6. DISCUSSION

Eyespot control

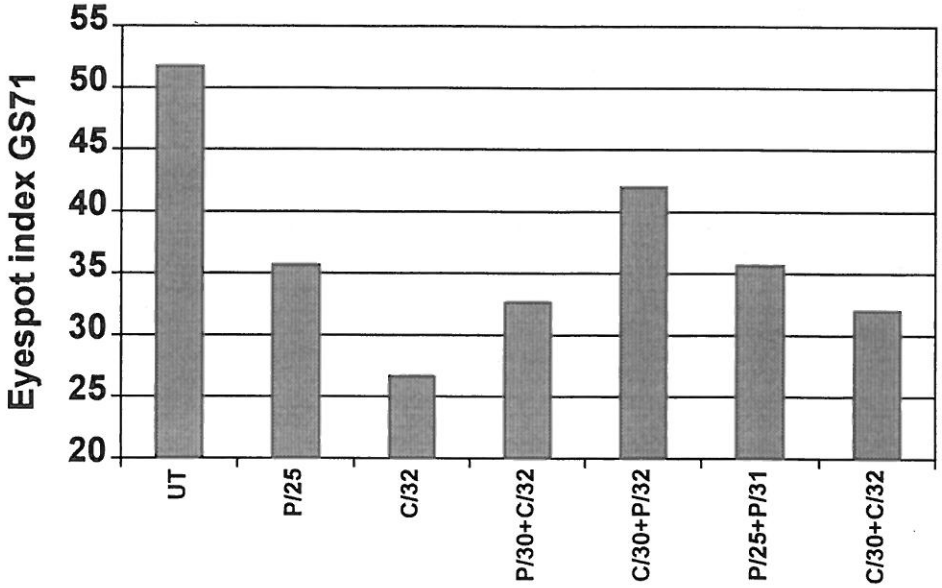
Eyespot levels were reduced by fungicide treatment and full rate cyprodinil gave the largest reduction in eyespot levels when applied at GS 32 (Figure 2.). Prochloraz also reduced eyespot levels at GS 71 when applied either as a single application at GS 25 or when applied as a split or tank mixed treatment at half rate. Prochloraz has been shown to give comparable control to cyprodinil if applied at it's optimum timing of GS 25 - 30 (HGCA Project 150). It reduced eyespot levels in this trial but did not, however, perform as well in this seasons trial as it had done in previous years. The season in which the trial was conducted meant that there was a period of several months from tillering until stem extension. This growth pattern meant that prochloraz was applied in February at GS 25 and GS 30 was not reached until 21 April. The eyespot infection did not occur until the crop was heading which again is later than is typically seen and may have reduced the efficacy of this very early treatment, which in more typical epidemics has been seen to perform better.

Cyprodinil performed better at eyespot control as a single full rate spray than it did in half dose rate tank mixes or as a split treatment applied at GS 30 and 32. Splitting the prochloraz treatment at GS 25 and GS 31 (Treatment 6) did not increase the eyespot control that resulted from a single full dose of prochloraz applied at GS 25 (Treatment 2).

Previous work on the optimum timings of cyprodinil and prochloraz (HGCA Project Report 150) showed that cyprodinil was best applied at GS 32 and prochloraz at GS 25 - 30. This project therefore investigated if applying these fungicides in sequence at their individual optimum timings would improve eyespot control. Treatment 4 had prochloraz applied at GS 30 and cyprodinil at GS 32, Treatment 5 had cyprodinil applied at GS 30 and prochloraz at GS 32 and Treatment 7 had cyprodinil applied at both timings. The eyespot levels at GS 71 are shown in Figure 2.

Figure 2.

