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THE USE OF CARBENDAZIM IN THE UNITED KINGDOM FOR THE CONTROL OF CERCOSPORELLA HERPOTRICHOIDES IN WINTER WHEAT

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Summary Trials carried out in 1974 and 1975 on winter wheat have shown that carbendazim is an effective treatment for the control of eyespot (*Cercosporella herpotrichoides*). The addition of tridemorph, maneb or Polyram* to carbendazim was of no advantage in these trials.

The most effective control of eyespot was generally obtained from applications of carbendazim at a rate of 0.25 kg a.i./ha applied at growth stages 5 to 6. Disease control was associated with increased yield, improved grain quality, and a reduction in the level of lodging. Applications at a lower rate or alternative growth stages resulted in a reduction in both yield response and disease control. The addition of chlormequat to carbendazim in a year when weather conditions did not encourage lodging (1975) produced no benefit in terms of disease control or yield response. All cultivars included in the trials in both years were shown to be susceptible to eyespot attack.

Résumé Les essais qui ont été exécutés en 1974 et 1975 sur le blé d'hiver ont montrés que le carbendazim est un traitement efficace pour le contrôle du piéton-verse (*Cercosporella herpotrichoides*). L'addition du tridemorph, du maneb ou du Polyram au carbendazim n'a point profité dans ces essais.

Quant au blé, on a atteint le contrôle le plus effectif de l'oidium par des applications du carbendazim au taux de 0.25 kg a.i./ha, appliquées aux cinquième et sixième degrés de maturité. Le contrôle de la maladie s'alliait à un accroissement de rendement, une amélioration de qualité de grains et à un niveau réduit du versage. Les applications à un niveau plus bas ou à des degrés alternatifs de croissance ont causé une réduction et du rendement et du contrôle de la maladie. L'addition du chlormequat au carbendazim pendant une année òu les conditions météorologiques n'encourageaient pas le versage (1975) n'a amené aucun profit en ce qui concerne le contrôle de la maladie ou la rendement-résponse.

Il a été montré que toutes les variétés cultivées dans les épreuves pendant toutes les deux années étaient susceptibles aux attaques du piéton-verse.

INTRODUCTION

Eyespot (*Cercosporella herpotrichoides*) has been recognised as a cereal disease of economic importance in the U.K. since the last war (Glynne, 1942). However, with the introduction of Cappelle Desprez in 1952 and subsequently other wheat varieties with Cappelle-type eyespot resistance, general interest in the disease declined in this country, although this was not so on the continent. The extent of the eyespot problem on winter wheat and winter barley is still not known in the U.K. since little survey work has been carried out. However, since 1969, a succession of mild winters has probably resulted in increased levels of eyespot infection.

The use of benzimidazole related fungicides to control eyespot has been well documented. In 1969, Doodson and Saunders reported the effective control of eyespot on artificially inoculated wheat plants using benomyl. More recently, evidence from Germany has demonstrated the efficacy of carbendazim and related chemicals for the control of eyespot infections in the field (Fehrmann et al, 1973; Hampel et al, 1973).

This paper reports on a series of trials carried out on winter wheat in 1974 and 1975. Carbendazim was applied at various rates and timings, with and without the addition of tridemorph, maneb, Polyram or chlormequat. Chlormequat was included in the 1975 trial series because of evidence from other workers (Bockmann, 1964; Diercks, 1965; Hampel et al, 1973) and also its effect in Trial III (table 1) showing that chlormequat can have an effect against the parasitic lodging caused by the eyespot fungus.

METHOD AND MATERIALS

Carbendazim (methyl-2-benzimidazole carbamate) is formulated as a 50% w.p. (formerly BAS 3460 F).
Tridemorph is formulated as an e.c. containing 75% w/v a.i. and was used at 0.26 l. a.i./ha.
Maneb is formulated as a w.p. containing 80% manganese-ethylene-bis-dithiocarbamate. Rate/ha was 1.6 kg a.i.
* Polyram (formerly metiram) is the trade name for zineb-ethylene-thiramdisulphide adduct, for which there is no common chemical name. It is formulated as a w.p. containing 80% a.i. Rate/ha was 1.6 kg a.i.
Chlormequat is formulated as an aqueous solution containing 46% w/v a.i. Rate/ha was 1.66 l. a.i.

In 1974, carbendazim was applied to fields of two or more successive winter wheat crops at a rate of 0.25 kg a.i./ha at timings between growth stages 5 and 10. In the 1975 series of trials the same material was applied in similar situations at rates of 0.15 kg and 0.25 kg a.i./ha, with or without the addition of chlormequat, at timings between growth stages 4 and 8. Small plot trials were of a randomised block design with four replicates. Plots measured 4 m x 12.5 m. All treatments were applied using a Van der Weij knapsack sprayer fitted with cone nozzles, delivering 250 l./ha volume at 2.5 kg/cm^2 pressure.

Eyespot was assessed at the commencement of each trial by recording the percentage number of tillers infected. More detailed assessments were made at approximately growth stage 11.1 by scoring the incidence and severity of eyespot lesions on random samples of 25 tillers per plot (Scott et al, 1974). Tillers were scored as follows:-

0 uninfected
1 slight eyespot (one or more small lesions occupying in total less than half the circumference of the stem)
2 moderate eyespot (one or more lesions occupying at least half the circumference of the stem)
3 severe eyespot (stem completely girdled by lesions; tissue softened so that lodging would readily occur)

An eyespot score was calculated for each treatment from the following formula. The eyespot score (0-100 scale) gives an indication of both incidence and severity of the attack.

Eyespot score =

$$\frac{(\text{tillers in class 1}) + 2(\text{tillers in class 2}) + 3(\text{tillers in class 3})}{\text{total tillers}} \times \frac{100}{3}$$

The percentage of lodging or 'straggling' (individual, weakened stems lodging spontaneously in random directions) was assessed prior to harvest. Disease levels, apart from eyespot, were very low in all trials reported in this paper except where otherwise stated. Yields were assessed by combine harvesting 22.7 m^2/plot, and grain samples were taken from each plot and sieved to measure grain quality. All treatment yields are expressed relative to the untreated yield (increases kg/ha).

Cereal growth stages are expressed by use of the Feekes-Large Scale (Large, 1954).

RESULTS

The results obtained are given in tables 1 to 4.

Table 3

Timing of application of carbendazim showing yield response and control of eyespot on winter wheat (1975)

Treatment kg a.i./ha	G.S. at applic^n	Cultivar and Location: M. Huntsman Suffolk	M. Nimrod Suffolk	Atou Lincs.	Atou Yorks.	Mean Yield kg/ha	Relative mean yield (%)
Untreated		5059 (71)	5737 (66)	4707 (65)	4645 (57)	5040	100
Carbendazim 0.25	4-5	+ 301 (72)	+ 414** (44)	+ 515 (42)	+ 439 (47)	+ 414	108.2
Carbendazim 0.25	5-6	+ 276 (67)	+ 527** (26)	+ 828 (30)	+ 565 (41)	+ 549	110.9
Carbendazim 0.25	7-8	+ 690** (48)	+ 326 (31)	+ 615 (37)	+ 326 (43)	+ 493	109.9
% tillers infected at G.S. 4-5		60	65	60	85		
L.S.D. (P = 0.05)*		402	305	N.S.	N.S.		
" (P = 0.01)**		541	410				

Figures in brackets represent the eyespot score.

Table 1

Eyespot control and yield response from treatments of carbendazim, chlormequat, and carbendazim in mixtures with tridemorph, maneb or Polyram applied at growth stage 6 on winter wheat trials (1974)

Trial & variety	Treatments applied at G.S. 6	Eyespot score at G.S. 11.1	% lodging G.S. 11.3	Yield kg/ha	Relative yield	% grain > 3 mm
I Bouquet	Untreated	65	60	3452	100	70.0
	Carbendazim	22	9	+ 1431 ***	141.5	82.0
	Carbendazim + tridemorph	16	7	+ 1303 ***	137.8	82.0
	Carbendazim + maneb	16	7	+ 1230 ***	135.6	82.0
	Carbendazim + Polyram	21	12	+ 1180 ***	134.2	80.0
II Cappelle	Untreated	54	23	3623	100	80.2
	Carbendazim	20	6	+ 577 **	115.9	84.7
	Carbendazim + tridemorph	10	6	+ 590 **	116.3	84.8
	Carbendazim + maneb	17	6	+ 615 **	117.0	85.2
	Carbendazim + Polyram	23	5	+ 690 **	119.1	86.0
III Bouquet	Untreated	74	50	3979	100	71.0
	Chlormequat	56	20	+ 402 *	110.1	71.0

*, **, *** significantly different from the untreated yield at (P = 0.05), (P = 0.01) and (P = 0.001) respectively.

L.S.D. (P = 0.05) for Trial I = 558 kg
Trial II = 382 kg
Trial III = 295 kg

Table 2

Eyespot control and yield response from treatments of carbendazim plus tridemorph applied between growth stages 5 and 10 on winter wheat trials (1974)

Variety	G.S. at application	Eyespot score at G.S. 11.1	% lodging G.S. 11.3	Yield kg/ha	L.S.D. kg/ha (P = 0.05)	Relative yield	% grain > 3 mm
Bouquet	Untreated	65	60	3452	558	100	70
	Treated G.S. 6	16	7	+ 1303 ***		137.8	82
	" G.S. 9	45	35	+ 751 **		121.8	77
Cappelle	Untreated	54	23	3623	382	100	80.2
	Treated G.S. 6	10	6	+ 590 **		116.3	84.8
	" G.S. 10	-	25	+ 289		108	82.7
Cappelle	Untreated	55	60	2950	816	100	70.2
	Treated G.S. 6	28	23	+ 1130 **		138.3	73.5
	" G.S. 10	-	33	+ 402		113.6	72.8
M. Huntsman	Untreated	58	46	5260	452	100	83.9
	Treated G.S. 6	19	11	+ 791 ***		115	87.5
	" G.S. 10	-	41	+ 465 *		108.8	87.2
M. Templar	Untreated	50	0	6073	N.S.	100	-
	Treated G.S. 5-6	10	0	+ 321		105.3	-
	" G.S. 8-9	-	0	+ 145		102.4	-
M. Ranger	Untreated	49	10	3804	578	100	69
	Treated G.S. 6-7	16	0	+ 552		114.5	74
	" G.S. 9-10	51	4	+ 226		105.9	74
Means of	Untreated	55.2	33	4194	-	100	74.7
Means of	Treated G.S. 5-7	17.5	8	+ 781		118.6	80.4
Means of	Treated G.S. 9-10	48.0	23	+ 380		110.1	78.8

*, **, *** significantly different from the untreated yield at (P = 0.05), (P = 0.01) and (P = 0.001) respectively.

- represents no assessment made.

Table 4

Yield responses (kg/ha) and disease control (eyespot score) from treatment with two rates of carbendazim, alone or in mixture with chlormequat, on winter wheat trials (1975)

Treatment (kg a.i./ha)	A Bouquet	B Bouquet	C Atou	D Atou	E Atou	F Atou	G Flinor	H Flinor	I Huntsman	J Nimrod	Mean yield &(eyespot score)	Relative mean yield (%)
Untreated	6176 (74)	7620 (59)	5875 (73)	6565 (82)	4645 (57)	4707 (65)	5950 (87)	5963 (17)	5059 (71)	5737 (66)	5825 (70)	100
Carbendazim 0.15 kg	602* (36)	351* (14)	665** (48)	502* (39)	377 (49)	665 (36)	502* (31)	326 (12)	640** (60)	238 (33)	490 (38)	108.4
Carbendazim 0.15 kg + chlormequat	238 (46)	339* (25)	916*** (36)	527* (37)	1042 (43)	653 (31)	515* (39)	- -	- -	276 (31)	565 (35)	109.7
Carbendazim 0.25 kg	577* (13)	364* (6)	1205*** (25)	665* (33)	565 (41)	828 (30)	577* (25)	414 (6)	690** (48)	527** (26)	640 (27)	111.0
Carbendazim 0.25 kg + chlormequat	389 (22)	427** (17)	703** (24)	565* (39)	879 (40)	615 (27)	778** (22)	- -	- -	502** (25)	603 (26)	110.4
Chlormequat	38 (80)	-75 (64)	276 (74)	138 (79)	377 (48)	301 (57)	-213 (82)	- -	- -	-88 (59)	95 (70)	101.6
G.S. at applic^n	6	5	6	7	5-6	5-6	6	6-7	7-8	5-6		
% tillers infected at application	85	40	95	62	85	60	92	10	60	60		
% straggling in untreated plots	15	<5	10	10	15	<5	5	<5	<5	<5		
L.S.D. (P = 0.05) *	427	303	392	390	N.S.	N.S.	480	N.S.	402	305		
(P = 0.01) **		408	557				683		541	410		
(P = 0.001)***			807									

DISCUSSION

In 1974, trials were carried out on sites with high infection levels of eyespot and where the level of foliar disease was negligible. Carbendazim alone at 0.25 kg a.i./ha when applied at G.S. 6 was shown to be highly effective against eyespot (table 1). Although the addition of tridemorph, maneb or Polyram to carbendazim resulted in a marginal improvement in eyespot control, this was not reflected in the yield. Trials in 1974 (table 2) where a mixture of carbendazim plus tridemorph was applied to a range of wheat cultivars between G.S. 5-7, resulted in yield increases averaging 18.6%. The yield responses were associated with a reduction in eyespot infection, an improvement in grain quality and a reduction in lodging. When this treatment was applied between G.S. 9-10 however, the effectiveness was considerably reduced.

The results from the trials in 1974 showed that carbendazim was the effective component against eyespot in all treatments. Therefore, this compound was used in 1975 to evaluate further, timing and application rate for eyespot control.

Results from 4 timing trials are given in table 3. Three trials demonstrated that the optimum timing for a single application of carbendazim for eyespot control on wheat is G.S. 5-6. The effectiveness was reduced with earlier applications at G.S. 4-5 or later at G.S. 7-8, the exception being one trial on M. Huntsman where the best response came with the later timing at G.S. 7-8. These results generally agree with those obtained by other workers (Fehrmann et al, 1973; Hampel et al,1973).

Rates of use were evaluated in ten trials in 1975 (table 4) comparing carbendazim at 0.15 kg and 0.25 kg a.i./ha. Although 0.15 kg a.i./ha gave a good response, the higher rate generally gave superior disease control and greater increases in yield (11% compared to 8.4% average increase). This effect was also confirmed when chlormequat was used in conjunction with the two carbendazim rates (table 4). In these trials, as in the 1974 series, again there was a close association between the eyespot control and yield response. Under the conditions prevailing in these trials, all the cultivars included were shown to be susceptible to eyespot attack, and all responded to treatment with carbendazim in terms of disease control and yield response. Comparing three cultivars drilled on one trial site with a history of eyespot (table 4), Trial A (Bouquet), Trial C (Atou) and Trial G (Flinor), all three cultivars were severely attacked, there being little difference between them.

Comparison of the results obtained with chlormequat in 1974 (table 1) when severe levels of eyespot and lodging occurred, and 1975 when lodging was minimal, shows that in situations of eyespot induced lodging, yield was increased by chlormequat treatment. Similar results are reported by Bockmann (1964); Diercks (1965). In the absence of lodging, chlormequat did not affect yield.

A comparison of yield results from the two years should be considered in conjunction with evidence from Scott and Hollins (1974). These workers have shown that eyespot reduces yield through the direct effect of the pathogen on host physiology, and secondly, through the indirect effects of lodging. It was noted that 'straggling' tillers occurred in many of the 1974 trials in the untreated areas, which with the onset of adverse weather conditions prior to harvest, resulted in severe lodging in many trials. In 1974 therefore, treatment with carbendazim probably prevented yield losses by acting against both the direct and indirect effects of eyespot. A comparison with the climatic conditions during the 1975 season however, showed that the extremely mild, wet winter and spring again provided ideal conditions for an eyespot attack, but in contrast to 1974, the very dry weather which persisted through until harvest was not conducive to lodging and probably also slowed lesion development. Hence in trials in 1975, it is probable that the yield responses obtained were mainly due to controlling the direct effect of the pathogen only.

