.

- Timing of the T2 spray has had no consistent impact on yield, regardless of the diseases present, but GS49 (awn emergence) remains the best compromise.

There is some evidence that the T2 application should be earlier (GS39) than GS49 rather than later (GS59) where rhynchosporium is still active. Where brown rust (or net blotch) are increasing at T2, if an eradicant partner is included application earlier than GS49 may be disadvantageous.

- Choice of strobilurin partner (either protectant as with Unix or eradicant as with Opus + Corbel) has had no consistent effect on yield, but in situations where delaying the T1 or T2 spray has been beneficial with Opus + Corbel as the partner, this has not generally been the case with Unix.

Use of a mainly protectant partner with a strobilurin might be expected to be more limiting to the flexibility in timing of the T1 and T2 sprays, especially where brown rust was the main disease present. Whilst there were some situations where this was true, overall the choice of partner made little difference. However it should be noted that the patterns of weather and disease development over the three years of the project did not generally result in a high requirement for disease eradication at any of the T1 or T2 timings.

- Application of a third fungicide spray at the ‘T3’ timing is unlikely to be justified on barley, in either rhynchosporium or brown rust dominated situations.

When this project first started, application of a third strobilurin-based fungicide spray at T3 offered potential to improve yields and grain quality through extending the green area duration of the crop canopy. Since then, resistance concerns have led to the use of strobilurins in cereals being limited to two applications. Despite occasional improvements in disease control or yield compared to the most effective two-spray programmes, neither strobilurin nor triazole based T3 sprays have been shown to be cost-effective here.

6.1 Acknowledgements

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6.2 References

ARC (2000). *Winter Cereal and Oilseed Rape Trials Results 2000.* Arable Research Centres, Cirencester 2000

HGCA (2000). *The Wheat Disease Management Guide*. Home-Grown Cereals Authority, London

7. Appendices

7.1 Appendix A: Treatment application dates and crop growth stages

Andover 2002

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS26-30	26/03/02	3/4
3,4,9,10,14,16,17	GS30 + 7 days	+ 8 days (GS30)	03/04/02	3
5,6,11,12,15	GS30 + 14 days	+ 14 days (GS30-1)	09/04/02	3
1,2,3,4,5,6,20,21	GS39	GS39	02/05/02	-
7,8,9,10,11,12,18,19	GS49	GS49	09/05/02	-
13,14,15,20,21	GS59	GS59	16/05/02	-

Caythorpe 2002

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS30	22/03/02	4
3,4,9,10,14,16,17	GS30 + 7 days	+ 6 days (GS30)	28/03/02	3/4
5,6,11,12,15	GS30 + 14 days	+ 13 days (GS30-1)	04/04/02	3
1,2,3,4,5,6,20,21	GS39	GS39	02/05/02	-
7,8,9,10,11,12,18,19	GS49	GS49	09/05/02	-
13,14,15,20,21	GS59	GS59	19/05/02	-

Cirencester 2002

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS30-1	22/03/02	4
3,4,9,10,14,16,17	GS30 + 7 days	+ 12 days (GS31)	03/04/02	3
5,6,11,12,15	GS30 + 14 days	+ 25 days (GS31-2)	16/04/02	3/2
1,2,3,4,5,6,20,21	GS39	GS39	24/04/02	-
7,8,9,10,11,12,18,19	GS49	GS49-55	09/05/02	-
13,14,15,20,21	GS59	missed	-	-

Morley 2002

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS30	27/03/02	4
3,4,9,10,14,16,17	GS30 + 7 days	+ 8 days (GS31)	04/04/02	3
5,6,11,12,15	GS30 + 14 days	+ 14 days (GS32)	10/04/02	3
1,2,3,4,5,6,20,21	GS39	GS39-45	01/05/02	-
7,8,9,10,11,12,18,19	GS49	GS49	07/05/02	-
13,14,15,20,21	GS59	GS59-61	19/05/02	-

Andover 2003

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS27-30	27/03/03	4
3,4,9,10,14,16,17	GS30 + 7 days	+ 7 days (GS30)	03/04/03	3/4
5,6,11,12,15	GS30 + 14 days	+ 15 days (GS30-1)	11/04/03	3
1,2,3,4,5,6,20,21	GS39	GS39	03/05/03	-
7,8,9,10,11,12,18,19	GS49	GS49	09/05/03	-
13,14,15,20,21	GS59	GS59	21/05/03	-

Caythorpe 2003

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS28	27/03/03	4
3,4,9,10,14,16,17	GS30 + 7 days	+ 8 days (GS31)	04/04/03	3/4
5,6,11,12,15	GS30 + 14 days	+ 15 days (GS31)	11/04/03	3
1,2,3,4,5,6,20,21	GS39	GS39	30/04/03	-
7,8,9,10,11,12,18,19	GS49	GS49	06/05/03	-
13,14,15,20,21	GS59	GS59	15/05/03	-

Cirencester 2003

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS30	07/04/03	3
3,4,9,10,14,16,17	GS30 + 7 days	+ 4 days (GS30-1)	11/04/03	3
5,6,11,12,15	GS30 + 14 days	+ 15 days (GS31-2)	22/04/03	2/3
1,2,3,4,5,6,20,21	GS39	missed	-	-
7,8,9,10,11,12,18,19	GS49	GS49-59	15/05/03	-
13,14,15,20,21	GS59	missed	-	-

Morley 2003

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS25-30	20/03/03	5
3,4,9,10,14,16,17	GS30 + 7 days	+ 7 days (GS30)	27/03/03	4/5
5,6,11,12,15	GS30 + 14 days	+ 15 days (GS30-1)	04/04/03	4
1,2,3,4,5,6,20,21	GS39	GS39-41	30/04/03	-
7,8,9,10,11,12,18,19	GS49	GS47-49	06/05/03	-
13,14,15,20,21	GS59	GS59-65	21/05/03	-

Andover 2004

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS30	02/04/04	4
3,4,9,10,14,16,17	GS30 + 7 days	+ 6 days (GS30)	08/04/04	4
5,6,11,12,15	GS30 + 14 days	+ 14 days (GS30-1)	16/04/04	3
1,2,3,4,5,6,20,21	GS39	GS37	02/05/04	-
7,8,9,10,11,12,18,19	GS49	GS49	13/05/04	-
13,14,15,20,21	GS59	GS59	19/05/04	-

Caythorpe 2004

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS26-30	29/03/04	4/5
3,4,9,10,14,16,17	GS30 + 7 days	+ 8 days (GS30-31)	06/04/04	4
5,6,11,12,15	GS30 + 14 days	+ 15 days (GS31)	13/04/04	¾
1,2,3,4,5,6,20,21	GS39	GS37	05/05/04	-
7,8,9,10,11,12,18,19	GS49	GS49	12/05/04	-
13,14,15,20,21	GS59	GS59	24/05/04	-

Cirencester 2004

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS30-31	08/04/04	¾
3,4,9,10,14,16,17	GS30 + 7 days	+ 8 days (GS31)	16/04/04	3
5,6,11,12,15	GS30 + 14 days	+ 14 days (GS32)	22/04/04	2/3
1,2,3,4,5,6,20,21	GS39	GS39-45	02/05/04	-
7,8,9,10,11,12,18,19	GS49	GS49-55	07/05/04	-
13,14,15,20,21	GS59	GS61-65	19/05/04	-

Morley 2004

Treatments	Planned Timing	Actual Timing	Date Applied	Leaf Emerging
1,2,7,8,13,20,21	GS30	GS29-30	31/03/04	4/5
3,4,9,10,14,16,17	GS30 + 7 days	+ 9 days (GS31-32)	09/04/04	¾
5,6,11,12,15	GS30 + 14 days	+ 15 days (GS32)	15/04/04	3
1,2,3,4,5,6,20,21	GS39	GS39	02/05/04	-
7,8,9,10,11,12,18,19	GS49	GS47-49	13/05/04	-
13,14,15,20,21	GS59	GS59-61	20/05/04	-

7.2 Appendix B: Assessment dates and crop growth stages

Andover 2002

Assessment	Actual Timing	Date
GS30 + 7 days (untreated)	GS30	02/04/02
GS49 (selected)	GS55	14/05/02
GS59 (all treatments)	GS65	29/05/02
GS75 (all treatments)	GS71	20/06/02

Caythorpe 2002

Assessment	Actual Timing	Date
GS30 (untreated)	GS30	22/03/02
GS30 + 14 days (untreated)	GS30-31	04/04/02
GS39 (selected)	GS39	01/05/02
GS49 (selected)	GS51-55	14/05/02
GS75 (all treatments)	GS83	17/06/02

Cirencester 2002

Assessment	Actual Timing	Date
GS30 + 7 days (untreated)	GS31	05/04/02
GS30 + 14 days (untreated)	GS31-32	17/04/02
GS39 (selected)	GS39	25/04/02
GS59 (all treatments)	GS53	14/05/02
GS75 (all treatments)	GS83	11/06/02

Morley 2002

Assessment	Actual Timing	Date
GS30 (untreated)	GS30	27/03/02
GS30 + 7 days (untreated)	GS31	04/04/02
GS30 + 14 days (untreated)	GS32	10/04/02
GS39 (selected)	GS45	03/05/02
GS49 (selected)	GS49	08/05/02
GS59 (all treatments)	GS65	21/05/02
GS75 (all treatments)	GS83	13/06/02

Andover 2003

Assessment	Actual Timing	Date
GS30 + 7 days (untreated)	GS30	03/04/03
GS59 (all treatments)	GS59	21/05/03
GS75 (all treatments)	GS71	12/06/03

Caythorpe 2003

Assessment	Actual Timing	Date
GS30 (untreated)	GS28	27/03/03
GS30 + 7 days (untreated)	GS31	04/04/03
GS30 + 14 days (untreated)	GS31	11/04/03
GS39 (selected)	GS39	30/04/03
GS49 (selected)	GS49	06/05/03
GS59 (all treatments)	GS59	23/05/03
GS75 (all treatments)	GS71	05/06/03
	GS85	18/06/03

Cirencester 2003

Assessment	Actual Timing	Date
GS30 (untreated)	GS30	07/04/03
GS30 + 7 days (untreated)	GS30-31	11/04/03
GS59 (all treatments)	GS59	16/05/03
GS75 (all treatments)	GS80-85	19/06/03

Morley 2003

Assessment	Actual Timing	Date
GS30 + 14 days (untreated)	GS30-31	04/04/03
GS39 (selected)	GS39-41	01/05/03
GS49 (selected)	GS47-49	06/05/03
GS59 (all treatments)	GS65	23/05/03
GS75 (all treatments)	GS85	18/06/03