Eyespot control from cyprodinil and prochloraz treatments

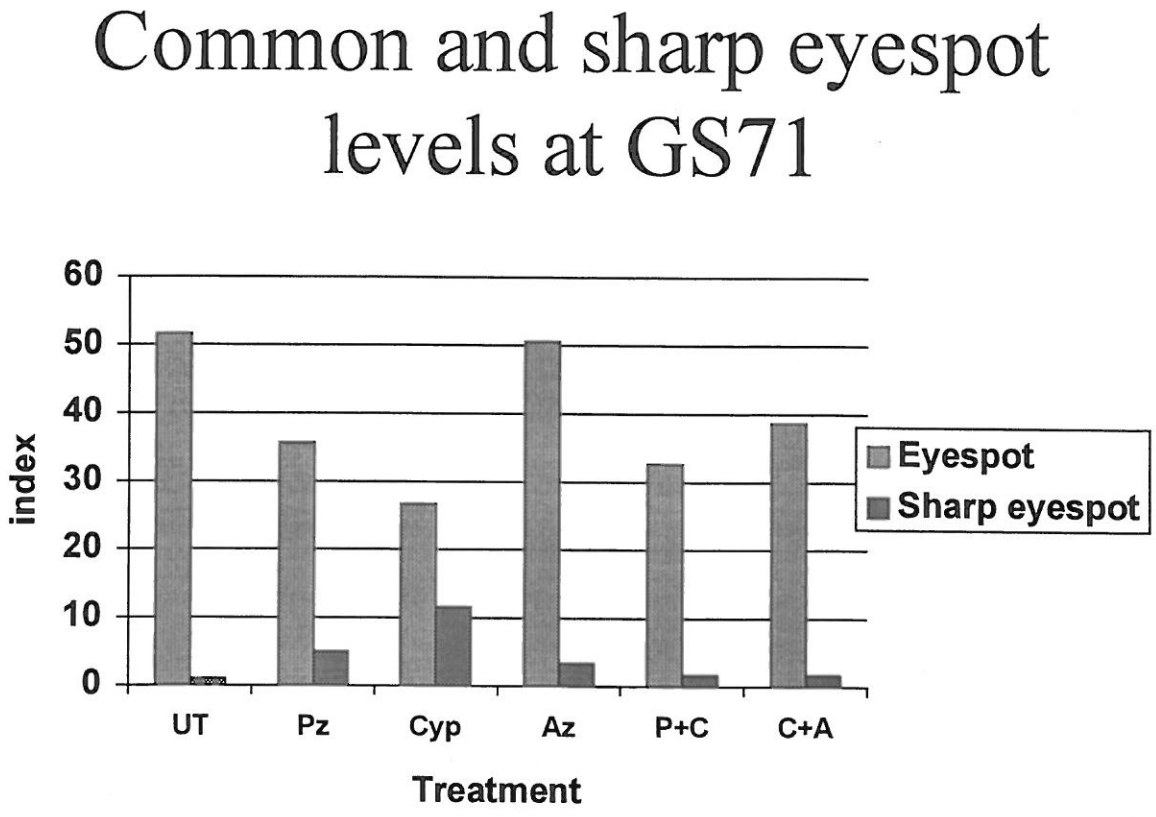


Reversing the treatments and applying cyprodinil and prochloraz away from their optimum timings lead to a significant decline in eyespot control when compared to treatment 4, where prochloraz was applied at GS 30 and cyprodinil at GS 32. This treatment did not however improve on the eyespot control achieved by applying cyprodinil at half rate at both these timings, and non of the split treatments matched the level of control achieved by applying a single full rate of cyprodinil.

Sharp eyespot control

Observations from previous eyespot studies have shown that treatments that clean the stem base of one disease can lead to an invasion of a second disease, colonising the empty stem. Sharp eyespot can therefore increase in severity where common eyespot is controlled, and in this trial azoxystrobin was used to try to reduce sharp eyespot infection. Sharp eyespot levels in the trial were very low at the beginning of the assessment period and dropped to zero during at GS 30 as lesions present on the leaf sheaths at tillering were shed. Sharp eyespot did reinfect at GS 31 but even by the end of the season levels in the plots were typically around 1% incidence, with a maximum of around 5% incidence. Levels of sharp eyespot were never high enough to quantify using the PCR technique.

Figure 3.



The results in figure 3 show that azoxystrobin (Az) had no effect on the common eyespot assessed visually at GS 71. Cyprodinil (Cyp) applied at GS 32 gave the largest reduction in common eyespot and there was a small increase in sharp eyespot when compared to the untreated control. This would support the theory that controlling common eyespot can lead to an increase in sharp eyespot. The addition of azoxystrobin to the cyprodinil suppressed this rise in sharp eyespot, although common eyespot levels also rose as the rate of cyprodinil was reduced so that this reduction in sharp eyespot could be partly due to the rise in common eyespot. There was a negative correlation between common eyespot levels in all plots at GS 71 and sharp eyespot levels at the same time (r = -0.270, P = 0.005) which would also

support the theory that sharp eyespot is more likely to infect where common eyespot levels are reduced. Sharp eyespot levels in the trial were so low however that this work would have to be repeated to validate this theory.

