ANNEX TO
PROJECT REPORT No. 255

# MANAGING EARLY-DRILLED SECOND WHEATS TO MINIMISE THE IMPACT OF TAKE-ALL

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# MANAGING EARLY-DRILLED SECOND WHEATS TO MINIMISE THE IMPACT OF TAKE-ALL

by

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This is the final report of a one-year extension to HGCA project 1929. The report of the first three years of the work funded by HGCA, Project Report No. 255, was published in July 2001. The extension started in March 2001 and was funded by a grant of £19,105 from HGCA. This report forms part of Project Report No. 255.

## Contents

## Abstract

In a 3-year HGCA-funded study between 1998 and 2000, it was shown that, even when seed treatments such as silthiofam and fuberidazole + triadimenol are used that can reduce the impact of take-all, it is still important to delay the sowing of second wheats from September until October, and to employ other crop husbandry measures that can help to alleviate the effects of the disease. Both seed treatment and sowing date can have implications for selecting an appropriate seed rate, and the project therefore investigated the effects of seed treatment on response to seed rate between 200 and 400 seeds/m$^2$, using fludioxonil as the control.

In the 2001 season, the seed rate range was extended down to 100 seeds/m$^2$, and a fourth seed treatment, fluquinconazole + prochloraz, was added. Three replicated trials were conducted at contrasting locations, with a target sowing date of late September. Plots were assessed for crop structure and yield components, take-all incidence and severity, and grain yield. Results were compared with those obtained in the 1998-2000 seasons.

Take-all was present at all three sites, but seed treatment differences were only recorded at two. Take-all severity in April was lower for fludioxonil + silthiofam and fluquinconazole + prochloraz than for fludioxonil alone. At one location, a higher incidence and severity of take-all were recorded at seed rates of 300 or 400 seeds/m$^2$ than at 100 or 200 seeds/m$^2$ with treatments that did not give control of the disease. Yield differences between seed treatments varied between sites, but fludioxonil + silthiofam was the highest ranking overall. A seed rate of 100 seeds/m$^2$ was below optimum regardless of treatment, but there was evidence of an interaction between seed treatment and rate at one location. The other treatments had a greater yield advantage over fludioxonil alone at the two higher seed rates than at the lower rates. However, the optimum seed rates (200-300 seeds/m$^2$) were the same for all seed treatments except fuberidazole + triadimenol (200 seeds/m$^2$).

Comparison of the 2001 results with equivalent trials in 1998-2000 showed similar seed rate responses for both fludioxonil alone and fludioxonil + silthiofam, although the yield benefit from silthiofam was above the previous average. The response for fuberidazole + triadimenol was different to previously. Increases in take-all incidence at higher seed rates had also been observed in some trials during the other three years.

The results suggest that, like silthiofam, a seed treatment based on fluquinconazole can give partial control of take-all. However, seed rate is also an important factor in managing second wheats at risk from take-all. Use of a non take-all seed treatment at a higher seed rate may cost less than a take-all treatment at a lower seed rate, but this could further depress yield. As later drilling is a key measure to reduce take-all impact, seed rates should however be adjusted to take into account sowing date, soil type and seedbed conditions.

## Summary

### Introduction

In a 3-year HGCA-funded study that preceded this investigation (HGCA Project Report No. 255) it was shown that, even when seed treatments are used that can reduce take-all, it is still important to delaying sowing from September until October. However, with the area of wheat being sown on many farms getting larger, an earlier start to second wheat drilling has become necessary. Both seed treatment and sowing date can have significant implications for selecting an appropriate seed rate. The study therefore examined the effects of seed treatment on response to seed rate, and the resulting take-all impact on grain yield. For seed rates ranging from 200 to 400 seeds/m$^2$, choice of seed treatment between fludioxonil (Beret Gold), fludioxonil + silthiofam (Beret Gold + Latitude), and fuberidazole + triadimenol (Baytan) did not alter the optimum seed rate for either September or October drilling. However, in some trials take-all incidence was greater at the highest seed rate.

The main objectives of this additional investigation were to extend the range of seed rates evaluated down to 100 seeds/m$^2$, allowing further evaluation of the cost/benefit relationship for silthiofam treatment, and to include fluquinconazole + prochloraz (Jockey) for comparison over the same range of seed rates.

### Methods

Replicated trials were established to compare four seed treatments at four seed rates on a single winter wheat variety (cv. Consort). These were conducted on three second wheat sites at locations with contrasting soils, which were Great Carlton in Lincolnshire (heavy fine clay loam), Andover in Hampshire (light chalkland soil) and Cirencester in Gloucestershire (light limestone brash clay). The target sowing date was late September, but wet weather prevented Andover from being sown until early November. The seed treatments examined are shown in Table 1. The seed rates evaluated were 100, 200, 300 and 400 seeds/m$^2$.

**Table 1 Seed Treatment Application Rates**

| Active Ingredient (s) | Product (s) | Application Rate |
|---|---|---|
| fuberidazole + triadimenol | Baytan Flowable | 4.5 + 37.5 g ai / 100 kg seed |
| fludioxonil | Beret Gold | 5 g ai / 100 kg seed |
| fludioxonil + silthiofam | Beret Gold + Latitude | 5 + 25 g ai / 100 kg seed |
| fluquinconazole + prochloraz | Jockey | 75 + 14 g ai / 100 kg seed |

A randomised split plot trial design was used, with three yield and three sampling replicates. Assessments carried out included autumn plant populations, spring shoot populations and ear counts, in marked quadrats. Root infection with take-all was assessed in April (at GS31) and June (at GS65). Both the incidence (number of plants affected) and severity (percentage of root area affected) of take-all necrosis were recorded, and converted to a severity index. All trials were taken to yield, and thousand grain weights were measured.

**2001 Results**

**Effects of Seed Treatment**

Plant populations varied between sites, but there were no differences between seed treatments apart from at Cirencester, where establishment averaged only 60% for fuberidazole + triadimenol and fluquinconazole + prochloraz, compared to 70% for fludioxonil. Seed treatment also had little effect on shoot or ear populations, although highest values were always recorded with fluquinconazole + prochloraz or fludioxonil + silthiofam.

At Cirencester, comparison of the yield components and grain yield shows a clear relationship (Table 2):

**Table 2 Effects of Seed Treatment on Yield Components at Cirencester**

| Seed Treatment (s) | Yield | Ears per $m^2$ | TGW (g) |
|---|---|---|---|
| fludioxonil | 3.95 | 172 | 41.4 |
| fludioxonil + silthiofam | 4.68 | 201 | 43.8 |
| fluquinconazole + prochloraz | 4.81 | 194 | 43.8 |
| fuberidazole + triadimenol | 3.60 | 160 | 42.2 |
| LSD 5% | 1.02 | 14.0 | 1.97 |

Grain yields were lower at Cirencester than at the other locations. The highest ranking seed treatment overall was fludioxonil + silthiofam. However, sites varied and treatment differences were generally not significant.

