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Validation of a risk assessment method to identify wheat crops at risk from eyespot

by

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1. ABSTRACT

Eyespot (causal organisms *Oculimacula yallundae* (W type) and / or *O. acuformis* (R type)) is a damaging disease of the stem base in winter wheat crops.

Replicated field trials in 2004, throughout the UK, showed that the new triazole, prothioconazole, tended to improve eyespot control and yield when compared to the standard treatment of cyprodinil plus epoxiconazole.

A second new fungicide, metrafenone, was tested at one site and also showed improved eyespot control and yield when used at the full rate. Both controlled both R and W type eyespot, in contrast to prochloraz which controlled only W type. R and W type eyespot were present at all sites as mixed populations in samples taken at stem extension, with W type being the dominant species. The proportion of W type eyespot increased when the same sites were tested at the end of the season.

A risk assessment model, produced in HGCA project 2382 and reported in Part 1 of Project Report No.347, was used to assess the need for eyespot treatment at each trial site. The model correctly predicted the need to treat or not treat (based on >30% incidence of eyespot by the end of the season) for 69% of the test sites. It was correct 54% of the time when predicting an eyespot incidence greater than 45%. The results show that the model approach to judging treatment need has potential and that it was better than the former 20% threshold approach to judging treatment need. The 20% threshold had a high number of false positives in its judgements, which could lead to pesticide usage being increased.

More work is needed to refine and progress the model and incorporate more information on weather factors.

2. SUMMARY

Eyespot (causal organisms *Oculimacula yallundae* (W type) and / or *O. acuformis* (R type)) is a damaging disease of the stem base in winter wheat crops. Its occurrence and severity is very variable, however, and judging the need for treatment in a crop is notoriously difficult. In addition, control with fungicides can consist of either the addition of an eyespot specific fungicide or the use of newer and potentially more expensive control agents at rates that may be higher than are used for foliar control alone. Several new fungicide treatments have been introduced to the market for eyespot control. The new triazole prothioconazole was compared to the previous standard treatment, cyprodinil, as part of this project, in replicated field trials carried out in 2004. Prothioconazole gave improved eyespot control and yield, with higher rates being significantly better than lower rates. Another new fungicide, metrafenone was also trialled at one site. It also controlled eyespot when applied at the full rate. The two new fungicides and cyprodinil controlled both R and W type eyespot, in contrast to the fungicide prochloraz which gave no reduction in R type.

Polymerase Chain Reaction (PCR) analysis of samples in 2004 showed that the two eyespot strains in the UK were found in mixed populations, with W type the dominant species. This represents a change over previous seasons, when R type eyespot was dominant throughout the UK. The proportion of W type in the populations increased between the early and late assessments carried out.

One aim of the project was to test the decision making capability of the risk model for eyespot developed in HGCA project 2382 (Part 1 of Project Report No. 347), as well as determining the efficacy of new fungicides against eyespot. Commercial crops and field trials were assessed to determine the success rate of the risk assessment model. It correctly predicted the risk of eyespot exceeding the economic treatment threshold of 30% in 69% of cases, and wrongly predicted a need to spray in 23% of cases. In 8% of cases it wrongly predicted a low risk of eyespot. Using the traditional 20% threshold identified 50% of crops where treatment would have been correctly justified, but incorrectly identified a need to spray in 42% of the crops where in fact no treatment was the correct decision. The model predicting a less sensitive economic treatment threshold of 45% eyespot incidence at the end of the season was correct in 54% of its judgements. Although less successful than the first, it was the only method to identify any of the true negatives. The aim

of the model is not to be prescriptive, but to provide flexible guidance to growers and to aid their judgement of the risk in their crop.

This validation project confirmed the potential for this approach to reaching better decisions in crop protection, but highlighted the need for further work to refine and progress the model, particularly in terms of improving the predictive capability of the weather components.

3. INTRODUCTION

Background

A complex of diseases infects the stem base of winter wheat of which eyespot is the most damaging to yield. In the UK, the disease is caused by two fungal species, *Oculimacula yallundae* and *O. acuformis*. These used to be called W type and R type eyespot respectively, and this nomenclature is still commonly used and understood by growers and researchers. The disease varies in its incidence and severity from season to season, and it has always been an issue deciding which fields will give a cost effective response to an eyespot fungicide. Visual eyespot at stem extension on its own is not a good predictor of what will develop in the crop by the end of the season. The new model, developed in project 2382 (Part 1 of Project Report No. 347), uses risk factors associated with eyespot and weights them according to their importance. The flexibility of this system is that it also takes into account the grower's experience of eyespot risk. Using the table below, each crop can be assessed, and the risk points that each one accrues, added up. The model is designed, not to be used prescriptively, but to be used flexibly and to incorporate the growers own perception of risk. Growers for whom eyespot has been a damaging problem in the past or with an aversion to taking risks can choose to treat at the lower treatment threshold of 20 accumulated risk points. Growers who perceive a lower risk, or who are more tolerant of risk, can choose to treat at a higher threshold of 29 risk points. These levels of risk points were selected when building the model, as the 20 risk points predicts a final eyespot incidence of 30%, which represents the economic treatment threshold using the Scott and Hollins (1976) model for yield losses to eyespot. The 29 risk points model predicts a final eyespot incidence of 45% that was the economic treatment threshold determined in HGCA project 2382.