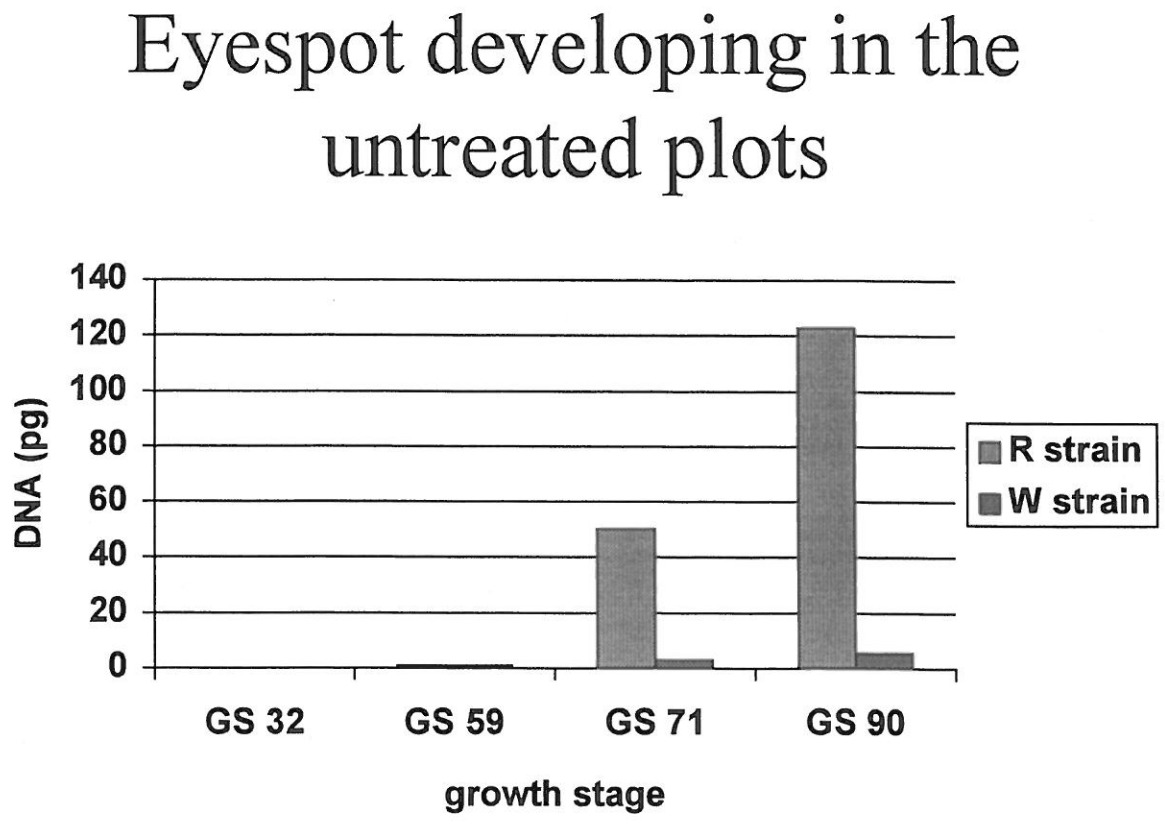
Fusarium

There was a positive association between visual eyespot levels and visual Fusarium levels at GS 71 ($r = 0.445$, $P < 0.001$) and GS 90 ($r = 0.685$, $P < 0.001$). This has been reported by other workers who have found *Microdochium nivale* and R strain eyespot are found associated more often than would be expected by chance (P. Nicholson, per. comm.), evidence that interactions do exist between the pathogens of the stem base.

PCR analysis

The PCR analysis allows the differentiation of the two eyespot strains that is not possible with visual assessments. Using the DNA probes the two strains were first detected at GS 59 in equal quantities. At the next assessment timings of GS 71 and GS 90 the R strain had increased rapidly to much higher levels than the W strain which remained at very low levels throughout the season. This is now thought to be typical of the situation throughout the UK where surveys have shown the R strain to be far more common at all but a very few sites than the W strain (Novartis Crop Protection Ltd, pers. com.).

Figure 4.



The variability of the PCR results meant that differences between treatments were seldom significant but several trends emerged over the season. In general the PCR assessments showed that treatment with either prochloraz or cyprodinil gave a reduction in fungal DNA levels measured at the next assessment. Previous work (HGCA Project 150) showed that eyespot levels always rose again after an initial reduction, and that the most successful treatments were those that could offer a sustained enough reduction in eyespot to allow for a yield improvement.

Figure 5 shows the levels of R strain DNA present at GS 90. Azoxystrobin did not reduce R strain levels compared to the untreated control. Prochloraz and cyprodinil did show a reduction in R strain DNA at this assessment timing. The split treatments or tank mixes showed larger reductions in fungal DNA. The treatment where prochloraz was applied at GS 30 and cyprodinil was applied at GS 32 (P+C) shows a larger reduction in R strain DNA, and this treatment was one of the highest yielding which could indicate more successful R strain control but this was not supported by the visual assessments which show the single full rates to be more successful.

