SESSION 8C

NEW NEEDS, CONCEPTS AND TREATMENTS FOR PEST AND DISEASE CONTROL IN ARABLE CROPS

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PESTICIDE SEED TREATMENT OF CHICKPEA-WILT CAUSED BY FUSARIUM OXYSPORUM F.SP. CICERI AND MELOIDOGYNE INCOGNITA : ITS EFFICACY AND ECONOMICS

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ABSTRACT

Studies were undertaken to evaluate the efficacy and economics of the three pesticides : carbofuran (CF) 2.0%, carbendazim (CD) 0.2% and thiram (T) 0.2% as seed treatment for control of wilt complex in chickpea (*Cicer arietinum*) caused by the nematode, *Meloidogyne incognita* (MI) and *Fusarium oxysporum* f. sp. *ciceri* (FOC). Six treatment in different combinations including untreated check were applied in a naturally infested field at the University Research Farm in a randomized block design. Observations were recorded for seedling emergence (SE), wilt incidence (WI), root-knot index (RKI) and yield. Subsequently it was found that CF 2.0% + CD 0.2% were highly effective in controlling WI, improving SE and yield and were also economical. Treatments CD 0.2% and CF 2.0%, respectively were found next in order of merit. Thiram 0.2% alone was found least effective in all respects, whereas CF 2.0% + T 0.2% were slightly superior to it.

INTRODUCTION

Recently, a wilt complex was observed on chickpea in the northen region of India. The crop exhibited marked wilting and drying in field. Such plants showed the presence of the root-knot nematode (*Meloidogyne incognita*) and of the fungus (*Fusarium oxysporum* f.sp. *ciceri*). The complex nature of the chickpea disease involving *M. incognita* and *Fusarium* spp. has been previously reported (Mani and Sethi, 1987).

The complex (MI & FOC) is responsible for poor emergence of different crops (chidambaranathan and Rangaswami, 1965) and the same also breaks the Fusarium wilt resistance in chickpea variety 'Avrodhi' (Upadhyay and Dwivedi, 1987).

Seed treatment with pesticides gives initial protection from soil micro- organisms and also cuts down subsequent chemical cost without any adverse effect on plant growth. In the present studies therefore fungicides and nematicides were evaluated as seed treatments with a view to economise on chemical use for the control of the wilt-complex of chickpea.

MATERIALS AND METHODS

The experiment was laid out during 1986-87 at the University Research Farm on sandy loam soil naturally infested with *M. incognita* and *F. oxysporum* . Three pesticides, carbofuran 2.0% (Furadan 50 S P), thiram 0.2% (80% W P), and carbendazim 0.2% (Bavistin 50%) alone and in combination were tested as seed dressings for chickpea cv T-3.

The required quantity of wettable formulation of the pesticide was mixed with a minimum quantity of water, added to the weighed seeds, mixed thoroughly to give a uniform smooth coating and dried in shade. Each treatment was replicated three times in a randomized block design and observations were recorded for % seedling emergence, pod yield, wilt incidence and root-knot index (after harvest) as reported by Powell *et al*. 1971, both based on 0-5 scale.

RESULTS & DISCUSSION

Seed treatment with carbofuran 2.0% + carbendazim 0.2% was the best amongst the tested pesticides. This treatment increased the seedling emergence and yield significantly whereas root-knot index and wilt incidence were significantly decreased (Table 1 and Table 2). Besides giving the best efficacy it was also found most economic (Table 2).

Application of carbendazim or carbofuran alone were not as effective at controlling the complex as when applied in combination but still showed significant improvement in all variables measured as compared with the untreated. Thiram alone showed no significant differences from the control with respect to any variables measured. However thiram + carbofuran did reduce the root knot index and wilt incidence. According to Mani and Sethi, 1984 seed treatment with thiram did not improve the seedling emergence of chickpea infested with *M. incognita*, *F. oxysporum* f. sp. *ciceri* and *F. solani*. Earlier findings have also shown that seed treatment with nematicides and fungicides improved the emergence of seedlings and reduced or inhibited infection by nematodes and soilborne fungi (Haware *et al*. 1978).

On the basis of the present findings the application of carbofuran and carbendazim in combination as a seed treatment may be recommended to reduce the incidence of root-knot and wilt on chickpea.

TABLE 1

Effect of seed treatment on seedling emergence, root-knot index and wilt incidence on chickpea.

Treatment	Pesticide concentration	Seedling emergence: Angular value	Seedling emergence: Transformed back value %	Root-knot* index	Wilt** incidence
Carbofuran	2.0	58.75	73.00	2.6	3.6
Carbofuran + Carbendazim	2.0+ 0.2	65.69	83.01	2.0	1.3
Carbendazim	0.2	60.06	75.01	3.0	1.6
Carbofuran + Thiram	2.0+ 0.2	55.55	68.00	3.6	2.6
Thiram	0.2	51.96	62.01	4.3	4.3
Untreated check	0.0	50.95	60.03	5.0	5.0
C.D. (L.S.D.) at 5%		1.28	-	0.72	0.98
C.V.		2.13%	-	11.42%	17.23%

*Gall Index Rating : 0 = no galling; 1 = 1-10; 2 = 11-25; 3 = 26-50; 4 = 51-75; 5 = 76-100

**Wilt Rating : 0 = no wilting; 1 = trace wilting;
2 = half leaves showing wilting;
3 = 3/4 leaves showing wilting;
4 = All leaves showing wilting;
5 = Plant dead

C.D. : Critical difference for significance

C.V. : Cofficient of variance

TABLE 2

Effect of seed treatment on yield of chickpea and its economics.

Treatment	Pesticide concentration	Yield q/ha	Additional income* over control(Rs)
Carbofuran	2.0	16.00	3217.00
Carbofuran + Carbendazim	2.0+ 0.2	26.23	7701.24
Carbendazim	0.2	22.00	5894.69
Carbofuran + Thiram	2.0+ 0.2	11.76	1317.44
Thiram	0.2	9.5	387.54
Untreated check	0.0	8.6	-
C.D. (L.S.D.) at 5%		3.85	-
C.V.		5.90%	-

*Economic Data : Cost of chickpea yield over control − Cost of pesticide + Additional labour charge = Additional income

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INTERACTIONS OF FUNGICIDES WITH NITROGEN AND PLANT GROWTH REGULATORS FOR COST-EFFECTIVE CONTROL OF WHEAT DISEASES

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ABSTRACT

Field experiments have demonstrated interactions between nitrogen timing and incidence of disease. Early nitrogen dressings retard sheath penetration by the eyespot pathogen, but result in more severe stem lesions at harvest; the converse is true for later nitrogen applications. For foliar pathogens, severity of mildew and Septoria tritici is increased by early nitrogen.

The plant growth regulator, chlormequat, whilst having little effect on disease, provided yield benefits in the absence of lodging. Integration of the biological properties of fungicides with these interactions suggest ways in which their selection and timing can be optimised.

A two-spray fungicide programme is proposed for collective control of eyespot, mildew, S. tritici and late season foliar and ear diseases. The first spray, prochloraz + a morpholine at GS 37, reduced the severity of eyespot, mildew and S. tritici sufficiently until GS 55/59, when the application of a triazole + chlorothalonil effectively controlled late foliar and ear diseases, and gave cost-effective yield responses.

INTRODUCTION

Disease development is influenced by host susceptibility and crop microclimate, both of which are affected by crop husbandry practices. However, these factors are seldom considered when selecting husbandry inputs. Increasing amounts of nitrogen and its timing have marked effects on crop susceptibility to disease and to lodging. This also influences fungicide use. There is little doubt that disease control by fungicides has contributed greatly to the increased wheat yields in recent years and that fungicides will be central to future efficient disease control. However, strategies for use must include their integration with other disease suppressant measures to ensure that minimum quantities are applied efficaciously.

Although several diseases infect winter wheat during autumn and winter, most have little affect on yield potential, and autumn treatment has seldom given consistent benefits. In spring, eyespot (Pseudocercosporella herpotrichoides) is the main disease target; although Fusarium spp., powdery mildew (Erysiphe graminis) and Septoria spp.also often prevail; the latter two are seldom damaging to yield at this stage, but are a source for later infections. Therefore, selection of an eyespot fungicide is necessary and one that also affects these other diseases is an added benefit. Much yield is lost through disease-induced destruction of green leaf from GS 37 (Zadoks et al. 1974) onwards. Powdery mildew, S. tritici, S. nodorum and the rusts (Puccinia recondita and P. striiformis) are damaging after this stage, and fungicide sprays are often therefore required. Methods of diagnosis, measurement and damage prediction, at early stages in disease development are currently inadequate given the complexity of farming practice. Hence, fungicides are applied either as routine prophylactic sprays, as managed disease control programmes, or else are targeted to specific disease risks. As a consequence between two and six fungicide sprays are made annually.

The following investigation was made to provide an understanding of the effects and interactions of some husbandry inputs in winter wheat, and to explore the possibilities of a more efficient use of both nitrogen and fungicides to sustain quality yield cost-effectively.

MATERIALS AND METHODS

Experiment 1

To examine the effects and interactions of nitrogen timing with plant growth regulator and the responsiveness of selected fungicide treatments for control of stem-borne and foliar diseases, an experiment was done on a 4th successive winter wheat, cv Avalon, sown at Long Ashton on 26 September 1986. Five fungicide treatments, prochloraz (1 l Sportak/ha) at GS 31 (B), prochloraz at GS 37 (C), prochloraz (half-rate) at GS 31 + GS 37 (D), prochloraz + chlorothalonil (1 l Bravo/ha) at GS 31 (E), prochloraz + fenpropimorph (0.7 l Corbel/ha) at GS 37 (F) were compared with unsprayed (A). Nitrogen (200 kg/ha) was applied either on 13 March (March-N, X) or on 18 April (April-N, Y) 1987. The plant growth regulator chlormequat (P) (formulated as 5C Cycocel) was applied to specific plots on 9 April 1987 (GS 31). The 24 treatments (6 x 2 x 2 factorial) were arranged in row and column design, plot size 12 x 4 m, with each treatment interaction replicated four times. At GS 55, 10 June 1987, propiconazole + chlorothalonil (1 l Tilt/ha + 1 l Bravo/ha) was applied overall.

Sprays were applied at manufacturers' recommended concentrations, unless stated otherwise, using an Oxford Precision Sprayer fitted with a 4 m-boom, and working at 200 kPa pressure using 110° flat-fan nozzles to apply 250 l/ha.

The incidence and sheath penetration of eyespot was measured on 13 March (GS 30), 18 April (GS 31) and 18 May (GS 37), and stem lesion severity was assessed on 16 July (GS 75), from a sample of 25 randomly taken stems per plot. Foliar diseases were identified and measured on 18 May (GS 37), 29 June (GS 59) and 15 July (GS 75), by estimating the diseased and green areas (%) on the topmost three leaves of 10 main stems removed at random from each plot.

At harvest, 14 August 1987, whole plots were harvested with a Claas Compact combine, 2.15 m cut. Plot yields were weighed on the combine and samples taken for moisture and grain weight determinations.

Experiment 2

Similar experiments were done at Long Ashton in 1988 on winter wheat cv Avalon (sown 5 October 1987) and cv Slejpner (sown 2 October 1987). Five fungicide treatments were compared with unsprayed; B, C and F (as in 1987 above), prochloraz + triadimenol/tridemorph (1 l Dorin/ha) at GS 37 (G), and prochloraz (GS 31) followed by fenpropimorph + chlorothalonil (1 l Mistral/ha + 1.5 l Bravo/ha) at GS 39 (H).

Nitrogen (160 kg/ha) was applied either on 14 March (I) or on 14 April (II); additionally, on cv Avalon only, 40 kg N/ha was applied on 13 May to plots that received 120 kg N/ha in March (III) or April (IV). The 24 treatments cv Avalon, and 12 treatments cv Slejpner were arranged in randomised blocks (plot size 12 x 4 m) and replicated four times. All treatments were oversprayed with flutriafol + chlorothalonil (2.5 l Impact Excel/ha) on 14 June (GS 55).

On 14 March, 2 x 50 cm lengths of adjacent rows were marked in each plot designated as unsprayed (A) or to receive Treatment H, and tiller numbers recorded. Counts were repeated on 14 April and at GS 75 the number of ear-bearing stems recorded.

Disease measurements were made, as described previously, on 6 April (GS 31), 17 May (GS 37), 13 June (GS 55) and 5 July 1988 (GS 75), and plots were harvested on 14 August 1988.

RESULTS

Experiment 1

On 13 March 1987, overall initial eyespot incidence was 63%; by 18 April this had increased to 74% (with 2.6 sheaths penetrated) on March-N plants, and 79% (3.7 sheaths penetrated) on April-N plants. At GS 37, stem lesions were observed on 15% of unsprayed plants, irrespective of N timing, and between 8-10% of plants that received prochloraz at GS 31. At GS 75, the earlier GS 31 applications of prochloraz gave more effective reductions in eyespot severity than those applied at GS 37, but yield differences between fungicide treatments were not significant. Eyespot stem lesions were more severe on March-N plants which gave less yield ($p = 0.05$) than on April-N plants. Whereas the growth regulator, chlormequat, did not affect eyespot severity, it increased yields overall ($p = 0.05$) (Table 1).

S. tritici was the most prevalent and severe foliar disease; low levels of *S. nodorum* were present throughout the year and powdery mildew from June onwards. On 18 May (GS 37), the topmost three leaves were fully green and *S. tritici* was present on leaf 5. On unsprayed plants that received March-N, there was significantly more *S. tritici* than on any other treatment, and least disease on April-N plants that received prochloraz at GS 31. By 29 May (GS 39), the flag leaf (leaf 1) and leaf 2 were fully green, and *S. tritici* was most severe on leaf 3 and 4 of unsprayed plants irrespective of N-timing. By 15 July (GS 75), low amounts of *S. tritici* were recorded on the flag leaf and leaf 2, however, any spray programme that included an application of fungicide at GS 37 gave better disease control than earlier applications or unsprayed. For each combination of nitrogen and growth regulator, the fungicide treatments responded differently. In March-N plots without chlormequat, fungicide treatments B and E (GS 31 sprays) gave more grain yield than the unsprayed, whereas the later sprays (GS 37) did not. With chlormequat only the split application of prochloraz (D) increased yield (Table 2). For April-N, yields of unsprayed plots were greater overall, and significant yield increases were only obtained on non-chlormequat crops with the split application of prochloraz (D) and on chlormequat-treated crops by the GS 37 spray of prochloraz + fenpropimorph (F) (Table 2).

TABLE 1

Effects of fungicides, nitrogen timing and plant growth regulator on eyespot severity and yield, cv Avalon, 1987.

Treatment**	Eyespot			Yield	TGW
	Incidence (%)	Mod-severe (%)	Disease Index*	(t/ha)	(g)
A	89	69	144	7.51	52.9
B	58	25	69	8.08	53.4
C	76	49	106	7.85	53.6
D	67	34	81	8.17	53.7
E	65	30	78	7.96	53.3
F	77	48	109	7.92	53.2
SED			28.94	0.203	0.371
X	78	53	114	7.43	53.9
Y	66	32	81	8.40	52.7
SED			11.94	0.117	0.214
P	71	41	94	8.11	53.7
nil-P	73	44	102	7.72	53.0
SED			13.77	0.117	0.214

* Disease Index (Hoare & Jordan, 1984).
** For definition of treatment letters, see text.

Experiment 2

On 14 March 1988, overall initial eyespot incidence was 35% in cv Avalon and 12% in cv Slejpner, this had increased to 57% and 45% respectively, by 6 April. Sheath pentration was less on plants that received March-N (2.7), than those that did not (3.2). By 17 May (GS 37) eyespot lesions were observed on 33% of unsprayed stems cv Avalon, and on 13% stems in March-N and 2% stems in April-N plots treated with prochloraz at GS 31. Data for cv Slejpner were 31%, 14% and 5% respectively. At GS 75 (5 July), all fungicide treatments on both cultivars had reduced eyespot severity, and between which there were no differences, compared with unsprayed. Overall, and within each treatment, with the exception of treatment F (cv Avalon), eyespot was less severe in treatments that received April-N than in those that received March-N, and in cv Avalon, irrespective of the later (May) nitrogen application (Table 3).

TABLE 2

Effects and interactions of fungicides, nitrogen timing and growth regulator on yield of winter wheat, cv Avalon, 1987.

Treatment	Yield (t/ha)				Thousand-grain-wt.(g)			
	March-N (X)		April-N (Y)		March-N (X)		April-N (Y)	
	-	+P	-	+P	-	+P	-	+P
A	6.68	7.21	8.00	8.13	53.9	53.2	52.3	52.1
B	7.59	7.77	8.10	8.87	54.0	54.8	52.4	52.6
C	7.13	7.58	8.07	8.62	53.9	53.7	54.1	52.7
D	7.14	8.45	8.85	8.23	55.8	53.5	53.4	52.0
E	7.51	7.36	8.37	8.58	54.3	53.7	53.4	51.7
F	7.27	7.45	7.94	9.04	53.5	53.0	53.1	53.0
SED (65 d.f.)		0.407				0.742		

(For comparing within one row or one column)
Coefficient of variation (%) 7.3

+P - plant growth regulator, chlormequat.

TABLE 3

Effects and interactions of fungicides and nitrogen timing on eyespot severity at GS 75 (Disease Index, Hoare & Jordan 1984) cvs Avalon and Slejpner, 1988.

Treatment	cv Avalon					cv Slejpner		
	N-I	N-II	N-III	N-IV	mean	N-I	N-II	mean
A	53.8	37.8	47.1	28.0	41.3	58.5	41.5	50.0
B	23.1	14.8	26.1	17.5	20.0	25.7	22.3	24.0
C	32.5	27.6	37.8	13.5	26.7	32.7	20.5	26.2
F	25.7	25.2	19.6	20.1	22.5	34.5	27.1	30.7
G	27.8	10.8	28.4	21.6	21.1	29.7	18.5	23.6
H	20.4	15.6	23.0	14.5	18.1	31.2	14.5	22.7
mean	29.7	20.6	29.6	18.8		34.9	23.2	
SED (43 d.f.)		3.097			SED (32 d.f.) 4.695			

(For comparing within one row or one column)

S. tritici was again the most damaging foliar disease. Although powdery mildew affected unsprayed crops from early June, mean diseased leaf areas rarely exceeded 3% during the season. On 6 April, 12% and 32% of laminar areas of leaf 6 and leaf 7 respectively, on plants, cv Slejpner, that had received March-N were affected by S. tritici, whereas on corresponding leaves of plants which had not received March-N, disease amounts were 9% and 23% respectively. Amounts of disease on leaves cv Avalon, were less (5% and 11%), and no differences between nitrogen application were found.