**Table 3 Effect of Location and Seed Treatment on Grain Yield**

| | Cirencester | Andover | G Carlton | 3 Site Mean |
|---|---|---|---|---|
| fludioxonil | 3.95 | 6.59 | 7.00 | 5.85 |
| fludioxonil + silthiofam | 4.68 | 7.07 | 7.44 | 6.39 |
| fluquinconazole + prochloraz | 4.81 | 7.01 | 7.03 | 6.28 |
| fuberidazole + triadimenol | 3.60 | 6.90 | 7.06 | 5.85 |
| Mean | 4.26 | 6.89 | 7.13 | 6.09 |
| LSD 5% | 1.02 | 0.47 | n.s. | |

Take-all was present at all sites, but incidence was highest at Great Carlton. Differences between seed treatments were apparent at only two of the three locations. At Andover, take-all severity in April was significantly lower for fludioxonil + silthiofam and fluquinconazole + prochloraz than for fludioxonil alone. These two treatments also gave the lowest severity at Cirencester (Table 4). By June, differences were small.

**Table 4 Effect of Location and Seed Treatment on Take-all Severity at GS31 in April**

| | Cirencester | Andover | G Carlton | 3 Site Mean |
|---|---|---|---|---|
| fludioxonil | 6.2 | 6.5 | 10.0 | 7.6 |
| fludioxonil + silthiofam | 1.6 | 2.8 | 10.9 | 5.1 |
| fluquinconazole + prochloraz | 1.3 | 4.2 | 12.3 | 5.9 |
| fuberidazole + triadimenol | 5.5 | 5.1 | 9.5 | 6.7 |
| LSD 5% | n.s. | 2.0 | n.s. | |

**Effects of Seed Rate**

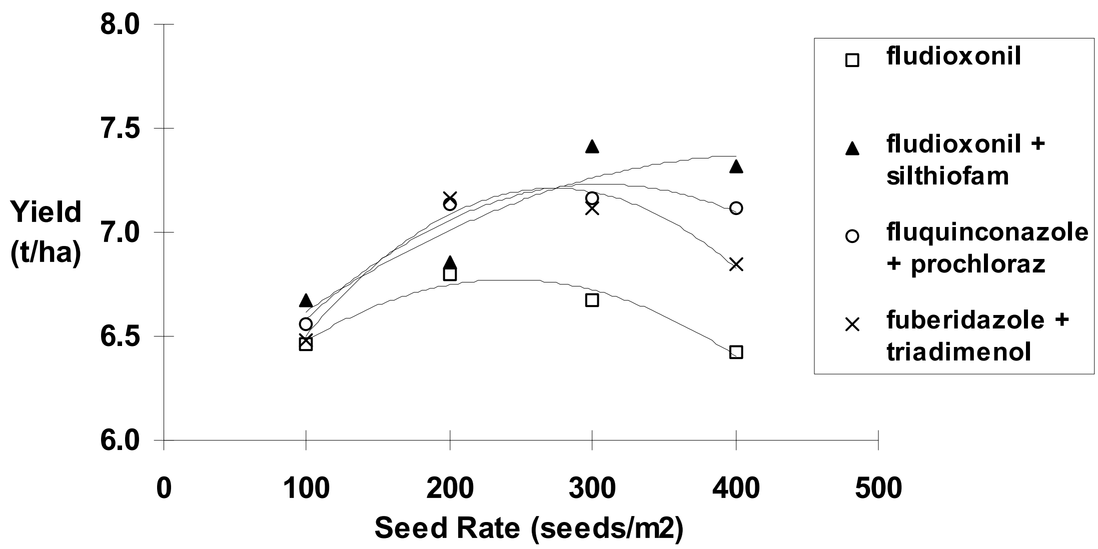
There were significant increases in plant, shoot and ear populations with seed rate at all locations, regardless of seed treatment (Table 5).

**Table 5 Effects of Seed Rate on Crop Structure (3 Site Mean)**

| Seed Rate (seeds/m$^2$) | Populations (per m$^2$) Plants | Shoots | Ears |
|---|---|---|---|
| 100 | 70 | 161 | 188 |
| 200 | 136 | 302 | 240 |
| 300 | 201 | 379 | 275 |
| 400 | 248 | 428 | 299 |

There was evidence of an interaction between seed treatment and rate at Andover, with the other treatments showing a greater yield advantage over fludioxonil at the higher seed rates than at the lower rates (Figure 1).

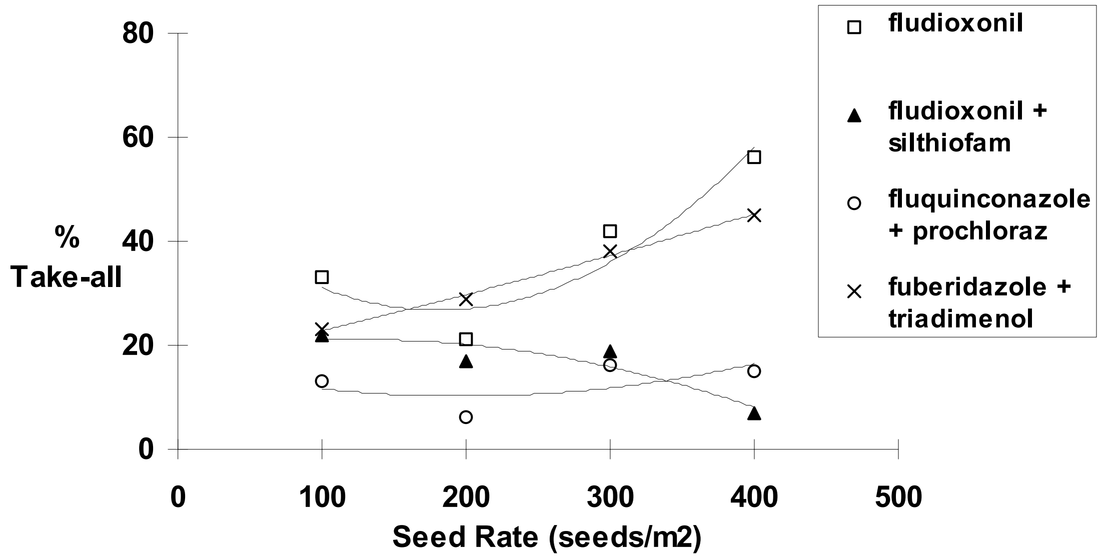
**Figure 1 Effect of Seed Treatment on Yield Response to Seed Rate at Andover**




Over all sites, the yield penalty from 100 seeds/m$^2$ compared to the other seed rates ranged from 0.39-0.67 t/ha for fuberidazole + triadimenol, 0.54-0.67 t/ha for fludioxonil, 0.71-1.04 t/ha for fluquinconazole + prochloraz, and 0.87-1.24 t/ha for fludioxonil + silthiofam.

