Union Internationale des Sciences Biologiques

ORGANISATION INTERNATIONALE DE LUTTE BIOLOGIQUE ET INTEGREE CONTRE LES ANIMAUX ET LES PLANTES NUISIBLES

SECTION REGIONALE OUEST PALEARCTIQUE

ISBN 92-9067-009-6

WORKING GROUP "INTEGRATED CONTROL IN OILSEED RAPE"

GROUPE DE TRAVAIL "LUTTE INTEGREE EN CULTURE DE COLZA"

BRAUNSCHWEIG
17-18.03.86

BULLETIN SROP
WPRS BULLETIN

1987/X/4

International Union of Biological Sciences

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL AND INTEGRATED CONTROL OF NOXIOUS ANIMALS AND PLANTS

WEST PALAEARCTIC REGIONAL SECTION

ORGANISATION INTERNATIONALE DE LUTTE BIOLOGIQUE ET INTEGREE
CONTRE LES ANIMAUX ET LES PLANTES NUISIBLES

INTERNATIONAL ORGANIZATION FOR BIOLOGICAL AND INTEGRATED CONTROL
OF NOXIOUS ANIMALS AND PLANTS

Lutte intégrée en culture de colza
Integrated control in oilseed rape

Braunschweig (Germany) 17.-18.3.86

Bulletin SROP
WPRS Bulletin

PREFACE

The working group on integrated control in oilseed rape has existed since 1982. The reason for forming this working group was a tremendous increase in the acreage of oilseed rape in Europe starting in the seventies. This soon resulted in problems with pests and diseases and subsequently an extensive use of pesticides. Research programs were initiated in many countries on the same or different problems. A major purpose of the working group is to coordinate the efforts in order to get faster and better results and to avoid overlapping.

In oilseed rape different pests and diseases are influenced by each other and therefore, contrary to most other working groups, problems with diseases have been included in the working group right from the beginning.

This bulletin contains most of the papers presented and discussed at the 2nd reunion in Braunschweig 17th-18th March 1986. They are characterized by the diversity in problems. Most pests and diseases are the same from France in the south to Sweden in the north, however, this is not always the case. Some countries almost only grow spring oilseed rape and some exclusively winter oilseed rape. Besides, the variation in climate affects both plants, pests and diseases.

The present papers reflect some of the problems delt with in the various countries and on this basis new cooperative projects were decided on. In this way the meeting in Braunschweig was an excellent opportunity to review progress and to develope future plans.

I sincerely want to thank dr. Stan Finch, professor dr. A. Pelerents and professor dr. F. Klingauf for a thorough criticism and correction of the manuscripts.

Bent Bromand
convenor

CONTENTS page

CURRENT STATUS OF DISEASES AND DISEASE CONTROL IN WINTER OILSEED RAPE IN ENGLAND AND WALES

P GLADDERS

Agricultural Development and Advisory Service,
Block 3, Government Buildings, Burghill Road
Wesbury-on-Trym, Bristol UK BS10 6NJ

Summary

The results of disease surveys in winter oilseed rape are reviewed. Light leaf spot has been the most common pathogen on pods and stems during 1983-85 but has declined in importance since the introduction of the variety Bienvenu. *Alternaria* pod spot has been a localised problem since 1982. *Sclerotinia* problems have been rare in England but spray warnings were used successfully in a small high risk area in Southern England. Recent fungicide trials indicate that spray treatments gave small yield responses in low disease situations but that nearly half of these treatments would not have paid for the cost of the chemical. Multiple spray programmes increased the consistency of yield responses but were generally not cost effective. Significant yield increases were mainly, but not exclusively, associated with control of disease. Virus diseases, particularly beet western yellows virus, have been confirmed in winter oilseed rape crops in most production areas and this has prompted investigations into the movement and control of the aphid vectors. The need for improved forecasting systems and to identify fields at risk from *Sclerotinia* is briefly discussed.

1.1 Introduction

The incidence and severity of diseases of winter oilseed rape have been recorded by the Agricultural Development and Advisory Service (ADAS) in England since 1976. The most recent review illustrated the major changes in diseases, crop area and variety during the past decate (1). This paper includes observations made in 1985. Surveys were extended to include testing for beet western yellows virus for the first time in 1985.