Figure 5.

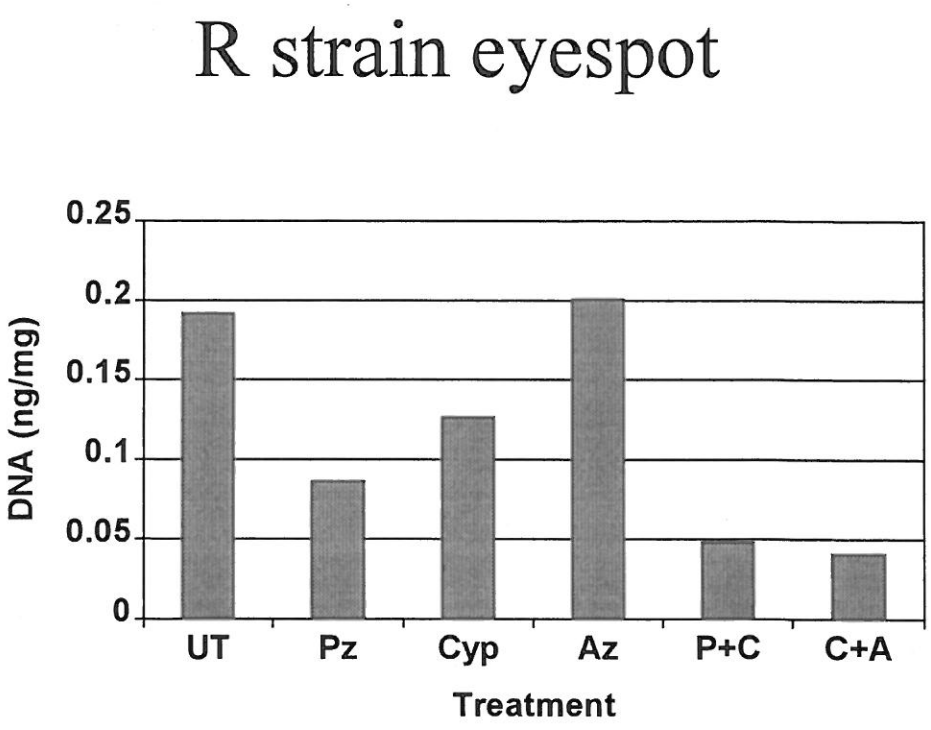
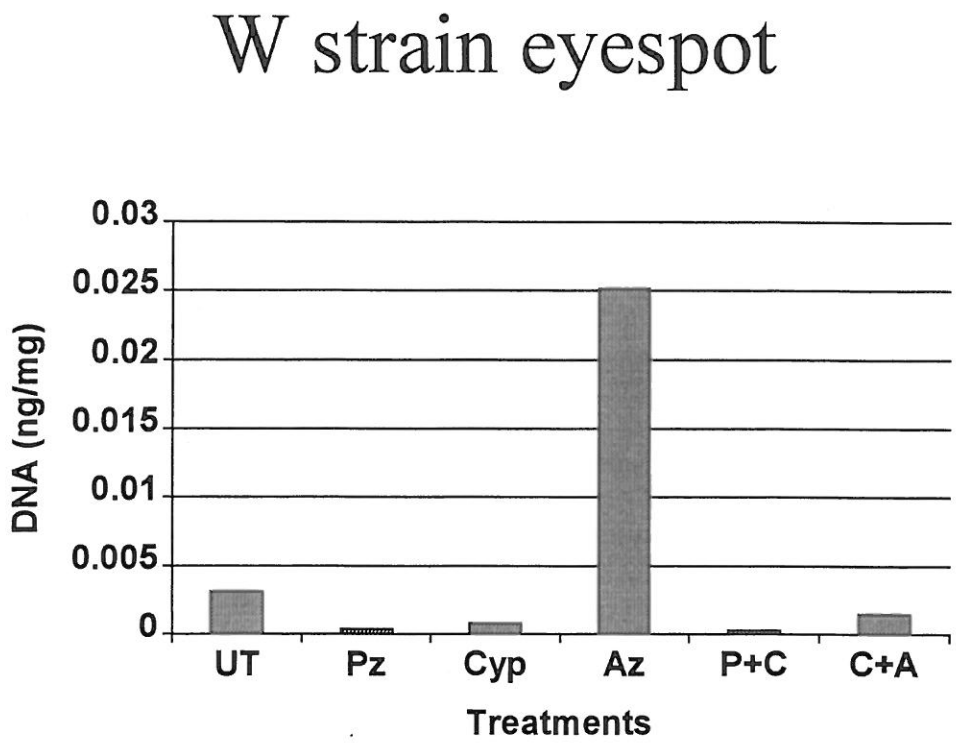


Figure 6 shows the levels of W type DNA at the end of the season. Again differences between treatments were seldom significant. Prochloraz and cyprodinil treatment did reduce W strain levels at GS 90. There were higher levels of W strain eyespot in the plots that were treated with azoxystrobin at GS 32, which probably shows the variability of the PCR technique rather than any significant treatment effect.

