SESSION 8

PEST AND DISEASE PROBLEMS IN OILSEED RAPE AND OTHER FIELD CROPS

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SESSION 8

SCLEROTINIA ON OILSEED RAPE: IMPLICATIONS FOR CROP ROTATION

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ABSTRACT

Stem rot has been reported on oilseed rape (*Brassica napus*) crops in England since 1973 but few crops have been severely affected to date. Usually the disease occurs in spring but winter attacks were reported in 1983/4. All isolates identified have been *S. sclerotiorum*, the same species that is found on dwarf beans, potatoes, peas and spring faba beans. Some of these crops, particularly peas, have been implicated as sources of inoculum for oilseed rape crops. Only *S. trifoliorum* has been isolated from winter faba beans; this appears to be less pathogenic on oilseed rape than *S. sclerotiorum* and cross infection is still not proven in English field conditions.

INTRODUCTION

Sclerotinia spp. are pathogens of many crops. In some European countries and Canada stem rot of oilseed rape caused by *S. sclerotiorum* is an important disease and with the expansion of the oilseed rape crop in the UK, it was feared that stem rot could also affect the crop here. In this paper the history of stem rot on oilseed rape and other field crops is reviewed, based mainly on Agricultural Development and Advisory Service (ADAS) Science Service Reports (Anon. 1973-1983). New information is given on the species of *Sclerotinia* involved and their host range.

INCIDENCE ON FIELD CROPS

Winter Oilseed Rape

A low incidence of stem rot was first recorded in England in 1973, in Berkshire, with 5% plants affected in one crop. Similar amounts were noted in the same area in 1974. In 1977 two crops were slightly affected in the West Midlands and Yorkshire. In 1978 the disease was reported only on one spring rape crop, cv Maris Haplona, in Kent. In 1979 affected pods containing sclerotia were observed in one East Midland crop and in both 1979 and 1980 a low incidence was recorded in most crops examined in Berkshire, Hampshire and Oxfordshire. In 1981 the disease was reported for the first time in the Eastern Region with low levels recorded from most other areas excluding the South West Region, Kent and Sussex. In 1982 the disease was more widely distributed with reports from all areas except the South West Region. Many crops were affected but severe outbreaks were confined to a few, 4 out of 204 surveyed were recorded with 20% or more plants infected (Evans *et al*. 1984). A few crops were slightly affected in 1983. In 1984 symptoms were reported for the first time in January (in crops in Kent and Sussex and three crops in the Eastern Counties).

Peas

Severe stem rot was first recorded in Great Britain (North East Scotland) in 1957 (Gray & Findlater 1960). In England it was first noted in 1971 in the Northern Region (Anon. 1971). The disease was not recorded again until 1982. In that year it was reported for the first time in Norfolk on vining peas with 2 out of 200 crops affected and in 1984 it was common in many crops of vining peas in the same area. In both years sclerotia were noted in samples of peas for freezing (C.E. Roberts personal communication). Stem rot was recorded in 1982 in two crops of peas in West Sussex and in one crop in the same area in 1984.

Winter Faba Beans

Stem rot has been recorded in winter beans in the Eastern Region in 1976, 1978, 1980 and 1984, causing severe damage with up to 25% plants infected in a few crops in some years. It was recorded in 1980 as a problem in one crop in the West Midlands.

Potatoes

Stem rot has occasionally been reported on this crop. It was observed at a low incidence in the Eastern Counties, mainly on the fens, on cvs Maris Piper, Wilja and Désirée in 1975, 1977, 1982, 1983 and 1984 (D.R. Humphreys-Jones personal communication). It was recorded on cv Pentland Dell in East Kent in 1974. A severe outbreak occurred in Cornwall on stems of cv Wilja in 1983; tubers containing sclerotia were also observed (S.F. Whitaker personal communication).

Dwarf Beans

Stem rot was recorded in 1973 in West Sussex crops with up to 5% plants affected in one field cv Provider and in 1978 in the West Midlands. In Norfolk the disease has been recorded annually from 1978 in crops grown for processing. In that year it was associated with severe defoliation of some crops and in 1984 at least eight fields were slightly affected (C.E. Roberts personal communication).

SOURCES OF INOCULUM

Two of the four rape crops surveyed in 1982 where stem rot was a problem (Evans et al. 1984) had a history of peas in the rotation; one field in West Sussex had grown two pea crops and one dwarf bean crop in the previous 10 years. An additional case was reported in Norfolk in 1982 which also had peas in the rotation (P. Gladders personal communication).

Table 1 shows the relationship between the incidence of stem rot on

TABLE 1

Percentage winter oilseed rape plants infected by Sclerotinia (winter 1984) in Kent and Sussex in relation to number of susceptible crops previously grown.

Grower/Field identity	BW	BE	S	GRN	GRH	NO	NK	B	BM
% rape plants affected	20	30	0.01	1	0.01	0.01	0.01	0.01	Tr*
Year crop records started	1970	1970	1975	1974	1976	1977	1977	1970	1971
Year of 1st susceptible crop in rotation	1970	1970	1975	1974	1980	1977	1977	1970	1973
No. susceptible crops in rotation:									
Peas	1	1	3	2	1	1	1	2	-
Dwarf beans	1	1	-	1	-	-	-	-	-
Potatoes	4	4	-	-	-	-	-	2	2
Oilseed rape	-	-	-	-	-	1	1	-	-

Tr* - Trace

rape occurring unusually early (January and February 1984) and the frequency of susceptible crops in the rotation of the fields affected.

Peas had been grown in eight out of the nine fields affected by stem rot. Fields with the highest incidence (BE and BW) had peas, potatoes and dwarf beans in the rotation. In these fields the peas had been grown in 1982 with no obvious disease, in fact they were very high yielding crops. The next highest incidence (1% in field GRN) occurred where the crop followed two peas and one dwarf bean crop. Although stem rot was recorded on that farm in 1973 it was not on the same field. The other outbreaks had less plants affected, the disease being restricted to small patches.

In the Eastern Region two rape crops were affected in the winter months of 1984. In one crop, in Hertfordshire, affected plants were detected in part of the field directly adjacent to one which grew peas in 1983, indicating spread by airborne ascospore inoculum (D.R. Ellerton personal communication). The other crop, in Cambridgeshire, had a history of peas grown every 3 years for the last 25 years.

Table 2 shows the extent of stem rot and the cropping history since 1970 for outbreaks recorded in Kent in the summer of 1984.

TABLE 2

Winter oilseed rape: Stem rot incidence in Kent, July 1984

Grower/Field identity	W1	W2 ½ fields	W3 ½ fields	W4	FK	JP	H	McH
% rape plants affected	0.8	1	0.2	2.5	1	Tr*	Tr	Tr
No. of crops since 1970								
Potatoes	3	6	5	3	2	-	-	-
Peas	1	-	1	2	1	-	1	-
Clover	1	-	-	-	-	-	-	-
Oilseed rape	-	-	-	-	1	-	-	-
Seed kale	-	-	-	-	-	-	2	-
Dwarf beans	-	-	-	-	-	-	-	3
Swede seed	-	-	-	-	-	1	-	-

Tr* - Trace

The most affected field (W4), with 2.5% plants affected, had a history of three potato crops and two pea crops in the rotation. Of the eight crops investigated, five had pea crops previously in the rotation.

Of the nine fields where stem rot was recorded in the winter months (Table 1), seven were treated in May with fungicide to control the disease and only a low incidence was recorded in July. A fungicide trial done in field BE reduced incidence in July from 48% in untreated plots to 2-21% in sprayed plots. Fungicides tested were iprodione, prochloraz thiophanate-methyl and vinclozolin.

One field in Essex, which had a history of faba beans in the rotation, was half in winter rape and half in winter beans in 1984. Sclerotinia trifoliorum was detected in the beans but no symptoms were seen in the winter rape (D.R. Ellerton personal communication). In a Hampshire rape crop in 1984, 1% of the plants were infected with Sclerotinia in a part of the field where faba beans had been grown in 1983; the other half of the field, following peas in 1983, had 3% plants infected (E.J. Evans personal communication).

Hims (1979) has shown that wild plants can act as a source of inoculum; he reported infection on rape in Yorkshire in a small area of a field where the height of stem lesions and their proximity to adjacent woodland containing infected umbelliferous weeds indicated that ascospores had originated from these weeds.

SPECIES INVOLVED AND THEIR HOST RANGE

Traditionally, Sclerotinia sclerotiorum, S. trifoliorum and S. minor have been regarded as three separate species. This has been questioned by some workers (eg. Purdy 1955) but recent work on morphological, cultural, physiological, ontogenetic, enzyme pattern, mycelial interaction, and cytological chracteristics of isolates of Sclerotinia led Willetts & Wong (1980) to conclude that the three species are distinct.

S. sclerotiorum has commonly been regarded as the species attacking oilseed rape; it usually forms apothecia in the spring or early summer (Williams & Western 1965). However infection by S. trifoliorum, which produces apothecia in the autumn, has been recorded in West Germany (Saur & Löcher 1983). The recent cases of autumn infection of rape crops in Southern and Eastern England gave rise to speculation that S. trifoliorum might be implicated. Isolates obtained from plants infected in either spring or autumn were therefore collected and identified. In addition, isolates of Sclerotinia from a range of hosts were tested for pathogenicity on rape.

Isolates of Sclerotinia from a range of plants grown principally in Southern or Eastern England were grown on potato dextrose agar (PDA) at 20°C, then shake-cultured in modified Czapek Dox liquid medium for 1-2 weeks, after which cultural characteristics were used for identification (Willetts & Wong 1980). Further identification was carried out using an electrophoretic technique to investigate the soluble proteins in sclerotia (Jellis et al. in press).

The pathogenicity of isolates on rape was tested in a glasshouse using 4-week-old seedlings of cv Jet Neuf. Isolates were grown on sterilized barley grains for 5-6 days and a colonized grain then placed in the second leaf axil and secured with parafilm. Controls were treated with uninfected, sterilized barley grains. Infection was scored after 15 days on a 0-3 scale, where 0 = no infection, 1 = petiole rotted, 2 = distinct stem lesion, 3 = plant collapsed.

In an additional test three isolates of S. sclerotiorum (one from rape and two from spring beans) and three isolates of S. trifoliorum (one from red clover and two from winter beans) were used to inoculate rape (cv Jet Neuf), bean (cv Maris Bead), red clover (cv Sabtoron) and potato (cv Foxton). The inoculation technique for rape, beans and potatoes was as described above but young clover plants were inoculated using mycelium growing on discs of PDA cut from 4-day-old cultures. These were placed in the folds of young, unfolding leaves and held in place with parafilm. Controls were inoculated with uninfected barley grains or mycelium-free agar as appropriate. The experiment was replicated ten times. Inoculated plants were held at 15°C, with high humidity and a 14 h photoperiod, for 7-9 days (14 days for potatoes) prior to scoring. Infection on clover leaves was rated on a 0-3 scale based on the extent of lesion development; rape, beans and potatoes were scored using the 0-3 scale described above.

Isolates obtained from all crops except red clover and winter beans were identified as S. sclerotiorum and were pathogenic on rape (Table 3). Isolates of S. trifoliorum from red clover and winter beans and S. sclerotiorum from rape and spring beans were pathogenic on beans, red clover and potatoes (except isolate 5 which was only weakly pathogenic on potatoes) but two of the three isolates of S. trifoliorum were only weakly pathogenic on rape (Table 4). None of the controls was affected.

TABLE 3

The identity of Sclerotinia isolates from a range of hosts and their pathogenicity on oilseed rape

Host	Locality and year of isolation	Species*	Pathogenicity on rape (0-3 scale)
Oilseed rape (spring infection)	Kent 1983	Ss	1.3
	Sussex 1982	Ss	2.7
	Cambridgeshire 1982	Ss	[see Table 4, isolate 6]
	Kent 1983	Ss	1.3
Oilseed rape (autumn infection)	Kent 1984	Ss	1.3
	Sussex 1984	Ss	3.0
Other brassicas:			
Savoy cabbage	Kent 1983	Ss	1.7
Dutch white cabbage	Kent 1983	Ss	1.7
Calabrese	Kent 1983	Ss	2.0
Lettuce	Sussex 1983	Ss	3.0
	Kent 1983	Ss	2.0
Chrysanthemum	Sussex 1983	Ss	3.0
	Kent 1983	Ss	3.0
Jerusalem artichoke	Kent 1982	Ss	3.0
Legumes:			
Red clover	Norfolk 1982	St	[see Table 4, isolate 1]
Faba bean (winter)	Greece 1983	St	[see Table 4, isolate 2]
	Cambridgeshire 1982	St	[see Table 4, isolate 3]
Faba bean (spring)	Cambridgeshire 1982	Ss	[see Table 4, isolate 4]
	Cambridgeshire 1983	Ss	[see Table 4, isolate 5]

* Identified by growth in liquid culture and electrophoresis.
Ss = Sclerotinia sclerotiorum, St = S. trifoliorum.

TABLE 4

The relative pathogenicity (0-3 scale) of S. sclerotiorum and S. trifoliorum on a range of crops

Host	S. trifoliorum				S. sclerotiorum			
Isolates*...	1	2	3	$\bar{x}$	4	5	6	$\bar{x}$
Oilseed rape	0.2	0.6	1.5	0.8	2.9	1.9	3.0	2.6
Faba bean	3.0	3.0	3.0	3.0	3.0	2.6	3.0	2.9
Red clover	3.0	2.9	2.5	2.8	2.2	2.0	3.0	2.4
Potato	2.7	2.7	1.7	2.4	2.1	0.9	2.7	1.9
SED (140 DF)				0.2				0.2

* For details of isolates see Table 3.

A further twelve isolates collected from rape in the UK or Canada have also been identified as S. sclerotiorum using electrophoretic, shake culture, or both techniques (Jellis et al. in press).

DISCUSSION

The incidence of stem rot in winter oilseed rape in England has generally been low, with few crops severely affected to date. On the majority of fields affected, winter oilseed rape was being grown for the first time in the rotation but in many cases crops known to be susceptible to sclerotinia disease, particularly peas and to a lesser extent potatoes and dwarf beans, had been grown previously. In artificial inoculation experiments, it was found that isolates from a wide range of crops will attack oilseed rape, confirming the general findings of Price & Colhoun (1975) that there is no evidence for physiologic specialization of S. sclerotiorum.

Early winter attacks of stem rot as recorded in the South and East of England in 1983/4 have also been noted in Southern Germany (W. Kruger personal communication) and in some parts of Central France (Y. Regnault personal communication). Autumn and early winter in 1983/4 in Southern England were very mild and because of this it is possible that infection could have originated from ascospores. Apothecia were recorded in a Kent lettuce crop in mid-October and in December 1983 in an artificially buried sclerotia 'depot' in Hull set up in 1982 (J.R. Coley-Smith personal communication). Circumstantial evidence also indicated ascospore infection in the Hertfordshire outbreak, the inoculum coming from an adjacent field which had peas in 1983.