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THE EFFECT OF BENOMYL ON CERCOSPORELLA HERPOTRICHOIDES AND YIELD IN WINTER WHEAT

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Summary Sequential sprays of benomyl in 1972 increased winter wheat yields by 8% - 16%, reduced the level of foliar diseases present, but most notably reduced the symptoms of eyespot, Cercosporella herpotrichoides.

A single spray of benomyl applied to observation plots in 1972 indicated similar worthwhile yield increases when applied at growth stages 8 and 10.0. (Feekes Large scale) This led to spray timing trials with benomyl in 1973 and 1974.

Single sprays of benomyl applied in early May, growth stage 6 in 1973 and 1974 increased yields of grain by 10.0% and 7.0% respectively, and eyespot symptoms were reduced.

A late benomyl spray at ear emergence, growth stage 10.5, was less effective for increasing yield or reducing eyespot symptoms.

The incidence of eyespot was significantly correlated with yields of grain; a one per cent increase in whitehead symptoms of severe eyespot infection was associated with a yield reduction of 0.11 tonnes/hectare.

Résumé En 1972, des pulvérisations successives de benomyl ont augmenté le rendement du blé d'hiver de 8% - 16% et ont réduit les maladies foliaires présentes, mais ce qu'est le plus important elles ont réduit les symptômes du piétin-verse, Cercosporella herpotrichoides.

En 1972, une seule pulvérisation de benomyl appliquée sur des parcelles d'observation, aux stades de croissance 8 et 10,0*, indiquait aussi une augmentation considérable du rendement. Cela a conduit aux essais de pulvérisation à intervalles réguliers de benomyl, en 1973 et 1974.

Une seule pulvérisation de benomyl appliquée au début de mai, au stade de croissance 6* en 1973 et 1974 a augmenté le rendement du grain de 10% et 7% respectivement et a réduit les symptômes du piétin-verse.

Une pulvérisation tardive au moment de la formation de l'épi, stade de croissance 10,5*, n'était pas assez efficace pour augmenter le rendement ou réduire les symptômes du piétin-verse.

L'incidence du piétin-verse était positivement liée au rendement du grain; Une augmentation d'un pour cent des têtes blanches du piétin-verse grave a réduit le rendement de 0,11 tonnes/hectare.
*Les stades de croissance sont à l'échelle de Feekes Large

INTRODUCTION

Surveys of winter wheat in Great Britain have shown eyespot to be most severe on wheat following wheat or barley (Glynne, 1942) and therefore a problem more in eastern England and in particular areas where cereal monoculture is practised.

Eyespot has been shown to be more prevalent following a wet spring and early sowing has also tended to increase the severity of the attack (Glynne, 1946).

Eyespot was recognized as one of the major cereal disease problems in the first years at Boxworth Experimental Husbandry Farm where in an area of continuous wheat now well known as Sykes Field, an attempt was made to control eyespot by means of seedrate, nitrogen and sulphuric acid sprayed in March. Results were inconclusive as far as eyespot control was concerned. A practical conclusion was that, as lodging was not a problem on heavy chalky boulder clay at Boxworth despite increasing levels of eyespot during the years of the trial, given adequate seedrate, and nitrogen in March, both of which tend to favour eyespot, satisfactory wheat yields could be obtained. The highest eyespot infection years were not positively correlated with low yields and frequently the highest yielding crops had the highest eyespot infection. (Ministry of Agriculture and Fisheries. Results of Experiments on Experimental Husbandry Farms 1953 - 1956).

It was finally concluded that, with the advent of Cappelle Desprez which was the first eyespot tolerant variety, eyespot was not a serious factor for winter wheat growing at Boxworth.

Straw burning increased during the 60's, and it was widely believed that eyespot control could result from this practice, but this claim has not yet been substantiated. (Slope _et al_ 1970).

A reduction of eyespot symptoms, with associated yield increases, has however occurred at Boxworth in 1972 as a result of the use of benomyl, even when applied to eyespot tolerant varieties. As a result of this a spray timing programme was started looking particularly at the effect of early sprays of this fungicide. Work in New Zealand reported in the Plant Disease Reporter 1971. 55.1. indicated reduced lodging due to eyespot control and good yield increases from early single sprays of benomyl at GS 6/8 (Witchalls J T, Close R 1971).

METHOD AND MATERIALS

Sites at Boxworth on chalky boulder clay of the Hanslope series were:-

1972 3rd wheat after beans
1973 2nd wheat after peas
1974 2nd wheat after oats but 5th white straw crop after spring beans
1975 1st wheat after winter barley, but 4th white straw crop after spring beans

Spray treatments and unsprayed control plots were replicated six times in 1972 and four times in 1973, 1974 and 1975 in randomised blocks. Plots were 25.60 m x 3.66 m, with a central harvest strip 2.31 m wide separated from the outer discard rows by blocked coulters. A tractor mounted farm sprayer followed the blocked coulter on one side, straddling the discard areas to apply the fungicide without wheeling the harvested area.

Treatment details. In 1972 sequential sprays of benomyl 0.56 kg/ha a.i. in 955 l/ha water were applied at 10 - 14 day intervals starting at GS 6/7 (9 May) to GS 11.2 (27 July) to early drilled winter wheat as part of a National series of trials (CL 2) investigating the effect on yield of mildew and Septoria. Observation plots received a single spray at GS 8 (22 May) or GS 10.0 (1 June). The effect on eyespot and yield prompted the spray timing trials in subsequent years.

In 1973 the timing of single sprays of benomyl at 0.56 kg/ha a.i. in 280 l/ha water at GS 6 (11 May) GS 8 (30 May) GS 10 (4 June) GS 10.5 (11 June) and a further treatment sprayed on all four occasions was investigated.

In 1974 single sprays were applied at GS 4/5 (11 April) GS 5/6 (19 April) GS 6/7 (7 May) and GS 10.5 (14 June) with a further two spray treatment at GS 5/6 and GS 10.5. In accordance with commercial recommendations and continental practise, the rate of application was reduced to 0.28 kg/ha a.i. in 280 l/ha water.

In the 1975 trial, for which full data is not available at the time of writing, benomyl was applied at 0.28 kg/ha a.i. at GS 4 (10 April) GS 6 (28 April) GS 7 (12 May) GS 9 (29 May) GS 10.5 (18 June) and a two spray treatment at GS 6 + GS 10.5.

Extra treatments in 1975 were benomyl + maneb applied at GS 9 at 0.28 kg/ha a.i. and 1.79 kg/ha a.i. respectively to compare the addition of a dithiocarbamate fungicide to benomyl, and to compare this commercially recommended tank mix with benomyl alone.

Captafol 50% col (Sanspor) @ 1.75 l a.i./ha was applied at GS 4 to compare the product with benomyl for its effect on reducing the early potential inoculum of eyespot infection.

Counts of tillers and whitehead symptoms of eyespot were by post anthesis counts of 4 x 0.91 m lengths of row in 1973 and 6 x 0.50 m lengths of row in 1974.

Growth stages for spraying are based on the Feekes Large Scale. (Large 1954).

RESULTS

In 1972 sequential sprays of benomyl were applied at 10 - 14 day intervals to early drilled winter wheat cultivars, Cappelle Desprez, Maris Ranger and Cama. Mildew (Erysiphe graminis), brown rust (Puccinia recondita) and low levels of yellow rust (Puccinia striiformis) which were particularly prevalent in that year were reduced and senescence possibly in part due to Septoria was delayed to some extent. The cosmetic effect on the wheat ears and straw due to the reduction of ear diseases including mildew and Cladosporium was most marked. Reductions in the symptoms of stem base diseases were also observed particularly of eyespot and Fusarium. The yield of the relatively eyespot susceptible cultivar, Cama was increased by these sprays by 16%, whereas yields of the less susceptible cultivars Maris Ranger and Cappelle Desprez were improved by 9% and 8% respectively.

Table 1

Effect of seven benomyl sprays applied at 10 - 14 day intervals GS 6 / 7 - 11.2 1972

	Yield tonnes/hectare @ 15% MC No spray	Benomyl sprays
	S.E. ± .110	
Cappelle Desprez	5.61	6.07
Maris Ranger	5.75	6.31
Cama	5.74	6.69
	S.E. ± .064	
Mean	5.70	6.35

SE @ 30 df SE ± 0.27 tonnes/ha or 4.5% of GM

Amounts of 'tailcorn' less than 2.4 mm were reduced from 4.8% to 3.3% by these sprays.

The effect of a single benomyl spray at GS 8 or GS 10.0 applied to observation plots drilled later than the main trial indicated that single sprays could give yield increases which were similar to those obtained by the complete sequential spray programme. (Table 2). These single sprays reduced tailcorn amounts from 7.3% to 4.1%.

Table 2

Effect of benomyl single sprays on yield - observation plots 1972

Yield tonnes/hectare @ 15% MC

	Date drilled	Spray GS	Yield No spray	Yield + benomyl	Increase	%
Maris Ranger	23 October	8.0	6.088	6.753	+ .655	11%
Cappelle Desprez	15 November	10.0	5.661	6.201	+ .540	9%
Maris Ranger	15 November	10.0	6.176	6.414	+ .238	4%
Cama	15 November	10.0	5.699	6.439	+ .740	13%

As a result of these observations, and the New Zealand work reporting eyespot control from sprays of benomyl applied at GS 6/8, a benomyl spray timing trial for 1973 was initiated.

In 1973 benomyl treatments were applied to cultivars Maris Ranger and Cappelle Desprez. Foliar diseases were almost absent and in consequence late applied sprays were less effective than in 1972, except on Cappelle Desprez which lodged after ear emergence sprays had been applied.

The benomyl spray at GS 6 alone resulted in a statistically significant yield increase of approximately 9% for both cultivars (Table 3). This early spray also reduced the incidence of whiteheads (Table 4) in the crop just after anthesis in cultivar Maris Ranger from 5.4% on the control plot to 0.7%. Tailcorn amounts less than 2.4 mm were reduced by 1 - 2% by treatments where an early GS 6 spray was applied.

Table 3

The effect of timing of benomyl sprays on yield, 1973

Yield tonnes/hectare

	Control	Benomyl applied GS 6	GS 8/9	GS 10.0	GS 10.5	All four sprays
Cappelle Desprez	5.41	5.83	5.84	5.50	5.61	5.90
Maris Ranger	5.58	6.11	5.80	5.71	5.69	6.07
		S.E. ± .103				
Mean	5.49	5.97	5.62	5.61	5.65	5.99

SE 28 df = ± 0.253 tonnes/hectare or 4.5% of GM

In 1974 the whitehead symptoms of eyespot in Champlein winter wheat grown as a second wheat after oats, were reduced from 6.1% to 2.1% by an early spray at GS 5/6 of benomyl. (Table 4). The percentage tillers infected with eyespot and the yield responses from the same trial are shown in tables 5 and 6 respectively.

Table 4

The effect of timing of benomyl sprays on eyespot, 1973 and 1974

Percentage of whiteheads in crop after anthesis

	Benomyl applied					
1973	Control	GS 6	GS 8	GS 10.0	GS 10.5	4 sprays
			S.E. ± 0.71			
	5.4	0.7	3.4	3.3	3.5	0.8
1974	Control	GS 4/5	GS 5/6	GS 6/7	GS 10.5	GS 5/6 + 10.5
			S.E. ± 1.77			
	6.1	3.9	2.1	2.8	3.9	0.9

Table 5

The effect of benomyl sprays on percentage of eyespot infected tillers at GS 10.5.5 1974

			% Eyespot infection		
			None	Slight	Severe
No Spray	Control		60.2	19.1	20.7
Benomyl	GS 4/5	April 11	53.7	30.0	16.3
"	GS 5/6	April 19	74.0	17.2	8.8
"	GS 6/7	May 7	61.9	23.2	14.9

The assessment of infected tillers (Table 5) showed that the percentage of tillers severely affected was least as a result of the early spray at GS 5/6 but the yield response was only 3.2%. The next spray on 11 May at GS 6/7 also showed reduced eyespot symptoms but the yield improvement was 7% possibly due to some control of foliar diseases present. (Table 6).

Table 6

The effect of timing of benomyl sprays on yield, 1974

Yield tonnes/hectare

		Benomyl applied				
	Control	GS 4/5	GS 5/6	GS 6/7	GS 10.5	GS 5/6 + GS 10.5
			S.E. ± .176			
Champlein	7.09	7.17	7.31	7.60	7.38	7.66

SE @ 12 df = ± 0.305 tonnes/hectare or 4.2% of GM

The two latest applied single sprays and the two spray treatment tended to reduce low levels of mildew and *Septoria*. The ear emergence spray whilst not having any marked effect on eyespot, did improve grain size and yield by 4.1%, probably due some reduction of foliar diseases.

Fertile tiller numbers tended to be increased in 1974 by all benomyl treatments except when applied at ear emergence. Tiller numbers were most increased by the GS 5/6 spray. (Table 7).

Table 7

The effect of timing of benomyl sprays on ear count 1974

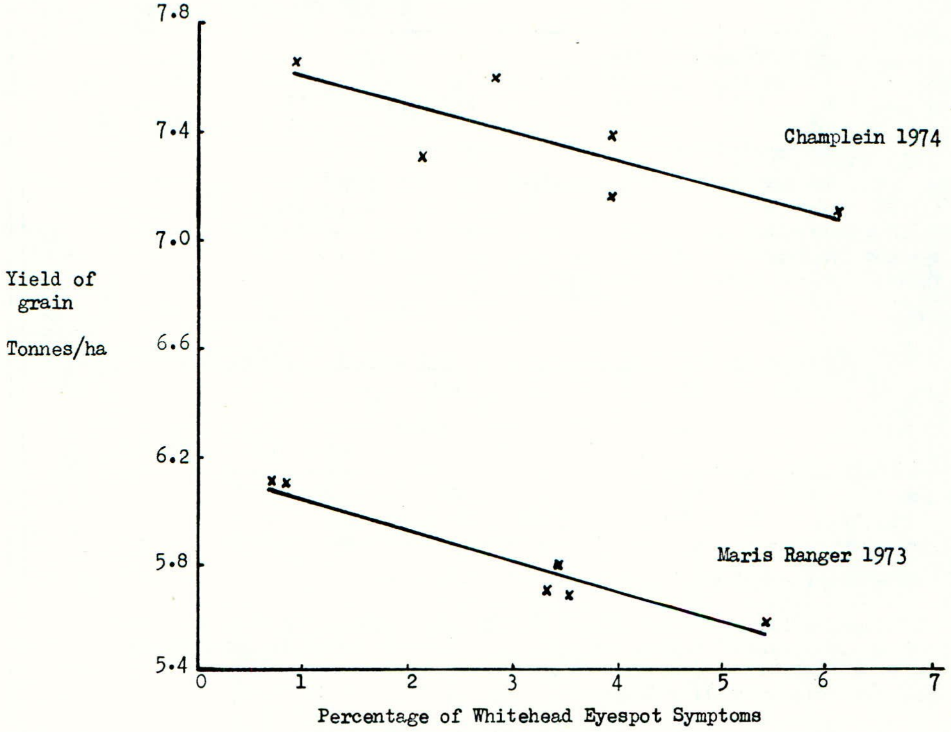
Ear count, thousands/hectare

Control No Spray	Benomyl applied GS 4/5	GS 5/6	GS 6/7	GS 10.5	GS 5/6 + 10.5
		S.E. ± 293.2			
5197	5315	5740	5365	4972	5715

There was a small reduction in lodging and grain size was improved by all treatments although tailcorn amounts were not significantly affected. There was clearly a relationship between the incidence of eyespot and the yield of wheat as shown in Figure 1.

