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CONTROL OF CEREAL INSECT PESTS BY CHLORPYRIFOS

J. R. Dowsett & P. J. Jeffery

Murphy Chemical Ltd., Wheathampstead, Herts.

A. J. Gilchrist

Dow Chemical Co. Ltd., Heathrow House, Bath Road, Hounslow, Middx.

Summary A number of replicated field trials on cereals have been carried out in England, Scotland and Wales since 1973 using chlorpyrifos for the control of insect pests. Chlorpyrifos at 0.72 kg a.i./ha has effectively protected winter wheat from attack at emergence by frit fly (Oscinella frit) and in late winter by wheat bulb fly (Leptohylemyia coarctata). Correct timing of applications is critical for optimum control of both pests. Excellent control of leatherjackets (Tipula spp.) in all winter and spring cereals at 0.72 - 0.75 kg a.i./ha has been demonstrated.

The grain aphid (Sitobion avenae) and wheat blossom midges (Sitodiplosis mosellana and Contarinia tritici) have been well controlled at 0.34 kg a.i./ha. Where high input systems are used on cereals, strategies for timely pest control are essential. By controlling most of the important cereal insect pests chlorpyrifos can help to maximise yields.

Résume Un nombre d'essais identiques de céréales ont été effectués depuis 1973 en Angleterre, l'Ecosse et le Pays de Galles en utilisant chlorpyrifos pour la lutte préventive contre les ravageurs céréales. Chlorpyrifos à 0.72 kg m.a./ha a protégé efficacement le blé d'hiver émergant contre les attaques des oscinies (Oscinella frit) et en fin d'hiver de la mouche grise du blé (Leptohylemyia coarctata). La synchronisation exacte est essentielle afin d'assurer les meilleurs effets contre les deux ravaguers céréales. On a obtenu des resultats excellents contre les larves des tipules (Tipula esp.) dans tous les céreales d'hiver et de printemps aux doses entre 0.72 - 0.75 kg m.a./ha.

Les pucerons des céreales (Sitobion avenae) et les moucherons (Sitodiplosis mosellana et Contarinia tritici) ont été contrôlés aux doses de 0.34 kg m.a./ha. Dans l'utilisation des méthodes intensives de culture des céréales, un programme rigoureux et opportun de contrôle des ravageurs est essential. Le chlorpyrifos donne des beaux effets contre la plupart des ravaguers céréales et ainsi aide à porter les récoltes au maximum.

INTRODUCTION

Chlorpyrifos is a broad spectrum organophosphorus insecticide introduced in 1965 by the Dow Chemical Company. The compound is used for the control of a wide variety of insect pests on many agricultural and horticultural crops. Control of

some cereal insect pests by chlorpyrifos namely wireworms (Agriotes spp.) wheat bulb fly (Leptohylemyia coarctata) and leatherjackets (Tipula spp.) has been reported at this conference previously (Sparrow, et al (1973); Rayner, (1975); and Oakley, (1977). This paper reviews the results obtained on these and other cereal insect pests over the period 1975-1979.

METHODS AND MATERIALS

Chlorpyrifos was applied in the majority of trials as an emulsifiable concentrate containing 48% a.i. (Dursban 48E). A 5% granular and a 50% wettable powder formulation were also included in some of the leatherjacket trials. Where other insecticides were included in trials as a comparison with chlorpyrifos, they were used as the commercially available formulation.

Several experiments were done using a range of experimental designs and application and assessment techniques and the relevant details are included with the results. In all tables results marked *, ** or *** differ significantly from untreated controls at P = 0.05, 0.01 and 0.001 respectively.

RESULTS AND DISCUSSION

Leatherjackets Rayner (1975) reported that in trials on cereals over three years a chlorpyrifos spray at 0.72 - 0.75 kg a.i./ha gave good control of leatherjackets. Air temperature was found to govern rate of kill and all treatments were most effective when applied at temperatures above 6°C. Chlorpyrifos in common with most other treatments included in the trials was less effective on organic soils.

A further series of trials was carried out on winter and spring cereals by Rayner in 1976 and the two years' trials have been summarised by Rayner (pers. comm.)