On 13 June, green leaf retention was less and S. tritici more severe on plots of cv Avalon, that received March-N (11% diseased area-leaf 3) than on those that received nitrogen in April (4% diseased area-leaf 3). On March-N plots, all fungicide treatments, with the exception of prochloraz at GS 31 (Treatment B), decreased disease severity and sustained more green leaf, whereas fungicides applied to April-N plots gave no further reductions in disease severity or improvements in green leaf retention. Similar nitrogen timing effects on green and diseased leaf areas were found with cv Slejpner (March-N, 34% diseased area leaf 4; April-N, 18% diseased area leaf 4). On cv Slejpner overall, prochloraz applied at GS 31 (B), prochloraz + fenpropimorph at GS 37 (F), and prochloraz at GS 31 followed by fenpropimorph + chlorothalonil at GS 39 (H) decreased disease, whereas the other treatments did not, but green leaf retention was only improved by treatments F and H and also by treatment G.

By 5 July, the overspray with flutriafol + chlorothalonil at GS 55/59, gave good control of late disease development, such that S. tritici-diseased areas on the flag leaf or leaf 2 of crops unsprayed prior to GS 55 did not exceed 6% on either cv Avalon or cv Slejpner. Nevertheless, the early fungicide treatments gave significantly less disease and more green leaf remaining ($p = 0.05$) on these topmost two leaves than on crops unsprayed prior to GS 55.

Disease incidence on ears and saprophytic colonisation of glumes were very small, and therefore not measured.

In cv Avalon, grain yield overall was significantly less ($p = 0.05$) when the main nitrogen top dressing was applied only in March than when applied on any other occasion. All fungicide treatments increased yield; prochloraz applied alone at GS 31 (B) or at GS 37 (C) was significantly different from unsprayed at the 5% level, and from prochloraz + fenpropimorph at GS 37 (F), prochloraz + triadimenol/ tridemorph at GS 37 (G), prochloraz at GS 31 followed by fenpropimorph + chlorothalonil at GS 39 (H), at the 0.1% level of significance (Table 4). There were no nitrogen/fungicide interactions.

In cv. Slejpner, higher overall yield figures were obtained from the April-nitrogen crops than from those to which nitrogen was applied in March. There was no clear pattern of differences between fungicide treatments nor any nitrogen/fungicide interactions (Table 4).

TABLE 4

Effects and interactions of fungicides and nitrogen timing on grain yield cvs Avalon and Slejpner, 1988.

Treatment	cv Avalon					cv Slejpner		
	N-I	N-II	N-III	N-IV	mean	N-I	N-II	mean
A	8.30	8.21	8.45	8.72	8.42	8.87	9.26	9.07
B	8.44	8.74	8.65	9.04	8.72	9.45	9.71	9.58
C	8.83	8.74	8.70	8.51	8.70	8.92	9.29	9.10
F	8.39	9.26	9.22	8.99	8.97	9.65	9.43	9.54
G	8.66	9.01	8.86	9.01	8.89	9.04	8.93	8.98
H	8.68	9.01	9.04	8.98	8.93	9.67	10.38	10.02
mean	8.55	8.83	8.82	8.88		9.27	9.50	

SED (43 d.f.) nitrogen (N1-NIV), 0.105 SED (32 d.f.) nitrogen, 0.190
fungicide(A - H) , 0.128 fungicide,0.330
nitrogen/fungicide,0.257 nitrogen/fungicide,0.466

Coefficient of variation (%) 3.6 7.0

DISCUSSION

Carbendazim-resistant eyespot is widespread in cereal crops in the UK (King & Griffin 1985), thus, prochloraz is the only chemical currently recommended for use (Anon 1986) that will effectively control this disease in field crops. Field experiments at Long Ashton between 1984 and 1987, have shown that an application of prochloraz on any single occasion between November (GS 22) and mid-May (GS 37) decreased the severity of eyespot on mature stems, albeit with differing efficacy, but gave no consistent differences in yield response between these timings (Hunter & Jordan, unpublished). The results presented here also demonstrate the ability of prochloraz to control eyespot when applied at GS 37, irrespective of the influence of nitrogen timing on differential pathogen penetration. The ability of this late spray to control eyespot not only offers the opportunity to defer spray decisions based on threshold criteria, but also to utilise its inherent biological activity against other foliar diseases, viz. S. tritici (Jordan et al. 1986), thus offering a dual control option. The limited ability of prochloraz against powdery mildew, at this stage, may necessitate the inclusion of a morpholine fungicide. This approach, demonstrated in these experiments, sustained effective control of stem and foliar diseases until GS 55/59. At this late stage, selection of a fungicide or fungicide mixture would be dependent on which diseases were considered to be a potential threat to quality. In these experiments, Septoria spp., powdery mildew and brown rust were considered likely to become damaging, and a mixture of a triazole + a phthalonitrile (chlorothalonil) was applied. This successfully contained late-season disease and gave a cost-effective yield response.

This two-spray programme, not only provides an effective and economic disease control option, but comprises fungicides selected from four different fungicide groups (imidazole, morpholine, triazole, phthalonitrile), and could form part of a strategy to combat the development of fungicide resistance.

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INFLUENCE OF TIME OF APPLICATION OF GROWTH RETARDANTS ON CANOPY STRUCTURE, DISEASE AND YIELD IN OILSEED RAPE

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ABSTRACT

Triapenthenol or flurprimidol, applied at early stem extension, reduced stem and crop height. These treatments increased the numbers of branches and pods, but canopy depth was unaffected. Later applications also reduced crop height and branch length and additionally canopy depth. Triapenthenol treatments decreased the incidence of *Alternaria* spp. and light leaf spot disease on leaves and pods, but they increased when the crop was sprayed with flurprimidol. In 1987, recovered yields were increased when triapenthenol but not flurprimidol, was applied early or late. Flurprimidol was effective only in combination with the fungicide prochloraz. In 1988, yields were increased by triapenthenol or flurprimidol treatment only if applied early to crops that did not lodge.

INTRODUCTION

The potential yield of oilseed rape, calculated by Daniels *et al.* (1982), is over 7 t/ha, yet the yields recovered by the combine vary between only 2 and 4 t/ha. Occasionally, yields recorded from small hand-harvested plots approach the calculated value, indicating much loss during harvesting. Different methods if continuous do not affect the recovered yield (Bowerman 1984a) but shorter-stemmed cultivars which are less susceptible to lodging or leaning, are more likely to maintain regular annual yields. Lodging can be very severe in oilseed rape but it occurs less frequently than in cereals because of differences in structure. However, many of the new cultivars which are low in glucosinolates and erucic acid ('double-lows') are tall and more susceptible to lodging than shorter outdated 'single-lows', and are likely to benefit from plant growth regulators (pgrs) which shorten and strengthen stems. Many pgrs have been tested for their ability to reduce susceptibility to lodging, improve access for management and improve recovered yield. Significant increases in yield of oilseed rape have been reported following treatment with the experimental triazole retardants, triapenthenol and BAS111, applied during stem extension (Hack *et al*. 1985, Child *et al*. 1985, Luib *et al*. 1987).

Other growth retardants such as daminozide (dimethyl amino-succinamic acid) and the quarternary ammonium retardants chlormequat and mepiquat chloride appear to be less consistent in their effects on growth and yield of oilseed rape (Scarisbrick *et al*. 1982, Bowerman 1984b, Child 1986). The pyrimidine retardant flurprimidol has been shown to be a powerful growth retardant in oilseed rape when applied before stem extension (Dawkins & Almond 1984), but it has not been applied later in the spring. Improvement in yield has also been reported following treatment with retardants in the absence of lodging. These appear to be associated with changes in the architecture of the canopy which may alter light profiles (Child et al. 1987). Canopy height and structure in oilseed rape is altered greatly by application of retardants but their effects depend on the stage of development at the time of spraying (Child 1984, Child et al. 1987). Treatment at the beginning of stem extension shortens stems and increases axillary stem branching and flowering. This results in a lower but denser canopy. Treatment at the end of stem extension shortens branches, decreases petal size and colour and results in an 'open' canopy in which the pods ripen more synchronously. Yield increases have been recorded as a result of treatment with retardants at both these stages of crop growth (Child et al. 1987). Applying pgrs to alter crop structure may also influence disease incidence. For example, light leaf spot (Pyrenopeziza brassicae) was reduced following treatment with triapenthenol but was unaffected by daminozide (Stinchcombe et al. 1986). The differences between treatments may be due partly to changes in density of the foliage and partly to the fungicidal properties of the retardants.

The experiments reported here, using triapenthenol show that the mechanism of effect on yield varies with time of treatment and includes influences on the structure of the canopy as well as on the fungicidal activity of the growth retardant. Flurprimidol, with similar retardant effects, but no known fungicidal activity, was included for comparison.

MATERIALS AND METHODS

Experiment 1

Winter oilseed rape, cv. Jet Neuf, was sown at Long Ashton, at 7.2 kg/ha on 30 August 1986. Top dressings of nitrogen were applied on 25 September 1986 (27 kgN/ha), 24 February (101 kNg/ha) and 30 March 1987 (121 kgN/ha). Post-emergence herbicides were applied as follows: metazochlor (1.25 kg a.i./ha) on 17 September, fluazifop-p-butyl (0.125 kg a.i./ha) on 8 October 1986, and pyridate (1 kg a.i./ha) on 16 March 1987. Experimental treatments: triapenthenol (490 g a.i./ha) or flurprimidol (100 g a.i./ha) was applied, in 250 l/ha water, on 30 March, during early stem extension when the crop was approximately 20 cm high and two-three new leaves had become exposed. These retardants were also applied to different plots on 24 April, during late stem extension, when the crop was 70 cm high, all the leaves had unfolded and the most advanced flower buds were yellow at the base of the terminal raceme. The fungicide prochloraz (400 g a.i./ha) was applied either alone or in combination with flurprimidol on 30 March 1987. The crop was desiccated with glyphosate (1.08 kg/ha) on 11 July and harvested with a Claas Compact plot harvester (2.15 m cut) 12 days later.

Crop measurements: samples were collected on 9 July 1987, when basal pods began to senesce. Plants, in random 0.5m x 0.5m quadrats, were cut at soil level; the pods were counted, then dried in ovens at 75°C for two days. After the pods had been weighed, the seeds were separated and weighed. Plots were assessed for incidence and severity of disease on several occasions from regrowth in spring until maturity. Prior to harvest, 20 plants were removed at random from each plot for measurement of disease severity on pods of the terminal racemes.

Experiment 2

The winter oilseed rape, cv Ariana, selected because of the need for seeds containing only small quantities of glucosinolates, was sown at Long Ashton at 8.0 kg/ha on 27 August 1987. Top dressings of nitrogen were given on 22 February (99 kgN/ha) and on 26 March 1988 (118 kgN/ha). The post-emergence herbicide, propyzamide + clopyralid, was applied at 1.67 kg/ha on 29 August 1987. The crop was desiccated with glyphosate on 15 July and harvested on 26 July 1988. Experimental treatments: triapenthenol (490 g a.i./ha) or flurprimidol (100 g a.i./ ha was applied at early stem extension (29 March) or at first-flower (21 April 1988), or split, at half-rate, on both occasions. The fungicide prochloraz (400 g a.i./ha) was applied to specified plots on 22 April 1988. The experimental treatments, applied to 12 m x 4 m plots, were replicated four times and arranged in randomised block design. Light leaf spot was assessed on 31 May by estimating the percentage of leaf area with disease on 10 plants taken at random from each plot. Just prior to harvest, the percentage diseased areas on all pods was recorded on 5 plants from each plot. A disease index for the pods was calculated using the method described by Stinchcombe et al. (1986).

RESULTS

Experiment 1

No lodging occurred in this experiment, and by harvest, the untreated crop was between 165 and 175 cm in height. Triapenthenol or flurprimidol applied at early stem extension reduced crop height by 20%, and by 10% when given at late stem extension. Alterations in crop structure, as a result of the retardant treatments, were similar to those previously reported (Child et al. 1987) and described above. Early treatment with either chemical reduced stem height by 30% but did not affect the depth of the canopy in which the branches and pods were situated. The number of branches was increased by this treatment but total branch weight was not significantly affected (Table 1). The later sprays reduced branch lengths and depth of the canopy by approximately 30%. There were no statistically significant effects of any treatment on dry matter accumulation although individual values were all higher in treated crops (Table 1). Dry weight distribution in the canopy and harvest indices were unaffected. Early application of either retardant significantly increased the number of pods. During stem growth and pod development, disease incidence was low. Light leaf spot on leaves and pods failed to reach measurable levels in any treatment and was not, therefore, recorded. Alternaria spp. affected 4% of the leaf area on unsprayed plants during early pod development and by harvest, 6% of the pod surface was diseased. The growth retardants differentially and significantly affected these amounts of disease. The severity of disease on pods was reduced by triapenthenol and by flurprimidol in combination with prochloraz, but was increased by flurprimidol alone. Yields were increased significantly by triapenthenol but unaffected by flurprimidol or prochloraz applied alone. In combination, flurprimidol and prochloraz increased yield to the level obtained with triapenthenol (Table 2).

Experiment 2

Early application of retardant prevented lodging completely, while untreated plants had lodged to an angle of 45° or more by early July. An intermediate level of lodging was seen in crop sprayed with retardant at late stem extension. Yields were increased by early applications of both retardants, but not by the later applications. Yield was not increased when the fungicide prochloraz was used alone (Table 3).

TABLE 1

Effect of time of application of growth retardants on pod numbers and biomass of components of oilseed rape canopy (cv Jet Neuf) 1987.

Treatment	Dry weight (g/m_2) branches	pods	seeds	total	Harvest index (%)	Number pods/m_2
unsprayed	232	949	509	1592	33.3	7040
triapenthenol-early	280	1122	601	1847	32.6	8814*
triapenthenol-late	243	1001	514	1698	30.0	7808
flurprimidol-early	287	1109	596	1800	33.1	8925*
flurprimidol-late	251	1121	631	1817	34.9	7793
SED (20 d.f.)	34.6	93.7	59.5	187.9	2.64	690.2

* indicates significant differences from unsprayed at p = 0.05.

TABLE 2

Alternaria spp. and yield in oilseed rape cv Jet Neuf, treated with growth retardants and prochloraz.

Treatment	Area diseased (%) leaves nil	leaves + p'rz	pods nil	pods + p'rz	Yield (t/ha) nil	Yield (t/ha) + p'rz
unsprayed	4.2	2.9	5.6	5.4	4.33	4.53
triapenthenol-early	2.5	-	4.0*	-	4.60*	-
triapenthenol-late	3.7	-	4.0*	-	4.60*	-
flurprimidol-early	4.8	1.6*	7.3*	4.2*	4.39	4.61*
flurprimidol-late	5.0	2.9	8.4*	4.5*	4.12	-
SED (35 d.f.)	0.74		0.21		0.115	

\+ p'rz; crops treated with prochloraz; - treatment not applied.
* indicates significant differences from unsprayed at p = 0.05.

TABLE 3

Effects of time of application of growth retardants and prochloraz on light leaf spot, lodging and yield of oilseed rape, cv Ariana, 1988.

Treatment	Leaf DA (%)	Pod DI	Lodging area (%)	Lodging angle	Yield (t/ha)
Triapenthenol-early	3.70	3.02*	0	0	3.11*
Flurprimidol-early	6.52*	6.74	0	0	3.00*
Triapenthenol-late	4.78	3.11*	90	13	2.58
Flurprimidol-late	6.95*	8.92	70	23	2.45
Triapenthenol-early + late	5.05	3.90*	0	0	3.34*
Flurprimidol-early + late	8.00*	4.74	0	0	3.18*
UNSPRAYED	5.61	7.17	85	45	2.55
Flurprimidol-early + prochloraz	6.83*	1.99*	0	0	3.21*
Flurprimidol-late + prochloraz	4.75	3.67*	90	13	2.92
Nil pgr + prochloraz	5.84	2.91*	60	45	2.89
SED (36 d.f.)	0.375	1.446			0.205

DA (%); diseased leaf area. DI; pod disease index (Stinchcombe et al. 1986). *; significantly different from unsprayed at p = 0.05.

Both the single triapenthenol applications markedly reduced leaf disease, especially when applied at early stem extension, whereas the split (early and late) application did not. All flurprimidol treatments caused substantial increases in the percentage diseased leaf areas. Adding prochloraz to flurprimidol treatment decreased disease, only when given late in stem extension. On pods, all triapenthenol treatments decreased disease, whereas similar treatments with flurprimidol did not. However, the inclusion of prochloraz with either flurprimidol treatment decreased pod disease (Table 3).

DISCUSSION

Yield increases of approximately 6%, obtained in 1987 with cv Jet Neuf, following treatment with triapenthenol during stem extension, were lower than previously reported with this cultivar (Child et al. 1985, Stinchcombe et al. 1986). Less disease in 1987 than in two previous years appears, in part, to account for the differences, but the changes in crop structure which occurred in all seasons, also improved potential yield and the proportion recovered by the combine.

Early treatment increased pod numbers in cv Jet Neuf at harvest in 1987, which indicated greater potential yield than in the unsprayed control. Pod data were similar for flurprimidol, but the harvested yield was not increased in the absence of fungicide. Thus the increased yield potential was only recoverable if disease protection was effective. The fungicidal properties of triapenthenol (Stinchcombe et al. 1986) were presumably sufficient to ensure that recovered yield also increased, although the full yield potential may not have been realised. Later treatments with growth retardants in 1987 also increased the pod number and although flurprimidol also gave greater seed weight values, none of these apparent effects differed significantly from those on unsprayed plants. Nevertheless, yield was increased by triapenthenol, and the proportion recovered by combining was greater than in any other treatment. The reduction in branch lengths may have provided a more compact canopy, which was more easily gathered by the combine. The late retardant treatment opened the canopy, and resulted in more even ripening which, in the case of the triapenthenol-treated crop, was similar in stage of maturity at harvest to the unsprayed control. By contrast, flurprimidol accelerated ripening, causing greater seed loss during harvesting and lower seed recovery. Earlier harvesting of crops receiving this treatment appears to be necessary to realise the improved potential.

