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Optimising the performance and benefits of take-all control chemicals

by

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PART 1: ABSTRACT

Optimising the performance and benefits of take-all control chemicals

Sequences and alternations of seed treatments (Jockey Flexi, based on fluquinconazole, and Latitude, based on silthiofam) were tested in field experiments in wheat or barley crops grown successively as second and third cereals (and in one case a fourth wheat) in eastern England. A spray treatment (Amistar, based on azoxystrobin) at growth stage 31 was tested in successive years, with or without seed treatment.

Seed treatment with Jockey or Latitude almost always decreased take-all and increased grain yield when applied to either second or third wheat crops. Yield increases, i.e. the differences between yields of treated and non-treated crops, were less at the Norfolk sites (where yield increase with Latitude was up to 0.42 t/ha in 2nd wheats and 0.54 t/ha in 3rd wheats) than at the Hertfordshire sites (up to 1.37 t/ha in 2nd wheats and 2.38 t/ha in 3rd wheats). Latitude decreased the amount of early take-all on roots, assessed in spring, more than did Jockey. Jockey usually controlled the development of severe take-all in the summer more effectively than did Latitude. Despite this, Latitude often increased yield more than did Jockey, although their relative effects were variable.

Each seed treatment applied to a second wheat crop delayed the development of the year-to-year epidemic, which affected the response to seed treatment in subsequent crops. A non-treated third wheat crop grown after a treated second wheat crop usually showed little or no benefit from treatment in the previous year (compared with no treatment in either crop), whilst non-treatment of a fourth wheat crop grown after one or two previous treated crops was detrimental, because the crop did not benefit from the take-all decline that developed in the fourth wheat in the absence of treatment. A treated third wheat crop grown after a treated second wheat crop often benefited from the treatment unless take-all was already becoming severe in the second wheat. The best yields in third wheat crops were obtained by treating the third crop with Latitude and the second crop with Jockey or Latitude, but were usually less than would be expected in the absence of take-all.

Amistar sometimes decreased take-all severity and increased grain yield in wheat but was very inconsistent. Information on the factors that influence its efficacy is required. Amistar sometimes added to the effects of seed treatment, especially Latitude.

Take-all development was usually slight in barley crops with little effect on yield. It was usually decreased by seed treatment but Amistar sprays were inconsistent. Severe take-all is known to increase grain nitrogen concentration (because it decreases starch content) but, in the absence of severe disease, we found no evidence that take-all fungicides can help to regulate grain nitrogen concentration.

PART 2: SUMMARY

Optimising the performance and benefits of take-all control chemicals

Objectives

Cost-effective take-all control could be vital to the economic health of large areas of arable production in the UK, where "second-wheat syndrome", a consequence mainly of take-all epidemics developing more quickly than previously, has put further constraints on rotational options. The aim of this research was to optimise the use of an array of chemical treatments available for controlling take-all, allowing each of them to be used appropriately, and sparingly, to ensure maximum cost-effectiveness, and minimum environmental effect and risk of selecting for fungicide resistance in the take-all fungus. Considerable benefits from treatment may be expected on the light soils in East Anglia, an area particularly important for malting barley, in which take-all may contribute to excessive grain nitrogen concentrations. Integrating the available control measures for take-all may increase yield and consistency of production, and enhance the quality of both winter wheat and winter malting barley. The specific objectives were:

1. To test the extent to which yields can be maintained in two-three successive wheat crops by integrating treatments applied to control take-all.
2. To test whether fungicides used to control take-all can improve the economics of growing malting barley in cereal sequences.

Methods

Sequences and alternations of seed treatments based on fluquinconazole (Jockey) or silthiofam (Latitude), with or without a foliar spray of the strobilurin fungicide azoxystrobin (Amistar), were tested in winter wheat cv. Claire or winter barley cv. Pearl, grown successively as second and third cereals, in field experiments on different soil types at Rothamsted Research (Hertfordshire and Bedfordshire) and TAG East (Norfolk). One wheat experiment in Hertfordshire, in which foliar sprays were not tested, was extended to a fourth cereal crop. Effects of treatments on take-all in spring and summer and on grain yield and quality were determined in seven experiments on wheat and five experiments on barley.

Results and Discussion

Fungicides in winter wheat

In winter wheat grown as a second cereal, take-all on roots of non-treated crops ranged from moderate (five experiments) to severe (two experiments) when assessed on samples taken in summer, during grain filling. In wheat grown as a third cereal, take-all in non-treated crops

remained moderate in experiments in Norfolk (soil: sandy loam over chalky boulder clay), and increased further, sometimes to very severe, with small yields, in experiments in Hertfordshire (soil: silty clay loam with flints). True take-all decline was apparent only in the fourth wheat crop.

The incidence of take-all on roots in spring was usually decreased by each seed treatment, but more by Latitude than by Jockey. The incidence of severe take-all in summer, on the other hand, was often decreased more by Jockey than by Latitude, indicating that Latitude provided greater protection in the early stages of growth whilst Jockey had more persistent effects, more effectively limiting the development of severe disease. Despite this, Latitude usually gave greater yield benefits than did Jockey. Whilst one-off treatments with Latitude gave yield increases of up to 1.31 t/ha in second wheats and up to 2.38 t/ha in third wheats, Jockey gave yield increases, in the same experiments, of 1.25 t/ha in the second wheats and 1.17 t/ha in the third wheats, compared with crops that were non-treated throughout. The relative performances of Jockey and Latitude differed between experiments, however. The apparent role of early take-all in determining yield suggests important effects on numbers of ears (tillers) or spikelets, which are determined relatively early in growth. This is consistent with the small effects of treatments on hectolitre and thousand-grain weights but more detailed information on yield components is needed.

Jockey and Latitude both affected development of the year-to-year epidemic. Take-all usually increased in a non-treated third wheat crop following a treated (Jockey or Latitude) second wheat crop because the epidemic continued to develop without the restraint of a fungicide. The amount of take-all was usually slightly less than, or similar to, that in a third wheat in a parallel non-treated sequence, and grain yields were usually greater or similar. A non-treated fourth wheat grown after treated crops had more take-all and smaller yield than in the equivalent fourth wheat in a non-treated sequence, since the latter crop was benefiting from take-all decline. This is consistent with earlier results from longer sequences of wheat crops (HGCA Project Report No. 309). Differences between experiments show how yield responses from treatments applied at different times within 2- and 3-year sequences are influenced by the rate of epidemic development.

Treatment of successive second and third wheat crops usually resulted in take-all in the treated third wheat being similar to or less than that in a third wheat in a non-treated sequence, with corresponding effects on yield. Overall yield increases in third wheat crops, relative to yields in comparable non-treated sequences, were usually greatest where successive second and third wheats had been treated. The most effective succession was Latitude after Latitude or, in one case, after Jockey, but Jockey after Latitude tended to give greater yield benefit in the most severe situations. Jockey following Jockey was the sequence that usually gave least yield benefit. In contrast, repeat treatment applied to a fourth wheat resulted in more take-all and less yield than in the non-treated sequence. It was found previously, in longer sequences, that Jockey was poor as a repeat treatment (i.e. Jockey after Jockey), when it often had a negative effect on yield greater than could be accounted for by its effects on take-all (HGCA Project Report No. 309). Sequences of non-treated crops (as used for comparison in our experiments) eventually benefit from the development of take-all decline, although, among the experiments reported here, this was evident only in the fourth wheat crop. The apparently greater effectiveness of Latitude as a repeat treatment in a third wheat may be because it is exerting its effect early on in a low-disease situation created by the previous treatment, whilst the inoculum is still depleted and before there has been any resurgence in disease.

Previous research led to the conclusion that Jockey could be of economic benefit if applied to a second or subsequent wheat at risk from take-all (HGCA Project Report No. 309), but that other measures to minimise take-all (e.g. maintaining adequate plant nutrition and good soil conditions, avoiding volunteers and grass weeds in previous break crops, avoiding very early drilling even of first wheats) are still necessary if acceptable yields are to be obtained. Treatment with Jockey did, however, often increase the risk to a following wheat, treated or non-treated. We have now demonstrated that, whilst it is still relatively risky to grow a third wheat, because it will often give only small yields, the risk can be lessened by growing a Latitude-treated third wheat after a Jockey-treated second wheat with only moderate take-all, whilst Latitude after Latitude tended to have greater overall benefit. Since yields of crops with take-all, whether treated or not, will usually be well below the potential of a healthy first wheat, the management of, and expected margins from, the whole sequence of crops, including successive wheat crops, need to be considered when planning rotations.

The effects of Amistar were inconsistent, despite previous evidence that it can sometimes have effects comparable with those of seed treatments. It was ineffective in 2003 but was more generally effective in 2004 and 2005. In the last year, its application was usually made during breaks in rainy weather. It may be most effective when applied to wet soil, which might encourage its movement in the root zone. This is being investigated further. The main effect of Amistar in wheat was to decrease the incidence of severe take-all. Decreased take-all sometimes occurred only where a seed treatment, usually Latitude, had also been applied, indicating an interaction, which also often resulted in a yield benefit.

Fungicides in winter barley

In barley, take-all development was often slow and insufficient for a realistic test of treatments. Jockey and Latitude sometimes decreased take-all, Latitude increasing yield on one occasion. The inconsistency of Amistar was further demonstrated in these experiments. It decreased take-all in one experiment and increased yield in another, but in the absence of take-all. There was no evidence that seed or spray treatments could be useful in moderating the excessive N concentrations in grain that can occur in crops suffering from take-all.

Conclusions

Objective 1: to test the extent to which yields can be maintained in two-three successive wheat crops by integrating treatments applied to control take-all

1. Seed treatment formulations based on fluquinconazole (Jockey) or silthiofam (Latitude) almost always decreased take-all and increased yields when applied to either second or third wheat crops in eastern England, but yield increases were less in Norfolk than in Hertfordshire.
2. Latitude decreased take-all during the spring more than did Jockey, through effective control of early disease.
3. Jockey usually controlled the development of severe take-all in the summer more effectively than did Latitude.
4. Latitude often increased yield more than did Jockey, but relative effects were variable.
5. A non-treated third wheat crop grown after a treated second wheat crop often benefited from treatment of the second wheat, unless take-all was already becoming severe in the second wheat; non-treatment of a fourth wheat crop grown after previous treated crops was detrimental, since the crop did not benefit from the take-all decline that developed in the absence of treatment.
6. The best yields in third wheat crops were obtained by treating the third crop with Latitude and the second crop with Jockey or Latitude, but were usually well below the yield expected from a healthy crop.
7. Amistar tended to decrease take-all severity more than incidence, and increase grain yield, but the effects were inconsistent and information on the conditions that are necessary for it to be effective is required.
8. Amistar can sometimes add to the effects of Latitude.

Objective 2: to test whether fungicides used to control take-all can improve the economics of growing barley in cereal sequences

1. Seed treatment with Jockey or Latitude, or spray treatment with Amistar, can decrease take-all in barley.

2. In the absence of severe take-all, fungicides rarely affected grain yield or quality and no evidence was found that fungicides could be helpful in regulating grain nitrogen concentration in crops affected by take-all.

Recommendations

Fungicides that limit the amounts and effects of take-all in winter wheat should be used in combination with other measures to minimise take-all. These include avoiding cereal volunteers and grass weeds, especially couch, but also bromes and black-grass, in preceding break crops, maintaining the soil in good condition, avoiding cultivars known to perform poorly as second wheats, and delaying drilling (even of the first wheat) as much as is practically and economically possible. It is also important to use previous experience to judge whether or not the field is prone to severe take-all and what yields might usually be expected from second and subsequent wheat crops grown in that field.

Second wheats known (mainly from the field's previous history) to be at risk from take-all will usually give an economic return from seed treatments based on fluquinconazole (such as Jockey) or silthiofam (Latitude). The yield benefit (up to 1.3 t/ha in these experiments) may be particularly good if take-all development was potentially rapid and would have become severe. Late, but rapid, developing take-all may be controlled more by Jockey, but prediction of this is not possible. Similarly, seed treatment will usually be effective in a third wheat crop grown after a non-treated second wheat crop in which take-all had not become severe.

Where take-all has become severe in a second wheat, or where a second wheat yielded greatly below its potential because of take-all, even with seed treatment, a third wheat crop should not be grown. It may be replaced, however, by a barley crop, which may benefit from seed treatment. Where seed treatment, or other measures, result in only slight take-all in a second wheat, with acceptable yields, a third wheat may be considered, but should be treated with Latitude.

Amistar applied at T1 (leaf 3 emerged) may give some protection from late-developing take-all, particularly if applied to Latitude-treated crops. It is possible that it will be most effective when applied to wet soils and/or in wet weather, but this is being investigated further.

It is not possible to recommend fungicide treatments for the control of take-all in winter barley on the basis of these experiments.

PART 3: TECHNICAL DETAILS

Optimising the performance and benefits of take-all control chemicals

1. Introduction

1.1 Background

Take-all is one of the most damaging diseases of wheat and barley in the UK. As the main contributor to "second wheat syndrome", it severely restricts rotational options. The recently registered fungicidal seed treatments active against take-all, based on fluquinconazole (e.g. Jockey, Galmano) or silthiofam (Latitude), can help to alleviate the situation if used in a rational way. Information on, and guidelines for, the use of seed treatments emerged from recent LINK projects (Bateman *et al*., 2003; 2004; Spink *et al*., 2002). Despite the availability of fungicides, and despite good understanding of many aspects of take-all biology resulting from research at Rothamsted and elsewhere (Hornby *et al*., 1998), the disease remains important, in part because of the continually changing circumstances in which cereal crops are grown. Some recent and longer-term changes known or suspected to affect take-all on farms, particularly the timing and scale of year-to-year epidemics, are: a) more cereals in rotations and fewer break crops; b) warmer winters; c) earlier sowing (and associated and consequent factors, contributing e.g. to more take-all in second wheats); d) newly available seed treatment fungicides; e) strobilurin fungicides with activity against take-all; f) grass weeds that aid inoculum survival and transmission (associated with minimum tillage, set-aside, etc.); g) an increase in the proportion of break crops that are oilseed rape; h) a move away from applying N fertiliser to cereals in autumn.

Take-all can easily be avoided, but in practice this is difficult because economic and other circumstances often mean there is a need to grow cereal crops in succession. A further stage in progress towards managing take-all is to understand how yield and quality can be optimised by integrating all components of the new chemical armoury, testing them together, in combination and in sequences.

Seed treatments for take-all control are expensive. Recent research, partly HGCA-funded, indicates that a treatment should ideally be applied only once in a sequence of wheat crops, and before a very severe disease peak is reached (Bateman *et al*., 2003; 2004). Seed treatment in very severe disease situations can result in proportionally large increases in yield, but will usually still be uneconomic because total grain yield is small and quality poor. Controlling slight to moderately severe take-all, usually in second wheats, may allow an additional cereal crop to be grown, which would itself probably require seed treatment. Even so, the yield and quality of this crop will be much less than in the absence of take-all.

Provisional evidence also suggests that a second successive treatment with fluquinconazole (Jockey) does not achieve the yield potential expected from a one-off treatment. A suppression of yield has occurred relatively consistently and is not fully explained by the response of take-all disease. Treatment in long sequences of wheat crops intended to exploit take-all decline may also not be worthwhile since the epidemic, and hence progress into decline, are likely to be delayed. The alternative seed-treatment fungicide, silthiofam (Latitude), may affect take-all epidemics differently, since it has a different mode of action and performance characteristics. In addition to seed-treatment fungicides, foliar sprays of azoxystrobin (Amistar) have been found to control take-all in some circumstances (Jenkyn *et al*., 2000). This is unusual and unexpected but appears to relate to its relative water/lipid solubility. Its performance may be influenced by rainfall. Most strobilurin fungicides do not behave in this way although at least one other shows promise.

Although potential yield losses in barley have been determined, by yield-on-disease regression analyses of Rothamsted data, as being at least as great as in wheat, past experience is that barley usually escapes the worst effects of the disease by earlier ripening and more root production. However, considerable yield losses in barley from take-all have been reported, especially on the light soils that comprise the major malting barley production areas of East Anglia. Problems have arisen from changes in the malting specifications, and the challenge of growing crops that meet the required minimum, as well as maximum, nitrogen contents, is causing concern. Trials at TAG East (Morley) have shown that nitrogen fertiliser applications necessary to achieve the specifications for grain nitrogen content for malting are now significantly greater than the amounts necessary to optimise the yield of feed barley on light soils. Higher yields, resulting from improved cultivars and fungicides, have had the effect of diluting the nitrogen content. On the other hand, the nitrogen content of grain may exceed the malting specification if a factor such as take-all and/or drought (which exacerbates the effects of take-all) limits yields. Control of take-all should result in more predictable yields and hence nitrogen contents of barley. Latitude is recommended for use on barley although there are few reports on its efficacy. Monsanto reports that winter barley is commonly treated with Latitude in Ireland. A yield response of 0.6 t/ha from Latitude was recorded in a malting variety of winter barley at Morley in 2001. Other research suggested that worthwhile responses might not be achieved in winter barley (Spink *et al*., 2002). However, this was on moisture-retentive soils at Rosemaund in a different rotational system. In addition, the single-purpose seed treatment Raxil S (containing tebuconazole + triazoxide) was used in conjunction with Latitude in the Morley trial. There was evidence that Raxil S also contributed to take-all control, probably resulting from its tebuconazole ingredient. The mixture of both Raxil S and Latitude may therefore have been responsible for the yield response, which was cost-effective.

There is some inconsistency in the performance of the two take-all seed-treatment fungicides, and their relative performances seem to differ according to the circumstances in which they are tested. The causes are unclear but may relate to: a) differences in the persistence of the two chemicals; or b) the incidence of naturally-occurring strains that are insensitive to silthiofam in populations of the take-all fungus. Item a) may explain reports from different research groups that show that the largest effects of silthiofam on symptoms are observed on winter wheat plants sampled in spring, whilst effects of fluquinconazole are greatest in summer; this difference in behaviour may also mean that optimum sowing-date ranges are different for the two treatments. Grain yields that are consistently less than expected in cereal crops grown immediately after fluquinconazole-treated crops, and usually accompanied by increases in take-all, may be partly a consequence of delayed epidemic development, but this and other disruptive effects on pathogen populations require further investigation.

Insensitivity to silthiofam is usually common in take-all fungus populations that have not been exposed to the fungicide (Freeman *et al*., 2005). Selection for insensitivity should not occur readily in a soil-borne fungal population, most of which is unlikely to make contact with the chemical. This may not be the case, however, where a relatively large proportion of the fungal population is naturally insensitive. Even so, there is no evidence that the level of insensitivity in populations of the fungus affects the performance of the fungicide.

1.2 Objectives

The aims of the project were to generate information that could be used to advise farmers on how to obtain maximum performance and economic benefit from the various chemicals available for controlling take-all by identifying circumstances in which they should be used together, separately or in sequence, with particular concern for their effects on take-all development from year to year. The investigations were also expected to help in understanding and overcoming negative aspects of the behaviour of take-all fungicides identified during previous research.

The specific objectives were:

1. To test the extent to which yields can be maintained in two-three successive wheat crops by integrating treatments applied to control take-all
2. To test whether fungicides used to control take-all can improve the economics of growing barley in cereal sequences.

2. Methods

2.1 Integrated use of chemical treatments to control take-all in wheat crops (Objective 1)

Sequences of seed treatments based on the fungicides fluquinconazole (Jockey) or silthiofam (Latitude), with or without a foliar spray of the strobilurin fungicide azoxystrobin (Amistar), were tested in experiments (listed in Table 1) on second and third wheats, cv. Claire, at Rothamsted (Hertfordshire) and Morley (Norfolk) on different soil types. The standard sequences of treatments tested on wheat were:

Year 1 (second wheat)	Year 2 (third wheat)
Non-treated	Non-treated
Non-treated	Jockey
Non-treated	Latitude
Jockey	Non-treated
Jockey	Jockey
Jockey	Latitude
Latitude	Non-treated
Latitude	Jockey
Latitude	Latitude
Amistar	Amistar
Jockey + Amistar	Jockey + Amistar
Jockey + Amistar	Latitude + Amistar
Latitude + Amistar	Jockey + Amistar
Latitude + Amistar	Latitude + Amistar

All wheat seed, including "non-treated", was treated, by the supplier, with Sibutol Secur, containing bitertanol, fuberidazole and imidacloprid, over which the experimental seed treatments were applied.

This set of treatments was not extended to fourth wheats since these are less likely to be grown. However, one experiment at Rothamsted was continued to a fourth wheat so that effects of the treatments (especially Latitude, on which there is no such information) on disruption of the take-all epidemic could be studied further. This experiment did not include a test of Amistar. Two of the experiments at Rothamsted included treatment with another foliar spray treatment (RR1) applied to successive wheat crops in the same way as Amistar.

2.2 Controlling take-all in barley (Objective 2)

Experiments at Rothamsted (including the farm at Woburn, Bedfordshire) and Morley (including a site at Colney, west of Norwich) on winter barley, cv. Pearl, grown successively as second and third cereals, were similar to those for wheat (Table 1). Jockey, not currently recommended for use on barley, was included because of the likelihood of its future approval for barley. The effects of Amistar and Raxil S seed treatment were tested in combination with Jockey or Latitude. The standard sequences of treatments tested on barley were:

Year 1 (second cereal)	Year 2 (third cereal)
Non-treated (no Raxil S)	Non-treated (no Raxil S)
Non-treated	Non-treated
Non-treated	Latitude
Latitude	Non-treated
Latitude	Latitude
Non-treated	Jockey
Jockey	Non-treated
Jockey	Jockey
Amistar (T1)	Amistar
Latitude + Amistar	Latitude + Amistar
Jockey + Amistar	Jockey + Amistar

The barley seed, including the "non-treated" (except where shown otherwise), was treated, by the supplier, with Raxil S, containing tebuconazole + triazoxide, over which the experimental seed treatments were applied.

2.3 Field sites, experiment design and husbandry

All Rothamsted experiments were on silty clay loam with flints at Rothamsted Experimental Farm except for barley experiment CS/575, which was on sandy loam at Woburn Experimental Farm. Plots measured 10 m x 3 m.