Figure 6.



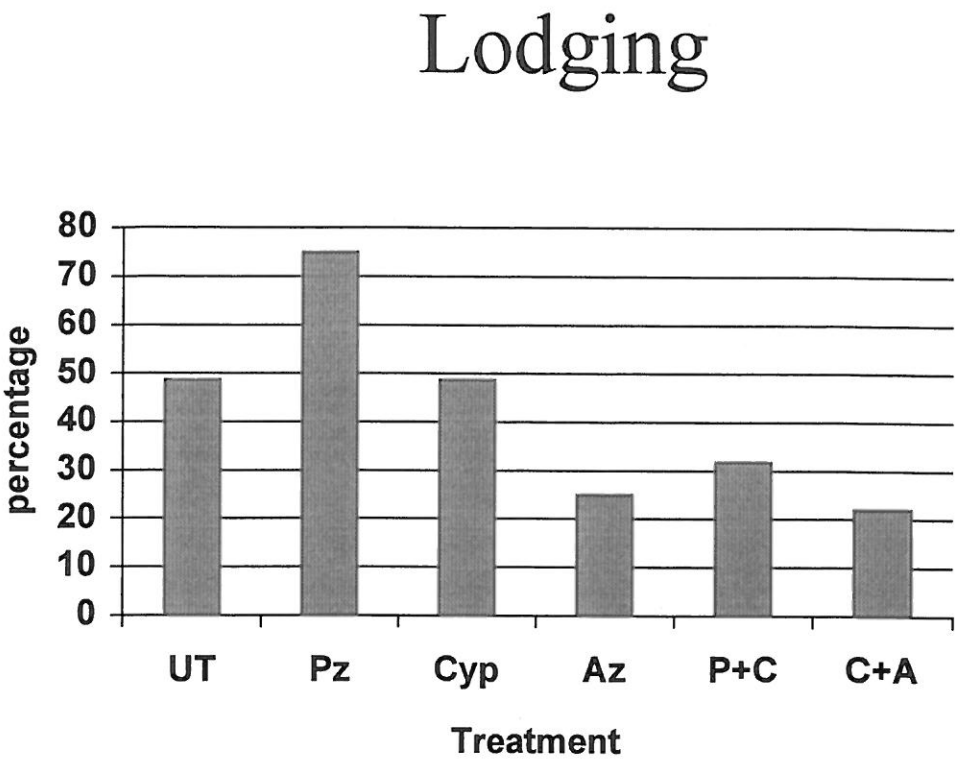
Again the treatment with prochloraz at GS 30 and cyprodinil at GS 32 had the lowest level of W strain eyespot as well as of R strain eyespot, compared to the other treatments.

PCR analysis is a useful tool to aid the interpretation of visual results, but because of the variability in the system results are best taken in conjunction with visual and other assessments rather than in isolation. One effect that has been documented in the past (HGCA Project Report 150) is that were eyespot lesions are very severe and plant tissue is dead or dying then fungal DNA also declines as the stem dies. This means that levels of DNA at the end of the season can be artificially low in plots where eyespot levels are high. This is typically seen with very low values of eyespot DNA in untreated plots where the stems are prematurely dead with eyespot lesions visible at severe levels, and clearly presents an inaccurate reflection of the eyespot in those plots. Limited resources and the expense of PCR analysis meant that analysis of all treatments was not made at GS 71, and had this been possible some of the variation seen at GS 90, just prior to harvest might have been avoided.

Lodging

There was significant levels of lodging prior to harvest in the trial. Prochloraz and cyprodinil as single full dose rate treatments did not reduce lodging compared to the untreated control, although as a split treatment with prochloraz applied at GS 30 and cyprodinil applied at GS 32 there was a reduction in lodging. Azoxystrobin gave reduced lodging as a single full dose rate treatment. Azoxystrobin tank mixed with cyprodinil applied at GS 32 gave the largest reduction in lodging (Figure 7).

Figure 7.



The season in which the trial took place was wet and as a consequence root development was shallow. The lodging that occurred was at the root rather than as a result of the stem lodging.. Prochloraz and cyprodinil have shown significant reductions in stem lodging (HGCA Project Report 150).