Figure 1

Regression of yield on the whitehead symptoms of eyespot



The regression coefficients for 1973 and 1974 were 0.94 and 0.80 respectively

$y = 6.16 - 0.116\ x$ 1973 Maris Ranger

$y = 7.71 - 0.102\ x$ 1974 Champlein

Where y = yield of wheat tonnes/ha   x = severe eyespot, whiteheads

This correlation indicates that at the level of eyespot encountered in 1973 and 1974, each one per cent increase in whitehead symptoms was associated with a yield reduction of approximately 0.11 tonnes/ha.

In 1975 there was a high incidence of eyespot in early March with approximately 70% of the tillers of cultivar Champlein infected, but at GS 10.0 tiller infection was about 30%, except where benomyl sprays were applied and tiller infection was reduced to approximately 5%. At the time of writing the full results of the 1975 trial are not available, but a preliminary examination of the data indicates only relatively small responses to treatments in spite of the apparent satisfactory reduction of eyespot infection.

Discussion

The application of benomyl to winter wheat in late April or early May at GS 6 reduced eyespot symptoms and gave economic yield increases at Boxworth during the period 1972 - 1974. The reduction in yield of wheat from eyespot was due to the direct effect of eyespot lesions in the almost complete absence of lodging. Where lodging has occurred as a result of severe eyespot, yield losses have been shown to be considerably greater, than where with similar eyespot infection, lodging was physically prevented. (Scott and Hollins 1974). It can be argued that the potential benefit from an early benomyl spray could be even greater where lodging is more prevalent than on chalky boulder clay.

The high incidence of eyespot infection in March 1975 indicated that a worthwhile result from an early application of benomyl should be obtained. However, dry sunny conditions prevailed, and in spite of lower numbers of infected tillers at GS 10.0 resulting from the early benomyl spray treatment, no whitehead symptoms of eyespot were seen in the control plots, and yield increases from the early sprays of benomyl were relatively small. It would therefore seem that the weather conditions in 1975 did markedly affect the extent to which the early eyespot infection developed. This is in contrast to earlier work elsewhere which has suggested that eyespot infection, once established, would develop regardless of external weather conditions. Scott 1975 (personal communication).

This work is continuing in co-operation with ADAS Eastern Region Plant Pathology Department to try to establish a basis on which firm recommendations for fungicide application can be made, based it is hoped on better information on the development of eyespot and other wheat plant diseases, and the climatic conditions which affect their development.

Acknowledgments

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A SURVEY OF FOOT ROT DISEASES OF WHEAT IN GERMANY AND THE EFFECT OF SYSTEMIC FUNGICIDES ON THE FUNGUS SPECTRUM

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Summary Investigations were carried out during 1974 and 1975 to ascertain the spectrum of pathogenic fungi involved in foot rot diseases of wheat in Germany and the extent to which they are affected by treatment with methyl thiophanate (BAS 32500 F) and a methyl thiophanate plus maneb mixture (BAS 36801 F). The two most frequently encountered diseases were *Cercosporella herpotrichoides*, the cause of eyespot, and *Fusarium spp.* which was often found to be coexisting with *Cercosporella herpotrichoides*. Eyespot was controlled by one application of either BAS 32500 F at 0.5 kg/ha or BAS 36801 F at 2.5 kg/ha applied at G.S. 5-7, but the treatments appeared to have little effect on the incidence of *Fusarium spp*. Other fungi that were found to be involved in foot rot symptoms included *Rhizoctonia solani*, *Helminthosporium sativum*, *Septoria nodorum* and a *Typhula*-like fungus.

Résumé On a effectué des recherches pendant 1974 et 1975 pour constater le spectre des mycètes pathogéniques impliquées dans les maladies de la cercosporellose parmi le blé en Allemagne, et à quel degré elles sont affectées si l'on les traite avec le methyl thiophanate (BAS 32500 F) et avec un mélange du methyl thiophanate et le maneb (BAS 36801 F). Les deux maladies qu'on a rencontrees le plus souvent etaient le *Cercosporella herpotrichoides* ce qui cause le piéton-verse, et le *Fusarium spp*, ce qui se trouve souvent coexister avec le *Cercosporella*. Le piéton-verse a été contrôlé par une application ou de BAS 32500 F à 0.5 kg/ha ou de BAS 36801 F à 2.5 kg/ha du cinquième au septième degré de maturité, mais les traitements paraissaient avour peu d'effet sur l'occurrence du *Fusarium spp*. D'autres mycètes qu'on a trouvé être en relation avec les symptomes de la cercosporellose comprenaient *Rhizoctonia solani*, *Helminthosporium sativum*, *Septoria nodorum* et une mycète qui ressemblait au *Typhula*.

INTRODUCTION

Considerable attention has been paid to eyespot of wheat caused by *Cercosporella herpotrichoides* and chemical control measures have been applied with varying degrees of success (Fehrmann, 1973, Fehrmann and Schroedter, 1972). More recently, however, attention has been paid to the other pathogens inhabiting the rhizosphere which are potential causal organisms of foot rot. *Fusarium spp*. (*F. nivale*, *F. culmorum*, *F. graminearum*) have always been recognised as being present, and can be controlled with mercurial seed dressings. The extent of yield loss for which they are directly responsible is, however, difficult to assess. Richardson (1975) has found that straws with brown lesions of indeterminate cause yielded 20% less than unaffected straws, and it thus appears that the "foot rot disease complex" deserves more attention than it has hitherto received.

Sharp eyespot (Rhizoctonia solani) has also come to prominence recently as a foot rot disease due reportedly to the application of benzimidazole-related fungicides to control eyespot (Bollen and van der Hoeven, 1973). Considering the number of potential pathogens in the rhizosphere, such factors as the effect of removal of competitors by specific fungicides cannot be ignored. More recently in Germany a case of an apparent increase in Typhula incarnata has been reported following benzimidazole-related fungicide application (Hossfeld, 1974); also Saur and Schoenbeck,(1975) have reported an increased infection of barley with Helminthosporium sativum following spraying with benomyl.

In view of current recommendations in Germany for the control of eyespot using methyl thiophanate(Hampel, 1975), it was considered important to investigate the spectrum of fungi causing foot rots, in order to ascertain which organisms were directly or indirectly affected by the fungicide.

The investigation was made on samples taken from routine fungicide trials laid down by BASF advisory staff throughout Germany, and not from specifically designed trials. The trials were carried out on commercial farms on land not thought to have been previously used for experiments. It may thus be assumed that the results reflect the normal spectrum of pathogens to be found.

During 1974, ten experiments from seven advisory centres were sampled in the untreated plots (cultivars Kormoran, Topfit and Benno) and detailed assessments were carried out on three sites at Munich, Kiel and Cologne. In 1975 detailed studies were again made on three trials, this time at Kiel (x 2) and Erlangen (varieties Topfit and Diplomat). In addition, untreated plots from eight experiments at seven advisory centres were sampled to monitor the fungus spectrum.

METHOD AND MATERIALS

Samples were taken at random from experiments containing plots sprayed at G.S. 5-7 with methyl thiophanate (BAS 32500 F) 0.5 kg/ha, from a methyl thiophanate (14%) + maneb (64%) mixture (BAS 36801 F) 2.5 kg/ha treatment also at G.S. 5-7 and from untreated plots. Three sampling dates were selected, namely G.S. 4 (just prior to spraying), G.S. 5-7 (shortly after spraying) and G.S. 11.1-11.2. Cereal growth stages are expressed using the Feekes Large Scale (Large, 1954).

During 1974 100 stems were sampled from each treatment while in 1975 100 stems were taken from each of four replicates in each treatment.

The stems were first visually assessed using a 1-8 assessment scheme originally developed for eyespot, but in this case modified to give a general idea of the degree of fungal attack at the stem base:

1. - no browning of stem, leaf sheath clean
2. - small, light brown flecks or slight discolouration (0-2.5% damage)
3. - slight, light brown discolouration or distinct lesions present (2.5-5% damage)
4. - brown discolouration or distinct eyespots (5-10% damage)
5. - lesions running together, distinct eyespots (10-15% damage)
6. - discolouration of up to 25% of the stem or leaf sheath (15-25% damage)
7. - discolouration of lesions covering up to 35% of the area assessed (25-35% damage)
8. - dark brown discolouration, leaf sheath and stem rotted (35-100% damage)

An attempt was also made to assess visually which organisms were mainly responsible for the damage, in order to ascertain how field assessments correlate with laboratory results. The results are expressed as % infected stems.

Following assessment, stems were divided into groups of ten and cut into 2 mm sections from the base up to the first node. After sterilization for 30 seconds in sodium hypochlorite solution the sections were plated directly on to 2% malt extract agar (Oxoid) containing 50 ppm streptomycin, 10 sections per plate. The number of colonies present was counted after seven and fourteen days. The results are expressed as % infected stems.

RESULTS

The relative frequency of the pathogenic fungi associated with foot rots in untreated plots are shown in Table 1.

The table is a summary based on results confirmed in both visual and plate assessments. The most frequently isolated fungi was Fusarium spp. and Cercosporella herpotrichoides.

Table 1

The relative occurrence of pathogenic fungi associated with foot rots in untreated samples of wheat in BASF trials in 1974

Trial Site	C. herpotrichoides	F. spp.	R. solani	S. nodorum	H. sativum	Typhula
Kiel 1 (Grossschlamin)	+++	+++	(+)	+	-	(+)
Kiel 11 (Honigsee)	+	+++	(+)	++	-	+
Cologne 1 (Port Zindorf)	+++	++	+	+	++	+
Cologne 11 (Flamersheim)	(+)	+++	-	+	-	+
Munich 1 (Gut Karlshof)	++	+++	-	(+)	(+)	+
Munich 11	++	+++	-	(+)	++	-
Münster	+++	+++	+	+	+	(+)
Erlangen	-	+	-	+	++	+
Oldenburg	+	++	-	-	-	-
Stuttgart	+	++	-	-	++	-

- absent
(+) trace
\+ detected in only one assessment
++ detected in at least two assessments
+++ common and readily isolated on all three assessment dates

With the exception of Port Zindorf, Helminthosporium sativum was only found on samples from Southern Germany. Septoria nodorum was found in the two areas where attack is normally common, namely the coastal area and Bavaria. A Typhula-like fungus occurred in small amounts in many areas. Sclerotia were occasionally found on old leaf sheaths, where the fungus was possibly existing as a saprophyte.

The effect of fungicide treatments (Table 2) generally reduced the level of Cercosporella while the population of Fusarium remained unaltered. From the limited results available it was noted that Helminthosporium sativum and Rhizoctonia solani appeared to be neither stimulated nor suppressed by fungicide treatments.

Table 2

The effect of fungicides on Cercosporella herpotrichoides and Fusarium spp. on wheat stem bases in 1974 (% stems infected from plating assessments)

Treatment	Cologne 1	Cologne 11	Kiel 1	Kiel 11	Munich 1	Munich 11	Mean
Cercosporella							
Untreated	16	0	14	0	12	14	9.3
BAS 32500 F	7	1	14	2	0	2	4.3
BAS 36801 F	7	0	15	2	0	9	5.5
Fusarium							
Untreated	20	20	20	20	10	10	16.7
BAS 32500 F	20	20	20	19	3	10	12.0
BAS 36801 F	20	20	20	19	9	10	13.0

Results show whether the fungi were detected after plating (20 plates per sample). Samples taken one week after spraying.

1975 was climatically a very different year from 1974, with a correspondingly different fungus spectrum. In particular, Cercosporella herpotrichoides was not abundant in samples (Table 3). Septoria nodorum was again found frequently in assessments in Northern Germany.

Table 3

The relative occurrence of pathogenic fungi associated with foot rots in untreated samples of wheat in BASF trials in 1975

Trial Site	C. herpotrichoides	F. spp.	R. solani	S. nodorum	H. sativum	Typhula
Kiel (Grossschlamin)	++	+++	+	(+)	-	-
Kiel (Honigsee)	(+)	++	+	++	-	-
Erlangen (Giebelstadt)	(+)	++	-	(+)	(+)	-
Erlangen (Hüttendorf)	+	++	-	(+)	+	-
Munich (Makhofen)	(+)	++	-	+	(+)	-
Giessen (Melbach)	+	++	+	(+)	-	-
Cologne	+	+	(+)	-	-	-
Oldenburg (Schaardeich)	-	(+)	-	-	-	-
Stuttgart (Ehingen)	-	(+)	(+)	-	-	-
Münster (Beerenbrock)	+	+	-	-	-	-
Münster	+	++	-	-	-	-

Again in 1975 application of methyl thiophanate or BAS 36801 F considerably reduced *Cercosporella herpotrichoides* infection (Fig. 1).

Considering both years, the visual difference between treated and untreated plots were not so great in the field as in the laboratory tests (Table 4).

Results (Table 4) also show the lack of correlation between visual and plating assessments. Plating assessments made soon after spraying show that the chemical treatments reduced the level of *Cercosporella herpotrichoides* but not of *Fusarium* or *R. solani*. The control of *Cercosporella herpotrichoides* observed in the plating tests on samples taken at G.S. 5-7 appear to be reflected in the visual assessments made at the end of the season at G.S. 11.1-11.2.

The discrepancy in the levels of *R. solani* recorded in the plating and visual assessments at G.S. 11.2-11.2 is difficult to explain but could be due to incorrect identification in the visual assessment.

Fig.1 Cercosporella development in unsprayed and BAS 36801 F - sprayed plots in 1975

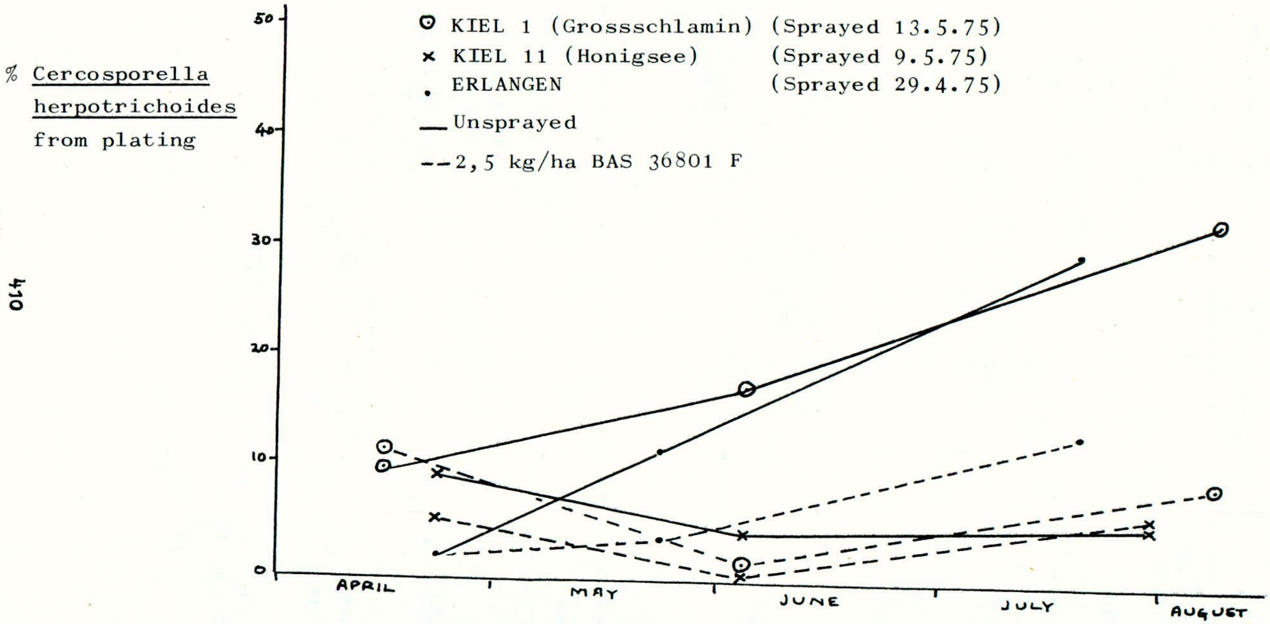

Table 4

Comparison of results from visual assessments and laboratory platings

Samples from Honigsee

G.S. at Sampling	Treatment	Degree of Disease (1-8 score)	Visual Score of Stem % Cerc.	% Fus.	% Rhiz.	Plating Result % Cerc.	% Fus.	% Rhiz.
4	Untreated	2.7	1.0	20.5	0.0	9.8	19.3	7.8
	BAS 32500 F	3.2	1.0	45.0	8.0	5.3	21.5	4.3
	BAS 36801 F	3.1	1.0	48.0	16.0	5.5	22.3	4.8
5-7	Untreated	2.3	3.5	23.5	21.5	4.7	7.3	7.1
	BAS 32500 F	2.2	3.5	21.5	15.0	1.1	6.1	7.3
	BAS 36801 F	2.0	3.5	17.5	14.0	0.3	3.7	14.1
11.1-11.2	Untreated	4.4	13.0	63.0	12.5	5.5	37.6	13.5
	BAS 32500 F	3.4	5.0	44.5	25.5	7.2	26.1	0.9
	BAS 36801 F	3.4	5.5	44.0	18.5	6.2	33.3	4.6

Helminthosporium was only found in laboratory tests and it is probable that this was initially assessed as *Fusarium* in those experiments where it was present, notably at Erlangen in 1975. Here a level of 10% was detected in the third assessment in treated plots at G.S. 11.1-11.2 whereas only 3% was detectable in the untreated sample.