Andover 2004

Assessment	Actual Timing	Date
GS30 (untreated)	GS28-30	31/03/04
GS30 + 14 days (untreated)	GS31-32	22/04/04
GS39 (selected)	GS39	05/05/04
GS49 (selected)	GS45-49	11/05/04
GS59 (all treatments)	GS61-65	20/05/04
GS75 (all treatments)	GS69	07/06/04

Caythorpe 2004

Assessment	Actual Timing	Date
GS30 (untreated)	GS28	30/03/04
GS30 + 7 days (untreated)	GS30-31	06/04/04
GS30 + 14 days (untreated)	GS31	14/04/04
GS39 (selected)	GS37-39	07/05/04
GS59 (all treatments)	GS65	26/05/04
GS75 (all treatments)	GS75	07/06/04
	GS83	18/06/04

Cirencester 2004

Assessment	Actual Timing	Date
GS30 (untreated)	GS30-31	08/04/04
GS30 + 7 days (untreated)	GS31-32	19/04/04
GS30 + 14 days (untreated)	GS32	22/04/04
GS39 (selected)	GS41	04/05/04
GS49 (selected)	GS51	10/05/04
GS75 (all treatments)	GS71-75	10/06/04

Morley 2004

Assessment	Actual Timing	Date
GS30 (untreated)	GS29-30	01/04/04
GS30 + 7 days (untreated)	GS31-32	09/04/04
GS30 + 14 days (untreated)	GS32	15/04/04
GS39 (selected)	GS39	04/05/04
GS49 (selected)	GS49	17/05/04
GS59 (all treatments)	GS61-65	24/05/04
GS75 (all treatments)	GS75	18/06/04

7.3 Appendix C: Results by season and site

Table 7.1 2002 Andover

Fungicide Treatment / Timings			Rhync	Rhync	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L1	% L2	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	7.0	17.5	5.79	119	61.9	45.8	286
GS30 Ac + Unx	GS39 Az + Unx	-	8.6	20.1	5.58	114	61.4	45.5	274
GS30 +7 Ac + O/C	GS39 Az + O/C	-	7.1	13.6	5.70	117	62.5	46.9	281
GS30 +7 Ac + Unx	GS39 Az + Unx	-	12.1	16.4	5.83	119	61.6	45.5	289
GS30 +14 Ac + O/C	GS39 Az + O/C	-	10.6	15.0	5.55	114	61.5	45.6	272
GS30 +14 Ac + Unx	GS39 Az + Unx	-	8.0	18.4	5.74	118	61.4	45.4	283
GS30 Ac + O/C	GS49 Az + O/C	-	8.2	19.6	5.66	116	60.5	45.4	279
GS30 Ac + Unx	GS49 Az + Unx	-	15.3	34.5	5.68	116	61.9	46.4	280
GS30 +7 Ac + O/C	GS49 Az + O/C	-	8.3	14.7	5.61	115	61.5	45.8	276
GS30 +7 Ac + Unx	GS49 Az + Unx	-	11.1	20.6	5.67	116	61.4	45.9	279
GS30 +14 Ac + O/C	GS49 Az + O/C	-	6.0	15.3	5.66	116	61.5	45.9	279
GS30 +14 Ac + Unx	GS49 Az + Unx	-	12.2	30.1	5.61	115	62.1	46.8	276
GS30 Ac + O/C	GS59 Az + O/C	-	8.8	17.7	5.69	117	62.1	46.5	280
GS30 +7 Ac + O/C	GS59 Az + O/C	-	8.3	17.9	5.45	112	61.7	45.9	266
GS30 +14 Ac + O/C	GS59 Az + O/C	-	4.6	16.1	5.81	119	61.1	44.2	288
GS30 +7 Ac + O/C	-	-	11.0	24.3	5.22	107	60.8	45.4	282
GS30 +7 Ac + Unx	-	-	14.7	37.4	5.21	107	61.4	45.5	281
-	GS49 Ac + O/C	-	10.3	32.0	5.39	111	61.9	45.4	292
-	GS49 Ac + Unx	-	9.7	22.8	5.48	112	61.5	45.8	297
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	5.3	14.5	5.76	118	61.1	45.3	266
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	5.1	9.0	5.66	116	61.3	45.9	261
untreated	-	-	28.8	49.5	4.88	100	61.0	44.8	293
LSD (P = 0.05)			8.72	12.37	0.32	6.6	1.42	2.35	
Prob.			0.0012	0.0001	0.000 1		NS	NS	
CV			61.3	40.3	4.11		1.63	3.64	

Table 7.2 2002 Caythorpe

Fungicide Treatment / Timings			GLA	GLA	GLA	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L1	% L2	% L3	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	74	68	43	8.71	132	68.8	35.4	462
GS30 Ac + Unx	GS39 Az + Unx	-	73	64	18	8.72	132	69.3	41.3	462
GS30 +7 Ac + O/C	GS39 Az + O/C	-	69	68	38	8.66	131	69.5	41.5	459
GS30 +7 Ac + Unx	GS39 Az + Unx	-	74	75	45	8.75	132	68.5	42.4	464
GS30 +14 Ac + O/C	GS39 Az + O/C	-	66	71	34	8.87	134	69.7	43.1	471
GS30 +14 Ac + Unx	GS39 Az + Unx	-	76	71	29	8.89	134	69.7	41.4	472
GS30 Ac + O/C	GS49 Az + O/C	-	68	58	14	8.78	133	69.6	39.7	466
GS30 Ac + Unx	GS49 Az + Unx	-	61	43	12	8.38	127	69.2	42.1	442
GS30 +7 Ac + O/C	GS49 Az + O/C	-	70	71	38	8.74	132	69.8	41.5	463
GS30 +7 Ac + Unx	GS49 Az + Unx	-	73	64	30	8.58	130	69.5	38.9	454
GS30 +14 Ac + O/C	GS49 Az + O/C	-	65	64	36	8.78	133	68.9	38.6	466
GS30 +14 Ac + Unx	GS49 Az + Unx	-	74	59	19	8.76	132	69.9	40.6	465
GS30 Ac + O/C	GS59 Az + O/C	-	69	59	15	8.68	131	69.8	41.7	460
GS30 +7 Ac + O/C	GS59 Az + O/C	-	70	63	26	8.77	133	70.0	38.6	465
GS30 +14 Ac + O/C	GS59 Az + O/C	-	63	63	16	8.63	130	69.4	41.8	457
GS30 +7 Ac + O/C	-	-	43	45	4	8.55	129	69.1	42.1	482
GS30 +7 Ac + Unx	-	-	28	26	0	8.19	124	68.0	41.0	460
-	GS49 Ac + O/C	-	61	51	8	8.31	126	68.6	38.9	467
-	GS49 Ac + Unx	-	58	30	1	7.60	115	69.5	40.2	425
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	66	64	30	8.51	129	69.7	39.7	431
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	66	70	30	8.68	131	69.5	43.8	442
untreated	-	-	3	1	0	6.62	100	65.1	40.6	397
LSD (P = 0.05)			11.1	15.5	20.4	0.38	5.7	1.06	4.44	
Prob.			0.000 1	0.000 1	0.000 1	0.000 1		0.0001	NS	
CV			12.62	19.38	65.85	3.17		69.13	7.72	

Table 7.3 2002 Cirencester

Fungicide Treatment / Timings			Yield	Yield	SPW	TGW	Margin
T1	**T2**	**T3**	**(t/ha)**	**(%)**	**(kg/hl)**	**(g)**	**(£/ha)**
GS30 Ac + O/C	GS39 Az + O/C	-	10.83	116	57.2	41.2	589
GS30 Ac + Unx	GS39 Az + Unx	-	10.77	115	55.8	39.5	585
GS30 +7 Ac + O/C	GS39 Az + O/C	-	10.73	115	56.5	40.8	583
GS30 +7 Ac + Unx	GS39 Az + Unx	-	11.04	118	56.7	43.0	601
GS30 +14 Ac + O/C	GS39 Az + O/C	-	10.50	112	57.2	40.6	569
GS30 +14 Ac + Unx	GS39 Az + Unx	-	10.59	113	56.7	40.8	574
GS30 Ac + O/C	GS49 Az + O/C	-	11.26	120	58.9	42.5	615
GS30 Ac + Unx	GS49 Az + Unx	-	11.59	124	57.6	42.1	634
GS30 +7 Ac + O/C	GS49 Az + O/C	-	11.14	119	58.4	41.9	607
GS30 +7 Ac + Unx	GS49 Az + Unx	-	10.88	116	57.8	41.3	592
GS30 +14 Ac + O/C	GS49 Az + O/C	-	12.12	130	57.6	46.1	668
GS30 +14 Ac + Unx	GS49 Az + Unx	-	11.08	118	58.6	41.8	604
GS30 +7 Ac + O/C	-	-	10.39	111	55.9	40.8	592
GS30 +7 Ac + Unx	-	-	10.24	109	54.8	37.8	583
-	GS49 Ac + O/C	-	10.56	113	58.1	43.1	602
-	GS49 Ac + Unx	-	10.10	108	57.1	42.8	575
untreated	-	-	9.36	100	53.7	37.7	562
LSD (P = 0.05)			0.67	7.2	1.25	3.79	
Prob.			0.000 1		0.0001	0.028 0	
CV			4.43		1.56	6.51	