Thresholds

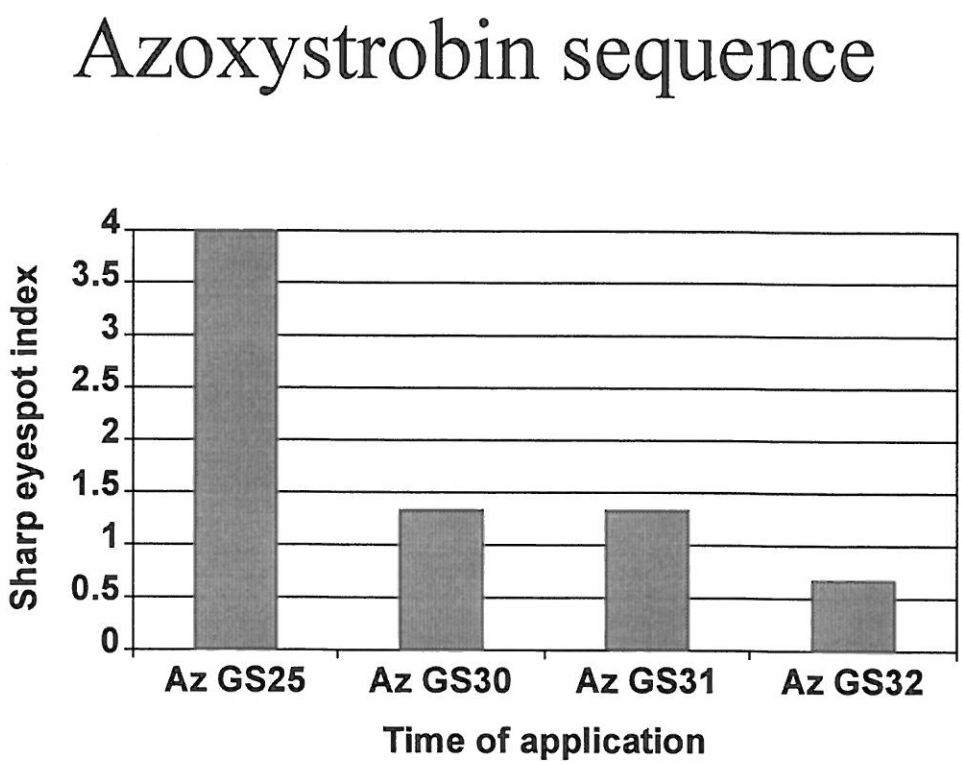
No eyespot was detected using PCR until GS 59. Visually at GS 30 - 31 levels of less than 10% incidence were recorded. This would not have been high enough to trigger the outdated 20% penetrating eyespot threshold used in the early 1980s. This bears out the findings of previous research that shows that the use of thresholds at stem extension are not helpful in predicting the severity of eyespot at harvest. HGCA Project Report 150 details previous work carried out at SAC which shows only a weak correlation between eyespot levels late in the season and those at harvest. There is some evidence to support the theory that the W strain may show a better correlation between levels at stem extension and those at harvest. In the early 80s the W strain was predominant in the UK, which maybe why thresholds used then used to be more successful in predicting which crops to treat. Recent surveys have shown that the R strain is now predominant throughout the UK (Novartis Crop Protection Ltd, pers. comm.)

In both this and previous projects (HGCA Project Report 150) total DNA at stem extension and at the end of the season do not correlate. This makes any attempt at determining a threshold at stem extension and before impossible, where a mixed R and W strain population is present, and it would appear that even early prediction of the W strain levels in an unmixed population would often be unsuccessful.

Azoxystrobin sequence

Within the treatments evaluated in the trial there was a sequence of azoxystrobin sprays applied at GS 25, 30, 31 and 32. Figure 8 shows the effect of timing on the sharp eyespot index at GS 71.