Isolates from plants showing symptoms in early winter and from those attacked in spring have all been identified as S. sclerotiorum. S. trifoliorum proved to be only weakly pathogenic on oilseed rape, and to date there is no evidence in the UK of S. trifoliorum from winter faba beans infecting oilseed rape in the field. Spring faba beans, however, may be a source of inoculum of S. sclerotiorum. The increase in area of rape grown in the UK and the long survival of sclerotia in soil make it important that more attention be given to the cropping history of fields destined for sclerotinia-susceptible crops. This will help avoid further outbreaks of this serious disease.

ACKNOWLEDGEMENTS

We are grateful to D.B. Smith for carrying out out the electrophoresis and to growers and colleagues in ADAS and elsewhere for providing information.

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INCIDENCE OF *SCLEROTINIA* STEM ROT IN OILSEED RAPE CULTIVAR TRIALS 1982-84

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ABSTRACT

The percentage of plants with stem rot (*Sclerotinia sclerotiorum*) on the main stem was assessed on eight trials between 1982 and 1984. These were conducted at three sites with a total of 31 winter oilseed rape cultivars selected from the National Institute of Agricultural Botany National Lists. At Silwood Park and Cambridge, inoculum came from sclerotia produced in culture by an isolate of *Sclerotinia sclerotiorum* from oilseed rape placed c. 1 cm deep in the soil after crop establishment. At Sutton Scotney, inoculum was derived naturally from an outbreak of stem rot in 1982, following a crop of peas. The incidence of stem rot varied considerably in the trials over the 3 years and between the 3 sites in any one year but, at each site, disease incidence was consistently higher on some cultivars than others. Jet Neuf and Bienvenu were among those most affected with maximum infections of 70% (in 1983) and 53% (in 1982) respectively.

INTRODUCTION

Stem rot induced by *Sclerotinia sclerotiorum* is a major disease of oilseed rape in Western Canada, Germany and France causing substantial yield losses in some years (Scheibert-Böhm *et al.* 1981). In the UK only a few outbreaks of stem rot have so far been reported, mainly in 1980, 1982 and 1984 (Jellis *et al.* 1984). However with even more oilseed rape being grown, the incidence of stem rot could increase, thus posing a serious threat to British growers. This study, which was part of a broader investigation of the disease (Mylchreest 1984), examined the susceptibility of different rape cultivars to stem rot in the field.

MATERIALS AND METHODS

Cultivars

In each trial there were 16 winter oilseed rape cultivars which were in at least their second year of National List Trial by the National Institute of Agricultural Botany (NIAB).

Sites and design of the trials

Three sites were used: Sutton Scotney, Hampshire (1981-2, 1982-3, 1983-4); NIAB, Cambridge (1981-2, 1982-3, 1983-4); Silwood Park, Berkshire (1982-3, 1983-4).

At Sutton Scotney, the first trial was drilled by NIAB on 28 August 1981 on land previously planted to peas which had been slightly infected with *Sclerotinia* in 1980. There were four replicate plots (each approximately 40 x 20 m) of each cultivar in a randomised block design. In the two subsequent trials, one block with a single plot (20 x 2 m) of each cultivar, was surrounded by a border of Jet Neuf and netted to prevent pest damage. Drilling took place on 8 September 1982 and 25 August 1983. Both of these trials were within the area previously occupied by the first trial, thus all three trials at this site relied on natural inoculum.

At NIAB Cambridge, there were four replicates (two rows of 2m) sown of each cultivar on 17 September 1981, 15 September 1982, 10 September 1983, in a randomised block design. Thirty sclerotia of *S. sclerotiorum* were buried c. 1 cm deep between the two rows of each cultivar; in January 1982 (first trial) and in September of 1982 and 1983 (second and third trials). Sclerotia were produced by growing the fungus on autoclaved wheat grain for 28 days at 25°C. The isolate used in the first trial was from an unknown oilseed rape cultivar; the isolate used in the other two trials was obtained from infected Jet Neuf at Sutton Scotney in 1982.

At Silwood Park, the 16 cultivars plus cv Doral (claimed by German workers (Krüger 1983) to have low susceptibility to stem rot) were drilled on 2 September 1982 and 26 August 1983. A single plot (3 x 3 m) of each cultivar formed a square enclosing a central, circular plot of Jet Neuf. Sclerotia (Jet Neuf isolate) were buried c. 1 cm deep in terylene net bags (100 sclerotia per 9 m^2 plot in 5 bags) after crop establishment in early September.

All trials were sown with dressed (iprodione) seed, at 18 cm row spacing, fertilised with NPK (40:60:60 kg/ha), to the seed bed and given 200 kg/ha nitrogen in the spring. Post-emergence herbicides were applied in all trials but only at stem extension at Sutton Scotney during the 1982-3 trial. Plots were harvested in mid-July in all years.

Assessment of stem rot

Stem rot was assessed as near to harvest as possible. At Sutton Scotney and Silwood Park a 2.5 m long cane was inserted across the drill rows at ground level in two or three places at random along the edge of each plot. Percentage plants infected was calculated from counts of presence or absence of stem rot lesions on a minimum of 50 plants touching the cane. At Cambridge every plant was assessed, by the presence/absence of lesions.

RESULTS

Table 1 shows the percentage of plants with stem rot in the eight trials and ranks the cultivars in each trial from least (1) to most infected (17). The mean rank is given where two or more cultivars had the same incidence of disease.

At sites where there were replicate plots of each cultivar (Sutton Scotney 1981-2; Cambridge 1981-2, 1982-3 and 1983-4), differences between cultivars were examined by analysis of variance of transformed ($\sqrt{x+0.5}$ data. The variance ratios indicated a significant difference between cultivars at Sutton Scotney in 1981-2 (P = 0.01) and at Cambridge in 1982-3 (P = 0.05) and 1983-4 (P = 0.01) but not at Cambridge 1981-2. These differences are shown in Table 2.

Mean transformed data from each season for the three sites were analysed to determine differences between sites (blocks) and cultivars. The difference between sites was highly significant (P = 0.01 for each year 1982, 1983, 1984) but that between cultivars was not, suggesting a low degree of agreement between the behaviour of cultivars at the three sites. This feature was examined further by two non-parametric tests (Siegel 1956) on the ranked values for 1981-2 (using Spearman's coefficient of rank correlation) and for 1982-3 and 1983-4 (using the Kendall coefficient of

TABLE 1

Percentage plants with stem rot (%) and ranking (R) of cultivars grown in winter oilseed rape trials, 1981-84

Cultivar	Site and Season															
	Sutton Scotney						Silwood				Cambridge					
	1981-2		1982-3		1983-4		1982-3		1983-4		1981-2		1982-3		1983-4	
	%	R(b)	%	R	%	R	%	R	%	R	%	R	%	R	%	R
Elvira	48	12	4	6			40	10			1	7	52	16		
Jet Neuf	68	16	30	16	4	9	70	16	4	11	1	14	39	11	14	4
Bienvenu	53	13	12	15	10	16	38	8.5	2	5.5	0	2	46	14	20	14
1(a)	40	7									0	5				
Korina	53	14	4	6	8	14	12	2	6	15.5	1	9	40	12	22	15
Lirama	27	3									2	15				
2	25	2									0	2				
3	46	11									0	5				
4	44	10									1	10				
5	37	8									1	12				
Norli	32	5	8	12.5			60	13.5			1	13	36	9		
Rafal	40	9	8	12.5	9	15	38	8.5	2	5.5	1	7	44	13	15	7
Fiona	55	15	4	6	2	4.5	46	12	4	11	0	2	31	6	15	8
6	31	4									0	5				
Lingot	22	1	4	6			44	11			5	16	47	15		
7	33	6									1	11				
Belinda			4	6	2	4.5	90	17					25	2	18	11
8			6	9.5			60	13.5					31	4		
9			8	12.5	0	1.5	64	15	4	11			36	8	18	12
10			2	3	2	3	34	6	2	5.5			31	5	15	6
11			8	12.5	6	12	26	4.5	2	5.5			37	10	28	16
Darmor			0	1.5	4	8	26	4.5	0	1.5			33	7	11	3
Doral							36	7	6	15.5						
12			6	9.5			10	1					18	1		
Tandem			0	1.5			18	3					27	3		
13					6	11			2	5.5					15	5
14					4	7			2	5.5					10	1
15					6	10			0	1.5					18	13
16					6	13			6	15.5					16	9
17					0	1.5			4	11					11	2
18					2	6			4	11					17	10

(a) Unlisted cultivars are coded by number

(b) Cultivars are ranked from least (1) to highest (17) incidence of stem rot.

(c) Figures are rounded up to nearest percentage, to fit into table. Ranks are derived from unrounded up figures.

(d) The mean rank is given for those cultivars with the same disease incidence.

TABLE 2

Differences in incidence of stem rot on varieties grown in replicated trials at individual sites

Ranking of cultivars in trials at					
Sutton Scotney 1981-82		Cambridge 1982-83		Cambridge 1983-84	
Lingot	a	12	a	Darmor	a
2	ab	Belinda	ab	11	ab
Lirama	ab	Tandem	abc	14	ab
Norli	abc	10	abc	15	abc
6	abc	8	abcd	Bienvenu	abc
7	abc	Fiona	abcd	Korina	abc
1	bcd	Darmor	abcd	10	abc
5	bcd	Norli	abcd	Rafal	abc
Rafal	bcd	9	abcd	16	abc
4	cd	11	abcd	9	abc
3	cd	Jet Neuf	abcd	Belinda	abc
Elvira	cd	Korina	bcd	18	bcd
Bienvenu	de	Rafal	bcd	Fiona	cd
Korina	de	Bienvenu	bcd	Jet Neuf	cd
Fiona	de	Lingot	cd	17	cd
Jet Neuf	e	Elvira	d	13	d

Cultivars are ranked in descending order - from least to highest incidence.
Values with no letter in common are significantly different at P = 0.05 (Duncan's multiple range test)

TABLE 3

Mean disease incidence of the cultivars grown in all eight trials

Cultivar	Mean % disease incidence	Rank
Jet Neuf	28.7	5
Bienvenu	22.8	4
Fiona	19.7	3
Rafal	19.6	2
Korina	18.3	1

concordance). These tests confirmed that there was no significant measure of agreement between the ranking of cultivars at the various sites.

Further analyses examined differences between disease (as mean transformed disease incidence and ranking of cultivars) recorded over 2 or 3 years for each site. These analyses showed a highly significant difference (i.e. P = 0.01 at each site, Sutton Scotney, Cambridge and Silwood) in disease incidence between the three years but again little agreement between the ranking of cultivars at any one site in those years.

However, despite this variation, again seen on analysis of variance of mean transformed disease incidence on the five cultivars common to all eight trials (P = 0.01 for sites and years, no significance was detected between cultivars), it was clear that the two currently recommended varieties (Anon. 1983) - Jet Neuf and Bienvenu - had the highest disease incidence (Table 3).

DISCUSSION

The results of these trials demonstrate that all the major oilseed rape cultivars tested by NIAB for the National List are susceptible to stem rot. The incidence of the disease varied on each cultivar with both year and site. The highly significant difference in disease incidence between the cultivars grown at the individual sites, disappeared when data were analysed for all sites in one year or for one site in all three years. This indicates that no consistent measure of cultivar susceptibility can be made from such records of disease incidence.

The differing expression of cultivar susceptibility in these trials may reflect important differences in environmental conditions at each location or in each year or in some cases may be due to simple escape from infection. At Cambridge 1981-2, the low infection detected was due to the late seeded sclerotia not receiving the overwintering required for apothecial production in May-June. Further investigation into the epidemiology of the disease has been carried out in the 8 trials (Mylchreest 1984) in order to understand the varying cultivar response to *Sclerotinia* more fully.

Nevertheless, the results show that no cultivar currently being evaluated for performance under UK conditions is resistant to stem rot. This includes cv Doral which proved to be as susceptible as the other cultivars under trial at Silwood. Moreover, the cultivars now commonly grown, Jet Neuf and Bienvenu, are among those most likely to be infected and thus may increase the risk of stem rot becoming more widespread in the UK.

ACKNOWLEDGEMENTS

I am indebted to my supervisor, Dr. B.E.J. Wheeler for his help in the preparation of this paper and acknowledge the award of a S.E.R.C. Case Research Studentship with the National Institute of Agricultural Botany.

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INCIDENCE OF CLUBROOT IN OILSEED RAPE CROPS IN ENGLAND, WALES AND SCOTLAND

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ABSTRACT

Thirty-one cases of clubroot in oilseed rape crops have been confirmed in England, Wales and Scotland in the last 6 years. Most were in northern and western areas of Britain and were associated with short rotations of brassicas, particularly fodder types. Of 1398 fields tested for presence of clubroot prior to potential cropping with oilseed rape in Scotland in the years 1981-84, 440 (31.5%) were infected. In pathogenicity tests, *Plasmodiophora brassicae* Wor. populations from forage and vegetable brassica sources infected oilseed rape and a population from oilseed rape infected other brassica species eg swede, turnip and kale.

INTRODUCTION

Clubroot disease of Cruciferae is caused by the soil-borne fungal pathogen *Plasmodiophora brassicae* Wor. and is one of the most damaging diseases associated with intensive cultivation of brassicas, particularly in temperate regions (Buczacki 1979). The characteristic symptom of clubroot is the presence of galls (clubs) on the root system, often with associated wilting and stunting of plants.

A number of outbreaks of clubroot on oilseed rape have been reported in recent years, mainly in northern and western areas of England (Evans *et al*. 1984) and have usually been associated with short rotations of brassica crops. The disease has become an increasing problem in intensive oilseed rape growing areas of France since 1981 (Rouxel *et al*. 1983). Clubroot can also occur on cruciferous weeds eg charlock (*Sinapsis arvensis* L.) and shepherds purse (*Capsella bursa-pastoris* (L.) Medic.) which could thus sustain and multiply inoculum in the soil in the absence of susceptible crops.

As the oilseed rape crop acreage extends to traditional fodder and vegetable brassica growing regions, particularly in the wetter northern and western parts of Britain, more outbreaks of clubroot might be expected. This paper gives details of the occurrence of disease attacks in recent years, the incidence of clubroot infection in soils of potential oilseed rape fields in Scotland and results of pathogenicity testing of *P. brassicae* populations.

MATERIALS AND METHODS

Disease incidence

Details of disease outbreaks have been collated from two sources: Firstly, from disease surveys carried out on randomly selected crops of winter oilseed rape by ADAS plant pathologists (Evans *et al*. 1984) and, secondly, from plant clinic samples of oilseed rape received in the general course of advisory work by ADAS Regional laboratories and the Scottish Colleges of Agriculture.