Table 1

Control of leatherjackets in cereals - mean of results 1975-1976

Treatment	Dose rate kg a.i./ha	Number of trials giving stated percentage control > 70%	60-69%	<60%	Mean % control
Chlorpyrifos e.c.	0.72-0.75	10	3	2	75
Chlorpyrifos gran.	0.75	6	1	0	77
Triazophos e.c.	0.8	11	1	4	70
Isazophos e.c.	1.0	7	2	4	64
Isazophos gran.	1.0	6	4	0	76
Fenitrothion spray	1.0	8	1	7	54
Fenitrothion bait	1.0	7	1	0	79
Gamma HCH spray	0.28	2	2	3	60
Gamma HCH bait	0.27	8	1	1	77
DDT e.c./coll.	1.0	4	0	3	< 71
Aldrin e.c.	0.83	4	1	1	< 70

Rayner has excluded results from this table where high natural winter mortality occurred, where unreliably low numbers were recovered at sampling or where poor control was due to low temperatures at application or to the high organic content of the soil.

As leatherjackets are mainly a problem in cereals drilled after grass, additional work reported by Rayner (1978) on leatherjacket control in grassland is also relevant to cereals and further emphasises the value of chlorpyrifos for control of this pest (Table 2).

Table 2

Control of leatherjackets in grassland - 1975-1976 trials

Site	Pre-treatment population (000/ha)	Post-treatment population in control plot (000/ha)	% control of leatherjackets by chlorpyrifos spray (0.72 kg a.i./ha)
Bute	1150	880	100
Northumbria	3320	3700	71
Gwynedd	2310	1750	89
Staffordshire	1670	1100	66
Powys	4000	2390	98
Oxon	3740	4080	58
Wiltshire	1850	1320	64
Devon	1200	670	84

Wheat bulb fly In commercial use over four seasons, chlorpyrifos at 0.72 kg a.i./ha has generally given good control of wheat bulb fly.

Timing of application is, however, important. Optimum results were obtained by application at egg hatch. (Tables 3 and 4)

Table 3

Effect of early application of chlorpyrifos spray on control of wheat bulb fly

(Mean of two trials at Wisbech and Hull, drilled 25-31 October, 1977)

	Untreated	Chlorpyrifos (0.72 kg a.i./ha) Applied mid-Dec	Applied mid-Jan+	Applied mid-Feb+
% plants attacked (30th March)	60.2	64.3	54.9*	46.0*
Live larvae per 100 plants (30th March)	40.9	38.2	34.3	29.1*
Ear counts (% of untreated)	100	102	103	107*
Yield (% of untreated)	100	100	105*	105*

+Egg hatch in 1978 was from late Jan - mid Feb. (England)

Table 4

Effect of late application of chlorpyrifos spray on control of wheat bulb fly. (McKinlay, 1978)

	Trial 1 Jan+ application		Trial 2 March+ application	
	Untreated	chlorpyrifos 0.72 kg a.i./ha	Untreated	chlorpyrifos 0.72 kg a.i./ha
% damaged shoots (angular transformation)	44.3	16.1*	45.5	31.9*
% shoots with live larvae (angular transformation)	226.6	57.7*	212.3	105.6*
Healthy shoots per 5.4 m row length	55.5	168.0*	60.0	99.0*
Grain yield (t/ha at 85% d.m.)	3.0	4.4*	3.7	4.4*

+ Egg hatch in 1978 was early-mid Feb. (Scotland)
Crop was drilled 14 November 1977

Too early application of chlorpyrifos can mean that the full concentration of chemical is not available when the larvae hatch and migration occurs. Applications after egg hatch can be less effective since once the larva has entered the shoot it is unlikely to be affected by the chemical.

Trials by ADAS showed that on mineral soils chlorpyrifos is one of the most effective spray treatments for wheat bulb fly control and it was generally superior to seed treatments. The results of a trial carried out in 1977-1978 are shown in Table 5.

Table 5

Comparison of wheat bulb fly treatments (Oakley, pers. comm.)

Treatment	Attacked plants/ m^2	Healthy plants/ m^2	Attacked shoots/ m^2	Healthy shoots/ m^2	Live larvae/ m^2	Yield t/ ha at 85% d.m.
chlorfenvinphos LST seed treatment at 875 ppm	235**	45	352**	419	286**	5.33
carbophenothion MOM seed treatment at 1065 ppm	273	11	541	281	459	4.83
chlorpyrifos spray at 0.72 kg a.i./ha applied January 4	177***	106**	234***	523	202***	6.36**
omethoate spray at 0.644 kg a.i./ha applied March 9	253*	24	357**	370	251**	6.26**
untreated control	305	31	505	419	420	4.51

Crop drilled 20 October.