The alterations of canopy structure following growth retardant treatment resulted in significant changes in the incidence and severity of disease on leaves and pods. The increased branch growth, which followed the early application of flurprimidol, resulted in a denser canopy that may have created a more favourable microclimate for disease infection. The same structural effects were obtained with triapenthenol, but the fungicidal properties of this retardant probably restricted disease levels. The shortened branches which resulted from the late treatment with flurprimidol, providing a more open canopy, did not greatly alter disease severity compared with that on the unsprayed area.

It is concluded (1), that in the absence of lodging, applying growth retardants can increase yield independently of their effect on disease incidence by changing canopy structure and improving light interception for photosynthesis and (2), when lodging is prevented by growth retardant treatment there are changes in canopy structure that conceivably improve combine efficiency.

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MYCLOBUTANIL SEED TREATMENT - A NEW APROACH TO CONTROL CEREAL DISEASES

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ABSTRACT

The fungicide myclobutanil, well known for foliar application in fruit and ornamentals, has been tested as a seed treatment formulation for cereal diseases in field trials in Greece between 1985 and 1988. Applied at low rates of 7.5 to 20g/100kg or in a mixture with mancozeb it provides an excellent control of common bunt of wheat (Tilletia foetida (Wallr.) Liro and T.caries (DC.) Tul.) and barley loose smut (Ustilago nuda (Jens.) Rostr.) which resulted in increased yield of crops. Trials have demonstrated also good crop safety. There was a correlation between the bunt or loose smut infection and yield increase following treatment.

INTRODUCTION

Since the appearance of new Tilletia foetida (Wallr.) Liro fungus strains resistant to most widely used seed-dressing fungicides, the problem of high bunt infection of wheat crops became very serious. Resistant strains of Tilletia were present in all samples collected from the whole country, except those originating from Crete where very small areas of cereals are grown (Skorda 1977, 1981).
The resistant strains compete well with the sensitive ones, they are geneticaly stable and become dominant in the pathogen population even though the application of ineffective seed dressing treatments has not been used by farmers for some years. Therefore, the evaluation of new fungicides as seed dressings against the new fungus population of bunt disease is very important not only for Greece but for other countries as well.

Barley loose smut (Ustilage nuda) as well as other cereal diseases is serious and its control with fungicides as seed dressing treatments will be very important.

The fungicide muclobutanil (2-(4-chlorphenyl)-2-(1-H-1,2,4-trialzole, -1-ylmethyl)hexanenitrile) is one of the third generation of trialzole fungicides exhibiting high activity at low use rates, combined with excellent crop safety. It is tested and registered for foliar use but not as a seed dressing in winter cereals.

This report describes field studies in which wheat bunt and barley loose smut control and crop safety were evaluated using either myclobutanil alone or in a mixture with mancozeb, in different formulations, as well as ome other fungicides.

MATERIALS AND METHODS

The fungicide myclobutanil alone or in a mancozeb mixture was tested for two years on wheat and one year on barley. All trials were fully replicated using randomized block designs and were conducted throughout the main cereal growing areas of Greece. Plot sizes were 5 m^2. Crop safety was assessed in the field and laboratory. Crop emergence and establishment were evaluated by randomly selecting two 1-m row lengths per plot and counting the number of normal plants. The standard laboratory germination test was also used where four replicates each of 100 seeds were put in Petri dishes, watered, covered, and kept at a constant 20° C for 6 days. Tests were assessed for the percentage of normal seedlings.

Bunt spores were collected in the previous season. In all cases a mixture of two inoculum types was used: spores apparently insensitive to HCB and spores collected from different regions all over the country. The wheat used throught was cv. Yecora, a commercial dwarf cultivar susceptible to bunt. The barley used was cv. Ingrid. The seed of this cultivar was harvested from a field highly infected with loose smut.

Wheat and barley seed was treated using an experimental applicator (Gustafson). The rates and formulations of the seed dressing fungicides are reported in the results tables.

Disease assessments were made in the laboratory on 300 mature ears per plot and recoreded as percentage diseased heads per plot.

Trials were harvested using a small-plot combine or by hand, and yields were recorded. On the results of each trial reported, Duncan's range test (Duncan 1955) was used to compare statistically each treatment mean. Values followed by a common letter are not significantly different at P=0.05 in Tables 1-3.

In none of the tests was any significant deleterious effect noted with myclobutanil alone or in mixtures with mancozeb at all tested rates.

RESULTS

Myclobutanil was safe for wheat and barley seeds, giving greater than the minimum 85% normal germination required by Cereal Seed Regulation (Tables 1, 2 & 3). Also, myclobutanil did not cause a reduction in the speed of emergence, while eventual crop establishment was good.

In none of tests was any significant deleterious effect noted with myclobutanil alone or in mixtures with mancozeb, at all tested rates. In early summer, wheat plants were taller and greener in some plots with myclobutanil - or myclobutanil + mancozeb - treated seeds suggesting that there might have been a beneficial effect of seed treatment unrelated to bunt or loose smut or other disease. This hypothesis will be studied next year.

Control of common bunt

Bunt infectin was high in the years of test. Tables 1 & 2 show that myclobutanil as well as its mixture with mancozeb significantly reduced the indicence of bunt compared with the control. Disease control was related to rate, with best rates lying between 8-15g/100kg seed (myclobutanil) and 6 to 8g/100kg seed (myclobutanil + 60 to 90g/100kg seed of mancozeb). However, myclobutanil alone at the rate of 15g/100kg seed was very effective, controlling 100% of the disease even when the infestation of untreated check was as high as 62%. Control of bunt by myclobutanil was about the same in three locations and two years of tests with different climatic and soil conditions, resulting in different bunt infection at different years and locations. The disease control achieved by myclobutanil was equal to that of the standard chemicals used.

In an experiment in Kopaida in 1986 - 1987, in which infection with bunt disease was very high, all myclobutanil treatments as well as the standard chemicals gave significantly higher yields than the untreated control. There was no difference between treatments except a slightly inferior performance of carboxin and the lowest myclobutanil treatment tested.
In the second trial in Larissa, in spite of the high infestation, the yield of the untreated control was not very much reduced. As a consequence the yield response to treatments did not produce as marked differences from the untreated control. However, the top rates of myclobutanil, as well as the myclobutanil + mancozeb mixtures gave the highest yield increases.

Loose smut control

Loose smut levels of barley in both experiments in Kopaida and Larisa were high, and myclobutanil as well as flutriafol controlled absolutely the disease with all rates and formulations (Table 3). On the contrary oxyquinolate de cuivre did not control loose smut.

In an experiment in Kopaida in 1987 - 1988, in which infection with loose smut disease was very high, all myclobutanil treatments gave significantly higher yields than the untreated control.

TABLE 1

Effect of seed treatment with fungicides on wheat bunt (1985 - 1986).
Formulation: Miclobutanil 5% dust, Mancozeb 80% WP.

Treatment	Rate (g a.i./ 100 kg seed)	Bunt spikes % Kopai.	Larisa	Ptolem.	Germination %
Control	-	62.0c	57.5b	24.5b	92
Myclobutanil	7.5	3.2b	3.0a	1.2a	96
Myclobutanil	10.0	2.0ab	1.7a	0.7a	96
Myclobutanil	15.0	0.0a	0.0a	0.0a	95
Myclobutanil	20.0	0.0a	0.0a	0.0a	95
Myclobutanil	7.5				
+ mancozeb	100.0	2.5ab	1.2a	0.7	98
Myclobutanil	10.0				
+ mancozeb	100.0	1.2ab	1.0a	0.5a	96
Myclobutanil	15.0				
+ mancozeb	100.0	0.0a	0.0a	0.0a	94
Myclobutanil	10.0				
+ mancozeb	60.0	2.7ab	1.5a	0.7a	96
Myclobutanil	15.0				
+ mancozeb	60.0	0.0a	0.0a	0.0a	94
Myclobutanil	20.0				
+ mancozeb	60.0	0.0a	0.0a	0.0a	94
Mancozeb	100.0	5.2b	4.7a	2.0a	95

TABLE 2

Effect of seed treatment with fungicides on wheat bunt (1986 - 1987).
Formulation: Miclobutanil fl: 6.0%; Miclobutanil ds: 40.0%;
Mancozeb wp: 80.0%; Fluatriafol ds: 2.5%; Carboxin fl: 28.0%

Treatment		Rate (g a,i/ 100 kg seed)	Bunt spikes % Kopai.	Larisa	Ptolem.
Control		-	24.0b	19.9b	19.3b
Myclobutanil	fl	6	15.9b	4.0b	9.6b
Myclobutanil	fl	8	1.0a	0.4a	0.6a
Myclobutanil	fl	10	0.5a	0.3a	0.3a
Myclobutanil	ds	10	0.1a	0.0a	0.1a
Myclobutanil	fl	6			
+ mancozeb	wp	60	0.3a	0.2a	0.2a
Myclobutanil	fl	8			
+ mancozeb	wp	60	1.0a	0.3a	0.7a
Myclobutanil	fl	6			
+ mancozeb	wp	90	0.3a	0.3a	0.3a
Mancozeb	wp	120	0.0a	0.0a	0.0a
Fluatriafol	ds	5	0.3a	0.3a	0.3a
Carboxin	fl	56	0.2a	0.4a	0.3a

TABLE 2 (Continued)

Effect of seed treatment with fungicides on wheat bunt
(1986 - 1987)

Treatment		Rate (g a.i/ 100 kg seed)	Grain yield Kopaida kg/ha	%	Larisa kg/ha	%	Germination %
Control		-	1800f	100	3050df	100	92
Myclobutanil	fl	6	2538de	141	2450f	80	90
Myclobutanil	fl	8	3013ae	167	2850ef	93	94
Myclobutasil	fl	10	2813bcde	156	3900ac	128	92
Myclobutanil	ds	10	3088ae	172	4350a	143	92
Myclobutanil	fl	6					
+ mancozeb	wp	60	3300ac	183	3800ad	125	96
Myclobutanil	fl	8					
+ mancozeb	wp	60	3600a	201	4050ab	133	96
Myclobutanil	fl	6					
+ mancozeb	wp	90	2925ae	163	3200cdf	105	96
Mancozeb	wp	120	2963ae	165	3400bcde	112	94
Fluatriafol	ds	5	3100ae	172	3250cde	107	94
Carboxin	fl	56	2640cde	147	3200cdf	105	93

TABLE 3

Effect of fungicide seed treatment on loose smut (Ustilago nuda) of barley (1987 - 1988)

Treatment	Rate (g a.i/ 100 kg seed)	Smut infected ears Kopaida %	Smut infected ears Larisa %	Grain yield Kopaida kg/ha	Germination % *	Germination % **
Control	-	19.3b	20.3b	2110g	96	92
Myclobutanil	10	0.3a	0.0a	2855cdf	98	88
Myclobutanil	15	0.0a	0.0a	3515a	98	95
Myclobutanil	10	0.5a	0.0a	2873cdf	96	91
Myclobutanil	15	0.0a	0.0a	3385ab	90	89
Myclobutanil + mancozeb	10 113	0.0a	0.0a	2693df	96	89
Myclobutanil + mancozeb	10 150	0.0a	0.0a	3015ad	96	93
Oxyquinolate de cuivre	21	22.5b	24.3b	2495efg	96	92
Flutriafol	5	0.0a	0.0a	2978bcde	92	88

Formulation:
Treatments 2 & 3: 50 gr/l myclobutanil as suspension concentrate
Treatments 4 - 7: 5% by weight myclobutanil as dry powder
Treatment 8: 15% by weight oxycinolate de cuivre as dry powder
Treatment 9: 2.5% by weight flutriafol as dry powder
* One month after fungicide application
** Ten months after fungicide application

DISCUSSION

These studies show that seed treatment with very low rates of different formulations of myclobutanil as well as the mixture of myclobutanil + mancozeb are able to provide excellent control - equal to the standard treatments - of bunt of wheat and loose smut of barley, under the differing conditions of two seasons and three locations. All myclobutanil rates and formulations, as well as the standard treatments, did not affect germination of seed or tiller survival, even with high rates.

Since the inoculum used in these experiments was a mixture of Tilletia spp spores with high level of insensitivity towards many seed dressing fungicides as well as spores sensitive to those fungicides (Skorda 1977, 1981), it is shown that the treatments used were able to control both, and possibly some new strains since the capacity of Tilletia spp to produce new strains is well known (Kendrick, 1964; Metzger and Kendrick, 1967).

Data over one year indicate that significant yield increases were obtained, with the highest response from the higher control of bunt or loose smut. There was a negative correlation between the bunt or loose smut infection and yield increase.

Myclobutanil has an advantage over organomercury or some other seed treatments of cereals in that it also controls smut disease of barley or some others. Loose smut of barley has been an increasing problem in Greece over the last few years.

This product has a wide margin of crop safety when used as a seed treatment.

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CONTROL OF ASCOCHYTA FABAE ON FABA BEANS

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ABSTRACT

Difficulties have arisen in the production of basic seed of faba bean varieties in recent years because of seed-borne infection with Ascochyta fabae. Trials to identify the best method of controlling the disease have demonstrated that seed dressing with thiabendazole + metalaxyl + thiram coupled with a post-emergence spray with the experimental product CGA 169374 + thiabendazole is very effective. Progress has also been made in the breeding of resistant varieties. In trials, the new winter bean variety Quasar had a lower incidence of disease than standard winter varieties.

INTRODUCTION

Ascochyta fabae Speg. causes leaf, stem and pod spot disease of faba beans (Vicia faba L.), sometimes known as 'Ascochyta blight'. In the UK, the disease is frequently not very damaging, only affecting the lower leaves of plants and possibly blemishing a low percentage of pods and seeds. When conditions are optimum for infection, especially when there is above-average rainfall in May and June and inoculum levels are high, severe damage (premature defoliation and lodging) and loss of crops can occur.

The main source of inoculum is the seed, although volunteer plants and debris from previous crops are also possible sources, and spore dispersal in aerosols may be more important than thought hitherto. Stringent standards of seed health are applied in the UK, as a means of controlling the disease. There are tolerances of 0.1% Ascochyta infection in pre-basic and basic seed, 0.2% in C1 seed and 1% in C2 seed. Breeders and seed merchants have experienced considerable difficulty in meeting the highest standard in recent years and this has resulted in shortages of some varieties and delays in introducing others. We have investigated two approaches to the control of the disease in seed crops; the use of more effective fungicidal treatments and the breeding of resistant varieties.

FUNGICIDE TRIALS

Seed treatments, either as slurries or dips, have been shown to provide some control of A.fabae, although results have been erratic (see Gaunt (1983) for a review). The effectiveness of using chlorothalonil as a foliar spray was investigated by Lockwood et al. (1982) and Jellis et al. (1984), following encouraging reports on its use in Canada (Kharbanda & Bernier 1979) and New Zealand (Liew & Gaunt 1980). Fungicide applied on seven occasions from February onwards significantly reduced the incidence of disease on pods, but seed still did not meet certification standards. Early applications (pre-flowering) were more effective than late ones aimed at protecting pods. In the experiments reported here, the effectiveness of two new fungicides has been studied. 'Apron Combi' is a seed dressing which includes two compounds previously reported to have activity against A.fabae, thiabendazole and thiram, as well as metalaxyl which controls Pythium and other Oomycetes. CGA 169374 is an experimental fungicide, not yet registered by Ciba-Geigy, which is very active against leaf-spotting diseases such as Alternaria on oilseed rape.

PRE-1988 TRIALS

Preliminary experiments with thiabendazole + metalaxyl + thiram (TMT) seed dressing were done at Whittlesford, Cambridgeshire. A PBI Cambridge winter variety, SB-22, with 25% Ascochyta infection in the seed was dressed with TMT at a rate of 300g a.i. per 100kg of seed before drilling. The incidence of young plants with lesions caused by A. fabae was scored in March (Table 1). Later scores would not have been meaningful as the plots did not have guard rows and cross infection would have occured. There is, however, generally a strong correlation between early leaf infection and pod infection (Lockwood et al. 1985).

TABLE 1

Control of Ascochyta fabae by seed treatment

Treatment	% of young plants infected		
	Site 1	Site 2	Site 3
untreated	17.8	15.5	68.0
thiabendazole + metalaxyl + thiram	6.2(65)*	4.0(74)	15.0 (78)

* % reduction compared with untreated

In these trials the seed dressing reduced the incidence of infection by 65%-78% (Table 1). Foliar spray trials to compare chlorothalonil + carbendazim ('Bravocarb') with CGA 169374 were done at Whittlesford in 1986-7 and Trumpington, Cambridge in 1986 only. In 1986, seed of SB22 with 13% Ascochyta infection was used and young plants were also inoculated with pycnospores (5 X 10^5 spores/ml) as described by Lockwood et al. (1985). In 1987 uninfected seed of Maris Bead was planted in a spring trial and inoculated with 5 X 10^5 spores/ml. CGA 169374 and chlorothalonil + carbendazim were applied in 200 l/ha water at concentrations of 125g a.i./ha and 100g a.i./ha respectively pre- and post-flowering. Plots were sprayed using a hand-held precision plot sprayer fitted with Leumark 02F110 flat fan nozzles and operating at 200-210 kPa. All plots were surrounded by guard rows. The incidence of pod infection was recorded as the percentage of pods infected, or as the area of pod infected on a 1-9 scale (Jellis et al. 1985) or expressed as a percentage (Anon. 1976). In addition, at Trumpington, seed was assayed for infection as described by Lockwood et al. (1985).

CGA 169374 reduced infection by 34-66%, compared with 23-42% for chlorothalonil + carbendazim (Table 2). Reduction in seed infection was similar to pod infection for CGA 169374 but greater for chlorothalonil + carbendazim.