At Cirencester, a higher take-all incidence and severity were recorded at GS31 at the two higher seed rates than at the two lower rates, for both fludioxonil alone and fuberidazole + triadimenol. By comparison, there was little or no increase in take-all as seed rate increased for the other two seed treatments (Figure 2).

**Figure 2 Effect of Seed Treatment and Seed Rate on GS31 Take-all Incidence at Cirencester**




**Economic Analysis**

The cost per hectare of a seed treatment depends on the cost per tonne for the treated seed, and the seed rate used. Using typical autumn 2001 prices for untreated seed and the four seed treatments, and assuming a thousand grain weight of 50g, the margin per hectare over the cost of the treated seed can be calculated for each of the combinations for grain prices of £60 and £75 per tonne, and these are summarised in Table 6.

**Table 6 Margin over Cost of Treated Seed (£/ha) - 3 Site Mean.**

| Seed Treatment(s) | Margin over cost £/ha (grain £60/t) | | | | Margin over cost £/ha (grain £75/t) | | | |
|---|---|---|---|---|---|---|---|---|
| | seed rate (seeds/m$^2$) | | | | | | | |
| | 100 | 200 | 300 | 400 | 100 | 200 | 300 | 400 |
| fludioxonil | 312 | 338 | 330 | 311 | 393 | 428 | 421 | 400 |
| fludioxonil + silthiofam | 319 | 351 | 354 | 317 | 403 | 449 | 457 | 416 |
| fluquinconazole + prochloraz | 319 | 344 | 341 | 329 | 403 | 439 | 440 | 429 |
| fuberidazole + triadimenol | 315 | 342 | 312 | 304 | 397 | 434 | 399 | 393 |

For three out of the four seed treatments, there was little difference in margin over cost between the 200 and 300 seeds/m$^2$ seed rates. The exception was fuberidazole + triadimenol, where 200 seeds/m$^2$ was superior. Regardless of seed rate or grain price, fludioxonil + silthiofam and fluquinconazole + prochloraz were more profitable than fludioxonil alone.

**Comparison with 1998-2000 Results**

Table 7 shows the yield response to seed rate and seed treatment (excluding fluquinconazole + prochloraz which was not included in 1998-2000) at Cirencester and Great Carlton in 2001 compared to the nearest equivalent sowing dates in the previous three seasons.

**Table 7 Grain Yield Response to Seed Treatment and Seed Rate**

| Seed Treatment(s) | Seed Rate (seeds/m$^2$) | Grain Yield as % of fludioxonil 200 seeds | | | |
|---|---|---|---|---|---|
| | | Cirencester | | Great Carlton | |
| | | 98-00 Mean | 2001 | 98-00 Mean | 2001 |
| | | (6.86 t/ha) | (4.07 t/ha) | (8.99 t/ha) | (7.12 t/ha) |
| fludioxonil | 200 | 100 | 100 | 100 | 100 |
| | 300 | 104 | 106 | 101 | 101 |
| | 400 | 103 | 105 | 100 | 100 |
| fludioxonil + silthiofam | 200 | 102 | 125 | 103 | 106 |
| | 300 | 106 | 129 | 105 | 112 |
| | 400 | 103 | 118 | 104 | 107 |
| fuberidazole + triadimenol | 200 | 98 | 99 | 102 | 102 |
| | 300 | 100 | 82 | 104 | 100 |
| | 400 | 102 | 94 | 103 | 101 |

At both locations, the 2001 seed rate response for fludioxonil at 200-400 seeds/m$^2$ was similar to the 1998-200 mean. The trend for fludioxonil + silthiofam was also similar, although the yield increases from silthiofam were larger than the 3 year mean. The performance of fuberidazole + triadimenol was quite different to 1998-2000.

Take-all severity in April was higher at Great Carlton in 2001 than previously, and whilst differences between seed treatments have tended to be smaller at this site, their ranking showed little similarity. In contrast, both severity and seed treatment differences at Cirencester were similar to the 3 year mean. In two out of four years at Cirencester, take-all incidence at GS31 has been substantially greater at 400 than at 200 seeds/m$^2$ with fludioxonil alone. Only in 1999 was there a small increase at the higher seed rate with fludioxonil + silthiofam.

**Table 8 Effects of Seed Rate on GS31 Take-all Incidence at Cirencester**

| Seed Treatment | Seed Rate (seeds/m2) | Take-all Incidence (%) at GS31 | | | | |
|---|---|---|---|---|---|---|
| | | 1998 | 1999 | 2000 | 2001 | Mean |
| fludioxonil | 200 | 16 | 12 | 44 | 21 | 23 |
| | 400 | 9 | 22 | 46 | 56 | 33 |
| fludioxonil + silthiofam | 200 | 3 | 9 | 33 | 17 | 16 |
| | 400 | 0 | 12 | 30 | 7 | 12 |

**Conclusions and Implications**

Results from 2001 indicate that, like silthiofam, a seed treatment based on fluquinconazole can give partial control of take-all, but the effect appears to diminish as the season progresses. It is not possible to conclude whether the level of take-all control obtained with fluquinconazole + prochloraz is likely to be more similar to that observed over the four years with silthiofam, or with fuberidazole + triadimenol. Differences in take-all severity observed were reflected in grain yields, but the relative performance of the seed treatments differed between sites. In 2001, fuberidazole + triadimenol gave the least consistent advantage over fludioxonil alone.

The impact of seed treatment on shoot and ear populations remains small compared to that of seed rate. However, the effects on establishment observed with fluquinconazole + prochloraz as well as fuberidazole + triadimenol in 2001, have been recorded in several of the previous trials featuring fuberidazole + triadimenol, notably when drilling on heavier land sites in October.

Seed rate has again been shown to be an important factor in managing second wheats at risk from take-all. Although the lowest seed rate evaluated, 100 seeds/$m^2$, was below optimum regardless of seed treatment, it should be remembered that one site could not be drilled until November, and both earlier sown locations had poor tillering and low ear populations due to the wet conditions. Further evidence of an interaction between seed treatment and seed rate was provided by the size of the yield penalty associated with the lowest seed rate. This was much greater for fludioxonil + silthiofam or fluquinconazole + triadimenol than for fludioxonil or fuberidazole + triadimenol. However, optimum seed rates were still the same for all seed treatments, with little difference between 200 and 300 seeds/$m^2$, apart from fuberidazole + triadimenol where 200 seeds/$m^2$ was best.

Whilst only some of the trials during the past four years have shown an effect of seed rate on take-all levels, results from one location in 2001 again suggest that incidence of the disease in April may be greater at higher than at lower seed rates, particularly where the seed treatment does not give control of take-all. Therefore, although the use of non take-all seed treatment at a higher seed rate might cost less than the use of a take-all seed treatment at a lower seed rate, the increased take-all risk would pose a particular threat to yield.