The trial results have also been confirmed in grower use (Table 6).

Table 6

Control of wheat bulb fly by chlorpyrifos[+] in grower trials 1975-76

Site	% plants attacked pre-spraying	Plot for comparison	% of comparison plots Ear counts	Yield
Old Goole	37	untreated	116	111
Lincoln	43	untreated	120	119
Goole	68	Dimethoate[++]	123	108
Peterborough	20	Dimethoate[++]	130	109

[+] chlorpyrifos at 0.72 kg a.i./ha applied at egg hatch.
[++] dimethoate at 0.68 kg a.i./ha applied at dead heart.

Frit fly (Oscinella frit) Winter wheat is most prone to damage by frit fly when drilled after grass. Trials have shown that chlorpyrifos at 0.72 kg a.i./ha will considerably reduce this damage and increase grain yield but is best applied as a preventative treatment. (Table 7)

Table 7

Effect of timing of chlorpyrifos application on frit fly control in winter wheat after grass

1. Trial by Murphy Chemical (at Dursley in 1979)

Treatment		% reduction in damage	% control of larvae	Yield as % of untreated plots
chlorpyrifos (0.72 kg a.i./ha)				
"	" pre-paraquat	100***	100***	110.6*
"	" pre-drilling	98***	100***	109.1*
"	" pre-emergence	99***	100***	109.1*
"	" post-emergence 2 leaf stage	0	2	102.2
DDT 7.1 l/ha	post-emergence 2 leaf stage	0	0	103.8

2. Two trials by ADAS (French, pers. comm.)

	% damaged plants		% plants with live larvae		Number of tillers	
	1	2	1	2	1	2
Untreated	22.4	12.4	17.6	10.3	226	349
chlorpyrifos (0.72 kg a.i./ha) at drilling	12.9**	6.3**	7.9	3.9	351**	360
" " at 100% emergence	9.4***	2.7***	4.4	1.2	306	423
" " at dead heart	not assessed		not assessed		253	321
fonofos (1.4 kg a.i./ha) at drilling	15.0*	7.6*	8.9	4.5	278	434

These results show that up to crop emergence chlorpyrifos gave excellent protection against frit fly attack. However, applications after the damage had been seen and the larvae had already migrated to the new host plants were much less effective.

Frit fly can also damage late-sown spring oats. The mode of attack is,however, different from attack on winter wheat after grass. The eggs are laid directly on the oat plant, and optimum control by chemical sprays is therefore obtained after the crop has fully emerged. Trials at Aberystwyth over three seasons showed that chlorpyrifos applied at the one leaf stage of the crop at a rate of 0.72 kg a.i./ha usually gave a reduction in shoot damage. (Table 8)

Table 8

Percentage oat shoots damaged by frit fly (Guile, pers. comm.)

Treatment	Rate (kg a.i./ha)	1975 Drilled end April	1976 Drilled 10 May	1978 Site 1 drilled 8 April	1978 Site 2 drilled 11 May
chlorpyrifos	0.72	11.7	18.9	11.1	45.2
triazophos	0.4	7.3	34.1	16.5	49.4
isazophos	0.5	-	35.3	-	-
iodofenphos	0.5	7.3	17.8	-	45.7
fenitrothion	1.0	17.3	38.0	17.8	48.3
pirimiphos methyl	1.0	8.9	28.6	-	-
DDT	1.0	14.2	-	-	-
untreated	-	13.7	44.6	17.3	58.4

Grain yields were taken on the 1976 trial and plots treated with chlorpyrifos produced 2.49 tonnes d.m./ha compared with 0.92 tonnes/ha from the untreated plots.

Wheat blossom midges (Sitodiplosis mosellana and Contarinia tritici) Trials by ADAS (Yorkshire and Lancashire Region) in 1977 - 1978 showed that chlorpyrifos at 0.34 - 0.48 kg a.i./ha applied at inflorescence emergence significantly reduced attack in winter wheat by wheat blossom midges.

In 1977 when the level of midge attack was high, chlorpyrifos produced a significant yield increase (Oakley, pers. comm.)