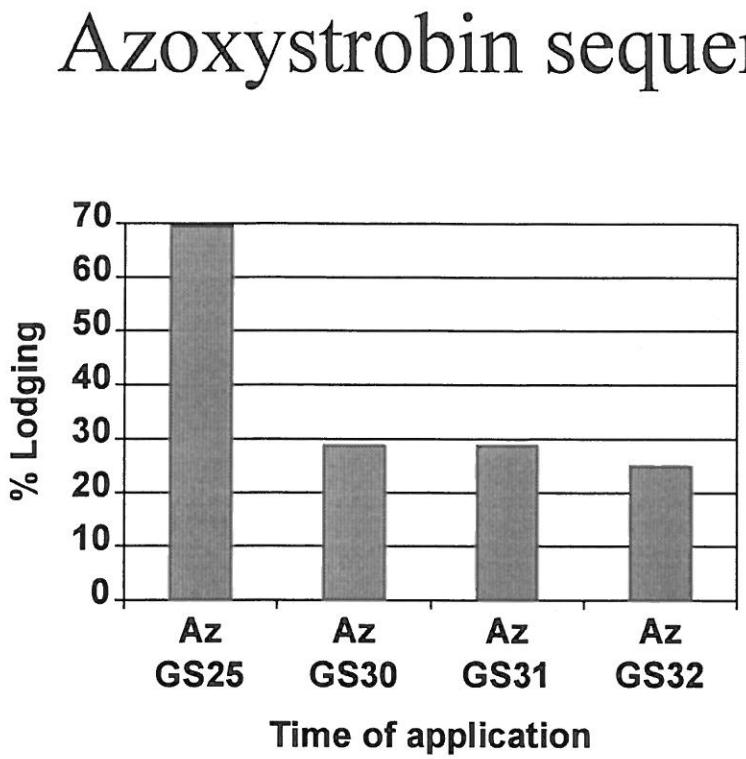
Figure 8. Azoxystrobin sequence and the effect on sharp eyespot index at GS 71



Sharp eyespot was best controlled by the azoxystrobin treatment at GS 32. The earlier the azoxystrobin was applied the poorer the level of control achieved.

Figure 9 shows the lodging reduction from azoxystrobin treatment. The trial season was wet and root establishment shallow and as a consequence the lodging seen at harvest was root rather than stem lodging.

Figure 9. Azoxystrobin sequence and the effect on lodging



The largest reduction in lodging was seen following the application of azoxystrobin at GS 32. The earlier treatments were progressively less effective. It is unknown why azoxystrobin has this effect on lodging.

Figure 10. Azoxystrobin sequence and the effect on yield

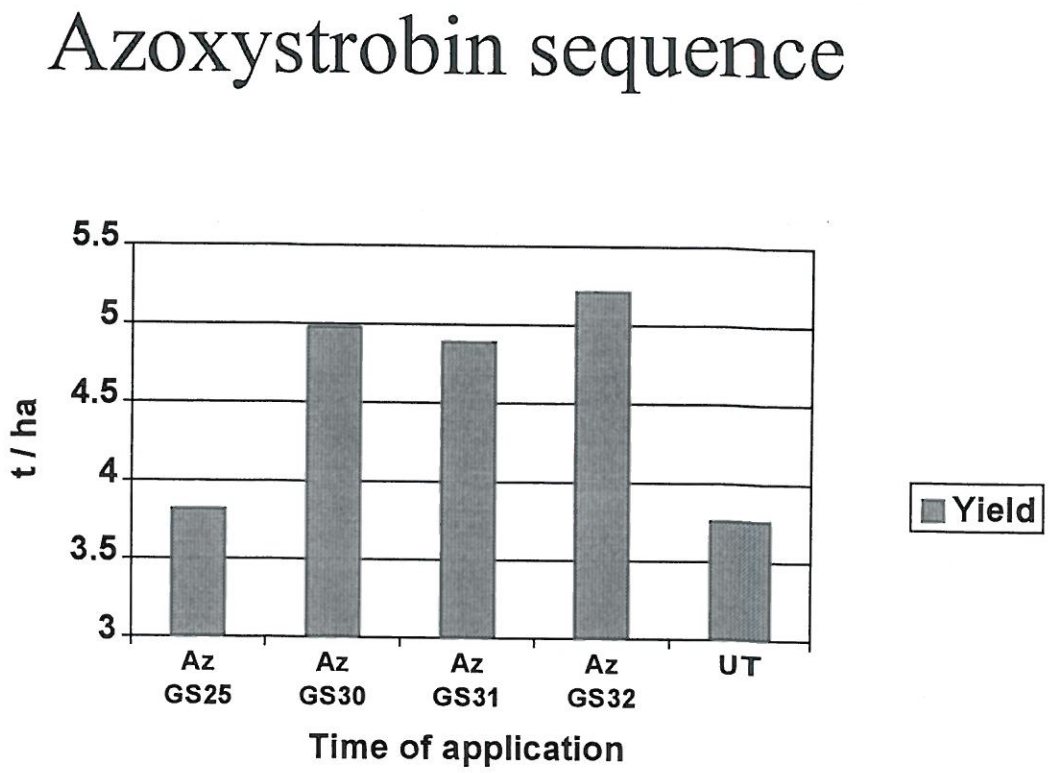


Figure 10 shows the effect of the azoxystrobin sprays on yield. The earlier the application the smaller the yield benefit. This yield benefit is most likely related to the control of foliar disease as well as the reduction in lodging rather than as a result of the sharp eyespot control, as levels of sharp eyespot in the trial were so low.