Table 7.4 2002 Morley

Fungicide Treatment / Timings			B Rus	Rhync	GLA	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L2	% L3	% L2	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	0.0	0.7	92.0	7.99	115	67.1	46.7	419
GS30 Ac + Unx	GS39 Az + Unx	-	0.1	0.4	95.0	8.06	116	67.1	46.2	423
GS30 +7 Ac + O/C	GS39 Az + O/C	-	0.0	0.7	89.0	8.16	117	68.0	47.2	429
GS30 +7 Ac + Unx	GS39 Az + Unx	-	0.0	0.4	95.5	8.37	120	67.6	46.0	441
GS30 +14 Ac + O/C	GS39 Az + O/C	-	0.0	1.1	88.8	7.96	115	67.1	45.2	417
GS30 +14 Ac + Unx	GS39 Az + Unx	-	0.0	0.7	93.8	8.12	117	67.3	46.2	426
GS30 Ac + O/C	GS49 Az + O/C	-	0.0	0.7	91.0	8.33	120	67.8	46.6	439
GS30 Ac + Unx	GS49 Az + Unx	-	0.0	0.3	96.3	8.28	119	67.7	47.8	436
GS30 +7 Ac + O/C	GS49 Az + O/C	-	0.0	0.7	90.3	7.88	113	67.3	46.0	412
GS30 +7 Ac + Unx	GS49 Az + Unx	-	0.0	0.6	95.3	8.00	115	67.4	47.7	419
GS30 +14 Ac + O/C	GS49 Az + O/C	-	0.0	0.5	90.0	8.11	117	67.9	46.4	426
GS30 +14 Ac + Unx	GS49 Az + Unx	-	0.0	0.4	95.3	7.98	115	67.2	46.4	418
GS30 Ac + O/C	GS59 Az + O/C	-	0.0	1.0	85.5	8.07	116	68.0	46.1	423
GS30 +7 Ac + O/C	GS59 Az + O/C	-	0.0	1.1	93.5	8.14	117	68.0	46.2	428
GS30 +14 Ac + O/C	GS59 Az + O/C	-	0.0	0.6	87.0	8.25	119	68.2	46.6	434
GS30 +7 Ac + O/C	-	-	1.4	3.4	62.8	7.60	109	67.1	44.8	424
GS30 +7 Ac + Unx	-	-	2.9	6.0	55.0	7.42	107	66.0	44.2	414
-	GS49 Ac + O/C	-	0.0	0.8	89.3	7.92	114	67.8	46.3	444
-	GS49 Ac + Unx	-	0.2	0.9	89.3	7.86	113	67.5	47.2	440
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	0.0	0.6	90.8	8.12	117	67.8	46.8	408
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	0.0	0.6	91.5	8.21	118	67.9	45.5	413
untreated	-	-	9.0	11.3	30.0	6.95	100	65.7	43.2	417
LSD (P = 0.05)			0.65	1.52	8.17	0.38	5.5	0.82	1.65	
Prob.			0.0001	0.0001	0.0001	0.0194		0.0001	0.0001	
CV			75.0	70.9	6.73	3.40		0.85	2.53	

Table 7.5 2003 Andover

Fungicide Treatment / Timings			Rhync % L1	Rhync % L2	Yield (t/ha)	Yield (%)	SPW (kg/hl)	TGW (g)	Margin (£/ha)
T1	T2	T3							
GS30 Ac + O/C	GS39 Az + O/C	-	0.4	1.1	7.11	109	60.6	51.8	366
GS30 Ac + Unx	GS39 Az + Unx	-	0.9	1.0	6.95	106	59.9	54.1	356
GS30 +7 Ac + O/C	GS39 Az + O/C	-	0.3	1.5	7.19	110	60.9	52.8	370
GS30 +7 Ac + Unx	GS39 Az + Unx	-	0.6	1.7	6.91	105	60.1	52.2	354
GS30 +14 Ac + O/C	GS39 Az + O/C	-	0.8	1.5	7.13	109	60.5	55.4	367
GS30 +14 Ac + Unx	GS39 Az + Unx	-	0.5	5.3	7.21	110	60.2	52.5	372
GS30 Ac + O/C	GS49 Az + O/C	-	2.2	6.5	7.17	109	61.6	52.2	369
GS30 Ac + Unx	GS49 Az + Unx	-	0.8	5.7	7.08	108	60.9	53.2	364
GS30 +7 Ac + O/C	GS49 Az + O/C	-	1.5	3.0	7.25	111	61.1	53.6	374
GS30 +7 Ac + Unx	GS49 Az + Unx	-	1.4	4.3	7.00	107	60.5	50.3	359
GS30 +14 Ac + O/C	GS49 Az + O/C	-	0.3	1.9	7.11	109	60.7	53.5	366
GS30 +14 Ac + Unx	GS49 Az + Unx	-	0.9	1.7	7.12	109	60.5	50.6	366
GS30 Ac + O/C	GS59 Az + O/C	-	2.3	9.8	6.84	104	60.2	52.0	349
GS30 +7 Ac + O/C	GS59 Az + O/C	-	1.6	9.3	6.82	104	60.5	52.8	348
GS30 +14 Ac + O/C	GS59 Az + O/C	-	2.9	4.7	7.00	107	60.3	53.3	359
GS30 +7 Ac + O/C	-	-	10.6	16.6	6.80	104	60.3	51.0	377
GS30 +7 Ac + Unx	-	-	10.8	16.6	6.63	101	59.6	50.6	366
-	GS49 Ac + O/C	-	1.2	1.3	7.17	109	62.0	54.0	399
-	GS49 Ac + Unx	-	4.7	7.9	6.71	102	60.0	52.5	371
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	0.2	0.6	7.15	109	61.5	53.3	350
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	2.5	5.2	7.13	109	59.3	53.0	349
untreated	-	-	16.6	19.1	6.55	100	60.7	51.1	393
LSD (P = 0.05)			4.29	6.79	0.45	6.9	2.27	3.17	
Prob.			0.0001	0.0001	0.0499		NS	NS	
CV			104.4	83.7	4.52		2.70	4.26	

Table 7.6 2003 Caythorpe

Fungicide Treatment / Timings			B Rus	Rhyn c	GLA	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L2	% L2	% L2	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	0.3	0.5	68.8	8.02	113	68.7	50.5	420
GS30 Ac + Unx	GS39 Az + Unx	-	1.3	0.8	33.8	8.09	114	69.1	50.5	424
GS30 +7 Ac + O/C	GS39 Az + O/C	-	0.3	1.0	60.0	7.90	111	68.8	49.3	413
GS30 +7 Ac + Unx	GS39 Az + Unx	-	0.8	1.5	38.8	8.42	118	68.7	50.8	444
GS30 +14 Ac + O/C	GS39 Az + O/C	-	0.3	0.8	65.0	8.28	116	68.8	50.3	436
GS30 +14 Ac + Unx	GS39 Az + Unx	-	1.3	0.3	36.3	8.28	116	68.4	48.8	436
GS30 Ac + O/C	GS49 Az + O/C	-	0.5	1.3	72.5	8.00	113	69.1	50.8	419
GS30 Ac + Unx	GS49 Az + Unx	-	1.0	1.5	31.3	8.40	118	69.7	50.3	443
GS30 +7 Ac + O/C	GS49 Az + O/C	-	0.3	0.3	68.8	8.25	116	69.4	50.3	434
GS30 +7 Ac + Unx	GS49 Az + Unx	-	1.0	0.5	31.3	8.21	115	68.9	51.8	432
GS30 +14 Ac + O/C	GS49 Az + O/C	-	0.3	1.0	63.8	8.24	116	69.5	50.8	433
GS30 +14 Ac + Unx	GS49 Az + Unx	-	1.0	1.0	45.0	8.33	117	69.4	50.8	439
GS30 Ac + O/C	GS59 Az + O/C	-	0.5	1.3	58.8	8.63	121	69.5	52.8	457
GS30 +7 Ac + O/C	GS59 Az + O/C	-	0.3	1.3	51.3	8.51	120	69.3	51.0	450
GS30 +14 Ac + O/C	GS59 Az + O/C	-	0.3	1.5	67.5	8.30	117	69.7	51.0	437
GS30 +7 Ac + O/C	-	-	1.5	2.5	25.0	7.95	112	69.3	50.3	446
GS30 +7 Ac + Unx	-	-	3.5	3.5	14.0	7.84	110	69.3	48.5	439
-	GS49 Ac + O/C	-	0.8	1.0	57.5	8.07	114	69.7	49.0	453
-	GS49 Ac + Unx	-	2.3	1.8	25.0	7.92	111	69.6	51.0	444
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	0.0	0.0	65.0	8.68	122	69.3	51.3	441
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	0.0	1.8	67.5	8.27	116	69.6	51.3	417
untreated	-	-	9.0	5.5	4.8	7.11	100	69.6	48.0	427
LSD (P = 0.05)			1.27	1.35	14.9	0.44	6.2	0.81	2.10	
Prob.			0.0001	0.0001	0.0001	0.0001		0.0308	0.0075	
CV			76.1	69.2	22.1	3.82		0.83	2.95	

Table 7.7 2003 Cirencester

Fungicide Treatment / Timings			B Rus % L1	B Rus % L2	Yield (t/ha)	Yield (%)	SPW (kg/hl)	TGW (g)	Margin (£/ha)
T1	**T2**	**T3**							
GS30 Ac + O/C	GS49 Az + O/C	-	1.7	2.1	7.21	114	59.1	44.8	372
GS30 Ac + Unx	GS49 Az + Unx	-	4.3	10.3	7.67	122	58.5	43.1	399
GS30 +7 Ac + O/C	GS49 Az + O/C	-	1.9	1.9	7.51	119	59.5	43.3	390
GS30 +7 Ac + Unx	GS49 Az + Unx	-	4.8	16.4	7.45	118	58.8	43.8	386
GS30 +14 Ac + O/C	GS49 Az + O/C	-	1.2	2.9	7.84	124	59.6	45.0	409
GS30 +14 Ac + Unx	GS49 Az + Unx	-	7.3	9.0	7.58	120	58.8	44.3	394
GS30 +7 Ac + O/C	-	-	7.2	11.9	6.91	110	58.0	42.0	383
GS30 +7 Ac + Unx	-	-	12.7	30.7	7.11	113	56.4	42.1	395
-	GS49 Ac + O/C	-	4.0	5.2	7.12	113	58.9	43.1	396
-	GS49 Ac + Unx	-	7.8	10.2	7.30	116	59.0	45.0	407
untreated	-	-	23.3	38.6	6.31	100	56.6	40.9	379
LSD (P = 0.05)			5.46	8.03	0.56	8.9	1.76	3.19	
Prob.			0.000 1	0.000 1	0.000 1		0.0597	NS	
CV			85.8	68.6	5.32		2.12	5.15	