TABLE 2

Control of Ascochyta fabae by foliar treatment

		Whittlesford		Trumpington	
		1986	1987	1986	
		% area pods infected		Pod score	% seed infected
Treatment	g a.i/ha				
untreated	-	32.4	59.8	4.3	31.7
Chlorothalonil + carbendazim	900+ 200	18.9(42)*	39.7(34)	3.3(23)	16.7(47)
CGA 169374 125	125	11.1(66)	39.5(34)	1.7(60)	11.7(63)

* % reduction compared with untreated

1988 TRIALS

SB-22 seed with 28% Ascochyta infection was used in experiments at Trumpington and Whittlesford designed to compare the effectiveness of various spraying regimes with CGA 169374 + thiabendazole, seed dressing with TMT and a combination of seed dressing and early foliar spray. At Trumpington, each plot consisted of four 4m rows with seeds spaced at 12 cm and 50 cm between rows. Fungicide treatments, as described in Tables 3 and 4, were applied to plots laid out as a randomized complete block with four replications. Methods of application were the same as those described for the pre-1988 trials. Each plot was surrounded by four guard rows of the resistant variety Quasar. At Whittlesford each plot consisted of 0.5m circular hand-sown tussock plots, each plot being surrounded by a 1.5m barrier of winter barley. The trial consisted of fungicide treatments replicated three times in a randomized complete block design. Infection was scored as the percentage of plants with lesions, and as the area of pod infected expressed as a percentage or on a 1-9 scale.

Control of infection in the foliage and pods by seed dressing and post-emergence spray is shown in Tables 3 and 4. Seed treatment proved to be more effective in these trials than in the previous year, although in the dense tussock plots the small amount of infection in the foliage gave rise to high pod infection. The post-emergence spray gave good control at both sites and a combination of seed plus post-emergence treatment was highly effective in controlling foliar and pod disease at

Trumpington (this treatment combination was not applied at Whittlesford). Later foliar sprays were much less effective. Treating pods alone was effective at Whittlesford only.

TABLE 3

Effect of seed dressing and post-emergence foliar spray on control of *Ascochyta fabae* on foliage.

	Whittlesford	Trumpington	
Treatment	April[x]	April	May
a) untreated	33.3°	12.5	42.7
b) thiabendazole + metalaxyl + thiram	3.7(89)*	0 (100)	3.6(92)
c) post-emergence CGA 1693744 + thiabendazole	2.3(93)	0 (100)	2.0(95)
d) b + c	-	0.2(98)	0.2(98)

° % of plants with lesions, * % reduction compared with untreated, x assessment date

TABLE 4

Effect of fungicide timing on control of pod infection by *Ascochyta fabae*.

	Whittlesford	Trumpington
Treatment	% of area affected	1 - 9 scale
untreated	38.3	4.2
thiabendazole + metalaxyl + thiram	23.3(39)*	1.7(60)
CGA 169374 + thiabendazole applied:		
post-emergence + seed treatment#	-	1.2(71)
post-emergence only	8.0(79)	1.7(60)
stem extension only	20.0(48)	3.7(12)
early flowering only	15.7(59)	3.0(29)
early podding only	3.7(90)	4.0(5)

* % control, # Seed treatment with thiabendazole + metalaxyl + thiram

VARIETAL RESISTANCE

Until recently, there was little evidence to suggest that faba bean varieties differed greatly in resistance to A. fabae. Lockwood et al. (1985) and Jellis et al. (1985) demonstrated that differences do occur. Some of these are phenotypic, such as straw length, but not all differences can be attributed to variation in morphology or maturity. Line IB18-1/3, now called Quasar, is a winter-hardy variety which had good resistance to A. fabae in initial tests. Trials comparing the resistance of Quasar with other winter-hardy varieties are summarized below.

Three trials were carried out at Trumpington, in 1983, 1985 and 1988. Plots were based on the four row module described above but only the inner two rows were sown with the variety being assessed, the outer rows being sown with a standard variety as a guard. Treatments (varieties) were replicated six, five and three times in 1983, 1985 and 1988 respectively. Plots were inoculated in March with pycnospores of A. fabae as described above and primary infection was assessed 1-2 months later. Results demonstrate the high resistance of Quasar (Table 5). Overall, Webo was significantly ($P<0.05$) more susceptible than the other varieties tested except Throws M.S. Other varieties did not differ consistently from each other.

TABLE 5

Incidence of infection* by Ascochyta fabae in winter bean varieties.

Variety	1983[x]	1985	1988	Mean
Webo	-	52.8	41.8	40.8
Throws M.S.	15.8	52.9	-	33.4
Punch	12.0	48.1	-	29.1
Bourdon	10.7	40.2	27.2	26.0
Bulldog	12.0	45.3	20.6	26.0
Boxer	-	43.1	19.7	24.9
Banner	13.5	35.6	23.3	24.1
Quasar	-0.2	8.8	0.5	3.0
S.E.D.	4.06	3.52	4.79	4.90

* % plants infected in spring (adjusted data, transformed to angles)
[x] year of test

DISCUSSION

The new seed dressing combining thiabendazole, metalaxyl and thiram provides control of seed-borne A. fabae. On its own, however, it is unlikely to provide adequate protection of susceptible varieties to ensure seed will be certified at the pre-basic or basic stage. CGA 169374 + thiabendazole gave good results when applied as a post-emergence spray. Although the transmission of infection from seed to foliage is not clearly understood, spores are likely to be carried up on the developing plumule. CGA 169374 is a systemic compound with curative as well as protective properties. Lesion development at this crucial early stage may therefore be prevented, even if spore germination has taken place. Later spray programmes are less effective. This is probably partially due to the high incidence of inoculum at this stage but the difficulty of spraying bean crops pre- or post-flowering is also an important factor. This was demonstrated by the difference in effectiveness of the post-flowering spray in the two trials. In small tussock plots it was much easier to apply the fungicide to the developing pods on the lower part of the plant than it was in row plots. Pod treatment may be worthwhile in breeders' small multiplication plots if Ascochyta is seen on the foliage but is unlikely to be effective when larger plots are being grown. A combination of seed dressing and post-emergence foliar spray will provide the most effective treatment on current evidence.

Fungicide trials to date have been designed to look at the protection of susceptible varieties. Improved Ascochyta resistance is now an objective of the PBI Cambridge breeding programme. Quasar has been used as a parent in the crossing programme and as a component of new composite varieties. Other sources of resistance are being sort. Resistant material is available from the International Center for Agricultural Research in the Dry Areas (Hanounik & Maliha 1984) and some of this has proved to be resistant under UK conditions (unpublished data). Varieties bred from such material should be much easier to protect with fungicides.

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POTATO TUBER DISEASE CONTROL BY SEED TREATMENT WITH TOLCLOFOS METHYL/ PROCHLORAZ MANGANESE CHLORIDE MIXTURES

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ABSTRACT

Tolclofos-methyl has been in successful commercial usage for the control of stem canker and black scurf of potato (Rhizoctonia solani) following its introduction in 1983. Since 1984 some 37 trials have been conducted in the United Kingdom with mixtures of tolclofos-methyl and prochloraz manganese chloride complex to develop a broad spectrum fungicide for application to seed potatoes. Applications made at varying intervals prior to planting have given good control of stem canker, "skin spot" (Polyscytalum pustulans) on stems, silver scurf (Helminthosporium solani), black scurf on tubers at harvest, and silver scurf during storage. Limited evidence of control of black dot (Colletotrichum coccodes) has also been obtained. Crop safety, measured by emergence and yield, has been satisfactory.

INTRODUCTION

Ever increasing demands by processors, retailers and consumers for higher quality potatoes is opening up the market for fungicides able to contribute significantly to production systems needed to meet these demands. Tolclofos-methyl as 'Rizolex[1] 10D', introduced commercially in 1983 (Harris et al. 1986), and the recently introduced Rizolex Flowable has given reliable control of black scurf, one of the major diseases affecting the marketability of the crop. However, the activity of tolclofos-methyl is very specific and gives no control of other blemishing diseases and storage rots.

Knowledge of the spectrum of activity of prochloraz and of its effectiveness against H. solani (Hide & Cayley 1981), P. pustulans (Hide & Cayley 1982), P. exigua var foveata and Fusarium spp (Hide & Cayley 1980) prompted trials which commenced in 1984, to develop mixtures of tolclofos-methyl and prochloraz manganese chloride complex (hereafter called prochloraz Mn) as seed tuber treatments for broad spectrum disease control. Progress to date is reviewed in this paper.

MATERIALS AND METHODS

Seed potatoes

All seed was from commercial certificated stocks.

Chemicals

tolclofos-methyl
- 100 g a.i./kg dust
- 250 and 500 g a.i./l SC

prochloraz Mn
8g a.i./kg dust
500g a.i./kg WP

prochloraz Mn/tolclofos-methyl co-formulations
8/100g a.i./kg dust
150/375g a.i./kg WP

pencycuron
125g a.i./kg dust

imazalil
200g a.i./l EC

thiabendazole
20g a.i./kg dust

Application

Dusts were applied by agitating together appropriate weights of product and potatoes in a paper sack immediately prior to planting. Sprays were applied either

i) by hand using a Binks Bullows cellulose spray gun

ii) through 2 Delavan HB 1.25 hollow cone nozzles positioned 35cm above tubers passing over a roller table.

iii) through a single Mantis CDA spray head positioned as for ii).

For methods i) and ii) chemicals were delivered in a volume equivalent to 2 l/t of potatoes and for iii) at 250-600 ml/t depending on the water dilution required to achieve a satisfactory atomisation.

Trial layout

These ranged from small plot trials with plots 2 row x 10m to grower type trials of 2-4 rows x field length for each treatment from which 5 x 5m lengths of row were selected for asessment.

Assessments

Stem diseases
Using the following key 15-50 stems were assessed from each plot

0 = no canker
1 = 1 small lesion
2 = 1 moderate or 2-3 small lesions
3 = 1 severe or 4+ small lesions
4 = stem girdled or stolon nipped off

A disease index was calculated using the following equation

$$\text{index} = \frac{(nx1) + (nx2) + (nx3) + (nx4)}{y \times 4} \times 100$$

n = number of stems in each category
y = total number of stems assessed (including zeros)

Tuber diseases

Using ADAS scales, 100-150 tubers were assessed for disease severity at harvest and after periods of up to 25 weeks' storage.

Yield

The total yield, or yield from 10 plants from each plot was recorded.

RESULTS

Crop emergence and yield

Crop safety to date has been satisfactory. Minor reductions in emergence with tank-mixed spray application during 1984-86 (Table 1) were not reflected in yield and in 1988 the same treatment applied as a co-formulated wettable powder was completely safe (Table 2).

TABLE 1

Final crop stand and yield of maincrop potatoes (1984-1986)

Treatment	g a.i./tonne	final stand	relative yield (% of untreated)
DUSTS			
prochloraz Mn	20	101 (11)	98 (9)
	50	100 (9)	103 (7)
tolclofos-methyl	250	97 (27)	100 (22)
prochloraz Mn/tolclofos-methyl	20/250	99 (15)	98 (13)
pencycuron	250	99 (4)	103 (4)
thiabendazole	60	99 (4)	94 (4)
SPRAYS			
prochloraz Mn + tolclofos-methyl	20+250	98 (4)	103 (6)
prochloraz Mn + tolclofos-methyl	50+125	90 (15)	99 (14)
tolclofos-methyl	125	97 (15)	98 (14)
imazalil	10	100 (15)	101 (13)

( ) = number of trials
\+ = tank mixture
/ = co-formulation

Disease control

Stem lesions caused by P. pustulans were well controlled by 50g a.i./t prochloraz Mn (Tables 2 & 3). Reductions in severity were at least equivalent to thiabendazole and imazalil. All tolclofos- methyl containing treatments gave good control of stem-canker and prochloraz Mn + tolclofos-methyl (50 + 125g a.i./t) was particularly effective.

Despite the occurrence of "skin spot" on the stems in 1984-86 trials none was found on the tubers at harvest or after storage; 1988 data will be presented late if available. Prochloraz Mn + tolclofos-methyl (50 + 125 g a.i./t) gave excellent control of silver scurf in one trial, and meaned over 7 trials, a co-formulated dust (20/250g a.i./t) was twice as effective as imazalil (10g a.i./t). Alone and in mixture with tolclofos-methyl, 50g a.i./t of prochloraz Mn was superior to 20g a.i./t. All treatments containing tolclofos-methyl gave excellent control of black scurf. On the basis of more limited data, there is some evidence that black dot may be controlled by tolclofos-methyl.

TABLE 2

Final stand and disease control in maincrop potatoes (1988)

Treatment	g a.i./ tonne	Final stand relative to untreated (100)			% control of skin spot on stems		
		Dusts	Sprays Mantis/	Hydraulic	Dusts	Sprays Mantis/	Hydraulic
DUSTS - applied at planting							
tolclofos-methyl	125	101			16		
thiabendazole	60	105			38		
pencycuron	250	102			33		
SRAYS - applied pre-planting							
prochloraz Mn/tolclofos-methyl	50/125		103	102		59	78
tolclofos-methyl	125		101	103		34	54
imazalil	10		104			51	
No of trials			5			4	

Little disease developed on stored potatoes. However, in one trial silver scurf was assessable and developed to a much lesser extent on progeny from prochloraz Mn treated seed than from untreated seed. Imazalil and thiabendazole were also effective but inferior to prochloraz Mn.

TABLE 3

Stem and tuber disease control in maincrop potatoes (1984-1986)

		% CONTROL					
		STEM DISEASES		TUBER DISEASES			
				at harvest			post-storage
Treatment	g a.i./tonne	skin spot	stem canker	silver scurf	black scurf	black dot	silver scurf
DUSTS							
prochloraz Mn	20	68 (8)	28 (8)	28 (7)	17 (8)	24 (4)	
	50	78 (5)	17 (5)	53 (3)	12 (5)	10 (3)	74 (1)
tolclofos-methyl	250	24 (14)	72 (19)	22 (8)	90 (15)	66 (5)	22 (1)
prochloraz Mn/tolclofos-methyl	20/250	70 (11)	75 (11)	53 (7)	86 (9)	35 (5)	72 (1)
pencycuron	250	45 (3)	52 (3)		54 (1)	0 (1)	29 (1)
thiabendazole	60	81 (3)	55 (3)		27 (1)	0 (1)	58 (1)
SPRAYS							
prochloraz Mn + tolclofos-methyl	20+250	62 (6)	76 (3)	54 (1)	86 (4)	12 (2)	
prochloraz Mn + tolclofos-methyl	50+125	78 (6)	92 (11)	87 (1)	87 (7)	57 (1)	77 (1)
tolclofos-methyl	125	48 (6)	64 (11)	9 (1)	86 (7)	7 (1)	4 (1)
imazalil	10	55 (11)	18 (11)	26 (7)	26 (9)	7 (5)	58 (1)

( ) = no. of trials

DISCUSSION

Quality standards for potatoes continue to be raised and the reduction of disease is an increasingly important objective to help meet them. Tuber diseases fall into two main categories; rotting diseases in store such as dry rot and gangrene and blemishing diseases such as skin spot, silver scurf and black scurf. Losses during storage or as a result of poor marketability are potentially high but can be minimised by the use of suitable fungicides (Jennings 1985, Anon 1985). Trials results, with mixtures of prochloraz Mn and tolclofos-methyl applied to seed tubers, show substantial reductions in stem, tuber and storage diseases. Reductions in stem disease are of benefit, allowing more rapid crop establishment and a reduction in inoculum sources of threat to the progeny tubers. Reductions in tuber diseases are of particular significance, firstly by minimising direct losses through rotting and water loss, and secondly by maintaining the appearance of the produce - either ware or seed - enabling it to be sold at a premium.

Recent studies are providing evidence that resistance to thiabendazole in populations of H. solani has developed (Hide & Hall 1986). The mixtures reported here offer not only broad spectrum activity but a different mode of action from thiabendazole and therefore have excellent potential in disease control programmes.

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[1] Registered trade mark of Sumitomo Chemical Co Ltd, Osaka, Japan

NEW FUNGICIDE DEVELOPED BY THE CHEMICAL COMPLEX OF BORSOD, HUNGARY, CONTAINING ALUMINIUM-ETHYL-PHOSPHONATE AND COPPER-OXYCHLORIDE AS ACTIVE INGREDIENTS

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ABSTRACT

A new formulation of EPAL + copper-oxychloride is described in this paper. A special formulation agent is incorporated into the formulation which elicits a synergistic fungicidal activity of the two active materials.
The new formulation is registered in Hungary for use on vines and hops, but the registration is also in progress for other crops.

INTRODUCTION

Over the last ten years the active fungicidal ingredient EPAL patented by Rhone-Poulenc was utilized as a component of certain fungicidal formulations. These formulations contain other active ingredients, too, (e.g. Folpet/N-(trichloro-methylthio-phtalimide/, or dithio-carbamates) and are marketed under the trade mark "MIKAL[R]".

MIKAL 75 WP has been known and used in plant protection technology in Hungary since 1982. In order to make this technology more effective and to make the choice of fungicides wider the Borsoki Vegyi Kombinát (Chemical Complex of Borsod) has developed a new MIKAL formulation called MIKAL C 64 WP, which was registered first in Hungary in 1988.
Plant parasitic fungi belonging to the Peronosporales cause significant losses of yield in Hungary. Our new product proved to be very effective against them. This paper demonstrates some chemical, toxicological and biological properties of our new product.

Chemical and physical properties

Active ingredients: 46 ± 2.5% aluminium tris (ethylphosphonate) and 18 ± 2.0% Cu in the form of copper-oxychloride.
Formulation: wettable powder (WP)
Impurities are in very low concentration (less than 1%)
Wettability of formulation: max. 120 sec
Floatability of formulation: min. 80%
Solubility: formulation in water is stable, but it is degradable in acidic or alkaline conditions.

Toxicology of formulation

Acute oral LD_{50} to rats: 207 mg/kg

Acute dermal LD_{50} to rats: greater than 5000 mg/kg

Inhalation LC_{50} to rats: greater than 3000 mg/m^3

Skin irritation to rabbit: negative

Eye irritation to rabbit: irritative, index: 24.3
Mutagenicity: neither EPAL, nor copper-oxychloride have mutagenic effects in Ames tests.

Biological properties

In connection with the fungicidal activity of the active ingredients incorporated into MIKAL C 64 WP we can conclude that both of them are well known fungicides. One of them (EPAL) has a very interesting biological activity, namely, it has a special induction role in the production of phytoalexins in host plants, when the fungicide and the hyphae of the parasite are jointly present in the host-plant tissues.

On the other hand, copper-oxychloride has a well known contact fungicidal activity against a number of plant pathogenic parasites.

At the same time, we have to note that unfavourable interaction between aluminium and copper ions may occur during joint use of them. To avoid this a special adjuvant was incorporated into the new formulation of these active materials. Using this adjuvant not only the mentioned interactions between metal ions were removed, but a synergistic fungicidal activity of MIKAL C 64 WP also appeared.
This new product was first registered in Hungary under registration number 34.246/1988.