Fungicide trials have included comparisons of commercial products against the major fungal pathogens and evaluation of fungicide programmes. Disease thresholds are used when advising treatment for *Alternaria brassicae* and light leaf spot (*Pyrenopeziza brassicae*) but forecasting has only been used for *Sclerotinia sclerotiorum* in Southern England.

There is a need to improve disease forecasting and to refine criteria used to identify crops which will benefit from fungicide treatment. Problems requiring further investigation in the UK are outlined.

1.2 Methods

Disease assessments were carried out on survey samples of 25 plants as described previously (2). Fungicide trials were located in commercial crops and consisted of fully replicated randomised block designs with a plot size of 0.01 ha. Treatments were applied by knapsack sprayer in 300 l water/ha. Fungicides were used at commercially recommended rates as follows: iprodione (25% oil; Rovral Flo) 0.5 kg a.i./ha: prochloraz (40% e.c.; Sportak) 0.5 kg a.i./ha and vinclozolin (50% w.p.; Ronilan or 50% e.c.; Ronilan FL) 0.5 kg a.i./ha.

1.3 Results

Most diseases were recorded at low levels in 1985 in spite of prolonged showery weather during April to August and above average rainfall in June. In the spring *Alternaria* incidence was lower than normal possibly because winter frost caused more leaf loss than usual.

Table I. Mean percentage of plants with disease in winter oilseed rape crops, England 1985

Disease	% Plants affected
Stem extension (April) - 135 crops	
Alternaria spp.	5
Leptosphaeria maculans (leaf)	9
Peronospora parasitica	61
Pyrenopeziza brassicae	38
Pod ripening (July) - 123 crops	
Alternaria spp (pod)	19
Botrytis cinerea (stem)	6
Leptosphaeria maculans (canker)	33
Pseudocercosporella capsellae (pod)	2
Pyrenopeziza brassicae (stem)	46
Pyrenopeziza brassicae (pod)	39
Sclerotinia sclerotiorum (stem)	2

Most crops were assessed again in July when light leaf spot was the most common disease on stems and pods for the third successive season. Bienvenue replaced Jet Neuf as the most widely grown variety and appeared to have contributed to the decline of light leaf spot since its peak incidence in 1983 (Fig 1).

White leaf spot (*Pseudocercosporella capsellae*) was more widely reported than in previous years and spread to pods in a few crops in Southern England.

The incidence of beet western yellows virus was determined in the spring using an ELISA technique (3). The virus was found in 39 out of 43 crops with a mean incidence of 45% plants affected.

The mean yield responses to fungicide treatments applied as single sprays, tank-mixtures or programmes in fully replicated field trials are shown in Table II. Sportak was the most frequently used fungicide at early stem extension whilst Ronilan was applied mainly at early flowering and Rovral Flo at the late flowering stage. These three products were also used in two and three spray programmes at the same timings.

The proportion of treatments which gave yield responses of 2% or more ≥5% and ≥10% are included to give an indication of the frequency of economic responses. Most trials during the period 1983-85 had low levels of disease and statistically significant yield increases were recorded at only one or two sites each year. Significant yield responses were generally related to disease control but unexplained yield increases occasionally followed a spring spray. Treatment costs are approximately 2% of yield for fungicide, 1% of yield for aerial application or wheeling losses at early flowering and 3% of yield for wheeling losses at the late flowering stage. Thus 'economic' yield responses should exceed 2% from spring treatment (but only 1% response needed if an MBC fungicide is used), and should exceed 5% to justify a ground application of a late flowering fungicide.

Relatively few trials have been carried out in commercial crops with high levels of light leaf spot in the spring. Recent observations (4) suggest that it is critical to use additional wetting agent or adjuvant oil with benomyl to achieve good disease control (Table III).