Soil testing

The Scottish colleges operate a chargeable service in which soil from fields to be sown with oilseed rape (or other brassicas) can be tested for presence of *P. brassicae* prior to sowing. Soil samples (2 kg soil per 5 ha block) are sieved through a 1 cm mesh sieve and placed in a seed tray. These are each planted with twenty 7-10 day old seedlings of chinese cabbage (cv Granaat) and placed in gravel trays on a glasshouse bench at an air temperature kept below 15°C with 16 h light/day. Trays are maintained at field capacity moisture content for the first 14 days and at a soil temperature of 18-20°C. Plants are removed after 4-6 weeks and are assessed for clubroot severity according to the key devised by Buczacki *et al*. (1975). The test is regarded as positive if at least one plant shows any degree of infection.

Pathogenicity testing

The 'slurry' method of Toxopeus & Janssen (1975), as modified by Lewis & Brokenshire (1977), was used to determine pathogenicity of *P. brassicae* populations from an oilseed rape host to other brassica species (performed at Wolverhampton) and from forage or vegetable brassica sources to oilseed rape (performed at Edinburgh). Inoculum was maintained as deep frozen galled plants and a slurry was prepared consisting of 100 ml sieved peat, 100 ml John Innes No. 3 potting compost (without lime) and spore suspension in distilled water to give a total volume of 250 ml at a concentration of 10^6 spores/ml. The slurry was mixed thoroughly and added to four drills in compost in a seed tray.

Ungerminated seed of the test species was sown on the slurry and covered with compost. Seedlings were thinned out after emergence to give 30 per seed tray and were assessed for clubroot severity after 6 weeks. Results were expressed as percentage plants infected (Wolverhampton) or as a disease index (Edinburgh).

RESULTS

Disease incidence

Table 1 shows the distribution of reported outbreaks of clubroot in oilseed rape in England (divided into MAFF Regions), Wales and Scotland in the years 1979-1984. Although the total number of attacks was small in relation to the large acreage of oilseed rape grown, it is noteworthy that the majority of reports came from northern and western areas of Britain. In most cases, further investigation of cropping history showed that short rotations of brassicas were implicated in disease occurrence. Many reports were associated with oilseed rape grown too soon (<5 years) after a previous fodder brassica crop eg swedes or turnips. Occasionally, presence of clubroot affected cruciferous weeds was thought to be responsible for maintaining inoculum between susceptible brassica crops.

TABLE 1

Number of confirmed outbreaks of clubroot in oilseed rape crops in England, Wales and Scotland, 1979-84

England (MAFF Region)					Wales	Scotland
Northern	Midlands & Western	Eastern	South Western	South Eastern		
4 (46 490)[1]	11 (34 748)	1 (103 301)	0 (6 882)	1 (26 181)	6 (344)	8 (3 956)

1, Hectareage of oilseed rape grown in 1982-83 season.

Soil testing

The results of soil tests for presence of clubroot in fields intended to be sown with oilseed rape, undertaken by the three Scottish colleges in the years 1981-1984, are given in Table 2. The range of percentage positive tests is from 20% (ESCA in 1982) to 77% (WOSAC in 1983). The results indicate the widespread incidence of P. brassicae in field soils in Scotland and thus a high potential risk of attack by clubroot if such fields are sown to oilseed rape, particularly in conditions favourable to the pathogen eg wet or acidic soil conditions.

TABLE 2

Results of soil tests for presence of clubroot in fields destined mainly for oilseed rape cropping, Scotland, 1981-1984

	NOSCA		ESCA		WOSAC	
	No.tests	% positive	No.tests	% positive	No.tests	% positive
1981	-	-	305	38	-	-
1982	-	-	306	20	17	41
1983	113	25	262	33	13	77
1984	99	24	229	40	54	24

NOSCA, North of Scotland College of Agriculture, Aberdeen.
ESCA, East of Scotland College of Agriculture, Edinburgh.
WOSAC, West of Scotland College of Agriculture, Auchincruive.
- , no data available.

Pathogenicity testing

The results from an experiment performed at Wolverhampton (Table 3) indicate that a population of P. brassicae isolated from oilseed rape (cv Jet Neuf) can infect a wide range of other brassica hosts particularly swede, chinese cabbage and Brassica oleracea types. Table 4 shows that P. brassicae populations isolated from Brussels sprouts, and from infested soil previously cropped with forage or vegetable brassicas, can infect oilseed rape plants. There was little difference in the severity of infections caused by the different populations and little difference in the reaction of the three oilseed rape cultivars tested.

Rouxel et al. (1983) also found that all oilseed rape cultivars tested were susceptible to clubroot infection.

TABLE 3

Infection of brassica hosts by a P. brassicae population from oilseed rape, ADAS Wolverhampton, 1983

Test host species and cultivar	Percentage plants infected
Swede cv Wilhelmsburger	18
Swede cv Acme	35
Rape cv Nevin	2
Rape cv Emerald	8
Stubble turnip cv Debra	3
Chinese cabbage cv Granaat	51
Cabbage cv Golden Acre	22
Kale cv Thousand Head	25
Brussels Sprouts cv Asmer Achilles	25

TABLE 4

Infection of oilseed rape by 5 P. brassicae populations from other brassica hosts, ESCA, 1981

Oilseed rape cultivar	P. brassicae population[1]				
	C13	C24	C37	C56	C57
Maris Haplona	100[2]	92	100	100	72
Mogul	100	100	100	100	82
Primor	100	92	99	100	100

1, Sources:- C13 from Brussels sprouts; C24, C56, C57 from infested soil previously cropped with forage brassicas; C37 from infested soil previously cropped with vegetable brassicas.

2, Disease index values (0 = No disease, 100 = 100% severe infection).

DISCUSSION

At least 31 attacks of clubroot in oilseed rape crops have occurred in the last six years in England, Wales and Scotland although it is likely that many more cases of slight infection have occurred. More outbreaks of this disease can be expected as a greater acreage of oilseed rape is grown in northern and western parts of Britain for the following reasons:-

1. Most disease attacks have occurred in the traditional fodder brassica growing areas when short rotations between fodder brassicas and oilseed rape have been employed.

2. The presence of P. brassicae is already widespread in fields in Scotland that are likely to be cropped with oilseed rape.

3. Populations of P. brassicae from fodder and vegetable brassica sources are able to infect oilseed rape in a non-specific manner. Conversely, oilseed rape populations are able to infect other brassicas (cf Rouxel et al. 1983) and thus overcropping of brassica species will perpetuate inoculum in the soil for potential infection of future crops. The fungus can survive for at least 18 years in soil (Buczacki et al. 1974).

Other factors may also enhance survival of the pathogen and disease expression eg presence of cruciferous weeds in non-brassica crops grown between susceptible brassica species, and occurrence of wet or acidic soil conditions.

Although certain measures can be employed to control clubroot in horticultural crops eg soil sterilisation (White & Buczacki 1977), control on a field scale, other than by liming (Welch et al. 1976), is not economic. Such control must await the development of effective fungicides; some new chemicals have shown promise in trials (Buczacki 1983, Dixon & Wilson 1983). Meanwhile, growers must adhere strictly to an appropriate crop rotation to avoid or minimise the likelihood of attack by this intractable pathogen.

ACKNOWLEDGEMENTS

We thank colleagues in ADAS and the Scottish Colleges for provision of data.

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BROAD SPECTRUM DISEASE CONTROL IN OILSEED RAPE WITH PROCHLORAZ

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ABSTRACT

Trials during 1982-84 have demonstrated the broad-spectrum activity of prochloraz 40% e.c. 'Sportak' against the major diseases of oil seed rape. Prochloraz at 500 g a.i./ha has given good control of dark leaf/pod spot (Alternaria spp.), light leaf spot (Pyrenopeziza brassicae), leaf spot/stem canker (Leptosphaeria maculans), grey mould (Botrytis cinerea) and stem rot (Sclerotinia sclerotiorum), with good yield benefits.

A two-spray programme of prochloraz, applied at stem extension and mid-late flowering, usually gave better disease control and yield increase than a single treatment at either timing. This was particularly true for light leaf spot, a disease of increasing occurrence and importance in oilseed rape, where an early spray appeared essential for good control. Two sprays of prochloraz, the first at stem-extension, gave good control of this disease on leaves, stems and pods and significant yield benefits.

INTRODUCTION

The area of oilseed rape grown in England and Wales has risen dramatically in the past four to five years, from c. 74000 ha in 1979/80 to c. 270000 ha in 1983, making oilseed rape second only to cereals in importance in the arable rotation. This increasing crop area has brought shorter rotations and closer proximity of crops with a consequently increased risk of disease and pest attack. Dark leaf and pod spot (Alternaria spp.) is generally considered the most damaging disease but the past two seasons have seen high levels of light leaf spot (Pyrenopeziza brassicae) in many crops. (Evans et al. 1984).

Other diseases with the potential to cause much damage are canker (Leptosphaeria maculans), grey mould (Botrytis cinerea), stem rot (Sclerotinia sclerotiorum) and downy mildew (Peronospora parasitica).

Most of these diseases can be found at low levels in most crops at some time during the season but it is not possible to predict which, if any, will become damaging. Under these circumstances a broad-spectrum fungicide with the ability to control all the major diseases of oilseed rape would offer obvious advantages to the farmer and adviser.

Prochloraz, a novel imidazole fungicide, was introduced in the UK in 1981 for the control of a wide range of stem-base, foliar and ear diseases in cereals (Harris et al. 1979). The broad-spectrum activity of prochloraz indicated that it would have potential in other crops and development work is progressing in many areas. This paper describes trials work with prochloraz in oilseed rape in the UK in the past three seasons which led to a commercial recommendation for the control of the major diseases of this crop.

MATERIALS AND METHODS

In the period 1982 to 1984 trials with prochloraz 40% e.c. formulation were conducted in winter oilseed rape crops in all the major arable areas of the UK.

The trials reported here were of randomized block design with 4 or 6 replicates. Plots were either 3 or 6m wide x 20m long.

Treatments were applied to 3m wide plots using CO_2-powered knapsack sprayers calibrated to deliver 200 l/ha through Tee Jet 80015 nozzles on a 3m boom at 200 k Pa. Plots 6m wide were treated using a tractor-mounted compressed air powered sprayer delivering 200 l/ha through F100/200 flat fan nozzles at a pressure of 235 k Pa.

Trials in 1982 and 1983 compared the effects of single applications of fungicides at stem-extension (T1) or 95% petal-fall (T2) and 2-spray fungicide programmes (T1 + T2).

In 1984 timings were slightly modified following the satisfactory completion of bee-toxicity studies with prochloraz and consequent Pesticide Safety Precaution Scheme clearance for sprays during flowering. T1 remained at stem-extension, T2 became mid-late flowering (when disease began to move up the plant).

Prochloraz was compared with the standard fungicides iprodione and vinclozolin; all were applied at 500 g a.i./ha.

Assessments of diseases present were made before spraying, 2 to 3 weeks after spraying, 4 to 6 weeks after spraying and at maturity. Diseases were assessed on leaves (area infected), stems (no. infected), racemes (area infected) and pods (area infected) using ADAS disease assessment keys or, when disease levels were low, by counts of lesions.

Yields were taken from most trials: plots were dessicated and the centre 2.5m of each plot harvested using a Claas Compact combine equipped with vertical cutting knives. Yields were corrected to 9% moisture.

RESULTS

Table 1 summarises the levels of disease control and yield benefits achieved with prochloraz and iprodione in this series of trials. Disease levels in oilseed rape over the period 1982-84 were generally low but prochloraz demonstrated a broad spectrum of activity giving good control of dark pod spot, light leaf spot, stem rot, canker and grey mould. Against all diseases except dark pod spot prochloraz gave better control than iprodione. Yield benefits were good with prochloraz and iprodione but were rarely significantly better than untreated.

TABLE 1

Summary of disease control and yields 1982-84

Treatment*	g a.i./ha	Mean % control dark pod spot	light leaf spot	stem-rot	stem canker	grey mould	Mean yield (% of un-treated)
prochloraz	500	62	63	65	67	62	109.5
iprodione	500	75	13	43	51	34	109.5
Untreated level of disease		4% pod area	7% pod area	2% stems	2% stems	5% leaf area	
Untreated yield (t/ha)							3.1
No. of results in mean		7	10	3	6	6	22

* one or two applications of each treatment per site determined by amount of disease in trial plots.

Light leaf spot was the most common disease in the trials and was unexpectedly severe in some crops, usually of cv Jet Neuf. The disease became obvious in crops in February/March and continued to develop infecting stems, leaves and, in some cases, pods. Infected pods were often smaller than uninfected and were distorted.

In 1983 and 1984 prochloraz gave excellent control of light leaf spot, better than iprodione and vinclozolin (Table 2). A two-spray programme of prochloraz at stem-extension (T1) and mid-late flowering (T2) gave particularly good control of light leaf spot on leaves, stems and pods, superior to a single spray at either T1 or T2.

TABLE 2

Light leaf spot control on pods in July and yields

Treatment	g ai/ha	% disease control 1983	% disease control 1984	Yield (% of untreated) 1983	Yield (% of untreated) 1984
prochloraz T1 + T2	500	59	80	112.6	114.3
prochloraz T1	500	-	65	-	106.2
prochloraz T2	500	32	62	107.7	109.7
iprodione T2	500	7	24	105.5	104.8
vinclozolin T2	500	10	-	103.2	-
Untreated pod area diseased/yield		12%	20%	3.32 t/ha	3.35 t/ha
No.of results in mean		3	4	3	4

Yield benefits from light leaf spot control were good, especially from the prochloraz two-spray programme. Significant yield increases over untreated were achieved at one site in 1983 and three sites in 1984. Results from two of these sites are shown in Tables 3 and 4.

TABLE 3

Disease control and yield, Bury St Edmunds 1983

Treatment	Timing	g ai/ha	% Disease Control (on pods) Light leaf spot	% Disease Control (on pods) dark pod spot	Yield % untreated
prochloraz	T1 + T2	500	71	86	130
prochloraz	T2	500	27	83	112
iprodione	T2	500	13	98	114
vinclozolin	T2	500	19	63	111
Untreated (% pod area infected)			12	4	
Untreated yield (t/ha)					2.26
LSD (P = 0.05)					15.3

In this trial light leaf spot was present at moderate-severe levels from late February and attacked leaves, stems and pods. A prochloraz two-spray programme (T1 + T2) increased yield significantly more than single (T2) sprays of prochloraz, iprodione or vinclozolin. The yield response from single sprays at T2 did not differ significantly from untreated.