MATERIALS AND METHODS OF FIELD EXPERIMENTS

In the following we demonstrate some samples concerning the biological activity of MIKAL C. These experiements were carried out in the main grape producing area of Hungary.

In these experiments, effectiveness of fungicides was calculated, based on the infection rate of leaves or bunches using a scale as follows:

0 = without infection; 1 = up to 10% infection;
2 = 11 - 25% infection; 3 = 26 - 50% infection;
4 = greater than 50% infection estimated on the leaf surfaces or on the bunches. From these data (200 leaves or 50 bunches in each plot) an infection index - showing the rate of pathogen infection - was calculated by the following formula:

$$\text{infection index} = \frac{\Sigma\, a_i \cdot f_i}{n}; \text{ where}$$

a_i = individual values of infection according to the scale mentioned above;
f_i = frequency of a_i values;
n = total of estimated leaves or bunches.

Depending on these data, the effectiveness of fungicides was also calculated using Abbot's formula.

RESULTS

Tables 1 and 2 summarise an experiment in which grape plants were artifically contaminated with spores of Plasmopara viticola.

TABLE 1

Effectiveness of MIKAL C on Plasmopara viticola

Treatments	Conc. of spray %	Infection index
Standard 1	0.4	0.00
Standard 2	0.2	0.00
Formulation 1	0.4	0.00
	0.2	0.12
	0.1	0.25
Formulation 2	0.4	0.00
	0.2	0.00
	0.1	0.25

Standard 1: Fungicide containing 50% EPAL + 25% folpet
Standard 2: Fungicide contianing 15% metalayl and 15% copper-oxychloride
Formulation 1: Experimental fungicide containing EPAL + copper oxychloride (20:70)
Formulation 2: MIKAL C 64 WP

TABLE 2

Effectiveness of MIKAL C against *Plasmopara viticola* in a field experiment

Treatments	Doses (kg/ha)	Infection of *Plasmopara viticola*						
			Aug 15		Sept 2		Sept 15	
			Inf. Ind.	Perc. of effect	Inf. ind.	Perc. of effect	Inf. ind.	Perc. of effect
Standard 1.	3.0* - 4.0**	L.	0.00	100	0.09	93.7	0.03	97.0
		B.	0.00	100	0.00	100	0.00	100
Standard 2.	1.5* - 2.0**	L.	0.00	100	0.01	98.0	0.02	98.0
		B.	0.00	100	0.00	100	0.00	100
MIKAL C	3.0* - 4.0*	L.	0.00	100	0.05	96.0	0.03	97.0
		B.	0.00	100	0.00	100	0.00	100

* : before flowering

**: after floweriing

L = leaves

B = bunches

BF-51 90 WSC: A NEW FUNGICIDE DEVELOPED BY CHEMICAL COMPLEX OF BORSOD

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ABSTRACT

A new fungicide containing 3-isononyl-oxipropil-ammonium-methyl-phosphonate is presented in this paper. Its formulation is a water-soluble concentrate. The product is recommended for use as a seed dressing in maize, winter wheat and rye or as a foliar spray in tobacco crops.

INTRODUCTION

Seed dressing of crop grains is of great economic importance in modern agriculture and many pesticides are in use for this purpose. BF-51-90 WSC is a new fungicide discovered and patented at the beginning of the 1980's and developed by the Borsodi Vegyi Kombinát (Chemical Complex of Borsod, Hungary).

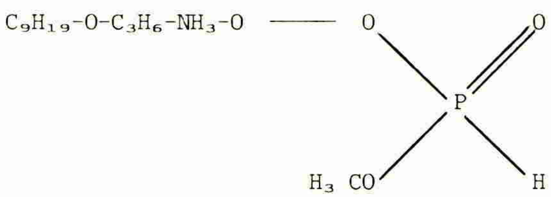
The main field of application of this fungicide is seed dressing of winter wheat and maize, but it is also usable as leaf-spray against Peronospora tabacina.

Its active ingredient (3-isononyl-oxipropyl-ammonium-methyl-phosphonate) belongs to the alkyl-ammonium-phosphonate class, which was first presented in 1983 (Sutak *et al*. 1983).

The main chemical, biological and toxicological properties of BF-51 90 WSC and its ingredient will be described in this paper.

Chemical and physical properties

Molecular structure:



Common name of a.i.:	izopamphos
Chemical name:	3-isonyl-oxipropyl-ammonium -methyl-phosphonate
Empirical formula:	$C_{13}H_{32}NO_4P$
Molecular weight:	297.394
Physical state:	liquid
Density:	979.0 kg/m³ (25°C)
log. P-octanol/water:	1.216±0.04 (25°C)

Formulation: water soluble concentration (WSC)

Toxicology of technical material: (Examined by the Toxicological Lab. of Hungarian Centre of Plant Protection and Agrochemistry, Keszthely.)

Acute orale LD_{50} to rats:	a.)	male:	1850 mg/kg
	b.)	female:	1700 mg/kg
Acute dermal LD_{50} to rats:		greater than	10700 mg/kg
to rabbits:		greater than	5000 mg/kg
Intraperitioneal LD_{50} to rats:		male:	66 mg/kg
		female:	55 mg/kg
Inhalation LC_{50} to rats:		greater than	3200 mg/kg
Eye irritation to rabbits:	a.)	undiluted (conc.) active ingredient: very strong	
	b.)	diluted formulation (used in practice): negative	
Skin irritation to rabbits:	a.)	undiluted: severe erythema 24 h	
	b.)	diluted formulation after irrigation: negative	
Mutagenicity to micro-organism:		Salmonella assays: negative	
Teratogenicity to rats and rabbits:		neither teratogenicity or maternal toxicity occured at 500 mg/kg dietary level.	

Other studies concerning the subchronic toxicological properties of the material were also carried out and, from the point of view of registration, they also showed favourable properties. The toxicological "no effect" level following dietary studies for 90 days was 200 ppm in rats. Mutagenicity studies to higher organisms (mammalian) also showed negative results.

MATERIALS AND METHODS

In the laboratory *in vitro* tests the fungicide BF-51 was homogeneously mixed with fungal nutritive media. These media were contaminated with inocula of different plant pathogens. Fungicidal activity was assessed upon the growth of fungi in comparison with that of the untreated controls. In fungicidal tests against *Tilletia caries* and *Tilletia foetida* seeds of winter wheat were inoculated with spores of pathogens and after seed treatment they were sown and fungicidal activity was estimated by calculation of the infection rate of ears in the next year. So as to estimate the efficacy of seed treatments, dressed seeds were also put on the surface of nutritive media and the growth rate of fungi was calculated and compared with the untreated ones.

In the field experiments not only the fungicidal effect of different treatments, but the percentage of germination and the amount of yield were also measured.

In those experiments where the fungicide was applied as a foliar spray, the effectiveness was calculated based upon the infection percentage of leaves.

RESULTS

Some results obtained in the laboratory and greenhouse tests were already demonstrated earlier (Csutak _et_ _al_., 1983). In this paper the field experiments and their results will be summarised. In these experiments the fungicide BF-51 90 WSC was applied as a seed dressing agent of winter wheat, maize and rye and as a foliar spray in tobacco crops.

Tables 1 and 2 show the fungicidal activity of BF-51 90 WSC against _Tilletia_ spp. in field experiments and against different soil-born and leaf infecting pathogens.

TABLE 1

Fungicidal activity of BF-51 90 WSC against _Tilletia_ _foetida_ and _caries_.

Treatments	Doses kg/t	Number of total ears m^{-2}	Number of infected m^{-2}	Percentage of infection
Békéscsaba, 1983. (mean values of 4 replications)				
Untreated contaminated	-	1924	1293	67.20
Standard No.1.	2.0	1984	2	0.10
BF-51 90 WSC	2.0	2002	3	0.10
	4.0	2000	2	0.10
Gyor, 184. (mean values of 4 replications)				
Untreated contaminated	-	1694	509	30,220
Standard 1	2.0	1513	1	0,000
Standard 2	2.5	1552	2	0,000
BF-51 90 WSC	1.0	1505	9	0,005
	2.0	1521	2	0,000
	3.0	1516	1	0,000

Standard 1: seed dressing fungicide containing active ingredients as follows: 50% carboxin + 15% oxine-copper
Standard 2: seed dressing fungicide containing active ingredients as follows: 22.5% carbendazim + 7.5% oxine-copper

TABLE 2

Effect of BF-51 90 WSC on the growth of fungi (in vitro lab. test)

Pathogens	Diameters of colonies (mm) on media containing fungicide in following conc. (ppm)						
	1	10	50	100	500	1000	Untreated
Alternaria alternata	23.8	12.5	m	0	0	0	28.5
Alternaria dianthi	25.0	20.5	m	0	0	0	28.0
Alternaria solani	26.5	14.8	0	0	0	0	29.0
Rhysoctonia solani	26.0	24.5	18.8	m	0	0	28.0
Pythium debarionum	10.5	6.5	0	0	0	0	29.0
Fusarium culmorum	24.0	21.8	3.5	0	0	0	29.0
Fusarium oxysporum	27.0	25.5	5.8	0	0	0	27.5
Fusarium oxysporum f. sp. *dianthi*	26.0	23.8	6.5	0	0	0	28.5

Effect of seed dressing with BF-51 90 WSC on *Fusarium* spp. and *Aspergillus* spp. on winter wheat and maize is demonstrated in Table 3.

TABLE 3

Effect of BF-51 90 WSC seed treatment on _Fusarium_ and _Aspergillus_ spp. (Data are mean values of 4 replications.)

Treatments	Doses kg/t	Percentage of infection _Fusarium_ spp. (wheat)	_Aspergillus_ spp. (maize)
Untreated	-	93.0	89.0
Standard No.1	2.0	2.0	-
Standard No.3	2.0	-	0.0
BF-51 90 WSC	1.0	5.6	0.0
	2.0	4.3	0.0
	3.0	2.0	0.0

Standard No.3 is a seed dressing fungicide containing 30% captan.

TABLE 4

Effect of BF-51 90 WSC on different seed-born pathogens of winter wheat

Treatments	Doses kg/t	Number of infected seeds (total: 200) _Fusarium_ spp.	_Alternaria_ spp.	_Penicillium_ spp.	_Acremoniella_ spp.	_Trichotecium_ spp.
Untreated	-	37	66	32	13	7
Standard No.4	2.5	2	15	4	0	0
BF-51 90 WSC	2.0	1	20	2	0	0

Standard No.4 is a seed dressing fungicide containing 22.7% thiophanate-methyl + 7.5% oxine-copper

TABLE 5

Effect of BF-51 90 WSC seed dressing on germination and yield of maize (cv. Pi Sc 3732). Field plot experiment. (Debrecen, 1985.)

Treatments	Doses	% of germination (in 2 leaves stadium)	Yield t/ha
Standard No. 3.	2.5	57.6	7.91
Standard No. 5.	2.0	50.2	6.01
BF-51 WSC	1.0	61.8	7.98
	1.5	68.9	7.70

Standard No. 5. is a fungicide (WP) containing 50% captan as the active ingredient.

From the results obtained in the experiments from 1981 to 1987, we can conclude that BF-51 90 WSC is a good fungicide which is suitable for seed dressing treatment of maize, winter wheat and other cereals.

Moreover depending on some field experiments in which the fungicide was applied as a foliar spray we can also state that it has a good controlling effect on some of leaf pathogenic fungi, primarily on *Peronospora tabacina*.

DISCUSSION

The first communication concerning the biological activity of alkyle-phosphonate-type compounds was published in 1983 (Csutak *et al*. 1983). Since that time the Borsodi Vegyi Kombinat (Chemical Complex of Borsod) has developed a new fungicide containing one of the active ingredients belonging to this chemical class.

The fungicide is recommended for use as a seed dressing agent of winter wheat at a dose of 2.0 l/t against *Tilletia* spp. and/or other soil-born pathogens. It is also suitable for the treatment of maize and rye seeds against pathogens during seed germination. The recommended doses are as follows: wheat: 2.0 l/t; maize: 1.5 l/t; rye: 2.0-2.5 l/t. Mode of treatment is wet seed dressing technology. This should be carried out with water in doses of 4-20 l/t depending on the seed dressing equipment used.

Applied as a foliar spray the BF-51 90 WSC (without colouring agent) is suitable against *Plasmopara tabacina* at a dose of 2 l/ha.
Volume of spray to be used: 600-1000 l/ha.
Duration of interval between two treatments is 10-14 days.

BF-51 90 WSC is a newly registered fungicide in Hungary. Registration procedures are in progress in some other countries as well (Yugoslavia, Czechoslovakia, the Soviet Union, Thailand etc.)

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FIELD TRIAL RESULTS IN THE UK WITH CGA169374 - A NEW FOLIAR FUNGICIDE AGAINST ARABLE CROP DISEASES

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ABSTRACT

CGA169374 is a new systemic triazole fungicide with good activity against fungi in the Ascomycotina, Basidiomycotina and Deuteromycotina. The strengths of this fungicide for UK arable crops lie in the control of Septoria spp, Alternaria spp, Puccinia spp and Ascochyta spp, making it particularly effective as a late-season treatment for winter wheat as well as offering excellent disease control in oilseed rape, horticultural brassicas and beans.

INTRODUCTION

CGA169374 is a new systemic triazole discovered and patented by Ciba-Geigy Ltd. It has been tested under field conditions in the United Kingdom since 1985. The molecule has outstanding activity against a number of diseases in a wide range of economically important crops. The particular strengths of this molecule are its excellent control of leaf spot diseases of many crops; along with the Cladosporium + Alternaria complex of winter and spring wheat.

This paper reviews the field performance of CGA169374 as a foliar spray against the major leaf spot diseases of arable crops in the United Kingdom.

Materials and Methods

Replicated trials were carried out in commercially-grown crops of wheat, oilseed rape, brussels sprouts, cauliflower and Vicia beans. All crops were selected as being at particular risk from attack by the target pathogens. All trials were sprayed using a hand-held precision plot sprayer operating at between 200 - 210 k Pa. Treatments were applied in 200 l/ha water using Lurmark 02F110 fan jet nozzles except in the case of horticultural brassicas where the water volume was 800 l/ha and nozzles used were Lurmark 06F110. All trials were of complete randomised block design.

Cereal, oilseed rape and bean trials were harvested using Claas Compact 25 or Hege 125C combine harvesters. Horticultural brassica trials were hand-harvested and graded.

Cereals

Plots were usually 3m x 12m, replicated five times. Applications were made mostly between GS55 and GS65 although additional data is included here to demonstrate the effect of application timing on the control of Septoria tritici with this fungicide.

Oilseed rape

Plots were 4m x 12m except in Scotland where 2.5m x 8m was used since these trials were not harvested. All trials were replicated four times. Trials in Scotland were selected to be particularly at risk of attack by light leaf spot (*Pyrenopeziza brassicae*) and were treated twice; in the autumn at the "green carpet" stage and again at stem extension in the early spring. Trial sites in East Anglia were selected for likely attack by light leaf spot and dark leaf and pod spot (*Alternaria* spp). Treatments were applied in various combinations of a) stem extension, b) 20-pod stage, c) 95% petal fall.

Horticultural brassicas

Trials were located in Cambridgeshire and Bedfordshire using a plot size of two rows of 10m length replicated four times. Three applications were made, at 14-day intervals commencing at the first signs of disease attack. At harvest, total yields of produce were recorded and, more importantly, the yield of class 1 buttons or curds.

Beans

Plots were either 1m x 4m or 3m x 10m replicated four times and trials were located in East Anglia. Treatments were applied at the flowering stage of the crop in 1986 and 1987, but earlier application was made in 1988. Repeat applications were made in most trials.

RESULTS

Winter wheat

CGA 169374 is highly active against *Septoria tritici*; being more effective than propiconazole or triadimenol. (Table 1).

TABLE 1

The Control of *Septoria tritici* using CGA 169374

	kg a.i./ha	% leaf area infected 19 days after treatment at GS64 - 75 (mean of 7)	% yield increase over untreated
untreated		34.0	(6.38 t/ha)
propiconazole	0.125	8.9	+ 9
triadimenol	0.125	14.8	+ 9
CGA 169374	0.075	3.6	+ 10
"	0.125	3.0	+ 12
"	0.250	2.1	+ 14
Tukey LSD (P=0.05) (Sokal and Rohlf 1981)		5.1	10%

Six trials carried out during 1987 showed clearly that CGA 169374 at 0.125, kg a.i./ha gave superior control to prochloraz at all timings studied (GS31-32, GS33-37, GS39 and GS55). Superiority of CGA 169374 was most evident at the later applications indicating the effectiveness of the fungicide against late attacks (Table 2).

TABLE 2

The effect of application timing on the control of Septoria tritici by CGA 169374, evaluated at GS69-75, 9 - 17 July (Zadoks and Chang 1974)

		kg a.i./ha	% leaf area infected, mean of 6 trials	% leaf area infected, trial 004	% yield increase (mean of 6)
	untreated		29.2	43.8	(5.2 t/ha)
GS31-32	propiconazole	0.125	14.0	15.4	+ 5%
	prochloraz	0.400	20.0	30.4	+ 0%
	CGA 169374	0.125	14.3	22.0	+ 2%
33-37	propiconazole	0.125	14.3	23.2	+ 6%
	prochloraz	0.400	17.0	29.8	+ 7%
	CGA 169374	0.125	8.8	7.4	+ 7%
39	propiconazole	0.125	8.1	14.0	+ 8%
	prochloraz	0.400	10.1	16.2	+ 8%
	CGA 169374	0.125	6.1	9.0	+12%
55	propiconazole	0.124	12.9	16.8	+ 8%
	prochloraz	0.400	11.4	23.4	+ 7%
	CGA 169374	0.125	8.0	4.9	+ 4%
Tukey LSD (P=0.05)			6.5	10.2	11%

Over four seasons of testing, many trials were treated at GS55-69 to give protection of the top leaves and ears against late attacks of Septoria spp and other ripening diseases. Of particular note are the results given in Table 3 showing the excellent control of sooty moulds given by CGA 169374, clearly superior to the standards tested. CGA 169374 also gives excellent control of brown rust (Puccinia recondita).