All Morley experiments were on sandy loam over chalky boulder clay (Ashley series) at Manor Farm, except for barley experiment NAS 2426 (= WB04 033B), which was on sandy loam at New Found Farm, Colney. Each replicate plot of each treatment was drilled in three adjacent strips, 12 m x 2.1 m, the two outer strips of which were used for plant sampling and the central strip for grain harvest.

Each standard experiment had four replicate plots, in randomised blocks, so that wheat experiments typically had 56 plots and barley experiments typically had 44 plots. The 3-year wheat experiment and the two experiments that included treatment RR1, all at Rothamsted, each had a total of 27 treatments in three replicate blocks.

Husbandry, including tillage, fertilisation and herbicide use, was standard for the host farms. A full programme of fungicide sprays to control stem-base and leaf diseases was used as necessary, but excluding the use of strobilurins before stem extension. Sowing dates (Table 2) were typical for the positions of the crops in the sequences.

2.4 Fungicide treatments

Fluquinconazole (75 g a.i./kg seed as Jockey Flexi) and silthiofam (25 g a.i./kg seed as Latitude) were applied at Rothamsted using a Rotostat seed-treating machine. Azoxystrobin was applied as Amistar sprays at 1.0 L (250 g a.i.) /ha at T1, i.e. growth stage (GS) 31-32 (Zadoks *et al*., 1974), and at 0.6 L (150 g a.i.) /ha at T2 (GS 37-39) (Table 2). RR1 was applied at the same time and at equivalent rates in two experiments (CS/573 and CS/597).

2.5 Sampling, disease assessments and yield measurements

Plant samples were taken from each experiment in spring, at GS 30-31 (Table 2), just before foliar spray treatments were applied, except when a preliminary examination of a site had indicated negligible take-all development. Five 15-cm lengths of row were dug from each plot in a zig-zag pattern. The root systems were washed immediately and kept in cold storage until assessed for disease, which was completed within a few days. The roots were examined while being held under water in a white dish. The total numbers of plants and the numbers of plants and roots per plant with take-all symptoms were recorded.

The main plant samples were taken from each experiment in late June or early July at GS 71-73 (or up to GS 83 in barley experiments) (Table 2). Ten 20-cm lengths of row, each tied in a labelled bundle, were dug from two approximately parallel zig-zag transects per plot. The root systems were washed immediately, the upper parts of the shoots chopped off, and the remainder allowed to dry thoroughly before being stored in a dry room. Before assessment, the root systems were wetted by soaking in water. Take-all was assessed on a 0-5 scale; slight disease with 1-10% of the root system affected scored 1, slight disease with 11-25% affected scored 2, moderate disease with 26-50% affected scored 3, moderate disease with 51-75% affected scored 4 and severe disease with >75% of the root system affected scored 5. A take-all index (0-100) was calculated as the sum of the percentage of plants in each score category multiplied by its score value, divided by five (Bateman *et al*., 2004). Stem-base diseases, where clearly scarce or mainly very slight, were assessed on a representative sample of plants. All plants from one of the two transects per plot were assessed where disease was clearly more prevalent. Eyespot was assessed as slight, moderate or severe, depending on the amount of girdling of, and damage to, the basal internodes (Scott & Hollins, 1974). Eyespot and brown foot rot (mainly caused by *Fusarium* and *Microdochium* spp.) were assessed similarly, but the moderate and severe categories were combined.

Where prematurely ripened patches caused by take-all were clearly visible in plots, the percentage of each plot affected was estimated and recorded.

Grain yields at 85% dry matter and, usually, thousand-grain weights and hectolitre (specific) weights were determined after combine harvesting the plots.

Treatment effects were compared by factorial analysis of variance using Genstat, percentage values being transformed to logits before analysis.

3. Results

For take-all index assessments and grain yields, two-factor or three-factor tables are usually presented, even where interactions among the factors (i.e. seed treatment, spray treatment and year of treatment) were not statistically significant. For overall incidence (% plants) and the incidence of different severity categories of take-all (% plants with moderate or severe symptoms, and % plants with severe symptoms), and for grain quality measurements (usually hectolitre weights; thousand-grain weights where measured), such detail is usually provided only where there were statistically significant interactions between factors. Where interactions were not significant, usually only the mean effects of seed or spray treatments are shown or described, and then only where there were significant main effects that provide additional information on the performance of the fungicides; otherwise the results are omitted completely. Where differences were not significant, but may be meaningful in that they were consistent with other results, treatment effects are described as “tending” to be different.

3.1 Take-all in successive crops

The effects of fungicides applied to control take-all need to be considered in the context of the amounts of disease that developed in successive non-treated crops, i.e. the ‘natural’ take-all epidemics that occurred without manipulation by fungicides (assuming no effects of the standard Sibutol or Raxil seed treatments), and hence the potential for disease reduction and yield increase. These data are shown in Tables 3-4 as take-all indices. Root infection in the spring is also a measure of epidemic development and, with the summer assessments, provides information on within-season, as well as between-season, epidemic development. Data from spring assessments are not included in Tables 3-4, however, since the amount of disease in spring was usually closely correlated with that in summer.

In wheat experiments begun at Rothamsted in harvest year 2003 (CS/573 and CS/574), moderate take-all developed in the second wheat crops (2003), with only moderate yields (Table 3). Take-all then became severe in the third wheats with very poor yields. In the fourth wheat, grown only in CS/574, there was evidence of take-all decline with decreased take-all severity and consequently increased yield. This is typical of recent take-all epidemics on this farm. Epidemics became more severe more quickly in the experiments that began in harvest year 2004: take-all was moderate in the second wheat in CS/597 and severe in CS/598, with only moderate grain yields, and very severe with very poor yields in the third wheats, and there was no evidence of effective take-all decline. None of the yields in the non-treated crops in any year in any experiment were acceptable by current standards.

In the wheat experiment begun at Morley in harvest year 2003 (NAS 2427), take-all was very severe and the grain yield was small (Table 3). Wheat cropping was discontinued and replaced with barley as the third cereal. In the wheat experiments begun at Morley in 2004, take-all became moderate in the second wheats but did not increase in the third wheats, with similar yields in both years. This was probably mainly a result of relatively late sowing of successive crops, the second wheat in early October and the third wheat in late October (Table 2).

Epidemic development was poor in barley. Take-all intensity remained slight to moderate in all crops treated only with Raxil S (and in non-treated crops, since Raxil S had no effect on take-all, see later tables) (Table 4). Even after severe take-all in wheat (NAS 2427 at Morley), only slight take-all developed in the following barley. The reasons for slow development of take-all in barley, particularly in Norfolk, are unclear. Grain yields were least where there was most take-all, but were variable as a result of overriding site differences not related to take-all.

3.2 Winter wheat crops at Rothamsted

3.2.1 Experiment CS/573, 2003-4

Take-all in spring 2003 (second wheat) was decreased by take-all seed treatments (Table 5). The effects of Latitude tended to be greater than the effects of Jockey. In summer 2003, take-all index was decreased by Jockey and Latitude; the latter tended to be slightly more effective (Table 6). This difference between the take-all seed treatments was significant when take-all was assessed as overall incidence but Jockey and Latitude decreased the incidence of moderate and severe infections by similar amounts. Amistar and RR1 were ineffective although spray treatments, especially RR1, tended to enhance the effects of Latitude. There was, however, no significant seed treatment x spray interaction. Grain yield in 2003 was increased by Latitude and, to a smaller extent, by Jockey (Table 7). Amistar and RR1 alone had no effect. In the absence of spray treatments, Jockey increased yield by 0.18 t/ha and Latitude increased yield by 0.55 t/ha.

In spring 2004 (third wheat), Latitude applied to those crops decreased take-all, halving its incidence on plants, whilst Jockey had no effect (Table 8). There were no effects of treatments applied to the previous crops. In summer 2004, take-all patches were decreased by both seed treatments, applied to those crops, more so by Latitude than by Jockey (Table 9). Effects of fungicide spray treatments were not significant. Jockey and Latitude treatments applied to the 2004 crops resulted in similar decreases in take-all index (Table 10). At this stage, overall incidence of take-all on roots was decreased only by Latitude, while the incidence of severe take-all was decreased more by Jockey than by Latitude (Table 11). The effect of Latitude, but not of Jockey, on the incidence of severe take-all was enhanced by Amistar. RR1 effectively decreased severe take-all in the absence of seed treatments. The incidence and severity of eyespot were increased by Latitude applied in 2004 and decreased by foliar sprays, more so by RR1 than by Amistar (Table 12). Grain yield in 2004 was increased by each take-all seed treatment applied to the 2004 crop (Table 13). In the absence of other treatments, Jockey increased yield by 1.09 t/ha and Latitude increased yield by 1.86 t/ha. RR1 also increased yield significantly, by 1.65 t/ha in the absence of all other treatments. An increase of 0.77 t/ha by Amistar was not significant. The smallest yields resulted from no treatments in either year (4.97 t/ha), or Jockey to the second wheat with Amistar to both crops and (4.98 t/ha). The greatest yield occurred where Latitude and RR1 had both been applied in successive years (8.49 t/ha) but the seed treatment x spray treatment interaction was not significant. Regression analyses showed that, over all plots, yield was strongly dependent on take-all index (regression $P \leq 0.001$, with 70% of the variance accounted for). The regression of yield on eyespot (% moderate or severe disease) was not significant ($P=0.4$). Multiple regression of yield on take-all and eyespot, and inclusion of spray fungicide as a factor, did not affect the regression, indicating that yield was strongly dependent on take-all and not at all on eyespot, and that most of the effect of fungicide sprays on yield was likely to be a consequence of their effects on take-all. Thousand-grain weights in 2004 (Table 14) were increased by seed treatments, the effect of Latitude being greater than that of Jockey, reflecting the effects on yield. The effects of the two seed treatments on hectolitre weight were the same, however, and not quite significant. Both foliar fungicides increased hectolitre weight but not thousand-grain weight.

3.2.2 Experiment CS/574, 2003-5

Take-all in spring 2003 (second wheat) was decreased by take-all seed treatments (Table 15). The effects of Latitude tended to be greater than the effects of Jockey, particularly on incidence of infected plants. In summer 2003, Jockey and Latitude decreased take-all index similarly although the overall incidence of take-all was decreased more by Latitude and the incidence of moderate plus severe disease tended to be less with Jockey. Grain yields were increased similarly by Jockey and Latitude, with increases of 0.46 and 0.50 t/ha, respectively.

In spring 2004 (third wheat), Latitude applied to the 2004 crop decreased take-all incidence (% plants) and severity (roots per plant infected), whilst Jockey decreased only severity (Table 16). Both treatments applied to the 2003 crop tended to decrease take-all in spring 2004 but the effects were not quite significant. In summer, take-all index was decreased similarly by Jockey and Latitude applied to the 2004 crop (Table 17). Treatments applied to the previous crop also decreased take-all index in 2004. Interactions between seed treatment and year suggest that Jockey was more effective in 2004 when applied after Latitude than after Jockey or after no treatment. The overall incidence of take-all (all severity categories) was decreased more by Latitude applied to the 2004 crop than by Jockey, whilst the incidence of severely diseased plants was decreased more by Jockey. Grain yield in 2004 was increased by both seed treatments applied to the 2004 crop (Table 18). A single application of Jockey, in 2004, increased yield by 1.17 t/ha, whilst Latitude increased yield by 2.38 t/ha. Two successive applications of each fungicide tended to be slightly more effective than a single application; this tendency for Jockey differed from that in CS/573 (although the effects were not significant statistically). Thousand-grain weight and hectolitre weight were, on average, increased similarly by each seed treatment applied to the 2004 crop. Effects on hectolitre weight were, however, apparent only where neither Jockey nor Latitude was applied to the 2003 crop.

In 2005 (fourth wheat), the percentage of plants infected in spring was decreased by Jockey and, to a greater extent, by Latitude applied to the 2005 crop, when averaged over all previous treatments (Table 19). The percentage of plants infected in 2005 was increased by treatment of the second wheat (2003) with Jockey, averaged over all subsequent treatments. The number of roots per plant infected in spring was decreased by Jockey and Latitude applied to the 2005 crop, the effect of Latitude tending to be greater. The number of roots infected was increased by treatment of the second wheat (2003) with Jockey or Latitude, and by treatment of the third wheat (2004) by Latitude, when averaged over treatments in all other years. There were no statistically significant interactions between treatments in different years in their effects on take-all. In summer 2005, the area of take-all patches in the crop (assessed on 28 June) was decreased, overall, more by Latitude applied to the 2005 crop than by Jockey (Table 20). However, Latitude applied to the 2004 crop increased patchiness in the 2005 crop more than did Jockey. Increases resulting from the application of each treatment to the 2003 crop were similar. There was no statistical support for differences between the same and different fungicides applied in sequence. In summer 2005, Latitude applied to the 2005 crop decreased take-all index more effectively than Jockey, averaged over all previous treatments (Table 21). Treatment of the second wheat (2003) increased take-all index in the fourth wheat, averaged over treatments in all other years. Only Jockey decreased take-all index when applied to the fourth wheat after no treatment of previous crops. Latitude applied to the 2005 crop was generally most effective in comparisons in which previous crops had been treated; it was relatively less effective where no previous crops had been treated, since less take-all had now developed here because of take-all decline. Jockey applied in 2005 tended to be less effective than Latitude after previous treatments. Results for percentage plants in the moderate and severe categories were similar to those for take-all index; little information was obtained from overall incidence, which was close to 100% for all treatments (results not shown). Both seed treatments applied to the 2005 crop increased grain yield, averaged over all previous treatments (Table 22). Latitude (1.51 t/ha increase) was more effective than Jockey (0.92 t/ha increase). Either treatment applied to the second or third wheat decreased yield in the fourth wheat, averaged over all treatments in other years. After no treatment in previous years, Jockey was effective (1.14 t/ha increase over non-treated fourth wheat), whilst Latitude had no effect. After previous crops that were treated, Latitude applied to the fourth wheat tended to be more effective than Jockey, and was especially (and significantly) so after Jockey applied to the third wheat and no treatment of the second wheat. The highest yield (8.72 t/ha) resulted from this treatment. Effects on hectolitre weight differed slightly from those on overall yield in that it was increased significantly by Latitude, but not Jockey, applied to the 2005 crop, and decreased significantly by Latitude, but not Jockey, after application to the 2004 crop (Table 23). The effects on thousand-grain weight were similar except that the mean values for Jockey in 2005 (28.6 g) and Latitude in 2005 (29.6 g) were both significantly greater (P<0.001, SED=0.42) than after no treatment in 2005 (27.8 g) (details not shown).

3.2.3 Experiment CS/597, 2004-5

Take-all in spring 2004 (second wheat) was decreased by Jockey and Latitude; Latitude tended to decrease incidence on plants more than did Jockey (Table 24). In summer 2004, an average of 5.1% of the area of each plot was affected by visible take-all patches, assessed on 8 July, but there were no significant differences between treatments (details not shown). Root systems showed moderate take-all, on average. Take-all index was not affected significantly by any treatment (Table 25). There were, similarly, no significant effects on the overall incidence of take-all (average 76.0% of plants, details not shown). Averaged over all spray treatments, the incidence of severe take-all tended to be decreased most by Jockey seed treatment and, averaged over all seed treatments, it tended to be decreased most by RR1 spray treatment, but neither effect was significant. There was an interaction that suggested that Amistar increased severe take-all in Jockey-treated plots, whilst spray treatments tended to decrease severe take-all in Latitude-treated plots, but it was barely significant and so these differences should be viewed with caution. Despite the few effects on take-all, grain yield in 2004 was increased by both Jockey and Latitude, averaged over all spray treatments, and by Amistar and RR1, averaged over all seed treatments (Table 26). A significant interaction indicated much larger responses to seed or spray treatment where no other treatment, as spray or to seed, respectively, had been applied. In the absence of other treatments, grain yield increases were 0.95 t ha^{-1} with Jockey, 1.37 t/ha with Latitude, 0.79 t/ha with Amistar and 1.24 t ha^{-1} with RR1. Hectolitre weight was increased by foliar fungicides but significantly so only by RR1 (averaged over all seed treatments).

In spring 2005, the incidence of take-all on plants and on roots was decreased similarly by Jockey and Latitude applied to the 2005 crop but was not affected by treatment of the previous crop (Table 27). In summer 2005, take-all was very severe. Take-all index was decreased by both Jockey and Latitude applied to the 2005 crop when averaged over all spray and previous seed treatments (Table 28). It was decreased more by Jockey than by Latitude, but not significantly so. Amistar also decreased take-all index and tended to be most effective where seed treatments, especially Jockey, were also applied to the 2005 crop. The clearest effects on disease are apparent in the incidences of severe take-all (Table 29). In this analysis, Jockey was more effective than Latitude. RR1 was also effective, but less so than Amistar. Grain yields in 2005 were very small as a consequence of the severe take-all. Both Jockey and Latitude, applied to the 2005 crop, increased grain yield when averaged over seed treatments applied in 2004 and all fungicide spray treatments (Table 30). Latitude increased yield (by 0.96 t/ha) more than did Jockey (0.75 t/ha). Amistar, but not RR1, increased grain yield (by 0.36 t/ha) when averaged over all seed treatments. There was also some evidence that these main effects were modified by interactions between the treatments, including seed treatments applied to the previous crop. Suggesting plausible (biological) explanations for many of the different responses, according to the combination of treatments that had been applied, is not, however, easy. Nevertheless, it may be worth noting that the smallest yields were obtained where Jockey or Latitude had been applied to the 2004 crop but no fungicides (seed treatments or sprays) had been applied in 2005 (1.98 and 2.22 t/ha, respectively). Conversely, the best yields were obtained where Amistar had been applied (in both years) and Latitude followed Jockey (4.42 t/ha) or Jockey followed Latitude (3.93 t/ha). Effects on hectolitre weight were mostly small but there was a significant interaction; this tended to suggest benefits from applying Jockey, and from applying foliar sprays, but the latter did not add to the effects of Jockey (Table 31). There were no significant effects on thousand-grain weight (overall mean = 23.7 g).

3.2.4 Experiment CS/598, 2004-5

Take-all in spring 2004 (second wheat) was decreased by both seed treatments; the effect of Latitude tended to be greater than that of Jockey (Table 32). In summer 2004, take-all index was decreased similarly by Jockey and Latitude, and by Amistar (Table 33). The incidence of severe take-all was decreased more by Jockey than by Latitude; Amistar also had a marked effect on severity as well as on incidence (Table 34). Grain yields in 2004 were increased by Jockey and Latitude, and, averaged over all seed treatments, by Amistar (Table

35). In the absence of other treatments, grain yield increases were 1.25 t/ha with Jockey, 1.31 t/ha with Latitude and 0.72 t/ha with Amistar. Specific weights (average 69.1 kg/hL) were not affected by treatments (not shown) but the effects on thousand-grain weights reflected those on grain yields (Table 35).

In spring 2005, both Jockey and Latitude applied to the 2005 crop decreased the percentages of plants and numbers of roots infected (Table 36). These seed treatments applied only to the previous crop, however, increased the numbers of roots infected. Fewest infected roots occurred where Jockey or Latitude were applied after neither was applied in 2004, but the largest effects of the 2005 treatments occurred mostly where the 2004 crop had been treated, especially with Latitude. In summer 2005, take-all was very severe and take-all index was decreased by both Jockey and Latitude applied to the 2005 crop when averaged over all spray and previous seed treatments (Table 37). Take-all index was decreased more by Jockey than by Latitude, but not significantly so. Amistar had no significant effect. Further information is obtained from the analysis of the incidence of severe take-all (Table 38). This shows that Jockey applied to the 2005 crop was more effective than Latitude, and that Amistar was also significantly effective. Grain yields in 2005 were small but were increased by Jockey (by 0.94 t/ha compared with no seed treatment) and Latitude (by 1.06 t/ha) applied in that year, averaged over all previous seed treatments and spray treatments (Table 39). The mean effect of Amistar on grain yield was small and not significant. The smallest grain yield resulted from no treatment applied to the 2005 crop and Jockey to the 2004 crop (2.26 t/ha). The largest yields resulted from using Amistar with Latitude after Latitude (4.36 t/ha). Amistar increased hectolitre weight (from 66.7 to 67.3 kg/hL) when averaged over all seed treatments (details not shown). There were no other significant effects or interactions. Thousand-grain weights were significantly increased by Jockey or Latitude applied to the 2004 crop (24.1 g and 24.2 g, respectively), compared with the Sibutol-only treatment (23.6 g), averaged over all other treatments in both years (P=0.009, SED=0.19).

3.3 Winter wheat crops at Morley

3.3.1 Experiment NAS 2427, 2003

Take-all in spring 2003 (second wheat) was decreased by seed treatments (Table 40). Latitude was more effective than Jockey. Take-all became very severe in summer 2003, when take-all index was decreased by both take-all seed treatments, but more by Jockey than by Latitude (Table 41). Whilst the incidence of take-all was not affected by treatments, the percentages of plants with moderate or severe disease were decreased significantly by Jockey but not by Latitude. Amistar had no additional significant effects. Grain yield and quality in 2003 were not affected by treatments (Table 42). The extreme severity of take-all in the second wheat of experiment NAS 2427 led to the decision to sow winter barley as the third cereal, testing a sequence of treatments similar to that proposed for wheat.

3.3.2 Experiment 034A, 2004-5

Take-all in spring 2004 (second wheat) was decreased only by Latitude (Table 43). In summer 2004, take-all index was decreased by Latitude and, to a lesser extent, by Jockey (Table 44). This resulted mainly from decreased incidence of moderate plus severe disease; overall incidence was decreased only by Latitude. Amistar had no effect. Grain yield and quality were not affected significantly although the smallest yield resulted from applying Amistar (-0.45 t/ha compared with Sibutol-only) and the largest yield resulted from applying Latitude + Amistar (+0.35 t/ha) (Table 45).