## The Effects of Seed Treatment and Seed Rate on the Impact of Take-all on Second Wheat Grain Yields.

### 1. Introduction

Crop husbandry is a vital element in managing second wheats to minimise the impact of take-all on yield. In a 3-year HGCA-funded study which preceded this investigation (HGCA Project Report No. 255), it was shown that even when seed treatments are used that can reduce take-all, it is still important to delaying sowing from September until October, and to apply a large enough first dose of nitrogen fertiliser during tillering. However, with the area of wheat being sown on many farms getting larger, an earlier start to second wheat drilling has become necessary, which then increases the take-all threat.

Both seed treatment and sowing date can have significant implications for selecting an appropriate seed rate. In particular, as a chemical applied to the seed, the cost per hectare of the take-all treatments is directly linked to seed rate. The preceding study therefore also examined the effects of seed treatment on response to seed rate, and the resulting take-all impact on grain yield. For seed rates ranging from 200 to 400 seeds/m$^2$, choice of seed treatment between fludioxonil (Beret Gold), fludioxonil + silthiofam (Beret Gold + Latitude), and fuberidazole + triadimenol (Baytan) did not alter the optimum seed rate for either September or October drilling. However, in some trials take-all incidence was greater at the highest seed rate.

The main objectives of this additional investigation were to extend the range of seed rates evaluated down to 100 seeds/m$^2$, allowing further evaluation of the cost/benefit relationship for silthiofam treatment, and to include fluquinconazole + prochloraz (Jockey) for comparison over the same range of seed rates.

### 2. Materials and Methods

#### 2.1 Trial Details

Replicated trials were established to compare four seed treatments at four seed rates on a single winter wheat variety. These were conducted on three second wheat sites at locations with contrasting soil types (Table 2.1). The target sowing date was late September, but wet weather prevented one trial (Andover) from being sown until early November.

**Table 2.1 Site Details and Sowing Dates**

| Location | Soil Type | Sowing Date | Harvest Date |
|---|---|---|---|
| North - Great Carlton, Lincs. | Heavy, fine clay loam | 25/09/2000 | 21/08/2001 |
| South - Andover, Hants. | light, chalkland soil | 10/11/2000 | 14/08/2001 |
| West - Cirencester, Gloucs. | light, limestone brash clay | 06/10/2000 | 23/08/2001 |

## 2.2 Seed Treatments and Seed Rates

Application rates for the four seed treatments examined are shown in Table 2.2. A single batch of winter wheat seed (cv. Consort) was used for all treatments at all sites. The seed for each plot was individually weighed, packeted and drilled to achieve seed rates of 100, 200, 300 and 400 seeds/m$^2$.

**Table 2.2 Seed Treatment Application Rates**

| Active Ingredient (s) | Product (s) | Application Rate |
|---|---|---|
| fuberidazole + triadimenol | Baytan Flowable | 4.5 + 37.5 g ai / 100 kg seed |
| fludioxonil | Beret Gold | 5 g ai / 100 kg seed |
| fludioxonil + silthiofam | Beret Gold + Latitude | 5 + 25 g ai / 100 kg seed |
| fluquinconazole + prochloraz | Jockey | 75 + 14 g ai / 100 kg seed |

## 2.3 Trial Design and Analysis

Trials were sown to a pre-determined layout, using a randomised split plot design, with seed treatment as the main plot and seed rate as the sub plot. Three replicates were used for yield and grain size measurements, and a further three were sampled for take-all and crop structure assessments. Multi-factor analysis of variance was conducted on all data.

## 2.4 Assessment Details

Autumn plant population was determined for all treatments at GS13 by counting 6 x 1.0m row lengths per plot. Shoot populations in spring at the end of GS30, and ear populations pre-harvest, were recorded in the same areas, enabling the number of shoots and ears per plant to be calculated.

Root infection with take-all was assessed in April (at GS31) and June (at GS65). At each timing, 4 x 0.25m row lengths were dug at random from each sample plot, avoiding the outside rows. Roots were then washed after excess soil had been removed. Both the incidence (number of plants affected) and severity (percentage of root area affected) of take-all necrosis were recorded. A take-all severity index was then calculated (see appendix A). Fresh grain yields were determined using a plot combine, and these were adjusted for moisture content and plot size to give a yield in tonnes/ha at 15% moisture content. Specific weight (kg/hl) and thousand grain weight (g) were measured from each plot sample.

## 3. Results

### 3.1 Grain Yield

Cirencester produced lower grain yields than the other two sites, as has often been the case when comparing these locations in previous trials. The highest yielding seed treatment overall was fludioxonil + silthiofam, although differences between treatments at individual sites were generally not significant. At Great Carlton, silthiofam was the only seed treatment that gave any apparent advantage over fludioxonil alone, compared to Cirencester where fluquinconazole + prochloraz was equally beneficial, and Andover where both fluquinconazole + prochloraz and fuberidazole + triadimenol were advantageous (Table 3.1).

**Table 3.1 Grain Yield Response to Seed Treatment and Seed Rate**

| Seed Treatment(s) | Seed Rate (seeds/m$^2$) | Grain Yield (t/ha) | | | |
|---|---|---|---|---|---|
| | | Cirencester | Andover | G Carlton | 3 Site Mean |
| fludioxonil | 100 | 3.12 | 6.46 | 6.60 | 5.39 |
| | 200 | 4.07 | 6.80 | 7.12 | 6.00 |
| | 300 | 4.33 | 6.67 | 7.18 | 6.06 |
| | 400 | 4.27 | 6.42 | 7.10 | 5.93 |
| | **Mean** | **3.95** | **6.59** | **7.00** | **5.85** |
| fludioxonil + silthiofam | 100 | 3.59 | 6.67 | 6.64 | 5.63 |
| | 200 | 5.09 | 6.86 | 7.55 | 6.50 |
| | 300 | 5.23 | 7.41 | 7.96 | 6.87 |
| | 400 | 4.79 | 7.32 | 7.59 | 6.57 |
| | **Mean** | **4.68** | **7.07** | **7.44** | **6.39** |
| fluquinconazole + prochloraz | 100 | 3.82 | 6.56 | 6.46 | 5.61 |
| | 200 | 4.84 | 7.13 | 6.98 | 6.32 |
| | 300 | 5.18 | 7.16 | 7.33 | 6.56 |
| | 400 | 5.38 | 7.20 | 7.36 | 6.65 |
| | **Mean** | **4.81** | **7.01** | **7.03** | **6.28** |
| fuberidazole + triadimenol | 100 | 3.19 | 6.48 | 6.73 | 5.47 |
| | 200 | 4.04 | 7.16 | 7.23 | 6.14 |
| | 300 | 3.32 | 7.12 | 7.13 | 5.86 |
| | 400 | 3.83 | 6.85 | 7.16 | 5.95 |
| | **Mean** | **3.60** | **6.90** | **7.06** | **5.85** |
| seed treatment only | F prob.<br>sed. (d.f.) | 0.073<br>0.415 (6) | 0.160<br>0.192 (6) | 0.965<br>0.985 (6) | |
| seed rate x treatment | F prob.<br>sed. (d.f.) | 0.342<br>0.412 (24) | 0.110<br>0.207 (24) | 0.115<br>0.312 (24) | |