TABLE 4

Light leaf spot control and yield, Bishop's Stortford 1984

Treatment	Timing	g ai/ha	% control	Yield (% of untreated)
prochloraz	T1 + T 2	500	76	115.3
prochloraz	T1	500	56	105.9
prochloraz	T2	500	60	109.5
iprodione	T2	500	35	100.4
Untreated (%pod area infected)			50	
Untreated yield (t/ha)				3.95
LSD (P = 0.05)				5.6

At the second site (Table 4) a prochloraz two-spray programme (T1 + T2) gave better control of light leaf spot and a significantly better yield than a single spray at T1 or T2. Both T1 and T2 applications of prochloraz gave significantly better yields than untreated. Prochloraz applied at either T1 or T2 gave better control of disease than iprodione applied at T2 and a significantly better yield at the T2 timing.

Dark pod spot occurred in few of our trials, usually at low levels. Prochloraz gave good control (Tables 1 and 3) better than vinclozolin but less effective than iprodione. Against this late-season disease, the two-spray prochloraz programme (T1 + T2) appeared to offer little advantage over a single spray at late-flowering T2 (Table 3).

Other diseases were recorded in several trials but were present at low levels and were usually accompanied by light leaf spot. Prochloraz gave better control of these diseases than iprodione (Table 1) but it was not possible to attribute yield benefits to the control of any single disease.

DISCUSSION

Prochloraz has demonstrated a broad spectrum of activity against the major diseases of oil seed rape. At 500g a.i./ha it has given good control of dark leaf/pod spot, light leaf spot, stem rot, canker and grey mould with good yield benefits. Based on these and other results prochloraz 40% e.c. formulation can be recommended for the control of the major diseases of oil seed rape. Our results show that for season-long disease control, two applications of prochloraz at 500 g ai/ha in 200-400 l/ha are advisable : one at the onset of stem extension and the second at mid-late flowering, when disease moves onto the upper leaves and bracts.

When dark pod spot is severe a spray during pod formation may be necessary.

During the period of these trials (1982-84) the disease pattern in winter oilseed rape appears to have changed with light leaf spot replacing dark leaf/pod spot as the most common (and perhaps potentially as important) disease. Prochloraz has given excellent control of light leaf spot and significant yield benefits, especially when used in a two-spray programme at stem-extension and mid to late-flowering. Other workers have also demonstrated significant yield benefits from the control of light leaf spot (Rawlinson & Cayley 1984). We have shown that good control of this disease appears to require an early fungicide treatment followed by a mid-late flowering spray; it may be that even stem-extension is a little late for best results and this aspect will feature in our future studies.

If light leaf spot continues to predominate in oilseed rape crops, as it has in our trials in the past two seasons, earlier fungicide treatments will become more common. At early growth stages several major disease of oilseed rape can be found at low levels in most crops and the merits of using a broad-spectrum fungicide, like prochloraz, are obvious.

ACKNOWLEDGEMENTS

The authors wish to thank their colleagues who were involved in the execution of these experiments. Thanks are also due to the many farmers on whose crops the experiments were carried out, often at considerable inconvenience.

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SPRAY TREATMENTS, METHODS AND TIMING FOR CONTROL OF LIGHT LEAF SPOT ON OILSEED RAPE

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ABSTRACT

Early control of light leaf spot (*Pyrenopeziza brassicae*) gave significant yield increases in three cultivars; at the rates used timing of sprays was more important than amount of active ingredient deposited on plants. A single spray of benomyl or prochloraz in autumn (November) contributed more to control severe light leaf spot and increase crop growth and yield than a spray in spring (April). Plots sprayed on both occasions yielded more than those sprayed once. Sprays of prochloraz or prochloraz + carbendazim in April gave equally good control of severe light leaf spot symptoms but had no significant effect on yield. A new growth regulator, UK140 (RSW0411, triapenthenol) applied in March, produced a shorter, more manageable crop and gave good control of light leaf spot; yield was increased but not significantly. Hydraulic and electrostatic application methods were equally effective; the latter showed promise as a method for control of diseases on pods. Spray treatments, application methods and timing are discussed in relation to epidemiology and disease forecasting.

INTRODUCTION

Light leaf spot (*Pyrenopeziza brassicae*) has occurred each year for the past decade on rape in south-eastern England and has occasionally merited control by fungicides. An experiment on cv Primor in 1980 (Rawlinson *et al*. 1984) showed that when infection by light leaf spot was likely an autumn spray of either benomyl or prochloraz maintained plant populations during winter, at least halved the percentage of leaves infected, doubled leaf area index and crop growth rate in spring, reduced infection on pods in July by up to 73% and doubled yield compared with untreated plots. Sprays applied in autumn and again in spring gave as good or better results than the autumn treatments alone, but those applied only in spring were generally less effective in controlling light leaf spot and increasing crop growth and yield. Other work (Anon. 1983), often on crops with little disease, has shown that while light leaf spot can be controlled by fungicides there is little benefit to yield. These differences in response stimulated the further work on spray treatments, methods and timing reported here. When sprays are applied to rape at an early growth stage by a conventional hydraulic sprayer much of the spray misses or runs off foliage onto soil. We also report comparisons of light leaf spot control by fungicides applied hydraulically or electrostatically, where the charged drops and small volumes of water used with the latter were expected to maximise spray contact with foliage and stems (Arnold *et al*. 1984).

MATERIALS AND METHODS

Full details of experiments done at Rothamsted in 1982 and 1983 are reported elsewhere (Rawlinson *et al*. 1984).

Experiments in 1984 were all done at Rothamsted in the same field of cv Jet Neuf sown 25 August at 9 kg/ha, given 58 kg nitrogen/ha to the seedbed, 116 kg on 15 February and 120kg/ha on 5 April. The fungicides prochloraz ('Sportak') and prochloraz + carbendazim ('Sportak Alpha') were applied by 'Jumbo' electrostatic rotary atomiser (Arnold 1983) at 400 g a.i. prochloraz and 150 g a.i. carbendazim/ha (1 and 1.5 litre product respectively) in 9.3 litre water/ha to each of 4 replicate plots (2 x 6 m) in 4 randomised blocks with 4 plots untreated.

The growth regulator UK140, a Bayer UK Ltd. w.p. formulation containing 70% RSW0411, (triapenthenol, proposed common name) was applied by 'Jumbo' electrostatic sprayer at 350 and 700 g a.i./ha and by conventional hydraulic sprayer (F110-200 Lurmark jets, 4 kph, 3 bar pressure) at the same rates in 200 litre water/ha to 4 replicate plots (3 x 10 m) in 4 randomised blocks with 4 plots untreated. Plots were desiccated before harvest.

Spray penetration studies were done with the same sprayers using a tracer compound applied at 100 g/ha. Four plots were sprayed using the 'Jumbo' in uncharged mode, 4 in charged mode, and 8 using the hydraulic sprayer. Two replicate samples (each of 10 plants) of pods and stems at different layers in the canopy of each plot were extracted with hexane and tracer deposit analysed by gas chromatography using an electron capture detector.

In all experiments disease assessments at each sampling date were on 20 plants per plot using methods described by Rawlinson et al. (1984). Plant height, internode and branch length were measured on 5 plants per plot and wax on leaves as described by Rawlinson et al. (1978a). All values significantly different from untreated at $P \leqslant 0.05$ are marked with an asterisk (*) in Tables; all % values were converted to logits for confirmatory statistical analysis.

RESULTS

Hydraulic and electrostatic application of prochloraz to cv Primor in autumn (A) and autumn + spring (A+S) 1982

Both methods of application of the A spray (9 November), at all dose rates, gave equally good control of light leaf spot on leaves up to mid-April (Table 1); most effect was on the incidence of severely lesioned leaves. All A sprays decreased plant death over winter, much increased leaf area and plant dry weight in spring and numbers of pods per unit area in June.

The additional spray in spring (A+S 5 April) gave little more disease control or increase in crop growth, but did increase yield further (Table 1). The yield increase may have been because there was greater control of lesions on stems and pods. In mid-April 82% of stems in untreated plots bore lesions compared with 72 and 66% in A and A+S plots respectively (S.E. 4.0). The severity score in June for lesions on stems in untreated plots was 1.5, in A plots 1.5, but in A+S plots it was significantly less at 1.1 (S.E. 0.08). Moreover, by mid-June the additional spring spray had delayed infection of pods; no pods were infected on any A+S plots, compared with 2.1% pods infected on A plots and 3.3% on untreated plots (S.E. 1.05). This protection of stems was also seen for canker (Leptosphaeria maculans). The additional spring spray gave little further control of incidence or severity of canker lesions at the stem base, but those on upper parts of the stem in mid-June were fewer and less severe (17% in untreated plots, 10 and 4% in A and A+S plots respectively, S.E. 2.5; corresponding mean severity scores were 0.2, 0.1 and 0.04, S.E. 0.023).

Untreated plots yielded 1.17 t/ha; mean yield for all A and A+S plots was significantly greater at 1.45 and 1.78 t/ha respectively (S.E. 0.061, increases of 24 and 52% respectively). No single treatment gave <17% yield increase and the best gave 71% increase.

TABLE 1

Effects of prochloraz applied 9 November by hydraulic(H) and electrostatic(E) sprayer on light leaf spot, growth and yield of cv Primor 1982

Date	Disease, Growth and Yield	Application method and dose rate				
		H4$^+$	E1	E2	E4	Untreated
7 Dec.	% leaves > 10%	9*	19*	12*	13*	31
5 Feb.	% leaves > 10%	29*	36*	26*	20*	72
19 April	% leaves > 50%	11	7*	12	9*	15
	leaf area/plant (cm^2)	311*	272	365*	397*	183
	dry wt/plant (g)	5.4*	4.2*	5.7*	7.0*	2.7
15 June	No. plants/m^2	96*	102*	92*	98*	49
	No. pods(x1000)/m^2	6.9*	7.3*	5.5	6.7*	4.5
28 July	Yield (t/ha)	1.47*	1.53*	1.37	1.41	1.17
		(1.85*	1.54*	2.00*	1.75*)	

> 10%, > 50% = with more than 10 and 50% respectively of leaf area lesioned. $^+$ 1, 2, 4 = 125, 250 and 500 g a.i./ha respectively. Yield values in parenthesis are for plots sprayed 9 November and 5 April.

Prochloraz deposits on leaves after the A spray were nearly three-times greater after electrostatic than after hydraulic spraying; hydraulic sprays at 500 g a.i./ha deposited 231 ± 17.9 µg/g dry weight and electrostatic sprays at the same rate of active ingredient deposited 679 ± 74.3 µg/g. Deposits after electrostatic application of 250 and 125 g a.i. were 350 ± 36.7 and 201 ± 22.5 µg/g respectively. Thus, despite a quarter or half reduction in active ingredient and a 95-fold decrease in application volume the electrostatic sprayer gave similar deposits on leaves to those from an hydraulic sprayer.

Hydraulic and electrostatic application of benomyl to cv Jet Neuf and Norli, 1983

Weather in eastern England in the growing season 1982-3 was favourable for the development of much light leaf spot on rape (Gladders

1984), providing good conditions to test the effects of fungicides on cultivars more resistant to the disease than cv Primor. The results (Table 2) showed that both hydraulic and electrostatic application of benomyl gave significant control of disease and increased yield in two comparatively resistant (Anon. 1981) cultivars. Under these conditions of much natural inoculum (enhanced by additional inoculum from chopped rape straw scattered before emergence on plots of cv Norli) it was clear that the second electrostatic application of benomyl to cv Norli in spring (12 April) was necessary to delay movement of the pathogen onto pods. This may have contributed to the greater yield increase on cv Norli (27%) than that given by the single autumn spray on cv Jet Neuf (13%). There was no evidence that plants were killed by light leaf spot in either experiment and other diseases were slight.

TABLE 2

Effects of benomyl applied by hydraulic and electrostatic sprayer on light leaf spot+ and yield of cv Jet Neuf and Norli, 1983

	Hydraulic cv Jet Neuf			Electrostatic cv Norli	
	Benomyl[1]	Untreated		Benomyl[2]	Untreated
Spray date........	15 Nov.			30 Nov.+ 12 April	
% plants	33*	89	% leaves	26*	70
Severity/plant	0.3*	1.2	Severity /leaf	0.1*	0.5
% stems	11*	55	% terminals	20*	53
Severity/stem	0.1*	0.6	% pod area	3*	23
Yield (t/ha)	3.47*	3.06	Yield (t/ha)	2.60*	2.05

+ = all incidence and severity assessed 25-26 May, except pod area on 13 July. 1 = 500 g a.i. in 250 litre water with 2.5 litre actipron oil/ha. 2 = 500 g a.i. in 4.2 litre water/ha.

Electrostatic application of prochloraz and prochloraz + carbendazim in spring to cv Jet Neuf, 1984

The results from two identical experiments, done in the same field, in which sprays were applied on 4 or 13 April were similar. The results for sprays applied on 13 April are given in Table 3.

Natural infection was established early in crop growth. By the end of April a mean of 84% and by the end of May 100% of plants were infected. Most effect of the fungicides was on leaves; they had no significant effect on stem lesions. Both fungicides significantly decreased overall incidence on leaves up to the end of June (8 infected leaves/plant in untreated plots, 4/plant in sprayed plots, S.E. 0.6, on 14 May; 68% leaves infected in untreated, 49% in sprayed plots, S.E. 5.8, 21 June), but had most effect on the development of severe symptoms (Table 3). By 21 June >80% of all plants had infection on the pods of the terminal branch, both fungicides gave some control by decreasing the percentage of those with severe (> 25% of total pod area) infection in early July. Both fungicides were equally effective; none of > 50 calculations from different measurements of incidence and severity on plants, leaves, stems and pods at fortnightly intervals during the season showed a significant difference in efficacy between the two fungicides. Plots treated with prochloraz + carbendazim gave slightly greater yield, but this was not significantly different from prochloraz alone or from untreated plots.

TABLE 3

Effects of prochloraz and prochloraz + carbendazim applied electrostatically on 13 April on light leaf spot and yield of cv Jet Neuf, 1984

Date	Disease & Yield	Prochloraz	Prochloraz + carbendazim	Untreated	S.E. (D.F.9)
27 April	% plants > 10%	10	14	24	4.8
14 May	% plants > 10%	5*	5*	26	4.0
	severity/plant	0.9*	0.9*	1.3	0.08
30 May	% plants > 10%	3*	3*	8	1.2
	severity/leaf	0.4*	0.3*	0.6	0.05
21 June	% plants > 10%	17*	13*	32	2.6
	severity/leaf	0.6	0.5*	0.9	0.11
10 July	% terminals + 25% pod area infected	10	7	19	5.5
31 July	Yield (t/ha)	4.72	4.94	4.75	0.211

> 10% = with more than 10% of total leaf area lesioned.