Table 7.8 2003 Morley

Fungicide Treatment / Timings			Rhync	B Rus	GLA	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L2	% L2	% L2	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	1.0	0.0	32.5	8.17	111	68.6	49.3	429
GS30 Ac + Unx	GS39 Az + Unx	-	0.4	0.0	61.3	8.29	113	69.2	50.8	436
GS30 +7 Ac + O/C	GS39 Az + O/C	-	1.2	0.0	45.0	8.22	112	68.5	49.3	432
GS30 +7 Ac + Unx	GS39 Az + Unx	-	0.5	0.0	45.0	8.13	111	68.6	51.0	427
GS30 +14 Ac + O/C	GS39 Az + O/C	-	0.4	0.0	41.3	8.19	112	68.0	51.8	430
GS30 +14 Ac + Unx	GS39 Az + Unx	-	0.3	0.0	60.0	8.01	109	69.0	51.1	420
GS30 Ac + O/C	GS49 Az + O/C	-	1.1	0.0	41.3	8.03	110	68.6	48.9	421
GS30 Ac + Unx	GS49 Az + Unx	-	0.2	0.0	66.3	8.44	115	68.8	50.7	445
GS30 +7 Ac + O/C	GS49 Az + O/C	-	0.8	0.0	33.8	8.23	112	69.3	52.0	433
GS30 +7 Ac + Unx	GS49 Az + Unx	-	0.3	0.0	55.0	8.62	118	68.8	49.7	456
GS30 +14 Ac + O/C	GS49 Az + O/C	-	1.0	0.0	32.5	8.10	111	69.2	51.0	425
GS30 +14 Ac + Unx	GS49 Az + Unx	-	0.2	0.0	62.5	8.61	117	69.0	51.1	456
GS30 Ac + O/C	GS59 Az + O/C	-	1.7	0.0	35.0	8.39	114	69.1	49.5	442
GS30 +7 Ac + O/C	GS59 Az + O/C	-	1.6	0.0	30.0	8.28	113	69.2	49.2	436
GS30 +14 Ac + O/C	GS59 Az + O/C	-	1.0	0.0	36.3	8.24	112	69.4	50.9	433
GS30 +7 Ac + O/C	-	-	3.0	0.0	13.0	7.61	104	67.9	49.9	425
GS30 +7 Ac + Unx	-	-	3.3	0.0	17.5	7.99	109	67.4	47.9	448
-	GS49 Ac + O/C	-	1.8	0.0	38.8	7.90	108	69.1	49.5	443
-	GS49 Ac + Unx	-	0.4	0.0	66.9	8.14	111	69.2	51.3	457
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	0.5	0.0	33.8	8.11	111	69.4	51.6	407
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	0.6	0.0	26.3	8.01	109	68.9	50.9	402
untreated	-	-	5.8	6.3	8.8	7.33	100	68.3	49.7	440
LSD (P = 0.05)			1.30	0.75	15.9	0.41	5.6	1.12	3.53	
Prob.			0.0001	0.0001	0.0001	0.0001		0.0512	NS	
CV			75.9	187.6	28.1	3.59		1.15	4.97	

Table 7.9 2004 Andover

Fungicide Treatment / Timings			Rhync % L3	Rhync % L4	Yield (t/ha)	Yield (%)	SPW (kg/hl)	TGW (g)	Margin (£/ha)
T1	**T2**	**T3**							
GS30 Ac + O/C	GS39 Az + O/C	-	4.4	0.5	8.31	111	62.9	57.5	438
GS30 Ac + Unx	GS39 Az + Unx	-	14.3	1.9	8.34	111	62.7	56.9	439
GS30 +7 Ac + O/C	GS39 Az + O/C	-	7.2	0.9	8.47	113	62.9	57.6	447
GS30 +7 Ac + Unx	GS39 Az + Unx	-	6.7	1.0	8.46	113	62.6	56.4	447
GS30 +14 Ac + O/C	GS39 Az + O/C	-	8.9	1.3	8.50	113	63.4	57.1	449
GS30 +14 Ac + Unx	GS39 Az + Unx	-	5.9	3.4	8.23	110	62.4	56.4	433
GS30 Ac + O/C	GS49 Az + O/C	-	6.5	1.8	8.66	115	62.5	56.6	459
GS30 Ac + Unx	GS49 Az + Unx	-	10.2	4.0	8.47	113	62.8	58.0	447
GS30 +7 Ac + O/C	GS49 Az + O/C	-	4.7	2.1	8.67	115	62.5	56.4	459
GS30 +7 Ac + Unx	GS49 Az + Unx	-	3.6	2.8	8.65	115	62.7	56.7	458
GS30 +14 Ac + O/C	GS49 Az + O/C	-	4.7	2.2	8.58	114	63.4	57.3	454
GS30 +14 Ac + Unx	GS49 Az + Unx	-	6.6	3.4	8.51	113	62.8	56.8	450
GS30 Ac + O/C	GS59 Az + O/C	-	6.5	2.5	8.70	116	63.1	57.7	461
GS30 +7 Ac + O/C	GS59 Az + O/C	-	5.1	1.7	8.75	117	63.7	57.2	464
GS30 +14 Ac + O/C	GS59 Az + O/C	-	9.5	2.4	8.54	114	62.7	58.1	451
GS30 +7 Ac + O/C	-	-	12.6	1.4	7.94	106	62.6	56.2	445
GS30 +7 Ac + Unx	-	-	10.6	1.4	7.69	102	62.5	54.8	430
-	GS49 Ac + O/C	-	18.8	4.4	8.52	113	63.5	55.8	480
-	GS49 Ac + Unx	-	16.8	9.9	7.88	105	63.3	56.0	441
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	7.6	2.2	8.06	107	62.7	58.7	404
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	6.8	1.1	8.81	117	63.4	57.6	450
untreated	-	-	52.2	13.2	7.51	100	61.8	53.7	451
LSD (P = 0.05)			12.6	3.05	0.69	9.2	1.30	2.24	
Prob.			0.0001	0.0001	0.0129		NS	0.0200	
CV			85.2	72.5	5.81		1.49	2.79	

Table 7.10 2004 Caythorpe

Fungicide Treatment / Timings			Rhync	GLA	GLA	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L3	% L1	% L2	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	6.0	70.0	55.0	9.29	113	66.2	44.5	496
GS30 Ac + Unx	GS39 Az + Unx	-	5.5	53.3	33.3	9.26	112	66.3	44.5	495
GS30 +7 Ac + O/C	GS39 Az + O/C	-	6.0	76.7	56.7	9.49	115	66.6	44.0	508
GS30 +7 Ac + Unx	GS39 Az + Unx	-	6.5	36.7	21.7	9.45	115	66.7	46.5	506
GS30 +14 Ac + O/C	GS39 Az + O/C	-	6.5	68.3	56.7	9.40	114	67.2	44.4	503
GS30 +14 Ac + Unx	GS39 Az + Unx	-	6.0	61.7	41.7	9.26	112	66.3	44.9	495
GS30 Ac + O/C	GS49 Az + O/C	-	6.0	71.7	55.0	9.53	116	66.3	45.9	511
GS30 Ac + Unx	GS49 Az + Unx	-	5.5	43.4	23.3	9.31	113	67.2	45.0	498
GS30 +7 Ac + O/C	GS49 Az + O/C	-	6.0	61.7	53.3	9.48	115	66.4	45.5	508
GS30 +7 Ac + Unx	GS49 Az + Unx	-	4.5	58.3	31.7	9.48	115	66.7	44.9	508
GS30 +14 Ac + O/C	GS49 Az + O/C	-	6.5	68.3	51.7	9.40	114	66.8	46.3	503
GS30 +14 Ac + Unx	GS49 Az + Unx	-	5.5	65.0	45.0	9.57	116	66.0	45.8	513
GS30 Ac + O/C	GS59 Az + O/C	-	5.5	66.7	46.7	9.29	113	66.3	44.7	496
GS30 +7 Ac + O/C	GS59 Az + O/C	-	7.8	68.3	58.3	9.52	116	66.9	45.7	510
GS30 +14 Ac + O/C	GS59 Az + O/C	-	5.0	50.0	40.0	9.42	114	67.7	44.4	504
GS30 +7 Ac + O/C	-	-	7.8	43.3	25.0	8.92	108	66.4	44.6	504
GS30 +7 Ac + Unx	-	-	5.5	30.0	23.3	8.86	108	65.8	45.4	500
-	GS49 Ac + O/C	-	6.5	58.3	50.0	9.18	111	67.0	45.0	519
-	GS49 Ac + Unx	-	5.0	61.7	26.7	9.45	115	67.5	45.4	536
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	5.5	75.0	63.3	9.30	113	67.2	43.6	479
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	5.5	71.7	71.7	9.59	116	66.8	46.4	496
untreated	-	-	8.0	16.7	11.7	8.24	100	65.0	42.2	494
LSD (P = 0.05)			1.57	23.1	22.4	0.39	4.7	1.07	3.23	
Prob.			0.0015	0.0001	0.0001	0.0001		0.0021	NS	
CV			18.4	24.1	31.8	2.96		1.13	5.08	

Table 7.11 2004 Cirencester

Fungicide Treatment / Timings			B Rus	GLA	GLA	Yield	Yield	SPW	TGW	Margin
T1	T2	T3	% L4	% L2	% L3	(t/ha)	(%)	(kg/hl)	(g)	(£/ha)
GS30 Ac + O/C	GS39 Az + O/C	-	0.0	65.6	27.8	7.67	119	56.1	38.5	399
GS30 Ac + Unx	GS39 Az + Unx	-	0.2	42.0	26.9	7.53	117	54.8	37.8	391
GS30 +7 Ac + O/C	GS39 Az + O/C	-	0.0	58.4	20.7	7.90	123	54.9	37.1	413
GS30 +7 Ac + Unx	GS39 Az + Unx	-	0.5	35.5	12.1	7.45	116	55.4	37.1	386
GS30 +14 Ac + O/C	GS39 Az + O/C	-	0.2	64.7	33.7	7.77	121	56.4	37.6	405
GS30 +14 Ac + Unx	GS39 Az + Unx	-	0.6	26.5	8.8	7.90	123	55.5	37.3	413
GS30 Ac + O/C	GS49 Az + O/C	-	0.0	65.9	18.8	7.85	122	56.0	37.5	410
GS30 Ac + Unx	GS49 Az + Unx	-	0.4	23.9	12.4	8.05	125	55.2	37.9	422
GS30 +7 Ac + O/C	GS49 Az + O/C	-	0.1	69.8	28.8	8.21	127	56.3	38.8	432
GS30 +7 Ac + Unx	GS49 Az + Unx	-	2.9	19.5	14.4	7.68	119	54.8	37.8	400
GS30 +14 Ac + O/C	GS49 Az + O/C	-	0.2	80.3	43.8	7.73	120	56.1	38.4	403
GS30 +14 Ac + Unx	GS49 Az + Unx	-	1.0	25.1	8.0	7.96	124	55.8	38.0	417
GS30 Ac + O/C	GS59 Az + O/C	-	0.0	74.9	30.4	7.95	123	56.6	40.1	416
GS30 +7 Ac + O/C	GS59 Az + O/C	-	0.1	59.5	23.8	7.55	117	56.4	38.8	392
GS30 +14 Ac + O/C	GS59 Az + O/C	-	0.1	79.9	47.4	7.81	121	57.5	40.8	408
GS30 +7 Ac + O/C	-	-	0.3	27.9	6.5	7.40	115	54.8	36.8	413
GS30 +7 Ac + Unx	-	-	1.3	18.6	23.5	7.46	116	54.7	36.6	416
-	GS49 Ac + O/C	-	1.9	41.7	14.1	7.57	118	55.4	37.8	423
-	GS49 Ac + Unx	-	5.6	27.4	5.4	7.49	116	55.6	37.9	418
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	0.0	85.8	48.7	7.99	124	57.3	39.5	400
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	0.0	73.7	34.0	7.85	122	56.1	38.8	392
untreated	-	-	13.4	3.9	0.4	6.44	100	54.8	37.0	386
LSD (P = 0.05)			1.65	17.6	20.2	0.50	7.7	1.20	1.69	
Prob.			0.000 1	0.000 1	0.000 1	0.000 1		0.0001	0.000 2	
CV			90.0	25.6	64.3	4.55		1.53	3.13	