Table 9

Control of wheat blossom midges by chlorpyrifos 1977

	Untreated	chlorpyrifos (0.34 kg a.i./ha)
S. mosellana per ear	8.0	2.66
C. tritici per ear	57.0	23.0
Grain yield (t/ha at 85% d.m.)	4.92	5.77

Commercial use has indicated that the dose of chlorpyrifos required to reduce blossom midges (0.34 kg a.i./ha) will also give good control of the cereal aphid (Sitobion avenae).

The trials reported above demonstrate that chlorpyrifos can give useful control of the major cereal insect pests and thus help to maximise yields. Table 10 gives a summary of the recommended dose rates and timings for the control of each pest.

Table 10

Summary of cereal insect pest control by chlorpyrifos

Pest	Crop	Dose rate kg a.i./ha	Application time
leatherjackets	all cereals	0.72	March-May, when damage is first seen
wheat bulb fly	wheat	0.72	At egg hatch
frit fly	winter wheat	0.72	As a preventative measure when drilling after grass
frit fly	spring oats	0.72	At 1-2 leaf stage of crop when attack first seen
wheat blossom midge	wheat	0.48	At first sign of pest in the crop
aphids	all cereals	0.34	At first sign of pest in the crop

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References

McKINLAY, R.G. (1978) Chemical control of wheat bulb fly as an exercise in environmental protection. 9th International Conference of Plant Protection, Washington DC, U.S.A. Abstract No. 50.

OAKLEY, J.N. (1977) Strategies for wheat bulb fly control in the Yorkshire and Lancashire region. Proceedings 9th British Insecticide and Fungicide Conference: 103-112

RAYNER, J.M. (1975) Chemical control of leatherjackets (Tipula spp.) in cereals. Proceedings 8th British Insecticide and Fungicide Conference: 231-236

RAYNER, J.M. (1978) Chemical control of leatherjackets (Diptera : Tipulidae) in grassland. Plant Pathology 27, 160-165

SPARROW, P.R., HURAUX, M.J., KOMBLAS, K.N. AND HUISMAN, A.H. (1973) Chlorpyrifos - a broad spectrum soil insecticide. Proceedings 7th British Insecticide and Fungicide Conference: 545-556

NOTES

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THE DEVELOPMENT OF PROCHLORAZ (BTS 40 542); A BROAD SPECTRUM FUNGICIDE FOR THE CONTROL OF CEREAL DISEASES

R. G. Harris, D. M. Weighton, A. de St. Blanquat and I. D. G. Rose

The Boots Company Limited, Lenton Research Station, Lenton House, Nottingham, NG7 2QD

Summary In an extensive evaluation programme conducted during 1977-1979 throughout Western Europe, prochloraz has demonstrated excellent eradicant and protectant activity against a wide range of important foliar, stem and ear diseases attacking cereal crops. Effective control is obtained against the early season diseases, eyespot, leaf blotch and powdery mildew. Prochloraz also shows considerable potential for the control of the late season disease complex of glume blotch, leaf spot, Fusarium spp. and the black and sooty moulds.

Excellent yield benefits associated with broad spectrum disease control have been achieved following single applications of prochloraz at rates of 300-750 g a.i./ha with a wide margin of crop safety. However results clearly show that full season control of both early and late season diseases is possible by a programme of two sprays.

Résumé Un vaste programme d'évaluation due prochloraz, conduit sur trois années (1977 a 1979) à travers l'Europe de l'ouest, a permis de démontrer son excellente activité éradicante et protectrice vis à vis de nombreuses et importantes maladies de la tige de la feuille et de l'épi des cultures cerealières. De très bons résultats ont été obtenus contre maladies précoces, telles que Piétin versé, Rhynchosporiose et Oidium. Sur maladies plus tardives, le prochloraz fait preuve d'une puissance de destruction considerable des Septoriose, Fusariose, Cladosporiose et Alternaria.

D'importantes augmentations de rendements, liées à une bonne efficacité, ont éte obtenues suite à une seule application de prochloraz a 300-750 g m.a./ha tout en assurant une excellente sélectivite. L'ensemble des resultats montrent clairement que la destruction, tout au long de la saison, des maladies précoces et tardives est rendue possible grace à un programme de deux applications.