Accumulated risk score table

Factor	Level	Risk points
Sowing date	on or after 6 October before 6 October	0 5
Eyespot infection @ GS 31-32	less than or equals 7% more than 7%	0 10
Cumulative rainfall (mm) in March / April / May	less than or equals 170 mm more than 170 mm	0 5
Tillage	Minimum tillage Plough	0 10
Soil type*	Light Medium Heavy	0 1 5
Previous crop	Non-cereal Other cereal Wheat	0 10 15

*Add a further 5 points for brash and limestone soils.

At the outset, two important points should be recognised. Firstly, discrimination between crops that need treatment and those that do not need treatment, on the basis of a predictor, can never be perfect. Only a proportion of the variability in crops causing them to fall into one or other of these two categories is 'explained' by a statistical model. Added to this, uncertainty is increased because data are collected by sampling (so the 'true' status of crops is unknown), because there is no guarantee that disease assessments are free of inspection errors, and because there is a period of time between when the prediction is made and the end of the season, during which events occur that may affect the outcome. If a threshold 'risk score' is set for the predictor, imperfect discrimination means that some crops that really need treatment will fall below this threshold, and some crops that really do not need treatment will fall above this threshold. Since different users may respond differently to these two different types of error, a useful asset in a predictor is a capability for users to modify the threshold risk score to suit their own attitude to risk.

Model validation

The aim of this project was to test the validity of the risk model developed in project 2382, and to determine the efficacy of several new products that were being introduced to the market in 2004. The work involved carrying out simple field trials at a range of sites throughout England, managed by Velcourt, and one detailed field trial Scotland, managed by SAC. The model was then used to predict the need for an eyespot treatment on each site. The treatments were then applied and the success rate of the model in prompting cost effective treatments, and avoiding false positives, determined.

Determine efficacy of new fungicides

Several new fungicides were introduced to the market, with label claims for eyespot reduction or control. Metrafenone is a new fungicide from BASF with a label claim for eyespot reduction and this was evaluated at one of trial sites. Prothioconazole is a new azole fungicide from Bayer, introduced to the market in late 2004 with a label claim for eyespot control. It will control foliar diseases as well but comes at an increased price to triazoles giving foliar control alone. Rates are likely to be different when using it for foliar or stem base disease control. Based on previous data, as an azole it was possible that it would have stronger efficacy on W type eyespot than against R type eyespot. A field trial was managed by SAC to look at efficacy, timing and rates and to determine any differential effects on the two eyespot species. Other trials to compare prothioconazoles efficacy with that of cyprodinil were managed by Velcourt.

Determine R/W status

Project 2382 identified a swing back to W type eyespot, possibly as a result of increased strobilurin use and decreased triazole use. Triazoles are known to control W type but not the R type eyespot. If strobilurin use decreases as seems likely for resistance reasons, then R type may increase again which has implications for the relative efficacy of cyprodinil, prochloraz and prothioconazole treatments. Samples from the sites used in this project were tested for the quantities of R and W type DNA present to determine the current status of the populations.

4. MATERIALS AND METHODS

There were three sections to the practical work carried out for the project.

A. Survey sites on commercial wheat crops

B. Field trials to compare prothioconazole and cyprodinil superimposed in commercial fields

C. Detailed field trial to examine fungicide rates and to evaluate eyespot active fungicides.

A. Survey sites

Eight winter wheat fields on Velcourt managed farms were selected for this section of work. Within each field four selected areas (20 m x 2 m) were sprayed with 0.7 kg/ha Unix in addition to foliar control as applied to the rest of the field.

The treatments were:-

1. Opus 0.5 l/ha + Bravo 1.0 l/ha at GS 32

2. Opus 0.5 l/ha + Bravo 1.0 l/ha + 0.7 kg/ha Unix at GS 32

Fields were then over sprayed at GS 39 and GS 59 with fungicides for control of foliar disease only. These varied by site. Other inputs were in line with local practice. Rainfall data and temperatures (max, min and average) were obtained from Met Office regional weather data. Soil status and texture were recorded from recent farm records (i.e. analysis from within two seasons).

Sampling and assessment details:

Stem base visual assessments

GS 32 (pre T1)	25 plants from field in ‘W’ pattern
GS 70	25 stems from each marked area in the crop

At GS 32, 25 whole plants (including tillers) per plot were sampled by digging whole plants randomly throughout the field. Sharp eyespot and Fusarium were recorded as present or absent. Eyespot was recorded as an incidence as well, but the leaf sheath penetrated to was also recorded. At GS 70, 25 single tillers were sampled per treated and untreated area. Eyespot was recorded as 0 = no symptoms, 1= lesions affecting less than 50% of the stem circumference, 2 = lesions affecting over 50% of the stem circumference and 3 = lesions affecting over 50% of the stem circumference and tissue softened so that lodging would readily occur. Sharp eyespot was recorded on the same scale and Fusarium was recorded as 0 = no symptoms, 1 = slight brown streaking on stem base, 2 = general browning on stem base and 3 = stem base rotted likely to cause lodging.

PCR assessments were carried out on the same sample as was used for the visual assessment. Care was taken not to remove outer leaf sheaths during the visual assessment. PCR analysis was carried out at the Central Science Laboratory using the methodology detailed in the main report.

A stem base index was then calculated for each disease
(((no. of score 1) + (no. of score 2 x 2) + (no. of score 3))/ no. of stems)) x 100 / 3
Analysis of variance was used for statistical analysis to show treatment means, degrees of freedom and SEDs.