Table 7.12 2004 Morley

Fungicide Treatment / Timings			N Blo	Rhync	GLA	Yield	Yield	SPW	TGW	Margin
T1	**T2**	**T3**	**% L2**	**% L2**	**% L2**	**(t/ha)**	**(%)**	**(kg/hl)**	**(g)**	**(£/ha)**
GS30 Ac + O/C	GS39 Az + O/C	-	3.4	0.9	26.5	8.35	124	66.2	47.4	440
GS30 Ac + Unx	GS39 Az + Unx	-	2.1	0.9	24.0	8.25	122	67.3	47.5	434
GS30 +7 Ac + O/C	GS39 Az + O/C	-	3.3	1.1	47.3	8.19	121	66.8	47.7	430
GS30 +7 Ac + Unx	GS39 Az + Unx	-	2.8	0.4	35.0	8.33	123	66.5	49.5	439
GS30 +14 Ac + O/C	GS39 Az + O/C	-	3.3	1.5	38.0	7.67	114	65.8	49.2	399
GS30 +14 Ac + Unx	GS39 Az + Unx	-	2.9	0.8	36.8	8.19	121	66.3	47.6	430
GS30 Ac + O/C	GS49 Az + O/C	-	4.4	1.8	40.0	8.03	119	67.6	49.6	421
GS30 Ac + Unx	GS49 Az + Unx	-	2.8	1.5	45.5	8.51	126	67.2	50.3	450
GS30 +7 Ac + O/C	GS49 Az + O/C	-	2.8	0.8	34.3	8.42	125	66.9	47.3	444
GS30 +7 Ac + Unx	GS49 Az + Unx	-	2.8	0.7	51.8	8.18	121	67.6	50.7	430
GS30 +14 Ac + O/C	GS49 Az + O/C	-	3.0	1.0	35.5	8.07	120	67.1	48.4	423
GS30 +14 Ac + Unx	GS49 Az + Unx	-	3.1	0.9	38.8	8.54	127	68.0	51.4	451
GS30 Ac + O/C	GS59 Az + O/C	-	3.3	1.3	31.8	8.05	119	66.1	46.4	422
GS30 +7 Ac + O/C	GS59 Az + O/C	-	3.3	0.6	38.0	8.07	120	67.2	49.8	423
GS30 +14 Ac + O/C	GS59 Az + O/C	-	3.9	0.6	42.5	8.05	119	67.5	51.1	422
GS30 +7 Ac + O/C	-	-	6.1	1.4	16.8	7.79	115	65.6	47.2	436
GS30 +7 Ac + Unx	-	-	7.6	2.9	9.0	7.48	111	65.6	46.6	417
-	GS49 Ac + O/C	-	3.9	2.1	24.3	7.47	111	66.0	47.3	417
-	GS49 Ac + Unx	-	5.5	3.9	43.5	7.90	117	67.1	49.3	443
GS30 Ac + O/C	GS39 Az + O/C	GS59 Az + O	2.6	1.1	38.0	8.20	121	65.6	48.6	413
GS30 Ac + O/C	GS39 Az + O/C	GS59 O	2.6	0.7	30.5	8.30	123	67.1	47.1	419
untreated	-	-	17.0	7.5	2.8	6.75	100	65.4	43.4	405
LSD (P = 0.05)			1.74	1.65	20.5	0.46	6.8	1.85	4.78	
Prob.			0.0001	0.0001	0.0010	0.0001		NS	NS	
CV			29.4	75.1	43.7	3.44		1.68	7.00	

7.4 Appendix D: Site Details and Overall Inputs

Table 7.13 Hampshire 2002

Location:	Andover, Hampshire		
Soil Type:	Andover series		
Soil Analysis (ppm):	P-28, K-163, Mg-83, Mn-592, S-11, pH-6.9		
Drill Date:	21/09/01		
Harvest Date:	22/07/02		
Previous Crop:	Spring Barley		
Variety:	Sumo		
Seed Rate:	350 seeds/m^2		
Plant Population:	337 plants/m^2		
	Product	**Rate**	**Date**
Fertiliser:	Double Top	50 kg N/ha 22 kg S/ha	07/03/02
	34.5%N AN	125 kg N/ha	15/04/02
Growth Regulators:	5C Cycocel	1.25 l/ha	25/03/02
	Terpal	0.5 l/ha	24/04/02
Herbicides:	Javelin Gold	2.5 l/ha	29/10/01
	IPU	0.5 l/ha	29/10/01
	Grasp	1.4 l/ha	19/04/02
	Starane 2	0.5 l/ha	23/04/02
	HBN	1.0 l/ha	23/04/02
Insecticide:	Hallmark Zeon	50 ml/ha	29/10/01
Adjuvant:	Agral	50 ml/ha	24/04/02

Table 7.14 Lincolnshire 2002

Location:	Caythorpe, Lincolnshire		
Soil Type:	Elmton series		
Soil Analysis (ppm)	P-37, K-220, Mg-55, Mn-326, S-9, pH-7.9, OM-4.1%		
Drill Date:	27/09/01		
Harvest Date:	15/07/02		
Previous Crop:	Spring Barley		
Variety:	Carat		
Seed Rate:	350 seeds/m^2		
Plant Population:	192 plants/m^2		
	Product	**Rate**	**Date**
Fertiliser:	34.5% N	50 kg/ha N	04/03/02
	34.5% N	110 kg/ha N	09/04/02
Growth Regulators:	Tricol	2.0 l/ha	23/03/02
	Terpal	1.0 l/ha	24/04/02
Herbicides:	Panther	2.0 l/ha	17/10/01
	Starane	1.0 l/ha	25/04/02
Insecticide:	Cypermethrin	0.25 l/ha	17/10/01
Adjuvant:	Citowett	0.08 l/ha	24/04/02

Table 7.15 Gloucestershire 2002

Location:	Cirencester, Gloucestershire		
Soil Type:	Elmton series		
Soil Analysis (ppm):	P-23, K-243, Mg-158, S-31, pH-7.5, OM-4.3%		
Previous Crop:	Winter Oilseed Rape		
Drill Date:	25/09/01		
Harvest Date:	22/07/02		
Variety:	Siberia		
Seed Rate:	350 seeds/m^2		
	Product	**Rate**	**Date**
Fertiliser:	Double Top	50 kg N/ha + 22 kg S/ha	05/03/02
	Nitraprill	150 kg N/ha	18/04/02
Herbicides:	Tolkan Turbo	5.0 l/ha	22/10/01
	Avenge 2	5.0 l/ha	03/04/02
	Starane 2	0.5 l/ha	03/04/02
Insecticide:	Toppel 10	0.25 l/ha	01/11/01
Growth Regulators:	New 5C Cycocel	1.75 l/ha	12/03/02
	Terpal	1.0 l/ha	23/04/02
Adjuvant:	Enhance	0.08 l/ha	23/04/02

Table 7.16 Norfolk 2002

Location:	Morley, Norfolk
Soil Type:	Ashley series
Soil Analysis (Index):	P-3, K-2-, Mg-1, pH-7.8
Previous Crop:	Spring Barley
Drill Date:	27/09/01
Harvest Date:	28/07/02
Variety:	Pearl
Seed Rate:	400 seeds/m^2
Plant Population:	209 plants/m^2

	Product	**Rate**	**Date**
Herbicides:	Stomp 400SC	1.75 l/ha	13/10/01
	IPU 500	1.0 l/ha	13/10/01
	Avadex Excel	15 kg/ha	02/11/01
Fertiliser:	Double Top	48 kg N/ha 22 kg S/ha	05/03/02
	34.5%N Ammonium Nitrate	104 kg N/ha	02/04/02
Insecticide:	Hallmark Zeon	50 ml/ha	10/10/01
Growth Regulators:	Chlormequat 700	2.25 l/ha	22/03/02
	Terpal	1.0 l/ha	01/05/02
Trace Elements:	Manganese sulphate	4 kg/ha	01/03/02
Adjuvant:	Non-ionic wetter	60 ml/ha	01/05/02

Table 7.17 Hampshire 2003

Location:	Andover, Hampshire		
Soil Type:	Andover series		
Soil Analysis (ppm):	P-28, K-213, Mg-65, Mn-416, S-4, pH-8.1		
Drill Date:	27/09/02		
Harvest Date:	21/07/03		
Previous Crop:	Spring Barley		
Variety:	Sumo		
Seed Rate:	350 seeds/m^2		
Plant Population:	195 plants/m^2 (based on site average establishment)		
	Product	**Rate**	**Date**
Fertiliser:	Double Top	50 kg N/ha 22 kg S/ha	07/03/03
	34.5%N AN	125 kg N/ha	14/04/03
	00:21:32	250 kg/ha	26/02/03
Growth Regulators:	5C Cycocel	1.25 l/ha	03/04/03
	Terpal	1.0 l/ha	01/05/03
Herbicides:	Javelin Gold	2.5 l/ha	19/11/02
	IPU	0.5 l/ha	19/11/02
	Ally	20 g/ha	21/03/03
	CMPP	1.5 l/ha	21/03/03
Insecticide:	Hallmark Zeon	50 ml/ha	06/12/02
Adjuvant:	Agral	80 ml/ha	01/05/03