Hydraulic and electrostatic application of UK140 in spring to cv Jet Neuf, 1984

There was much infection by light leaf spot in this experiment and UK140, at both dose rates and methods of application, significantly decreased incidence and severity (Table 4); control was better at the higher dose rate. Disease tended to be least on plots sprayed electrostatically, but at no time was it significantly less than on plots sprayed hydraulically. UK140 effectively limited the development of severe symptoms on leaves, stems and pods. On 19 June mean severity scores for the top three bracts on untreated and treated plants respectively was 0.3 and 0.1 (S.E. 0.05) for the topmost bract, 0.6 and 0.2 (S.E. 0.05), 0.6 and 0.2 (S.E. 0.09) for second and third bracts, with mean severity scores on pods of 0.8 and 0.4 (S.E. 0.10).

UK140 also significantly decreased plant height on all sprayed plots from a mean of 58 to 45cm (S.E. 2.1) on 26 April and from 126 to 108cm (S.E. 2.9) on 3 July. The decrease in height was due to shortening of the lower internodes; the distance from soil level to lowest branch in untreated plots was 59cm and in treated plots 48cm (S.E. 2.2) on 3 July. There was no effect on other internodes or on branch length or number, although the terminal branch tended to be shorter (44cm in untreated, 40cm in treated plots, S.E. 2.1). Spray methods and dose rates did not differ significantly in their effects on these measurements, although the higher dose tended to be more effective. Plants in treated plots were more glaucous up to 4 weeks after spraying, but on 16 April there was no significant difference in weight of epicuticular wax per unit area of leaf (untreated 0.060, mean of treated 0.065 mg/cm^2, S.E. 0.0073). Flowering began and finished slightly earlier on treated plots, especially on those given the higher dose by either sprayer. Yield was slightly increased on all treated plots. Greatest yield was on plots given the higher dose applied hydraulically, but differences between spray method and dose rate were not significant.

TABLE 4

Effects of UK140 applied by hydraulic and electrostatic sprayer at two rates on 19 March (GS 2.7) on light leaf spot and yield of cv Jet Neuf, 1984

Date	Disease & Yield	Hydraulic 1	Hydraulic 2	Electrostatic 1	Electrostatic 2	Un-treat-ed	S.E. (D.F. 12)
26 April	% plants	61*	49*	46*	49*	80	4.6
	severity/plant	0.6*	0.5*	0.5*	0.5*	0.9	0.05
10 May	% leaves	46*	40*	54	34*	57	3.2
	% plants > 10%	16*	6*	17*	0*	35	3.3
24 May	% stems	9*	10*	21	10*	31	4.5
19 June	% leaves	35*	30*	40*	38*	60	4.7
	severity/leaf	0.3*	0.3*	0.3*	0.2*	0.7	0.07
	% plants > 10%	6*	4*	4*	3*	18	1.9
6 July	% terminals > 10%	29	6*	19*	7*	35	4.8
1 August	Yield (t/ha)	3.47	3.76	3.66	3.58	3.44	0.129

> 10% = with more than 10% of total leaf or pod area lesioned. 1 = dose rate 350 g a.i./ha, 2 = dose rate 700 g a.i./ha.

TABLE 5

Hydraulic and electrostatic spray penetration of rape canopy at pod development (GS 5.1, crop height 1.4m, cv Jet Neuf, 6 June 1984)

Sprayer	Canopy layer.... (cm)	Top (0-5)	Middle (20-25)	Bottom (40-45)
Hydraulic		13.6 ± 1.6	12.9 ± 0.5	7.9 ± 0.5
Electrostatic uncharged		17.6 ± 3.9	8.5 ± 2.2	2.6 ± 0.4
Electrostatic charged		277.6 ±57.1	35.9 ± 9.5	4.5 ± 0.8

Hydraulic and electrostatic spray penetration of rape canopy, 1984

At all levels in the crop canopy the electrostatic sprayer gave greater deposits when charged than when uncharged; only in the bottom layer (containing the lowest pods in the canopy) did the hydraulic sprayer give greater deposits (Table 5). Deposits from the hydraulic sprayer were more uniformly distributed down the canopy, implying that more was deposited further down than the lowest pods so not likely to contribute to disease control on pods.

DISCUSSION

In our trials autumn control of light leaf spot on cv Primor was clearly beneficial (Table 1), consequent yield increases in cv Jet Neuf and Norli (Table 2) indicate that there is also benefit on comparatively resistant cultivars. Although sprays applied only in spring (Tables 3, 4) can give significant control there may be little benefit to yield. Electrostatic application can greatly increase the amount of fungicide deposited on plants, but even this advantage when spraying is done in autumn(Table 1) or spring (Table 4) does not significantly and consistently enhance disease control or improve yield over that achieved by an hydraulic spray. Adding a second fungicide, carbendazim, to an already effective fungicide, prochloraz, did not significantly enhance control (Table 3). These results indicate strongly that timing of fungicide, at the rates we used, is more important than amount. On farms early control must be justifiable economically. The principal difficulty is forecasting the need to spray sufficiently early i.e. before the disease becomes widely apparent. Prophylactic sprays may give control in some seasons, but cannot be advocated generally until there is more information to enable prediction of severe disease.

Initial infection by P. brassicae on winter rape is usually in autumn and winter; tissues may be extensively infected yet obvious symptoms on leaves take months to appear (Rawlinson et al. 1978b) and are often not seen until March. Our results with spring sprays show that good control, mainly of severity not incidence, is possible, but since there was little yield benefit this indicates that important damage by the pathogen may be done much earlier when primordial tissue of leaves and floral structures may be infected latently. This view is supported by the high incidence and severity of infection that developed in 1984 (Tables 3, 4) despite a long dry period in spring (no rain for 19 days up to 5 May) which hitherto has been widely held to check the development of damaging symptoms. Disease severity on leaves, stems and pods of sprayed plots in the triapenthenol trial (sprayed 19 March) was generally less than in the adjacent prochloraz trial (sprayed 13 April); this may reflect better fungicidal action, but is more likely to have been the result of earlier application of triapenthenol.

Shortening rape with growth regulators could increase disease by changing the crop microclimate, especially in seasons wetter than 1984, but this disadvantage does not seem to apply to triapenthenol because of its additional fungicidal action.

Our results (Tables 1, 4, 5) showed that the electrostatic sprayer can be at least as good as the hydraulic sprayer for application of agrochemicals to rape. It may be more suitable than hydraulic for pesticides applied up to late rosette stage when more active ingredient will reach plants, rather than wastefully deposited on soil. Its use for effective penetration of the upper layers of rape canopy holds promise for control of pests and diseases on pods.

ACKNOWLEDGEMENTS

We thank Bayer UK Ltd. and FBC Ltd. for supplying chemicals.

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WL 85871 - AUTUMN AND SPRING APPLICATIONS FOR CONTROL OF PESTS OF OILSEED RAPE

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ABSTRACT

WL 85871 ('Fastac'), a pyrethroid insecticide, was first commercialised in 1983 and now has official clearance in several European countries. One of the major potential uses in Europe is for control of insect pests of rape.

All results from field trials carried out in France, using autumn applications against Psylliodes chrysocephala (cabbage stem flea beetle) and spring applications against Meligethes aeneus (blossom beetle) and Ceutorhynchus assimilis (cabbage seed weevil), show good control by WL 85871 in comparison with standard insecticides.

Concurrent field trials demonstrated that WL 85871 can be applied safely whilst bees are foraging on flowering rape.

The results of autumn treatments of winter barley, for the control of the aphid vectors of barley yellow dwarf virus (BYDV), showed that WL 85871 reduced the incidence of virus and gave significant increases in yield.

INTRODUCTION

WL 85871 ('Fastac') was introduced in 1983 (Fisher & Robinson 1983). Clearance has been granted already in France, Italy, Spain and the U.K. The product is registered in Czechoslovakia and Bulgaria and many other registrations are expected by the end of 1984.

WL 85871 has very high activity against a wide range of insect pests particularly against beetles and caterpillars.

A major programme of studies has been carried out to determine the effect of WL 85871 on non-target organisms. Under the practical conditions of the field WL 85871 has been shown to be safe to foraging honey bees.

The high activity against beetles combined with safety to bees indicated that WL 85871 could be an effective product for control of insect pests in oilseed rape. The crop is grown extensively in a number of European countries (459,000 ha in France in 1983) and is susceptible to a variety of beetle pests.

The relative importance of the pests attacking oilseed rape varies in different countries. Of the major pests, the cabbage stem flea beetle (Psylliodes chrysocephala) can attack the young plants in the autumn, the blossom beetle (Meligethes aeneus) attacks the flower buds and the cabbage seed weevil (Ceutorhynchus assimilis) the developing seeds. These three pests all attack autumn sown rape in France and WL 85871 has been evaluated for their control.

In addition to oilseed rape, WL 85871 has been extensively evaluated in France against a variety of other crop pests. The timing of application for control of the aphid vectors of barley yellow dwarf virus (BYDV) coincides with the autumn application against flea beetles and trials results are included.

MATERIALS AND METHODS

WL 85871 is a pyrethroid insecticide, a 1:1 mixture of the (IR cis) S and (IS cis) R isomer pair of alpha cyano 3-phenoxybenzyl 3-(2,2 dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate.

Trial layout

The majority of trials included four replicates (plot size c. 6 x 15m) in randomised blocks. Treatments were applied using a knapsack sprayer delivering 250-300 litres of water per hectare. Except where stated otherwise all trials tested WL 85871 at three rates, i.e. 5, 7.5 and 10 g a.i./ha. The trials included a recommended standard insecticide and untreated controls.

Spring-application

Meligethes aeneus - Winter and Spring rape

In both 1982 and 1983, WL 85871 was evaluated for control of M. aeneus and compared with deltamethrin used at the recommended dose rate of 5.0 g a.i./ha.

Treatments were applied when assessments on 50 flower stems per plot showed a mean of 1 or more adult beetles per stem. Trials were assessed by counting numbers of beetles on 50 stems/plot pre-treatment and at 1-2, 4-6 and 7-14 days after treatment.

Ceutorhynchus assimilis

Field populations of C. assimilis were low in 1983 and an artificial infestation technique was used. Plants were sprayed under normal field conditions with WL 85871 and dialiphos at 600 g a.i./ha was applied as the standard insecticide. Plants were picked immediately after spraying and placed in bowls of water inside cages. Twenty-five adult weevils were placed in each cage and the numbers of those dead and moribund were counted at 2, 24, 48 and 72 hours after infestation.

Honey bees

Large isolated fields of oilseed rape were selected for treatment. Eight bee hives were placed next to the crop in each field and WL 85871 was applied at 10-20 g a.i./ha. Spraying took place at mid-day when the bees were actively foraging in the crop.

Autumn applications

Psylliodes chrysocephala

In 1982, WL 85871 was applied early post-emergence, as soon as insect damage was observed on the cotyledons. The standard insecticide was ethyl parathion at 200 g a.i./ha applied early post-emergence, with a second application at 350 g a.i./ha plus oil made after the majority of larvae had penetrated into the plant stems.

WL 85871 was evaluated further in 1983 using deltamethrin at 7.5 g a.i./ha as the standard insecticide.

Crop damage assessments were carried out in each plot on the day of application and 2-3 weeks later; 4 x 2.5m of row per plot were examined on each occasion. On day 0 the number of cotyledons that had 0, 1-5 or more than 5 insect bites was recorded. The second post-treatment assessment was made on the cotyledons and the first two leaves.

Numbers of living larvae were counted in dissected petioles of 25 plants taken at random from each plot at the end of winter.

Aphid vectors of BYDV

In 1981, WL 85871 was applied at 7.5, 10, 12.5 and 15 g a.i./ha; the highest dose was discontinued for 1982. In both years the standard insecticide was bromophos at 375 g a.i./ha.

Application was made as soon as one in three plants were infested with young, apterous aphids (normally early/mid October). The dominant aphid in most of the trials was *Rhopalosiphum padi*.

Observations were made on numbers of aphids, development of virus in the crop and yield. Aphids were assessed on 100 plants per plot before spraying and at 2-5 and 14-18 days after spraying. The intensity of yellowing was scored on a 0-10 scale at end of tillering/beginning of shooting (approximately 6 months after treatment); 0 = plots totally green, 10 = plots severely yellowed showing 100% attack by virus. The yield was recorded for each plot and converted to t/ha.

RESULTS

Spring applications

Meligethes aeneus

During both 1982 and 1983 the level of infestation was moderate, the flight period was of short duration and the numbers on the control plots fell during the course of the trials.

Percentage reduction in number of beetles, relative to the untreated control, is shown in Table 1 (1982 - 4 trials, 1983 - 3 trials).

All treatments gave excellent control in 1983. The 1982 results show a dose response for WL 85871 and for all treatments a slight reduction in activity with time from application. WL 85871 at 10 g a.i./ha was more active than deltamethrin.

TABLE 1

Control of *M. aeneus*. % Reduction in number of beetles relative to untreated

Treatment	g a.i./ha	1982 - DAT			1983 - DAT		
		1 - 2	4 - 6	7 - 14	1 - 2	4 - 6	7 - 14
WL 85871	5	90.5	89.8	86.8	97.7	100	97.3
WL 85871	7.5	94.8	93.8	92.0	97.7	99.7	97.3
WL 85871	10	97.0	97.3	93.5	98.3	99.3	98.7
deltamethrin	5	93.3	93.0	90.8	98.3	98.7	98.0
Untreated no./plant	-	1.2	0.8	0.5	1.0	0.8	0.5

Ceutorhynchus assimilis

Percentage efficacies (mean of five trials) are shown in Table 2.

TABLE 2

Control of C. assimilis

Treatment	g a.i./ha	% Efficacy (Abbott's formula) Hours after infestation			
		2	24	48	72
WL 85871	5	5	57	73	79
WL 85871	7.5	10	59	72	82
WL 85871	10	16	69	80	86
dialiphos	600	1	5	14	24
Untreated % mortality	-	0.4	3.2	5.4	7.6

The results for WL 85871 indicated good activity at 10 g a.i./ha. The activity of the standard dialiphos was low in these trials probably because dialiphos, with its different mode of action, has a lower contact activity than WL 85871.

Honey bees

Results of the trials with foraging honey bees will be reported in detail elsewhere (Shires et al. 1984 a & b). WL 85871 had no significant effect on honey bee survival, pollen collection or long term hive development. The only effect observed following the application of WL 85871 was a marked, yet transient, decline in foraging activity due to a repellent effect immediately after spraying.

Autumn applications

Psylliodes chrysocephala

The 1982 and 1983 results are given in Table 3.