There was an indication of an interaction between seed rate and seed treatment at Andover (Table 3.1). The yield advantage of the other three seed treatments over fludioxonil alone averaged 0.11 t/ha at 100 seeds/m$^2$, 0.25 t/ha at 200 seeds, 0.56 t/ha at 300 seeds and 0.66 t/ha at 400 seeds/m$^2$. However, only fludioxonil + silthiofam appeared to have a higher optimum seed rate of 300 seeds/m$^2$ compared to 200 seeds/m$^2$ for fludioxonil alone. A similar trend was apparent for fludioxonil + silthiofam at Great Carlton, and for fluquinconazole + prochloraz at Cirencester, but not for fuberidazole + triadimenol at either location.

### 3.2 Crop Structure and Yield Components

Establishment varied between sites, ranging from an average of 50% at Great Carlton to 80% at Andover Significant plant population increases with seed rate were obtained in all cases (Table 3.2). Although there were no significant differences between seed treatments, at Cirencester establishment averaged 60% for fluquinconazole + prochloraz and fuberidazole + triadimenol, compared to 70% for fludioxonil. At Great Carlton, all four seed treatment gave similar final plant populations, but fluquinconazole + prochloraz and fuberidazole + triadimenol were slower to emerge than either fludioxonil or fludioxonil + silthiofam.

**Table 3.2 Effects of Seed Treatment and Seed Rate on Crop Structure (3 Site Mean)**

| | **Populations (per $m^2$)** | | |
|---|---|---|---|
| **Seed Treatment(s)** | **Plants** | **Shoots** | **Ears** |
| fludioxonil | 169 | 309 | 231 |
| fludioxonil + silthiofam | 169 | 343 | 268 |
| Fluquinconazole + prochloraz | 154 | 312 | 258 |
| fuberidazole + triadimenol | 162 | 306 | 244 |
| **Seed Rate (seeds/$m^2$)** | | | |
| 100 | 70 | 161 | 188 |
| 200 | 136 | 302 | 240 |
| 300 | 201 | 379 | 275 |
| 400 | 248 | 428 | 299 |

Shoot and ear populations also increased with seed rate (Table 3.2). One again seed treatment differences were mostly not significant, but highest recorded populations were always either with fluquinconazole + prochloraz or fludioxonil + silthiofam. Regardless of seed rate, fludioxonil alone produced the lowest number of ears per plant, but the effect of seed treatment was small compared to that of seed rate (Table 3.3).

**Table 3.3 Effect of Seed Treatment and Rate on Number of Ears per Plant (3 Site Mean)**

| **Seed Rate** | **Number of Ears per Plant** | | | | |
|---|---|---|---|---|---|
| **And Seed Treatment** | fludioxonil | fludioxonil + silthiofam | fluquinconazol e + prochloraz | fuberidazole + triadimenol | Mean |
| 100 | 2.5 | 2.9 | 3.1 | 2.8 | 2.8 |
| 200 | 1.5 | 1.9 | 2.0 | 1.7 | 1.8 |
| 300 | 1.3 | 1.5 | 1.5 | 1.4 | 1.4 |
| 400 | 1.1 | 1.3 | 1.4 | 1.2 | 1.2 |
| Mean | 1.6 | 1.9 | 2.0 | 1.8 | |

Comparison of the yield components (ear populations and thousand grain weights) and grain yield for the four seed treatments at Cirencester shows a clear relationship between them (Table 3.4):

**Table 3.4 Effects of Seed Treatment on Yield Components at Cirencester**

| Seed Treatment (s) | Yield | Ears per $m^2$ | TGW (g) |
|---|---|---|---|
| fludioxonil | 3.95 | 172 | 41.4 |
| fludioxonil + silthiofam | 4.68 | 201 | 43.8 |
| fluquinconazole + prochloraz | 4.81 | 194 | 43.8 |
| fuberidazole + triadimenol | 3.60 | 160 | 42.2 |
| F prob.<br>sed. (d.f.) | 0.073<br>0.415 (6) | 0.002<br>5.74 (6) | 0.060<br>0.804 (6) |

### 3.3 Take-all Assessments

Take-all was present at all sites, with an average of 46% (range 25-75%) of plants showing at least one area of black root rot at GS31 in April, and 82% (range 61-98%) at GS65 in June. The highest incidence of take-all was at Great Carlton, which notably was the earliest-sown site. In June, take-all severity was also highest at Great Carlton, and lowest at Andover where sowing was delayed until November. In previous trials, take-all levels have tended to be lower on the heavier land site at Great Carlton than on lighter land sites in the south and south-west of England, where sowing dates have not differed.

Differences between seed treatments were evident at two locations, but not at Great Carlton. At Andover, take-all severity at GS31 was significantly lower for fludioxonil + silthiofam and fluquinconazole + prochloraz than for fludioxonil alone. These two treatments also gave the lowest take-all severity at Cirencester (Table 3.5). By GS65, differences at Andover were small, and only fludioxonil + silthiofam was still showing a benefit at Cirencester.

**Table 3.5 Effect of Seed Treatment on Take-all Severity at GS31**

| Seed Treatment(s)<br>or Seed Rate (seeds/$m^2$) | Take-all Severity Index at GS31 | | |
|---|---|---|---|
| | Cirencester | Andover | G Carlton |
| fludioxonil | 6.2 | 6.5 | 10.0 |
| fludioxonil + silthiofam | 1.6 | 2.8 | 10.9 |
| fluquinconazole + prochloraz | 1.3 | 4.2 | 12.3 |
| fuberidazole + triadimenol | 5.5 | 5.1 | 9.5 |
| F prob.<br>sed. (d.f.) | 0.173<br>2.325 (6) | 0.020<br>0.817 (6) | 0.864<br>3.528 (6) |

At Cirencester, a higher take-all incidence and severity were recorded at GS31 at the two higher seed rates than at the two lower rates with fludioxonil alone and fuberidazole + triadimenol. By comparison, there was little or no increase in take-all as seed rate increased for the other two seed treatments (Table 3.6). For fludioxonil + silthiofam, this difference persisted through to GS65, such that take-all severity was 44% less with the addition of silthiofam at 100 seeds/$m^2$, but 64% less at 400 seeds/$m^2$ (Table 3.7).