8. CONCLUSIONS

The most effective treatment for eyespot control of those evaluated in the trial was cyprodinil applied at GS 32 as a single full dose treatment. Splitting this dose of cyprodinil between GS 30 and GS 32 was not as effective as the single full rate application. Prochloraz applied at full dose rate at GS 25 also reduced the levels of eyespot assessed at the end of the season at GS 71. Splitting the prochloraz treatment between GS 25 and GS 31 did not improve eyespot control.

One aim of the work was to investigate if applying cyprodinil at it's optimum time of application for eyespot control of GS 32 as a split treatment with prochloraz also applied at it's optimum time of application (GS 25 - 30). Visually this treatment was not as successful at reducing eyespot as cyprodinil either as a single full dose application at GS 32 or as a split treatment as GS 30 and GS 32. The PCR analysis however shows lower levels of eyespot DNA in the prochloraz followed by cyprodinil treatment than in these other treatments, which may support the theory that better eyespot control could be achieved by using both products at their optimum timing than could be achieved using either one straight. The yield from this split treatment of prochloraz and cyprodinil was also higher. As discussed, too much emphasise should not be placed on the PCR results because of the variability inherent in this form of analysis but the result would support further work being done to confirm, or otherwise, the theory that splitting the treatments at their optimum timings would improve eyespot control.

Analysis of the eyespot DNA present using a PCR technique showed that the R strain was the dominant strain at the site and that the W strain of eyespot was only present at very low levels. This is now felt to be typical of the situation in the UK where most sites surveyed have either only the R strain or, if a mixed population, the R strain dominating. Only a very few sites have any significant level of the W strain. The W strain is more easily controlled with fungicides and tends to show symptoms earlier in the season. The R strain typically comes in later and increase rapidly, and this is thought to be the reason why thresholds for eyespot treatment no longer work. In this trial eyespot was not seen until the crop was heading with no eyespot present at the critical time for making an eyespot spray choice, of stem extension. This shows how a threshold approach to treating this crop would not have been successful, and also demonstrates how the fungicides worked well as protectants in reducing final eyespot levels in the plots.

Sharp eyespot levels in the trial were very low, but a reduction in sharp eyespot was seen following an application of azoxystrobin compared to earlier applications of this fungicide. Despite levels of sharp eyespot being so low there was a negative correlation between sharp eyespot and common eyespot levels at the end of the season. There was a small but not significant increase in sharp eyespot levels following the most successful treatments to control common eyespot and this increase was reduced by tank mixing azoxystrobin with the eyespot treatment.

This finding is important as it emphasises the importance of correctly identifying stem base pathogens as treatment for common eyespot if sharp eyespot was the problem would make a sharp eyespot infection worse. Where common eyespot is the dominant pathogen then at the

moment a sharp eyespot treatment (azoxystrobin) is probably not merited as the cyprodinil plus azoxystrobin mix would still require the addition of a triazole fungicide for foliar disease protection at GS 32. The resultant three way mix required to target foliar diseases, common and sharp eyespot would be unlikely therefore to be cost effective.

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The Home-Grown Cereals Authority is a public body set up by the Cereals Marketing Act 1965. A number of important amendments to the Act were made by the Agriculture Act 1986 and the Cereals Marketing Act (Application to Oilseeds) Order 1989. The Act, as amended, defines the Authority's functions, constitution and the specific functions which it may undertake for the purpose of improving the production and marketing of home-grown cereals and oilseeds. In 1990 the HGCA Oilseeds Levy Scheme was introduced to fund research and development.

As well as sponsoring research and development in relation to both cereals and oilseeds, the Authority's other functions are:-

- providing a market information service for cereals and oilseeds;
- developing UK cereals exporting capabilities;
- promoting increased consumption of cereal based products in the home market and overseas.

The Authority is funded principally by levies paid by growers of cereals and oilseeds and by cereal dealers and processors.

The Authority administers its R&D function with the assistance of two Advisory Committees, one dealing with cereals and the other with oilseeds R&D. Cereals growers, dealers and processors all contribute in differing proportions to the funding of cereals R&D and all these sectors are represented, therefore, on the R&D Advisory Committee for Cereals. The R&D Advisory Committee for Oilseeds represents the interests of oilseed growers who are the sole funders of oilseeds R&D.

Details of subject areas of interest to both committees are published in strategy documents. Reports of all funded R&D are also published and promoted within the industry.

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