INTRODUCTION

It has been recognised for several years that cereal yields and the quality of harvestable grain can be substantially reduced by several diseases but it is only recently that national losses due to specific pathogens in the United Kingdom have been quantified (King, 1977). As cereal production intensifies greater attention is being directed to evaluating the importance of the whole cereal disease complex and the benefits that can be gained from the use of broad spectrum fungicides. Generally broad spectrum activity is achieved by the use of fungicide mixtures but evaluation of the carbamoylimidazole group (Birchmore et al, 1977) culminating in the development of prochloraz, 1-(N-propyl-N-(2-(2,4,6-trichlorophenoxy)ethyl)carbamoyl)imidazole,

which is active against powdery mildew (Weighton et al, 1977) and many other diseases, enables season-long disease control to be obtained with a single compound.

This paper reports an extensive series of trials carried out on cereals in Western Europe during the period 1977-79 to evaluate the field activity of prochloraz against diseases affecting the leaf, stem and ear of cereals. The programme was devised with the objective of achieving control, throughout the season, of the important early season diseases, eyespot (Cercosporella herpotrichoides), leaf blotch (Rhynchosporium secalis) and powdery mildew (Erysiphe graminis), and of the late season diseases such as glume blotch and leaf spot (Septoria spp.), Fusarium spp. and the black and sooty moulds (Cladosporium herbarum and Alternaria spp.).

METHODS AND MATERIALS

In the U.K., trials were mostly located in the East Midlands region and were of randomised block design with four replicates of each treatment. Plot area was 140m^2 and treatments were applied using the Lenton Small Plot Sprayer (Lush and Mayes, 1972) equipped with fan jet nozzles applying a volume of 200-225 l/ha at a pressure of 2 bars. In trials reported from France and Austria, experimental techniques were essentially the same as those used in the United Kingdom with some slight modifications in application equipment and trial design. Crop growth stages were described using a decimal growth stage key (Zadoks et al, 1974).

Quantitative assessments of mildew, leaf blotch and leaf spot were made using the Plant Pathology Laboratory Disease Assessment Keys. Eyespot was measured as proportion of infected tillers; severity of infection was based on a 0-5 scale where 0 indicates no stem penetration and 5 complete necrosis. Disease severity was expressed as $\frac{\text{Total score x 100}}{\text{Total number of tillers x 5}}$. In France the percentage of stem necrosis due to eyespot was measured. Infection by glume blotch and Fusarium spp. was assessed by counting numbers of infected ears. Techniques employed in each country were in accordance with the requirements of the relevant Registration Authority.

Yields were measured in all trials using combine harvesters modified for harvesting small plots.

In all the trials reported prochloraz was applied as a 25% or 40% a.i. emulsifiable concentrate at rates of 300-750 g a.i./ha. Standard treatments used in the trials were tridemorph (75% a.i. e.c.), triadimefon (25% a.i. w.p.), triadimefon + carbendazim (37.5% total a.i. w.p.), triadimefon + captafol (70% total a.i. w.p.), captafol (50% a.i. col), carbendazim (50% a.i. col or w.p.) and carbendazim + mancozeb (60% total a.i. w.p.). Sprays were applied when disease first appeared, generally at G.S. 30-33 and later against late season diseases at G.S. 59-65.

RESULTS

Results are reported from representative field trials carried out in the United Kingdom, France and Austria in 1977-79. In all years, infection levels of the early season diseases were generally high.

Eyespot (Cercosporella herpotrichoides)

Eyespot was widespread in the U.K. and France in 1978-79 and was particularly severe on winter wheat. In U.K. trials prochloraz applied at 400 g a.i./ha reduced the number of infected tillers and also limited the extent of lesion development (Table 1) producing considerable yield increases which compared very favourably with the standard carbendazim.

Table 1

United Kingdom 1978. Effects of prochloraz on eyespot and yield of winter wheat at five sites

Treatment	Rate (g a.i./ha)	Eyespot (% tillers infected)	Eyespot (% disease severity)	Yield (as % untreated)
Prochloraz	400	31.2	10.0	107
Prochloraz	500	32.3	10.4	107
Carbendazim	250	31.6	10.4	105
Untreated	-	53.8	19.3	100

Treatments applied at G.S. 23, 31 (20-40% infected tillers)
Assessments made 4-6 weeks after application
Untreated yield: 5818 kg/ha

Generally eyespot was more severe in France than in the U.K. in 1978 but control and yield benefits with prochloraz at rates of 450-750 g a.i./ha were similar (Table 2). There was a slight rate response to prochloraz in terms of disease control but yield increases did not differ and were of essentially the same order as the standards.