DISCUSSION

The two most frequently occurring foot rot pathogens of wheat encountered in 1974 and 1975 were *Cercosporella herpotrichoides* and *Fusarium* (Tables 1 and 3). In many cases in 1975 the fungi were found co-existing in stem lesions and since they were usually isolated from stem sections simultaneously any estimate of which was the primary disease organism was practically impossible.

Applications of BAS 32500 F or BAS 36801 F at G.S. 5-7 reduced eyespot levels, caused by *Cercosporella herpotrichoides*, by more than 50% (Fig. 1). Hampel (1975) has shown that yield increases of up to 10% were obtained in 1973 and 1974 following this treatment of eyespot.

Fusarium increased considerably in June and July in both 1974 and 1975 (Table 4) but at this late stage some saprophytic colonisation of dead leaf sheaths may be expected. It could not be concluded from these experiments whether reduction in *Cercosporella herpotrichoides* allowed greater development of *Fusarium*.

Helminthosporium was only detected at the last sampling date in 1974 and was generally only found at sites in Southern Germany. In 1975 measurable amounts of *Helminthosporium* were found at only one site at Erlangen where results tended to confirm the findings of Saur and Schoenbeck (1975) with benomyl in barley, namely that an increase in *Helminthosporium* infection over the control level was obtained when plants had previously been sprayed with benomyl. *Helminthosporium* is known to be insensitive to benzimidazole-related fungicides (Saur and Schoenbeck 1975), and in view of the ease with which symptoms may be mistaken for *Fusarium* in visual assessments this is a fungus which may need careful attention in the future as its incidence may increase.

During 1974 sharp eyespot, caused by Rhizoctonia solani, was not found to any great extent and its occurrence was again sporadic in 1975. The highest level of disease recorded in 1975 was at Honigsee and laboratory platings indicated that it was possible to over-estimate disease levels. Results of fungicide treatments on R. solani are not clear but there was no indication from plating assessments of increased levels of the disease as reported by Bollen and van der Hoeven in 1973. Reschke (1975) has reported good control of Rhizoctonia solani on rye after two applications of BAS 32500 F at G.S. 4-6 and 7-9.

The observations reported serve to indicate the direction of future experiments, in so far as they have shown which diseases are important and may become important in Germany. In development of a foot rot fungicide the trend of disease development is equally as important as the situation at the time of treatment. Opportunities do exist in Germany to carry out experiments in areas of unusually high infection levels of minor pathogens such as Helminthosporium and Rhizoctonia, a point important in the planning and testing of new foot rot fungicides.

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THE CONTROL OF CEREAL FOLIAR DISEASES USING DITALIMFOS ALONE AND IN MIXTURES

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Summary Ditalimfos is a preventive and curative non-systemic fungicide with long persistence and high vapour phase activity. It is primarily active against powdery mildews and has a secondary activity against certain other foliar diseases. Extensive replicated trials throughout Europe have shown that 500 g a.i./ha of ditalimfos 20% e.c. gives excellent control of cereal powdery mildew (Erysiphe graminis) with consequent yield increases in winter and spring barley. This has been confirmed by grower trials and in commercial usage. Good mildew control has been demonstrated on winter wheat, coupled with some suppression of cereal rust diseases. Mixtures of ditalimfos with carbendazim and/or maneb and with oxycarboxin have given effective broad spectrum cereal disease control.

Résumé Ditalimfos est un fongicide non-systemique à action préventive et curative doué d'une longue persistance et d'une grande activité par phase vapeur. Il est efficace principalement sur les oidiums mais il a également une action secondaire sur certaines autres maladies foliaires. De nombreux essais avec répétitions entrepris à travers l'Europe ont montré l'excellente efficacité du ditalimfos 20% e.c. a 500g m.a./ha sur l'oidium des céréales (Erysiphe graminis) se traduisant par des augmentations de rendement en culture d'orge d'hiver et de printemps. Ces resultats on été confirmés par des essais de demonstration chez l'agriculteur et par l'utilisation commerciale. L'efficacité sur oidium des céréales particulièrement bonne en culture de blé d'hiver jointe à un effet sur les rouilles des céréales font du ditalimfos un composant hautement actif dans les mélanges fongicides des céréales à large spectre.

INTRODUCTION

Ditalimfos is the B.S.I. approved common name for O,O-diethylphthalimidophosphonothioate. Clare et al (1968) first reported its efficacy against powdery mildews on fruit, vegetables and ornamentals and also demonstrated useful activity against other diseases such as apple scab (Venturia inaequalis). Huisman and Peskett (1973a) demonstrated excellent curative as well as preventive activity. Ellal and Dinoor (1973) reported a complete lack of systemic activity but demonstrated very effective persistence and high vapour phase activity. Huisman (1972) first reported its activity against cereal powdery mildew in glasshouse and pilot field studies. Huisman and Peskett (1973b) reported persistant control of spring barley mildew at 450 to 550 g a.i./ha of ditalimfos with consequent yield increases using an e.c.formulation. This paper reports the results of field trial programmes carried out initially to evaluate ditalimfos alone for cereal powdery mildew control and later as formulated mixtures with other fungicides for broad spectrum cereal disease control.

METHODS AND MATERIALS

Field trials were carried out throughout Europe in 1973 with a 20% w/v e.c. formulation of ditalimfos except in France where a 25% w/v e.c. was used. A range of dose rates from 250-550 g a.i./ha were evaluated for the control of wheat and barley mildew. In 1974 both formulations were superceded by a new 20% w/v e.c. giving a more rapid knock-down of mildew. This was evaluated in replicated and grower trials in the U.K. and replicated trials elsewhere in Europe. A requirement for broad spectrum as well as specific fungicides was identified in France. Consequently mixtures of ditalimfos + maneb w.p., ditalimfos + carbendazim flowable and ditalimfos + carbendazim + maneb w.p. were formulated and evaluated in replicated trials in 1974/1975. Additionally a ditalimfos + oxycarboxin e.c. was evaluated in 1975.

Site and application details vary from country to country and are thus presented with each table of results. All trials unless otherwise indicated were of randomised block design with four or six replicates.

RESULTS

1. Control of cereal powdery mildew (Erysiphe graminis)

Spring barley - Dosage response trials carried out in 1973 on spring barley indicated that acceptable control with useful persistence and worthwhile yield response were achieved with dose rates of 450 and 550 g a.i./ha. (Table 1).

In 1974 41 grower trials were carried out throughout England, Scotland and Wales. Three dose rates of ditalimfos were compared with the grower's mildewicide (tridemorph, ethirimol, chloraniformethan, triforine or quinoxaline) and an unsprayed control. Overall mean results (Table 2) show that the 450gm rate was slightly inadequate but both 500gm and 550gm rates compared very favourably with standard mildewicides. Applications were made between growth stages 4 and 10 with optimum results obtained from sprays applied at g.s. 5-6.

Winter wheat - Ditalimfos 25% e.c. was evaluated in France at 250 g and 1 kg a.i./ha for the control of wheat mildew in 1973. Mildew control on the ear using 250 g a.i./ha ditalimfos was superior to tridemporph (as shown in Table 3) giving a 6% yield increase, whilst the 1 kg rate indicated that greater yield increases (up to 16%) could be achieved. Yield increase would appear to have resulted from the increased number of grains per ear following the spray at g.s. 5 and increased grain weight following the spray at g.s. 10.4 which protected the flag leaf and ear.

Further field trials in France during 1974 using the 20% e.c. confirmed these results. Ditalimfos at 500g a.i./ha (as shown in Table 4) gave excellent mildew control, particularly on the flag leaf and ear resulting in a yield increase of up to 12%, whilst the 1 kg rate gave a yield increase of 17%.

2. Control of Cereal Rusts (Puccinia spp.)

Laboratory experiments - The effect of ditalimfos on barley brown rust (P. hordei) and wheat black rust (P. graminis f.sp. tritici) was studied in France in 1972 using a 50% w.p. formulation. Young plants at the two leaf stage were sprayed to run-off at a range of dose rates (as shown in Table 5) and artificially inoculated when the spray had dried using cotton pads soaked in spore suspensions.

Table 1

Spring barley mildew control and yield response - U.K. replicated trials, 1973

Application details: sprayed with Van der Weij @ 333 l/ha and 2 kg/cm^2
Plot size: 15m x 2m x 4 replicates
Assessment: 'Guide for the assessment of Cereal Diseases 1971'
10 tillers per plot

Treatment	Rate ai/ha	Mean % mildew cover on 2nd leaf Zephyr	Proctor	Julia	Yield (t/ha) Zephyr	Proctor	Julia
ditalimfos	250g	4.03	4.03	9.58	4.24	3.65	3.64
ditalimfos	350g	3.80	4.60	4.00	4.20	3.41	3.69
ditalimfos	450g	2.08	4.43	5.01	4.42	3.64	3.85
ditalimfos	550g	2.15	2.85	1.89	4.41	3.97	3.79
tridemorph	562.5g	2.05	2.60	2.90	4.39	3.68	4.11
control	-	3.98	4.25	12.50	4.07	3.48	3.51
L.S.D.	5%	1.66	N.S.	4.56	N.S.	N.S.	0.30
g.s. at spraying		7-8	7	7			
days between spraying and assessment		31	32	28			

Table 2

Spring barley mildew control and yield response - U.K. grower trials, 1974

Application details: using tractor mounted or drawn field sprayer at 20-30g.p.a.
Assessment: using 0-6 scale based on MAFF barley mildew key (5B).
Carried out on 20 tillers per plot scoring leaf 2 or 3 as appropriate.

Treatment	Rate ai/ha	Mean mildew score 3-4 weeks (11 sites)	5-6 weeks (31 sites)	Mean yield (t/ha) (12 sites)
ditalimfos	450g	2.05	2.52	4.45
ditalimfos	500g	1.77	2.40	4.51
ditalimfos	550g	1.84	2.23	4.69
standards		1.93	2.29	4.46
control		3.55	3.60	4.15*

* unsprayed control plots harvested at only eight sites.
Plot size: one hectare

Table 3

Winter wheat mildew control and yield response - France, 1973

Application details: cv. Hardi sprayed 17.5.73 (g.s. 5) and 15.6.73 (g.s. 10.4) @ 590 l/ha and 2 kg/cm^2.
Plot size: 14m x 12m x 6 replicates
Assessment: ear mildew scored on a 1-10 linear scale on 50 ears per plot where 0 = no mildew and 10 = 100% mildew. Green flag leaf area scored on 25 leaves per plot.

Treatment	Rate ai/ha	% green flag leaf area	ear mildew mean score	Yield (t/ha)	1000 grain wt(g)	No.grains per ear
ditalimfos	250g	71.6	2.9	4.82	40.4	31.6
ditalimfos	1 kg	87.7	1.1	5.29	41.7	32.3
tridemorph	375g	79.4	4.0	4.87	41.2	30.9
control	-	53.7	7.4	4.56	39.7	30.7
L.S.D. 5%				0.23	1.0	N.S.
date assessed		3/7	10/7	7/8		
growth stage		11.1	11.2			

Table 4

Winter wheat mildew control and yield response - France, 1974

Application details: cv. Hardi sprayed 7.5.74 (g.s. 6) and 6.6.74 (g.s. 10.4) @ 500 l/ha and 3 kg/cm^2.
Plot size: 12m x 10m x 6 replicates
Assessment: % mildew on leaf and ear scored on 50 fertile tillers per plot using Canadian Plant Disease Survey pictorial key.

Treatment	Rate ai/ha	Mean % leaf surface mildewed leaf 2	leaf 1	Mean % ear mildew	Yield (t/ha)	1000 grains wt (g)	No.grains per ear
ditalimfos	250g	20.7	18.7	16.1	5.72	39.0	38.6
ditalimfos	500g	18.9	13.7	7.9	5.98	38.7	39.5
ditalimfos	1 kg	18.6	6.4	2.8	6.26	41.3	39.2
tridemorph	375g	18.3	24.3	18.0	5.66	38.1	38.8
control	-	27.3	37.3	68.8	5.35	35.6	38.3
L.S.D. 5%					0.25	2.0	N.S.
date assessed		28/5	18/6	28/6			
growth stage		9	10.5.3	11.1			

Table 5

Rust control in laboratory experiments

Treatment	Rate ai/l	Mean number lesions per plant *P. hordei*	*P. graminis*
ditalimfos	0.25g	2	3
ditalimfos	0.5 g	0	0
ditalimfos	0.75g	0	0
ditalimfos	1.0 g	0	0
maneb	2.0 g	-	0
control	-	25	12
Number of plants per treatment		>12	>30

Field experiments - The effect of ditalimfos 20% e.c. on wheat brown rust (*Puccinia recondita*) in the field is shown in Table 6. Both ditalimfos and tridemorph exerted a significant suppression of brown rust. (Using amended Chi^2 test)

Table 6

Winter wheat brown rust control and yield response - France, 1974

Application details: cv. Etoile de Choisy sprayed 29.5.74 (g.s. 10.5.3) @ 445 l/ha and 3 kg/cm^2.
Plot size: 12m x 10m x 6 replicates
Assessment: scored on 0-3 scale where 1 = 1-5 pustules, 2 = 6-12 pustules and 3 =>12 pustules per leaf.

Treatment	Rate ai/ha	Brown rust mean score	Yield t/ha
ditalimfos	500g	2.06	5.33
tridemorph	375g	1.96	4.98
control	-	2.46	5.00

assessed 13.6.74 at g.s. 11.1 on leaf 1 on 50 tillers per plot

3. Broad Spectrum Disease Control

Since disease complexes rather than specific diseases alone are commonly encountered particularly in winter wheat in France, a number of fungicide mixtures of ditalimfos with maneb and/or carbendazim and with oxycarboxin were formulated and evaluated.

Four separate field trial programmes were carried out in France to compare the following mixture formulations with appropriate competitive products and untreated controls.
(1) ditalimfos/maneb (Tradename NOLON*) w.p.
(2) ditalimfos/carbendazim/maneb (Tradename GREX TRIPLE*) w.p.
(3) ditalimfos/carbendazim (Tradename CEREFLOR+) flowable.
(4) ditalimfos/oxycarboxin e.c.

* Trade Mark of Pepro. + Trade Mark of Seppic.

Mean mildew control for each formulation and mean yield response from those sites where mildew was encountered are shown in Table 7. Control of yellow rust (Puccinia striiformis) and associated yield responses following applications of ditalimfos/oxycarboxin are shown in Table 8. Additionally yellow and brown rust control was recorded on hard wheat by applications of ditalimfos/carbendazim/maneb. Mixtures of ditalimfos/carbendazim ± maneb also gave good control of eyespot (Cercosporella herpotrichoides) and brown foot rot (Fusarium nivale) in winter wheat.