In spring 2005, the incidence of take-all was decreased significantly by Latitude applied only to the 2005 crop only (Table 46). Incidence and severity (number of infected roots per plant) were increased by Jockey applied to the 2005 crop after Jockey or Latitude applied to the 2004 crop. In summer 2005, take-all index was decreased by Jockey applied to the 2005 crop after any or no treatment of the 2004 crop (Table 47). Latitude was not effective when applied to the 2005 crop except where Jockey or Latitude had been applied in 2004. Amistar alone also significantly decreased take-all index but did not usually add to the effects of Jockey or Latitude seed treatments. The smallest indices occurred with Latitude in 2005 following Jockey in 2004. Similar results were obtained for percentages of root systems with disease in different severity categories, except that Jockey applied to both the 2004 and 2005 crops decreased the incidence of moderate plus severe disease but not overall incidence. Effects on grain yield and hectolitre weight in 2005 were almost significant (Table 48). The largest yield occurred after Latitude plus Amistar applied to the 2005 crop following Jockey + Amistar to the 2004 crop (+0.87 t/ha compared with the Sibutol-only treatment) and the smallest yield occurred after Sibutol-only in 2005 following Latitude applied to the 2004 crop (-0.70 t/ha).

3.3.3 Experiment 034B, 2004-5

Take-all in spring 2004 (second wheat) was decreased by Latitude (Table 49). In summer 2004, take-all incidence and severity, which were slightly greater than in experiment 034A, were decreased by Jockey and Latitude (Table 50). Amistar had no effect. Plant stand and grain yield were not affected by treatments but the largest grain yield resulted from applying Latitude plus Amistar (+0.48 t/ha compared with Sibutol-only) (Table 51). Thousand-grain weight was increased by Latitude and Amistar, when applied separately or together.

In spring 2005, the incidence of take-all on plants was decreased consistently by Latitude applied to the 2005 crop (Table 52). The number of roots per plant with take-all was affected similarly but not significantly. In summer 2005, take-all index and take-all incidence (all severity categories) were decreased similarly and consistently by Latitude applied to the 2005 crop. Take-all indices were smallest, and significantly so, where Latitude was applied only to the 2005 crop, and where Latitude with Amistar to the 2005 crop followed Jockey or Latitude with Amistar applied to the 2004 crop (Table 53). In contrast, the incidence of moderate or severe take-all was decreased significantly by Jockey as well as by Latitude alone but only where they were applied to the 2005 crop and had not been applied to the 2004 crop. Both fungicides, applied alone to the 2005 crop, were less effective where the previous crop had been treated. Despite this, and despite no significant effects of Amistar sprays alone (applied to both crops), the combination of Latitude plus Amistar applied to the 2005 crop following either Jockey plus Amistar or Latitude plus Amistar to the 2004 crop, was effective. Non-treated crops in 2005 that followed Jockey- or Latitude-treated crops in 2004 tended to have more moderate or severe take-all than crops that were non-treated in both years; this tendency was even more apparent in measurements of severe take-all (Table 53). Grain yield in 2005 was increased by applying Latitude in 2005, and responses were similar whether the 2004 crop had been non-treated (Sibutol only), treated with Jockey or treated with Latitude (+0.54, +0.59 and +0.69 t/ha, respectively, compared with Sibutol-only in 2005) (Table 54). There was little or no evidence of yield responses to Jockey or Amistar. There were small treatment effects on hectolitre weight but none on thousand-grain weight or grain protein content.

3.4 Winter barley crops at Rothamsted

3.4.1 Experiment CS/575, 2003

In spring 2003 (second cereal), no treatments affected take-all significantly but Latitude tended to cause least disease (Table 55). In summer, take-all development was slight to moderate overall. Take-all index and the incidence of moderate plus severe disease were decreased by most treatments (except Raxil alone), including Amistar, whilst overall incidence was not affected by treatments (Table 56). Grain yield and quality were not affected by fungicide treatments (Table 57). Grain N was excessive for malting barley.

Experiment CS/575 was abandoned in 2004 because of crop failure, an unexplained phenomenon that sometimes occurs in cereal sequences at Woburn and may be associated with reduced availability of manganese.

3.4.2 Experiment CS/596, 2004-5

There was negligible take-all in 2004 (second cereal). Grain yield and hectolitre weight were, however, increased by all treatments that included Amistar, and thousand-grain weight was increased by Jockey or Latitude plus Amistar (Table 58). Grain yield increases, compared with Raxil, were 0.73 t ha^{-1} (Amistar only) to 0.80 and 0.81 t ha^{-1} (Amistar with Jockey or Latitude, respectively). Grain N was unaffected by treatments and exceeded the optimum for malting barley.

In summer 2005, there was slight to moderate take-all overall. No treatment decreased take-all index significantly compared with Raxil-only treatment of successive crops (Table 59). Take-all index did, however, tend to be decreased where Jockey or Latitude had been applied to the 2004 crop, and application of Latitude to the successive barley crops significantly decreased overall incidence and the incidence of moderate plus severe take-all. Take-all incidence and severity were increased by application of Amistar to the successive crops and tended to be increased where Jockey or Latitude had been applied to the 2003 crop but not to the 2004 crop. Grain yield in 2005 was relatively large. There were several significant responses in comparison with none but, in comparison with Raxil, only the effect of Latitude applied to the 2005 crop was significant (Table 60). Thousand-grain weight, hectolitre weight and the relatively large grain N concentration were not affected significantly.

3.5 Winter barley crops at Morley

3.5.1 Experiment NAS 2425, 2003-4

There was negligible take-all in spring 2003 (second cereal), with less than 1% of plants affected. In summer 2003, take-all remained very slight (results not shown). Grain yield and quality were not affected by fungicide treatments (Table 61).

In summer 2004, take-all was slight overall. No treatments decreased take-all index significantly compared with none or Raxil alone (Table 62). Take-all incidence was decreased most by Jockey applied only to the 2004 crop. Amistar applied to successive crops increased take-all index and incidence. Few plants had moderate or severe take-all and there were no significant effects of treatments. Grain yield was not affected significantly by treatments but, compared with none or Raxil alone, thousand-grain weights were increased by all treatments that included Jockey or Latitude in either year (Table 63). Nitrogen content was generally close to that required for malting and all treatments except Raxil, including Amistar, tended to decrease it to a more acceptable level.

3.5.2 Experiment NAS 2426, 2003-4

In spring 2003 (second cereal), seed treatment with either Jockey or Latitude decreased take-all but the effects on incidence (% plants) were not significant (Table 64). In summer 2003, take-all development was slight overall. Take-all index was less with Jockey or Latitude than with Raxil alone but, in comparison with none, most differences were not significant (Table 65). The incidence of moderate plus severe disease was less with all treatments that included Jockey or Latitude than with Raxil alone, but was decreased relative to the non-treated only by Latitude. Grain yield and quality were not affected by fungicide treatments (Table 66).

In spring 2004, there was much take-all but there were no effects of treatments (Table 67). In summer 2004, take-all index tended to be decreased by Jockey applied to the 2004 crop but was decreased more by application of Latitude, especially, and significantly, where it was applied to successive crops (Table 68). Incidence of take-all, in any severity class, was not decreased significantly by any treatment. Grain yields were small and not affected by treatments (Table 69). Nitrogen in the grain was generally acceptable for malting and was not affected by treatments.

3.5.3 Experiment NAS 2427, 2004

This experiment tested barley as a third cereal, following wheat as the second cereal (see above). In summer 2004, despite severe take-all in the preceding wheat, take-all was slight and was not affected by treatments (Table 70). Grain yields were moderately high and not affected by treatments (Table 71). Thousand-grain weight tended to be least (<44 g) where no treatment had been applied or only the previous wheat crop had been seed-treated with Jockey or Latitude. Grain N concentration was not acceptable for malting.

3.6 Stem-base diseases

Since Jockey and Amistar can, potentially, affect stem-base diseases, these were assessed in most summer samples. Usually the incidence of these diseases was low and symptoms on individual stems were slight (Table 72). In some experiments, the amounts of eyespot were sufficient to justify full statistical analysis, and the results are described in the sub-sections on the individual experiments (see above and Table 12). In the third wheat in CS/573 (2004), the incidence and severity of eyespot were increased by Latitude applied in 2004 and decreased by foliar sprays, more by RR1 than by Amistar (Table 12). The effects of seed treatments in CS/574 in 2004 were similar to those in CS/573 (details not shown).

3.7 Gout fly

Gout fly was common in the wheat experiments begun in 2004 at Rothamsted (i.e. sown in autumn 2003) and the incidence of damage was usually assessed. In the third wheat crop in CS/598 (2005), Latitude applied to the 2005 crop increased the incidence of gout fly damage (Table 73). A smaller increase in CS/597 in the same year was not significant.

4. Discussion

Relative effects of treatments were not the same in different experiments since they were influenced, as expected, by amounts of take-all and rates of epidemic development, which would have been determined by many site and year factors, e.g. soil type, condition and nutrient status, previous cropping and residual inoculum, sowing date and weather. Results from a range of epidemics, as encountered here and supplemented by those reported previously (Bateman *et al*., 2003, 2004), provide confidence in the conclusions that emerge.

4.1 Jockey vs *Latitude seed treatments in wheat*

Take-all was usually decreased and grain yield increased by seed treatment with either Jockey or Latitude. The effects were, however, generally much greater at the Rothamsted sites than in Norfolk. It may or may not be relevant that take-all did not become severe at two of the three Norfolk sites (experiments 034A and 034B). Epidemic development was probably delayed at those sites by the relatively late sowing of the 2004 crops and, particularly, the 2005 crops, emphasising the contribution that delayed sowing can make to take-all control in successive crops. It is also possible that a degree of natural take-all suppression, perhaps related to previous cropping but not characteristic of take-all decline, was also operating, but this is less likely.

In wheat sampled in spring, the effects of Latitude were almost always greater than those of Jockey, often significantly so. The early effects of Latitude contributed greatly to decreased overall incidence of take-all (% plants infected). This is consistent with published evidence that Latitude controls primary infection of seminal roots from inoculum in the soil but not secondary, root to root, infection (Bailey *et al*., 2005).

In summer, Latitude was only rarely more effective than Jockey, except sometimes in its effects on overall incidence. Jockey commonly decreased the severity of disease on individual plants more effectively; its effect on the incidence of severe take-all in CS/573 (Table 11) is among the best examples of this. This may indicate that limited relocation of fluquinconazole (in Jockey) in the root system and the rhizosphere (Russell *et al*., 2002) decreased secondary infection by the take-all fungus. The relative effects of Jockey and Latitude may therefore depend on the rate and timing of epidemic development within a cropping year. Thus early development of severe disease, perhaps associated with early sowing and warm conditions, might be expected to elicit a good performance from Latitude. Where disease develops later in crop growth, but quickly, as a consequence of favourable weather, perhaps following late sowing, Jockey may be particularly effective. The conditions encountered in 2003-2005 did not generate such clearly contrasting patterns of disease development as this but the significantly smaller amounts of take-all in summer after Jockey than after Latitude generally occurred in those experiments that had the most severe take-all, i.e. the second wheat crop in NAS 2427 and in third wheat crops in CS/597 and CS/598. In all those examples, however, responses in grain yield still tended to be greater after treatment with Latitude than with Jockey. This suggests that early protection of roots by Latitude may have ensured better survival of tillers (and ears) or spikelets, the numbers of which are established in this period, and that this was relatively more important than the effects of later root damage on grain filling.

4.2 Sequences of seed treatments in wheat

Take-all usually increased in a non-treated crop following a treated crop because the epidemic continued to develop without the restraint of a fungicide.

The amount of take-all in a non-treated third wheat following a treated (Jockey or Latitude) second wheat was usually similar to, or less than, that in a third wheat in a non-treated sequence. A tendency for treatments to decrease take-all (not significantly) in a non-treated following crop, compared with no treatment in successive crops, occurred, for example, in experiment CS/574 in 2004 (third wheat). This indicates delayed build-up of disease in the third wheat, an indirect effect of the previous year's treatment. Such a persistent effect was observed once before, in a second wheat following a Jockey-treated first wheat with almost no take-all (Bateman *et al*., 2003). This may occur particularly in the early stages of year-to-year epidemics, where there is little take-all in the treated crop. There was, however, more take-all in a non-treated fourth wheat following a treated third wheat than in the fourth wheat in a non-treated sequence (CS/574). This is consistent with earlier results, some of which were from longer sequences; it is almost certainly a consequence of fourth and later wheats in non-treated sequences benefiting from take-all decline, an effect that is less evident in third wheat crops where take-all decline is inevitably weaker or absent. Smallest, and sometimes negative, yield responses from the two-crop treatment sequences occurred most often where a non-treated crop followed a treated crop (Table 74).

Repeated treatment of successive second and third wheat crops usually resulted in take-all in the treated third wheat that was similar to or less than that in a third wheat in a non-treated sequence, with converse effects on yield. Overall yield increases in third wheat crops, relative to yields in comparable non-treated sequences, were usually greatest where successive second and third wheats had been treated (Table 74). The most effective succession was Latitude after Latitude, but Jockey after Latitude tended to give greater benefit in the most severe epidemics (CS/597 and CS/598). Jockey following Jockey was the sequence that usually gave least yield benefit, whilst Latitude after Jockey was almost always more beneficial. In contrast, repeat treatment applied to a fourth wheat (CS/574), resulted in more take-all and less yield relative to the non-treated sequence. Jockey was found previously, in longer sequences, to be poor as a repeat treatment, and it often had a negative effect on yield greater than could be accounted for by the associated increase in take-all (Bateman *et al*., 2003). In such situations, the resurgence of the epidemic after being suppressed by treatment in previous years, was apparently beyond the control of the re-applied late-acting Jockey seed treatment. Sequences of non-treated crops (as used for comparison in our experiments) would, at the same time, be gaining additional benefit from the onset of take-all decline, although this was evident only in a fourth wheat crop. The frequently greater effectiveness of Latitude compared with Jockey as a repeat treatment in third wheats (often more evident in yields than in take-all index, exceptions being CS/597 and CS/598) is probably because it is able to take effect early on in a relatively low-disease situation created by the previous treatment, whilst the inoculum is still depleted and before the resurgence has had time to take effect.

Our previous research led to the recommendation that Jockey could be of economic benefit if applied to a second wheat at risk from take-all, provided that other measures were also used to minimise take-all (e.g. maintaining adequate plant nutrition and soil conditions, avoiding volunteers and grass weeds in previous break crops, avoiding very early drilling of the first and second wheat), but that this treatment increased the risk to a following third wheat, treated or non-treated (Bateman *et al*., 2003, 2004). We have now demonstrated that, whilst it will often still be risky to grow a third wheat, the risk can be lessened by applying Latitude to a third wheat after a Jockey-treated second wheat with only moderate take-all. Latitude after Latitude did, however, tend to give greater overall benefit. Where take-all is already becoming severe in a second wheat (as in CS/598), even more severe take-all and very small yields can be expected in a following third wheat, which should not therefore be grown. Since yields of crops with significant take-all, whether treated or not, will almost invariably fail to reach the potential of a healthy crop, the management of, and expected margins from, the whole sequence of susceptible crops need to be considered when planning a cropping system.

Estimates of financial margins over treatment costs must be treated with some caution because of variable seed costs and grain prices. Approximate margins have, however, been calculated on the basis of the yields shown in Table 74. Relative differences between the margins (Table 75) and the yields are explained by differences in the costs of Jockey Flexi and Latitude. In the relatively slow epidemics that resulted in severe take-all in the non-treated third wheats (CS/573 and CS/574), treatment of the third wheat with Latitude after treatment of the second wheat with Jockey was the most profitable sequence. In the epidemics that developed more quickly, with take-all already becoming moderate or severe in the second wheats (CS/597 and CS/598), treatment of the second wheat with Latitude followed by treatment of the third wheat with Jockey was the most profitable sequence, but the very small yields from the third wheats meant that growing them was not worthwhile, regardless of the response to treatment. Where severe take-all did not develop, probably because of late sowing, and the disease had little or no effect on yield (034MRA, 034MRB), the margin over costs was negative except where only the third wheat was treated.

Differences in the way epidemics developed at Rothamsted, where take-all became very severe in the second or third wheat, but did not show evidence of take-all decline until the fourth wheat, and at Morley, where take-all became severe in the second wheat or did not become severe even by the third wheat, emphasise the importance of local knowledge of a site's vulnerability to take-all, and of the impact of husbandry practices that might affect take-all, when estimating the cost implications of a rotation and of fungicide inputs.

4.3 Fungicide sprays, combinations and sequences in wheat

Foliar spray treatments were erratic, despite previous evidence that Amistar can have effects comparable with those of seed treatments (Jenkyn *et al*., 2000). In 2003, it was ineffective. It was more generally effective in 2004, and in 2005 when its application was usually attempted in wet weather, when rainfall had occurred and more was expected. We suspect that it may be more effective when applied to wet than to dry soil, which might aid its movement in the root zone. Although it has not been possible to confirm this by retrospective examination of weather records (Jenkyn *et al*., 2000), only a relatively small data-set was available at that time. It was further investigated in 2005, in plots prepared for an HGCA demonstration, which were not fully replicated. Some of the plots were watered with the equivalent of about 1 cm of rainfall before application of an Amistar spray, and the foliage then sprayed with a further 0.2 cm, as coarse droplets, soon after application of the fungicide. Wetting the soil and washing the foliage appeared to improve the performance of Amistar against take-all (Table 76).

The main effect of Amistar in wheat was on the incidence of severe take-all (CS/573 in 2004; CS/597 and CS/598 in 2005), presumably a consequence of its being applied after most primary infection of roots had occurred. Decreased take-all sometimes occurred only where a seed treatment had also been applied, usually Latitude (CS/573, 2004), so that the effects of the two fungicides were additive. A yield benefit often occurred, especially from the combined effect. In CS/597 in 2005, the combined effect of Latitude and Amistar on yield was evident only in plots that had been treated with Jockey in the previous year. In contrast, in the same experiment in 2004, both Amistar and RR1 increased yields most in plots without seed treatment. However, these fungicides may also affect other diseases that can affect yield: for example, RR1, but not Amistar, was shown to decrease eyespot. The conditions in which Amistar will give benefit from decreasing take-all clearly need further investigation so that it can be used rationally. The effect of wet soil is being investigated in 2006 as an extension to this project.

4.4 Fungicides in barley

In barley, take-all development was often slow and insufficient for a realistic test of treatments despite usually following wheat crops that had left abundant inoculum in the soil. There was no evidence of an effect of Raxil on take-all, but Jockey and Latitude sometimes decreased the disease, and Latitude increased yield on one occasion. It is likely, therefore, that barley crops that develop moderate or severe take-all would benefit from these seed treatments in the same way as wheat.

The inconsistency of Amistar was further demonstrated in the barley experiments. It decreased take-all in CS/575 at Woburn in 2003 without affecting yield but increased yield in CS/596 in 2004 in the absence of take-all. It increased take-all in NAS 2425 in 2003.

There was no evidence that seed or spray treatments can be useful in moderating the excessive N concentrations in grain that can occur in crops suffering from take-all.

5. Conclusions

5.1 Objective 1: to test the extent to which yields can be maintained in two-three successive wheat crops by integrating treatments applied to control take-all

1. Seed treatment formulations based on fluquinconazole (Jockey) or silthiofam (Latitude) almost always decreased take-all and increased yields when applied to either second or third wheat crops in eastern England, but yield increases were less in Norfolk than in Hertfordshire.
2. Latitude decreased take-all during the spring more than did Jockey, through effective control of early disease.
3. Jockey usually controlled the development of severe take-all in the summer more effectively than did Latitude.
4. Latitude often increased yield more than Jockey, but relative effects were variable.
5. A non-treated third wheat crop grown after a treated second wheat crop usually showed little or no benefit from treatment of the second wheat, since take-all continued to develop. Non-treatment of a fourth wheat crop after previously-treated crops was

detrimental, since the crop did not benefit from the take-all decline that developed in the absence of treatment.

6. The best yields in third wheat crops were obtained by treating the third crop with Latitude and the preceding second crop with Jockey or Latitude, but were usually well below the yield that would have been expected from a healthy crop.
7. Amistar tended to decrease take-all severity more than incidence, and sometimes increased grain yield, but the effects were inconsistent, and information on the circumstances and conditions in which it is likely to be effective is required.
8. Amistar can sometimes add to the effects of Latitude.

5.2 Objective 2: to test whether fungicides used to control take-all can improve the economics of growing barley in cereal sequences

1. Seed treatment with Jockey or Latitude, or spray treatment with Amistar, can decrease take-all in barley.
2. In the absence of severe take-all, fungicides rarely affected grain yield or quality and no evidence was found that fungicides could be helpful in regulating grain nitrogen in crops affected by take-all.

5.3 Recommendations

Some recommendations for the use of fungicides to limit the effects of take-all in winter wheat can now be made. It is, however, advisable also to exploit other measures to minimise take-all. These include avoiding cereal volunteers and grass weeds, especially couch, but also bromes and black-grass, in preceding break crops, maintaining the soil in good condition, avoiding cultivars known to perform poorly as second wheats, and delaying drilling (even of first wheat) as much as is practically and economically possible. It is particularly important to know whether or not the field is prone to severe take-all, and the yields that might be expected from second and third wheat crops grown in that field.

Second wheats known (mainly from the field's previous history) to be at risk from take-all will usually give an economic return from seed treatments based on fluquinconazole (such as Jockey) or silthiofam (Latitude). The yield benefit (up to 1.3 t/ha in our experiments) may be particularly good if take-all development was potentially rapid and likely to have become severe. Late, but rapid, developing take-all may benefit more from Jockey, but prediction of this is not practical. Similarly, seed treatment will usually be effective in a third wheat crop grown after a non-treated second wheat crop in which take-all had not become severe.

Where take-all has become severe in a second wheat, or where a second wheat yielded below its potential because of take-all, even with seed treatment, a third wheat crop should not be grown. It may be replaced, however, by a barley crop, which may benefit from seed treatment, although is not possible to recommend fungicide treatments for winter barley on the basis of these experiments. Where seed treatment, or other measures, resulted in only slight take-all and acceptable yields in a second wheat, a third wheat might be considered but, if grown, it should be treated with Latitude.