Table II Yield responses to fungicide treatments at different stages of crop development in ADAS trials on winter oilseed rape 1983-85

Number of sprays applied /crop	Number of treatment comparisons	Mean % Yield Response	% Treatments with responses		
			2%	5%	10%
1. 1 (Early stem extension)	40	+ 2.7	53	23	10
2. 1 (Early flowering)	28	+ 1.7	57	18	4
3. 1 (Late flowering)	35	+ 2.0	49	29	6
4. 2 (Combination of 1 + 2 or 3)	52	+ 4.2	65	48	27
5. 2 (Other combinations)	35	+ 3.8	69	46	17
6. 3 (" ")	23	+ 3.6	57	35	22
7. 4-6 (" ")	20	+ 4.9	70	60	15
8. 7-12 (" ")	15	+10.1	100	87	53

necessary to develop spray warning schemes.

Sclerotinia remains a minor problem in the UK and only the Chichester area has had consistent problems. Spray warnings were used successfully in 1985 but there remains the problem of identifying fields at risk. Where peas and oilseed rape are grown in the same rotation the examination cleanings from pea seed can give an indication of *Sclerotinia* infestations. In the Chichester area some pea crops have been severely affected by *Sclerotinia* and over 100 sclerotia per m^2 of crop have been collected in seed samples (J.M.L. Davies, *pers. comm.*). Further evaluation of the method is required to develop threshold levels for 'low risk' and 'high risk' fields. Similarly thresholds derived from *Sclerotinia* incidence in the previous oilseed rape crop would also be valuable.

Examination of the distribution of yield responses in fungicide trials indicates that routine use of fungicide is not worthwhile. Currently recommended products on average gave a small positive yield response and treatment effects were almost additive when two or more fungicides were used. Significant yield responses to one or two spray treatments were mainly due to disease control and unexplained yield responses were noted at less than 5% of sites. Multiple spray treatments increased the consistency and magnitude of yield responses but such treatments would only reduce economic benefits on less than 10% of crops. A fungicide applied at late flowering is often combined with insecticide as an insurance treatment against pod pests and diseases. In most areas this insurance spray would only have been worthwhile in 1981 and 1982. However in parts of Southern England, coastal areas, the Fens and the Yorkshire Wolds, *Alternaria* has warranted treatment in 4 of 5 years since 1980 and late flowering fungicides can be justified in such areas. Current advice is to apply a fungicide for *Alternaria* control when the disease reaches the upper leaves during flowering or at any time up to three weeks before harvest. A reliable forecasting system would be of value for this disease.

The identification of crops at risk from light leaf spot remains a problem. The benefits of early disease control with autumn sprays has been demonstrated at Rothamsted (6) and in ADAS trials. However only a small proportion of crops appear to justify treatment in the spring and ideally these should be identified in the autumn prior to the appearance of symptoms. Significant yield responses have been recorded following the application of fungicides to control light leaf spot in March (Table III) and April (J.M.L. Davies, unpublished results) at few sites but overall 53% of trial treatments applied at early stem extension would have been economically viable (Table II). The use of surfactants appears to be important for good control of leaf spot when using benomyl as a wettable powder formulation. Further investigation of the need for surfactants with other benzimidazoles and with triazoles should also be considered.

Acknowledgements

I thank Dr E J Evans, Dr J M L Davies and Dr N J Giltrap for contributions to this review.

Table III Evaluation of fungicides and surfactants for light leaf spot control

Treatment*	Light leaf spot infection % Leaf area 17 April	% Pod area 9 July	Yield t/ha
Benomyl	9.4 c	5.0 bc	2.46 ab
Benomyl + 0.03% Agral	3.8 a	4.0 ab	2.72 d
Benomyl + 1% Actipron	3.0 a	1.3 a	2.72 d
Benomyl + 2% Actipron	3.4 a	2.7 ab	2.69 cd
Prochloraz	5.5 ab	3.8 ab	2.58 bc
Untreated	13.4 d	7.0 bc	2.29 a

Means with the same letter do not differ significantly (P = 0.05)
*Benomyl used at 0.55 kg ai/ha (50% wp, Benlate Fungicide)
Prochloraz used at 0.50 kg ai/ha (40% ec, Sportak)

Treatments were applied on 12 March to cv. Jet Neuf when 60% plants (23% leaves) were affected. Disease control was not apparent when infection was analysed on presence/absence basis on 17 April (90% of plants in all treatments showed some symptoms) but the severity of leaf infection was reduced (Table III). Disease severity had increased from 1% leaf area affected to 13% leaf area affected in control plots during this period. Subsequent stem and pod infection were highly correlated ($P<0.001$) with disease severity in mid April and negatively correlatively with yield.