Table 7

Mildew control and yield response of wheat and barley treated with various broad spectrum fungicide formulations based on ditalimfos - France, 1974/5

Summary of trials results

Number of sites and assessments shown by figures in brackets

Treatment	Rate ai/ha	Spring barley Mean % mildew	Spring barley Mean yield (t/ha)	Winter wheat Mean % mildew	Winter wheat Mean yield (t/ha)
(1)		(3 sites)		(3 sites)	
ditalimfos	500g	5.5	4.54	3.7	6.26
+ maneb	2 kg				
tridemorph	562.5g	5.5	4.36	3.0	5.96
control	-	22.1	4.23	5.0	5.72
(2)		(3 sites)		(3 sites)	
ditalimfos	240g				
+ maneb	2 kg	9.0	4.94	4.1	6.19
+ carbendazim	240g				
benomyl	300g	9.0	4.60	4.4	6.20
+ maneb	1.92kg				
control	-	22.1	4.42	8.4	5.71
(3)				(5 sites)	
ditalimfos	350g				
+ carbendazim	250g			0.83*	5.72
carbendazim	300g				
+ maneb	2.4kg			1.42	5.65
control	-			2.08	5.05
(4)				(3 sites)	
ditalimfos	500g				
+ oxycarboxin	400g			10.7	3.66
control	-			22.9	3.18

* mildew control assessed on 0 - 4 scale in this programme (see text).

Programmes (1) and (2) S. barley cv's Rika, Julia and Mamie sprayed by motor sprayer @ 700 l/ha and 8 kg/cm^2 or knapsack @ 500 l/ha and 3 kg/cm^2 at g.s. 8 and/or 10.4, June 1974. Mildew assessed according to Canadian Plant Disease Survey Key 14-18 days after spraying on leaves 1,2,3 and 4. W. wheat cv's Hardi, Champlein and Joss Cambier sprayed by propane sprayer @ 500 l/ha and 3 kg/cm^2 at g.s. 10 June 1974. Mildew assessed according to Canadian Plant Disease Survey Key 18-21 days after spraying on leaves 1,2 and 3. Plot size 25m x 4m x 4 replicates.

Programme (3) W. wheat sprayed by knapsack at approx 500 l/ha and 3-4 kg/cm^2 at g.s. 6 and 10.3 May and June 1975. Mildew assessed on 0-4 scale where 0 = no mildew and 4 = heavy infection.

Programme (4) W. wheat sprayed 10.4 or 10.5 June 1975. Mildew assessed according to Canadian Plant Disease Survey Key 9-25 days after spraying.

Table 8

Yellow rust control and yield response of wheat and barley treated with broad spectrum fungicide formulations based on ditalimfos - France,1975

Summary of trials results: wheat sprayed @ g.s. 7-10, barley @ g.s. 10.5.4.
Assessed: 8 - 16 days after spraying.

Treatment	Rate ai/ha	Winter wheat mean % rust per leaf	Winter wheat mean yield (t/ha)		Spring barley mean % rust per leaf	Spring barley Yield t/ha
		(8 sites)	(6sites)	(2sites*)	(1 site)	
ditalimfos + oxycarboxin	500g 400g	2.12	3.78	4.39	6.6	2.76
control	-	18.02	3.56	3.77	63.9	2.30

one application all sites except * = 2 applications

DISCUSSION

The efficacy of a 20% e.c. formulation of ditalimfos at 500 - 550 g a.i./ha against spring barley powdery mildew has been demonstrated both in replicated and grower trials in the U.K. Similar results on spring barley have been obtained in other European countries, particularly France and Germany. The persistence of ditalimfos is of particular value in winter barley where adequate mildew control over a long period may be required for a worthwhile yield response. Trials in France, have shown ditalimfos to be an effective fungicide for the control of mildew on both leaf and ear in winter wheat. A contributory activity against rust diseases enhances the value of ditalimfos as a component in broad spectrum cereal fungicides. Such mixtures containing ditalimfos and formulated as wettable powders, an emulsifiable concentrate and a flowable have been shown to give effective mildew control during two years of trials on cereals in France. The mixtures ditalimfos + carbendazim + maneb and ditalimfos + oxycarboxin have also given good control of brown and yellow rust on wheat and barley.

Ditalimfos, alone and in the four mixture formulations reported here, has shown a wide margin of crop safety on all wheat and barley varieties tested in the U.K. and France.

Commercial usage under the registered trademark LAPTRAN* fungicide in France and FARMIL+ in the U.K. has shown ditalimfos to be safe to crops and operators and consistently effective for the control of cereal powdery mildew.

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* Trade mark of The Dow Chemical Company Limited.
\+ Trade mark of Farm Protection Limited.

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A BROAD SPECTRUM PROTECTANT FOR USE AGAINST MILDEW AND SEPTORIA IN WHEAT

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Summary A formulation containing halacrinate[1] and captafol (trade name TILT)[2] was widely tested in small and large plot field trials in the UK and continental Europe during 1974 and 1975. Sprays at crop growth stage 9 to 10.5 were found to be active against wheat mildew and *Septoria* spp. on the ear and to a limited extent on the upper leaves. Yield increases of up to 20% were recorded depending on location and severity of disease, but there was not a consistent correlation of disease control and yield increase.

Résumé Une formulation contenant de l'halacrinate et du captafol (désignation commerciale TILT)[2] a été testée en 1974 et 1975 sur une grande échelle dans des essais en champs sur petites et grandes parcelles au Royaume Uni et en Europe continentale. On a pu ainsi montrer que des traitements au stade de développement 9 - 10.5 sont actifs contre l'oïdium et les Septorioses de l'épi et jusqu'à un certain point des feuilles supérieures. On a pu enregistrer des augmentations de rendement jusqu'à 20 % selon les lieux et l'intensité de l'attaque, mais on n'a pas trouvé de correlation consistante entre l'augmentation de rendement et le contrôle de la maladie.

INTRODUCTION

In recent years the control of foliar and ear diseases of wheat has received much attention in the UK and continental Europe. For example, the results of the MAFF cereal foliar disease surveys as reported by King, J.E. (1973) showed that between 1971 and 1973 *Septoria* spp., (*S. tritici* and *S. nodorum*) resulted in the greatest loss of green leaf area when assessed at crop growth stage 11.1, followed by mildew and yellow rust, although attack by the latter was erratic. Substantial yield losses of around 200,000 to 250,000 tons of grain were estimated to have occurred due to each disease. In continental Europe these three diseases also cause considerable yield losses, and so our objective was to develop a broad spectrum fungicide adapted to this market.

TILT is a mixture of CGA 30599, an oxyquinoline derivative, and of captafol. The active ingredients are both non-systemic fungicides. CGA 30599 alone offers effective control of *Erysiphe graminis* and has marked side effects on other pathogens. In greenhouse tests it showed marked inhibitory activity on powdery mildew. CGA 30599 stops the development of lesions provided that it is applied not more than two days after spore germination.

Captafol was included in the mixture to improve control of the *Septoria* diseases against which the compound is known to be active.

1) halacrinate is the ISO proposed common name for 8-acryloyloxy-7-bromo-5-chloroquinoline. Code number CGA 30599.
2) TILT is a proposed trade mark of CIBA-GEIGY SA Basle.

METHOD AND MATERIALS

The UK small plot trials were conducted in the Hereford area and in East Anglia, including the areas of heavy clay soils to the East and West of Cambridge, the organic fen land to the North of Cambridge, and the reclaimed marsh land on the Essex coast. The trial design was a randomized block with five replications. Plot size was $30m^2$ from which $20m^2$ were harvested by small plot combine. All grain yields are corrected to 16% moisture content. Assessments of percentage leaf diseased were made using the appropriate MAFF key, 21 days after spraying which was at crop growth stage 9 to 10 in all cases. This varied in time between areas and from year to year ranging from 1st to 9th June in 1974 and 3rd to 11th June in 1975. The treatments were applied using a hand held precision plot sprayer through Spraying Systems "Teejet" nozzles at 2.1 kg/cm^2 and at a volume rate of 200 l/ha.

Small plot trials conducted in continental Europe were as above except that only four treatment replications were made per trial in Germany. The fungicides were applied at crop growth stage 10 to 10.5. Disease assessments were made using locally adopted scoring systems, i.e. a 1 - 9 scale in Germany and a 0 - 5 scale in Switzerland. For comparison, these have been transformed to percentage disease on the plant parts specified.

Large plot trials were conducted in the UK and Switzerland in 1975. The mixture of CGA 30599 + captafol was applied by farmers using their own standard farm sprayers or by aircraft in the case of 5 sites in the UK and compared with unsprayed areas. The tractor mounted sprayers applied 200 to 600 l/ha and the aircraft-mounted machines, 20 to 50 l/ha. Plot size in these trials was at least 1 ha in the UK with no treatment replication and at least 0.13 ha in Switzerland with 2 to 4 treatment replications. At least 0.4 ha was harvested from the treated and untreated areas per trial using the farm combine harvester. Disease assessments on leaf 2 at treatment were made in the English trials and assessment of disease was as in the table, 4 to 5 weeks after treatment in the Swiss trials.

Cereal growth stages are expressed on the Feekes-Large scale (Large, E.C. 1954). The standard treatment selected from those locally available, was the most widely used product recommended for mixed Septoria/mildew situations. In the UK this was a tank mix of benomyl 50% WP and maneb 80% WP in 1974 and a formulated mix of carbendazim plus maneb, 10 + 64% WP in 1975. No standard treatment was used in the Swiss trials as there were no commercial recommendations in that country. In Germany, thiophanate-methyl 70% WP was the standard treatment used.

All dose rates are given in kg ai/ha.

RESULTS

1. Mildew sites : small plot replicated trials in the UK

Nine small plot trials were conducted in 1974 and 1975 in the UK against wheat mildew. In 1974 there was little disease development at three of the five sites during the trial period, but an appreciable attack occurred on the other two. Some increase was recorded at all sites in 1975 but eventual levels remained relatively low. The disease control and yield data are given in table 1.

Mildew control by CGA 30599 + captafol and the standard treatment was similar at all sites and both gave statistically significant reductions ($P = 0.05$) in disease levels relative to untreated at site 061 74. No other statistically significant differences were recorded. In trials with low levels of disease, little or no control with either treatment was recorded.

Table 1 : Wheat mildew (leaf 2) and grain yields 1974 and 1975. Mean results of 5 replicates

Trial No.	Location	% mildew on leaf 2 at treatment	% mildew 21 days after treatment				Grain yield as % untreated			
			Untreated	Standard* treatment	CGA 30599 + captafol 0.28 + 1.79	SE of means	Untreated t/ha	Standard* treatment	CGA 30599 + captafol 0.5 + 1.0	SE of means
					1974					
061	Cambs	1.6	12.4	7.9	6.7	0.912	3.03	105	117	0.145
063	"	4.3	7.5	5.7	4.8	0.753	4.37	105	107	0.125
062	"	2.7	2.8	1.8	2.5	0.407	5.42	102	98	0.100
064	Huntingdon	2.0	1.9	0.7	2.2	0.434	4.26	109	112	0.181
068	"	3.2	3.8	2.1	3.5	1.04	4.37	105	108	0.133
Mean		2.8	5.7	3.6	3.9		4.29	105	108	
					1975					
031	Hereford	1.1	4.8	3.3*	2.2	0.505	4.46	92	102	0.087
035	Brandon	0.75	2.4	1.8	1.5	0.253	5.49	108	109	0.008
036	Ely	2.05	10.2	6.4	6.7	1.12	4.41	105	109	0.197
038	Hereford	0.65	4.7	2.2	2.2	0.416	5.43	99	101	0.209
Mean		1.14	5.5	3.4	3.2			101	105	

* standard in 1974 trials was benomyl + maneb at 0.28 + 1.79 and carbendazim + maneb at 0.28 + 1.79 kg/ha in 1975

Table 2 : Septoria trials UK 1974/75. Disease levels (leaf 2) and grain yields as % untreated. Mean of 5 replicates

			% Septoria at 21 days				Grain Yield as % untreated			
Trial No.	Location	% Septoria on leaf 2 at treatment	Untreated	Standard* treatment	CGA 30599 + captafol 0.5 + 1.0	SE of means	Untreated t/ha	Standard* treatment	CGA 30599 + captafol 0.5 + 1.0	SE of means
					1974					
065	Northants	2.6	0.5	0.10	0.30	3.364	6.46	106	104	0.130
067	Hereford	4.3	1.5	1.5	1.30	0.823	5.58	107	106	0.239
069	Hereford	1.9	2.2	0.9	1.00	0.443	2.90	104	104	0.090
070	Hereford	2.0	3.9	2.9	2.80	0.588	3.28	106	108	0.111
Mean		2.8	2.03	1.35	1.35		4.56	106	106	
					1975					
031	Hereford	1.2	7.4	6.60	8.53	0.385	4.46	92	102	0.087
032	Hereford	1.5	9.1	3.75	5.01	1.365	8.25	97	99	0.369
033	Essex coast	2.5	9.3	8.49	9.71	1.677	7.51	98	101	0.118
034	Essex coast	1.1	4.6	4.57	3.84	1.207	7.35	108	112	0.216
037	Cambridge	0	8.2	7.17	9.93	1.438	2.72	101	105	0.135
038	Hereford	4.6	11.1	9.59	9.91	0.968	5.43	99	101	0.209
039	Essex coast	0.4	2.0	1.47	1.27	0.386	6.32	105	110	0.260
Mean		1.61	7.39	5.95	6.89			100	104	

* standard in 1974 trials was benomyl + maneb at 0.28 + 1.79 and carbendazim + maneb at 0.28 + 1.79 kg/ha in 1975

Table 3 : Small plot trials 1974 Switzerland (CH) and Germany (D)

		Disease level on ears (%)			Yield			
						% of Untreated		
Trial No.	Days after application	Untreated	Standard* treatment	CGA 30599 + captafol 0.5 + 1.0	Untreated t/ha	Standard* treatment	CGA 30599 + captafol 0.5 + 1.0	SE of means
		Septoria spp.						
CH 040	33	80	—	18	3.8	–	118	0.058
D 755	34	17	2	2	4.8	107	111	0.129
D 650	41	18	10	3	5.0	106	108	0.136
D 135	40	15	12	6	7.6	106	104	0.076
		Powdery mildew						
CH 121	32	56	—	17	3.6	–	107	0.101
CH 125	32	82	—	30	3.3	–	103	0.080
D 134	43	35	15	15	7.2	110	110	0.139
D 138	24	15	3	5	6.4	110	110	0.070
		Septoria spp. (S) + powdery mildew (P)						
CH 458	28	S 60/P 40	—	S 8/P 4	2.8	–	106	0.038
CH 459	37	S 90/P 60	—	S 25/P 10	4.1	–	118	0.051
CH 460	35	S 90/P 100	—	S 30/P 20	4.2	–	108	0.076
CH 041	40	S 50/P 25	—	S 40/P 2.5	2.0	–	118	0.044

* standard : thiophanate-methyl at 0.35 kg/ha.

S = *Septoria* spp.