Yield was assessed and corrected to 85% moisture content for some of the sites. At others, this was not possible because of the commercial nature of the site.

B Commercial slot sites

Five winter wheat trial sites were selected on Velcourt managed farms. Trials were laid out as fully randomised, replicated blocks with the treatments listed below added to each of the 5 replicated slot trials. There were four replicates of each treatment. Plot size was 2 m x 15 m.

1. Opus 0.75 l/ha at GS 32
2. Opus 0.75 l/ha plus Unix 0.7 kg/ha at GS 32
3. Proline at 0.6 l/ha GS 32

Plots were over sprayed at GS 39 with Twist 1.0 l/ha and Opus 0.75 l/ha. Other inputs were in line with local practice. Rainfall data and temperatures (max, min and average) were obtained from Met Office regional weather data. Soil status and texture were recorded from recent farm records (i.e. analysis from within two seasons).

Sampling and assessment details:

Stem base visual assessments

GS 32 (pre T1)	25 plants from untreated plots only
GS 70	25 stems from all plots

Stem base diseases were assessed as described above. Samples from untreated plots were also used to quantify the R and W type DNA present at the two sample timings. The methodology for this is as described in the main report. Yield was measured and corrected to 85% moisture content.

C. Detailed fungicide trial

The trial was sited in East Lothian and was superimposed in a commercial second wheat crop in a predominantly cereal rotation. The trial design was fully randomised blocks, with four replicated of each treatment. Plot size was 2 m by 18 m. Treatments were applied as shown in Table 1.

Table 1. Fungicide treatments applied to detailed fungicide trial (units in l/ha with the exception of Unix which is in kg/ha)

Code	GS 25-30	GS 31-32	GS 39	GS 59-69
1	Nil	Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5
2	Nil	Proline 0.4	Swift 0.25 + Opus 0.5	Folicur 0.5
3	Nil	Proline 0.6	Swift 0.25 + Opus 0.5	Folicur 0.5
4	Nil	Proline 0.8	Swift 0.25 + Opus 0.5	Folicur 0.5
5	Nil	Poraz 0.45 + Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5
6	Nil	Poraz 0.9 + Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5
7	Nil	Unix 0.5 + Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5
8	Nil	Unix 0.7 + Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5
9	Nil	Unix 1.0 + Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5
10	Nil	Flexity 0.5 + Opus 0.5	Swift 0.25 + Opus 0.5	Folicur 0.5

Application details: Treatments to be applied with a hand held CP3 Knapsack sprayer in 200 L of water per ha. Meteorological data and crop growth stage were recorded at application timings.

Sampling and assessment details:

Assessments

GS 25-30	Eyespot visual assessment over trial site
GS 31-32	Eyespot visual assessment and Eyespot PCR assessment (R&W fully quantitative) over trial area
Pre GS 39	Before flag sprays applied, foliar disease assessment all plots
GS 45	Eyespot visual assessment all plots only
GS 65 - 70	Eyespot visual assessment, and Eyespot PCR assessment (R&W fully quantitative) on treatments 1,6,9,10
Harvest	Lodging and whiteheads, yield, specific weight

Disease was assessed as described above. PCR assessments were carried out on the same sample as was used for the visual assessment. Care was taken not to remove outer leaf sheaths during the visual assessment. PCR analysis was carried out at the Central Science Laboratory using the methodology detailed in the main report. Analysis of variance was used for statistical analysis to show treatment means, degrees of freedom and SEDs.

The fungicides used in trials are shown in Table 2 below.

Fungicides used in trials

Table 2. Full commercial doses for the products used in trials

Active ingredient	*Product*	*Manufacturer*	*g a.i./ha*
krexoxim methyl + epoxiconazole	Landmark	BASF	125 125
Azoxystrobin	Amistar	Syngenta	250
Prochloraz	Stefes Poraz	Stefes	405
Cyprodinil	Unix	Syngenta	1000
Epoxiconazole	Opus	BASF	125
Tebuconazole	Folicur	Bayer	250
Prothioconazole	Proline	Bayer	200
Metrafenone	Flexity	BASF	150
Chlorothalonil	Bravo 500	Syngenta	500
Trifloxystrobin	Swift SC or Twist	Bayer	250

Treatments applied by CO_2 knapsack sprayer in 200 - 250 litres of water/ha at 200 -300 kPa

5. RESULTS

Model validation

The success rate of the judgement methods is shown below in Table 3, as one of four possible outcomes, namely false positive (FP), false negative (FN), true positive (TP) or true negative (TN).

Table 3. Eyespot incidence at GS 31/32 and GS 70-80 with the judgement made by the two risk models and the 20% threshold

Site	GS 31/32 eyespot incidence (%)	Final eyespot incidence (%)	Risk score	Model judgement for >30 % eyespot	Model judgement for >45% eyespot	20% Threshold judgement
Vel 01	32	12	30	FP	FP	FP
Vel 02	24	33	20	TP	TN	FP
Vel 03	28	49	20	TP	FN	TP
Vel 04	36	66	40	TP	TP	TP
Vel 05	34	33	15	FN	TN	TN
Vel 06	18	63	35	TP	TP	FN
Vel 07	34	42	55	TP	FP	FP
Vel 08	36	74	30	TP	TP	TP
Velft a	52	86	20	TP	FN	TP
Velft b	36	6	45	FP	FP	FP
Velft c	28	*	30	*	*	*
Velft d	*	7	35	FP	FP	*
Velft e	60	86	31	TP	TP	TP
Markle	56	85	40	TP	TP	TP

TP = true positive, TN = true negative, FP = false positive, FN = false negative

* = missing data

Ten of the sites (77%) had levels of eyespot greater than 30% incidence at the end of the season and 7 sites (53%) had levels greater than 45% final eyespot incidence. Where yield data was available from sites, the majority (80%) gave a positive margin over fungicide cost at a Unix price of £22/kg and a grain price of £70/t. The yield increase from treatment did not correlate with the level of eyespot found in the crops. Twelve of the sites (92%) exceeded the 20% incidence of eyespot at GS 31/32 threshold.