TABLE 3

The control of sooty moulds (Cladosporium spp, Alternaria spp)

	kg a.i./ha	Index of attack* 1985 6 trials	1986 7 trials	1987 4 trials	1988 8 trials
untreated		3.0	3.0	2.0	2.1
propiconazole	0.125	3.0	2.8	1.8	1.3
flutriafol + captafol	0.118+0.938	3.0	-	-	-
CGA169374	0.075	1.2	1.4	1.2	0.9
"	0.125	0.6	0.3	1.3	0.6
"	0.250	0	0	-	-

* sooty moulds were recorded as mean ear colour using an index of 0-3 where 3 = heavily infected, black ears and 0 = completely golden

TABLE 4

The Control of brown rust (*Puccinia recondita*) with CGA 169374

	kg a.i./ha	% flag leaf attacked 32 days after treatment (trial 001 88)	% flag leaf attacked 32 days after treatment (trial 004 88)
untreated	-	21.0	62.0
propiconazole	0.125	6.6	22.0
flutriafol + chlorothalonil	0.118 + 0.75	16.4	-
CGA 169374	0.075	4.2	8.0
"	0.125	1.8	4.0
fenpropimorph	0.75	3.9	-
Tukey LSD (P=0.05)		5.1	14.7

Oilseed Rape

CGA 169374 was active against light leaf spot (*Pyrenopeziza brassicae*). There was, however, a clear benefit to be gained from early application of this fungicide, before first symptom expression. Table 5 shows that, when used protectively, the control given by CGA 169374 was a little weaker than prochloraz; and was improved by the addition of carbendazim.

TABLE 5

The control of light leaf spot on oilseed rape by CGA 169374 (1987/88) (% leaf infection)

	kg a.i./ha	(1) protective application (Nov 1987 and Mar 1988) (mean of 2)	(2) application at stem extension only (mean 3)
untreated		11.7	14.9
prochloraz	0.2, 0.3	2.7	3.5
carbendazim	0.25	3.8	-
CGA 169374	0.063	3.8	-
"	0.125	3.4	8.3
propiconazole	0.125	7.8	-
CGA 169374 + carbendazim	0.125 + 0.25	-	3.5
CGA 169374 + carbendazim	0.075 + 0.25	-	5.9
Tukey LSD (P=0.05)		3.8	4.2

The fungicide was also particularly effective against Alternaria spp., both on the leaves and the pods. In several heavily attacked trials, CGA 169374 gave similar control to the iprodione standard.

TABLE 6

The control of Alternaria on oilseed rape by CGA 169374

	kg a.i./ha	% surface attacked on pods 1987 (mean of 3) (applications at 20-pod stage)	% surface attacked on pods 1988 (applications at 95% petal fall stage)	1988 Yield (t/ha)
untreated	-	64.3	20.0	2.55
iprodione	1.0	27.3	1.0	3.07
CGA 169374	0.125	21.7	0.8	3.19
"	0.250	15.4	-	
Tukey LSD (P=0.05)		13.4	4.2	0.81

Horticultural brassicas

CGA 169374 was extremely active in trials against Alternaria spp on Brussels sprouts and cauliflowers. Excellent control of leaf infections was given but most important are the clear quality gains in button quality achieved by treatment with this fungicide.

TABLE 7

The Control of Alternaria spp on Brussels sprouts with CGA 169374

	kg a.i./ha	% leaf area infected (2 trials)	yield (kg/plot)	% class I buttons
untreated		18.75	3.63	29.3
metalaxyl + chlorothalonil	0.15 + 1.0	10.75	3.10	61.0
CGA 169374	0.125	5.5	3.48	63.5
CGA 169374 + metalaxyl + chlorothalonil	0.075 + 0.15 + 1.0	7.25	3.54	73.5
Tukey LSD (P=0.05)		4.9	0.80	8.4

Beans

Trials over four years show CGA 169374 to be highly active against *Ascochyta* spp on field beans. Good disease control is maintained throughout the late season and results in clean pods at crop maturity, thus minimising the chance of seed infection, a factor important in both seed and processing crops.

TABLE 8

The Control of *Ascochyta fabae* on field beans with CGA 169374

	kg a.i./ha	% leaf area infected trial 6400188	% pods infected at senescence, trials 6400188	0400188
untreated	-	30.0	43.3	38.3
CGA 169374	0.125	0.5	1.0	0.3
chlorothalonil	0.5	-	5.3	5.7
Tukey LSD (P=0.05)		8.6	26.6	20.5

DISCUSSION

The results presented in this paper show CGA 169374 to be a highly effective fungicide for the control of many diseases in a wide range of economically important crops in the UK. Of particular importance is the persistent control of late-season diseases in wheat and in oilseed rape thus complementing the activity of other fungicides suited to earlier season use. This fungicide also provides a valuable aid for the production of quality horticultural brassicas and to aid the seed trade to combat *Ascochyta* in field beans and related crops.

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CHEMICAL CONTROL OF POWDERY MILDEW AND RUSTS IN COMMON WHEAT IN NORTHERN ITALY

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ABSTRACT

The effectiveness of new ergosterol biosynthesis inhibiting fungicides was studied in field trials against powdery mildew and rusts on common winter wheat (cv. Irnerio) . All tested fungicides exerted a good activity against powdery mildew and effective control also on rusts with some differences among the products. The highest yield increases (7-10%) were obtained either by a single application at heading or by two treatments at shooting and heading. No significant differences in yield increases were noticed between the two application timings.

INTRODUCTION

Powdery mildew (<u>Erysiphe graminis</u> f.sp.<u>tritici</u>) and rusts are the most important diseases in common wheat in Northern Italy. Powdery mildew occurs in most years mainly in period between shooting and heading. Brown rust (<u>Puccinia recondita</u> f.sp.<u>tritici</u>) is present every year,yellow rust (<u>Puccinia striiformis</u>) is less frequent,stem rust (<u>Puccinia graminis</u> f.sp.<u>tritici</u>) is sporadic in epidemic form but it is more destructive.

This paper presents the results of some trials carried out in order to test the activity of new ergosterol biosynthesis inhibiting fungicides applied in different times against these diseases.

MATERIALS AND METHODS

The trials were carried out from 1983 to 1986 in Bologna district on cv.Irnerio (common wheat) seeded in medium-textured soil. Randomised block design with 4 replications and a plot size from 21 to 35 m^2 was used.The seeds were treated with mancozeb. Weed control was obtained with pre-emergence applications of methabenzthiazuron and manuring was realized with 190 units/ha of nitrogen. The treatments were applied by precision plot sprayers at 4 bar pressure and in water volume of 800 l/ha at growth stage (G S) 32 and/or in G S 58-59 (Zadoks et al, 1974).

Assessments were made on 100 plants per plot and the percentage area of leaf covered by disease or the percentage of stems infected were recorded. Yield was measured using a combine harvester modified for trials work and all grain yelds were corrected to 13% moisture content.

Tested products are reported in Table 1

RESULTS

In trial carried out in 1983-84 (Table 2) all fungicides exerted a good activity on powdery mildew preventing completely the infection of the flag leaf. A good effectiveness was showed also against the rusts but some products revealed a better protection: flutriafol, triadimenol+carbendazim and diniconazole on *P. recondita*; flutriafol and triadimenol (alone or mixed with carbendazim) and diniconazole on *P. graminis*.

All fungicides increased significantly the yield (7-8%) compared to unsprayed but there were no significant yield differences between treatments.

In year 1984-85 (Table 3) the tested fungicides showed a good control of powdery mildew with all treatment timings. Against yellow and brown rusts the products exerted a better

TABLE 1

Fungicides tested

Fungicide	% a.i.	Product
Triadimefon	5.0	Bayleton PB
Triadimefon+carbendazim	12.5+25.0	Bayleton BCM
Triadimenol	5.0	Bayfidan EW
Triadimenol+carbendazim	12.5+25.0	Bayfidan BCM
Propiconazole	10.6	Tilt 10 EC
Flutriafol	12.5	Impact
Flutriafol+carbendazim	9.4+20.0	Impact R
Diniconazole	12.5	-
Cyproconazole	10.0	-
Flusilazol	40.0	Nustar 40 EC
HWG 1608	12.5	-
Fenpropimorph	79.5	Corbel

TABLE 2

Control of powdery mildew (Erysyphe graminis) and rusts (Puccinia recondita, and Puccinia graminis) in 1983 - 1984

Treatment	Dosage g a.i./ha	Leaf infection % E.graminis 18* F.l.-1	E.graminis 18* F.l.	E.graminis 28* F.l. -1	E.graminis 28* F.l.	P.recondita 28* F.l. -1	P.recondita 28* F.l.	P.recondita 40* F.l.	Stems infected % P.graminis 40*	Yield t/ha	Yield Relative
Triadimefon	125	0.0a**	0.0	0.0a	0.0	7.5a	5.0a	47.5d	28.7c	7.9a	107
Triadimefon+Carbendazim	125+250	0.0a	0.0	0.0a	0.0	6.2a	6.2a	37.5c	33.7c	7.9a	107
Propiconazole	125	0.0a	0.0	5.0a	0.0	5.0a	6.2a	30.0b	21.2b	7.9a	107
Fenpropimorph	795	0.0a	0.0	6.2a	0.0	6.2a	6.2a	40.0c	28.7c	7.9a	107
Flutriafol	125	0.0a	0.0	0.0a	0.0	0.0a	8.7a	21.2a	5.0a	8.0a	108
Flutriafol+Cambendazim	94+200	5.0a	0.0	5.0a	0.0	7.5a	8.7a	28.7b	5.0a	7.9a	107
Triadimenol	125	0.0a	0.0	0.0a	0.0	0.0a	10.0a	47.5b	5.0a	7.9a	107
Triadimenol+Carbendazim	125+250	0.0a	0.0	0.0a	0.0	10.0a	15.0a	22.5a	5.0a	8.0a	108
Diniconazole	75	6.2a	0.0	7.5a	0.0	6.2a	11.2a	23.7a	5.0a	8.0a	108
Untreated	-	55.0b	10.0	57.5a	15.0	55.0b	70.0b	80.0e	87.5d	7.4b	100

F.l. = Flag leaf   F.l. - 1 = first leaf underneath flag leaf   Application: At growth stage 58-59

* = Days after application   ** = Means followed by the same letter are not significantly different (P = 0.05; Duncan [1951])

TABLE 3

Control of powdery mildew (*Erysiphe graminis*) and rusts (*Puccinia striiformis* and *Puccinia recondita*) in 1984–1985

Treatment	Dosage	Spray timing		Leaf infection %						Yield	
	g a.i./ha	Month	G S	E.graminis		P.striiformis		P.recondita		t/ha	Relative
				49*(15)		49*(15)	55*(21)	49*(15)	55*(21)		
				F.l.-2	F.l.-1	F.l.-1+F.l. (Average)	F.l.-1+F.l. (Average)	F.L.-1+F.l. (Average)	F.l.-1+F.l. (Average)		
Triadimefon	125	April	32	0a**	0a	25c	30.0c	6.5ab	45.0d	8.3b	105
Triadimefon	125	May	58-59	5a	5a	5ab	10.0b	0.0a	12.5a	8.6c	108
Propiconazole	125	April	32	0a	0a	10ab	30.0c	12.5b	45.0d	8.3b	105
Propiconazole	125	May	58-59	5a	0a	0a	10.0b	0.0a	7.5a	8.6c	108
Flutriafol	125	April	32	0a	0a	5ab	30.0c	6.5ab	32.5c	8.3b	105
Flutriafol	125	May	58-59	5a	0a	0a	5.0a	0.0a	5.0a	8.6c	108
Diniconazole	75	April	32	0a	5a	10ab	40.0d	8.5b	45.0d	8.3b	105
Diniconazole	75	May	58-59	0a	0a	5ab	12.5b	0.0a	20.0b	8.5c	107
Untreated	-	-	-	55b	15b	35d	65.0e	20.0c	75.0e	7.9a	100

F.l. = Flag leaf F.l.-1; F.l.-2 = first and second leaf underneath the flag leaf

* = Days after application in stage 32 ( )= Days after application in stage 58-59

** =Means followed by the same letter are not significantly different (P = 0.05; Duncan [1951])

TABLE 4

Control of brown rust (Puccinia recondita) in 1985-1986

Treatment	Dosage g a.i./ha	Spray timing Month	G S	Leaf infection % 51* F.l -1	(20) F.l.	58* (26) F.l.	Yield t/ha	Relative
Triadimefon	125	April	32	28.5c**	55.0d	67.5d	8.2a	102
Triadimefon	125	May	58-59	0.0a	10.0c	31.2b	8.7b	108
Triadimefon	125	April + May	32 + 58-59	5.0a	0.0a	32.5b	8.7b	108
Propiconazole	125	May	58-59	0.0a	5.0ab	48.7c	8.7b	108
Propiconazole	125	April + May	32 + 58-59	0.0a	5.0ab	43.7c	8.7b	108
Flutriafol	125	May	58-59	5.0a	7.5bc	35.0b	8.7b	108
Flutriafol	125	April + May	32 + 58-59	0.0a	5.0ab	30.0b	8.7b	108
Diniconazole	75	May	58-59	0.0a	5.0ab	5.0a	8.8b	110
Diniconazole	75	April + May	32 + 58-59	0.0a	5.0ab	5.0a	8.8b	110
Cyproconazole	80	April	32	16.2b	45.0e	70.0d	8.2a	102
Cyproconazole	80	May	58-59	0.0a	0.0a	0.0a	8.8b	110
Flusilazol	160	May	58-59	0.0a	5.0ab	28.7b	8.8b	110
HWG 1608	250	May	58-59	0.0a	0.0a	0.0a	8.8b	110
Untreated	-	-	-	46.2d	72.5f	80.0e	8.0a	100

F.l. = Flag leaf F.l.-1 = first leaf underneath the flag leaf

* = Days after application in stage 32 () = Days after application in stage 58-59

** = Means followed by the same letter are not significantly different (P = 0.05; Duncan [1951]) activity when applied at heading.

All fungicide treatments gave significant yield increases over untreated but applications at heading provided yield signficantly higher than at shooting ones (7-8 as to 5%).

In the trial of 1985-1986 (Table 4) the best control of brown rust (the only disease occurred in this year) was exerted by HVG 1608,cyproconazole and diniconazole when applied at heading. A good effectiveness was showed by flusilazol (spray timing G S 58-59) triadimefon,propiconazole and flutriafol (with 1 or 2 treatments). The activity of triadimefon and cyproconazole distributed at shooting (GS 32) was poor.

Significant yield increases (8-10%) were obtained both with 1 treatment at heading and with 2 treatments (shooting+heading) but no significant differences were noticed between the two application times.

DISCUSSION

The results of trials show that new ergosterol biosynthesis inibithing fungicides exert a good control of powdery mildew during about 4-5 weeks after the application. A similar good effectiveness is showed against rusts but with some different performances among the products. On yellow rust all tested fungicides (triadimefon, propiconazole,flutriafol,diniconazole) provided an activity persisting for 21 days after a single application,against brown rust the best activity was exerted by HVG 1608,cyproconazole and diniconazole for 26 days after the treatment,on stem rust flutriafol and triadimenol (alone or mixed with carbendazim) and diniconazole resulted the most effective.

Statistically significant yield increases were obtained with most application timings but the highest ones (7-10%) were showed by a single treatment at heading or by two treatments at shooting and at heading.

From these results it is clear that with the modern efficacious ergosterol biosynthesis inhibiting fungicides the most profitable treatment timing against wheat powdery mildew and rusts in Northern Italy is a single application at heading stage.

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TIMING OF FUNGICIDE APPLICATIONS IN RELATION TO THE DEVELOPMENT OF SEPTORIA NODORUM IN WINTER WHEAT.

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ABSTRACT

The population development of *Septoria nodorum* in winter wheat cultivar Norman was investigated in field trial experiments during the 1985-87 period. The optimum timings for fungicide applications were determined by measuring the quantity of inoculum occurring on plants and by monitoring the development of the pathogen on symptomless leaves using a selective isolation technique. *S. nodorum* development on leaves differed in each season examined. In 1985-86 high levels of inoculum were recorded on lower and middle leaves in early spring leading to a fungicide programme consisting of applications at GS 15, GS 37 and GS 61. Highest yields were obtained from programmes consisting of a GS 37 application timing. In the 1986-87 season, however, the build-up of inoculum was delayed and consequently no fungicide applications were made prior to GS 32. Early applications retarded pathogen development in both seasons examined. Efficacy of fungicides and effects of different application timings for control of *S. nodorum* are discussed.

INTRODUCTION

Cereal crop surveys have established that *Septoria nodorum* is one of the most prevalent foliar and ear pathogens of winter wheat and yield losses of up to 10 % are commonly reported (King *et. al*. 1983). Yield responses to fungicide applications, however, are variable because disease development is often irregular. The actual levels present can also be difficult to determine due to the similarity of foliar symptoms with those of natural leaf senescence. These factors make the development of an effective chemical control programme problematic.

This paper presents results on the effectiveness of spray programmes in which the application timings were determined by regularly monitoring the activity and increase in inoculum levels of *S. nodorum* on symptomless and senescing leaves of wheat.

MATERIALS AND METHODS

Fungicide trials

Trials were of randomized block design with 4 replicates. Plots were 5 m long x 1.8 m wide. Two weeks after sowing, infested chaff and debris taken from a previous winter wheat crop were sprinkled evenly over each plot to enhance inoculum levels of S. nodorum. Fungicide applications were made with an Azo-propane sprayer through Birchmeier Helico Sapphire hollow cone nozzles using an output of 240 l/ha at 3 bars. In 1985-86 the treatments applied were maneb ('Manzate') at 800 g a.i./ha and propiconazole ('Tilt 250') at 125 g a.i./ha whereas in 1986-87 chlorothalonil ('Bravo 500') at 1000 g a.i./ha, prochloraz ('Sportak') at 400 g a.i./ha and the flusilazol + carbendazim formulation ('Punch C') at 160 + 80 g a.i./ha respectively were used. Yields were determined using a Claas Compact 25 small plot harvester and corrected to 15 % moisture.

Monitoring of S. nodorum on symptomless leaves

A random sample of 100 symptomless leaves per leaf number (position on stem ; 1 equals flag leaf) was taken for each treatment at sampling dates before and after fungicide applications. Leaves were surface sterilized in 0.5 % wt/vol sodium hypochlorite for 1 min and washed three times in distilled water. A 2 cm segment was taken from each leaf, plated on Bannon's Selective Medium (BSM, Bannon 1978) and incubated under 12 h darkness 12 h near ultra-violet irradiation at 21° C. Microscopic examination for sporulating S. nodorum was carried out after 7 days.