P = Powdery mildew

Table 4 : Farmer applications of CGA 30599 + captafol in comparison with untreated 1975

Trial No.	Location	Cultivar	Major Pathogen	% infection on leaf 2 at treatment	Crop growth stage at treatment	Grain Yield kg/ha over untreated	Grain Yield % of untreated
135 Air	GB Stowmarket	Bouquet	*Septoria* spp.	1.1	10.1	+ 399	110
129	GB Norwich	Atou	*Septoria* spp.	0.8	9	+ 550	113
102	GB Burford	Bouquet	*Septoria* spp.	3.3	10	+ 300	109
145 Air	GB Halesworth	Flinor	*Septoria* spp.	0.5	10.1	+ 350	106
142 Air	GB Chichester	Champlein	*Septoria* spp.	1.5	9	+ 375	110
141 Air	GB Chichester	M. Huntsman	*Pucc. recondita*	5.0	9	+ 375	109
148 Air	GB Feltwell	M. Fundin	*Septoria* spp.	1.7	10.5	+ 200	103
136	GB Cambridge	Flinor	*Septoria* spp.	5.2	9	+ 225	104
139	GB Cambridge	M. Freeman	*Septoria* spp.	0.3	10	+ 300	106
107	GB Pulborough	M. Huntsman	*Septoria* spp.	3.3	9	+ 76	122

Trial No.	Location	Cultivar	Disease assessment after treatment: Major Pathogen	Plant part assessed	% infection untreated	% infection treated	Crop growth stage at treatment	Grain Yield kg/ha over untreated	Grain Yield % of untreated
FR 075	CH Fribourg	Relin	mildew	ear	32	9	10.2	+ 420	110
FR 076	CH Fribourg	Probus	*Septoria* spp.	ear	36	3	10.3	+ 257	106
FR 077	CH Fribourg	Probus	*Septoria* spp.	ear	12	1	10.2	+ 300	108
FR 078	CH Fribourg	Lita	*Septoria* spp.	leaf 1	28	8	10.1	+ 963	121
FR 079	CH Fribourg	Lita	mildew	ear	22	0.3	10.2	+ 784	115
FR 080	CH Fribourg	Probus	*Septoria* spp.	ear	36	3	10.2	+ 426	112
FR 013	CH Fribourg	Lita	*Septoria* spp.	ear	82	27	10.1	+ 600	113
AG 520	CH Aargau	Kolibri	*Septoria* spp.	ear	45	16	10.2	+ 424	109
AG 521	CH Aargau	Zenith	*Septoria* spp.	ear	74	23	10.2	+ 527	111
TG 001	CH Thurgau	Kolibri	*Septoria* spp.	ear	60	8	10.2	+ 155	103
ZH 001	CH Zurich	Kolibri	*Septoria* spp.	ear	77	16	10.2	+ 324	109
ZH 002	CH Zurich	Kolibri	*Septoria* spp.	ear	43	20	10.2	+ 305	106

The yield data show that in 1974 up to 17% yield increase was obtained following treatment with CGA 30599 + captafol; this was where high levels of disease had been recorded. The standard gave a 5% yield increase at the site where the greatest response was obtained with CGA 30599 + captafol. The mean yield for the five trials was 108% for the standard treatment and 108% for CGA 30599 + captafol. The 1975 yield data showed generally lower yield increases than in 1974. CGA 30599 + captafol treatment gave yields which ranged from 101 to 109% of the untreated and the standard treatment gave yields from 92 to 108% of the untreated. Again there were no statistically significant differences at the 5% level.

2. Septoria sites : small plot replicated trials in the UK

In 1974 and 1975 a total of eleven trials were completed in the UK on crops suffering from attack by Septoria spp. at crop growth stage 9. Trial details and results are given in table 2. In both seasons, neither the benzimidazole standard treatment nor CGA 30599 + captafol had any appreciable effect on disease levels. The pathogens were relatively inactive during the 21 day period (June) and apart from one site (038 75) disease levels had not reached 10% on leaf 2 at the timed assessment.

The yield data given in table 2 show that in spite of the negligible disease control recorded, yield increases over the untreated frequently occurred. In 1974 both CGA 30599 + captafol and the standard treatment increased grain yields by an average of 6%, individual trial results varying from 104 to 108% of untreated. In 1975 the yield results were more variable being 92 to 108% of untreated for the standard treatment and 99 to 112 of untreated for CGA 30599 + captafol. The mean increase for the 7 trials was 4% for CGA 30599 + captafol, and the standard treatment gave no increase. Yield increase was not correlated with the disease control when assessed at 21 days after treatment, as shown in the table. In the two trials (034 and 039) where the biggest increase (10 and 12%) occurred, disease levels were 1.27% and 9.71% on leaf 2 respectively. Both these trials were on the Essex coast where rain fell during July when the ears were ripening. It is probable that glume blotch (S. nodorum) developed during this period and if so, this could explain the good results.

Apart from the above example no other correlations between yield benefit and other site factors were apparent from the UK small plot trials.

3. Small plot replicated trials in Germany and Switzerland

The results of some of the small plot trials in Switzerland and Germany in 1974 are given in table 3. Disease levels in both trials series were high having 15 to 80% infection by mildew or Septoria spp. on the ears. Treatment with CGA 30599 + captafol at crop growth stage 10.1 to 10.3 resulted in reduction in both diseases of at least 50% in all but one trial (CH 041) where there was a 10% reduction in Septoria spp. but a 90% reduction in powdery mildew. The thiophanate methyl standard treatment also gave appreciable reduction in the levels of both mildew and Septoria spp. but was inferior to CGA 30599 + captafol for control of Septoria spp. in two of the three trials in which it was used.

The yield results from these trials show that there was a considerable benefit in treatment with either the standard fungicide or CGA 30599 + captafol. Yield increases ranged from 3 to 18% with a mean of 10% for CGA 30599 + captafol and 8% for the standard treatment. In two trials, D 134 and D 138, the increases were statistically significant at the 5% level.

4. Farmer applications in England and Switzerland

Septoria spp. were the major pathogens in both English and Swiss trials. In the former, infection levels were again low, as in the small plot trials. Nevertheless, yield increases relative to untreated of 3 to 22% were obtained with a mean of 315 kg/ha grain for the ten trials. There were no differences between aerial and ground applied trials. In the Swiss trials, higher levels of disease occurred (12 to 82% infection on untreated ears). At least 50% reduction of both Septoria spp. and mildew was achieved by CGA 30599 + captafol and yield increases of 3 to 21% were obtained. The mean increase in grain yield was 457 kg/ha.

DISCUSSION

The results presented show that CGA 30599 + captafol, sprayed onto wheat at between flag leaf emergence and flowering (GS 9 - 10.5) can give an appreciable yield benefit in moderate to severe disease situations as experienced in Switzerland and Germany. In the latter trials yield increase appeared to be correlated with the presence of high levels of disease late in the growing season. In these cases appreciable reductions in the level of both mildew and Septoria spp. were obtained. Where disease incidence was less, as in many of the Uk trials, smaller yield increases were generally recorded. However, in these trials a satisfactory correlation between disease control and yield increase has not been established and it is possible that other pahtogens were involved in causing yield loss, or the activity of major pathogens was not recorded at a critical time when they were most affecting yield. Even in the Swiss and German trials though there was little correlation between the level of disease control and subsequent yield increase.

The results of farmer applications showed particularly encouraging yield responses in both England and Switzerland and we conclude that CGA 30599 + captafol is an effective and potentially economic treatment for wheat crops infected with mildew or Septoria spp. at the later stages of crop growth.

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THE EFFECT OF FLUOTRIMAZOLE ON POWDERY MILDEW OF CEREALS

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Summary Fluotrimazole is a new active ingredient which effectively controls powdery mildew in spring barley, winter wheat and winter and spring oats, and is compatible with a wide range of cereal cultivars. The compound has shown some activity against brown rust in spring barley and yellow rust in spring barley and winter wheat.

Fluotrimazole appears to have both curative and protectant properties against powdery mildew.

In spring barley single sprays of fluotrimazole at 94g a.i./ha and 188g a.i./ha were applied over a wide range of crop growth stages. Good mildew control was achieved at both rates though the 188g a.i./ha rate produced the most consistent yield response. There is no apparent correlation between growth stage at application and optimum yield response. A two spray programme of 94g a.i./ha gave excellent mildew control with yield increases between 13 and 27% over the untreated.

A similar level of mildew control was achieved on winter wheat and on winter and spring oats with consequent yield responses.

Résumé Fluotrimazole est une nouvelle matière active qui maitrise efficacement l'oïdium des orges de printemps, des blés d'hiver et des avoines de printemps et d'hiver. Il est sélectif de nombreuses variétés de céréales. Le composé a fait preuve d'une certaine efficacité sur la rouille brune de l'orge de printemps et sur la rouille jaune de l'orge de printemps et du blé d'hiver.

Fluotrimazole possède à la fois des propriétés curatives et préventives sur l'oïdium.

Pour l'orge de printemps, une pulvérisation unique de fluotrimazole à la dose de 94g et 188g de m.a./ha a été appliquée à divers stades de la culture. Une bonne efficacité sur oïdium a été obtenue aux deux doses bien que la dose de 188g m.a./ha ait entraîné les plus fortes incidences sur les rendements. Il n'y a pas de corrélation apparente entre les stades de traitement et les actions les plus favorables sur la récolte. Un programme comprenant deux traitements à la dose de 94g m.a./ha a donné un excellent résultat sur oïdium avec des augmentations de rendement comprises entre 13 et 27% par rapport aux témoins non traités.

On a obtenu un même niveau d'efficacité pour des blés d'hiver et des avoines d'hiver et de printemps avec des actions correspondantes sur les rendements.

INTRODUCTION

Bayer 6660 is a new fungicide formulation containing fluotrimazole (coded BUE 0620). Its effectiveness against powdery mildews has been reported by Grewe and Büchel (1973), Anon (1974), Hickey (1974), Braun (1974), Shipton (1975) and Büchel et al (1975). Grewe and Büchel (1973) specifically referred to its effectiveness against powdery mildew (Erysiphe graminis) in cereals, and Anon (1974) and Shipton (1975) reported control of powdery mildew on spring barley and winter wheat respectively, with consequent yield increase. Fluotrimazole* is 1-(3-trifluoromethyltrityl)-1,2,4-triazole, with an acute oral LD_{50} of > 5000 mg/kg, and currently being tested on brassicae and top fruits.

This preliminary research (1975 yield results not yet available) report describes the results of field trials carried out in the United Kingdom between 1973 and 1975 to investigate the effect of fluotrimazole against powdery mildew on cereals. The major development work has been on spring barley where the importance of powdery mildew is now well established (Large and Doling, 1962; James, 1969); though work has also been carried out on wheat and oats.

METHOD AND MATERIALS

In the work reported in this paper various rates of a 12.5% w/v e.c. formulation of fluotrimazole (coded Bayer 6660) were applied in a water volume of 300-400 l/ha to crops of spring barley, winter wheat, winter and spring oats. In the sixteen small plot trials a randomised block design with four replicates was used. Plots measured 3m x 15m-20m of which 2 metre bands were sprayed, leaving 1m guards. Other non-replicated small plot trials were conducted to establish crop tolerance on a wide range of cereal cultivars. Treatments were applied with either a Drake and Fletcher or a modified Van der Weij knapsack sprayer fitted with flat fan nozzles. The four grower trials were applied using farmers' sprayers on large duplicated plots (not less than 0.2 ha).

Disease assessments were made at application and at G.S. 10.5-11.1 using a modified key based on the percentage infected leaf area on the top three leaves or ear in the case of wheat, as devised by the Plant Pathology Laboratory, Harpenden. The two parameters calculated were (a) Percent mildew control and (b) Relative yield. Percent mildew control refers to the percent reduction in mildew compared with the untreated. Relative yield is the percent increase or decrease in yield compared with the untreated. Growth stages are expressed using the Feekes-Large scale (Large, 1954). Yields were taken using a modified Claas Compact 25 combine and 2 kg sub-samples of grain were taken from each plot and quality analysed according to grain size and weight.

The standard chemicals employed were the commercial formulations of tridemorph (75% a.i. w/v emulsifiable concentrate) on spring barley and winter and spring oats, with tridemorph alone and as a mixture with Polyram (80% zineb-ethylene thiuramdisulphide adduct) on wheat.

RESULTS

Spring Barley

Disease information was obtained from ten small plot trials and four grower trials, (Tables 1 and 3) with yield data being obtained from eight small plot trials (Table 2). Adverse weather conditions in 1974 led to treatments being applied over a wide range of crop growth stages, in some instances after Growth Stage 9.

* BSI common name

Table 1

Spring Barley Small Plot Trials, 1973-75 - % Mildew Control

(Mean of 3 leaves - Assessed at Growth Stage 10.5-11.1)

Site		Suffolk	Suffolk	Suffolk	Hereford	Yorks	Kent	Kent	Yorks	Kent	Suffolk
Drilling Date		29/3/73	4/4/74	1/5/74	15/4/74	4/4/74	15/3/74	16/3/74	23/3/75	21/4/75	26/4/75
Cultivar		Sultan	Sultan	Tern	Hassan	Proctor	Julia	Proctor	Zephyr	Proctor	Berac
Treatments	**Application Growth Stage**										
Single Sprays											
Fluotrimazole											
94g a.i./ha	4-5		39*								
	7-8			71	84**	93**					
	9-10.1		31*				60	69**			
188g a.i./ha	4-5	49	70						67	97**	86
	7-8	75		77	90**	97**			98**	98**	
	9-10.1		38*				50	67**			91
Tridemorph											
525g a.i./ha	4-5	53	65						68	66	89
	7-8	55		83	66	66					
	9-10.1		72				51	45			90
Two Sprays											
Fluotrimazole											
94g a.i./ha	4-5+7-8			95**	99**				97**	99**	
	5+9-10.1		67				74**	80**			99
% Mildew Cover	4-5	0.7	5.0	2.2			3.0	0.8	1.3	0.2	0
On Untreated	7-8	1.5		12.7	2.8	5.4			3.6	1.6	0
	9-10.1		10.6				18.7	15.4			
	10.5-11.1	17.7(a)	8.9(b)	16.4	50.9	19.8	40.8	40.5	12.6	11.8(c)	4.7

** Significantly better than tridemorph at P=0.05
* Significantly lower than tridemorph at P=0.05

(a) = Mean of leaf 1 and 2
(b) = Mean of leaf 2 and 3
(c) = Mean of leaf 1, 2, 3 and 4

Table 2

Spring Barley Small Plot Trials, 1973-75 - Relative Yields

Site Drilling Date Cultivar		Suffolk 29/3/73 Sultan	Suffolk 1/5/74 Tern	Hereford 15/4/74 Hassan	Yorks 4/4/74 Proctor	Kent 15/3/74 Julia	Kent 16/3/74 Proctor	Yorks 23/3/75 Zephyr	Kent 21/4/75 Proctor
Treatments	Application Growth Stage								
Single Sprays									
Fluotrimazole									
94g a.i./ha	4-5								
	7-8		121*	111*	103				
	9-10.1					99	107		
188g a.i./ha	4-5	122*						115*	111
	7-8	119*	123*	113*	106			100	118
	9-10.1					107*	109*		
Tridemorph									
525g a.i./ha	4-5	118*						113*	111
	7-8	122*	114*	113*	105				
	9-10.1					104	103		
Two Sprays									
Fluotrimazole									
94g a.i./ha	4-5+7-8		127*	116*				116*	115
	5+9-10.1					114*	113*		
Yield on Untreated (Kg/ha)		3323	2404	5258	4148	5000	4121	4613	3148

* = Significantly higher than the untreated controls at P=0.05

Table 3

Spring Barley Grower Trials 1975 - % Mildew Control

(Mean of 3 leaves - Assessed at Growth Stage 10.5-11.1)

Site Drilling Date Cultivar	Norfolk 25/4/75 Julia	Hants. 15/3/75 Golden Promise	Angus 20/3/75 Golden Promise	Kent 23/4/75 Julia
Application Details				
Application Date	20/6	12/6	24/6	5/6
Growth Stage	7	9	9	5
Treatments				
Fluotrimazole 188g a.i./ha	92	97	96	91
Tridemorph 525g a.i./ha	89	95	84	85
% Mildew Cover On Untreated	2.4	31.9	38.0	8.1

Winter Wheat - Disease information and yield data was obtained from three small plot trials.