Table 4 shows the success rate of the judgement methods as the percentage of correct and incorrect judgements.

Table 4. Judgement of the two risk models and the 20% threshold for predicting final eyespot risk

	Model for >30% eyespot	Model for >45% eyespot	Threshold at GS 31/32 >20%
% Correct judgements	69%	54%	50%
% True positives	69	39	50
% True negatives	0	15	0
% False negatives	8	15	8
% False positives	23	31	42

The most successful method of judging risk in this data set was the model predicting a final incidence of eyespot of more than 30%, which was correct in 69% of cases. It identified the need to treat in the majority (9/10) of those crops where the final incidence exceeded 30%. It did not correctly identify the two crops where treatment would not have been needed and gave 3 false positive results where it predicted a need to treat, where treatment later turned out not to be needed. The model predicting 45% final eyespot incidence identified five of the seven crops where final eyespot exceeded 45% and where treatment would have been justified. It also identified two of the four crops where treatment was not justified as eyespot did not exceed 45% by the end of the season. It falsely identified a need to treat in 4 of the 13 crops tested and missed two crops where treatment was merited. The 20% threshold was the least successful method of identifying the need to treat. It was correct in 50% of its judgements. It identified six of the nine crops where final eyespot exceeded the economic threshold of 45% eyespot, but had the highest number of false positives (five out of thirteen judgements) where it wrongly predicted a need to spray.

R and W status

Table 5. The amount of R and W type eyespot at stem extension and at the end of the season by site.

Site	Area	R type GS 31 mg / unit	W type GS 31 mg / unit	R type GS 70-80 mg / unit	W type GS 70-80 mg / unit	Response to treatment t/ha
Vel 01	Kent	0.07	0.00	49.3	48.8	*
Vel 02	Lincolnshire	0.01	0.03	24.0	120	0.39
Vel 03	Lincolnshire	0.06	2.53	18.4	20.0	0.24
Vel 04	Kent	0.03	0.02	22.3	236	*
Vel 05	Northamptonshire	0.01	0.01	43.3	468	*
Vel 06	Northamptonshire	0.01	0.05	106	846	*
Vel 07	Gloucestershire	0.04	0.03	3125	212	0.29
Vel 08	Gloucestershire	0.28	1.73	359	320	-0.12
Velft a	E Anglia	1.99	0.33	1164	1599	0.38
Velft b	E Anglia	0.02	0.00	0.02	0.04	0.0
Velft c	Dorset	0.15	0.85	*	*	0.28
Velft d	E Anglia	*	*	0.26	87.9	0.35
Velft e	Kent	2.82	18.8	421	1080	0.40
Markle	Lothians	0.13	6.27	117	160	0.44

* = missing data

Table 5 shows the amount of eyespot DNA extracted from stem samples taken from sites at the beginning and the end of the season. Both R type eyespot and W type eyespot were present at all sites by the end of the season. R type was the dominant species at only one site, Vel 07 with W type being the dominant species at all but two sites. Four sites were approximately evenly balanced between the two species and at seven sites W type dominated. The proportion of W type eyespot increased from the early to the late assessment, as shown in Figures 1 and 2. The amount of both species present increased markedly from the early assessment at stem extension to the late assessment at grain filling.

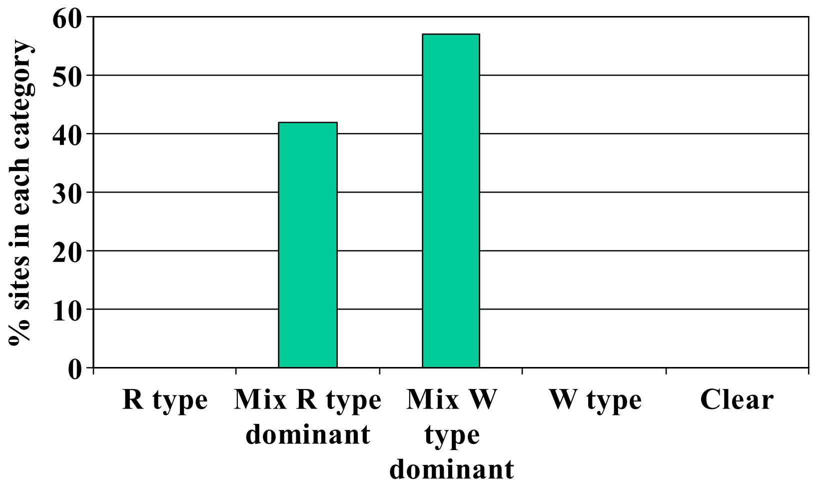

Figure 1. Frequency of R and W type eyespot at GS 31 (2004)