Table 2

France 1978. Effects of prochloraz on eyespot and yield of winter wheat at four sites

Treatment	Rate (g a.i./ha)	Eyespot (% tillers infected)	Eyespot (% stem necrosis)	Yield (as % untreated)
Prochloraz	450	59.0	23.2	116
Prochloraz	600	56.0	21.4	118
Prochloraz	750	52.5	20.9	117
Triadimefon + carbendazim	100 + 200	52.3	18.0	119
Untreated	-	93.3	51.3	100

Treatments applied at G.S. 30 (5% infected tillers, 2% stem necrosis)
Assessments made 6-8 weeks after treatment
Untreated yield: 5320 kg/ha

Leaf blotch (Rhynchosporium secalis)

Cool wet weather in spring encouraged the spread of Rhynchosporium on winter barley in the U.K. and France in 1978. Prochloraz applied at 400 g a.i./ha where infection was severe prevented the spread of disease and gave very large yield benefits (Table 3).

Table 3

United Kingdom 1978. Effects of prochloraz on leaf blotch and yield of winter barley at four sites

Treatment	Rate (g a.i./ha)	Leaf blotch (% infection) Leaf 1	Leaf 2	Yield (as % untreated)
Prochloraz	400	7.3	45.3	123
Triadimefon	125	9.5	50.6	112
Captafol	1345	21.7	70.9	101
Untreated	-	21.2	69.3	100

Treatments applied at G.S. 23, 32 (15% leaf blotch on leaf 1)
Assessments made 1-2 weeks after treatment
Untreated yield: 3823 kg/ha

The valuable protectant and eradicant properties of the compound were clearly demonstrated in a trial at Cachy where disease was already severe when sprays were applied and continued to increase during the trial period (Table 4).

Table 4

France 1978. Effects of prochloraz on leaf blotch and yield of winter barley at Cachy

Treatment	Rate (g a.i./ha)	Leaf blotch (% infection on leaf 1) T + 14 days	T + 35 days	Yield (as % untreated)
Prochloraz	450	0.5	5.5	107
Triadimefon	125	0.9	25.2	104
Tridemorph	562.5	3.1	66.1	102
Untreated	-	15.5	78.4	100

Treatments applied at G.S. 45 (=T) (0% leaf blotch on leaf 1; 33% on leaf 3)
Untreated yield: 5350 kg/ha

Powdery mildew (Erysiphe graminis)

In the U.K. in 1978 in spite of cool, wet conditions in the early summer, mildew had become severe in spring barley by mid July. Results from six spring barley trials (Table 5) demonstrated that prochloraz applied at 300-400 g ai/ha had excellent protectant activity against very high infection pressures and gave significant yield increases. The compound's eradicant activity has been well illustrated in trials evaluated in 1979 after moderate levels of mildew were present at application (Table 6).

Table 5

United Kingdom 1978. Effect of prochloraz on mildew and yield of spring barley at six sites

Treatment	Rate (g a.i/ha)	Mildew (% infection) Leaves 1+2	Leaves 3+4	Yield (as % untreated)
Prochloraz	300	6.4	44.4	107
Prochloraz	400	6.8	42.8	110
Tridemorph	525	7.9	46.8	105
Triadimefon	125	4.1	38.0	108
Untreated	-	34.6	77.0	100

Treatments applied at G.S. 24, 33 (22% mildew on leaves 1-4)
Assessments made 4-6 weeks after treatment
Untreated yield: 5050 kg/ha

Table 6

United Kingdom 1979. Effect of prochloraz on mildew and yield of spring barley at three sites

Treatment	Rate (g a.i/ha)	Mildew (% infection) Leaf 3	Leaf 4	Yield (as % untreated)
Prochloraz	300	4.5	3.5	118
Prochloraz	400	5.7	4.3	115
Tridemorph	525	0.9	3.4	116
Triadimefon	125	3.9	6.9	116
Untreated	-	39.9	50.4	100

Treatments applied at G.S. 23, 32 (18% mildew on leaf 4)
Assessments made 4-5 weeks after treatment
Untreated yield: 4270 kg/ha

Leaf spot and glume blotch

In contrast to the generally high levels of the early season diseases, the occurrence of the late season diseases was rather variable in trial sites. Moderate levels of leaf spot Septoria tritici and glume blotch Septoria nodorum did however develop on winter wheat in France in 1979. In trials in Northern France, prochloraz gave very promising control of both pathogens on the flag leaf and maturing ear (Table 7) at rates of 400-600 a.i./ha.