**Table 3.6 Effect of Seed Rate on GS31 Take-all Incidence at Cirencester**

| Seed Rate and Seed Treatment | Take-all Incidence (%) at GS31 | | | | |
|---|---|---|---|---|---|
| | fludioxonil | fludioxonil + silthiofam | fluquinconazole + prochloraz | fuberidazole + triadimenol | Mean |
| 100 | 33 | 22 | 13 | 23 | 23 |
| 200 | 21 | 17 | 6 | 29 | 18 |
| 300 | 42 | 19 | 16 | 38 | 29 |
| 400 | 56 | 7 | 15 | 45 | 31 |
| Mean | 38 | 16 | 13 | 34 | 0.066 |
| F prob. sed. (d.f.) | 0.082 9.34 (6) | | | | 4.86 (24) |

**Table 3.7 Effect of Seed Rate on GS65 Take-all Severity at Cirencester**

| Seed Rate and Seed Treatment | Take-all Severity at GS65 | | | | |
|---|---|---|---|---|---|
| | fludioxonil | fludioxonil + silthiofam | fluquinconazole + prochloraz | fuberidazole + triadimenol | seed rate x treatment |
| 100 | 13.0 | 7.3 | 15.7 | 14.7 | |
| 200 | 10.3 | 9.3 | 16.7 | 13.6 | F prob. 0.057 |
| 300 | 16.0 | 9.7 | 12.0 | 15.0 | sed. 1.28 |
| 400 | 18.7 | 6.3 | 15.7 | 20.0 | (d.f. 24) |
| Mean | 14.5 | 8.2 | 15.0 | 15.8 | |
| F prob. sed. (d.f.) | 0.116 2.86 (6) | | | | |

All sites were examined for the presence of whiteheads at GS77 in July. However, due to rapid ripening resulting from soil and weather conditions, no differences were observed between treatments.

## 4. Discussion

### 4.1 2000/01 Results

The exceptionally wet conditions experienced in autumn and winter 2000, followed by long spells of dry weather between May and July 2001, not surprisingly had a significant impact on field trials conducted during the season (not to mention the effect on many farm crops). Even where sowing was possible on the target date, subsequent variability tended to mask the more subtle effects that might be attributable to differing treatments. Although many of the differences recorded at individual sites were not statistically significant, there were some obvious similarities and contrasts between sites, and further evidence of effects observed in previous seasons.

Despite having the earliest sowing date and the highest take-all levels, the Great Carlton trial appeared to show least benefit from the take-all seed treatments. It should be noted however that the soil type at this location was a heavy clay loam that is prone to waterlogging even in an normal season, and grain yields were lower than would typically be expected for that cropping situation. It is also interesting to note the differences in yield and take-all severity recorded between seed treatments at Andover, even though sowing was delayed until early November, which is recognised as the main cultural defence against the disease.

Clearly, a seed rate of 100 seeds/m$^2$ would not have been expected to produce the optimum yield when sown in early November, but at the two earlier locations it was equally unsuccessful under the conditions experienced during the season. Poor tillering was a feature at both Cirencester and Great Carlton, resulting in low ear populations and therefore marked responses to seed rate. However, the size of the yield penalty associated with the lowest seed rate was affected by choice of seed treatment. Averaged over the three trials, the yield penalty from 100 seeds/m$^2$ compared to the other seed rates ranged from 0.39-0.67 t/ha for fuberidazole + triadimenol, 0.54-0.67 t/ha for fludioxonil alone, 0.71-1.04 t/ha for fluquinconazole + prochloraz, and 0.87-1.24 t/ha for fludioxonil + silthiofam. At the same time, as Table 4.1 shows, the yield advantage over fludioxonil alone of the highest ranking seed treatment tended to be greater at 300 or 400 seeds/m$^2$ than at 100 or 200 seeds/m$^2$.

**Table 4.1 Advantage over fludioxonil of Highest Ranking Seed Treatment at each Location**

| Location and highest ranking seed treatment | Yield advantage (t/ha) over fludioxonil at a seed rate of 100 seeds/m$^2$ | 200 seeds/m$^2$ | 300 seeds/m$^2$ | 400 seeds/m$^2$ |
|---|---|---|---|---|
| Cirencester fluquinconazole + prochloraz | 0.70 | 0.77 | 0.85 | 1.11 |
| Andover fludioxonil + silthiofam | 0.21 | 0.06 | 0.74 | 0.90 |
| Great Carlton fludioxonil + silthiofam | 0.04 | 0.43 | 0.78 | 0.49 |
| Mean yield advantage (t/ha) | 0.32 | 0.42 | 0.79 | 0.83 |

Like fuberidazole + triadimenol, fluquinconazole + prochloraz is a conazole-based seed treatment, and it might therefore be expected to show properties that are more similar to the former than to silthiofam, which is from the hindered silyl amide fungicide group. There were few effects of seed treatment on crop growth this season, but the slight delay in emergence at Great Carlton and the small reduction in establishment at Cirencester, that have previously been recorded with fuberidazole + triadimenol, were apparent with both conazole treatments. However, at Cirencester despite this fluquinconazole + prochloraz had the highest shoot population, and had an ear population similar to fludioxonil + silthiofam, and higher than fuberidazole + triadimenol.

None of the seed treatments appeared to give any reduction in the very high take-all levels experienced at Great Carlton, which might explain the lack of any significant yield benefits. The reason for this is not clear. Both silthiofam and fluquinconazole + prochloraz gave partial control at the other two locations, averaging 66% and 57% reductions in take-all severity respectively at GS31 in April. It is notable, however, that by GS65 control was effectively only 10-15% for both treatments at Andover, and fluquinconazole + prochloraz was no longer showing any reduction compared to fludioxonil at Cirencester. This underlines the role of seed treatments as a means of delaying rather than preventing the development of take-all in the crop.

**4.2 Economic Analysis**

To be of benefit to wheat growers, seed treatments that are applied for take-all control must not only reduce disease severity and increase yield, but they must also be cost-effective. The per hectare cost of a seed treatment depends on the additional cost per tonne for the treated seed, and the seed rate used. Table 4.2 shows how this might vary for the seed treatments and seed rates used in these trials, based on typical seed treatment prices for autumn 2001, and assuming a thousand grain weight of 50g.

**Table 4.2 Effect of Seed Treatment Cost per Tonne and Seed Rate on Cost per Hectare**

| | Seed Treatment and Approximate Cost (£/ha) | | | |
|---|---|---|---|---|
| **Seed Rate (seeds/m$^2$)** | **fludioxonil (£44/t)*** | **fuberidazole + triadimenol (£87/t)*** | **fludioxonil + silthiofam (£162/t)*** | **fluquinconazole + prochloraz (£170/t)*** |
| 100 | 2.20 | 4.35 | 8.10 | 8.50 |
| 200 | 4.40 | 8.70 | 16.20 | 17.00 |
| 300 | 6.60 | 13.05 | 24.30 | 25.50 |
| 400 | 8.80 | 17.40 | 32.40 | 34.00 |

* Source: Farmers Weekly Seeds Focus Supplement, 13 July 2001

Using these values, and an untreated seed cost of £180 per tonne, the margin per hectare over the cost of the treated seed can be calculated for each of the seed treatment and seed rate combinations for grain prices of £60 and £75 per tonne (see appendix B). These are summarised (as the mean of the three sites) in Table 4.3.