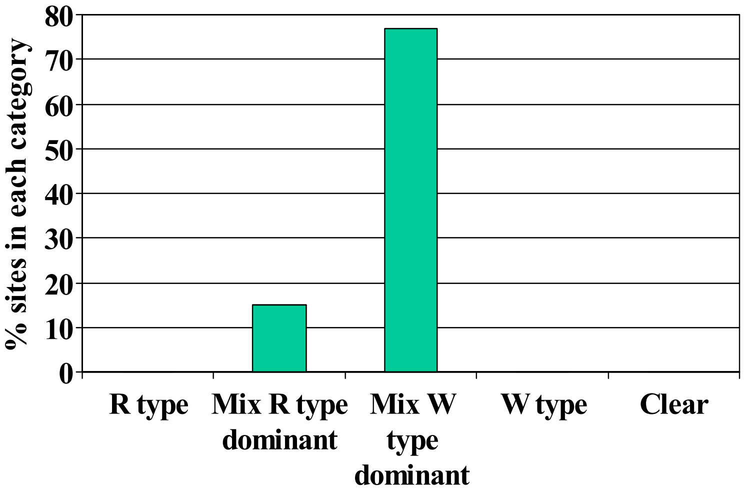

Figure 2. Distribution of R and W type eyespot at GS 70-80 (2004)

Fungicide efficacy

Table 6. Eyespot incidence and yield at commercial slot trial sites 2005

Treatment	Eyespot index	Yield (t/ha)
Opus	27.2	10.2
Opus + Unix	20.4	10.5
Proline	23.8	10.8
SED	16.93	0.84
P	0.729 (NS)	0.335 (NS)

The eyespot index and yield, meaned across the five Velcourt managed field trials is shown in Table 6. The variability between sites meant that differences in mean eyespot levels and mean yields were not significant. There was a trend for Unix and Proline to reduce eyespot levels and for Proline to give the highest yield.

Table 7. Stem base disease levels, yield and specific weight at trial site VELFT A

Treatment	Eyespot index %	Fusarium index %	Sharp eyespot index %	Yield t/ha	Specific weight kg/hl
Opus	45.3	43.3	2.00	11.1	70.3
Opus + Unix	32.0	53.0	5.00	11.4	70.4
Proline	35.3	55.7	1.67	11.2	69.8
SED	8.660	8.544	2.636	0.246	0.174
P	0.323 (NS)	0.359 (NS)	0.416 (NS)	0.332 (NS)	0.115 (NS)

Table 7 shows the stem base disease levels, yields and specific weights from trial Velft a in East Anglia. There were no significant differences in yield or in disease levels at this site, although there was a trend for eyespot to be reduced with Unix or Proline treatment and for Unix to increase yield.

Table 8. Stem base disease levels, yield and specific weight at trial site VELFT B

Treatment	Eyespot index %	Fusarium index %	Sharp eyespot index %	Yield t/ha	Specific weight kg/hl
Opus	2.7	43.3	2.0	11.0	64.4
Opus + Unix	3.0	53.3	5.0	11.0	63.5
Proline	2.3	55.7	1.7	11.4	65.1
SED	1.523	8.544	2.636	0.731	0.497
P	0.910 (NS)	0.359 (NS)	0.416 (NS)	0.741 (NS)	0.329 (NS)

Table 8 shows the stem base disease levels, yields and specific weights from trial Velft b in East Anglia. Eyespot levels were very low at this site. There were no significant differences in disease levels or yield.

Table 9. Stem base disease levels, yield and specific weight at trial site VELFT C

Treatment	Eyespot index %	Fusarium index %	Sharp eyespot index %	Yield t/ha	Specific weight kg/hl
Opus	-	-	-	11.52	70.3
Opus + Unix	-	-	-	11.8	71.7
Proline	-	-	-	11.9	71.3
SED				0.139	0.866
P				0.060 (NS)	0.308 (NS)

- = no assessment carried out

Table 9 shows the stem base disease levels, yields and specific weights from trial Velft c in Dorset. Stem base samples were not collected from this site at the end of the season so the stem base disease levels are not known. There were no significant differences in yield or specific weight although there was a trend for Unix and Proline to increase yield.

Table 10. Stem base disease levels, yield and specific weight at trial site VELFT D

Treatment	Eyespot index %	Fusarium index %	Sharp eyespot index %	Yield t/ha	Specific weight kg/hl
Opus	3.67	30.0	2.67	8.58	66.4
Opus + Unix	1.33	28.0	2.67	8.92	66.0
Proline	1.00	24.3	4.00	9.58	65.6
SED	1.387	4.722	0.682	0.231	0.784
P	0.168 (NS)	0.504 (NS)	1.722 (NS)	0.006	0.646 (NS)

Table 10 shows the stem base disease levels, yields and specific weights from trial Velft d in East Anglia. There was a trend for Proline and Unix to reduce eyespot levels. Yield was significantly increased with the application of Unix in addition to Opus. The Proline treatment yielded significantly better than the Unix treatment.

Table 11. Stem base disease levels, yield and specific weight at trial site VELFT E

Treatment	Eyespot index %	Fusarium index %	Sharp eyespot index %	Yield t/ha	Specific weight kg/hl
Opus	57.0	26.3	3.67	9.12	67.4
Opus + Unix	45.3	22.7	1.00	9.52	68.3
Proline	56.3	26.7	4.33	9.98	68.3
SED	5.291	7.906	1.483	0.269	0.587
P	0.096 (NS)	0.856 (NS)	0.111 (NS)	0.035	0.286 (NS)

Table 11 shows the stem base disease levels, yields and specific weights from trial Velft e in Kent. There were no significant differences in stem base disease levels or specific weight between treatments. Yield was significantly increased with the application of Unix in addition to Opus. The Proline treatment yielded significantly better than the Unix treatment.