Table 4

Winter Wheat Small Plot Trials, 1974-75 - % Ear Mildew Control And Relative Yield

Site Drilling Date Cultivar		Suffolk 5/10/73 Cappelle Desprez	Suffolk 25/10/73 Cama	Suffolk 15/11/74 Champlein
Treatments	**Application Growth Stage**			
Single Sprays				
Fluotrimazole				
188g a.i./ha	6-7		20 (101)	49 (107)**
	10.1-10.5	59* (98)	75 (101)	95* (107)**
Tridemorph				
525g a.i./ha	7		12 (105)	
	10.5	30 (99)	52 (95)	
Two Sprays				
94g a.i./ha	6-7+10.5			80* (107)**
Tridemorph 525g a.i./ha + Polyram 1792g a.i./ha	6-7+10.5			57 (103)
% Mildew Cover On Untreated		19.5	5.0	10.2
Yield on Untreated (Kg/ha)		6370	5760	5705

** Significantly higher than untreated controls at P=0.05
* Significantly better than tridemorph at P=0.05
Figures in brackets are relative yields

Oats - Disease and yield data were obtained from two winter oat trials with disease information only from a single spring oat trial.

Table 5

Oat Small Plot Trials 1975 - % Mildew Control And Relative Yield

Site Drilling Date Cultivar		Yorks 29/10/74 Maris Quest	Hereford 15/10/74 Maris Quest	Hereford 30/4/74 Condor
Treatments	Application Growth Stage			
Single Sprays				
Fluotrimazole				
188g a.i./ha	5			86*
	7-8	99* (107)**	39 (106)**	89*
Tridemorph				
525g a.i./ha	5			35
	7-8	35 (98)	34 (103)	
Two Sprays				
Fluotrimazole				
94g a.i./ha	5-6+7-8	99* (108)**	72* (109)**	97*
% Mildew Cover On Untreated		22.9	29.0	39.0
Yield On Untreated (Kg/ha)		3818	5103	

** Significantly higher than untreated controls at P=0.05
* Significantly better than tridemorph at P=0.05
Figures in brackets are relative yields

Grain Analysis

At the time of writing this paper, data are only available for the 1974 small plot trials. Results from these indicate that all rates of fluotrimazole increased quality in terms of grain size compared with the control, although differences were small and in most cases not significant.

Crop Tolerance

During the development programme fluotrimazole was applied at rates of up to 376g a.i./ha to the following range of cereal cultivars. No phytotoxicity was recorded.

Winter Wheat

Atou	Bouquet	Cama	Cappelle Desprez
Chalk	Champlein	Flinor	Joss Cambier
Maris Bilbo	Maris Freeman	Maris Fundin	Maris Huntsman
Maris Nimrod	Maris Ranger	Maris Templar	Maris Widgeon
Mega	Tommy	Val	West Desprez

Spring Wheat

Maris Dove	Maris Butler	Maris Ensign	Kleiber	Kolibri
Cardinal	Rothwell Sprite	Sappo	Sirius	Sicco

Winter Barley

Astrix	Malta	Maris Otter	Maris Trojan	Senta	Hoppel

Spring Barley

Abacus	Berac	Gerkra	Golden Promise	Julia
Maris Mink	Mazurka	Deba Abed	Lofa Abed	Hassan
Midas	Proctor	Sultan	Universe	Vada
Wing	Zephyr	Armelle	Tern	

Spring Oats

Astor	Condor	Mostyn	Selma
Leanda	Nelson	Maris Tabard	Maris Oberon

Winter Oats

Maris Osprey	Maris Quest	Peniarth

DISCUSSION

In the spring barley small plot and grower trials (Tables 1 and 3) fluotrimazole at 188g a.i./ha gave satisfactory to excellent control (49-98%) of powdery mildew with the exception of one application made at Growth Stage 10.1. In small plot trials (Table 1) the single sprays of 94g a.i./ha performed similarly. Excellent mildew control (95-99%) was obtained with two sprays of 94g a.i./ha when applied at Growth Stage 4-5 and 7-8; in all cases this was significantly better than the single tridemorph spray.

Uneven crop growth invalidated the yield results from one trial in 1974 and not all the 1975 results are available at the time of writing (Table 2). The two spray programme of fluotrimazole at 94g a.i./ha produced a significant yield response of between 13% and 27%.

Of the single sprays the most consistent was fluotrimazole at 188g a.i./ha which gave responses relative to the untreated of between zero and 23%. The responses in one trial were small and not significant.

There is no apparent correlation between growth stage timing and yield response since in the Yorkshire/Zephyr trial in 1975 a yield increase was obtained from application at Growth Stage 5, but there was no response to treatment at Growth Stage 7-8; whereas in the Kent/Proctor trial in the same year, a greater yield response was obtained from the later application at Growth Stage 7-8. Significant yield responses of between 7 and 9% were obtained with sprays applied at Growth Stage 10.1 in the two Kent trials in 1974. Timing of single applications of fluotrimazole between Growth Stages 4 and 10.1 does not, therefore, appear to be correlated with the yield response obtained.

Observations on brown rust (*Puccinia hordei*) and yellow rust (*Puccinia striiformis*) infection in spring barley and yellow rust infection in winter wheat indicate that fluotrimazole possesses some activity against both pathogens.

Results from three winter wheat small plot trials (Table 4) showed that fluotrimazole at 188g a.i./ha applied between Growth Stages 10.1 and 10.5 gave good to excellent control (59-95%) of mildew on the ear, although there were no consistent yield responses. Applications at Growth Stage 6-7 gave poor to moderate control (20-49%) of ear mildew.

Two small plot trials on winter oats (Table 5) showed that a single fluotrimazole spray at 188g a.i./ha applied at Growth Stage 7-8 gave superior mildew control when compared with a single tridemorph spray applied at the same timing.

A two spray programme of fluotrimazole at 94g a.i./ha applied at Growth Stage 5-6 and 7-8 gave excellent mildew control.

All fluotrimazole treatments resulted in significantly greater yield responses than the single tridemorph spray.

In one small plot trial on spring oats, a single spray of fluotrimazole at 188g a.i./ha applied at Growth Stage 5 or 7 and a two spray programme at 94g a.i./ha applied at Growth Stage 5-6 and 7-8 gave excellent mildew control (86, 89 and 97% respectively), significantly better than the single tridemorph spray applied at Growth Stage 5. No yield data are available on this trial at the time of writing.

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THE USE OF CARBENDAZIM AND TRIDEMORPH IN THE UNITED KINGDOM FOR THE CONTROL OF RHYNCHOSPORIUM SECALIS IN BARLEY

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Summary Trials have been carried out over the last four years to evaluate a mixture of carbendazim and tridemorph for the control of leaf blotch (*Rhynchosporium secalis*) of barley. Carbendazim is the more effective component of the mixture, but tridemorph has some effect against the disease. The mixture is generally more effective than carbendazim alone and the addition of tridemorph to carbendazim enables the rate of carbendazim to be reduced. The most effective control is achieved when application is made at the first signs of infection and a second application may be required if weather conditions continue to favour disease development.

Treatment with the mixture at 0.52 kg tridemorph + 0.125 kg carbendazim per hectare has resulted in good yield responses and an associated improvement in grain quality. Control of other diseases has been recorded with the mixture including mildew (*Erysiphe graminis*) and eyespot (*Cercosporella herpotrichoides*).

Résumé On a exécutés des essais pendant les quatre dernières années pour évaluer un mélange de carbendazim et de tridemorph pour le contrôle de l'anthracnose (*Rhynchosporium secalis*) dans l'orge. Le carbendazim est le composant le plus effectif du mélange, mais le tridemorph a un certain effet contre la maladie. En général le mélange est plus effectif que le carbendazim seul, et l'addition du tridemorph au carbendazim fait qu'on puisse réduire la proportion du carbendazim. Le contrôle le plus efficace s'achève en faisant l'application au premier indice d'infection, et il se peut qu'une seconde application puisse être nécessaire si les conditions météorologiques continuent à favoriser le développement de la maladie.

Le traitement avec le mélange à 0.52 kg de tridemorph et 0.125 kg de carbendazim par hectare a produit de bonnes rendement-résponses et au même temps une amélioration associée de la qualité de grains.

On a remarqué le contrôle d'autres maladies en employant ce mélange, y compris l'oidium (*Erysiphe graminis*) et le piéton-verse (*Cercosporella herpotrichoides*).

INTRODUCTION

It has been previously reported that tridemorph has a side effect against leaf blotch (*Rhynchosporium secalis*) and that an improved effect was obtained with a mixture of tridemorph and carbendazim (Frost and Brown, 1973). Trials were planned to evaluate this mixture using various rates of carbendazim. Tridemorph was applied at

0.52 kg/ha, the rate recommended for effective control of mildew (*Erysiphe graminis*). Since carbendazim is also active against eyespot (*Cercosporella herpotrichoides*) (Hampel and Löcher, 1973) the effect of treatment against this disease was also examined.

METHOD AND MATERIALS

All trials were of randomised block design, four times replicated and plot size was 12.5 x 4 m. Treatments were applied with a Van der Weij knapsack sprayer fitted with cone nozzles, using 250 l /ha water at a pressure of 2-3 kg cm^2.

Foliar disease levels were assessed using the appropriate key from the Guide for the Assessment of Cereal Diseases devised by the Plant Pathology Laboratories, Harpenden, and were expressed as % leaf area infected. Eyespot was assessed by scoring the incidence and severity of lesions caused by eyespot on random samples of 25 tillers per plot (Scott et al, 1974). This eyespot score combines incidence and severity of attack.

Yield was assessed with a Hege 125 or a Class Compact 25 combine harvester, harvesting an area of 14 m^2 and 23 m^2 respectively per plot.

Cereal growth stages are expressed by use of the Feekes-Large Scale (Large, 1954).

The formulation of carbendazim used was a 50% wettable powder and that of tridemorph a 75% emulsifiable concentrate. Tridemorph was applied at 0.52 kg/ha in all trials.

Site and Application Details:

Trial No.	Cultivar	Sowing date	Site	G.S. at application	Disease level at application (%) leaf blotch	mildew
A	Deba Abed	24.3.72	Glos.	G.S. 9	5-10	10-15
B	Maris Otter	21.10.72	Suffolk	G.S. 9	trace	5-10
C	Maris Mink	28.3.73	Wilts.	G.S. 4-5	trace	nil
D	Deba Abed	7.3.73	Glos.	G.S. 8-9	7% (leaf 3)	nil
E	Universe	16.3.74	Avon	G.S. 5 G.S. 9	trace trace	nil nil
F	Maris Otter	20.10.74	Glos.	G.S. 5-6 G.S. 8-9	0-10 (leaf 4) 0-10 (leaf 3)	trace nil
G	Golden Promise	1.3.73	Wilts.	G.S. 8-9	2 (leaf 4)	2 (leaf 4)

RESULTS

Table 1

The effect of carbendazim and tridemorph, alone and in mixture, on levels of leaf blotch and mildew (Trial A)

Treatment	Rate of use (kg/ha)	% leaf blotch (leaf 2)	% mildew (whole plant)	Yield (kg/ha)	Yield (relative)	% grain <2.2 mm
Untreated	-	51	10.0	3970	100.0	40.0
Carbendazim	0.30	22	7.5	4406	111.0	28.2
Tridemorph	0.52	46	0.5	4296	107.4	27.8
Tridemorph + carbendazim	0.52 + 0.30	17	0.5	4767	119.3	15.4
L.S.D. (P = 0.05)				44		

Table 2

The effect of carbendazim and tridemorph, alone and in mixture, on levels of leaf blotch and mildew (Trial B)

Treatment	Rate of use (kg/ha)	% leaf blotch (leaf 2)	% mildew (whole plant)	Yield (kg/ha)	Yield (relative)
Untreated	-	5.3	13.5	5244	100
Carbendazim	0.25	1.5	11.1	5496	105
Tridemorph	0.52	3.0	2.0	5633	107
Tridemorph + carbendazim	0.52 + 0.125	0.9	1.0	5931	113
L.S.D. (P = 0.05)				N.S.	

Table 3

The effect of tridemorph, alone and in mixture with carbendazim, on levels of leaf blotch in the absence of mildew (Trial C)

Treatment & rate of use (kg/ha)	% leaf blotch at G.S. 11.1		
	leaf 1	leaf 2	leaf 3
Untreated	7.6	16.3	28.5
Carbendazim 0.5	2.7	9.9	11.9
Carbendazim 0.25	4.3	7.7	21.0
Tridemorph 0.52	8.9	12.2	19.7
Tridemorph + carbendazim 0.25	0.7	2.4	4.6

Table 4

The effect of varying rates of carbendazim in mixture with tridemorph on levels of leaf blotch in the absence of mildew (Trial D)

Treatment & rate of use (kg/ha)	% leaf blotch (leaf 1)	Yield (kg/ha)	Yield (relative)	% grain $<$ 2.2 mm
Untreated	42.0	3556	100	25.3
Tridemorph	18.1	3805	107	11.7
Tridemorph 0.52 + carbendazim 0.125	5.7	4306	121.1	10.4
Tridemorph 0.52 + carbendazim 0.25	3.5	4260	119.8	10.4
L.S.D. (P = 0.05)		393		

Table 5

The effect of single and double applications of carbendazim + tridemorph on leaf blotch in the absence of mildew (Trial E)

Treatment & rate of use (kg/ha)	% leaf blotch (whole plant)	Yield (kg/ha)	Yield (relative)	% grain < 2.2 mm
Untreated	27.0	5402	100	8.2
Tridemorph 0.52 + carbendazim 0.25	15.0	5821	107.8	7.0
Tridemorph 0.52 + carbendazim 0.125	14.0	6130	113.5	6.5
Tridemorph 0.52 + carbendazim 0.125 (x 2)	3.5	6350	117.6	5.7
L.S.D. (P = 0.05)		477		
(P = 0.01)		644		

Table 6

The effect of varying rates of carbendazim, alone and in mixture with tridemorph, on levels of leaf blotch and eyespot (Trial F)

Treatment & rate of use (kg/ha)	% leaf blotch (leaf 3)	Eyespot score	Yield (kg/ha)	Yield (relative)
Untreated	42.5	56.3	4579	100
Carbendazim 0.15	2.1	7.3	4827	105
Carbendazim 0.25	1.8	4.7	4965	108
Tridemorph 0.52	32.5	37.3	4910	100
Tridemorph 0.52 + carbendazim 0.125	1.2	8.7	5103	107
Tridemorph 0.52 + carbendazim 0.15	1.8	7.3	5075	112
Tridemorph 0.52 + carbendazim 0.25	0.8	5.0	4993	111
Tridemorph 0.52 + carbendazim 0.15 (x 2)	0.3	5.3	5048	109
Tridemorph 0.52 + carbendazim 0.15 / carbendazim 0.15	1.0	3.3	4910	110
L.S.D. (P = 0.05)			237	
(0.01)			320	
(0.001)			423	

Treatment applied for leaf blotch control also reduced levels of eyespot in Trial F, and may have contributed to the yield responses recorded.

Table 7

The effect of tridemorph alone and in mixture with carbendazim on levels of leaf blotch in a high mildew situation (Trial G)

Treatment & rate of use (kg/ha)	% mildew		% leaf blotch	
	leaf 1	leaf 2	leaf 1	leaf 2
Untreated	10.4	23.7	12.5	13.5
Tridemorph 0.52	1.7	1.5	14.6	21.7
Carbendazim 0.25	7.0	18.2	3.4	7.6
Tridemorph + carbendazim 0.125	2.2	4.8	4.4	5.7

DISCUSSION

An initial trial in 1972 was carried out with carbendazim at 0.3 kg/ha alone, and in mixture with tridemorph at 0.52 kg/ha. Two similar trials were carried out in 1973, but with the rate of carbendazim reduced to 0.25 kg/ha alone and at 0.125 kg/ha when tested in mixture with tridemorph. The results in tables 1-3 show that the mixture is more effective than carbendazim alone in controlling leaf blotch and by controlling both leaf blotch and mildew the mixture gave a substantial yield response (Trials A and B).