**Table 4.3 Margin over Cost of Treated Seed (£/ha) - 3 Site Mean.**

| Seed Treatment(s) | Margin over cost £/ha (grain £60/t) | | | | Margin over cost £/ha (grain £75/t) | | | |
|---|---|---|---|---|---|---|---|---|
| | seed rate (seeds/m$^2$) | | | | | | | |
| | **100** | **200** | **300** | **400** | **100** | **200** | **300** | **400** |
| fludioxonil | 312 | 338 | 330 | 311 | 393 | 428 | 421 | 400 |
| fludioxonil + silthiofam | 319 | 351 | 354 | 317 | 403 | 449 | 457 | 416 |
| fluquinconazole + prochloraz | 319 | 344 | 341 | 329 | 403 | 439 | 440 | 429 |
| fuberidazole + triadimenol | 315 | 342 | 312 | 304 | 397 | 434 | 399 | 393 |

For three out of the four seed treatments, there was little difference in margin over cost between the 200 and 300 seeds/m$^2$ seed rates. The exception was fuberidazole + triadimenol, where 200 seeds/m$^2$ was superior. Grain price had little effect on the optimum seed rate, although at £75/t 400 seeds/m$^2$ was generally more cost-effective than 100 seeds/m$^2$, whereas at £60/t this was not the case. Regardless of seed rate or grain price, fludioxonil + silthiofam and fluquinconazole + prochloraz were more profitable than fludioxonil alone. Overall fuberidazole + triadimenol was similar to fludioxonil, and any advantage with fuberidazole + triadimenol at the two lower seed rates was reversed at the higher rates.

### 4.3 Comparison with 1997/98, 1998/99 and 1999/2000 Seasons

Table 4.4 shows the yield response to seed rate and seed treatment (excluding fluquinconazole + prochloraz which was not included in 1998-2000) at Cirencester and Great Carlton in 2001 compared to the previous three seasons. For best comparison with 2001, the 1998-2000 mean for Cirencester is based on the October sowing date, whereas Great Carlton is based on the mean of the September and October sowing dates.

**Table 4.4 Grain Yield Response to Seed Treatment and Seed Rate**

| Seed Treatment(s) | Seed Rate (seeds/m$^2$) | Grain Yield t/ha (and % of fludioxonil 200 seeds) | | | |
|---|---|---|---|---|---|
| | | Cirencester | | Great Carlton | |
| | | **98-00 Mean** | **2001** | **98-00 Mean** | **2001** |
| fludioxonil | 100 | n/a | 3.12 (77) | n/a | 6.60 (93) |
| | 200 | 6.86 (100) | 4.07 (100) | 8.99 (100) | 7.12 (100) |
| | 300 | 7.16 (104) | 4.33 (106) | 9.06 (101) | 7.18 (101) |
| | 400 | 7.06 (103) | 4.27 (105) | 8.98 (100) | 7.10 (100) |
| | **Mean** | **7.03** | **3.95** | **9.01** | **7.00** |
| fludioxonil + silthiofam | 100 | n/a | 3.59 (88) | n/a | 6.64 (93) |
| | 200 | 6.98 (102) | 5.09 (125) | 9.23 (103) | 7.55 (106) |
| | 300 | 7.26 (106) | 5.23 (129) | 9.45 (105) | 7.96 (112) |
| | 400 | 7.04 (103) | 4.79 (118) | 9.35 (104) | 7.59 (107) |
| | **Mean** | **7.09** | **4.68** | **9.34** | **7.44** |
| fuberidazole + triadimenol | 100 | n/a | 3.19 (78) | n/a | 6.73 (95) |
| | 200 | 6.71 (98) | 4.04 (99) | 9.18 (102) | 7.23 (102) |
| | 300 | 6.83 (100) | 3.32 (82) | 9.37 (104) | 7.13 (100) |
| | 400 | 7.01 (102) | 3.83 (94) | 9.24 (103) | 7.16 (101) |
| | **Mean** | **6.85** | **3.60** | **9.26** | **7.06** |

At both Cirencester and Great Carlton the seed rate response for fludioxonil at 200-400 seeds/m$^2$ in 2001 was similar to the 1998-2000 mean. The trend for fludioxonil + silthiofam was also similar, with yield peaking at 300 seeds/m$^2$ in all cases. However, the yield benefits from silthiofam in 2001 were greater than the 3 year means for comparable sowing dates. The performance of fuberidazole + triadimenol in 2001 was quite different to 1998-2000, with relative yield declining above 200 seeds/m$^2$ rather than improving as previously.

In 2001, as in the three previous years, the effects of seed treatment on shoot and ear populations were small compared to the effects of seed rate. Nevertheless, where any differences have been observed, the tendency has been for fludioxonil + silthiofam to have higher numbers than fludioxonil alone. The slightly reduced level of establishment observed at Cirencester with fluquinconazole + prochloraz as well as fuberidazole + triadimenol, has also been observed with the latter in several of the previous trials, but more often on the heavy land sites.

In Table 4.5, take-all levels at Cirencester and Great Carlton in 2001 are compared with the equivalent 1998-2000 means. Severity at GS31 was higher at Great Carlton in 2001 than for similar timings in previous years. Differences between seed treatments have tended to be smaller at this site than at other locations, and whereas Cirencester is showing a fairly similar treatment ranking in 2001 to previously, Great Carlton is not.

**Table 4.5 Effects of Seed Treatment on Take-all Severity at GS31 in April**

| Seed Treatment(s) | Take-all Severity Index at GS31 | | | |
|---|---|---|---|---|
| | Cirencester | | Great Carlton | |
| | 98-00 Mean | 2001 | 98-00 Mean | 2001 |
| fludioxonil | 4.05 | 6.2 | 3.26 | 10.0 |
| fludioxonil + silthiofam | 1.63 | 1.6 | 2.02 | 10.9 |
| fuberidazole + triadimenol | 3.27 | 5.5 | 2.78 | 9.5 |
| fluquinconazole + prochloraz | n/a | 1.3 | n/a | 12.3 |

In two out of the four years at Cirencester, take-all incidence at GS31 has been substantially greater at 400 seeds/m$^2$ than at 200 seeds/m$^2$ with fludioxonil alone (levels at other seed rates were not assessed prior to 2001). Only in 1999 was there an increase at the higher seed rate with fludioxonil + silthiofam, and even this was small. Similar differences have been observed in some of the other trials during the four year period, but there is no consistent pattern to these.