Amistar applied at T1 may give some protection from late-developing take-all, particularly if applied to Latitude-treated crops. It is possible that it will be most effective when applied to wet soils and/or in wet weather, but this is being investigated further.

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Table 1. *Field experiments in harvest years 2003-2005*

Crop, location	Second cereal, 2003	Third cereal, 2004	Second cereal, 2004	Third cereal, 2005	Fourth cereal, 2005
Wheat, Rothamsted	CS/573 CS/574	[CS/573] [CS/574]	CS/597 CS/598	[CS/597] [CS/598]	 [CS/574]
Wheat, Morley	NAS 2427	-	034A 034B	[034A] [034B]	-
Barley, Woburn (Rothamsted)	CS/575[a]	-	-	-	-
Barley, Rothamsted	-	-	CS/596	[CS/596]	-
Barley, Morley	NAS 2425 NAS 2426	[NAS 2425 = 033A] [NAS 2426 = 033B] [NAS 2427 = 034][b]	-	-	-

Square brackets indicate continuation of experiment from preceding year.
[a]Discontinued after second cereal because of crop failure in third cereal.
[b]Barley as a third cereal after wheat as the second cereal.
The "NAS" experiment coding system was discontinued after 2003.

Table 2. *Dates (growth stages) on which experiments were sown, plants and soils were sampled, experimental sprays were applied and grain was harvested in field experiments begun in winter wheat or barley crops grown as second cereals*

Experiment	Previous crop (1^{st} cereal)	Sowing date (seeds/m^2))	Date of spring sample (GS)	Amistar or RR1 applied[a]	Date of summer sample (GS)	Date of grain harvest
Rothamsted wheat						
CS/573, 2003	Winter wheat	23 September (300)	1 May (22-30)	7 May + 28 May	1 July (73)	7 August
CS/573, 2004	Winter wheat	14 October (400)	15 April (22)	6 May + 7 June	5 July (73)	15 August
CS/574, 2003	Winter wheat	23 September (300)	8 May (30)	Not treated	3 July (71)	7 August
CS/574, 2004	Winter wheat	14 October (400)	19 April (22)	Not treated	5 July (73)	20 August
CS/574, 2005	Winter wheat	17 September (350)	20 April (31)	Not treated	27 June (73)	12 August
CS/597, 2004	Winter wheat	25 September (400)	13 April (30)	6 May + 7 June	6 July (73)	15 August
CS/597, 2005	Winter wheat	16 September (350)	12 April (30)	20 April + 31 May	4 July (75)	11 August
CS/598, 2004	Winter wheat	25 September (400)	16 April (30)	6 May + 7 June	2 July (73)	15 August
CS/598, 2005	Winter wheat	16 September (350)	16 March (22)	20 April + 31 May	1 July (73)	8 August
Morley wheat						
NAS 2427, 2003	Winter wheat	28 September (400)	7 April (23)	8 May + 28 May	7 July (73)	15 August
WW04-034A, 2004	Winter wheat	9 October (400)	5 April (22)	6 May +26 May	29 June (73)	5 September
WW05-034A, 2005	Winter wheat	28 October (400)	22 April (31)	12 May +27 May	29 June (73)	28 August
WW04-034B, 2004	Winter wheat	9 October (400)	5 April (21)	6 May +26 May	29 June (73)	2 September
WW05-034B, 2005	Winter wheat	28 October (400)	22 April (30)	12 May +27 May	29 June (73)	28 August
Rothamsted barley						
CS/575, 2003 (Woburn)	Winter wheat	1 October (350)	23 April (23-24)	6 May + 28 May	25 June (83)	22 July
CS/596, 2004	Winter barley	22 September (350)	30 March (23)	5 May + 17 May	25 June (77)	29 July
CS/596, 2005	Winter barley	14 September (350)	10 March (24)	12 April + 29 April	21 June (83)	2 August
Morley barley						
NAS 2425, 2003	Spring barley	26 September (400)	7 April (31)	17 April +30 April	19 June (77)	19 July
NAS 2425, 2004 (=WB04-033A)	Spring barley	25 September (400)	22 March (23)	16 April + 12 May	22 June (83)	29 July
NAS 2426, 2003	Durum wheat	27 September (400)	7 April (31)	16 April + 6 May	19 June (85)	28 July
NAS 2426, 2004 (=WB04-033B)	Durum wheat	8 October (400)	22 March (23)	23 April + 12 May	22 June (85)	29 July
NAS 2427, 2004 (=WB04-034)[b]	Winter wheat	25 September (400)	22 March (30)	9 April + 5 May	22 June (83)	29 July

[a]Amistar was applied at 1.0 and 0.6 L/ha, respectively, on the dates shown, RR1 at 2.5 and 1.5 L/ha. [b]Barley as 3^{rd} cereal after wheat as the 2^{nd} cereal.

Table 3. *Take-all in summer and grain yields in Sibutol-treated (control) plots in field experiments on winter wheat*

Experiment	Harvest years	Take-all index (0-100) 2nd cereal	3rd cereal	4th cereal	Grain yield (t/ha) 2nd cereal	3rd cereal	4th cereal
Rothamsted							
CS/573	2003-04	32	86	-	7.74	4.97	-
CS/574	2003-05	37	88	61	7.48	4.91	7.36
CS/597	2004-05	41	94	-	6.87	3.13	-
CS/598	2004-05	75	94	-	7.07	3.18	-
Morley							
NAS2427	2003	88	-	-	5.60	-	-
034MRA	2004-05	33	33	-	9.34	9.86	-
034MRB	2004-05	44	37	-	7.09	7.60	-

Table 4. *Take-all in summer and grain yields in Raxil-treated (control) plots in field experiments on winter barley*

Experiment	Harvest years	Take-all index (0-100) 2nd cereal	3rd cereal	Grain yield (t/ha) 2nd cereal	3rd cereal
Rothamsted					
CS/575 (Woburn)	2003	29	-	5.51	-
CS/596	2004-05	0	11	7.95	9.21
Morley					
NAS2425	2003-04	0	10	8.61	8.00
NAS2426	2003-04	17	28	5.34	3.91
NAS2427	2004	-	9	-	8.95

Table 5. *Experiment CS/573: effects of seed treatments on take-all in spring in wheat grown as a second cereal, 2003*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None (Sibutol)	0.27 (62.7)	1.06
Jockey	0.07 (52.9)	0.74
Latitude	-0.12 (43.4)	0.58
SED (22 d.f.)	0.142	0.117
P	0.036	0.002

Table 6. *Experiment CS/573: effects of seed treatments and foliar fungicides on take-all in summer in wheat grown as a second cereal, 2003*

	Foliar treatment			
	None	Amistar	RR1	All foliar treatments
Seed treatment				
	Take-all index (0-100)			
None[a]	32.4	35.6	29.3	32.4
Jockey	18.8	17.8	21.5	19.4
Latitude	17.6	14.0	13.1	14.9
SED	3.85, 3.91 (48 d.f.)			2.15 (22 d.f.)
P	0.350 (interaction)			<0.001
All seed tr.	22.9	22.5	21.3	
SED	2.26 (48 d.f.)			
P	0.758			
	Logit % plants with take-all (back-transformed mean)			
None[a]	0.61 (76.7)	0.54 (74.0)	0.45 (70.4)	0.53 (73.8)
Jockey	0.20 (59.2)	0.12 (55.3)	0.25 (61.9)	0.19 (58.8)
Latitude	-0.06 (46.4)	-0.07 (45.8)	-0.17 (41.3)	-0.10 (44.5)
SED	0.162, 0.171 (48 d.f.)			0.084 (22 d.f.)
P	0.838 (interaction)			<0.001
All seed tr.	0.25 (61.6)	0.19 (59.0)	0.18 (58.3)	
SED	0.099 (48 d.f.)			
P	0.761			
	Logit % plants with moderate or severe take-all (back-transformed mean)			
None[a]	-0.68 (20.0)	-0.34 (33.3)	-0.57 (23.6)	-0.53 (25.3)
Jockey	-1.29 (6.6)	-1.44 (4.9)	-1.11 (9.2)	-1.28 (7.0)
Latitude	-1.19 (8.0)	-1.35 (5.8)	-1.44 (4.9)	-1.32 (6.1)
SED	0.235, 0.238 (48 d.f.)			0.141 (22 d.f.)
P	0.287 (interaction)			<0.001
All seed tr.	-1.05 (10.4)	-1.04 (10.6)	-1.04 (10.6)	
SED (d.f.)	0.136 (48 d.f.)			
P	0.995			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons within the same seed treatment, the smaller one for all other comparisons.

Table 7. *Experiment CS/573: effects of seed treatments and foliar fungicides on grain yield of wheat grown as a second cereal, 2003*

	Grain yield (t/ha)			
Foliar treatment…	None	Amistar	RR1	All foliar treatments
Seed treatment				
None (Sibutol)	7.74	7.63	7.66	7.68
Jockey	7.92	7.91	8.01	7.95
Latitude	8.29	8.13	8.10	8.17
SED	0.158, 0.168 (48 d.f.)			0.078 (22 d.f.)
P	0.831 (interaction)			<0.001
All seed tr.	7.99	7.89	7.92	
SED	0.097 (48 d.f.)			
P	0.602			

Where two SEDs are shown, the larger one is for comparisons within the same seed treatment, the smaller one for all other comparisons.

Table 8. *Experiment CS/573: effects of seed treatments on take-all in spring in wheat grown as a third cereal, 2004*

Seed treatment 2003	None[a] 2004	Jockey 2004	Latitude 2004	All 2004
	Logit % plants (back-transformed mean)			
None[a]	0.40 (68.3)	0.42 (69.2)	-0.31 (34.7)	0.17 (57.9)
Jockey	0.28 (63.0)	0.29 (63.7)	-0.43 (29.2)	0.05 (51.8)
Latitude	0.08 (53.3)	0.07 (52.8)	-0.35 (32.5)	-0.07 (46.0)
SED (16 d.f.)	0.310			0.179
P	0.937 (interaction)			0.430
All 2003	0.25 (61.7)	0.26 (62.2)	-0.36 (32.1)	
SED (16 d.f.)	0.179			
P	0.004			
	No. infected roots per plant			
None[a]	1.44	1.48	0.59	1.17
Jockey	1.35	1.21	0.43	1.00
Latitude	1.57	0.98	0.62	1.05
SED (16 d.f.)	0.398			0.230
P	0.807 (interaction)			0.754
All 2003	1.45	1.22	0.55	
SED (16 d.f.)	0.230			
P	0.003			

[a]Sibutol only.

Table 9. *Experiment CS/573: effects of seed treatments and foliar fungicides on areas of take-all patches in wheat grown as a third cereal, 8 July 2004*

		Logit % plot area (back-transformed mean)			
		Foliar treatment (both years)			
Seed treatment 2003	Seed treatment 2004	None	Amistar	RR1	All foliar treatments
None[a]	None[a]	0.32 (64.9)	-0.18 (40.6)	-0.78 (16.9)	-0.22 (38.9)
None[a]	Jockey	-0.57 (23.6)	-1.00 (11.5)	-1.14 (8.7)	-0.90 (13.6)
None[a]	Latitude	-0.92 (13.2)	-1.78 (2.3)	-1.62 (3.2)	-1.44 (4.8)
Jockey	None[a]	-0.23 (38.2)	0.39 (68.2)	-0.85 (15.1)	-0.23 (38.3)
Jockey	Jockey	-0.12 (43.7)	-0.91 (13.4)	-0.54 (24.9)	-0.52 (25.5)
Jockey	Latitude	-1.42 (5.0)	-2.40 (0.3)	-0.62 (21.8)	-1.48 (4.4)
Latitude	None[a]	-0.12 (43.8)	-0.35 (32.5)	-1.20 (7.8)	-0.56 (24.2)
Latitude	Jockey	-1.00 (11.5)	-0.30 (35.0)	-0.80 (16.4)	-0.70 (19.4)
Latitude	Latitude	-1.47 (4.5)	-1.50 (4.2)	-1.69 (2.8)	-1.55 (3.8)
SED		0.576, 0.678 (36 d.f.)			0.160 (16 d.f.)
P		0.630 (interaction)			0.151
None[a]	All 2004	-0.01 (30.9)	-0.99 (11.7)	-1.18 (8.1)	-0.85 (14.9)
Jockey	All 2004	-0.59 (23.0)	-0.97 (12.0)	-0.67 (20.3)	-0.74 (17.9)
Latitude	All 2004	-0.86 (14.7)	-0.72 (18.7)	-1.23 (7.4)	-0.94 (12.8)
SED		0.333, 0.391 (36 d.f.)			0.092 (16 d.f.)
P		0.442 (interaction)			0.147
All 2003	None[a]	-0.01 (49.0)	-0.05 (47.1)	-0.94 (12.7)	-0.33 (33.4)
All 2003	Jockey	-0.56 (24.0)	-0.74 (18.2)	-0.83 (15.6)	-0.71 (19.0)
All 2003	Latitude	-1.27 (6.8)	-1.89 (1.7)	-1.31 (6.3)	-1.49 (4.3)
SED		0.333, 0.391 (36 d.f.)			0.092 (16 d.f.)
P		0.139 (interaction)			<0.001
All 2003	All 2004	-0.61 (22.2)	-0.89 (13.9)	-1.03 (10.9)	
SED		0.226 (36 d.f.)			
P		0.190			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 10. *Experiment CS/573: effects of seed treatments and foliar fungicides on take-all index in summer in wheat grown as a third cereal, 2004*

		Take-all index (0-100)			
		Foliar treatment (both years)			
Seed treatment 2003	Seed treatment 2004	None	Amistar	RR1	All foliar treatments
None[a]	None[a]	85.7	77.4	65.8	76.3
None[a]	Jockey	61.9	62.8	54.4	59.7
None[a]	Latitude	55.7	48.8	52.7	52.4
Jockey	None[a]	69.4	83.9	69.3	74.2
Jockey	Jockey	64.1	55.2	57.6	59.0
Jockey	Latitude	55.9	43.2	67.3	55.5
Latitude	None[a]	84.7	79.4	67.9	77.3
Latitude	Jockey	54.8	62.8	47.8	55.1
Latitude	Latitude	59.3	47.6	45.2	50.7
SED		10.28, 11.16 (36 d.f.)			4.75 (16 d.f.)
P		0.758 (interaction)			0.736
None[a]	All 2004	67.8	63.0	57.6	62.8
Jockey	All 2004	63.1	60.8	64.7	62.9
Latitude	All 2004	66.3	63.3	53.6	61.1
SED		5.93, 6.44 (36 d.f.)			2.74 (16 d.f.)
P		0.493 (interaction)			0.760
All 2003	None[a]	79.9	80.2	67.7	75.9
All 2003	Jockey	60.3	60.3	53.3	57.9
All 2003	Latitude	57.0	46.5	55.1	52.9
SED		5.93, 6.44 (36 d.f.)			2.74 (16 d.f.)
P		0.230 (interaction)			<0.001
All 2003	All 2004	65.7	62.3	58.7	
SED		3.72			
P		0.180			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 11. *Experiment CS/573: effects of seed treatments and foliar fungicides on take-all incidence in summer in wheat grown as a third cereal, 2004*

	Logit % plants with take-all (back-transformed mean)			
	Foliar treatment (both years)			
Seed treatment 2004 (averaged over 2003 treatments)	None	Amistar	RR1	All foliar treatments
	All severity categories			
None (Sibutol)	2.14 (98.1)	2.22 (98.3)	2.08 (98.0)	2.15 (98.1)
Jockey	2.05 (97.9)	1.82 (96.9)	1.42 (94.0)	1.76 (96.6)
Latitude	1.26 (92.0)	1.01 (87.7)	1.31 (92.7)	1.19 (91.1)
SED	0.289, 0.319 (36 d.f.)			0.127 (16 d.f.)
P	0.440 (interaction)			<0.001
	Severe take-all only			
None (Sibutol)	0.12 (55.5)	0.19 (58.8)	-0.42 (29.9)	-0.04 (47.7)
Jockey	-0.92 (13.2)	-0.84 (15.1)	-0.97 (12.1)	-0.91 (13.4)
Latitude	-0.42 (29.6)	-0.87 (14.5)	-0.53 (25.1)	-0.61 (22.4)
SED	0.188, 0.207 (36 d.f.)			0.081 (16 d.f.)
P	0.033 (interaction)			<0.001

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 12. *Experiment CS/573: effects of seed treatments and foliar fungicides on eyespot incidence in summer in wheat grown as a third cereal, 2004*

	Foliar treatment (both years)			
Seed treatment 2004	None	Amistar	RR1	All foliar treatments
	Logit % stems with eyespot (back-transformed mean)			
None (Sibutol)	-0.14 (42.5)	-0.58 (23.3)	-1.69 (2.8)	-0.81 (16.2)
Jockey	-0.29 (35.3)	-0.50 (26.8)	-1.74 (2.5)	-0.84 (15.1)
Latitude	0.03 (50.9)	-0.38 (31.4)	-1.55 (3.8)	-0.63 (21.5)
SED	0.146, 0.159 (36 d.f.)			0.068 (16 d.f.)
P	0.865 (interaction)			0.015
All seed tr.	-0.14 (42.8)	-0.49 (26.9)	-1.66 (3.0)	
SED	0.092 (36 d.f.)			
P	<0.001			
	Logit % stems with moderate or severe eyespot (back-transformed mean)			
None (Sibutol)	-0.67 (20.3)	-1.29 (6.5)	-2.42 (0.3)	-1.46 (4.6)
Jockey	-0.76 (17.5)	-1.21 (7.7)	-2.28 (0.5)	-1.42 (5.1)
Latitude	-0.59 (23.1)	-1.15 (8.6)	-2.12 (0.9)	-1.23 (6.6)
SED	0.155, 0.176 (36 d.f.)			0.058 (16 d.f.)
P	0.848 (interaction)			0.022
All seed tr.	-0.67 (20.2)	-1.22 (7.6)	-2.28 (0.5)	
SED	0.102 (36 d.f.)			
P	<0.001			

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 13. *Experiment CS/573: effects of seed treatments and foliar fungicides on grain yield of wheat grown as a third cereal, 2004*

		Grain yield (t/ha)			
		Foliar treatment (both years)			
Seed treatment 2003	Seed treatment 2004	None	Amistar	RR1	All foliar treatments
None[a]	None[a]	4.97	5.74	6.62	5.78
None[a]	Jockey	6.06	6.72	7.03	6.60
None[a]	Latitude	6.83	8.03	8.09	7.65
Jockey	None[a]	5.50	4.98	6.67	5.72
Jockey	Jockey	6.11	6.69	6.63	6.41
Jockey	Latitude	7.50	8.46	6.63	7.53
Latitude	None[a]	5.88	5.74	7.07	6.23
Latitude	Jockey	6.90	5.89	7.18	6.65
Latitude	Latitude	7.23	8.44	8.49	8.05
SED		0.845, 0.952 (36 d.f.)			0.333 (16 d.f.)
P		0.837 (interaction)			0.914
None[a]	All 2004	5.95	6.83	7.25	6.68
Jockey	All 2004	6.37	6.71	6.58	6.55
Latitude	All 2004	6.67	6.58	7.58	6.98
SED		0.488, 0.550 (36 d.f.)			0.192 (16 d.f.)
P		0.515 (interaction)			0.105
All 2003	None[a]	5.45	5.49	6.79	5.91
All 2003	Jockey	6.36	6.43	6.88	6.56
All 2003	Latitude	7.19	8.31	7.73	7.74
SED		0.488, 0.550 (36 d.f.)			0.192 (16 d.f.)
P		0.188 (interaction)			<0.001
All 2003	All 2004	6.33	6.74	7.13	
SED		0.317 (36 d.f.)			
P		0.052			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 14. *Experiment CS/573: effects of seed treatments and foliar fungicides on quality of grain from wheat grown as a third cereal, 2004*

Seed treatment 2004 (averaged over 2003 treatments)	Foliar treatment (both years) None	Amistar	RR1	All foliar treatments
	1000-grain weight (g)			
None (Sibutol)	31.5	31.9	32.3	31.9
Jockey	33.1	32.6	33.0	32.9
Latitude	33.6	34.2	33.6	33.8
SED		0.83, 0.89 (36 d.f.)		0.41 (16 d.f.)
P		0.802 (interaction)		<0.001
All seed tr.	32.7	32.9	33.0	
SED		0.51		
P		0.871		
	Hectolitre weight (kg hL^{-1})			
None (Sibutol)	67.1	68.8	69.5	68.4
Jockey	68.9	70.2	70.1	69.7
Latitude	68.7	70.2	69.0	69.5
SED		0.86, 0.85 (36 d.f.)		0.50 (16 d.f.)
P		0.431 (interaction)		0.056
All seed tr.	68.2	69.7	69.5	
SED		0.49 (36 d.f.)		
P		0.008		

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 15. *Experiment CS/574: effects of seed treatments on take-all in spring and summer and on grain yield in wheat grown as a second cereal, 2003*

	Spring		Summer			
Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	Logit % plants with moderate or severe take-all (back-transformed mean)	Grain yield (t/ha)
None[a]	0.08 (53.3)	0.82	36.7	0.61 (76.9)	-0.41 (30.2)	7.48
Jockey	-0.11 (44.0)	0.59	16.3	0.05 (52.0)	-1.44 (4.9)	7.94
Latitude	-0.43 (29.0)	0.41	16.5	-0.06 (46.4)	-1.22 (7.5)	7.98
SED (76 d.f.)	0.100	0.076	2.69	0.101	0.139	0.111
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[a]Sibutol only.