Table 7.18 Lincolnshire 2003

Location:	Caythorpe, Lincolnshire		
Soil Type:	Elmton series		
Soil Analysis (ppm):	P-40, K-242, Mg-112, Mn-233, S-6, pH-8.0, OM-3.7%		
Previous Crop:	Spring Barley		
Drill Date:	17/09/02		
Harvest Date:	11/07/03		
Variety:	Carat		
Seed Rate:	350 seeds/m^2		
Plant Population:	232 plants/m^2		
	Product	**Rate**	**Date**
Fertiliser:	34.5%N	50 kg N/ha	27/02/03
	34.5%N	50 kg N/ha	04/03/03
	34.5%N	70 kg N/ha	11/04/03
Growth Regulators:	Tricol	2.0 l/ha	31/03/03
	Terpal	0.75 l/ha	24/04/03
Herbicide:	Javelin	2.0 l/ha	12/12/02
Insecticide:	Cypermethrin	0.25 l/ha	12/12/02

Table 7.19 Gloucestershire 2003

Location:	Cirencester, Gloucestershire		
Soil Type:	Elmton series		
Soil Analysis (ppm):	P-15, K-320, Mg-97, Mn-641, S-5, pH-7.8, OM-6.3%		
Previous Crop:	Winter Oilseed Rape		
Drill Date:	24/09/03		
Harvest Date:	24/07/03		
Variety:	Siberia		
Seed Rate:	350 seeds/m^2		
Plant Population:	259 plants/m^2 (based on site average establishment)		
	Product	**Rate**	**Date**
Fertilisers:	Double Top	50 kg N/ha + 22 kg S/ha	06/03/03
	Nitraprill	150 kg N/ha	17/04/03
Herbicides:	Ice	3.0 l/ha	28/09/02
	Grasp	1.4 l/ha	17/03/03
	Arelon 500	2.0 l/ha	17/03/03
Insecticide:	Toppel 10	0.25 l/ha	17/03/03
Growth Regulators:	New 5C Cycocel	1.25 l/ha	08/04/03
Adjuvants:	Output	0.75 l/ha	17/03/03
	Enhance	0.05 l/ha	08/04/03

Table 7.20 Norfolk 2003

Location:	Morley, Norfolk
Soil Type:	Ashley series
Soil Analysis (Index):	P-1+, K-2-, Mg-2-, pH-7.2
Previous Crop:	Set-aside
Drill Date:	20/09/02
Harvest Date:	24/07/03
Variety:	Pearl
Seed Rate:	400 seeds/m^2
Plant Population:	205 plants/m^2

	Product	**Rate**	**Date**
Herbicides:	Stomp 400SC	2.5 l/ha	30/11/02
	IPU 500	1.5 l/ha	30/11/02
	Tigress Ultra	1.75 l/ha	07/04/03
	Ally	20 g/ha	22/04/03
	Starane 2	1.0 l/ha	22/04/03
Fertiliser:	Double Top	47 kg N/ha 21 kg S/ha	13/03/03
	34.5%N Ammonium Nitrate	51 kg N/ha	28/03/03
	34.5%N Ammonium Nitrate	51 kg N/ha	17/04/03
Insecticide:	Toppel 10	0.25 l/ha	30/11/02
Growth Regulators:	Mirquat	2.2 l/ha	13/03/03
	Terpal	0.75 l/ha	30/04/03
Trace Elements:	Manganese sulphate	2 kg/ha	13/03/03
Adjuvant:	Non-ionic wetter	0.01 l/ha	30/04/03

Table 7.21 Hampshire 2004

Location:	Andover, Hampshire		
Soil Type:	Andover series 1		
Soil Analysis (ppm):	P-27, K-156, Mg-48, Mn-577, S-6, pH-8.0, OM-5.5%		
Previous Crop:	Spring Barley		
Drill Date:	25/09/03		
Harvest Date:	22/07/04		
Variety:	Sumo		
Seed Rate:	350 seeds/m^2		
Plant Population:	208 plants/m^2		
	Product	**Rate**	**Date**
Herbicides:	Panther	1.0 l/ha	27/10/03
	IPU	2.0 l/ha	27/10/03
	Grasp	1.4 l/ha	08/04/04
Fertiliser:	Double Top	50 kg N/ha 22 kg S/ha	02/03/04
	AN 34.5%	125 kg N/ha	14/04/04
Insecticide:	Hallmark Zeon	0.05 l/ha	27/10/03
PGRs:	5C Cycocel	1.75 l/ha	31/03/04
	Terpal	1.0 l/ha	02/05/04
Adjuvant:	Output	0.75 l/ha	08/04/04

Table 7.22 Lincolnshire 2004

Location:	Caythorpe, Lincolnshire		
Trial Code:	WB04-026CA		
Soil Type:	Elmton 1 series		
Soil Analysis:	P-46, K-283, Mg-123, Mn-291, S-8, pH-8, OM-3.5%		
Previous Crop:	Spring Barley		
Drill Date:	18/09/03		
Harvest Date:	20/07/04		
Variety:	Carat		
Seed Rate:	350 seeds/m^2		
Plant Population:	168 plants/m^2		
	Product	**Rate**	**Date**
Herbicides:	Javelin	2.0 l/ha	04/12/03
	IPU	0.5 l/ha	04/12/03
Fertiliser:	AN 34.5% N	50 kg N/ha	08/03/04
	AN 34.5% N	110 kg N/ha	15/04/04
Insecticide:	Cypermethrin	250 ml/ha	04/12/03
Growth Regulators:	5C Chlormequat	2.0 l/ha	13/04/04
	Terpal	1.0 l/ha	26/04/04
Adjuvant:	Enhance	80 ml/ha	26/04/04

Table 7.23 Gloucestershire 2004

Soil Type:	Elmton series		
Soil Analysis (ppm):	P-23, K-285, Mg-85, S-7, pH-7.8		
Previous Crop:	Winter Wheat		
Drill Date:	25/09/03		
Harvest Date:	26/07/04		
Variety:	Siberia		
Seed Rate:	350 seeds/m^2		
Plant Population:	256 plants/m^2 (based on site average establishment)		
	Product	**Rate**	**Date**
Herbicides:	Ice	3.0 l/ha	29/09/03
	Arelon	3.0 l/ha	06/11/03
	Stomp	3.0 l/ha	06/11/03
Fertiliser:	Sulphur Gold	50 kg N/ha N + 12.6 kg S/ha	05/03/04
	34.5% AN	150 kg N/ha	13/04/04
Growth Regulators:	New 5C Cycocel	1.25 l/ha	08/04/04
	Terpal	0.75 l/ha	26/04/04
Insecticide:	Toppel 10	0.25 l/ha	06/11/03

Table 7.24 Norfolk 2004

Location:	Morley, Norfolk		
Soil Type:	Ashley series		
Soil Analysis:	P-, K-, Mg-, Mn-, S-, pH-, OM-%,		
Previous Crop:	Spring Barley		
Drill Date:	26/09/03		
Harvest Date:	29/07/04		
Variety:	Pearl		
Seed Rate:	400 seeds/m^2		
Plant Population:	223 plants/m^2		
	Product	**Rate**	**Date**
Herbicides:	Stomp	1.5 l/ha	28/10/03
	IPU 500	0.75 l/ha	28/10/03
	Panther	0.25 l/ha	28/10/03
	Avadex Excel	15 kg/ha	27/11/03
Fertiliser:	Phosphorus	60 kg P/ha	25/09/03
	Potassium	60 kg K/ha	25/09/03
	Nitrogen	70 kg N/ha	11/03/04
	Nitrogen	80 kg N/ha	28/03/04
Insecticide:	Cyperkill 10	0.25 l/ha	28/10/04
Growth Regulators:	Mirquat	2.0 l/ha	01/04/04
	Terpal	1.0 l/ha	01/05/04
Trace Elements:	Sedema Mn sulphate	2 kg/ha	01/04/04
Adjuvant:	Non-ionic wetter	60 ml/ha	01/05/04

7.5 Appendix E: Monthly Rainfall Data

Figure 7.1 Monthly rainfall (mm) for Andover, Hampshire (2001/02 season)

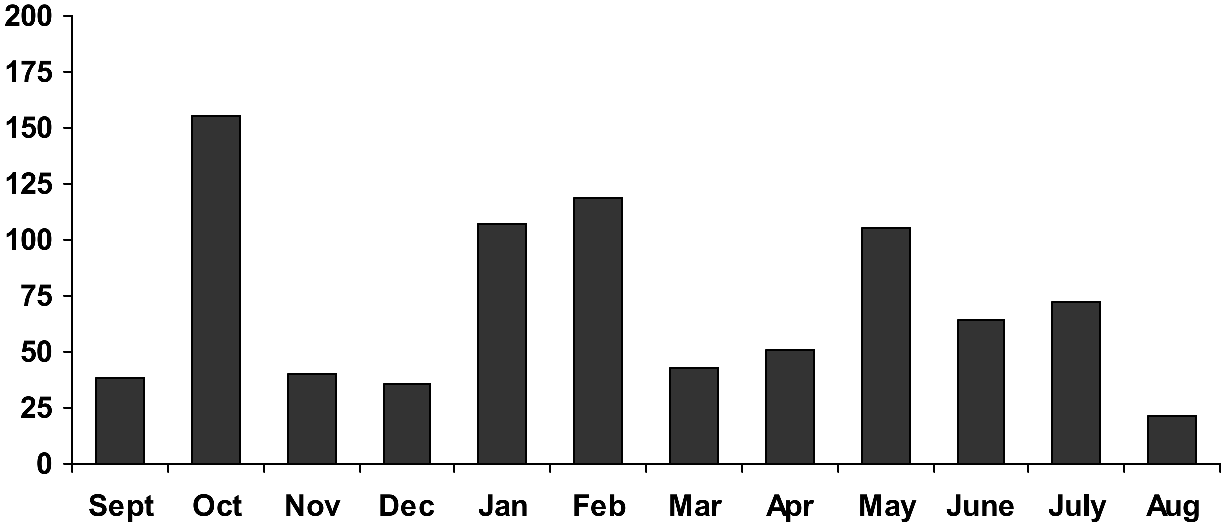

Figure 7.2 Monthly rainfall (mm) for Andover, Hampshire (2002/03 season)