Table 12. Stem base disease levels at Gs 37-45 in detailed fungicide trial

Treatment	Eyespot index % GS 37-45	Fusarium index % GS 37-45	Sharp eyespot index % GS 37-45
Opus 0.5	16.0	6.00	2.00
Proline 0.4	12.4	6.22	1.33
Proline 0.6	10.9	4.27	2.40
Proline 0.8	8.3	5.00	1.33
Poraz 0.45 + Opus 0.5	13.0	3.33	2.67
Poraz 0.9 + Opus 0.5	13.3	3.00	1.33
Unix 0.5 + Opus 0.5	10.7	6.67	1.00
Unix 0.7 + Opus 0.5	12.3	6.33	0.00
Unix 1.0 + Opus 0.5	7.67	4.33	1.67
Flexity 0.5 + Opus 0.5	9.00	5.67	1.33
SED	2.692	2.031	0.900
P	0.109	0.612	0.215

Table 12 shows the stem base disease levels at booting in the detailed fungicide trial in East Lothian. Levels of stem base disease were low at this assessment timing and differences between treatments were not significant.

Table 13. Stem base disease levels at Gs 75 in detailed fungicide trial

Treatment	Eyespot index % GS 75	Fusarium index % GS 75	Sharp eyespot index % GS 75
Opus 0.5	40.3	23.0	1.67
Proline 0.4	29.3	20.4	0.44
Proline 0.6	22.7	8.00	1.87
Proline 0.8	19.3	14.7	1.00
Poraz 0.45 + Opus 0.5	30.0	15.3	2.00
Poraz 0.9 + Opus 0.5	27.7	12.3	1.67
Unix 0.5 + Opus 0.5	30.0	12.3	1.67
Unix 0.7 + Opus 0.5	24.3	13.3	0.33
Unix 1.0 + Opus 0.5	23.7	16.7	1.00
Flexity 0.5 + Opus 0.5	20.0	11.0	0.67
SED	4.359	3.413	0.883
P	0.002	0.005	0.497

Table 13 shows the stem base disease levels at the end of the season in the detailed fungicide trial in East Lothian. There were significant differences in levels of eyespot and Fusarium at this assessment timing. All the treatments evaluated reduced eyespot significantly when compared to the Opus only control. The most effective treatments were full rate Proline and full rate Flexity. Proline at 0.6 l/ha was comparable to the standard treatment of Unix at either 0.7 kg/ha or 1.0 kg /ha. All treatments, with the exception of the lowest rate of Proline (0.4 l/ha) were effective in reducing Fusarium levels. Sharp eyespot levels at the site were very low.

Table 14. Yield and amounts of R and W type eyespot in detailed fungicide trial

Treatment	R type eyespot DNA GS 75 ng/unit	W type eyespot DNA GS 75 ng/unit	Yield t/ha
Opus 0.5	117.36	251.98	9.46
Proline 0.4	-	-	9.68
Proline 0.6	-	-	9.83
Proline 0.8	25.23	87.42	10.3
Poraz 0.45 + Opus 0.5	-	-	10.2
Poraz 0.9 + Opus 0.5	150.56	150.72	9.42
Unix 0.5 + Opus 0.5	-	-	9.63
Unix 0.7 + Opus 0.5	-	-	9.90
Unix 1.0 + Opus 0.5	37.19	140.0	9.89
Flexity 0.5 + Opus 0.5	30.24	100.1	9.67
SED	38.94	48.47	0.388
P	0.022	0.048	0.046

The results of PCR analysis to quantify the amount of R and W type DNA present in the plots (Table 14) showed that both species were present. In the Opus control plots where eyespot was not controlled W type eyespot dominated. The differential nature of some of the fungicides in controlling the two species was apparent. Poraz did not show any control of R type eyespot but did control W type. The standard treatment, Unix, gave significant reduction of both strains. The two new treatments Flexity and Proline also showed significant control of both strains.

Yield was significantly increased in the highest rate Proline treatment and in the lower rate Poraz treatment, as shown in Figure 3.