In 1973, 1974 and 1975, different rates of carbendazim were evaluated, both alone and in mixture with tridemorph. These results indicated that in general, the mixture containing both carbendazim at 0.125 kg/ha + tridemorph at 0.52 kg/ha was as effective as higher rates alone or in mixture with tridemorph, both in terms of disease control and yield (tables 4, 5 and 6).

Where early infections occurred, a second application was made, either at reinfection or at G.S. 8-9 when all leaves had emerged. The results in tables 5 and 6 show that the second application was only beneficial in Trial E where reinfection had occurred. In 1975 (table 5) high temperature and low rainfall conditions in the early summer prevented continued development of the disease and therefore no benefit resulted from a second application.

Generally, the treatments have been applied in the early stages of disease development in order to prevent the loss of green tissue which could not be restored by treatment.

In the absence of mildew, tridemorph showed a marked effect against leaf blotch (tables 3, 4 and 5). However, where high levels of mildew were controlled by the use of tridemorph, an increase in the levels of leaf blotch was recorded (table 7). Little and Doodson (1972) have previously reported that where mildew fungicides had been used there was a tendency for leaf blotch levels to increase, probably due to the removal of competition from mildew. Where a mixture of tridemorph + carbendazim was used, both diseases were well controlled.

In one trial in 1975, eyespot was recorded and was well controlled by the mixture, the treatments being applied at G.S. 5-6.

Yield Response

The results show that where moderate or severe leaf blotch develops, the mixture of tridemorph at 0.52 kg/ha + carbendazim 0.125 kg/ha gives a good yield response. This mixture will also control mildew and when present a corresponding improvement in yield can be expected. The yield responses are associated with an improvement in grain quality (tables 1, 4, 5 and 6).

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THE EFFECT OF SOME FUNGICIDES ON POWDERY MILDEW OF BARLEY AND OATS IN GREECE

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Summary Nine field trials have been carried out between 1972 and 1975 in Greece using 13 chemicals as seed dressings or as single foliar sprays on three barley and one oat cultivars of differing susceptibility to *Erysiphe graminis*, in order to determine their response to mildew control. In the three years, with different levels of mildew infection, grain yield increases in the cultivar Elasson were up to 38%, in Piroline up to 50%, in Zephyr up to 13% and in Kassandra (oat) up to 25%. The best control of mildew in all the cultivars examined, was obtained with ethirimol seed dressing, due to the early disease infection in Greece. A single foliar spray with imazalil at growth stage 5-6 reduced infection by about the same amount, while the other compounds tested were less effective. Control of diseases other than mildew contributed to the increase in yield with some chemicals. Results suggest that in practice, where mildew and other diseases are present in cereals, the application of fungicides as seed dressings or as single sprays may be expected to give a worthwhile yield response in some cultivars.

Résumé On a effectué neuf essais au champ entre 1972 et 1975 en Grèce, employant treize produits chimiques en facon de grains ou en pulverisation foliaire unique sur trois variétés cultivées d'orge et sur une variété d'avoine, qui différaient en susceptibilité a l'*Erysiphe graminis*, pour constater leur réponse au contrôle de l'oidium. Pendant les trois années, avec de divers niveaux d'infection de l'oidium, les accroissements de récolte chez la variété Elasson se sont éleves à 38 pour cent, Piroline à 500 pour cent, Zephyr à 13 pour cent et Kassandra (avoine) à 25 pour cent. On a réalisé le meilleur contrôle de l'oidium avec toutes les variétés qu'on examinait avec l'ethirimol en façon des grains, à cause de l'infection précoce de la maladie en Grèce. Uné pulverisation foliaire unique avec l'imazalil, au degré de maturité cinq à six, a reduit l'infection par à peu près le même degré, tandis que les autres composés qu'on a éprouvés étaient moins effectifs. Le contrôle des maladies autres que l'oidium a contribué à l'augmentation du rendement avec certains produits chimiques. Les résultats font paraitre que, en pratique, la ou l'oidium se trouve dans les céréales on peut attendre que les applications de fongicides en façons de grains, ou pulverisations uniques puissent effectuer une rendement-réponse satisfaisant avec quelques variétés cultivées.

INTRODUCTION

Powdery mildew of cereals (Erysiphe graminis) is not believed to be a very important problem in Greece. However, more recently the changes in cultural practice and the intensification of cereal growing coupled with widespread use of some new cultivars has led to mildew becoming an increasing problem. In addition there have been particularly favourable weather conditions for mildew during the past three years.

Three systemic fungicides, benomyl, ethirimol and tridemorph, tested in Greece have been shown to be effective against powdery mildew of barley and to increase grain yield up to 19% (Skorda 1972).

Trials were carried out at the Plant Breeding Institute during the years 1972-1975 to determine the crop response resulting from the control of mildew by seed treatment or by spray application under the condition of typically early disease development as found in Greece.

METHOD AND MATERIALS

The trials were of randomized block design with four or six replicates using plots of 2 x 10 m. Nearly all the crops were drilled in early to late November, which is near normal. With the later drillings, mildew appeared relatively later and was much slower to build up.

One winter (3 year's trials) and two spring (2 and 1 year's trials) barley cultivars and one oat cultivar (3 year's trials) differing in mildew susceptibility were used in the trials.

The seed was treated with an organo-mercurial or similar fungicide, and the experimental fungicides, ethirimol or benomyl, were applied over this, using a rotating drum to apply the dressing. Wettable powder formulations of ethirimol and benomyl were used. The cereal sowing rate was about 150 kg/ha.

Foliar applications of the various fungicides, formulated as emulsifiable concentrates or "cols", were applied using an Azo propane knapsack sprayer with cone nozzles 34 cm apart producing a fine spray and delivering a water volume of about 600 l/ha.

The fungicide formulations used were as follows: benomyl 50% wp, ethirimol 50% wp, drazoxolon 40% "col", tridemorph 75% ec, oxythioquinox 25% wp, imazalil 20% wp, thiophanate methyl 50% wp, carbendazim 50% wp, dinocap 25% wp, dikar 80% wp, pyrazophos 30% ec, triforine 20% ec, and 26019 RP 50% wp [1-isopropyl-carbamoyl-3-(3,5-dichlorophenyl) hydantoin].

To ensure uniform exposure to disease, inoculum (barley or oat infected leaves) were spread on the plots in early January.

Mildew was assessed on the scale 0-9 (Anon 1971) between Feekes growth stage 6 and 10.5 (Large 1954) on all leaves at each assessment. Grain was harvested from a central strip 1.25 m wide from each plot, using a Hege mini plot harvester. Yields were expressed in kg/ha corrected to 15.5% moisture content.

RESULTS

Control of mildew. There was a marked contrast between the pattern of mildew attack in the three years of trials. The 1972/1973 season was typified by light or moderate disease attacks late in winter, infection being low in the cultivars

Table 1

Effect of fungicides on powdery mildew of barley and oat

Treatment	Rate kg a.i./ha	G.S. at application	Infection of *E. graminis* (scale 0-9) 1973 A*	1973 C	1973 D	1974 B	1974 C	1974 D	1975 B	1975 C	1975 D
Control			2.3b**	4.3bc	1.5a	6.0d	7.5c	5.8c	1.8a	8.8c	1.0
Benomyl	0.300)	Seed	2.0a	4.7c	1.2a	5.3bcd	6.8c	5.2bc			
Ethirimol	1.125)	dressing	1.0a	1.2a	1.0a	4.7ab	2.3a	4.8b	1.3a	6.3a	1.0
Ethirimol	0.750	5-6	1.3a	4.0bc	1.3a						
Tridemorph	0.375	4-5	1.0a	3.5b	1.0a						
Tridemorph	0.562	4-5	1.0a	4.0bc	1.0a						
Oxythioquinox	0.150	5-6	1.2a	4.2bc	1.2a	5.2abc	6.8c	5.7c			
Imazalil	0.300	5-7	1.7a	3.5b	1.2a	4.5a	4.0b	2.3a			
Thiophanate methyl	0.450	5-6	2.0a	5.0c	1.2a	5.2abc	7.3c	5.3bc			
Carbendazim	0.250	5-6	1.8a	4.5bc	1.0a	5.2abc	6.8c	5.3bc	1.5a	7.8bc	1.0
Dinocap	0.500	4-5				5.3bcd	7.0c	5.5c	2.0a	8.7bc	1.0
Dikar	1.600	4-5				5.3bcd	7.0c	5.5c	2.0a	8.8c	1.0
Pyrazophos	0.108	4-5				5.8cd	7.3c	5.7c	1.7a	8.3bc	1.0
Triforine	0.180	4-5				5.5cd	7.2c	5.3bc	1.5a	7.5bc	1.0
26019 RP	0.400	5-6							1.7a	8.8c	1.0
Drazoxolon	1.000	4-5							1.5a	8.5bc	1.0

* A: Piroline (barley) C: Elasson (barley)
B: Zephyr (barley) D: Kassandra (oat)

** Figures suffixed by the same letter are not significantly different at the 5.0% level

Piroline and Kassandra, and moderate in the susceptible Elasson, due to generally unfavourable spring weather. The reverse situation occurred in 1973/1974, with moderate winter mildew and heavy early spring attacks.

This season was favourable for both crop and disease, and mildew infection was high in all three tested cultivars. The 1974/1975 season was unusually dry during winter and spring resulting in both crop growth and mildew development being restricted early in spring. Drought accentuated the effect of soil variations in this experimental area, and the resulting data are more variable than those of the previous season. Mildew development was very late in spring, near to crop ripening. Infection was heavy in Elasson, light in Zephyr and there was no attack in Kassandra.

When mildew appeared early in winter, control with ethirimol and benomyl as seed dressings was over 95% until the end of winter. In later assessments control with both fungicides was less, although ethirimol seed dressing still gave better control than the other chemicals, except imazalil on Kassandra in 1974, due to late infection (Table 1).

This control of mildew in early winter, with both chemical seed dressings, gave an improvement in crop colour, growth and vigour compared to the untreated plots which remained yellow and stunted. This effect persisted well into spring and in some years also through until harvest.

A foliar spray with most products gave satisfactory results when applied soon after the start of the epidemic, which normally occurs before stem extension, (Last 1957).

The effect of a foliar spray with most chemicals tested was mainly curative, as pustules appeared to dry up within 5 days of application. Later, however, the disease developed rapidly and uniformly (Table 2). Therefore control measures are necessary over a relative long period.

Table 2

Mildew infection of Elasson barley

at different times after fungicide spray application

Treatment	Date of assessment (0-9 scale)		
	4 April	5 May	15 May
Control	4.3	4.8	6.7
Ethirimol	1.2	3.5	6.0
Tridemorph	3.5	4.7	7.0
Imazalil	3.5	4.7	7.0

In some trials single spray applications early in spring with the tested chemicals gave responses similar to those by ethirimol seed treatment, but in later assessments mildew control was lower. In these later assessments imazalil and tridemorph gave better mildew control than any other chemical tested in the same year, except ethirimol.

There appeared to be variation in the response of cultivars to chemical mildew control. In Zephyr chemicals gave less mildew control than in Elasson and Kassandra in 1974.

Grain yield. Severe attack of mildew caused substantial reduction in yield and quality. With the more usual early attacks, the loss was up to 38% and with the relatively late attacks losses were up to 20% (Table 3).

Table 3

Effect of fungicides on grain yield as a percentage of control

Treatment	Rate kg a.i./ha	G.S. at application	Grain yield as a percentage of control 1973 A*	1973 C	1973 D	1974 B	1974 C	1974 D	1975 B	1975 C	1975 D
Control (Yield of control kg/ha)			100 (2328)	100 (3058)	100 (2823)	100 (3607)	100 (1942)	100 (2250)	100 (3971)	100 (3065)	100 (2600)
Benomyl	0.300)	Seed	124	109	111	106	115	97			
Ethirimol	1.125)	dressing	150	112	125	98	124	94	102	103	98
Ethirimol	0.750	5-6	137	106	104						
Tridemorph	0.375	4-5	133	121	118						
Tridemorph	0.562	4-5	132	115	101						
Oxythioquinox	0.150	5-6	150	110	120	103	111	91			
Imazalil	0.300	5-7	150	109	101	92	138	95			
Thiophanate methyl	0.450	5-6	150	105	109	105	138	98			
Carbendazim	0.250	5-6	132	102	116	96	131	95	107	104	102
Dinocap	0.500	4-5				95	121	99	111	99	104
Dikar	1.600	4-5				92	128	98	110	106	99
Pyrazophos	0.108	4-5				95	133	94	101	105	99
Triforine	0.180	4-5				100	110	101	112	106	99
26019 RP	0.400	5-6							108	108	97
Drazoxolon	1.000	4-5							113	98	101
L S D	0.5%		± 20	± 11	± 10	N.S.	± 15	N.S.	± 7	± 8	N.S.

* A: Piroline (barley)
B: Zephyr (barley)
C: Elasson (barley)
D: Kassandra (oat)

Yield responses were normally greater with ethirimol seed dressing than with foliar sprays. In two years of tests on Kassandra and one on Zephyr there were no differences in yield after treatment, probably due to low infection at the end of the season. In 1973, with very light powdery mildew infection, Kassandra and Piroline have still given yield increases up to 25% and 50% respectively, which cannot be explained in terms of mildew control alone, and control of diseases other than mildew (e.g. *Septoria*, *Helminthosporium*, etc.) may have contributed to the increase in yield. Some chemicals gave less control than others but no significant yield differences were observed. In general mildew control was not closely correlated to yield increase.

Seed germination. The influence of benomyl and ethirimol on seed germination has been investigated in both laboratory and field experiments. Even at rates higher than those recommended, germination was unaffected. Also the germination of subsequent crops was not influenced with all chemicals tested.

DISCUSSION

In some years fungicide treatment of cereals in Greece as seed dressing or foliar spray against *E. graminis* gives yield increases and improved grain quality. However, there are many factors affecting recommendations for control in each situation. These include the behaviour of each cultivar, the time of application and the weather conditions.

Mildew infection varies between seasons and varieties. The effectiveness of fungicides and the yield response also varies. This may be due to cultivar susceptibility, response to chemical, differences associated with crop structure, differing weather conditions, the presence of other diseases and early or late disease incidence.

The seed dressing when used at the higher rate (1.125 kg a.i./ha) tended to give better mildew control than the other treatments tested, but this was not consistently reflected in yield increase, particularly when late mildew infection occurred as in 1975. Under these conditions the most effective sprays gave the best yield increase. However, in 1973 and 1974 when infection started in early winter, which is usual in Greece, the higher rate seed dressing and the best sprays gave similar yield results. Brooks (1972) showed that early epidemics had the most severe effect on yield. The prevention of mildew in cereals leads to a better development of the grains, resulting in an increased yield and improved grain quality. Although the disease could not be fully controlled, treatment with effective fungicides resulted in yield increases. Evans and Hawkins (1971) found that the highest yield responses were achieved with sprays applied prior to, or during, the early stages of epidemic development, while Hall (1971) and Skorda (1972) have already shown that yields of winter barley can be substantially increased by the use of ethirimol seed dressing.

In Greece there are two main factors to consider: early application as seed dressing, or foliar spray treatment with a wider spectrum of disease control. Where mildew appears with other diseases, the best yield results have been obtained with wide spectrum foliar chemicals, which in addition to controlling cereal powdery mildew, have a marked effect against other cereal pathogens such as *Septoria spp.*, *Rhynchosporium secalis* and *Cercosporella herpotrichoides* (Fehrmann and Schrodter 1973, Frost and Brown 1973). With wide spectrum sprays it is not possible to relate yield effect to individual disease levels and consequently the extent of mildew infection and yield loss was rather conflicting. However, Skorda (1972) and Evans et al. (1973) using one chemical against mildew only found very close correlation between the percentage loss in yield and the amount of mildew recorded on the crop at G.S. 10.5.

The use of effective chemicals against foliar diseases of cereals could change cultural techniques, intensifying cereal cropping and increasing yields, if the cost of chemicals is not too high.

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