Investigations on the control of Sclerotinia have been carried out in Southern England and co-ordinated by Dr J M L Davies. Depots of Sclerotinia have been used to monitor the production of apothecia and are an important component of a spray warning scheme. In 1985 a reliable weather forecast prompted a spray warning in high risk fields in the Chichester area and farmers achieved 85-90% control of Sclerotinia (J.M.L Davies pers. comm.).

1.4 Discussion

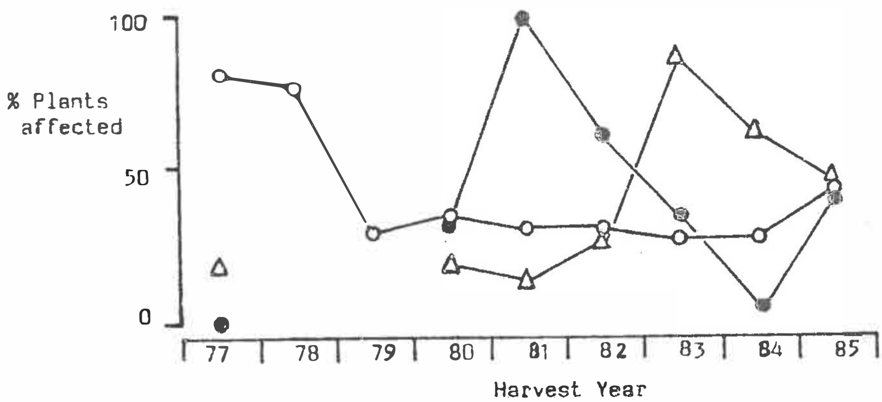
Recent observations on disease incidence have dmonstrated that marked seasonal variations occur. Alternaria brassicae has declined in importance since 1981, partly due to an increase in the use of fungicides at the end of flowering. Light leaf spot has been the most common disease on stems and pods at harvest for the last three years (1983-1985) but has declined in importance since the introduction of cv Bienvenue in 1984.

There is considerable interest in beet western yellows virus which has been widespread in winter oilseed rape crops (3). Observations in recent ADAS trials support earlier work (3) that this virus may reduce yields by about 10 per cent. (M. Holliday and D. Smallshire pers. comm). In 1984 cauliflower mosaic virus was common at trace levels in Eastern England and occasionally affected small groups of plants (1). The incidence and control of aphids particularly Myzus persicae, in the autumn are currently being investigated by ADAS Entomologists. Further observations are required on the effects of viruses on seed yield but preliminary results suggest that it may be

REFERENCES

1. GLADDERS, P. (1984). Present and potential disease interactions between oilseed rape and vegetable brassicas. Proceedings 1984 British Crop Protection Conference - Pests and Diseases 791-798.
2. EVANS, E. J. and GLADDERS, P. (1981) Diseases of winter oilseed rape and their control, east and south-east England, 1977-81. Proceedings 1981 British Crop Protection Conference - Pest and Diseases 505-512.
3. SMITH, H G. and HINCKES, J. A. (1985). Studies on beet western yellows virus oilseed rape (Brassica napus ssp. oleifera) and sugar beet (Beta vulgaris). Annals of Applied Biology, 107, 473-484.
4. GILTRAP, N. J. (1986). Light leaf spot control in oilseed rape; Evaluation of fungicides and surfactants. Tests of Agrochemicals and Cultivars No 7 (Annals of Applied Biology 108 Supplement), 60-61.
5. JELLIS, G. J. DAVIES, J. M. L. and SCOTT, E. S (1984) Sclerotinia on oilseed rape: implications for crop rotation. Proceedings 1984 British Crop Protection Conference - Pests and Diseases 709-715.
6. RAWLINSON, C. J and CAYLEY, G R. (1984). Spray treatments methods and timing for control of light leaf spot on oilseed rape. Proceedings 1984 British Crop Protection Conference - Pests and Diseases 735-742.