TABLE 3

Control of P. chrysocephala

Treatment	g a.i./ha	% of plants with more than 5 insect bites		No. of larvae/ 100 plants	
		1982*	1983+	1982**	1983++
WL 85871	5	10	3	36	55
WL 85871	7.5	12	2	28	34
WL 85871	10	8	3	23	32
parathion	200	8	-	25	-
deltamethrin	7.5	-	3	-	29
Untreated		22	40	126	454

*, **, +, ++ = Mean values for 3, 4, 8 and 9 trials respectively

In 1982 all treatments gave reductions in damage and number of larvae compared with the untreated; WL 85871 at 10 g a.i./ha was as active as parathion.

Pest levels were higher in 1983 than in 1982. All treatments significantly reduced the level of damage and WL 85871 at 7.5 and 10 g a.i./ha and deltamethrin at 7.5 g a.i./ha gave over 90% reduction in the number of larvae.

Yields were recorded in one trial in 1983. There were no significant differences between the treatments but yields from treated plots were 24-36% higher than from untreated plots.

BYDV

The percentage of barley plants infested with winged or apterous aphids are shown in Table 4, degree of yellowing and yield in Table 5. All results are the means of two trials in 1981 and three in 1982. The trials included the cultivars Astrix, Sonia and Igris.

TABLE 4

Control of aphid vectors of BYDV by WL 85871

Treatment	g a.i./ha	1981 - % infested plants DAT			1982 - % infested plants DAT		
		0	3	14-18	0	2-5	14-15
WL 85871	7.5	47	1.1	0.5	61.7	2.0	1.2
WL 85871	10	47	3.0	0.1	56.7	1.3	2.0
WL 85871	12.5	46	2.0	0	60.0	3.0	1.5
WL 85871	15	50	1.5	0	-	-	-
bromophos	375	47	1.6	0.1	62.0	4.3	2.3
Untreated	-	45	47	84	58.3	57.0	55.3

TABLE 5

Effect of WL 85871 on yellowing by BYDV and yield of barley

Treatment	g a.i./ha	1981		1982	
		Yellowing 0-10 scale	Yield t/ha	Yellowing 0-10 scale	Yield t/ha
WL 86871	7.5	2.5	4.52	1.3	3.99
WL 85871	10	2.3	4.61	0.7	3.36
WL 85871	12.5	1.8	4.63	0.3	4.11
WL 85871	15	2.0	4.65	-	-
bromophos	375	2.8	4.44	2.3	3.56
Untreated		8.0	2.10	6.3	1.65

All treatments gave almost complete control of aphids, significantly reduced yellowing and more than doubled yield. WL 85871 at 7.5 g a.i./ha was as effective as the standard treatment, bromophos at 375 g a.i./ha.

DISCUSSION

Results of trials carried out in France against three of the major insect pests of oilseed rape, M. aeneus, C. assimilis and P. chrysocephala, demonstrated that WL 85871 at 7.5 - 10 g a.i./ha is as active as standard commercial products. The one product provides the farmer with an efficient insecticide for use against both autumn and spring pest infestations. Its use is enhanced by the fact that the product in practice is not harmful to foraging bees when applied at recommended rates. In countries where a fungicide is required during flowering WL 85871 can be applied as a tank mix (i.e. prochloraz + carbendazim); treatments after flowering, with ground equipment, become increasingly difficult because of the density of the crop.

In addition to the studies in France on honey bees, effects on non-target organisms have been studied following an application of WL 85871 to oilseed rape in the U.K. Oilseed rape is one of the crops included in a five-year study to determine the effect of annual applications to the same area of land. Results will be reported in detail elsewhere (Inglesfield 1984).

WL 85871 has been evaluated on a wide variety of crops (Fisher & Robinson 1983) and the spectrum of activity against a wide range of pests should enhance the value of this product for the farmer. Further trials are needed to fully establish the effect of WL 85871 on yield of oilseed rape; much promise is already offered by the substantial increases recorded following control of BYDV in barley.

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CABBAGE STEM FLEA BEETLE CONTROL ON OILSEED RAPE IN THE UK WITH WL 85871

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ABSTRACT

This paper reports trials work on the control of cabbage stem flea beetle *Psylliodes chrysocephala* and rape winter stem weevil *Ceutorhynchus picitarsis*. The synthetic pyrethroid WL 85871 'Fastac' applied at 10 g a.i. when adult damage was evident on the crop, or when larval damage was first seen, proved effective in controlling either adults or larvae of the cabbage stem flea beetle. The most effective control was obtained when two applications were made. WL 85871 also controlled *C. picitaris* when larvae or adults were present at the time of spraying.

INTRODUCTION

Oilseed rape has become a valuable crop in Great Britain; its area has increased from 5315 ha in 1971 to around 220000 ha in 1983 and in 1982 the value of seed produced was £155.4 million (John & Holliday 1984).

One of the major pests of winter oilseed rape is the cabbage stem flea beetle, *Psylliodes chrysocephala*, which causes economic damage to the crop in autumn and winter particularly in the 'traditional' rape growing areas of Buckinghamshire, Cambridgeshire and Northamptonshire (Graham & Alford 1981). More recently, surveys have shown that the distribution has extended eastward to the Suffolk coast, southward to Kent, westward into the West Midlands and northward into Humberside (Anon.1983).

Another pest with potential to become very important is the rape winter stem weevil, *Ceutorhynchus picitarsis*. This is an infrequent pest of oilseed rape in Europe but occasionally large numbers occur causing considerable damage. Numbers have increased considerably in France since 1981 (Wimmer & Dardy 1983) and damage was confirmed in the UK in Essex, Suffolk and Lincolnshire in 1982. In 1983 the pest was reported in other areas from South Humberside to Essex, but as yet its distribution is still limited (John & Holliday 1984).

Both these pests cause delays to crop growth and, particularly where the main raceme is damaged, lead to uneven flowering and pod set.

Until recently gamma-HCH sprays have been used to control these pests, but synthetic pyrethroids sprays have now been found to be effective in controlling the adults and larvae (John & Holliday 1984, Black & Hewson 1984).

This paper presents the results of trials conducted in the UK in 1983/84 to evaluate the pyrethroid WL 85871 against these pests.

MATERIALS AND METHODS

Seven replicated trials were done on winter rape on commercial crops where cabbage stem flea beetle attacks had occurred on adjacent fields in the previous year. Four trials were done in Lincolnshire, one in Cambridgeshire and two in the Thames Valley. Details of the sites are shown in Table 2. The pyrethroid insecticide WL 85871 (a 1:1 mixture of the (IRcis) S and (IScis) R isomer pair of alpha cyano 3-phenoxybenyl 3-(2,2,dichlorovinyl)-2,2-dimethylcyclopropanecarboxylate, Shell International Chemical Company Ltd.) was evaluated at two stages in the life cycle of the pest. The first treatment was timed to coincide with the appearance of adult beetle feeding damage (A) on the crop and the second with egg hatch (B). These applications were compared with HCH ('Lindacol', Shell Chemicals UK Ltd) applied at application time A. The treatments, rates and timings are summarised in Table 1 and dates of application are shown in Table 2. All treatments were applied with a Van Der Weij sprayer operating at 2.1 KPa, delivering 197 l/ha.

TABLE 1

Details of Treatments

Treatments	g a.i./ha	Timing	Replicates
WL 85871	10	A	3
WL 85871	10	B	3
WL 85871	10	A+B	3
HCH	550	A	3
Untreated	-	-	6

Treatments were each replicated 3 times (controls 6 times) on plots 4 x 12m arranged in randomised blocks. Pest assessments were done on five plant samples from each plot. Within each sample the number of damaged plants and the number of live larvae present was counted. The time between application and assessment is shown in Tables 3 - 5.

TABLE 2

Details of Trials

Trial No.	Location		Cultivar	Drilling Date	Dates of Application	Pest Species
250	Harmsden	1	Jet Neuf	23.08.83	A 22.09.83 B 11.10.83	P.chrysocephala C.picitarsis
251	Waddington	1	Jet Neuf	02.09.83	A 30.09.83 B 11.10.83	P.chrysocephala
252	Willingborough	2	Bienvenue	01.09.83	A 14.10.83 B 10.11.83	P.chrysocephala
253	Hanby	3	Jet Neuf	02.09.83	A 05.10.83 B 10.11.83	P.chrysocephala C.picitarsis
254	Chinnor	4	Bienvenue	23.08.83	A 23.09.83 B 21.10.83	P.chrysocephala
255	M.Claydon	4	Bienvenue	23.08.83	A 30.09.83 B 21.10.83	P.chrysocephala
256	Ashby de la Launde	1	Bienvenue	24.08.83	A 11.10.83 B 09.11.83	P.chrysocephala C.picitarsis

1 = Lincolnshire, 2 = Cambridgeshire, 3 = Grantham, 4 = Buckinghamshire

RESULTS

The results are shown in Tables 3 to 5 inclusive.

The times of beetle damage and egg hatch varied with the location of trials, so sprays varied considerably over the seven trials. Adult feeding damage was recorded on sites 250, 251, 254 and 255 in late September. An early application of WL 85871 (see Table 2) on these sites gave a greater reduction in the number of plants attacked by the pest and in the number of larvae present than an application in mid-October. On sites 252, 253 and 256, no adult damage was seen until October. The first application on these latter sites corresponded with the second application on the early sprayed sites. On sites where the first application was made in mid-October the second application was made one month later in mid-November. The plant damage assessments on these sites showed little difference between the two timings but the larval assessments showed an appreciable reduction in the numbers of live larvae present following the second application in November.

TABLE 3

Mean number of larval damaged plants in a five plant sample

Treatment	g a.i./ha	Timing	Trial Number						
			250	251	252	253	254	255	256
WL 85871	10	A	0	1.0	3.0	1.7	1.0	2.7	3.3
WL 85871	10	B	1.0	1.7	0.7	2.3	3.3	2.0	2.0
WL 85871	10	A+B	0.3	0	3.0	0.3	0.3	1.0	2.0
HCH	550	A	3.3	2.3	4.0	2.7	2.0	2.7	4.0
Untreated			4.8	4.0	4.3	3.8	4.3	4.7	5.0
LSD (3 x 3,P = 0.05)			1.11	1.36	1.39	1.65	1.07	1.97	0.97
LSD (3 x 6,P = 0.05)			0.96	1.18	1.20	1.43	0.93	1.71	0.84
DAT B			135	141	63	68	90	88	92

TABLE 4

Mean number of live P.chrysocephala larvae in five plants

Treatment	g a.i./ha	Timing	Trial number						
			250	251	252	253	254	255	256
WL 85871	10	A	0	1.0	6.7	1.3	1.7	3.0	9.7
WL 85871	10	B	1.0	2.0	0.7	1.0	6.7	3.7	3.7
WL 85871	10	A+B	0.3	0	3.7	0	0.3	0.3	2.7
HCH	550	A	6.7	5.0	9.0	2.7	5.0	10.0	12.0
Untreated			21.7	13.2	15.5	10.2	25.8	17.0	32.3
LSD (3 x 3, P = 0.05)			5.27	3.44	5.28	4.10	8.83	7.73	9.98
LSD (3 x 6, P = 0.05)			4.56	2.98	4.57	3.55	7.65	6.69	8.65
DAT B									

Single applications of WL 85871 gave better control than HCH when measured by plant damage and larval assessments. Two applications gave better control than a single application and much superior control to HCH on both assessments.

TABLE 5

Mean number of live C.picitarsis larvae in five plants

Treatment	g a.i./ha	Timing	Trial number		
			250	253	256
WL 85871	10	A	0	0	0.3
WL 85871	10	B	0	0.7	0
WL 85871	10	A+B	0	0	0
HCH	550	A	0	0	0
Untreated			3.8	1.7	4.5
LSD (3 x 3, P = 0.05)			2.79	0.94	4.99
LSD (3 x 6, P = 0.05)			2.42	0.81	4.32
DAT B			141	68	92

The C. picitarsis results were not conclusive because of low pest populations, however, all treatments gave good control.

DISCUSSION

Cabbage stem flea beetle (P. chrysocephala) causes serious economic damage to winter oilseed rape if populations exceed five larvae per plant over the winter period. However, damage also results from infestations lower than this threshold. The presence of one or two larvae per plant at a particular stage may be sufficient to damage the main raceme and lead to later flowering of secondary racemes with consequent yield loss. The range of this pest has increased steadily over recent years and undoubtedly now is an important factor in winter oilseed rape production.

Although the rape winter stem weevil C. picitarsis does not appear to be spreading to new areas as rapidly as P. chrysocephala and is relatively uncommon on the continent it is a potentially serious pest. This pest almost invariably does damage to the main raceme rather than just to leaf petioles.

The work described shows the activity of the synthetic pyrethroid WL 85871 against these pests. The pyrethroids have been shown to be active against both phases of the life cycle of these pests. When applied to the foliage at the time of adult feeding damage WL 85871 kills the adults either by direct contact or by the adults coming into contact with toxic residues on the leaves. It is also able to kill young larvae as they move from the soil where they have hatched to burrow into the plant. WL 85871, in common with other pyrethroids, is strongly adsorbed onto cuticular wax and therefore persists for a long time during the winter. Larvae have been observed to occasionally exit from the petioles and re-enter the plant (Black & Hewson 1984). This may explain why in our trials the sprays applied later (mid-November) were still successful in controlling the pest even though larvae may have been present within the plant at the time of application.

Our trials have demonstrated that the best time to control the pests is when the adults are seen causing damage to plants. However, WL 85871 has the ability to give excellent control of the pests even when applied after this stage. Recommendations for the use of WL 85871 have been made on the basis of these trials, for the control of both cabbage stem flea beetle and rape winter stem weevil.

Both the pests can seriously affect the early development of the oilseed rape plant and, depending on their numbers, produce slight or total crop loss. Their control therefore is becoming a more important factor in crop production and the use of suitable insecticides, such as WL 85871 is warranted by the yield increases that are likely to be achieved when pest populations are high.

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CONTROL OF CABBAGE STEM FLEA BEETLE AND RAPE WINTER STEM WEEVIL ON OILSEED RAPE WITH DELTAMETHRIN

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ABSTRACT

Results are reported from a series of trials carried out in Great Britain on winter oilseed rape (Brassica napus) to investigate control of cabbage stem flea beetle (Psylliodes chrysocephala). This pest can be damaging both in the adult and larval phases and, for this reason, treatments were applied to control both. Deltamethrin, a synthetic pyrethroid applied at 5.0, 6.25 or 7.5 g a.i./ha to coincide with either the onset of adult or larval damage, gave very good control. Plant loss and delayed maturation, attributable to pest attack, were consequently minimised. At harvest the treated crops were more uniformly ripe and yields were much increased compared with untreated areas. Deltamethrin, applied and timed for control of cabbage stem flea beetle, also reduced a coincidental attack of rape winter stem weevil (Ceutorhynchus picitarsis). Results from similar trials on the control of cabbage stem flea beetle carried out in Germany, France and Sweden are also reported.