Table 16. *Experiment CS/574: effects of seed treatments on take-all in spring in wheat grown as a third cereal, 2004*

Seed treatment	None[a] 2004	Jockey 2004	Latitude 2004	All 2004
	Logit % plants (back-transformed mean)			
None[a] 2003	0.60 (76.4)	0.73 (80.8)	0.05 (52.0)	0.46 (71.1)
Jockey 2003	0.51 (72.8)	0.30 (63.9)	-0.11 (43.8)	0.23 (60.7)
Latitude 2003	0.54 (74.0)	0.30 (63.8)	-0.04 (47.7)	0.27 (62.4)
SED (70 d.f.)		0.175		0.101
P		0.500 (interaction)		0.052
All 2003	0.55 (74.4)	0.44 (70.3)	-0.03 (47.8)	
SED (70 d.f.)		0.101		
P		<0.001		
	No. infected roots per plant			
None[a] 2003	2.04	1.58	0.97	1.53
Jockey 2003	1.67	1.24	0.77	1.23
Latitude 2003	1.91	1.05	0.88	1.28
SED (70 d.f.)		0.232		0.134
P		0.570 (interaction)		0.060
All 2003	1.87	1.29	0.88	
SED (70 d.f.)		0.134		
P		<0.001		

[a]Sibutol only.

Table 17. *Experiment CS/574: effects of seed treatments on take-all in summer in wheat grown as a third cereal, 2004*

Seed treatment 2003	None[a] 2004	Jockey 2004	Latitude 2004	All 2004
	Take-all index (0-100)			
None[a]	88.0	66.1	56.2	70.1
Jockey	76.2	61.4	55.2	64.3
Latitude	77.1	53.5	56.5	62.4
SED (70 d.f.)		4.16		2.40
P		0.005 (interaction)		0.005
All 2003	80.5	60.3	56.0	
SED (70 d.f.)		2.40		
P		<0.001		
	Logit % plants with take-all (back-transformed mean)			
None[a]	2.58 (98.9)	2.03 (97.8)	1.28 (92.3)	1.97 (97.6)
Jockey	1.85 (97.1)	1.74 (96.5)	1.19 (91.0)	1.59 (95.3)
Latitude	1.82 (97.0)	1.68 (96.1)	1.17 (90.7)	1.56 (95.2)
SED (70 d.f.)		0.241		0.139
P		0.302 (interaction)		0.007
All 2003	2.09 (98.0)	1.82 (96.9)	1.21 (91.4)	
SED (70 d.f.)		0.139		
P		<0.001		
	Logit % plants with moderate or severe take-all (back-transformed mean)			
None[a]	1.41 (93.9)	0.59 (76.0)	0.19 (58.9)	0.73 (80.7)
Jockey	0.72 (80.4)	0.40 (68.7)	0.16 (57.2)	0.43 (69.6)
Latitude	0.76 (81.6)	0.16 (57.4)	0.14 (56.5)	0.35 (66.5)
SED (70 d.f.)		0.135		0.078
P		0.004 (interaction)		<0.001
All 2003	0.97 (86.8)	0.38 (67.8)	0.16 (57.5)	
SED (70 d.f.)		0.078		
P		<0.001		
	Logit % plants with severe take-all (back-transformed mean)			
None[a]	0.34 (66.1)	-0.71 (19.0)	-0.66 (20.7)	-0.34 (33.1)
Jockey	0.07 (53.2)	-0.77 (17.1)	-0.72 (18.6)	-0.47 (27.5)
Latitude	0.00 (49.6)	-1.18 (8.2)	-0.60 (22.7)	-0.59 (23.0)
SED (70 d.f.)		0.159		0.092
P		0.087 (interaction)		0.030
All 2003	0.14 (56.5)	-0.89 (14.1)	-0.66 (20.6)	
SED (70 d.f.)		0.092		
P		<0.001		

[a]Sibutol only.

Table 18. *Experiment CS/574: effects of seed treatments on grain yield and quality in wheat grown as a third cereal, 2004*

Treatment 2003	None[a] 2004	Jockey 2004	Latitude 2004	All 2004
	Grain yield (t/ha)			
None[a]	4.91	6.08	7.29	6.09
Jockey	5.96	6.37	7.43	6.59
Latitude	6.05	6.90	7.49	6.81
SED (70 d.f.)	0.374			0.216
P	0.286 (interaction)			0.005
All	5.64	6.45	7.40	
SED (70 d.f.)	0.216			
P	<0.001			
	1000-grain weight (g)			
None[a]	29.7	33.4	33.1	32.0
Jockey	31.2	32.7	33.5	32.5
Latitude	31.6	33.0	33.4	32.7
SED (70 d.f.)	0.81			0.47
P	0.250 (interaction)			0.366
All	30.8	33.0	33.4	
SED (70 d.f.)	0.47			
P	<0.001			
	Hectolitre weight (kg/hL)			
None[a]	66.1	69.7	68.9	68.2
Jockey	68.7	67.7	68.8	68.4
Latitude	67.6	68.9	69.4	68.7
SED (70 d.f.)	0.93			0.54
P	0.020 (interaction)			0.710
All	67.5	68.8	69.1	
SED (70 d.f.)	0.54			
P	0.011			

[a]Sibutol only.

Table 19. *Experiment CS/574: effects of seed treatments on take-all in spring in wheat grown as a fourth cereal, 2005*

Treatment 2003	Treatment 2004	None[a] 2005	Jockey 2005	Latitude 2005	All 2005
		Logit % plants infected (back-transformed mean)			
None[a]	All 2004	1.05 (88.6)	0.78 (82.2)	0.62 (77.2)	0.82 (83.2)
Jockey	All 2004	1.57 (95.4)	1.21 (91.4)	0.86 (84.2)	1.21 (91.4)
Latitude	All 2004	1.45 (94.3)	1.04 (88.3)	0.66 (78.4)	1.05 (88.6)
SED (52 d.f.)			0.207		0.120
P			0.771 (interaction)		0.007
All 2003	None[a]	1.33 (93.0)	0.74 (81.0)	0.60 (76.5)	0.89 (85.1)
All 2003	Jockey	1.41 (93.9)	1.04 (88.4)	0.68 (79.0)	1.04 (88.5)
All 2003	Latitude	1.34 (93.0)	1.25 (91.9)	0.86 (84.3)	1.15 (90.4)
SED (52 d.f.)			0.207		0.120
P			0.527 (interaction)		0.107
All 2003	All 2004	1.36 (93.3)	1.01 (87.8)	0.71 (80.1)	
SED (52 d.f.)			0.120		
P			<0.001		
		Number of infected roots per plant			
None[a]	All 2004	3.47	2.12	2.02	2.54
Jockey	All 2004	4.78	2.83	2.63	3.41
Latitude	All 2004	4.81	2.68	1.93	3.14
SED (52 d.f.)			0.461		0.266
P			0.300 (interaction)		0.006
All 2003	None[a]	4.04	2.22	1.89	2.72
All 2003	Jockey	4.39	2.52	1.93	2.95
All 2003	Latitude	4.63	2.90	2.75	3.43
SED (52 d.f.)			0.461		0.266
P			0.928 (interaction)		0.030
All 2003	All 2004	4.35	2.55	2.19	
SED (52 d.f.)			0.266		
P			<0.001		

[a]Sibutol only.

Table 20. *Experiment CS/574: effects of seed treatments on areas of severe take-all patches in wheat grown as a fourth cereal, 28 June 2005*

		Logit of % plot area with severe take-all patch (back-transformed mean)			
Treatment 2003	Treatment 2004	None 2005	Jockey 2005	Latitude 2005	All 2005
None[a]	None[a]	-0.65 (21.1)	-1.00 (11.5)	-0.73 (18.3)	-0.79 (16.6)
None[a]	Jockey	0.01 (49.7)	-0.03 (47.8)	-1.34 (5.9)	-0.46 (28.1)
None[a]	Latitude	0.14 (56.5)	-0.10 (44.7)	-0.60 (22.8)	-0.18 (40.4)
Jockey	None[a]	-0.07 (46.1)	-0.48 (27.2)	-0.59 (23.1)	-0.38 (31.4)
Jockey	Jockey	0.14 (56.4)	-0.37 (31.7)	-0.48 (27.1)	-0.24 (37.8)
Jockey	Latitude	0.27 (62.4)	0.00 (49.5)	-0.40 (30.5)	-0.05 (47.3)
Latitude	None[a]	0.18 (58.2)	-0.48 (27.1)	-0.79 (16.7)	-0.36 (32.1)
Latitude	Jockey	0.10 (54.5)	-0.46 (28.0)	-0.52 (25.7)	-0.29 (35.3)
Latitude	Latitude	0.17 (57.9)	-0.26 (37.0)	-0.39 (30.9)	-0.16 (41.6)
SED (52 d.f.)			0.270		0.156
P			0.054 (interaction)		0.472
None[a]	All 2004	-0.17 (41.3)	-0.38 (31.6)	-0.89 (13.9)	-0.48 (27.3)
Jockey	All 2004	0.11 (55.1)	-0.28 (35.7)	-0.49 (26.8)	-0.22 (38.7)
Latitude	All 2004	0.15 (56.9)	-0.40 (30.6)	-0.57 (23.9)	-0.27 (36.3)
SED (52 d.f.)			0.156		0.090
P			0.436 (interaction)		0.015
All 2003	None[a]	-0.18 (40.7)	-0.65 (20.8)	-0.70 (19.2)	-0.51 (26.0)
All 2003	Jockey	0.08 (53.6)	-0.29 (35.5)	-0.78 (16.8)	-0.33 (33.6)
All 2003	Latitude	0.19 (59.0)	-0.12 (43.7)	-0.46 (27.9)	-0.13 (43.1)
SED (52 d.f.)			0.156		0.090
P			0.323 (interaction)		<0.001
All 2003	All 2004	0.03 (51.1)	-0.35 (32.6)	-0.65 (21.0)	
SED (52 d.f.)			0.090		
P			<0.001		

[a]Sibutol only.

Table 21. *Experiment CS/574: effects of seed treatments on take-all index in summer in wheat grown as a fourth cereal, 2005*

		Take-all index (0-100)			
Treatment 2003	Treatment 2004	None[a] 2005	Jockey 2005	Latitude 2005	All 2005
None[a]	None[a]	60.9	38.8	51.4	50.3
None[a]	Jockey	77.3	63.5	31.5	57.4
None[a]	Latitude	76.0	69.2	43.8	63.0
Jockey	None[a]	80.1	53.7	51.4	61.7
Jockey	Jockey	83.5	64.5	43.3	63.8
Jockey	Latitude	77.9	69.1	54.7	67.2
Latitude	None[a]	86.2	54.9	50.0	63.7
Latitude	Jockey	73.6	56.3	63.7	64.5
Latitude	Latitude	79.1	60.5	50.9	63.5
SED (52 d.f.)			7.91		4.57
P			0.015 (interaction)		0.408
None[a]	All 2004	71.4	57.2	42.2	56.9
Jockey	All 2004	80.5	62.4	49.8	64.2
Latitude	All 2004	79.6	57.3	54.9	63.9
SED (52 d.f.)			4.57		2.64
P			0.351 (interaction)		0.011
All 2003	None[a]	75.7	49.1	50.9	58.6
All 2003	Jockey	78.1	61.4	46.2	61.9
All 2003	Latitude	77.7	66.3	49.8	64.6
SED (52 d.f.)			4.57		2.64
P			0.034 (interaction)		0.086
All 2003	All 2004	77.2	58.9	49.0	
SED (52 d.f.)			2.64		
P			<0.001		

[a]Sibutol only.

Table 22. *Experiment CS/574: effects of seed treatments on grain yield of wheat grown as a fourth cereal, 2005*

		Grain yield (t/ha)			
Treatment 2003	Treatment 2004	None[a] 2005	Jockey 2005	Latitude 2005	All 2005
None[a]	None[a]	7.36	8.50	7.33	7.73
None[a]	Jockey	5.61	6.29	8.72	6.87
None[a]	Latitude	6.05	5.87	6.85	6.26
Jockey	None[a]	5.70	6.89	7.03	6.54
Jockey	Jockey	5.14	6.46	7.19	6.26
Jockey	Latitude	5.75	5.48	6.71	5.98
Latitude	None[a]	5.06	6.75	7.79	6.53
Latitude	Jockey	5.46	6.73	6.60	6.26
Latitude	Latitude	5.11	6.48	6.62	6.07
SED (52 d.f.)			0.627		0.362
P			0.015 (interaction)		0.324
None[a]	All 2004	6.34	6.89	7.63	6.95
Jockey	All 2004	5.53	6.28	6.98	6.26
Latitude	All 2004	5.21	6.65	7.00	6.29
SED (52 d.f.)			0.362		0.209
P			0.501 (interaction)		0.002
All 2003	None[a]	6.04	7.38	7.38	6.93
All 2003	Jockey	5.40	6.49	7.50	6.47
All 2003	Latitude	5.64	5.94	6.73	6.10
SED (52 d.f.)			0.362		0.209
P			0.089 (interaction)		<0.001
All 2003	All 2004	5.69	6.61	7.20	
SED (52 d.f.)			0.209		
P			<0.001		

[a]Sibutol only.

Table 23. *Experiment CS/574: effects of seed treatments on hectolitre weight of grain from wheat grown as a fourth cereal, 2005*

		Hectolitre weight (kg/hL)			
Treatment 2003	Treatment 2004	None[a] 2005	Jockey 2005	Latitude 2005	All 2005
None[a]	None[a]	69.3	69.8	69.8	69.7
None[a]	Jockey	67.3	67.2	70.8	68.4
None[a]	Latitude	67.5	68.0	69.5	68.3
Jockey	None[a]	67.2	68.7	69.5	68.4
Jockey	Jockey	67.2	67.5	70.8	68.5
Jockey	Latitude	66.8	65.3	67.8	66.7
Latitude	None[a]	66.2	67.0	69.5	67.6
Latitude	Jockey	67.3	68.0	68.3	67.9
Latitude	Latitude	65.3	67.3	65.8	66.2
SED (52 d.f.)			1.28		0.74
P			0.213 (interaction)		0.402
None[a]	All 2004	68.1	68.3	70.1	68.8
Jockey	All 2004	67.1	67.2	69.4	67.9
Latitude	All 2004	66.3	67.4	67.9	67.2
SED (52 d.f.)			0.74		0.43
P			0.535 (interaction)		0.002
All 2003	None[a]	67.6	68.5	69.6	68.6
All 2003	Jockey	67.3	67.6	70.0	68.3
All 2003	Latitude	66.6	66.9	67.7	67.1
SED (52 d.f.)			0.74		0.43
P			0.464 (interaction)		0.002
All 2003	All 2004	67.1	67.6	69.1	
SED (52 d.f.)			0.43		
P			<0.001		

[a]Sibutol only.

Table 24. *Experiment CS/597: effects of seed treatments on take-all in spring in wheat grown as a second cereal, 2004*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None (Sibutol)	-0.21 (38.9)	0.84
Jockey	-0.57 (23.7)	0.35
Latitude	-0.70 (19.5)	0.34
SED (22 d.f.)	0.141	0.167
P	0.007	0.010

Table 25. *Experiment CS/597: effects of seed treatments and foliar fungicides on take-all in summer in wheat grown as a second cereal, 2004*

	Foliar treatment			
	None	Amistar	RR1	All foliar treatments
Seed tr. 2004				
	Take-all index (0-100)			
None (Sibutol)	40.9	42.7	41.9	41.8
Jockey	37.3	55.2	31.9	41.5
Latitude	39.8	36.7	39.8	38.8
SED	7.27, 6.96 (48 d.f.)			3.76 (22 d.f.)
P	0.087 (interaction)			0.677
All seed tr.	39.3	44.9	37.7	
SED	4.14 (48 d.f.)			
P	0.216			
	Logit % plants with severe take-all (back-transformed mean)			
None (Sibutol)	-1.24 (7.2)	-0.98 (11.9)	-1.16 (8.4)	-1.13 (9.0)
Jockey	-1.51 (4.1)	-0.85 (15.1)	-1.95 (1.5)	-1.44 (4.9)
Latitude	-0.82 (15.7)	-1.15 (4.7)	-1.47 (4.6)	-1.25 (7.1)
SED	0.348, 0.347 (48 d.f.)			0.202 (22 d.f.)
P	0.050 (interaction)			0.322
All seed tr.	-1.19 (7.9)	-1.09 (9.7)	-1.53 (4.0)	
SED	0.200 (48 d.f.)			
P	0.084			

Where two SEDs are shown, the larger one is for comparisons within the same seed treatment, the smaller one for all other comparisons.

Table 26. *Experiment CS/597: effects of seed treatments and foliar fungicides on grain yield and quality of wheat grown as a second cereal, 2004*

	Foliar treatment			
	None	Amistar	RR1	All foliar treatments
Seed tr. 2004				
	Grain yield (t/ha)			
None (Sibutol)	6.87	7.66	8.11	7.55
Jockey	7.82	8.06	7.96	7.94
Latitude	8.24	8.27	8.63	8.38
SED	0.286, 0.241 (48 d.f.)			0.208 (22 d.f.)
P	0.018 0.050 (interaction)			0.002
All seed tr.	7.64	7.99	8.23	
SED	0.139 (48 d.f.)			
P	<0.001			
	Hectolitre weight (kg/hL)			
None (Sibutol)	69.2	69.4	70.3	69.6
Jockey	69.2	70.2	70.2	69.3
Latitude	70.1	70.3	70.3	69.7
SED	0.65, 0.70 (48 d.f.)			0.29 (22 d.f.)
P	0.772 0.050 (interaction)			0.352
All seed tr.	68.8	69.6	70.2	
SED	0.41 (48 d.f.)			
P	0.004			

Where two SEDs are shown, the larger one is for comparisons within the same seed treatment, the smaller one for all other comparisons.

Table 27. *Experiment CS/597: effects of seed treatments on take-all in spring in wheat grown as a third cereal, 2005*

Seed treatment 2004	None[a] 2005	Jockey 2005	Latitude 2005	All 2005
	Logit % plants (back-transformed mean)			
None[a]	1.76 (96.6)	1.60 (95.6)	1.04 (88.4)	1.47 (94.5)
Jockey	1.71 (96.3)	1.33 (93.0)	1.20 (91.2)	1.42 (93.9)
Latitude	1.90 (97.3)	1.39 (93.7)	1.23 (91.6)	1.51 (94.8)
SED (16 d.f.)		0.282		0.163
P		0.788 (interaction)		0.850
All 2004	1.79 (96.8)	1.44 (94.2)	1.16 (90.5)	
SED (16 d.f.)		0.163		
P		0.005		
	No. infected roots per plant			
None[a]	5.41	3.70	2.77	3.96
Jockey	4.87	3.51	3.12	3.83
Latitude	5.17	2.91	4.21	4.10
SED (16 d.f.)		0.608		0.351
P		0.137 (interaction)		0.757
All 2004	5.15	3.37	3.37	
SED (16 d.f.)		0.351		
P		<0.001		

[a]Sibutol only.

Table 28. *Experiment CS/597: effects of seed treatments and foliar fungicides on take-all index of wheat grown as a third cereal, 2005*

		Take-all index (0-100)			
		Foliar treatment (both years)			
Seed treatment 2004	Seed treatment 2005	None	Amistar	RR1	All foliar treatments
None [a]	None [a]	93.6	92.1	92.8	92.8
None [a]	Jockey	79.0	64.3	87.0	76.8
None [a]	Latitude	86.0	83.9	86.2	85.4
Jockey	None [a]	96.9	94.4	89.7	93.6
Jockey	Jockey	83.0	82.9	83.6	83.2
Jockey	Latitude	85.5	73.4	82.4	80.5
Latitude	None [a]	91.7	89.8	95.0	92.2
Latitude	Jockey	81.4	71.4	79.4	77.4
Latitude	Latitude	93.0	80.8	77.2	83.7
SED		5.50, 5.69 (36 d.f.)			2.94 (16 d.f.)
P		0.155 (interaction)			0.133
None [a]	All 2005	86.2	80.1	88.6	85.0
Jockey	All 2005	88.5	83.6	85.2	85.8
Latitude	All 2005	88.7	80.7	83.8	84.4
SED		3.18, 3.29 (36 d.f.)			1.70 (16 d.f.)
P		0.454 (interaction)			0.737
All 2004	None [a]	94.1	92.1	92.5	92.9
All 2004	Jockey	81.1	72.9	83.3	79.1
All 2004	Latitude	88.2	79.4	81.9	83.2
SED		3.18, 3.29 (36 d.f.)			1.70 (16 d.f.)
P		0.137 (interaction)			<0.001
All 2004	All 2005	87.8	81.5	85.9	
SED		1.90 (36 d.f.)			
P		0.006			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 29. *Experiment CS/597: effects of seed treatments and foliar fungicides on the incidence of severe take-all in wheat grown as a third cereal, 2005*

		Logit % plants with severe take-all (back-transformed mean)			
		Foliar treatment (both years)			
Seed treatment 2004	Seed treatment 2005	None	Amistar	RR1	All foliar treatments
None[a]	None[a]	0.57 (75.2)	0.48 (71.6)	0.73 (80.6)	0.59 (76.0)
None[a]	Jockey	-0.39 (31.0)	-1.03 (10.8)	0.05 (51.9)	-0.46 (28.1)
None[a]	Latitude	0.13 (56.1)	0.07 (52.7)	0.18 (58.6)	0.13 (55.8)
Jockey	None[a]	1.23 (91.6)	0.70 (79.8)	0.31 (64.6)	0.75 (81.2)
Jockey	Jockey	-0.07 (46.1)	-0.26 (36.7)	-0.11 (44.0)	-0.15 (42.2)
Jockey	Latitude	0.19 (59.0)	-0.34 (33.1)	-0.02 (48.4)	-0.06 (46.7)
Latitude	None[a]	0.83 (83.6)	0.26 (62.1)	0.68 (79.1)	0.59 (76.0)
Latitude	Jockey	-0.04 (47.3)	-0.75 (17.7)	-0.43 (29.4)	-0.41 (30.2)
Latitude	Latitude	0.58 (75.5)	-0.08 (45.3)	-0.23 (38.1)	0.09 (53.8)
SED		0.328, 0.353 (36 d.f.)			0.157 (16 d.f.)
P		0.479 (interaction)			0.254
None[a]	All 2005	0.10 (54.7)	-0.16 (41.4)	0.32 (64.9)	0.09 (53.8)
Jockey	All 2005	0.45 (70.7)	0.03 (51.2)	0.06 (52.5)	0.18 (58.5)
Latitude	All 2005	0.46 (70.8)	-0.19 (40.0)	0.01 (49.8)	0.09 (54.0)
SED		0.190, 0.204 (36 d.f.)			0.091 (16 d.f.)
P		0.150 (interaction)			0.506
All 2004	None[a]	0.88 (84.8)	0.48 (71.8)	0.57 (75.4)	0.64 (77.8)
All 2004	Jockey	-0.17 (41.3)	-0.68 (19.9)	-0.16 (41.4)	-0.33 (33.3)
All 2004	Latitude	0.30 (64.1)	-0.12 (43.5)	-0.02 (48.3)	0.05 (52.1)
SED[a]		0.190, 0.204 (36 d.f.)			0.091 (16 d.f.)
P		0.546 (interaction)			<0.001
All 2004	All 2005	0.34 (65.8)	-0.11 (44.2)	0.13 (55.9)	
SED		0.118 (36 d.f.)			
P		0.002			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 30. *Experiment CS/597: effects of seed treatments and foliar fungicides on grain yield of wheat grown as a third cereal, 2005*

		Grain yield (t/ha)			
		Foliar treatment (both years)			
Seed treatment 2004	Seed treatment 2005	None	Amistar	RR1	All foliar treatments
None[a]	None[a]	3.13	2.91	2.60	2.88
None[a]	Jockey	3.46	3.66	3.12	3.41
None[a]	Latitude	3.55	3.86	3.50	3.64
Jockey	None[a]	1.98	2.83	2.83	2.55
Jockey	Jockey	3.04	3.37	3.08	3.16
Jockey	Latitude	3.22	4.42	3.19	3.61
Latitude	None[a]	2.22	2.33	2.48	2.34
Latitude	Jockey	3.41	3.93	2.99	3.44
Latitude	Latitude	3.33	3.27	3.60	3.40
SED		0.298, 0.292 (36 d.f.)			0.179 (16 d.f.)
P		0.027 (interaction)			0.158
None[a]	All 2005	3.38	3.48	3.07	3.31
Jockey	All 2005	2.75	3.54	3.03	3.11
Latitude	All 2005	2.99	3.18	3.02	3.06
SED		0.172, 0.169 (36 d.f.)			0.103 (16 d.f.)
P		0.028 (interaction)			0.064
All 2004	None[a]	2.44	2.69	2.64	2.59
All 2004	Jockey	3.30	3.65	3.06	3.34
All 2004	Latitude	3.37	3.85	3.43	3.55
SED		0.172, 0.169 (36 d.f.)			0.103 (16 d.f.)
P		0.189 (interaction)			<0.001
All 2004	All 2005	3.04	3.40	3.04	
SED		0.097 (36 d.f.)			
P		<0.001			

[a]Sibutol only.