**Table 4.6 Effects of Seed Rate on GS31 Take-all Incidence at Cirencester**

| Seed Treatment | Seed Rate (seeds/m2) | Take-all Incidence (%) at GS31 | | | | |
|---|---|---|---|---|---|---|
| | | 1998 | 1999 | 2000 | 2001 | Mean |
| fludioxonil | 200 | 16 | 12 | 44 | 21 | 23 |
| | 400 | 9 | 22 | 46 | 56 | 33 |
| fludioxonil + silthiofam | 200 | 3 | 9 | 33 | 17 | 16 |
| | 400 | 0 | 12 | 30 | 7 | 12 |

## 5. Conclusions and Implications

Results from 2001 indicate that, like silthiofam, a seed treatment based on fluquinconazole can give partial control of take-all. However, comparison of assessments in April and June suggest that as with silthiofam the effect diminishes as the season progresses. It should also be noted that at one location this year seed treatment appeared to have no effect on take-all levels. From these results alone, it is not possible to conclude whether the level of take-all control obtained with a fluquinconazole + prochloraz is likely to be more similar to that observed over the four years with silthiofam, or with fuberidazole + triadimenol.

The differences in take-all severity observed at two of the locations were reflected in grain yields. The relative performance of seed treatments differed between sites, but overall fuberidazole + triadimenol gave the least consistent advantage over fludioxonil in 2001, and was less beneficial than in the previous three years. Seed rate had a significant effect upon yield, with 100 seeds/$m^2$ below optimum regardless of seed treatment. However, this would have been expected as one of the sites could not be drilled until November, and at both the earlier sown locations poor tillering and low ear populations resulted from the wet conditions.

The impact of seed treatment on shoot and ear populations remains small compared to that of seed rate. The effects on establishment, observed with fluquinconazole + prochloraz as well as fuberidazole + triadimenol in 2001, have though been observed in several of the previous trials featuring fuberidazole + triadimenol. This has tended to be on the heavier land sites, where drilling has taken place in wet conditions in October.

Further evidence of an interaction between seed treatment and seed rate in the presence of take-all was provided by the size of the yield penalty associated with the 100 seeds/$m^2$ rate. This was much greater for fludioxonil + silthiofam or fluquinconazole + prochloraz than for fuberidazole + triadimenol or fludioxonil, reflecting both their effectiveness against take-all and their overall yield ranking. Despite this, due to their higher cost, the optimum seed rates for fludioxonil + silthiofam or fluquinconazole + prochloraz were the same as for fludioxonil, with little difference between 200 and 300 seeds/$m^2$. Fuberidazole + triadimenol was less cost-effective at 300 than at 200 seeds/$m^2$ in 2001, but has not recorded a lower optimum in previous years.

Whilst only some of the trials during the past four years have shown an effect of seed rate on take-all levels, results from one location in 2001 again suggest that the incidence of take-all in April may be greater at higher than at lower seed rates, particularly where the seed treatment does not give control of take-all. This would offer an explanation for the yield differences mentioned above.

Seed treatment and seed rate are clearly important considerations in the management of second wheats at risk from take-all. Levels of the disease, yield and margin over cost can all be affected. Although the use of a non take-all seed treatment at a higher seed rate might cost less than the use of a take-all seed treatment at a lower seed rate, far from recouping some of the yield loss due to take-all a high seed rate may simply depress yields even further. Whatever the choice of seed treatment, it is still vital to delay drilling wherever possible from September until October at the earliest. in order to reduce the take-all risk. Seed rates will therefore need to be adjusted to take into account sowing date, soil type and seedbed conditions.

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## References

Knight SM (2001). *Managing Early-Drilled Second Wheats to Minimise the Impact of Take-all. HGCA Project Report No. 255*. Home-Grown Cereals Authority, London.

## Appendices

### Appendix A

**Formulae for Calculation of Take-all Incidence and Severity Index**

The severity of root necrosis on each plant was recorded by category as follows

| Category | % Root area affected |
|---|---|
| 0 | 0 |
| 1 | 1-10 |
| 2 | 11-30 |
| 3 | 31-60 |
| 4 | 61-100 |

**Incidence** of Take-all was calculated as:

$$\frac{\text{Number of plants with Take-all}}{\text{Number of plants assessed}} \times 100\ \%$$

Take-all **Severity Index** was calculated as:

$$\frac{(0 \times a) + (10 \times b) + (30 \times c) + (60 \times d) + (100 \times e)}{\text{Total number of plants}}$$

where a, b, c, d and e are the number of plants in categories 0, 1, 2, 3 and 4 respectively

### Appendix B

Table of Margins over Cost of Treated Seed

| Seed Treatment | Seed rate seeds/m 2 | Yield (t/ha) | Output Value (£/ha) | | Seed cost (£/ha) | MOC treat seed (£/ha) | |
|---|---|---|---|---|---|---|---|
| | | | grain £60/t | grain £75/t | | grain £60/t | grain £75/t |
| fludioxonil | 100 | 5.39 | 323.40 | 404.25 | 11.20 | 312.20 | 393.05 |
| | 200 | 6.00 | 360.00 | 450.00 | 22.40 | 337.60 | 427.60 |
| | 300 | 6.06 | 363.60 | 454.50 | 33.60 | 330.00 | 420.90 |
| | 400 | 5.93 | 355.80 | 444.75 | 44.80 | 311.00 | 399.95 |
| fludioxonil + silthiofam | 100 | 5.63 | 337.80 | 422.25 | 19.30 | 318.50 | 402.95 |
| | 200 | 6.50 | 390.00 | 487.50 | 38.60 | 351.40 | 448.90 |
| | 300 | 6.87 | 412.20 | 515.25 | 57.90 | 354.30 | 457.35 |
| | 400 | 6.57 | 394.20 | 492.75 | 77.20 | 317.00 | 415.55 |
| fluquinconazole + prochloraz | 100 | 5.61 | 336.60 | 420.75 | 17.50 | 319.10 | 403.25 |
| | 200 | 6.32 | 379.20 | 474.00 | 35.00 | 344.20 | 439.00 |
| | 300 | 6.56 | 393.60 | 492.00 | 52.50 | 341.10 | 439.50 |
| | 400 | 6.65 | 399.00 | 498.75 | 70.00 | 329.00 | 428.75 |
| fuberidazole + triadimenol | 100 | 5.47 | 328.20 | 410.25 | 13.35 | 314.85 | 396.90 |
| | 200 | 6.14 | 368.40 | 460.50 | 26.70 | 341.70 | 433.80 |
| | 300 | 5.86 | 351.60 | 439.50 | 40.05 | 311.55 | 399.45 |
| | 400 | 5.95 | 357.00 | 446.25 | 53.40 | 303.60 | 392.85 |

Based on untreated seed at £180/t, fludioxonil seed treatment at £44/t, silthiofam at £162/t, fuberidazole + triadimenol at £87/t, fluquinconazole +prochloraz at £170/t, a thousand grain weight of 50g, and grain prices of £60/t and £75/t