INTRODUCTION

Winter oilseed rape is an important arable crop. The area grown in Great Britain has increased from 5 315 ha in 1971 to an estimated 220 000 ha in 1983 (John & Holliday 1984). Cabbage stem flea beetle (Psylliodes chrysocephala) has been recognised as a pest causing economic damage, particularly in the 'traditional' oilseed rape areas of Cambridgeshire, Bedfordshire, Northamptonshire and Buckinghamshire (Graham 1981) and has been observed to be spreading into adjacent counties (John & Holliday 1984). With the increasing area of rape grown, new drillings of rape are more likely to be adjacent to previously-infested sites. This is likely to put a crop at high potential risk (Anon. 1982).

Rape winter stem weevil (Ceutorhynchus picitarsis) is less well-established as a pest than cabbage stem flea beetle and is confined at present to Essex, Suffolk and Lincolnshire. Nevertheless, damage to crops in Lincolnshire has resulted in some crops being ploughed up. It has also been reported to cause economic damage in France (Anon. 1982).

Both pests can cause delays in crop growth and maturation which can lead to plant loss, uneven flowering and pod set and consequent yield loss. An indirect effect of the damage is the 'open crop' situation conducive to pigeon (Columba sp.) attack and opportunist weed competition.

Deltamethrin was reported to control both cabbage stem flea beetle (Bocquet *et al*. 1981; Roâ *et al*. 1983) and rape winter stem weevil (Anon. 1979) in France. This paper reports the results of a programme of trials initiated to investigate the effects of deltamethrin on these pests in winter oilseed rape in Great Britain, France, Germany and Sweden.

MATERIALS AND METHODS

Trials in Great Britain

Seven trials were carried out in East Anglia and one in Gloucestershire during the harvest years 1983 and 1984. All were on commercially-grown crops of cv Jet Neuf (3 sites) or Bienvenu (5 sites) where cabbage stem flea beetle attack had occurred on adjacent fields in the previous year. Site locations are shown in Table 1. The trials were fully-randomised and replicated 4 times (Site 3 had 3 replicates). The plot size was 2.0 or 4.0 x 7.5 m. Treatments were applied in 300 or 400 l/ha with a hand-held van der Weij 'AZO' small-plot sprayer, using Spraying Systems 80015 or 8002 Tee Jets at a pressure of 2.5 bar.

TABLE 1

Site and application details

Site No.	Location	Date of Drilling	Timing	Date of Application	Level of Infestation*
1983 Harvest Year					
1	Chevington, Suffolk	22/08/82	A	22/09/82	SA
			B	15/10/82	L
2	Chesterford, Essex	01/09/82	A	28/09/82	SA
			B	09/11/82	L
3	Stretham, Cambridgeshire	25/08/82	A	22/09/82	SA
			B	28/10/82	L
4	Aston, Gloucestershire	08/09/82	A	11/10/82	A
			B	02/12/82	L
1984 Harvest Year					
5	Sudbury, Suffolk	24/08/83	A	26/09/83	SA
			B	01/11/83	L
			C	28/11/83	L
6	Moreton, Essex	04/09/83	A	29/09/83	SA
			B	14/11/83	L
			C	13/12/83	L
7	Stretham, Cambridgeshire	25/08/83	A	28/09/83	A
			B	09/11/83	L
			C	Not applied	-
8	Little Thetford, Cambridgeshire	29/08/83	A	Not applied	-
			B	09/11/83	L
			C	Not applied	-

* L = Larvae seen in petioles.
A = Adult damage visible.
SA = Severe adult attack, (c. 50% plant damage).

Deltamethrin, as 'Decis' (25 g/litre e.c.) was used in trials in both 1983 and 1984. In 1983 only triazophos ('Hostathion' - 420 g/litre e.c.) and dimethoate ('Hoechst Dimethoate' - 380 g/litre e.c.) were used. In 1984 Gamma-HCH ('Gamma-Col' - 800 g/litre s.c.) was included. Application timings were chosen according to the stage of the pest. Timing A was at the onset of adult damage to the leaf lamina or to the petioles. Timing B was at the first signs of larval presence within the petioles (to coincide with egg-hatch). Timing C was 3-4 weeks after Timing B (in 1984 only). Dates of application are given in Table 1.

Control of cabbage stem flea beetle was assessed in February/March of each year by dissecting 5 plants per plot and counting live larvae remaining in all the petioles and stems (20 plants per treatment).

In the harvest year of 1983 yield data was obtained from two of the four sites (Sites 2 and 3) using a Hege 125 B small-plot combine; a 1.5 m cut was taken along the entire length of the plots.

Trials in Europe

A total of 18 trials was carried out in Germany, France and Sweden between the harvest years 1979-1984; materials and methods were similar to those used in the U.K. Single applications were made at each site at the onset of adult damage in the autumn (= Timing A in the British trials).

RESULTS

In both seasons deltamethrin consistently gave the highest level of cabbage stem flea beetle control at all rates of application (Table 2 - 1983, Table 3 - 1984) when applied either at the onset of adult attack or at early larval invasion.

TABLE 2

1983 Trials: effects of deltamethrin on number of larvae and crop yield

% reduction in numbers of cabbage stem flea beetle larvae
Relative Yield (Untreated = 100)

		Timing A					Timing B				
	Rate	Site No.					Site No.				
Treatment	g a.i./ha	1	2	3	4	Mean	1	2	3	4	Mean
DELTAMETHRIN	5.0	33	88	76	94	73(86)	90	91	94	87	91
		–	**120**	**244**	–	**182**	–	**121**	**142**	–	**132**
DELTAMETHRIN	6.25	76	90	93	87	87(90)	93	97	87	87	91
		–	**139**	**270**	–	**204**	–	**114**	**176**	–	**145**
DELTAMETHRIN	7.5	53	95	92	92	83(93)	98	95	90	87	93
		–	**143**	**243**	–	**193**	–	**115**	**134**	–	**125**
TRIAZOPHOS	420	24	80	32	50	47(54)	52	80	36	69	59
		–	**81**	**134**	–	**107**	–	**96**	**137**	–	**117**
TRIAZOPHOS +	294 +	43	51	32	39	41(41)	56	–	–	–	–
DIMETHOATE	152	–	**100**	**94**	–	**97**	–	–	–	–	–
Untreated (Live larvae/		18	24	61	18	30(34)	36	24	50	18	32
5 plants, **Yield in t/ha)**		–	**3.10**	**1.12**	–	**2.11**	–	**3.15**	**1.75**	–	**2.45**
Relative Yield - S.E.						**30.78**					**10.84**
Relative Yield - LSD (p = 0.05)						**87.93%**					**30.97%**

( ) Mean exlcudes Site 1 data.
 - Not tested or not recorded.

In 1983, due to an extended egg-hatch period at Site 1, larvae continued to invade petioles until late January. The level of control with Timing A was reduced, presumably because of the long period between treatment and final hatch, or to plants growing away from the treatment. The yield from plots treated with deltamethrin was considerably higher than that from untreated plots (Table 2) and crops were more uniformly ripe. Significant yield increases were obtained when the chemical was applied at the onset of adult attack (Timing A).

In the trial at Site 1 rape winter stem weevil was found with cabbage stem flea beetle. Although numbers of stem weevil were low, observations showed that deltamethrin, applied at both timings A and B, decreased the symptoms of stem weevil attack.

Data for 1984 trials is presented in Table 3. The result for Timing A at Site 6 has been considered separately due to an extended egg-hatch period. The excellent control obtained from the two-spray programme of deltamethrin (Timings A and C) incidates the need for sequential treatment in such situations.

TABLE 3

1984 Trials: effects of deltamethrin on number of larvae

Treatment	Rate g a.i./ha	Timing	% reduction in numbers of cabbage stem flea beetle larvae — Site No. 5	6	7	8	Mean
DELTAMETHRIN	5.0	A	97	57	99	-	84 (98)*
DELTAMETHRIN	7.5	A	100	63	94	-	86 (97)*
Gamma-HCH	560	A	79	37	67	-	61 (73)*
DELTAMETHRIN	5.0	B	92	77	94	95	90
DELTAMETHRIN	6.25	B	98	73	88	95	89
DELTAMETHRIN	7.5	B	99	87	96	96	95
Gamma-HCH	560	B	86	80	57	55	69
DELTAMETHRIN	7.5	C	94	87	-	-	91
Gamma-HCH	560	C	84	80	-	-	82
DELTAMETHRIN	7.5	A + C	99	93	-	-	96
Gamma-HCH	560	A + C	82	70	-	-	76
Untreated (live larvae/ 5 plants)			53	6	16	11	22

( )* Mean excludes Site 6 data.
- Not tested or not recorded.

DISCUSSION

Deltamethrin, a synthetic pyrethroid, has several modes of action, all of which contribute to the control of this pest (Hervé 1982). When applied at the onset of adult attack, it will kill by direct contact or by acting as a stomach poison when the pest feeds on treated foliage. Repellant action by deltamethrin has also been observed. Deltamethrin, although not systemic, is strongly adsorbed onto cuticular wax. Larvae have been seen to occasionally exit from the petioles, so that even those present in the plant at application, can come into contact with treated plant tissue and die. It is not possible to state whether the application made at adult attack (Timing A) killed adults or newly-hatched larvae, or, as is most likely, achieved the high level of control by a combination of both.

Results from trials carried out in Germany and France by Hoechst and in Sweden (Nilsson 1984, unpublished data) during the period from 1979 to 1984 (Table 4) confirm our findings that applications made at the time of adult attack give good pest control.

TABLE 4

European Trials: effects of deltamethrin (applied at onset of adult attack) on number of larvae

		% reduction in numbers of cabbage stem flea beetle larvae					
		Germany		France		Sweden	
	Rate	Harvest Year					
Treatment	g a.i./ha	1979	1981	1980	1981	1983	1984
DELTAMETHRIN	7.5	82	83	97	94	89	-
DELTAMETHRIN	10.0	-	-	-	-	-	89
DELTAMETHRIN	12.5	88	84	-	-	-	-
Standard*	-	21	86	53	35	40	60
Untreated (live larvae/ 40 plants)		10	9	16	25	32	60
Number of Trials		2	3	4	4	3	2

* Standard - Germany: 1979 - Triazophos (240 g a.i./ha)
1981 - Parathion (105 g a.i./ha)
France: 1980 - Parathion M (250 g a.i./ha)
1981 - "
Sweden: 1983 - Seed dressing of 'Oftanol T' (40 g./kg seed)
1984 - "

Results from applications made at the first signs of larval presence in the petioles (Timing B), also confirm that deltamethrin gives persistent and excellent control (Tables 2 and 3). Where treatments were delayed until 3-4 weeks after larval invasion (Timing C), when they were fully established within the plant, control was still very good (Table 3).

Gamma-HCH applied alone (Timings A, B or C) or sequentially (Timings A and C) gave varied results (Table 3).

Our observations on control of rape winter stem weevil have been confirmed by data from France (Bocquet, personal communication) where similar control was given by a single treatment of deltamethrin applied when adults were first seen.

Recommendations for deltamethrin have been made on the basis of these results for control of both cabbage stem flea beetle and rape winter stem weevil in winter oilseed rape, for which Ministry Approval has now been given.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to their colleagues in the Technical Department of the Agriculture Division, Hoechst U.K. Limited, of the Agro-Veterinary Division of Roussel Uclaf, to C Nilsson, Swedish University of Agricultural Sciences at Alnarp, Sweden, and to the Agriculture Division of Hoechst in Germany.

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YIELD BENEFITS FROM THE CONTROL OF RUST ON SPRING-SOWN FIELD BEANS

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ABSTRACT

Rust (*Uromyces viciae-fabae*) on spring-sown beans has become increasingly frequent and early at Rothamsted and elsewhere in the U.K. In 1982 and 1983 experiments were made to assess the damage and yield loss being caused by the disease. Plots received sprays of either benomyl to control chocolate spot (*Botrytis fabae*), maneb plus mancozeb (protective) or propiconazole (systemic) to control rust, or no fungicide. In 1982 rust was first found on 7 July and sprays applied from 9 July but by 19 August plants of all treatments were dead; mainly from drought. Fungicides controlled rust development about equally effectively during July and at harvest yields in unsprayed and sprayed treatments were 4.51 and 5.43 t/ha respectively. In 1983 rust was first found on 15 July and sprays applied from 18 July but by 2 August plants of all treatments were dead, again from drought. At harvest, unsprayed and sprayed plot yields were respectively 3.58 and 4.04 t/ha; propiconazole treated plots (4.30 t/ha) outyielded maneb plus mancozeb (3.77 t/ha). Rust has been considered unimportant but its potential for damage is obviously considerable.

INTRODUCTION

Rust (*Uromyces viciae-fabae*) affects the leaves and stems of both broad- and field-bean (*Vicia faba*), pea, vetch and lentil. The disease is distributed world-wide and although generally claimed to cause only slight damage, severe attacks do occur occasionally, especially on susceptible cultivars.

In northern parts of Egypt it is currently considered one of the most destructive diseases attacking faba beans (Mohamed *et al*. 1981). The disease is common in the U.K. but has been thought to occur too late in the growing season to do damage.

Since 1980 in a series of field experiments at Rothamsted on spring beans, rust has become prevalent, attacking the crop during August and leading to almost complete defoliation by late August or early September (Lester 1982), whereas previously in the late 1970s amounts had been rarely measurable (McEwen *et al*. 1981). One of the purposes of the experiments was to control all pests and pathogens attacking spring beans and therefore it was important to assess the damage done by rust and to find methods for control. Therefore in 1982 experiments were started to assess the effect of rust on yield (Lapwood *et al*. 1984) and the results for 1982 and 1983 are reported here.

MATERIALS AND METHODS

Spring beans cv Minden were machine drilled at 270 kg/ha on 29 March 1982 (8 March 1983) in rows 51cm apart. Paths were cut out later by rotavator to give 30 small plots (36 in 1983) each of four rows by 3m. These were arranged in three randomised blocks of ten plots (12 plots in 1983). In 1982, within each block, two plots received no fungicide and eight plots were used for the combinations:-

1. With and without two foliar benomyl sprays (0.6 kg/ha) to control chocolate spot (Botrytis fabae)

2. With two alternative rust fungicide sprays, either maneb plus mancozeb (0.8 kg of each) or propiconazole (0.12 kg)

3. With two or three sprays of the rust fungicides

In 1983 the treatments were basically the same except that one and two sprays of the rust fungicides were used and the two additional plots per block received benomyl sprays only (not included in 1982).

The whole area of the experiments was sprayed with trietazine/simazine mixture to control weeds and with permethrin to control insect pests. In 1982 the benomyl treatment was applied on 2 July and 13 August and the rust fungicide treatments on 9 July, 23 July and 13 August (three-spray treatments) and 9 July and 13 August (two spray treatments). In 1983 benomyl was applied on 7 July and rust fungicides on 18 July (one spray) and 18 July and 27 July (two spray treatment).