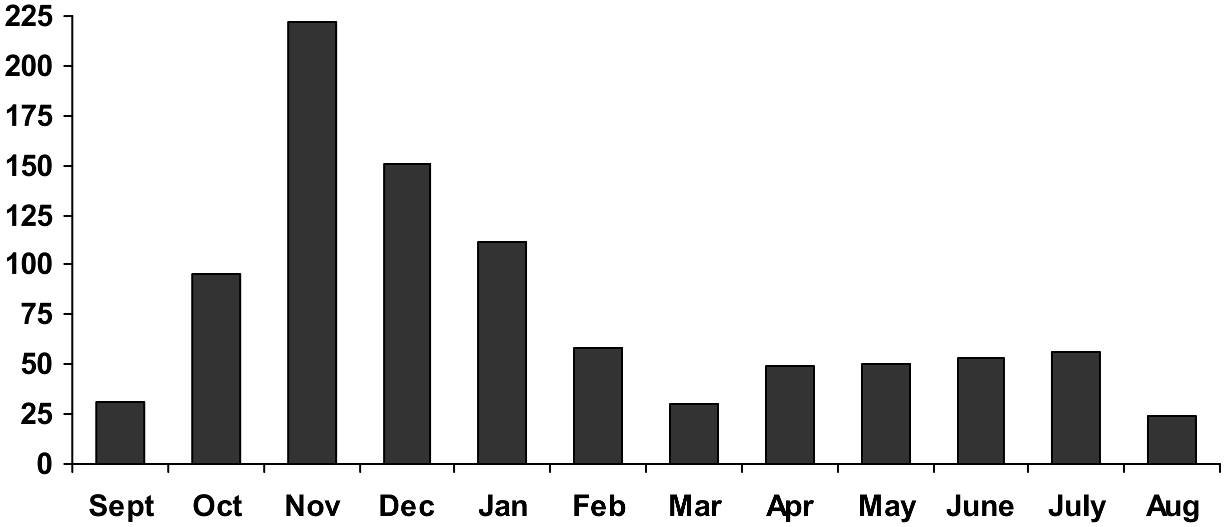

Figure 7.3 Monthly rainfall (mm) for Andover, Hampshire (2003/04 season)

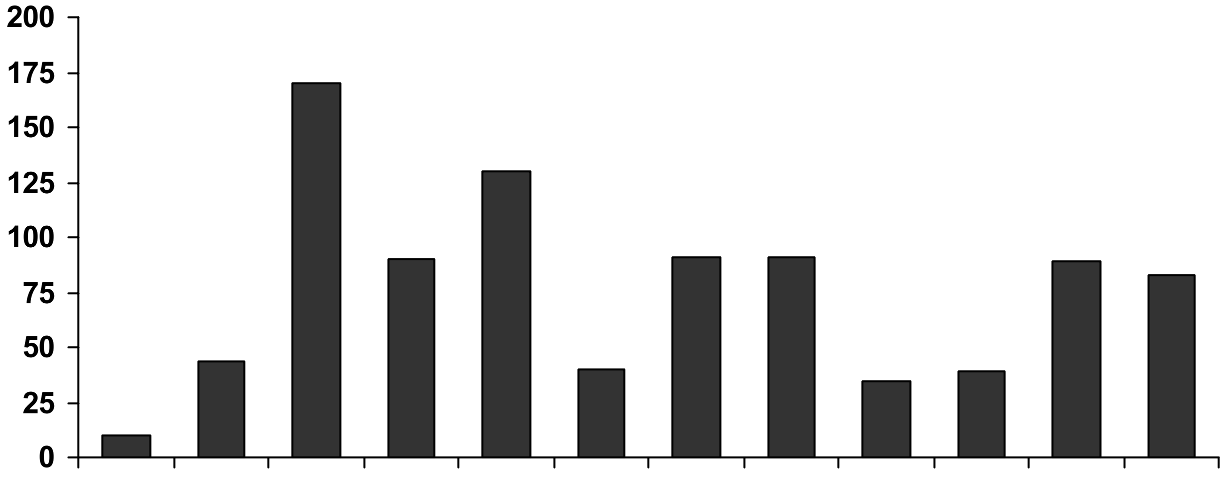

Figure 7.4 Monthly rainfall (mm) for Caythorpe, Lincolnshire (2001/02 season)

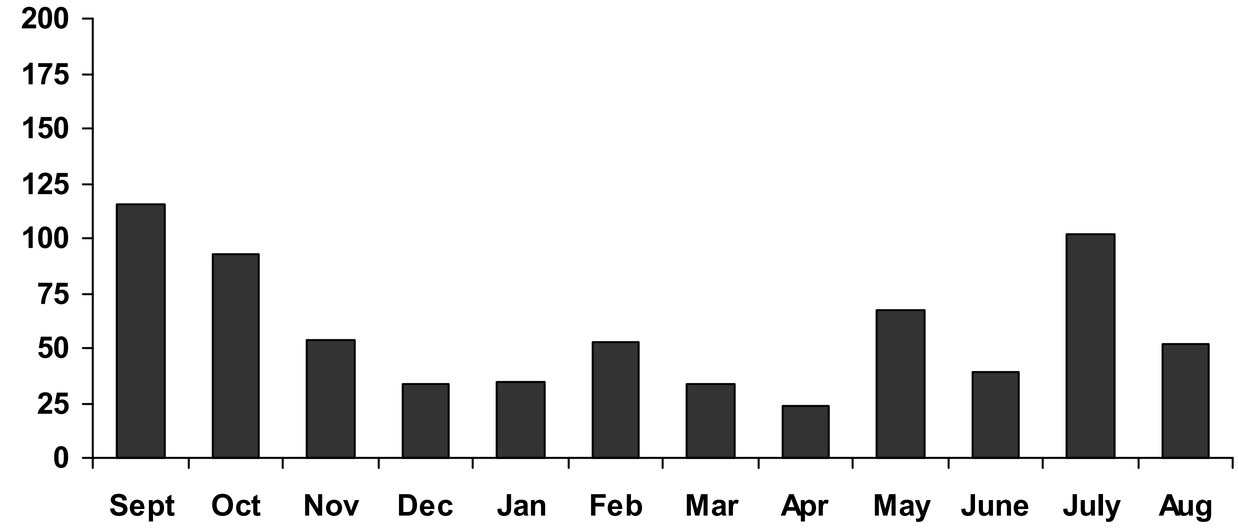

Figure 7.5 Monthly rainfall (mm) for Caythorpe, Lincolnshire (2002/03 season)

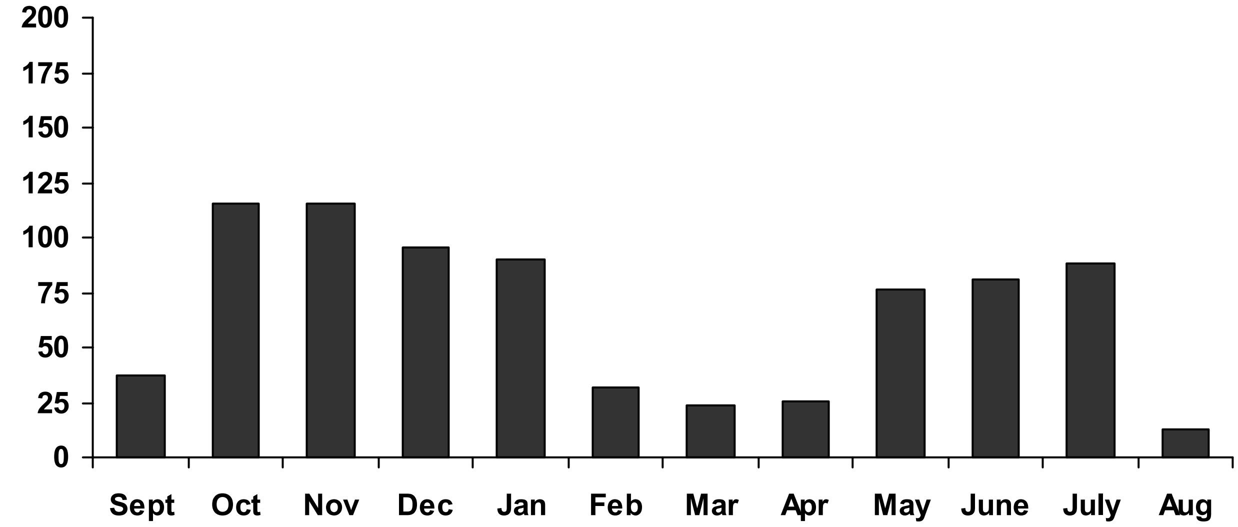

Figure 7.6 Monthly rainfall (mm) for Caythorpe, Lincolnshire (2003/04 season)

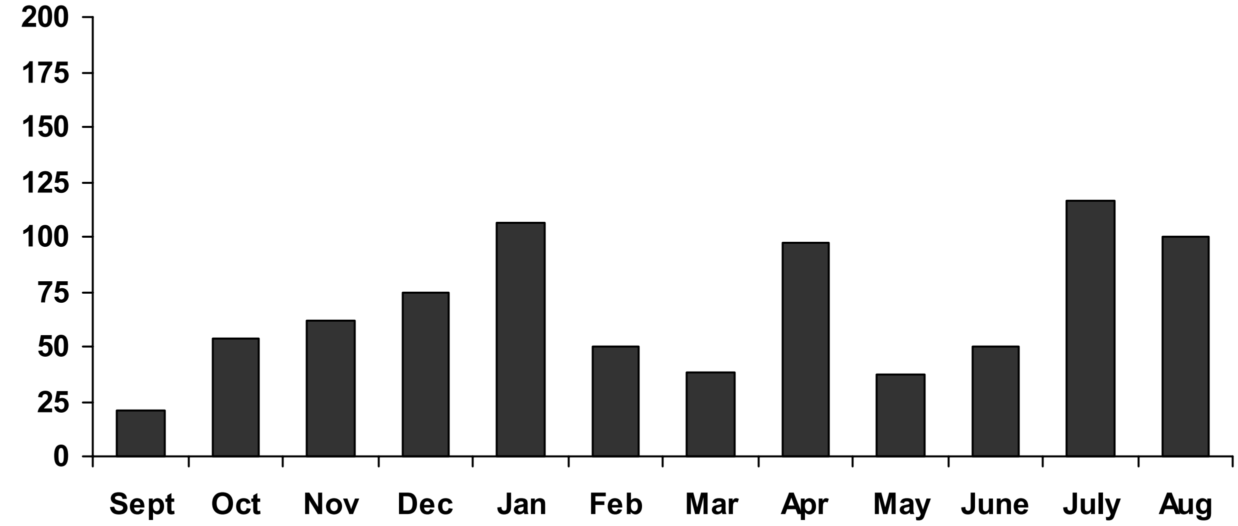

Figure 7.7 Monthly (mm) rainfall for Cirencester, Gloucestershire (2001/02 season)