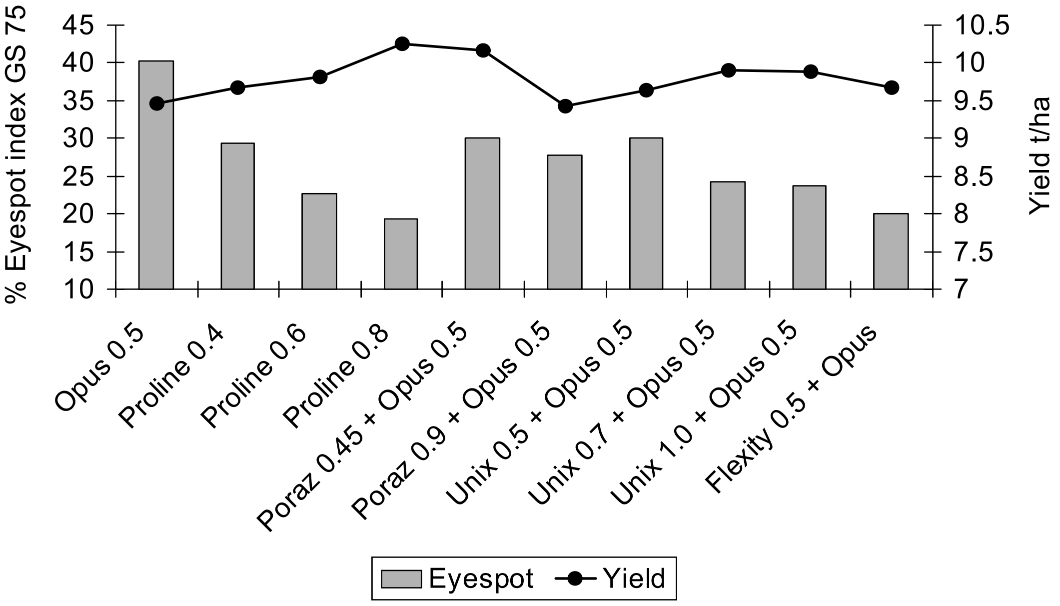

Figure 3. Eyespot control and yield benefit from fungicides 2004

6. DISCUSSION

The results indicated that R and W type eyespot exist in the UK as mainly mixed populations and give evidence that W type eyespot was the dominant species in the 2004 season. This supported the evidence of the previous project of which this work was a continuation. In the previous work, the Scottish site was dominated by R type eyespot, but this site too now appears to be predominantly W type. This evidence of a swing towards more W type eyespot is consistent with the results of the fungicide trial at the site that showed significant control from the prochloraz based fungicide, Poraz. This fungicide is known to control only W type eyespot and has performed poorly at the site in most previous seasons apart from the 2004 season where W type eyespot was the main species present. The PCR data confirmed that R type eyespot was not controlled by prochloraz. W type eyespot is considered to be the easier of the two eyespot species to control as it tends to be controlled by the commonly used triazole group of fungicides. One hypothesis tested in the work was that the new product, prothioconazole, would control W type eyespot and perform less well in controlling R type. The data, however, show that prothioconazole gave good control of both species and was comparable, or better, than the former standard treatment of cyprodinil (Unix). Metrafenone (Flexity), the second new active evaluated also controlled both R and W type eyespot. A product that controlled one species better than the other would inevitable lead to an increase in the harder to control species, and it is encouraging that the new chemistry available to growers does not appear to do this. It is possible that the current swing towards more W type eyespot in the UK is as a result of decreased triazole usage when strobilurin chemistry was in use. Now that triazole rates have risen again as a consequence of resistance issues with the strobilurins, there is the possibility that R type eyespot levels in the UK will increase in coming seasons. There was no evidence of any swing back to R type in the 2004 season, however, and the results showed that W type eyespot increased as a proportion of the total population in the course of that season.

The introduction of new fungicides with efficacy against eyespot is particularly important for growers who have problems with eyespot in most seasons. Eyespot levels in 2004 were low compared to the peaks seen in the late nineties in CSL / Defra survey work, now called Crop Monitor. The sites selected for this project in 2004 work did not concur with the CSL data as 77% of sites had levels of eyespot greater than 30% eyespot. Using the Scott and Hollins model for yield loss to eyespot this is the level of eyespot that would be expected to give an economic margin over cost if treated. The previous project (2382) did not identify such a high level of loss in response to eyespot treatment and the economic treatment level was higher, at 45% incidence. In the 2004 season 53% of sites exceeded this level of eyespot. The work again demonstrated that the link between eyespot and yield is not strong. 80% of the sites gave an economic response to the eyespot treatment cyprodinil but this response did not correlate to the level of eyespot at the sites. The issue of yield loss to eyespot is one that would merit further study. It is possible that some crops compensate for infection better than others.

Prothioconazole has been shown in SAC trial work to give good protection against *Septoria tritici* when used at the half rate of 0.4 l/ha at the stem extension spray timing of GS 31/32. The work in this project shows that for effective eyespot control the rate used should be higher than this at either 0.6 l/ha or 0.8 l/ha. There was a clear dose response in yield when increasing the rate although yield was poorly related to eyespot levels, as has been seen in the previous project. There will be obvious advantages to using a single product for both foliar and stem base disease control compared to using a separate product for each that require tank mixing at a point in the season when herbicides, growth regulator or trace elements may need to be applied to a crop. Metrafenone is a protectant fungicide applied to control mildew, but which can also give eyespot reduction when applied at the full rate of 0.5 l/ha. At this rate, it is unlikely to be used for eyespot control alone, but growers using it for mildew protection may also benefit from some reduction of eyespot risk.

The validation work on the eyespot model showed the potential for this approach to judging the need for treatment. It also showed that further work is needed to refine some aspects of the model. The model correctly judged the decision to spray, or not to spray, in 69% of cases when predicting the externally validated economic treatment level of 30% incidence of eyespot at the end of the season. The 20% plants infected at stem extension threshold was less successful and predicted correctly in 50% of cases. It also had the highest number of false positives, predicting five times as many false positives as false negatives. To wrongly identify crops as needing treatment, when they do not, could lead to an unnecessary increase in pesticide use which has other negative connotations besides the economic loss in the crop in question, when there is a drive to reduce pesticide usage. The model predicting eyespot at the 45% incidence level by the end of season was correct in 54% of cases and predicted twice as may false positives as it did false negatives. It was the only one of the three methods however to identify some of the true negative cases, i.e. the crops that really did not need treatment. If a judgement aid is overly cautious it is likely to be over sensitive and judge a need to treat more often, hence missing many true negatives, as may be the case here with the threshold approach and the model predicting 30% eyespot.