Measurement of S. nodorum inoculum levels

At each sampling date 10 tillers per treatment were taken and all necrotic and symptom bearing segments immersed and agitated for 30 min in distilled water containing 0.05 % of the surfactant Tween 20. Plant pycnidiospore concentrations were obtained using a haemocytometer. Ear infection assessments were made of the tiller samples taken in August of each year.

RESULTS

In both seasons S. nodorum was the dominant pathogen with ear infections caused by Fusarium spp. also present at moderate levels, particularly in 1986.

1985-86

S. nodorum was present at high levels on symptomless fifth and fourth leaves in early April (Table 1). A gradual increase in the incidence of this pathogen was recorded on successive leaf layers with time. Maneb and propiconazole treatments recorded lower levels of S. nodorum than untreated plots 9 DAT, but only propiconazole remained effective 21 DAT, at which time the pathogen was present on over 80 % of some untreated leaf categories. Propiconazole continued to maintain the levels of S. nodorum significantly below that of the untreated and of the maneb treated leaves at the end of May. Applications of this compound at GS 37 and GS 61 were generally effective in reducing the levels of S. nodorum on symptomless upper leaves. Although in some treatments the pathogen was detected on up to 50 % of symptomless flag leaves on 16 July, symptom expression was not observed until early August.

TABLE 1

Recovery of *S. nodorum* from symptomless leaves of cv. Norman in 1986 and 1987 as determined on BSM.

Leaf number	Sampling date		Application timing	% leaves bearing *S. nodorum*									
			1 April 1986	A**	B	B	B	C	C	C	A		
5	9 April		(GS 15)	48a*	26bc	31b	27bc	20c	21bc	28bc	51a		
4				29a	16c	26b	12c	10c	13c	10c	28a		
5	21 April			88a	87a	83a	84a	66b	68b	61b	91a		
4				43a	40a	38a	40a	16b	10b	17b	47a		
4	26 May			56a	60a	56a	52a	42b	28c	38b	54a		
		1985-86	5 June 1986	A	C	C	A	C	A	A	C		
3	2 July		(GS 37)	77a	36c	38c	78a	40c	71a	66a	57b		
2				48a	11b	17b	50a	4c	50a	47a	11b		
1				8a	1b	8a	11a	2a	11a	9a	0b		
			14 July 1986	A	C	A	C	C	C	A	C		
1	16 July		(GS 61)	51a	15b	50a	20b	0c	20b	47a	15b		
1	13 August			74a	11d	69a	30c	0d	31c	61b	10d		
			5 May 1987	A	A	A	A	D	D	D	E	E	E
4	7 May		(GS 32)	17a	17a	17a	20a	2b	2b	1b	4b	0b	3b
4	26 May			67a	71a	69a	67a	7bc	10b	6bc	3bc	3bc	0c
3				21a	20a	14a	14a	0b	0b	0b	0b	0b	0b
4	17 June			78a	81a	73a	75a	29b	34b	36b	18c	21a	17c
3				31a	30a	34a	29a	3b	7b	4b	3b	7b	6b
		1986-87	26 June 1987 (GS 61)	A	F	E	C	D	D	F	D	F	D
			3 July 1987 (GS 71)	A	D	D	D	A	D	D	D	D	A
3	20 July			64a	43b	40b	46b	43b	41b	40b	37b	43b	40b
2				38a	3b	4b	7b	8b	2b	4b	8b	4b	3b
1				17a	0b	2b	1b	3b	0b	4b	1b	2b	2b

* Figures followed by the same letter in each row are not significantly different (P = 0.05). Arcsine transformation followed by Duncan's Multiple Range Test.

** A = Untreated ; B = Maneb ; C = Propiconazole ; D = Chlorothalonil ; E = Prochloraz ; F = Flusilazole + carbendazim.

The programme consisting of three propiconazole applications was the most effective in preventing development of S. nodorum on flag leaves. These results were supported by the quantity of inoculum measured in treatments between April and August (Table 2).

TABLE 2

Effect of foliar fungicide applications on S. nodorum inoculum production and ear infection, and yield of cv Norman in 1986.

April 1 GS15	June 5 GS37	July 14 GS61	April 21	May 26	June 9	July 2	August 1	September 7
Treatment			Pycnidiospores per tiller ($x10^3$/ml)				% Ear infection	Mean yield as % untreated
A**	A	A	85a*	111a	130a	87a	24.7a	100a(7.7 t/ha)
B	C	A	43b	94b	87b	21d	1.8c	114b
B	A	C	47b	87b	110b	64b	11.9b	107ab
B	C	C	38b	87b	82c	19d	3.1c	114b
C	A	A	17c	14c	81c	43c	21.3a	100a
C	A	C	21b	17c	44d	44c	7.4bc	110b
A	C	C	79a	119a	91bc	14d	2.9c	113b
C	C	C	17c	17c	20e	0.7e	0c	124c

* Figures followed by the same letter are not significantly different (P = 0.05). Arcsine transformation followed by Duncan's Multiple Range Test.

** A = Untreated ; B = Maneb ; C = Propiconazole.

Highest numbers of pycnidiospores were recorded on untreated plants in May and June. Applications of propiconazole, and to a lesser extent maneb, caused a significant reduction in inoculum production on plants in April and May. A decline in pycnidiospore numbers was observed for all treatments in July, probably caused by the senescence and decay of lower leaves, which have been found to be the chief source of inoculum for infection of upper plants parts (O'Reilly et. al. 1986).

The mean yield determinations were directly related to the levels of ear infection recorded for each treatment in August. Three applications of propiconazole resulted in a 24 % yield increase and was significantly higher than two foliar sprays of this fungicide. A single application of this compound at GS 15 failed to influence ear infection levels or enhance yield. Application of maneb at GS 15 followed by propiconazole at GS 37 gave a yield response similar to the two spray propiconazole programme at the more conventional timings of GS 37 and GS 61. Lowest yields were recorded in treatments without a fungicide application at GS 37.

1986-87

Although symptomless lower leaves were monitored for the presence of S. nodorum during the Spring months using BSM, levels greater than 10 % were not detected until the end of April. Fungicides chlorothalonil and prochloraz applied at GS 32 in early May were equally effective in significantly reducing the levels of S. nodorum occurring on symptomless fourth and third leaves (Table 1). These compounds remained active until mid-June despite a substantial increase in S. nodorum levels on untreated plants. Further applications at GS 61 and GS 71 led to only negligible levels of the pathogen being detected on uppermost leaves.

The quantity of inoculum measured on untreated plants increased between May and July (Table 3).

TABLE 3

Effect of foliar fungicide applications on S. nodorum inoculum production and ear infection, and yield of cv Norman in 1987.

May 5 GS32	June 26 GS61	July 3 GS71	May 26	June 17	July 20	August 5	September 13
Treatment			Pycnidiospores per tiller ($x10^3$/ml)			% Ear infection	Mean yield as % untreated
A*	A	A	44a**	61a	79a	16.8a	100a(7.9 t/ha)
A	F	D	49a	66a	37c	4.1c	117b
A	E	D	51a	65a	33c	4.4c	116b
A	C	D	44a	63a	50b	10.8b	107a
D	D	A	21b	24b	19d	2.1c	121b
D	D	D	21b	20b	23d	2.4c	121b
D	F	D	24b	19b	18d	2.1c	122b
E	D	A	17b	21b	17d	3.6c	118b
E	D	D	21b	24b	21d	2.0c	120b
E	F	D	20b	24b	20d	3.4c	119b

* A = Untreated ; C = Propiconazole ; D = Chlorothalonil ; E = Prochloraz ; F = Flusilazole + Carbendazim.

**Figures followed by the same letter are not significantly different (P = 0.05). Arcsine transformation followed by Duncan's Multiple Range Test.

Levels of inoculum were generally lower than those recorded in 1985-86 (Table 2). Chlorothalonil was as effective as prochloraz in reducing sporulation of S. nodorum in May and June. Fungicides applied at GS 61 and GS 71 continued to suppress the population development of S. nodorum in July. The use of propiconazole at GS 61, however, was significantly less effective than chlorothalonil, prochloraz or flusilazole + carbendazim. This observation was supported by ear infection results, where all treatment combinations produced substantially lower levels of infection than that of propiconazole and chlorothalonil applied at GS 61 and GS 71 respectively.

In all cases lowest yields were obtained in treatments without a foliar application at GS 32. In two-spray programmes, application at GS 61 of either flusilazole + carbendazim or prochloraz resulted in at least a 9 % higher yield increase than application of propiconazole at this timing. The chlorothalonil - flusilazole + carbendazim - chlorothalonil programme produced the highest yield but application of chlorothalonil at GS 32 and GS 61 provided the most economical return on spray costs.

DISCUSSION

In field trial experiments performed during 1986 and 1987 increasing levels of S. nodorum inoculum were recorded on leaves between April and July. Timing of foliar fungicide applications had a strong influence on subsequent levels of ear infection and eventual yields. In 1986, applications of propiconazole and to a lesser extent maneb at GS 15 delayed population development of the pathogen on middle leaves. The simultaneous appearance of symptoms on flag leaves and glumes indicated that the inoculum responsible for ear infection originated from middle than from uppermost leaves. In 1987, applications of chlorothalonil at GS32 and GS61 proved an effective fungicide programme. In other seasons, however, when alternative pathogens may dominate, the lack of disease spectrum of such a programme could militate against its effectiveness.

In both seasons, two-spray programmes consisting of fungicides applied at first and second timings were at least as efficacious as those applied at second and third timings. These results indicate that early application of fungicides at GS 15 and GS 32 are effective in delaying the development of S. nodorum and can be considered to be economically justified, particularly in continuous wheat cropping situations where high disease pressure can be expected.

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CONTROL OF STEM BASE AND FOLIAR DISEASES OF WINTER CEREALS WITH PROCHLORAZ PLUS CYPROCONAZOLE

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ABSTRACT

A novel co-formulation of prochloraz + cyproconazole is shown to be effective against the pathogens causing major stem and foliar diseases of winter cereals, including *Pseudocercosporella herpotrichoides*, *Septoria* spp., *Puccinia* spp., *Rhynchosporium secalis* and *Erysiphe graminis*. The high levels of disease control achieved resulted in good yield responses in trials over a 3 year period.

This paper also considers delaying the application of prochloraz + cyproconazole until GS 32-33, the first spray in a two-spray programme, as a means of reducing the number of fungicide sprays needed to achieve effective disease control in winter wheats.

INTRODUCTION

Prochloraz, an imidazole fungicide introduced in the UK in 1981 (Harris *et al* 1979) is widely used for the control of eyespot, *Pseudocercosporella herpotrichoides* and foliar diseases in cereals. Although prochloraz controls many important diseases of cereals it gives little control of rusts, *Puccinia* spp. and only protectant activity against powdery mildew of wheat, *Erysiphe graminis* var *tritici*. It is therefore often used in mixture with fungicides of complementary activity.

Cyproconazole, a new broad spectrum triazole fungicide announced by Sandoz Ltd (Gisi et al 1986) is active against several cereal pathogens including rusts and powdery mildews, *Rhynchosporium* and *Septoria* spp. This paper reports the results of replicated trials conducted in the UK from 1986 to 1988 in which foliar sprays of a co-formulation of prochloraz + cyproconazole gave good control of stem and foliar diseases in winter cereals and excellent yield responses.

MATERIALS AND METHODS

Trials were conducted in commercial crops of winter wheat and winter barley. Stem-base and/or foliar diseases were present in these crops, at low levels, at the time of spraying.

Fungicides used were:

prochloraz 320g + cyproconazole 48 g/l EC, 'Sportak Delta'
prochloraz 400 g/l EC, 'Sportak'
prochloraz 266g + carbendazim 100 g/l SC, 'Sportak Alpha'
prochloraz 225g + fenpropimorph 375 g/l EC, 'Sprint'
propiconazole 250g + carbendazim 200 g/kg WP, 'Hispor 45 WP'
flutriafol 94g + carbendazim 150 g/l SC, 'Early Impact'

Trials were of randomized block design with 6 replicates; plots were 2-3m wide and 10m long. Treatments were applied using a pressurised knapsack sprayer calibrated to deliver 200-220 l/ha through TeeJet nozzles operating at 210-285 kPa.

Details of treatments, doses and timings, are given in Tables 1-3. Trials examining the effects of fungicide treatments applied at growth stage (GS) 30-31 (Zadocks et al 1974), were oversprayed with a broad spectrum fungicide at GS 37-39 to minimise the effects of foliar diseases on yields.

Stem base diseases were assessed at GS 75 on 10 main stems per plot, using a disease key (Clarkson and Polley 1981) to calculate a disease index. Foliar disease assessments were made on 30 leaves per plot using ADAS assessment keys.

Trials were yielded using a small plot combine, taking the centre 1.25m or 1.5m of each plot. Yields were corrected to 15% moisture.

RESULTS

In each of the three seasons, 1986-88, prochloraz + cyproconazole gave very good control of eyespot from a GS 30-31 spray, better than prochloraz or prochloraz + carbendazim, and excellent yield responses (Table 1). Prochloraz + cyproconazole sprays applied at GS 30-31 also gave good early season control of a wider range of foliar diseases than prochloraz or prochloraz + carbendazim and better retention of green leaf area (Table 2).

In spray timing trials in winter wheat in 1987 and 1988 (Table 3) a two-spray programme; prochloraz + cyproconazole at GS 32-33 followed by prochloraz + fenpropimorph at GS 51, proved as effective in terms of disease control, green leaf area retention and yield, as a three-spray programme; prochloraz at GS 30-31, prochloraz + fenpropimorph at GS 37-39, maneb + carbendazim at GS 51.

Delaying the application of prochloraz + cyproconazole until GS 37-39 resulted in reduced eyespot control and reduced yields.

DISCUSSION

In trials in the past three seasons a novel co-formulation of prochloraz + cyproconazole, applied to winter cereals at GS 30-31, gave more effective control of stem-base and foliar diseases and better yield responses than prochloraz, prochloraz + carbendazim and other early season fungicides. The co-formulation removes the need to tank-mix prochloraz with other fungicides to achieve effective control of powdery mildews and rusts and when product registration is achieved should prove an attractive early season fungicide for winter cereals.

Timing trials in winter wheat in 1987 and 1988 showed that a two-spray fungicide programme; prochloraz + cyproconazole applied at GS 32-33 followed by prochloraz + fenpropimorph at GS 51, can give excellent stem-base and foliar disease control and yield as well as a standard three-spray programme - prochloraz at GS 30-31, prochloraz + fenpropimorph at GS 37-39, carbendazim + maneb at GS 51.

Such a 2-spray approach requires confirmation in other seasons but is of great interest at a time when farmers are seeking to reduce inputs on cereal crops. It is encouraging that it gave good results in two very different seasons; 1987 dominated by stem-base diseases, especially eyespot and 1988 by foliar diseases, especially powdery mildews and rusts.

The timing trials also demonstrated that delaying the application of an eyespot fungicide, in this case prochloraz + cyproconazole, beyond GS 33 resulted in reduced eyespot control and reduced yield responses. Similar effects have been recorded with prochloraz-containing fungicides in timing trials in other seasons (Marshall et al 1986).

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TABLE 1

Treatments, eyespot control and yields (as % of untreated) from a GS 31 spray in winter cereals, 1986-88

Treatment	g a.i./ha	1986		1987		1988		1986-88	
		eyespot control	yield	eyespot control	yield	eyespot control	yield	eyespot control	yield
prochloraz	400	64	103.8	54	107.4	60	110.1	59	107.4
prochloraz + cyproconazole	400 + 60	75	104.2	58	109.3	68	112.8	66	109.3
prochloraz + carbendazim	400 + 150	67	105.2	42	106.6	55	108.8	54	107.1
propiconazole + carbendazim	125 + 100	-	-	14	105.8	19	107.3	16*	106.7**
flutriafol + carbendazim	118 + 188	24	102.2	15	104.0	11	107.8	15	105.0
Untreated: Disease Index and Yield (t/ha)		44	6.8	54	6.5	55	6.7	51	6.7
No. of trials in mean		12	12	14	12	15	17	43	41

* 31 trials in mean   ** 29 trials in mean.

TABLE 2

Treatments, control of stem and foliar diseases (as % of untreated) and green leaf area retention in winter cereals, assessed 4 to 14 weeks after a GS 31 spray, 1986-88

Treatment	g a.i./ha	P.her	R.cer	Fus	S.tri	E.grt	P.str	R.sec	E.grh	P.hor	GLA
prochloraz	400	59	36	35	55	45	0	78	25	29	107
prochloraz + cyproconazole	400 + 60	66	48	23	63	71	84	77	37	47	116
prochloraz + carbendazim	400 + 150	54	43	32	53	59	-	76	35	22	113
propiconazole + carbendazim	125 + 100	16	24	-2	61	44	86	76	35	54	113
flutriafol + carbendazim	118 + 188	15	54	8	64	64	-	77	43	30	109
Untreated: % Disease (Index)		(51)	(8)	(29)	14	2	3	8	56	40	57
No. of trials in mean		41	6	16	5	4	1	5	1	1	7

Key
P.her *Psuedocercosporella herpotrichoides*
R.cer *Rhizoctonia cerealis*
Fus *Fusarium* species
S.tri *Septoria tritici*
E.grt *Erisyphe graminis tritici*
P.str *Puccinia striiformis*
R.sec *Rhynchosporium secalis*
E.grh *Erisyphe graminis hordei*
GLA Green leaf area
P.hor *Puccinia hordei*

TABLE 3

Treatments, spray timings, stem and foliar disease control and yield (as % of untreated) and green leaf area retention in winter wheat, assessed GS 71 to 75, 1987, 1988

Fungicide Treatment (g a.i./ha) GS 30-31	GS 32-33	GS 37-39	GS 51	P.her	R.cer	Fus	S.tri	E.grt	P.str	GLA	YIELD
prochloraz (400)	-	prochloraz + fenpropimorph (394 + 656)	maneb + carbendazim (1600 + 250)	65	5	50	83	97	61	158	122.7
-	prochloraz cyproconazole (400 + 60)	-	prochloraz + fenpropimorph (394 + 656)	65	33	36	80	89	98	159	122.4
-	-	prochloraz + cyproconazole (400 + 60)	maneb + carbendazim (1600 + 250)	47	59	44	81	79	93	163	118.1
Untreated: % Disease (Index) Yield [t/ha]				(46)	(16)	(34)	31	4	44	43	[6.2]
No. of trials in mean				13	4	3	13	1	1	5	12

'FERRAX' SEED TREATMENT - DISEASE CONTROL AND GROWTH BENEFITS

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ABSTRACT

'Ferrax' (flutriafol, ethirimol and thiabendazole) continues to give excellent control of powdery mildew of winter and spring barley. In addition to controlling all the major seed-borne diseases, the product produces beneficial growth effects. Monitoring studies have confirmed that the sensitivity of mildew populations to ethirimol remains high. Trials in 1987/88 across a range of winter barley varieties have demonstrated high levels of mildew control 14 to 16 weeks after drilling.