The incidence of chocolate spot was assessed in the six untreated plots recording spot (non-aggressive) and blotch (aggressive) lesions separately using a modification of the ADAS Key No. 4.1.1 (Anon. 1976). Five stems in each of the two centre rows were selected and measurements made on three representative leaves from the upper, middle and lower parts of the canopy. After rust had been detected both diseases were monitored in all plots on the top seven leaves of each of ten stems per plot. Rust was assessed using a pictorial key devised for chocolate spot by A. Bainbridge (unpublished). The number of leaves remaining attached to stems was also recorded.

Bean pods were hand harvested from all stems in 1.5m lengths of the two central rows per plot on 8 September 1982 (16 August 1983). Numbers of stems, pods per plant and the total fresh weight of grain were recorded. A sub-sample of 100g of grain was dried at 100°C overnight to determine dry matter; two lots of 100 grains were dried overnight at 80°C before weighing to calculate 'thousand-grain' weight.

RESULTS

A detailed account of the 1982 experiment is published elsewhere (Lapwood et al. 1984), only the main findings are presented here. The percentage leaf area affected by chocolate spot on the 4 August [Table 1 (a)] showed that the benomyl spray of 2 July contained the disease and had some effect on grain yield [Table 1(c)].

Rust was first found in the experiment on 7 July and rust fungicides first applied on 9 July. Disease assessments of 4 August [Table 1(b)] showed that both chemicals gave good control. The effect of the second spray on 23 July was not evident until 12 August when it was impossible to assess the diseases separately. Then, in untreated plots, 68% leaf area was affected where for 'two' and 'three' sprays respectively, propiconazole

TABLE 1

The main effect of fungicides on the incidence of chocolate spot and rust on the top five leaves (% leaf area affected) of spring bean plants on 4 August 1982 and the final yield

	Rust fungicide			
	None	Propiconazole	Maneb + Mancozeb	S.E.D. (19 DF)
(a) Chocolate spot				
No benomyl	3.9	1.5	1.3	0.52
Benomyl	-	0.6	0.7	
(b) Rust				
No benomyl	5.2	1.3	1.5	0.52
Benomyl	-	0.8	1.2	
(c) Yield t/ha (85% DM)				
No benomyl	4.51	5.18	5.28	0.20
Benomyl	-	5.60	5.65	
(d) Thousand grain wt (g)				
No benomyl	348	376	390	1.07
Benomyl	-	397	398	

plots had 35 and 20 and maneb plus mancozeb plots 42 and 20% leaf area affected (S.E.D. 3.7). Leaves, showing signs of curling and drying on 12 August, had fallen or were dead by 19 August and therefore the spray on 13 August had no effect.

Maneb plus mancozeb and propiconazole increased yields equally [Table 1(c)]. Mean yield was increased from 4.51 to 5.43 t/ha (S.E.D. 0.154) and best yield (5.92 t/ha S.E.D. 0.276) was from plots treated with benomyl and sprayed three times with propiconazole. The thousand grain weights ([Table 1(d)] reflected the yield differences.

In 1983, the percentage leaf area affected by chocolate spot was assessed in the six untreated plots on 22 June and 12 July. On 22 June plants had 11 leaves and inspection of leaves 3, 6 and 9, representing respectively, upper, middle and lower canopies, showed 0.2% spots only on the lowest leaves. On 12 July, when plants had 20 leaves, leaf 3 showed little or no infection, leaf 10 0.06% and leaf 17 0.13% spots and 1.0% aggressive (blotch) lesions. Disease increased only slowly and on 26 July, when chocolate spot was assessed on the top seven leaves of plants, there was a small but insignificant effect of the benomyl spray [Table 2(a)].

Rust was first found in a crop of winter beans at Rothamsted on 20 June and in our experiment on 15 July. Assessments of rust on 26 July showed no effects of the first rust fungicide sprays [Table 2(b)]. Because of drought and strong drying winds by 2 August very few leaves were left, many stems were broken and no further observations were practicable.

TABLE 2

The main effect of fungicides on the incidence of chocolate spot and rust on the top seven leaves (% leaf area affected) of spring bean plants on 26 July 1983 and the final yield

	Rust fungicide			
	None	Propiconazole	Maneb + Mancozeb	S.E.D. (24 DF)
(a) Chocolate spot				
No benomyl	0.05	0.05	0.08	0.027
Benomyl	0.03	0.02	0.06	
(b) Rust				
No benomyl	0.08	0.11	0.06	0.024
Benomyl	0.04	0.07	0.07	
(c) Yield t/ha (85% DM)				
No benomyl	3.64	4.22	3.68	0.25
Benomyl	3.51	4.39	3.86	
(d) Thousand grain wt (g)				
No benomyl	316	317	317	7.30
Benomyl	319	321	311	

However, propiconazole-treated plots showed a significant increase in yield over untreated [Table 2(c)] and the highest yield 4.76 t/ha was achieved in benomyl treated plots sprayed twice with propiconazole.

DISCUSSION

The attack of rust at Rothamsted in 1982 was unusually early as it is not normally found on spring beans until August. However, it was not a local effect as commercial crops in other parts of the country were also seriously attacked (D.R. Jones, pers. comm.).

In 1982, unsprayed plots (mean 4.51 t/ha) were outyielded by sprayed (mean 5.43), an increase of 0.92 t/ha. The best treatment (three sprays of propiconazole plus two of benomyl) gave 5.92 t/ha, an increase of 1.41 t/ha but this yield benefit was from the two July sprays as that of 13 August was ineffective. Fungicides were not applied until rust was seen and, as spraying frequency was arbitrarily chosen, the disease was not completely checked and hence yield benefits might have been greater.

In 1983, rust appeared about a week later than in 1982 but, unlike that year, failed to develop. Nevertheless, the application of propiconazole increased mean yield from 3.58 t/ha to 4.30 t/ha, a yield gain of 0.72 t/ha, while the best treatment (two sprays of propiconazole plus benomyl) gave 4.76 t/ha, an increase of 1.18.

The difference in rust development in the two years may be related to rainfall. In June 1982 it was 58mm above the average (57mm) and 46mm fell in July between the first appearance of lesions and first assessment. By contrast, in 1983 June rainfall was 31mm below average and only 2mm fell between discovery and first assessments. In a nearby companion experiment in 1983 (Rothamsted Experimental Station, 1984) rust infection was increased by irrigation whereas chocolate spot was apparently unaffected. Rust was first found in this experiment on 15 July and between 28 July and 11 August, in plots receiving no maneb plus mancozeb fungicide, it increased from 0.6 to 6.0% on the top seven leaves; in plots sprayed once, on 18 July, the increase was from 0.4 to 3.0% and in those sprayed three times (18 and 26 July and 4 August) from 0.3 to 1.3%. The final yields were respectively 4.8, 5.1 and 5.4 t/ha (S.E.D. 0.13 12 d.f.).

The 1982 results [Table 1] showed interactions between fungicides in terms of disease control and yield in that benomyl had some effect on rust development [Table 1(b)] and the rust fungicides on chocolate spot [Table 1(a)]. In 1983, when both diseases were slight, propiconazole, not maneb plus mancozeb, showed a significant effect on yield [Table 2(c)] but, unlike 1982 [Table 1(d)], had no effect on the thousand-grain weight [Table 2(d)]; this cannot be explained just in terms of disease control.

Thus the results from these initial experiments show the need for more work and indicate the potential danger and yield loss that could result if attacks of rust become more common.

ACKNOWLEDGEMENTS

We thank Mrs. J. Spokes, Mrs. N.F. Creighton and L. Nicolas (Angers, France) for assistance and Dr. D.R. Jones (ADAS, Bristol) for information.

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METHODS OF APPLICATION OF TOLCLOFOS METHYL FOR THE CONTROL OF STEM CANKER AND BLACK SCURF OF POTATOES

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ABSTRACT

Tolclofos methyl, introduced commercially in the United Kingdom in 1983, is extremely effective in controlling stem canker and black scurf of potatoes (*Rhizoctonia solani*). The current recommendation is to apply the fungicide at planting as a dust treatment to seed tubers, but investigational work on alternative application techniques is in progress. Dust and liquid formulations of tolclofos methyl have been applied through commercially available machinery at different pre-planting timings, including both into and out of store. Results are very promising with disease control comparable to the commercially recommended at-planting application. Although no consistent increases in gross yield have so far been obtained there have been considerable improvements in tuber quality, an important benefit to the quality potato producer.

INTRODUCTION

Stem canker and black scurf of potato (*R. solani*) are diseases of major importance in United Kingdom potato production. Stem canker can reduce yields (Hide & Bell 1978, Weinhold *et al*. 1982) and black scurf, besides being an important source of inoculum on seed potatoes, can lower the market value of ware produce through the production of blemished tubers.

Reliable control of stem canker and black scurf has been made possible by the commercialisation of tolclofos methyl formulated as a 10% dust and applied to seed potatoes at planting (Barnes *et al*. 1983). The current recommendation for application is to layer chemical between potatoes in the planter hopper in "sandwich" fashion. Investigations, which began in 1983, have evaluated alternative application methods and timings i.e. dust and spray application at store loading and unloading. The results of two seasons' trials experience are presented in this report.

MATERIALS AND METHODS

Application

Tolclofos-methyl was applied pre-planting as a 25% suspension concentrate (SC) and as 'Rizolex' 10% dust (D) to separate batches of a common stock of seed potatoes (Table 1). The dust was applied by a Ludlow Tuber Duster and the spray by a Dorman low volume sprayer, as the tubers passed along a roller table. At-planting application was simulated by shaking together potatoes and chemical in paper sacks immediately before planting.

Four trials on maincrop potatoes were carried out in 1983 and six (3 early and 3 maincrop) in 1984. Plot size in 1983 was 6 rows x 24 metres, and in 1984 2 rows x 50 plants. Treatments were replicated 4 times.

TABLE 1

1983 Trials

i) Application details:

Variety		Rate g a.i./ tonne	Volume rate/ tonne	Date
King Edward	dust	250	2.5 kg	17.11.82
	spray	250	2 l	(into store)
King Edward	dust	250	2.5 kg	2.3.83
	spray	250	2 l	(out of store)
King Edward	dust	250	2.5 kg	see site details (at planting)

ii) Site details:

Site	Variety	Planting Date
Gedney, Lincs.	King Edward	17.3.83
Roughton, Norfolk	King Edward	17.5.83
Chesterford, Essex	King Edward	25.5.83
Bayford, Herts.	King Edward	7.6.83

1984 trials:
Application and site details will be presented elsewhere.

Assessment

Stem canker was assessed during the growing season by sampling 15 stems from each plot and assigning each to one of 5 disease severity categories, ranging from 0 for no stem canker to 4 for a girdling lesion. The data were then converted to disease indices.

$$\text{Stem canker disease index} = \frac{(n \times 1) + (n \times 2) + (n \times 3) + (n \times 4) \times}{\sum n \times 4} 100$$

where n = number of stems in each disease severity grade
$\sum n$ = total number of stems assessed

The number of tubers with black scurf and the percent tuber surface cover by black scurf was assessed and the total yield from each plot recorded.

RESULTS AND DISCUSSION

Results to date are very encouraging. In the 1983 trials tolclofos methyl gave very good stem canker control irrespective of the method and timing of application (Table 2). Disease levels across the four sites varied from low to high and all chemical treatments were equally effective irrespective of disease pressure. Stem canker failed to develop in 1984 trials due to unfavourable weather conditions, but data for black scurf and yield were obtained and these will be presented elsewhere.

TABLE 2

1983 Trials : Stem canker index

Treatment	Formu- lation % a.i.	Time of appli- cation	Site 1	Site 2	Site 3	Site 4
Tolclofos methyl	25 SC	November	0.0 A	0.0 A	0.0 A	0.9 A
Tolclofos methyl	25 SC	March	0.3 A	0.0 A	0.0 A	0.0 A
Tolclofos methyl	10D	November	0.9 A	0.0 A	0.0 A	0.0 A
Tolclofos methyl	10D	March	1.3 A	0.0 A	0.0 A	0.0 A
Tolclofos methyl	10D	At planting	0.0 A	0.0 A	0.0 A	0.0 A
Untreated			7.5 B	11.3 B	5.0 B	17.8 B

1 = Gedney, 2 = Roughton, 3 = Chesterford, 4 = Bayford

Figures with the same letter subscript are not significantly different at p = 0.05 (Student Newman Keuls Multiple Range Test)

Black scurf control in 1983 was also very good for all chemical treatments, significantly reducing the number of tubers with sclerotia (Table 3).

TABLE 3

1983 Trials : Percent tubers with black scurf.

Treatment	Formu-lation % a.i.	Time of appli-cation	Site 1		Site 2		Site 3		Site 4	
Tolclofos methyl	25 SC	November	0.5	A	2.3	A	3.5	A	1.8	A
Tolclofos methyl	25 SC	March	0.3	A	0.0	A	6.5	A	1.0	A
Tolclofos methyl	10D	November	0.0	A	0.0	A	0.3	A	0.0	A
Tolclofos methyl	10D	March	0.3	A	0.0	A	0.8	A	0.3	A
Tolclofos methyl	10D	At planting	1.5	A	0.3	A	0.3	A	0.3	A
Untreated			9.8	B	18.5	B	18.8	B	22.0	B

1 = Gedney, 2 = Roughton, 3 = Chesterford, 4 = Bayford

Figures with the same letter subscript are not significantly different at p = 0.05 (Student Newman Keuls Multiple Range Test).

Although, typically, there were no consistent yield increases in the 1983 maincrop trials (Table 4) there were considerable improvements in tuber quality from all tolclofos methyl treatments, an important benefit to the quality potato producer.

TABLE 4

1983 Trials : Relative yield (untreated = 100)

Treatment,	Formulation % a.i.	Time of application	Site 1	Site 2	Site 3	Site 4
Tolclofos methyl	25 SC	November	97 A	101 A	114 AB	101 A
Tolclofos methyl	25 SC	March	97 A	119 A	97 AB	89 A
Tolclofos methyl	10D	November	99 A	123 A	134 A	100 A
Tolclofos methyl	10D	March	98 A	124 A	73 B	99 A
Tolclofos methyl	10D	At planting	95 A	106 A	114 AB	98 A
Untreated t/ha			55.3	33.6	22.5	40.0

1 = Gedney, 2 = Roughton, 3 = Chesterford, 4 = Bayford

Figures with the same letter subscript are not significantly different at P = 0.05 (Student Newman Keuls Multiple Range Test)

ACKNOWLEDGEMENTS

The co-operation and assistance of staff at the Potato Marketing Board Experimental Station, Sutton Bridge and colleagues at Chesterford Park Research station is gratefully acknowledged.

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