Where two SEDs are shown, the smaller is for comparisons between foliar sprays after the same seed treatment, the larger one for all other comparisons.

Table 31. *Experiment CS/597: effects of seed treatments and foliar fungicides on hectolitre weights of grain from wheat grown as a third cereal, 2005*

		Hectolitre weight (kg/hL)			
		Foliar treatment (both years)			
Seed treatment 2004	Seed treatment 2005	None	Amistar	RR1	All foliar treatments
None[a]	None[a]	66.3	66.7	67.0	66.7
None[a]	Jockey	66.0	64.0	67.5	65.8
None[a]	Latitude	65.2	66.3	66.5	66.0
Jockey	None[a]	66.0	67.7	65.5	66.4
Jockey	Jockey	67.0	66.8	66.3	66.7
Jockey	Latitude	65.7	67.5	67.5	66.9
Latitude	None[a]	64.3	67.3	67.2	66.3
Latitude	Jockey	67.8	66.5	68.2	67.5
Latitude	Latitude	66.5	67.2	66.5	66.7
SED		1.09, 1.15 (36 d.f.)			0.55 (16 d.f.)
P		0.438 (interaction)			0.147
None[a]	All 2005	65.8	65.7	67.0	66.2
Jockey	All 2005	66.2	67.3	66.4	66.7
Latitude	All 2005	66.2	67.0	67.3	66.8
SED		0.63, 0.66 (36 d.f.)			0.32 (16 d.f.)
P		0.229 (interaction)			0.124
All 2004	None[a]	65.6	67.2	66.6	66.4
All 2004	Jockey	66.9	65.8	67.3	66.7
All 2004	Latitude	65.8	67.0	66.8	66.5
SED		0.63, 0.66 (36 d.f.)			0.32 (16 d.f.)
P		0.035 (interaction)			0.750
All 2004	All 2005	66.1	66.7	66.9	
SED		0.38 (36 d.f.)			
P		0.105			

[a]Sibutol only.

Where two SEDs are shown, the larger one is for comparisons between foliar sprays after the same seed treatment, the smaller one for all other comparisons.

Table 32. *Experiments CS/598: effects of seed treatments on take-all in spring in wheat grown as a second cereal, 2004*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None (Sibutol)	-0.18 (40.4)	0.93
Jockey	-0.47 (27.5)	0.43
Latitude	-0.63 (21.6)	0.39
SED (22 d.f.)	0.145	0.211
P	0.018	0.033

Table 33. *Experiment CS/598: effects of fungicides on take-all index in summer in wheat grown as a second cereal, 2004*

	Take-all index (0-100)		
Foliar treatment…	None	Amistar	Both foliar treatments
Seed treatment			
None (Sibutol)	75.2	66.9	71.1
Jockey	50.9	42.9	46.9
Latitude	58.6	44.0	51.3
SED	4.21, 4.98 (24 d.f.)		3.99 (22 d.f.)
P	0.478 (interaction)		<0.001
All seed tr.	61.6	51.3	
SED	2.43 (24 d.f.)		
P	<0.001		

Where two SEDs are shown, the larger one is for comparisons within the same seed treatment, the smaller one for all other comparisons.

Table 34. *Experiment CS/598: effects of fungicides on take-all incidence and severity in summer in wheat grown as a second cereal, 2004*

	Logit % plants with take-all (back-transformed mean)	Logit % plants with severe take-all (back-transformed mean)
Seed treatment		
None (Sibutol)	1.54 (95.1)	-0.11 (44.2)
Jockey	1.02 (87.9)	-1.33 (6.0)
Latitude	0.92 (85.9)	-0.79 (16.5)
SED (22 d.f.)	0.197	0.127
P	0.011	<0.001
Foliar treatment		
None	1.29 (92.4)	-0.50 (26.3)
Amistar	1.03 (88.2)	-0.98 (11.8)
SED (24 d.f.)	0.079	0.136
P	0.004	0.002

Table 35. *Experiment CS/598: effects of seed treatments and foliar fungicides on grain yield and quality of wheat grown as a second cereal, 2004*

Foliar treatment…	None	Amistar	Both foliar tr.
Seed treatment			
	Grain yield (t/ha)		
None (Sibutol)	7.07	7.79	7.43
Jockey	8.32	8.74	8.53
Latitude	8.38	8.87	8.62
SED	0.228, 0.177 (24 d.f.)		0.191 (22 d.f.)
P	0.501 (interaction)		<0.001
All seed tr.	7.92	8.47	
SED	0.102 (24)		
P	<0.001		
	1000-grain weight (g)		
None (Sibutol)	31.7	32.0	31.9
Jockey	33.1	34.1	33.6
Latitude	32.6	34.4	33.5
SED	0.64, 0.55 (24 d.f.)		0.51 (22 d.f.)
P	0.178 (interaction)		0.004
All seed tr.	32.5	33.5	
SED	0.32 (24 d.f.)		
P	0.003		

Where two SEDs are shown, the smaller one is for comparisons within the same seed treatment, the larger one for all other comparisons.

Table 36. *Experiment CS/598: effects of seed treatments on take-all in spring in wheat grown as a third cereal, 2005*

Treatment 2004	None (Sibutol) 2005	Jockey 2005	Latitude 2005	All 2005
	Logit % plants (back-transformed mean)			
None (Sibutol)	1.59 (95.5)	1.36 (93.3)	1.05 (88.5)	1.33 (93.0)
Jockey	2.18 (98.2)	1.84 (97.0)	1.31 (92.6)	1.78 (96.7)
Latitude	2.06 (97.9)	1.34 (93.1)	1.56 (90.5)	1.52 (94.9)
SED (16 d.f.)		0.367		0.211
P		0.854 (interaction)		0.142
All 2004	1.95 (97.5)	1.51 (94.9)	1.17 (90.7)	
SED (16 d.f.)		0.211		
P		0.008		
	No. infected roots per plant			
None (Sibutol)	4.08	2.77	2.97	3.27
Jockey	4.84	3.93	3.11	3.96
Latitude	5.58	3.03	3.20	3.94
SED (16 d.f.)		0.395		0.228
P		0.044 (interaction)		0.012
All 2004	4.83	3.24	3.10	
SED (16 d.f.)		0.228		
P		<0.001		

Table 37. *Experiment CS/598: effects of fungicides on take-all index in summer in wheat grown as a third cereal, 2005*

		Take-all index (0-100)		
		Foliar treatment (both years)		
Seed treatment 2004	Seed treatment 2005	None	Amistar	Both foliar treatments
None[a]	None[a]	93.7	91.8	92.8
None[a]	Jockey	84.2	80.4	82.3
None[a]	Latitude	91.3	84.8	87.9
Jockey	None[a]	95.5	93.6	94.5
Jockey	Jockey	88.3	83.4	85.9
Jockey	Latitude	88.8	91.1	89.9
Latitude	None[a]	96.1	90.2	93.1
Latitude	Jockey	82.1	83.6	82.9
Latitude	Latitude	89.0	82.0	85.5
SED		5.60, 5.11 (18 d.f.)		4.27 (16 d.f.)
P		0.587 (interaction)		0.978
None[a]	All 2005	89.7	85.7	87.7
Jockey	All 2005	90.8	89.4	90.1
Latitude	All 2005	89.1	85.3	87.2
SED		3.23, 2.95 (18 d.f.)		2.47 (16 d.f.)
P		0.798 (interaction)		0.467
All 2004	None[a]	95.1	91.9	93.5
All 2004	Jockey	84.9	82.5	83.7
All 2004	Latitude	89.6	86.0	87.8
SED		3.23, 2.95 (18 d.f.)		2.47 (16 d.f.)
P		0.950 (interaction)		0.004
All 2004	All 2005	89.9	86.8	
SED		1.70 (18 d.f.)		
P		0.085		

[a]Sibutol only.

Where two SEDs are shown, the smaller one is for comparisons within the same seed treatment, the larger one for all other comparisons.

Table 38. *Experiment CS/598: effects of fungicides on incidence of severe take-all in summer in wheat grown as a third cereal, 2005*

		Logit % plants with severe take-all (back-transformed mean)		
		Foliar treatment (both years)		
Seed treatment 2004	Seed treatment 2005	None	Amistar	Both foliar treatments
All 2004	None (Sibutol)	0.84 (83.8)	0.49 (72.1)	0.66 (78.5)
All 2004	Jockey	0.06 (52.4)	-0.18 (40.6)	-0.06 (46.4)
All 2004	Latitude	0.43 (69.9)	0.21 (59.7)	0.32 (65.0)
SED		0.188, 0.172 (18 d.f.)		0.143 (16 d.f.)
P		<0.001 (interaction)		0.085
All 2004	All 2005	0.44 (70.3)	0.17 (58.0)	
SED		0.099 (18 d.f.)		
P		0.013		

Where two SEDs are shown, the smaller one is for comparisons within the same seed treatment, the larger one for all other comparisons.

Table 39. *Experiment CS/598: effects of fungicides on grain yield of wheat grown as a third cereal, 2005*

		Grain yield (t/ha)		
		Foliar treatment (both years)		
Seed treatment 2004	Seed treatment 2005	None	Amistar	Both foliar treatments
None[a]	None[a]	3.18	2.75	2.97
None[a]	Jockey	3.79	3.82	3.80
None[a]	Latitude	4.06	3.86	3.96
Jockey	None[a]	2.26	2.61	2.44
Jockey	Jockey	3.20	3.80	3.50
Jockey	Latitude	3.39	3.64	3.52
Latitude	None[a]	2.65	2.91	2.78
Latitude	Jockey	3.75	3.69	3.72
Latitude	Latitude	3.44	4.36	3.90
SED		0.374, 0.351 (18 d.f.)		0.280 (16 d.f.)
P		0.369 (interaction)		0.980
None[a]	All 2005	3.68	3.48	3.58
Jockey	All 2005	2.95	3.35	*3.15*
Latitude	All 2005	3.28	3.65	3.47
SED		0.216, 0.202 (18 d.f.)		0.161 (16 d.f.)
P		0.087 (interaction)		0.046
All 2004	None[a]	2.69	2.76	2.73
All 2004	Jockey	3.58	3.77	3.67
All 2004	Latitude	3.63	3.95	3.79
SED		0.216, 0.202 (18 d.f.)		0.161 (16 d.f.)
P		0.672 (interaction)		<0.001
All 2004	All 2005	3.30	3.49	
SED		0.117 (18 d.f.)		
P		0.117		

[a]Sibutol only.

Where two SEDs are shown, the smaller one is for comparisons within the same seed treatment, the larger one for all other comparisons.

Table 40. *Experiment 2427: effects of seed treatments on take-all in spring in wheat grown as a second cereal, 2003*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None (Sibutol)	1.11 (89.8)	1.94
Jockey	0.78 (82.1)	1.60
Latitude	0.29 (63.4)	1.11
SED (50 d.f.)	0.151, 0.142	0.146, 0.138
P	<0.001	<0.001

The first SED is for comparing either Jockey or Latitude with none, the second for comparing Jockey and Latitude.

Table 41. *Experiment 2427: effects of seed treatments and foliar fungicide on take-all in summer in wheat grown as a second cereal, 2003*

Treatment	Take-all index (0-100)	Logit % plants with take-all index (back-transformed mean)	Logit % plants with moderate or severe take-all (back-transformed mean)
None (Sibutol)	87.9	2.54 (98.9)	1.56 (95.3)
Jockey	71.6	2.59 (98.9)	0.80 (82.7)
Latitude	80.4	2.58 (98.9)	1.31 (92.7)
Amistar	94.7	2.63 (99.0)	2.63 (99.0)
Jockey+Amistar	66.1	2.43 (98.7)	0.60 (76.3)
Latitude+Amistar	71.4	2.35 (98.6)	1.01 (87.7)
SED (47 d.f.)	4.39, 6.21	0.103, 0.146	0.275, 0.389
P	<0.001	0.262	<0.001

The first SED is for comparisons between none, Jockey alone and Latitude alone, the second for all other comparisons.

Table 42. *Experiment 2427: effects of seed treatments and foliar fungicide on grain yield and quality of wheat grown as a second cereal, 2003*

Treatment	Grain yield (t/ha)	Hectolitre weight kg/hL)	% protein in grain
None (Sibutol)	5.60	70.7	13.9
Jockey	5.08	71.1	14.0
Latitude	5.95	70. 6	13.8
Amistar	4.74	70.3	13.7
Jockey+Amistar	5.39	72.0	13.9
Latitude+Amistar	6.17	72.7	13.7
SED (47 d.f.)	0.458, 0.647	0.74, 1.05	0.19, 0.27
P	0.156	0.092	0.731

The first SED is for comparisons between none, Jockey alone and Latitude alone, the second for all other comparisons.

Table 43. *Experiment 034A: effects of seed treatments on take-all in spring in wheat grown as a second cereal, 2004*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None (Sibutol)	-0.41 (30.1)	0.47
Jockey	-0.43 (29.2)	0.42
Latitude	-0.73 (18.3)	0.26
SED (50 d.f.)	0.105, 0.099	0.066, 0.063
P	0.003	0.006

The first SED is for comparing either Jockey or Latitude with none, the second for comparing Jockey and Latitude.

Table 44. *Experiment 034A: effects of seed treatments and foliar fungicide on take-all in wheat grown as a second cereal, 2004*

Treatment	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	Logit % plants with moderate or severe take-all (back-transformed mean)
None (Sibutol)	33.0	0.84 (83.9)	-0.72 (18.7)
Jockey	24.9	0.65 (78.1)	-1.07 (10.0)
Latitude	19.0	0.26 (62.1)	-1.30 (6.4)
Amistar	30.8	0.82 (83.1)	-0.74 (17.9)
Jockey+Amistar	27.3	0.59 (76.2)	-0.88 (14.2)
Latitude+Amistar	21.4	0.34 (68.8)	-1.12 (9.2)
SED (47 d.f.)	2.84, 4.01	0.128, 0.181	0.172, 0.243
P	<0.001	<0.001	0.022

The first SED is for comparisons between none, Jockey alone and Latitude alone, the second for all other comparisons.

Table 45. *Experiment 034A: effects of seed treatments and foliar fungicide on grain yield and quality of wheat grown as a second cereal, 2004*

Treatment	Grain yield (t/ha)	1000-grain weight (g)	Hectolitre weight (kg/hL)	% protein in grain
None (Sibutol)	9.34	41.5	69.1	10.7
Jockey	9.43	42.8	69.0	10.7
Latitude	9.61	41.9	69.6	10.8
Amistar	8.89	42.1	69.5	10.6
Jockey+Amistar	9.45	42.6	69.4	10.8
Latitude+Amistar	9.69	42.8	69.5	10.8
SED (47 d.f.)	0.217, 0.307	0.50, 0.71	0.37, 0.52	0.12, 0.17
P	0.197	0.095	0.539	0.689

The first SED is for comparisons between none, Jockey alone and Latitude alone, the second for all other comparisons.

Table 46. *Experiment 034A: effects of seed treatments and foliar fungicide on take-all in spring in wheat grown as a third cereal, 2005*

Treatment 2004	Treatment 2005	Logit % plants with take-all (back-transformed mean)	No. infected roots per plant
None (Sibutol)	None (Sibutol)	-1.25 (7.0)	0.07
None (Sibutol)	Jockey	-1.00 (12.2)	0.15
None (Sibutol)	Latitude	-1.64 (3.1)	0.03
Jockey	None (Sibutol)	-1.14 (8.8)	0.11
Jockey	Jockey	-0.85 (15.1)	0.20
Jockey	Latitude	-1.12 (9.1)	0.10
Latitude	None (Sibutol)	-1.00 (11.9)	0.14
Latitude	Jockey	-0.79 (16.5)	0.20
Latitude	Latitude	-1.30 (6.4)	0.08
Amistar	Amistar	-0.95 (12.5)	0.14
Jockey+Amistar	Jockey+Amistar	-0.97 (12.1)	0.14
Jockey+Amistar	Latitude+Amistar	-1.05 (10.5)	0.14
Latitude+Amistar	Jockey+Amistar	-1.03 (10.8)	0.12
Latitude+Amistar	Latitude+Amistar	-1.52 (4.0)	0.04
SED (39 d.f.)		0.186	0.043
P		0.001	0.006

Table 47. *Experiment 034A: effects of seed treatments and foliar fungicide on take-all in summer in wheat grown as a third cereal, 2005*

Treatment 2004	Treatment 2005	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	
			All severities	Moderate or severe
None (Sibutol)	None (Sibutol)	33.1	0.47 (71.6)	-0.51 (25.9)
None (Sibutol)	Jockey	14.8	-0.02 (48.4)	-1.58 (3.6)
None (Sibutol)	Latitude	27.0	0.22 (60.1)	-0.66 (20.7)
Jockey	None (Sibutol)	27.6	0.27 (62.5)	-0.59 (22.9)
Jockey	Jockey	19.7	0.25 (61.5)	-1.47 (4.6)
Jockey	Latitude	10.1	-0.42 (29.8)	-1.74 (2.5)
Latitude	None (Sibutol)	31.1	0.24 (61.1)	-0.44 (28.7)
Latitude	Jockey	18.9	0.04 (51.3)	-1.08 (9.9)
Latitude	Latitude	12.8	-0.21 (39.1)	-1.59 (3.5)
Amistar	Amistar	16.9	-0.02 (48.7)	-1.33 (6.1)
Jockey+Amistar	Jockey+Amistar	13.6	-0.00 (49.4)	-1.75 (2.4)
Jockey+Amistar	Latitude+Amistar	12.4	-0.31 (34.6)	-1.81 (2.1)
Latitude+Amistar	Jockey+Amistar	19.1	0.20 (59.5)	-1.20 (7.9)
Latitude+Amistar	Latitude+Amistar	14.1	-0.29 (35.2)	-1.50 (4.3)
SED (39 d.f.)		4.92	0.205	0.398
P		<0.001	0.002	0.003

Table 48. *Experiment 034A: effects of seed treatments and foliar fungicide on grain yield and quality of wheat grown as a third cereal, 2005*

Treatment 2004	Treatment 2005	Grain yield (t/ha)	1000-grain weight (g)	Hectolitre weight (kg/hL)	% protein in grain
None (Sibutol)	None (Sibutol)	9.86	42.5	73.3	11.8
None (Sibutol)	Jockey	10.21	42.7	73.9	11.7
None (Sibutol)	Latitude	10.03	42.8	73.6	11.5
Jockey	None (Sibutol)	9.94	42.6	73.4	11.5
Jockey	Jockey	10.00	43.2	73.3	11.7
Jockey	Latitude	9.99	42.3	73.5	11.6
Latitude	None (Sibutol)	9.16	40.9	72.5	11.9
Latitude	Jockey	9.90	41.7	73.6	11.6
Latitude	Latitude	10.13	42.7	73.6	11.5
Amistar	Amistar	10.31	43.4	74.0	11.6
Jockey+Amistar	Jockey+Amistar	10.37	44.2	73.8	11.7
Jockey+Amistar	Latitude+Amistar	10.73	43.7	74.3	11.7
Latitude+Amistar	Jockey+Amistar	10.29	42.5	73.8	11.6
Latitude+Amistar	Latitude+Amistar	10.46	44.0	74.2	11.5
SED (39 d.f.)		0.371	1.21	0.452	0.19
P		0.056	0.425	0.057	0.680

Table 49. *Experiment 034B: effects of seed treatments on take-all in spring in wheat grown as a second cereal, 2004*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None (Sibutol)	-0.07 (45.8)	0.70
Jockey	-0.03 (48.0)	0.72
Latitude	-0.59 (23.0)	0.30
SED (50 d.f.)	0.077, 0.082	0.058, 0.061
P	<0.001	<0.001

The first SED is for comparing either Jockey or Latitude with none, the second for comparing Jockey and Latitude.