INTRODUCTION

'Ferrax' was introduced in 1984 as a seed treatment for control of all the major seed, soil-borne and early foliar diseases of barley (Northwood et al. 1984). In combining flutriafol and ethirimol in a single formulation, it has provided a dual mode of action product for effective control of powdery mildew. Thiabendazole is added to improve control of soil and seed-borne diseases.

Four years of commercial experience have demonstrated its effectiveness and revealed the useful early growth benefits associated with its use. Monitoring work has been undertaken to study the sensitivity of powdery mildew populations to both triazoles and ethirimol so that any changes noted may be used to influence the technical management of the product.

This paper describes recent work by ICI Agrochemicals which has evaluated seed-borne disease control, growth benefits, sensitivity of mildew populations to the product and mildew control across a range of barley varieties. It highlights the continued good performance of the product on winter and spring barley.

MATERIALS AND METHODS

Field trials compared a flutriafol/ethirimol/thiabendazole (TBZ) formulation ('Ferrax') with a triadimenol/fuberidazole formulation and a mercury standard. In some trials, a flutriafol/ethirimol/TBZ/imazalil formulation was also compared with a triadimenol/fuberidazole/imazalil standard.

Naturally-infected seed stocks were used for all seed-borne disease work. Trials were fully replicated using randomised block designs. Seed was treated in a 'Rotostat' machine and drilled into plots ranging from 3 m^2 to 100 m^2.

The sensitivity of mildew populations to triazole fungicides and ethirimol was monitored using methods described by Heaney _et al_. (1986).

Disease assessments were made according to recognised guidelines on 10 to 25 stem, plant, leaf or ear samples per plot. Measurements were sometimes made of the numbers of tillers on each plant, the weight of individual tillers and whole plants, and the frequency of plants with sub-crown internodes. Duncan's multiple range test (Duncan 1955) was used to compare statistically each treatment mean. Values followed by a common letter are not significantly different at $p = 0.05$.

In the tables of results, 'WAD' means 'weeks after drilling' and 'DAD' means 'days after drilling'.

RESULTS AND DISCUSSION

The results with flutriafol formulations on winter barley have confirmed the plant-growth benefits associated with its use. Both the flutriafol formulation and the triadimenol/fuberidazole standard significantly reduced tiller number per plant, increased tiller weight and whole plant weight, and reduced the frequency of sub-crown internodes (Table 1). These effects can improve survival and over-wintering of winter barley.

TABLE 1

Triazole-based seed treatments - plant-growth benefits in winter barley trials 1987 (expressed as % of mercury treatment).

Treatment	Rate (mg/ a.i. kg seed)	Tiller number per plant Midlands 19 WAD	Tiller weight E. Anglia 22 WAD	Plant weight E. Anglia 22 WAD	Frequency of sub-crown internodes E. Anglia 22 WAD
Flutriafol/ ethirimol/ TBZ/imazalil	150/ 2000/ 50/30	84b	135b	126b	58b
Triadimenol/ fuberidazole	375/ 45	81b	147b	128b	64b
Mercury (actual figures)	22	100a (6.3)	100a (0.2g)	100a (0.9g)	100a (91)
Variety		Igri	- - - - -	Maris Otter	- - - - -

Good control of both seed-borne diseases and early foliar diseases was achieved (Table 2).

TABLE 2

Control of seed-borne and other foliar diseases in winter and spring barley, 1985 and 1987.

Treatment	Rate (mg/ a.i. kg seed)	% Disease control: Winter barley 1985 Loose smut (*Ustilago nuda*) At heading	Winter barley 1985 Leaf stripe (*Pyrenophora graminea*) At heading	Spring barley 1987 Leaf blotch (*Rhynchosporium secalis*) cv. Triumph 98 DAD	Spring barley 1987 Brown rust (*Puccinia hordei*) cv. Maris Otter 275 DAD
Flutriafol/ ethirimol/ TBZ	150/ 2000/ 50	100a	68a	95b	87b
Flutriafol/ ethirimol/ TBZ/imazalil	150/ 2000/ 50/30	100a	98b	-	-
Triadimenol/ fuberidazole	375/ 45	100a	-	82b	92b
Triadimenol/ fuberidazole/ imazalil	375/ 45/ 50	-	96b	-	-
Mercury (% disease)	22	0b (15.4)	-	0a (10.2)	0a (6.4)
Untreated (% disease)		-	0c (6.4)	-	-

The widespread use of ethirimol as a single-ingredient product in the early 1970s and of triazole fungicides in the late 1970s led to changes in the sensitivity of barley powdery mildew populations to both fungicide groups (Shephard *et al*. 1975, Butters *et al*. 1984). In order to maintain acceptable levels of barley powdery mildew control, the mixing of the two modes of action was explored. Continued monitoring of mildew populations has confirmed that good sensitivity to ethirimol has been retained throughout the period that the mixed product has been used. In the early 1970s, the mean ethirimol sensitivity value declined to 11.9 while, in 1988, this value for ethirimol in mixture with flutriafol remained at 14.0 despite four years of population exposure (Table 3).

TABLE 3

Sensitivity of mildew populations from England and Scotland to ethirimol from 1985 to 1988.

Year	Number of samples	Sensitivity grade <6 (least sensitive)	6-9	9-12	12-15	15-17	>17 (most sensitive)	Mean sensitivity grade ± standard deviation
1985	77	0	4	4	48	20	24	14.7 ± 2.9
1986	71	0	0	3	54	36	7	14.8 ± 1.6
1987	109	0	1	20	56	21	2	13.5 ± 1.9
1988	75	0	0	8	65	24	3	14.0 ± 1.4

Efficacy results on ten winter barley varieties at three locations in 1987/88 confirmed the monitoring studies. The autumn and winter of 1987/88 were relatively mild and high levels of powdery mildew occurred on untreated winter barley. Use of 'Ferrax' gave high levels of disease control across all varieties, 14-16 weeks after drilling (Table 4). The product provided good protection throughout a period where soil conditions were generally inappropriate for fungicide spraying.

TABLE 4

% Mildew control on ten winter barley varieties at three locations in England, 1987/88.

Variety	Trial location: Linton, Cambridgeshire	Kineton, Warwickshire	Sparsholt, Hampshire
Maris Otter	89 (19.2)	-	-
Panda	88 (13.9)	89 (23)	100 (2.5)
Halcyon	87 (12.4)	-	100 (7)
Magie	94 (5.3)	86 (5)	86 (36)
Igri	93 (23.3)	98 (4.9)	90 (7)
Plaisant	92 (26)	94 (28.5)	75 (72)
Frolic	-	75 (29.5)	-
Marinka	-	93 (16.1)	-
Fallon	-	97 (14.6)	-
Nevada	-	-	81 (20)

Assessments were of leaf 2 or 3, 14-16 weeks after drilling.
Disease levels on untreated plots are in brackets.

Recent trials on spring barley varieties have confirmed the yield benefits associated with its use. In a trial on ten varieties in Suffolk, yield increases ranged from 4 to 21% on those crops affected by powdery mildew (Table 5).

TABLE 5

Yield responses from 10 spring barley varieties, Cambs, 1987.

Variety	NIAB powdery mildew resistance rating *	Yield following seed treatment with flutriafol-based product (as % untreated)
Blenheim	6	121
Natasha	6	117
Cameo	4	110
Corniche	8	109
Triumph	2	107
Klaxon	5	107
Regatta	7	105
Doublet	7	104
Digger **	9	102
Atem **	8	100

(Mean untreated yield = 3.23 t/ha)

* NIAB 1987, Farmers' Leaflet No. 8.
** Varieties unaffected by powdery mildew in these trials.

CONCLUSION

'Ferrax' continues to provide effective control of seed-borne diseases, useful growth benefits which aid over-wintering and robust control of powdery mildew infections. These benefits simplify crop management and can lead to substantial yield increases, especially in situations of high disease pressure.

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FLUTRIAFOL-BASED FORMULATIONS FOR CONTROL OF OILSEED RAPE DISEASES

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ABSTRACT

Flutriafol-based formulations containing either carbendazim or chlorothalonil were evaluated on oilseed rape against dark leaf spot (*Alternaria brassicae*), light leaf spot (*Pyrenopeziza brassicae*), stem rot (*Sclerotinia sclerotiorum*) and white leaf spot (*Pseudocercosporella capsellae*) in the UK and France. Good control of all four diseases was demonstrated, together with significant yield increases.

INTRODUCTION

Oilseed rape crops in Western Europe are attacked by several diseases which infect stems, leaves and pods with a concomitant reduction in yield. Important diseases include stem rot (*Sclerotinia sclerotiorum*), dark leaf and pod spot (*Alternaria brassicae*), light leaf spot (*Pyrenopeziza brassicae*) and white leaf spot (*Pseudocercosporella capsellae*). The increasing importance of these diseases and their control has been reported previously (Evans and Gladders 1981, Cox *et al*. 1981, Messeliere 1981).

In late spring, *Sclerotinia*-infected stems become evident following the release of ascospores which infect through petals shed on to the leaves and stems. Dark and light leaf spot are most common on early-sown crops and, in common with white leaf spot, the greatest yield losses occur if disease develops on the pods. Fungicide treatment aims to prevent petiole and stem infection by *S. sclerotiorum* and limit the development of foliar diseases on upper leaves and the pods. Such an objective necessitates two fungicide applications, preferably using products with broad-spectrum activity.

The chemical and biological properties of flutriafol as a broad-spectrum, cereal foliar fungicide and seed treatment have been described previously (Skidmore *et al*. 1983, Northwood *et al*. 1984). This paper describes field trials undertaken by ICI Agrochemicals in the UK and France to evaluate flutriafol-based fungicides for the control of the major diseases of oilseed rape.

MATERIALS AND METHODS

Flutriafol-based fungicides were evaluated from 1985 onwards in oilseed rape trials in France and the United Kingdom. All trials were fully replicated using randomised block designs and plot sizes were about 40 m^2. Sites were selected in regions with recognised disease problems and sites sown with susceptible varieties. In most cases, disease resulted from natural infections although, in France, some trials were inoculated with spore suspensions of A. brassicae. Fungicides were applied with a high volume pressurised knapsack sprayer at 300 l/ha at prescribed growth stages or at the first appearance of disease.

Disease severity on leaves and pods was recorded as percentage area affected while incidence was assessed by recording the number of diseased leaves or pods in a sample. Light leaf spot, white leaf spot and dark leaf spot were assessed on a sample of 50 leaves or on the pods of 20 flower stalks taken at random in each plot. In the case of Sclerotinia, 10 replicates of 5 or 10 consecutive plants were assessed in each plot. Yields were taken from 12 m^2 cuts in the centre of each plot and expressed in t/ha at 9% moisture content.

The following flutriafol-based formulations were evaluated:

Formulation	Active ingredients	g a.i./l
Early 'Impact'	Flutriafol/carbendazim	94/150
'Impact' R SOPRA	Flutriafol/carbendazim	94/200
'Impact' RM SOPRA	Flutriafol/carbendazim	117.5/250
'Impact' Excel	Flutriafol/chlorothalonil	47/300

RESULTS AND DISCUSSION

Results of trials are presented in Tables 1 to 6. Data from single trials were analysed statistically using a Fisher protected t test. Percentages were first arcsin transformed prior to analysis. Values within a trial followed by a common letter are not significantly different at p = 0.05. The efficacy of treatments is generally expressed as % reduction in disease compared with the untreated, calculated using the equation $\frac{C-T}{T} \times 100$ where C = untreated value and T = treated value. Yields from treated plots are given as % of those from untreated plots. Yields from untreated plots and disease levels on untreated plots are actual values.

Table 1 presents results from two French trials in 1987 which compared three applications of a flutriafol/carbendazim formulation with three applications of prochloraz/carbendazim. Both formulations gave significant control of light leaf spot, resulting in yield increases. In the case of the Vitry Le Francois trial, the yield increase was considerable and statistically significant.

TABLE 1

Control of light leaf spot (*Pyrenopeziza brassicae*), France 1987.

Treatment	Rate g a.i./ ha	% Disease control Vitry Le Francois 23 DAT 3	% Disease control Baigneux Les Juifs 20 DAT 1	Yield (as % untreated) Vitry Le Francois	Yield (as % untreated) Baigneux Les Juifs
Untreated (actual % disease/yield)		(40)a*	(14)a**	(1.8 t/ha)a	(3.4 t/ha)a
Prochloraz + carbendazim	450 + 120	46b	35b	164b	111a
Flutriafol + carbendazim	94 + 200	43b	34b	167b	117a
Variety:		Jet Neuf	Jet Neuf		
First application date:		15/4/87	21/4/87		
Second application date:		19/5/87	25/5/87		
Third application date:		22/6/87	None made		

* Diseased pods. ** Diseased leaves.

In a UK trial (Table 2), a different formulation of flutriafol/ carbendazim was compared with prochloraz and with carbendazim. The flutriafol-based formulation was significantly superior in disease control to both carbendazim and prochloraz, thus demonstrating the value of incorporating flutriafol into the mixture.

TABLE 2

Control of light leaf spot (*Pyrenopeziza brassicae*), Waltham St Lawrence, Berkshire, England, 1986.

Treatment	Rate g a.i./ha	% Disease control 21 DAT	Yield (as % untreated)
Untreated (actual % leaves diseased/yield)		(32.9)a	(4.1 t/ha)a
Prochloraz	500	36bc	95a
Carbendazim	500	47bc	100a
Flutriafol + carbendazim	94 + 150	77d	106a
Variety:	Rafal		
Two applications:	First at green bud and second at mid-flowering		

Data on control of dark leaf spot are presented in Tables 3 and 4. In a French trial (Table 3), flutriafol/carbendazim significantly reduced the number of diseased pods and the severity of disease on the pods. In two UK trials, flutriafol/carbendazim and flutriafol/chlorothalonil gave significant control of disease on the pods and leaves, resulting in substantial yield increases. In all three trials, iprodione was superior, however, and the yield increases associated with its use in the two UK trials were significantly greater.

TABLE 3

Control of dark leaf spot (A. brassicae), Chambray, France, 1987.

Treatment	Rate g a.i./ha	% Diseased pods 39 DAT	% Pod area diseased 39 DAT
Untreated		81.4a	3.5a
Iprodione	500	31.9c	0.5c
Flutriafol + carbendazim	117.5 + 250	49.5b	0.9bc
Variety:	Bienvenu		
Treated:	25.6.87		
Inoculated:	26.6.87		

TABLE 4

Control of dark leaf spot (A. brassicae) on leaves and pods, UK, 1987, two trials.

Treatment	Rate g a.i./ ha	% Disease control Cambs 14 DAT Pods	Wilts 28 DAT Pods	Wilts 28 DAT Leaves	Yield (as % of untreated) Cambs	Yield (as % of untreated) Wilts
Untreated (actual % disease/yield)		(7.6)a	(5.0)a	(24.4)a	(2.7 t/ha)a	(2.4 t/ha)a
Flutriafol + carbendazim	117.5 + 187.5	74b	60bc	80b	123bc	125b
Flutriafol + chlorothalonil	94 + 600	77b	79bc	83b	121b	127b
Iprodione	750	82b	95c	93b	126c	144c
Variety:		Bienvenu	Bienvenu			
Single application date:		30/6/87	27/05/87			

Climatic conditions in France in 1987 particularly favoured white leaf spot and the disease was well controlled in two French trials (Table 5). The flutriafol/carbendazim formulation was superior against white leaf spot compared with the standard, prochloraz/carbendazim. Both treatments significantly increased yield.

TABLE 5

Control of white leaf spot (Pseudocercosporella capsellae), France, 1987.

Treatment	Rate g a.i./ ha	Disease grading* Sermaize Les Bains 76 DAT	Disease grading* Vitry Le Francois 69 DAT	Yield Sermaize Les Bains	Yield Vitry Le Francois
Untreated		0a	0.8a	(2.8 t/ha)a	(4.2 t/ha)a
Prochloraz + carbendazim	450 + 120	3.0b	6.7b	127b	114b
Flutriafol + carbendazim	117.5 + 250	5.7c	7.0b	129b	114b
Variety:		Bienvenu	Bienvenu		
Single application date:		30/4/87	28/4/87		

* 0-10 scale, where 0 = lowest and 10 = highest disease control.

TABLE 6

Control of stem rot (Sclerotinia sclerotiorum), France, 1987.

Treatment	Rate g a.i./ ha	Disease control St. Martin des Champs 69 DAT	Disease control Is Sur Tille 57 DAT	Yield St. Martin des Champs	Yield Is Sur Tille
Untreated (actual % disease/yield)		(26.3)a*	(25.4)a**	(2.5 t/ha)a	(3.1 t/ha)a
Prochloraz + carbendazim	450 + 120	80c	62c	113a	113b
Flutriafol + carbendazim	117.5 + 250	82c	86d	126a	121b
Variety:		Bienvenu	Bienvenu		
Single application date:		28/4/87	7/5/87		

* % diseased stems. ** % stem area diseased.

Sclerotinia stem rot occurred in two trials in France in 1987 (Table 6). In both trials, a flutriafol/carbendazim formulation gave significant disease control. At both sites, a complex of diseases was present so yield increases were not necessarily attributable only to the control of stem rot.

In all trials, no phytotoxic effects were observed from the use of these flutriafol-based formulations on oilseed rape.

CONCLUSIONS

These results demonstrate the breadth of spectrum and crop safety of flutriafol/carbendazim and flutriafol/chlorothalonil. Their ability to provide good control of the principal diseases of cereals is well-known. More recently, the value of these formulations against sugar beet diseases was reported (Brown et al. 1986). Thus, they provide the arable farmer with a very flexible range of products for disease management in these major crops.

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