The data set used is very small to draw conclusions from. A larger data set from 2004 from the Defra funded Crop Monitor work at CSL was analysed in the course of the project, but CSL would not allow its inclusion in this project so as not to preempt scientific papers in preparation. On this larger data set of 63 sites, the model judged the need to treat correctly in between 60-70% of cases, making allowance for some missing data – a similar success rate to the smaller data set used in the project.

The eyespot model has been well received by growers. It rated more highly for interest than variety trials at the HGCA Balgonie Soil2Crop Open day in 2004, in a gate survey of growers. The model is designed to assist them in making a judgement on the need to treat for eyespot and to take account of their own experiences and attitude to risk. A useful predictor is one that discriminates between crops that need treatment and those that do not on the basis of information that can be obtained at a sufficiently early stage of the growing season to enable action to be taken if the risk is deemed sufficiently high. Discrimination between crops that need treatment and those that do not need treatment, on the basis of a predictor, can never be perfect. Only a proportion of the variability in crops causing them to fall into one or other of these two categories is 'explained' by a statistical model. If a threshold 'risk score' is set for the predictor, imperfect discrimination means that some crops that really need treatment will fall below this threshold, and some crops that really do not need treatment will fall above this threshold. Since different users may respond differently to these two different types of error, a useful asset in a predictor is a capability for users to modify the threshold risk score to suit their own attitude to risk. It follows, therefore, that predictors such as the one described in this project are best considered as guidelines to be used as part of the crop protection decision-making process, rather than rules that are meant to be followed without wider consideration of the circumstances in which a decision is made.

The work demonstrates the potential of this type of flexible judgement aid but also highlights the need for further work to refine and develop the model. An area of future study that would be beneficial, would be the inclusion of probabilistic weather modeling to that the seasonal risk of eyespot could be better judged.

7. CONCLUSIONS

The project demonstrated that the new fungicide prothioconazole tended to improve eyespot control and yield when compared to the standard treatment of cyprodinil plus epoxiconazole. A second new fungicide, metrafenone, was tested at one site and also showed improved eyespot control and yield when used at the full rate. Both fungicides controlled both R and W type eyespot, in contrast to prochloraz which controlled only W type. R and W type eyespot were present at all sites as mixed populations in samples taken at stem extension, with W type being the dominant species. The proportion of W type eyespot increased when the same sites were tested at the end of the season.

The risk assessment model, produced for HGCA project 2382, was used to assess the need for eyespot treatment at each trial site. The model correctly predicted the need to treat or not treat (based on >30% incidence of eyespot by the end of the season) for 69% of the test sites. It was correct 54% of the time when predicting an eyespot incidence greater than 45%. The results show that the model approach to judging treatment need has potential and that it was better than the former 20% threshold approach to judging treatment need. The 20% threshold had a high number of false positives in its judgements, which could lead to pesticide usage being increased. The dataset used was too small to base conclusions on. More work is needed to refine and progress the model and incorporate more information on weather factors. Probabilistic weather modeling would assist in predicting the risk associated with seasonal variations in diseases as a result of the weather risk factors identified.

Not all factors that lead to variations in disease level can be included in a statistical model, and no model can be entirely accurate. It follows, therefore, that predictors such as the one described in this project are best considered as guidelines to be used as part of the crop protection decision-making process, rather than rules that are meant to be followed without wider consideration of the circumstances in which a decision is made.

8. APPENDIX 1

SITE DETAILS

Year	Trial code	County	Tillage	Actual sow date	Variety	Soil type	soil pH	Rotation
2004	Vel-01	Kent	Min Till	19/09/2003	Soltice	Loam over chalk	7.8	1st WINTER WHEAT
2004	Vel-02	Lincolnshire	Min Till	25/09/2003	Soltice	Silty loam	8.4	1st WINTER WHEAT
2004	Vel-03	Lincolnshire	Ploughed	07/11/2003	Xi 19	Silty loam	8.2	1st WINTER WHEAT
2004	Vel-04	Kent	Ploughed	21/09/2003	Hereward	Loam over chalk	8.2	1st WINTER WHEAT
2004	Vel-05	Northamptonshire	*	10/09/2003	*	*	*	1st WINTER WHEAT
2004	Vel-06	Northamptonshire	Ploughed	20/09/2003	Xi 19	*	*	2nd WINTER WHEAT
2004	Vel-07	Gloucestershire	Ploughed	10/09/2003	Consort	Limestone Brash	7.7	2nd WINTER WHEAT
2004	Vel-08	Gloucestershire	Min Till	20/09/2003	Hererward	Limestone Brash	8	1st WINTER WHEAT
2004	Velft a	E-anglia	Min Till	15/09/2003	Consort	Silty Clay Loam	*	1st WINTER WHEAT
2004	Velft b	E-anglia	Ploughed	08/10/2003	Consort	Silty Clay Loam	*	2nd WINTER WHEAT
2004	Velft c	Dorset	Min Till	13/09/2003	Consort	Loam over chalk	8.1	1st WINTER WHEAT
2004	Velft d	E-anglia	Ploughed	08/10/2003	Consort	Silty Clay Loam	*	2nd WINTER WHEAT
2004	Velft e	Kent	Min Till	11/09/2003	Consort	Sandy Clay Loam	*	1st WINTER WHEAT
2004	MARKLE	East Lothian	Ploughed	21/09/2003	Riband	Clay loam	6.4	2nd WINTER WHEAT

* = missing data