Table 50. *Experiment 034B: effects of seed treatments and foliar fungicide on take-all in summer in wheat grown as a second cereal, 2004*

Treatment	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	Logit % plants with moderate or severe take-all (back-transformed mean)
None (Sibutol)	44.8	1.11 (89.7)	-0.18 (40.5)
Jockey	32.3	0.95 (86.6)	-0.65 (20.8)
Latitude	29.6	0.50 (72.7)	-0.68 (19.9)
Amistar	42.4	1.10 (87.8)	-0.22 (38.8)
Jockey+Amistar	29.7	0.84 (83.7)	-0.85 (14.9)
Latitude+Amistar	24.9	0.47 (71.4)	-0.96 (12.3)
SED (47 d.f.)	3.27, 4.62	0.152, 0.215,	0.145, 0.204
P	<0.001	<0.001	<0.001

The first SED is for comparisons between none, Jockey alone and Latitude alone, the second for all other comparisons.

Table 51. *Experiment 034B: effects of seed treatments and foliar fungicide on grain yield and quality of wheat grown as a second cereal, 2004*

Treatment	Grain yield (t/ha)	1000-grain weight (g)	% protein in grain
None (Sibutol)	7.09	35.5	11.8
Jockey	7.39	36.4	11.9
Latitude	7.51	37.0	11.7
Amistar	7.13	37.2	11.8
Jockey+Amistar	7.42	36.7	11.8
Latitude+Amistar	7.57	36.9	11.7
SED (47 d.f.)	0.256, 0.362	0.49, 0.70	0.10, 0.14
P	0.496	0.043	0.439

The first SED is for comparisons between none, Jockey alone and Latitude alone, the second for all other comparisons.

Table 52. *Experiment 034B: effects of seed treatments and foliar fungicide on take-all in spring in wheat grown as a third cereal, 2005*

Treatment 2004	Treatment 2005	Logit % plants with take-all (back-transformed mean)	No. infected roots per plant
None (Sibutol)	None (Sibutol)	-0.62 (22.1)	0.27
None (Sibutol)	Jockey	-0.61 (22.2)	0.28
None (Sibutol)	Latitude	-1.10 (9.5)	0.10
Jockey	None (Sibutol)	-0.61 (22.4)	0.34
Jockey	Jockey	-0.83 (15.6)	0.16
Jockey	Latitude	-0.88 (14.2)	0.14
Latitude	None (Sibutol)	-0.50 (26.5)	0.31
Latitude	Jockey	-0.47 (27.6)	0.30
Latitude	Latitude	-0.73 (18.5)	0.21
Amistar	Amistar	-0.56 (24.0)	0.32
Jockey+Amistar	Jockey+Amistar	-0.54 (24.7)	0.28
Jockey+Amistar	Latitude+Amistar	-1.17 (8.3)	0.09
Latitude+Amistar	Jockey+Amistar	-0.47 (27.4)	0.34
Latitude+Amistar	Latitude+Amistar	-0.92 (13.3)	0.19
SED (39 d.f.)		0.203	0.091
P		0.012	0.059

Table 53. *Experiment 034B: effects of seed treatments and foliar fungicide on take-all in summer in wheat grown as a third cereal, 2005*

Treatment 2004	Treatment 2005	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	Logit % plants with moderate or severe take-all (back-transformed mean)	Logit % plants with severe take-all (back-transformed mean)
None (Sibutol)	None (Sibutol)	36.8	0.67 (78.7)	-0.36 (32.1)	-1.29 (6.5)
None (Sibutol)	Jockey	24.6	0.51 (73.1)	-1.14 (8.7)	-1.87 (1.8)
None (Sibutol)	Latitude	17.8	-0.08 (45.7)	-0.96 (12.2)	-1.87 (1.8)
Jockey	None (Sibutol)	43.5	1.01 (87.8)	-0.22 (38.5)	-0.87 (14.3)
Jockey	Jockey	40.9	0.94 (86.2)	-0.26 (36.9)	-1.67 (2.9)
Jockey	Latitude	31.4	0.40 (68.6)	-0.52 (25.5)	-1.40 (5.2)
Latitude	None (Sibutol)	47.8	0.88 (84.9)	-0.10 (44.5)	-0.72 (18.8)
Latitude	Jockey	35.5	0.75 (81.2)	-0.51 (26.2)	-1.41 (5.1)
Latitude	Latitude	31.7	0.34 (65.7)	-0.50 (26.3)	-1.03 (10.8)
Amistar	Amistar	34.5	0.52 (73.4)	-0.38 (31.3)	-1.37 (5.6)
Jockey+Amistar	Jockey+Amistar	25.8	0.51 (73.1)	-0.97 (12.1)	-2.11 (1.0)
Jockey+Amistar	Latitude+Amistar	19.6	0.16 (57.6)	-1.15 (8.6)	-2.19 (0.7)
Latitude+Amistar	Jockey+Amistar	29.2	0.56 (74.8)	-0.58 (23.5)	-2.18 (0.8)
Latitude+Amistar	Latitude+Amistar	16.4	0.00 (49.5)	-1.20 (7.9)	-2.13 (0.9)
SED (39 d.f.)		6.59	0.261	0.283	0.341
P		<0.001	0.002	0.001	<0.001

Table 54. *Experiment 034B: effects of seed treatments and foliar fungicide on grain yield and quality of wheat grown as a third cereal, 2005*

Treatment 2004	Treatment 2005	Grain yield (t/ha)	1000-grain weight (g)	Hectolitre weight (kg/hL)	% protein in grain
None (Sibutol)	None (Sibutol)	7.60	40.4	73.1	12.5
None (Sibutol)	Jockey	7.71	41.0	73.0	12.7
None (Sibutol)	Latitude	8.14	40.1	73.2	12.8
Jockey	None (Sibutol)	7.28	39.2	72.7	12.7
Jockey	Jockey	7.56	40.9	72.6	12.7
Jockey	Latitude	7.87	39.6	72.7	12.6
Latitude	None (Sibutol)	7.33	39.6	71.9	12.9
Latitude	Jockey	7.64	39.8	73.0	12.9
Latitude	Latitude	8.02	39.9	72.5	12.6
Amistar	Amistar	7.55	40.3	72.9	12.7
Jockey+Amistar	Jockey+Amistar	7.38	40.2	73.3	12.6
Jockey+Amistar	Latitude+Amistar	8.19	41.6	73.3	12.5
Latitude+Amistar	Jockey+Amistar	7.72	39.5	73.4	12.5
Latitude+Amistar	Latitude+Amistar	7.64	40.5	72.9	12.6
SED (39 d.f.)		0.242	1.37	0.38	0.16
P		0.007	0.921	0.031	0.26

Table 55. *Experiment CS/575: effects of seed treatments on take-all in spring in barley grown as a second cereal, 2003*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None	0.41 (69.0)	1.37
Raxil (R)	0.45 (70.7)	1.17
Jockey+R	0.51 (73.1)	1.17
Latitude+R	0.19 (58.7)	0.96
SED (37 d.f.)	0.259	0.193
P	0.338	0.185

Table 56. *Experiment CS/575: effects of seed treatments and foliar fungicide on take-all in summer in barley grown as a second cereal, 2003*

Treatment	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	
		All severities	Moderate or severe
None	31.0	0.97 (86.9)	-0.81 (16.0)
Raxil (R)	29.3	0.96 (86.6)	-1.01 (11.2)
R + Jockey	19.8	0.70 (79.6)	-1.78 (2.3)
R + Latitude	21.0	0.65 (78.1)	-1.45 (4.8)
R + Amistar	21.3	0.67 (78.6)	-1.69 (2.8)
R + Jockey +Amistar	25.1	1.01 (87.8)	-1.58 (3.6)
R + Latitude + Amistar	21.6	0.66 (78.5)	-1.40 (5.3)
SED (34 d.f.)	4.63, 3.78	0.283, 0.231	0.390, 0.318
P	0.015	0.426	0.033

The first SED is for comparisons among treatments involving Amistar or Amistar and none, the second for all other comparisons.

Table 57. *Experiment CS/575: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a second cereal, 2003*

Treatment	Grain yield (t/ha)	Thousand-grain weight (g)	Hectolitre weight (kg/hL)	% N in grain
None	5.13	44.59	59.75	2.31
Raxil (R)	5.51	43.84	60.69	2.21
R + Jockey	5.24	43.88	59.86	2.26
R + Latitude	5.49	45.21	60.52	2.30
R + Amistar	5.63	45.74	60.70	2.26
R + Jockey +Amistar	5.14	44.40	59.10	2.25
R + Latitude + Amistar	5.59	44.28	60.65	2.24
SED (34 d.f.)	0.397, 0.324	1.123, 0.917	1.441, 1.176	0.074, 0.060
P	0.648	0.317	0.821	0.530

The first SED is for comparisons among any treatments involving Amistar or Amistar and none, the second for all other comparisons.

Table 58. *Experiment CS/596: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a second cereal, 2004*

Treatment	Grain yield (t/ha)	Thousand-grain weight (g)	Hectolitre (kg/hL)	% N in grain
None	8.12	39.35	68.5	1.98
Raxil (R)	7.95	40.28	68.0	1.98
R + Jockey	7.95	40.55	67.9	2.00
R + Latitude	8.05	40.16	68.1	1.98
R + Amistar	8.68	41.72	69.1	1.98
R + Jockey +Amistar	8.75	42.45	68.9	2.01
R + Latitude + Amistar	8.76	42.40	69.9	1.97
SED (34 d.f.)	0.161, 0.131	1.040, 0.849	0.53, 0.43	0.034, 0.028
P	<0.001	0.017	0.001	0.837

The first SED is for comparisons among any treatments involving Amistar or Amistar and none, the second for all other comparisons.

Table 59. *Experiment CS/596: effects of seed treatments and foliar fungicide on take-all in summer in barley grown as a third cereal, 2005*

Treatment		Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)		
2003	2004		All severities	Moderate or severe	Severe
None	None	7.2	-0.71 (18.8)	-1.50 (4.3)	-2.33 (0.4)
Raxil (R)	Raxil	11.1	-0.70 (19.2)	-1.46 (4.6)	-1.96 (1.4)
Raxil	R+Jockey	6.4	-0.96 (12.4)	-1.59 (3.5)	-2.29 (0.5)
R+Jockey (J)	Raxil	16.0	-0.69 (19.6)	-1.31 (6.3)	-1.71 (2.7)
R+Jockey	R+Jockey	7.6	-0.77 (17.1)	-1.41 (5.1)	-2.45 (0.2)
Raxil	R+Latitude	4.7	-1.01 (11.3)	-1.97 (1.4)	-2.48 (0.2)
R+Latitude (L)	Raxil	16.2	-0.50 (26.4)	-0.97 (12.0)	-1.77 (2.3)
R+Latitude	R+Latitude	1.7	-1.39 (5.3)	-2.29 (0.5)	-2.43 (0.3)
R+Amistar	R+Amistar	26.5	-0.02 (48.5)	-0.49 (26.8)	-1.42 (5.0)
R+J+Amistar	R+J+Amistar	7.5	-0.99 (11.7)	-1.86 (1.8)	-2.58 (0.1)
R+L+Amistar	R+L+Amistar	4.5	-1.37 (5.6)	-2.10 (1.0)	-2.10 (1.0)
SED (30 d.f.)		6.33	0.369	0.418	0.339
P		0.024	0.048	0.009	0.027

Table 60. *Experiment CS/596: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a third cereal, 2005*

Treatment		Grain yield (t/ha)	1000-grain weight (g)	Hectolitre weight (kg/hL)	%N in grain
2003	2004				
None	None	9.02	36.8	64.5	1.79
Raxil (R)	Raxil	9.21	37.6	65.0	1.80
Raxil	R+Jockey	9.10	39.2	65.0	1.83
R+Jockey (J)	Raxil	9.50	37.4	64.4	1.80
R+Jockey	R+Jockey	9.42	39.1	64.9	1.81
Raxil	R+Latitude	9.59	37.7	64.8	1.84
R+Latitude (L)	Raxil	9.03	37.9	65.5	1.79
R+Latitude	R+Latitude	9.03	38.9	65.2	1.80
R+Amistar	R+Amistar	9.30	38.1	64.4	1.80
R+J+Amistar	R+J+Amistar	9.56	38.5	64.9	1.84
R+L+Amistar	R+L+Amistar	9.36	38.4	64.4	1.77
SED (30 d.f.)		0.183	0.82	0.43	0.030
P		0.012	0.113	0.258	0.328

Table 61. *Experiment 2425: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a second cereal, 2003*

Treatment	Grain yield (t/ha)	Thousand-grain weight (g)	Hectolitre weight (kg/hL)	% N in grain
None	8.39	45.8	72.1	1.91
Raxil	8.61	46.4	71.9	1.95
Raxil + Jockey	8.51	47.0	71.7	1.95
Raxil + Latitude	8.59	47.0	71.8	1.91
Raxil + Amistar	8.55	46.6	72.2	1.95
Raxil + Jockey +Amistar	8.71	46.9	72.3	1.95
Raxil + Latitude + Amistar	8.59	46.8	72.4	1.94
SED (34 d.f.)	0.125, 0.153	0.73, 0.90	0.43, 0.53	0.020, 0.025
P	0.483	0.692	0.660	0.063

The first SED is for comparisons among any treatments involving Amistar or Amistar and none, the second for all other comparisons.

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Table 62. *Experiment 2425: effects of seed treatments and foliar fungicide on take-all in summer in barley grown as a third cereal, 2004*

Treatment		Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	
2003	2004		All severities	Moderate or severe
None	None	9.5	-0.39 (31.0)	-1.88 (1.78)
Raxil ®	Raxil	10.3	-0.20 (39.5)	-1.93 (1.57)
Raxil	R+Jockey	3.4	-1.03 (10.8)	-2.62 (0.03)
R+Jockey (J)	Raxil	10.9	-0.38 (31.5)	-1.78 (2.25)
R+Jockey	R+Jockey	7.3	-0.53 (25.4)	-2.26 (0.58)
Raxil	R+Latitude	5.0	-0.72 (18.6)	-2.45 (0.24)
R+Latitude (L)	Raxil	7.3	-0.51 (26.0)	-2.14 (0.88)
R+Latitude	R+Latitude	8.2	-0.38 (31.2)	-2.11 (0.96)
R+Amistar	R+Amistar	18.2	0.03 (51.2)	-1.07 (10.10)
R+J+Amistar	R+J+Amistar	6.3	-0.45 (23.4)	-2.37 (0.37)
R+L+Amistar	R+L+Amistar	8.0	-0.58 (28.4)	-2.19 (0.73)
SED (30 d.f.)		3.72	0.263	0.427
P		0.049	0.052	0.084

Table 63. *Experiment 2425: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a third cereal, 2004*

Treatment		Grain yield (t/ha)	1000-grain weight (g)	Specific weight (kg/hL)	%N in grain
2003	2004				
None	None	7.49	41.8	66.0	1.71
Raxil (R)	Raxil	8.00	42.2	66.4	1.81
Raxil	R+Jockey	7.55	43.5	66.6	1.62
R+Jockey (J)	Raxil	7.41	43.8	66.9	1.61
R+Jockey	R+Jockey	7.71	43.6	67.1	1.66
Raxil	R+Latitude	7.65	43.9	67.0	1.69
R+Latitude (L)	Raxil	7.47	44.3	67.4	1.64
R+Latitude	R+Latitude	7.51	43.7	66.8	1.61
R+Amistar	R+Amistar	7.45	43.0	67.0	1.61
R+J+Amistar	R+J+Amistar	7.32	44.5	66.6	1.57
R+L+Amistar	R+L+Amistar	7.40	44.5	67.3	1.55
SED (30 d.f.)		0.306	0.73	0.44	0.097
P		0.662	0.011	0.149	0.342

Table 64. *Experiment 2426: effects of seed treatments on take-all in spring in barley grown as a second cereal, 2003*

Treatment	Logit % plants (back-transformed mean)	No. infected roots per plant
None	-0.39 (30.9)	0.55
Raxil	-0.37 (31.6)	0.49
Jockey + Raxil	-0.66 (20.6)	0.28
Latitude + Raxil	-0.54 (24.7)	0.33
SED (37 d.f.)	0.160	0.110
P	0.068	0.018

Table 65. *Experiment 2426: effects of fungicides on take-all in summer in barley grown as a second cereal, 2003*

Treatment	Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)	
		All severities	Moderate or severe
None	13.5	0.00 (49.5)	-1.76 (2.4)
Raxil (R)	16.5	0.11 (54.8)	-1.45 (4.7)
R + Jockey	12.0	-0.03 (48.2)	-2.14 (0.9)
R + Latitude	7.9	-0.36 (32.3)	-2.36 (0.4)
R + Amistar	17.6	0.26 (62.0)	-1.55 (3.8)
R + Jockey +Amistar	11.5	-0.12 (43.7)	-2.11 (0.9)
R + Latitude + Amistar	11.4	0.00 (49.7)	-2.28 (0.5)
SED (34 d.f.)	2.72, 2.22	0.161, 0.132	0.321, 0.262
P	<0.001	0.001	0.001

The first SED is for comparisons among any treatments involving Amistar or Amistar and none, the second for all other comparisons.

Table 66. *Experiment 2426: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a second cereal, 2003*

Treatment	Grain yield (t/ha)	Thousand-grain weight (g)	Hectolitre weight (kg/hL)	% N in grain
None	5.34	52.1	67.7	1.62
Raxil	5.34	52.1	67.8	1.66
Raxil + Jockey	5.49	53.0	67.7	1.65
Raxil + Latitude	5.42	52.4	67.8	1.64
Raxil + Amistar	5.41	52.6	68.0	1.66
Raxil + Jockey +Amistar	5.41	52.7	68.1	1.60
Raxil + Latitude + Amistar	5.44	52.3	67.8	1.68
SED (34 d.f.)	0.144, 0.118	0.71, 0.58	0.47, 0.38	0.042, 0.034
P	0.781	0.591	0.948	0.421

The first SED is for comparisons among any treatments involving Amistar or Amistar and none, the second for all other comparisons.

Table 67. *Experiment 2426: effects of seed treatments and foliar fungicide on take-all in spring in barley grown as a third cereal, 2004*

Treatment 2003	Treatment 2004	Logit % plants (back-transformed mean)	No. infected roots per plant
None	None	0.51 (73.2)	1.51
Raxil (R)	Raxil	0.68 (78.9)	1.63
Raxil	R+Jockey	0.80 (82.6)	1.37
R+Jockey (J)	Raxil	0.66 (78.5)	1.45
R+Jockey	R+Jockey	0.56 (74.8)	1.32
Raxil	R+Latitude	0.43 (69.7)	1.28
R+Latitude (L)	Raxil	0.59 (75.8)	1.52
R+Latitude	R+Latitude	0.46 (71.1)	1.13
R+Amistar	R+Amistar	0.56 (74.8)	1.67
R+J+Amistar	R+J+Amistar	0.44 (70.1)	1.31
R+L+Amistar	R+L+Amistar	0.25 (61.9)	0.98
SED (30 d.f.)		0.211	0.237
P		0.492	0.168

Table 68. *Experiment 2426: effects of seed treatments and foliar fungicide on take-all in summer in barley grown as a third cereal, 2004*

Treatment		Take-all index	Logit % plants with take-all (back-transformed mean)	
2003	2004	(0-100)	All severities	Moderate or severe
None	None	27.4	1.05 (88.6)	-1.45 (4.8)
Raxil (R)	Raxil	28.3	0.96 (86.6)	-0.95 (12.4)
Raxil	R+Jockey	20.5	0.47 (71.3)	-1.51 (4.2)
R+Jockey (J)	Raxil	29.7	1.00 (87.5)	-1.00 (11.5)
R+Jockey	R+Jockey	23.0	0.89 (85.2)	-1.48 (4.7)
Raxil	R+Latitude	21.6	0.67 (78.6)	-1.53 (4.0)
R+Latitude (L)	Raxil	27.5	1.01 (87.8)	-0.98 (11.8)
R+Latitude	R+Latitude	17.5	0.48 (72.0)	-1.88 (1.8)
R+Amistar	R+Amistar	30.7	0.94 (86.3)	-0.84 (15.2)
R+J+Amistar	R+J+Amistar	21.6	0.60 (76.5)	-1.37 (5.6)
R+L+Amistar	R+L+Amistar	17.9	0.41 (69.0)	-1.70 (2.7)
SED (30 d.f.)		4.24	0.278	0.401
P		0.027	0.165	0.215

Table 69. *Experiment 2426: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a third cereal, 2004*

Treatment		Grain yield (t/ha)	1000-grain weight (g)	Hectolitre weight (kg/hL)	%N in grain
2003	2004				
None	None	3.76	39.4	59.1	1.56
Raxil (R)	Raxil	3.91	39.8	59.8	1.63
Raxil	R+Jockey	3.87	41.3	60.2	1.56
R+Jockey (J)	Raxil	3.84	39.8	59.7	1.59
R+Jockey	R+Jockey	3.80	40.9	58.7	1.57
Raxil	R+Latitude	3.88	40.3	60.3	1.60
R+Latitude (L)	Raxil	3.88	39.2	59.7	1.64
R+Latitude	R+Latitude	3.99	41.2	60.8	1.55
R+Amistar	R+Amistar	3.85	39.4	60.5	1.62
R+J+Amistar	R+J+Amistar	4.14	41.4	60.7	1.61
R+L+Amistar	R+L+Amistar	3.89	40.8	60.5	1.57
SED (30 d.f.)		0.157	0.90	0.92	0.045
P		0.587	0.128	0.429	0.532

Table 70. *Experiment 2427: effects of seed treatments and foliar fungicide on take-all in summer in barley grown as a third cereal after wheat, 2004*