Table 7

France 1979. Effects of prochloraz on leaf spot and glume blotch of winter wheat at St. Aignan

Treatment	Rate (g a.i./ha)	% infected: Leaf spot on leaf 1	% infected: Glume blotch on ears
Prochloraz	400	11.5	13.9
Prochloraz	600	11.5	15.1
Triadimefon + carbendazim	125 + 250	16.7	17.2
Triadimefon + captafol	125 + 1300	10.2	16.2
Untreated	-	31.0	29.0

Treatments applied at G.S. 65
Assessments made 19 days after treatment

Black and sooty moulds (Cladosporium herbarum and Alternaria spp.)

In Austrian trials, severe infections of the ears by black and sooty moulds and by mildew have been well controlled by prochloraz at rates of 500-750 g a.i./ha, leading to substantial yield increases (Table 8).

Table 8

Austria 1977. Effects of prochloraz on yield of winter wheat in two trials following control of ear mildew and black and sooty moulds

Treatment	Rate (g a.i./ha)	Yield (as % untreated)
Prochloraz	500	107
Prochloraz	750	110
Captafol	1200	107

Treatments applied at G.S. 59

Fusarium spp. are frequently associated with glume blotch (S. nodorum) on winter wheat and early indications are that prochloraz will give good control of these diseases also. This potential is further underlined in the effective control of Fusarium spp. infecting the stem bases.

Rusts (Puccinia spp.) often form part of the disease complex and moderate activity against these pathogens is shown by the compound when applied as a late season spray. However, for total control a specific rust fungicide should be mixed with prochloraz.

During the four year period of field evaluation and varietal testing, prochloraz has shown a wide margin of crop safety on cereals when applied at rates up to twice

those needed for effective disease control. In the U.K. it has been applied to 33 winter and spring varieties of barley, 26 of wheat and 9 of oats without any detrimental effect.

A large programme of over 200 grower trials conducted throughout the U.K. has confirmed the findings of the replicated trials reported.

DISCUSSION

Prochloraz has excellent activity when applied as a foliar spray against the important early season diseases, powdery mildew, leaf blotch and eyespot that affect cereals. It also shows considerable potential for the control of the late season disease complex which includes Septoria spp., Fusarium spp. and the black and sooty moulds. Trials evidence clearly demonstrates that against these diseases, prochloraz at rates between 300-750 g a.i./ha is effective both as an eradicant and protectant fungicide without any evidence of phytotoxicity. This dual action ensures effective control and provides greater flexibility in spray timing.

An application at the onset of disease attack, usually at G.S. 30-35, provides very effective control and protection from all the early season diseases for up to six weeks after treatment, usually with substantial yield benefits. Against most of the late season diseases on the upper leaves and ear, prochloraz applied at G.S. 55-60 gives effective control but when rusts are a problem, an additive is required for full protection.

The clear indications are that the broad spectrum activity of prochloraz embracing both early and late season diseasesis sufficient to provide long term protection of the crop when an early season spray at the onset of disease attack is followed by a second application at ear emergence.

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References

BIRCHMORE, R.J.; BROOKES, R.F.; COPPING, L.G.; WELLS, W.H. (1977) BTS 40 542, a new broad spectrum fungicide. Proceedings of 1977 British Crop Protection Conference - Pest and Diseases 2, 593-598.

KING, J.E. (1977) The incidence and economic significance of diseases in cereals in England and Wales. Proceedings of the 1977 British Crop Protection Conference - Pests and Diseases 3, 677-687.

LUSH, G.B.; MAYES, A.J. (1972) Towards more efficient field experimentation. Proceedings of the 1972 British Weed Control Conference 1, 104-111.

WEIGHTON, D.M.; ROSE, I.D.G.; WRIGHT, D.S. (1977) Field trials on cereal mildew with BTS 40 542, a new broad spectrum fungicide. Proceedings of the 1977 British Crop Protection Conference - Pests and Diseases 1, 25-32.

ZADOKS, J.C.; CHANG, T.T.; KONZAK, C.F. (1974) A decimal code for the growth stages of cereals. Weed Research 14, 415-421.