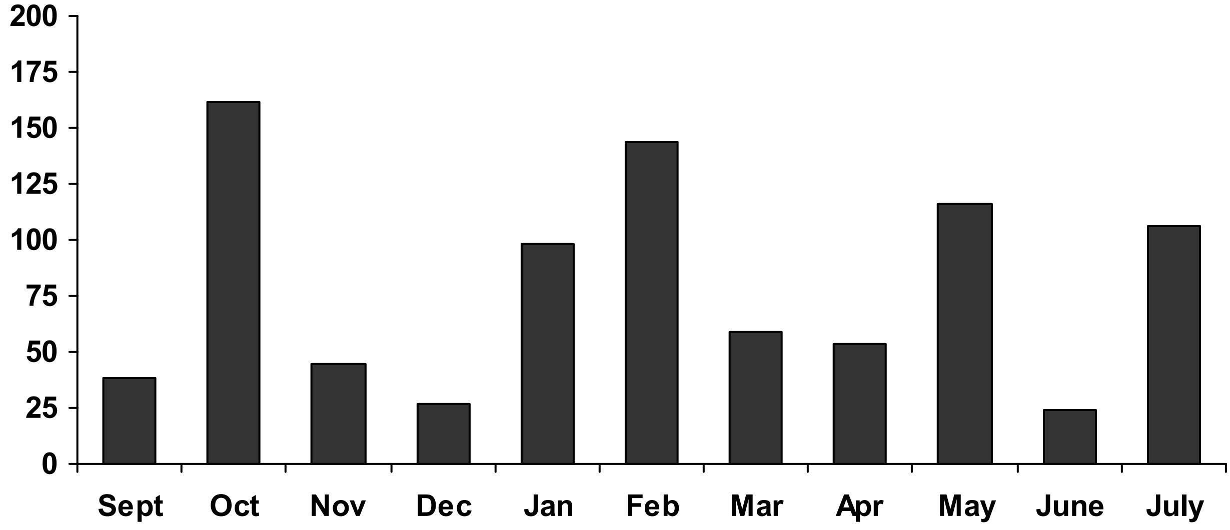

Figure 7.8 Monthly rainfall (mm) for Cirencester, Gloucestershire (2002/03 season)

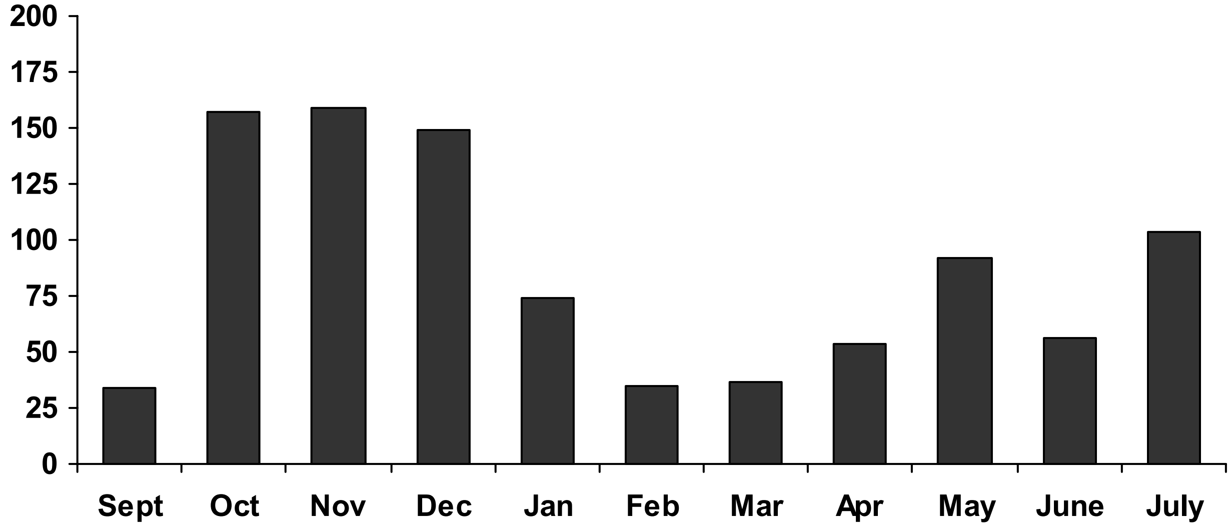

Figure 7.9 Monthly rainfall (mm) for Cirencester, Gloucestershire (2003/04 season)

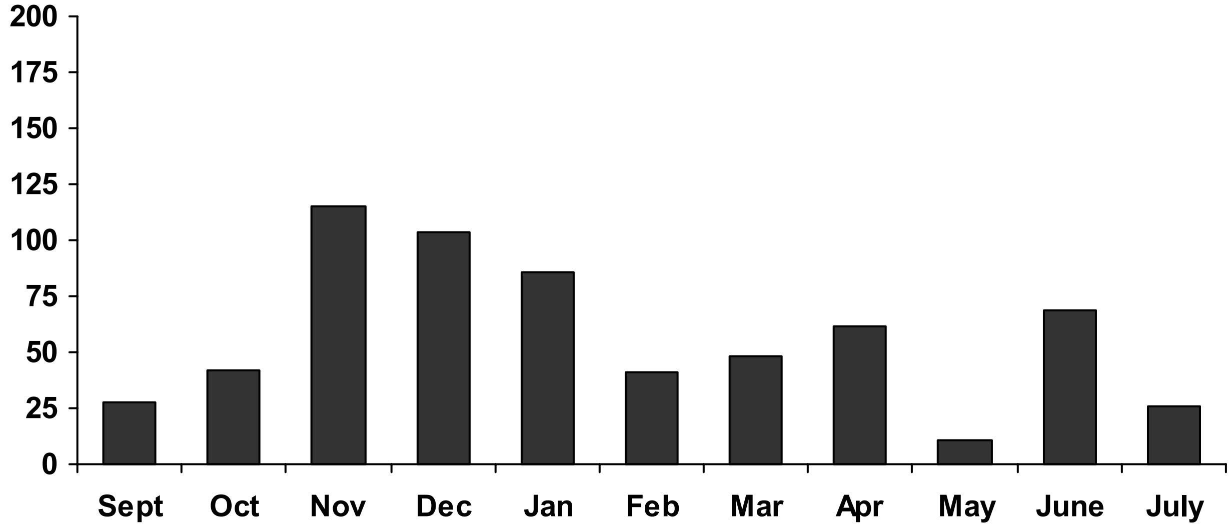

Figure 7.10 Monthly rainfall (mm) for Morley, Norfolk (2001/02 season)

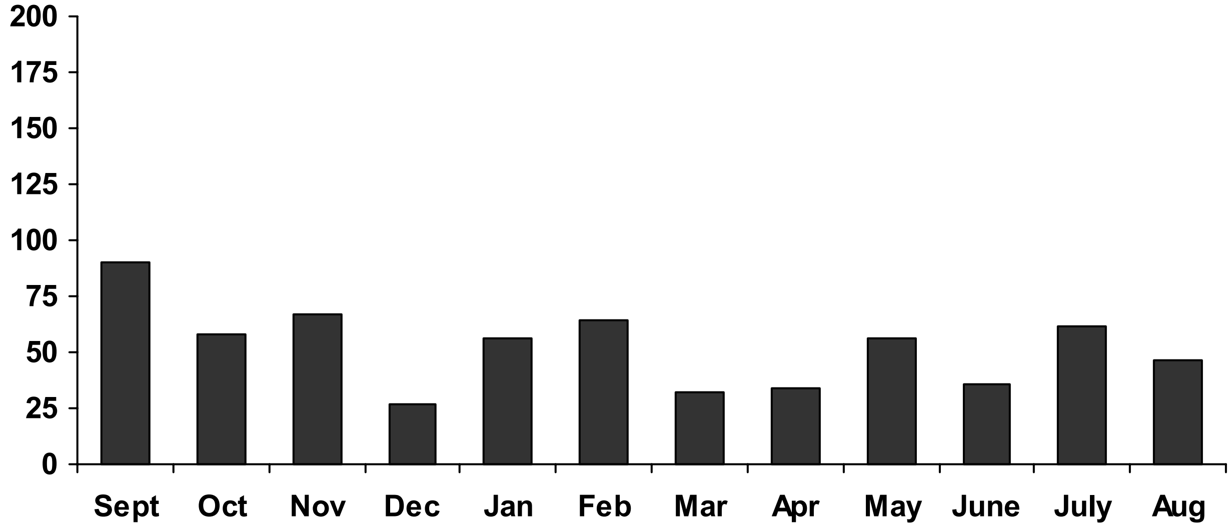

Figure 7.11 Monthly rainfall (mm) for Morley, Norfolk (2002/03 season)

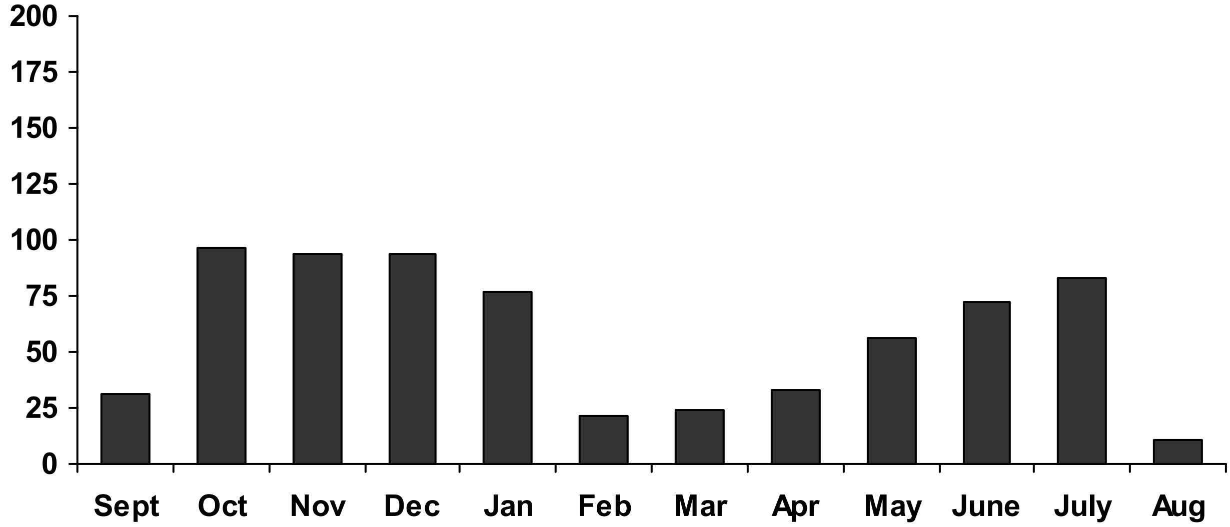

Figure 7.12 Monthly rainfall (mm) for Morley, Norfolk (2003/04 season)