Treatment		Take-all index (0-100)	Logit % plants with take-all (back-transformed mean)
2003 (wheat)	2004		
None	None	5.2	-0.58 (23.4)
None	Amistar	7.6	-0.32 (34.0)
None	Raxil	8.6	-0.22 (38.7)
Jockey	Jockey	5.0	-0.58 (23.5)
Jockey	R+Latitude	5.2	-0.55 (24.6)
Jockey	Raxil	8.2	-0.33 (33.5)
Latitude	Latitude	5.4	-0.57 (23.7)
Latitude	R+Jockey	5.7	-0.49 (26.8)
Latitude	Raxil	8.4	-0.20 (39.6)
Amistar	Amistar	8.8	-0.35 (32.9)
Jockey +Amistar	Jockey+Amistar	3.1	-0.84 (15.2)
Jockey +Amistar	Latitude+Amistar	7.2	-0.36 (32.2)
Latitude +Amistar	Latitude+Amistar	9.1	-0.26 (36.8)
Latitude +Amistar	Jockey+Amistar	6.8	-0.37 (31.9)
SED (39 d.f.)		2.33	0.216
P		0.312	0.222

Table 71. *Experiment 2427: effects of seed treatments and foliar fungicide on grain yield and quality of barley grown as a third cereal after wheat, 2004*

Treatment		Grain yield (t/ha)	1000-grain weight (g)	Specific weight (kg/hL)	%N in grain
2003 (wheat)	2004				
None	None	8.63	43.8	67.3	2.23
None	Amistar	8.46	45.3	67.6	2.14
None	Raxil	8.95	44.1	67.1	2.21
Jockey	Jockey	8.28	44.6	67.3	2.20
Jockey	Raxil+Latitude	8.79	45.8	67.6	2.15
Jockey	Raxil	8.32	43.6	66.8	2.17
Latitude	Latitude	9.20	45.5	67.7	2.14
Latitude	Raxil+Jockey	8.59	44.7	67.2	2.17
Latitude	Raxil	8.45	43.9	67.0	2.18
Amistar	Amistar	8.44	44.4	67.5	2.15
Jockey+Amistar	Jockey+Amistar	8.97	44.9	67.8	2.21
Jockey+Amistar	Latitude+Amistar	8.73	45.8	67.5	2.19
Latitude+Amistar	Latitude+Amistar	9.24	44.2	67.4	2.19
Latitude+Amistar	Jockey+Amistar	9.25	45.4	67.8	2.18
SED (39 d.f.)		0.457	0.81	0.44	0.076
P		1.10	0.078	0.648	0.995

Table 72. *Mean incidences of stem-base diseases in each experiment and year*

Experiment	Harvest year	% stems with symptoms			
		Eyespot	Moderate-severe eyespot	Sharp eyespot	Brown foot rot
Rothamsted wheat					
CS/573	2003	5.1	1.0	0.1	4.0
CS/573	2004	25.1	10.3	0.1	17.8
CS/574	2003	8.6	1.7	0.1	9.0
CS/574	2004	50.1	31.2	1.4	29.7
CS/574	2005	37.2	10.1	2.3	6.7
CS/597	2004	7.4	2.4	3.7	5.8
CS/597	2005	9.8	3.5	4.5	0.2
CS/598	2004	16.5	4.7	8.2	4.4
CS/598	2005	14.2	2.4	3.8	0
Morley wheat					
NAS2427	2003	28.7	6.9	7.7	NA[a]
MRA	2004	18.5	7.8	2.9	5.8
MRA	2005	11.9	5.8	6.3	3.7
MRB	2004	9.0	2.5	0.9	6.9
MRB	2005	9.8	3.5	2.0	7.3
Rothamsted barley					
CS/575	2003	0.4	0.1	0.1	8.2
CS/596	2004	13.5	0.3	0	8.6
CS/596	2005	NA[b]	NA[b]	NA[b]	NA[b]
Morley barley					
NAS2425	2003	2.9	0.3	3.3	0
NAS2425	2004	1.2	0.1	0	0.2
NAS2426	2003	2.4	0.1	0.5	27.4
NAS2426	2004	0.5	0	0	0
NAS2427	2004	6.5	0.8	1.9	0.6

[a]Not assessed; obscured by stem blackening caused by take-all.

[b]Not assessed; observations suggested about 20% eyespot, manly slight, no sharp eyespot and about 5% brown foot rot.

Table 73. *Experiments CS/597 and CS/598: effects of seed treatments on incidence of gout fly damage in spring in wheat grown as a third cereal, 2005*

	Logit % plants with gout fly (back-transformed mean)			
Treatment	None 2005	Jockey 2005	Latitude 2005	All 2005
CS/597 (12 April)				
None 2004	0.45 (70.7)	0.16 (57.2)	0.27 (62.8)	0.29 (63.8)
Jockey 2004	0.17 (58.1)	0.29 (63.4)	0.44 (70.2)	0.30 (64.1)
Latitude 2004	-0.10 (44.3)	0.10 (54.4)	0.40 (68.7)	0.13 (56.1)
SED(16 d.f.)		0.225		0.130
P		0.302		0.370
All 2004	0.17 (58.1)	0.18 (58.4)	0.37 (67.3)	
SED(16 d.f.)		0.130		
P		0.251		
CS/598 (16 March)				
None 2004	0.18 (58.3)	-0.06 (46.5)	0.28 (62.9)	0.13 (56.0)
Jockey 2004	0.09 (53.8)	0.07 (53.1)	0.31 (64.6)	0.16 (57.3)
Latitude 2004	0.23 (60.8)	0.11 (55.1)	0.35 (66.2)	0.23 (60.8)
SED(16 d.f.)		0.132		0.077
P		0.810		0.423
All 2004	0.16 (57.6)	0.04 (51.6)	0.31 (64.6)	
SED(16 d.f.)		0.077		
P		0.010		

Table 74. *Summary of effects on grain yield (t/ha) of seed treatments applied to second and/or third wheat crops in different combinations in six experiments on winter wheat*

	Yield increase (t/ha)					
Treatment sequence[a]	2nd wheat	3rd wheat	Total (2 years)	2nd wheat	3rd wheat	Total (2 years)
	Experiment CS/573			Experiment CS/574		
[0]	[7.74]	[4.97]	[12.71]	[7.48]	[4.91]	[12.39]
0-J	-	+1.09	+1.09	-	+1.17	+1.17
0-L	-	+1.86	+1.86	-	+2.38	+2.38
J-0	+0.18	+0.53	+0.71	+0.46	+1.05	+1.51
J-J	+0.18	+1.14	+1.32	+0.46	+1.46	+1.92
J-L	+0.18	+2.53	+2.71	+0.46	+2.52	+2.98
L-0	+0.55	+0.91	+1.46	+0.50	+1.14	+1.64
L-J	+0.55	+1.93	+2.48	+0.50	+1.99	+2.49
L-L	+0.55	+2.26	**+2.81**	+0.50	+2.58	**+3.08**
	Experiment CS/597			Experiment CS/598		
[0]	[6.87]	[3.13]	[10.00]	[7.07]	[3.18]	[10.25]
0-J	-	+0.33	+0.33	-	+0.61	+0.61
0-L	-	+0.42	+0.42	-	+0.88	+0.88
J-0	+0.95	-1.35	-0.40	+1.25	-0.92	+0.33
J-J	+0.95	-0.09	+0.86	+1.25	+0.02	+1.27
J-L	+0.95	+0.09	+1.85	+1.25	+0.21	+1.46
L-0	+1.37	-0.91	+0.46	+1.31	-0.53	+0.78
L-J	+1.37	+0.28	**+1.65**	+1.31	+0.57	**+1.88**
L-L	+1.37	+0.20	+1.57	+1.31	+0.26	+1.57
	Experiment 034MRA			Experiment 034MRB		
[0-0]	[9.34]	[9.86]	[19.20]	[7.09]	[7.60]	[14.69]
0-J	-	+0.35	+0.35	-	+0.09	+0.09
0-L	-	+0.17	+0.17	-	+0.54	+0.54
J-0	+0.09	+0.08	+0.17	+0.30	-0.32	-0.02
J-J	+0.09	+0.14	+0.23	+0.30	-0.04	+0.26
J-L	+0.09	+0.13	+0.22	+0.30	+0.27	+0.57
L-0	+0.27	-0.70	-0.53	+0.42	-0.27	+0.15
L-J	+0.27	+0.04	+0.31	+0.42	+0.04	+0.46
L-L	+0.27	+0.27	**+0.54**	+0.42	+0.42	**+0.84**

[a]0, no test treatment (Sibutol only); J, Jockey; L, Latitude. The two symbols, separated by a hyphen, describe treatments in second wheat crops and third wheat crops, respectively. Actual yields for the 0-0 sequences are shown in square brackets.
The greatest total yield increase, compared with no treatment in both crops over the two crops is shown in bold type for each experiment.

Table 75. *Approximate margins over costs of treatment in second and third wheats, based on arbitrary grain price of £65 per tonne for feed wheat and seed treatment costs of £80 per tonne (approx. £16 per hectare) for Jockey Flexi and £155 per tonne (approx. £31 per hectare) for Latitude, assuming a sowing rate of 200 kg/ha*

	Margin (£/ha)					
Treatment sequence[a]	2nd wheat margin (£)	3rd wheat margin (£)	Total margin (£)	2nd wheat margin (£)	3rd wheat margin (£)	Total margin (£)
	Experiment CS/573			Experiment CS/574		
0-J	-	+54.85	+54.85	-	+60.05	+60.05
0-L	-	+89.90	+89.90	-	+123.70	+123.70
J-0	-4.30	+34.45	+30.15	+13.90	+68.25	+82.15
J-J	-4.30	+58.10	+53.80	+13.90	+78.90	+92.80
J-L	-4.30	+133.45	**+129.15**	+13.90	+132.80	**+146.70**
L-0	+4.75	+59.15	+63.90	+1.50	+74.10	+75.60
L-J	+4.75	+109.45	+114.20	+1.50	+113.35	+114.85
L-L	+4.75	+115.90	+120.65	+1.50	+136.70	+138.20
	Experiment CS/597			Experiment CS/598		
0-J	-	+5.45	+5.45	-	+23.65	+23.65
0-L	-	+3.70	+3.70	-	+26.20	+26.20
J-0	+45.75	-87.75	-42.00	+65.25	-59.80	+2.45
J-J	+45.75	-21.85	+23.90	+65.25	-14.70	+50.55
J-L	+45.75	-25.15	+20.60	+65.25	-17.35	+47.90
L-0	+58.05	-59.15	-1.10	+54.15	-34.45	+19.70
L-J	+58.05	+2.20	**+60.25**	+54.15	+21.05	**+75.20**
L-L	+58.05	-18.00	+40.05	+54.15	-14.10	+40.05
	Experiment 034MRA			Experiment 034MRB		
0-J	-	+6.75	**+6.75**	-	-10.15	-10.15
0-L	-	-19.95	-19.95	-	+4.10	**+4.10**
J-0	-10.15	+5.20	-4.95	+3.50	-20.80	-17.30
J-J	-10.15	-6.90	-17.05	+3.50	-13.40	-9.90
J-L	-10.15	-22.55	-32.70	+3.50	-13.45	-9.95
L-0	-13.45	-45.50	-58.95	-3.70	-17.55	-21.25
L-J	-13.45	-13.40	-26.28	-3.70	-13.40	-17.10
L-L	-13.45	-13.45	-26.90	-3.70	-3.70	-7.40

[a]0, no test treatment (Sibutol only); J, Jockey; L, Latitude. The two symbols, separated by a hyphen, describe treatments in second wheat crops and third wheat crops, respectively. The greatest total margin over the two crops is shown in bold type for each experiment.

Table 76. *Effects of Amistar (at 1 L/ha), with and without additional watering, on take-all in summer in demonstration plots with limited replication in a third wheat (cv. Claire) at Rothamsted, 2005*

		Sown 15 September		Sown 15 October	
Fungicide spray	Irrigation	Take-all index (0-100)	% plants with moderate or severe take-all	Take-all Index (0-100)	% plants with moderate or severe take-all
		Sampled 1 June (GS 53)			
None	None	92.0	100	41.6	40.5
Amistar	None	70.0	73.1	49.6	51.8
Amistar	Irrigated	49.6	47.7	23.3	0.0
		Sampled 7 July (GS 75)			
None	None	99.5	100	85.4	94.6
Amistar	None	92.7	100	82.5	92.5
Amistar	Irrigated	80.5	89.5	59.0	55.9

OPTIMISING THE PERFORMANCE AND BENEFITS OF TAKE-ALL CONTROL CHEMICALS

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This is supplementary to final report (Project Report No. 395) of Project No. 2732

Objective

To test the hypothesis that the activity against take-all of azoxystrobin applied as a foliar spray is enhanced by wet soil.

Procedures

A field trial was located in a third wheat crop, where take-all was expected, in Delafield on Rothamsted Farm. Standard operating procedures were followed for all farm operations and experimentation. Winter wheat cv. Hereward, treated with Sibutol Secur, was sown at 350 seeds m^{-2} on 28 September 2005. Herbicides were applied as appropriate and according to standard practice on the farm. No further pesticides were applied other than experimental treatments. A split application of Double Top fertiliser (27% N and 12% S) was made: at 185 kg ha^{-1} on 15 March and at 556 kg ha^{-1} on 20 April.

The design of the trial was four randomised replicate blocks of 17 treatments. Plots were 10 m x 3 m, separated by 3 m paths. There were 12 fungicide treatments (i.e. sequences of treatments), five of which were duplicated, applied as mixed formulations on 6 April (T0), 24 April (T1) and 25 May (T2). All were applied in 220 L ha^{-1}. Fungicide mixtures other than those that included azoxystrobin (Amistar; 125 g a.i. L^{-1}) at T1 are not disclosed. The duplicated treatments were tested with or without irrigation to simulate rainfall and to wet the soil. Irrigation was applied as a coarse spray from a tractor-mounted boom at the equivalent of 5 mm of rainfall on 24 April, before and after the T1 fungicide applications. Sampling, disease assessments and yield determinations followed standard operating procedures in place at Rothamsted. The plots were combine-harvested on 10 August for grain yield and quality measurements to be made.

The plots were examined at intervals for the presence of leaf diseases.

The extent of take-all patches in the ripening crops was assessed as approximate percentage of plot area on 28 June when the crop was at Zadoks growth stage (GS) 71.

A preliminary sample of plants was taken from across the site on 3 May (GS 32) to assess the incidences of take-all and eyespot.

The main plant sample was taken on 5 July (GS 75) by digging ten 20-cm lengths of row from each plot. The root systems were washed and the plants were allowed to dry. They were stored, after cutting off the upper parts of the stems, in a dry condition and re-wetted before assessment of take-all and stem-base diseases.

Take-all was assessed on each plant as slight (two categories: 1-10% and 11-25% of the root system affected), moderate (two categories: 26-50% and 51-75% of the root system affected) or severe (76-100% of the root system affected). The incidences of all symptom categories and of moderate or severe symptoms (most likely to affect yield) were determined for each plot. A take-all index for each plot was also calculated, as [% plants assessed as slight 1 + 2 (% slight 2) + 3(% moderate 1) + 4(% moderate 2) + 5(% severe)] ÷ 5; maximum = 100.

Individual stems on the same plants were examined for eyespot, sharp eyespot and brown foot rot. The results are not reported here, since grain yield was not affected.

The data were analysed using Genstat. Percentage values were transformed to logits for analysis of variance, but actual percentage data are also presented.

Results and discussion

In the preliminary sample taken at GS 32, take-all was present on 89.1% of 137 plants, and on an average of 3.76 roots per plant. Most plants had eyespot, which affected 60-70% of shoots. Septoria was common on lower leaves at this time but did not progress extensively later.

The extent of take-all patches was significantly less where irrigation had been applied than where it had not (Table 1). This is consistent with the known effect of dry conditions, which exacerbate the effects of take-all. Where azoxystrobin was applied at T1, take-all patches were less extensive in irrigated than in non-irrigated plots but the effect was not statistically significant.

The incidence of take-all on root systems was also less after irrigation than after no irrigation, but the effect was significant only for overall incidence, i.e. take-all in all severity categories (Table 1). Where azoxystrobin was applied at T1, there was less take-all on the root systems, except in the severe category, in irrigated than in non-irrigated plots but the effect was not statistically significant.

There were no significant effects of irrigation on grain yield or hectolitre weight, although these tended to be greater where irrigation was applied (Table 2). Where azoxystrobin was applied at T1, yields and hectolitre weights were greater, but not significantly, in irrigated than in non-irrigated plots.

The lack of significant effects on take-all is probably mainly a consequence of the considerable patchiness and severity of the disease in this experiment. Regression analyses based on means of all plots show that grain yield was strongly correlated with take-all incidence and severity (Table 3) and not correlated with stem-base diseases. This suggests that take-all was a principal cause of yield variation although the effects of treatments on yield did not clearly reflect their effects on disease. Effects may have been clearer with less disease pressure, or if the early development of take-all had been suppressed by seed treatment containing silthiofam, as suggested by results of previous experiments (HGCA Project Report No. 395, 2006).

Conclusions

1. Take-all was severe and very patchy, resulting in few significant effects of treatments on take-all or grain yield.
2. Irrigation, applied to wet the soil at the time of T1 fungicide treatments, decreased the severity of above-ground take-all (premature ripening) and take-all incidence on root systems, and tended to increase yield averaged over all fungicide treatments.
3. Wetting the soil at the time of the T1 treatments tended to improve the performance against take-all of fungicide mixtures containing azoxystrobin at T1.

Table 1. Effects of fungicides and irrigation on take-all

Treatment: azoxystrobin (g a.i. ha^{-1}) at T1[a]	Logit % (non-transformed mean) Plot area with take-all patch	Plants with take-all on roots	Plants with moderate-severe take-all on roots	Plants with severe take-all on roots	Take-all index on roots (0-100)
No azoxystrobin at T1[b]	(21.5)	(97.5)	(74.5)	(30.7)	67.9
Azoxy. at T1 (150 or 250)[c]	(17.1)	(96.8)	(62.6)	(18.8)	59.0
Azoxystrobin (150)	-0.42 (36.2)	2.13 (97.4)	0.62 (76.8)	-0.43 (30.1)	69.0
Azoxy. (150) + irrigation	-0.99 (13.0)	1.46 (94.7)	0.40 (69.1)	-0.65 (21.4)	62.6
Azoxystrobin (250)	-0.48 (30.0)	2.06 (98.5)	0.54 (68.5)	-0.81 (22.6)	63.0
Azoxy. (250) + irrigation	-0.97 (21.7)	1.50 (91.8)	0.30 (60.6)	-0.67 (25.1)	59.3
SED (48 df)	0.393	0.397	0.332	0.360	8.11
P	0.387	0.421	0.171	0.099	0.114
All in irrigation test	-0.64 (26.7)	2.16 (98.3)	0.64 (74.7)	-0.52 (31.1)	68.3
All in irrigation test	-1.00 (15.5)	1.71 (95.8)	0.51 (69.8)	-0.66 (24.5)	64.0
All not in irrigation test	-0.78 (22.9)	2.00 (97.0)	0.56 (70.9)	-0.60 (28.0)	65.3
SED (48 df)[d]	0.176, 0.163	0.178, 0.164	0.149, 0.138	0.161, 0.149	3.63,3.36
P	**0.043**	**0.016**	0.385	0.387	0.233

[a]Azoxystrobin was applied in mixtures with other fungicides not expected to have activity against take-all.
[b]Means of 11 treatment sequences, some including azoxystrobin at T0 or T2 or azoxystrobin at less than 150 g ha^{-1} at T1.
[c]Means of two treatment sequences, with additional azoxystrobin at either T0 or T2.
[d]The larger SED is for comparisons between non-irrigated and irrigated within the irrigation test-treatment set (20 plots each); the smaller SED is for comparisons between either of these and the mean of plots not in the irrigation test (28 plots).
The analyses of variance included all 17 treatments but most have been grouped together and shown as non-transformed means for reasons of confidentiality.

Table 2. Effects of fungicides and irrigation on grain yield

Treatment: azoxystrobin (g a.i. ha^{-1}) at T1[a]	Grain yield (t ha^{-1})	Hectolitre weight (kg)
No azoxystrobin at T1[b]	7.17	69.7
Azoxy. at T1 (150 or 250)[c]	7.63	70.9
Azoxystrobin (150)	7.12	70.2
Azoxy. (150) + irrigation	7.42	70.8
Azoxystrobin (250)	7.09	67.5
Azoxy. (250) + irrigation	7.57	70.6
SED (48 df)	0.487	1.43
P	0.447	0.135
All in irrigation test	7.10	69.5
All in irrigation test	7.42	70.3
All not in irrigation test	7.24	69.9
SED (48 df)[d]	0.218, 0.202	0.64, 0.59
P	0.156	0.205

[a]Azoxystrobin was applied in mixtures with other fungicides not expected to have activity against take-all.
[b]Means of 11 treatment sequences, some including azoxystrobin at T0 or T2 or azoxystrobin at less than 150 g ha^{-1} at T1.
[c]Means of two treatment sequences, with additional azoxystrobin at either T0 or T2.
[d]The larger SED is for comparisons between non-irrigated and irrigated within the irrigation test-treatment set (20 plots each); the smaller SED is for comparisons between either of these and the mean of plots not in the irrigation test (28 plots).
The analyses of variance included all 17 treatments but most have been grouped together and shown as non-transformed means for reasons of confidentiality.

Table 3. Regressions of grain yield on disease variates over all plots[a]

Independent variable	Regression equation	Variance ratio	% variance accounted for	*P*
% plot with take-all patch	y=7.89-0.093x	80.18	54.2	<0.001
% plants with take-all (all severity classes)	y=15.29-0.083x	14.49	16.8	<0.001
% plants with moderate-severe take-all	y=9.56-0.032x	55.79	45.0	<0.001
% plants with severe take-all	y=7.80-0.020x	21.43	32.4	<0.001
Take-all index	y=9.66-0.037x	42.60	38.3	<0.001

[a]Degrees of freedom = 66 in all regression analyses. Regressions of yield on stem-base disease variates were all highly non-significant (*P*>0.3) and statistics are not shown.