Fig 1 Incidence of diseases in winter oilseed rape in eastern England 1977-85 (● Alternaria on pods: O canker Δ light leaf spot on stem and pod)



SCLEROTINIA STEM ROT ON OILSEED CROPS IN SWEDEN.

K. NORDIN and C. SVENSSON
Swedish University of Agricultural Sciences
P O Box 7044, S-750 07 Uppsala, Sweden

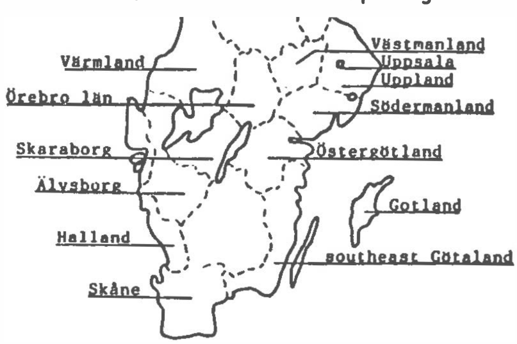
Summary

In Sweden 60-70 % of the area planted with oilseed crops is springsown. Stem rot caused by *Sclerotinia sclerotiorum* is the major disease on the springsown oilseed crops in central Sweden. Investigations on *Sclerotinia* stem rot have been carried out since 1979. The disease incidence varied considerably between years, the most serious infections occurring during 1984.

Introduction

During the last 10 years the total area planted with oilseed crops in Sweden has been about 160 000 ha. Of these about 110 000 ha are spring rape (*Brassica napus*) and spring turnip rape (*Brassica campestris*). 80 % of the wintersown oilseed crops are grown in Skåne, the southernmost province of Sweden, but they are to some extent grown as far north as Uppsala. Gotland and Östergötland are also two of the more important areas for wintersown oilseed crops. Currently there are no problems with *Sclerotinia* stem rot in winter rape and winter turnip rape in Sweden.

Spring rape and spring turnip rape are grown in the areas mentioned above and somewhat further north. Springsown oilseed crops are used as break crops in cereal rotations, especially in the central parts of Sweden. In this area oilseed crops are often grown every fourth year and *Sclerotinia* stem rot, caused by *Sclerotinia sclerotiorum*, has become a serious problem on many farms.



Surveys of *Sclerotinia* stem rot.

Surveys have been carried out in certain areas of Sweden since 1979 to obtain information about the annual incidence of *Sclerotinia* stem rot and to estimate the economic importance of the disease. Attempts have also been made to relate certain weather factors, e.g. amount of rain and the incidence of *Sclerotinia*. These surveys have been funded by the Swedish Oil Plant Growers Association.

About 100 plants were inspected per field and the numbers infected by *Sclerotinia* were recorded. The results presented are only approximate, since the surveys were carried out over a period of several weeks. Usually an early observation gives a lower level of disease than a later one. However high levels of disease do not always develop from early infections. Table 1 shows that a low level of disease at the end of July does not always result in high levels of disease later in the season. Disease incidence may remain low in one field after one month while in another it may develop from 2 to 25%.

The amount of *Sclerotinia* stem rot recorded in different years is shown in Table 2 & 3. The different classifications used in these tables make direct comparisons difficult. The disease incidence varies greatly between years. Severe infections occurred in some provinces in 1981 and also in 1984. During 1984 certain fields contained 90-100 % diseased plants. The amount of *Sclerotinia* was not as high in western compared with the eastern parts of central Sweden.

Table 1 shows differences in disease incidence between different fields in the same area. The mean level of disease in an area is greatly influenced by the amount of rain just before and during the flowering period. The differences between fields in the same area are probably due to above all differences in the number of sclerotia in the fields and differences in crop density.

The somewhat earlier flowering of spring turnip rape helps to explain why this crop is often less diseased by *Sclerotinia* than spring rape. The development of apothecia often coincides better with the flowering of spring rape than spring turnip rape. Spring rape also has a longer flowering period and so has a correspondingly higher risk of infection by *Sclerotinia*.

Table 1. Development of *Sclerotinia* stem rot in spring rape in 1984 in Uppland.

Date	20/7	26/7	1/8	15/8
	Per cent diseased plants			
Field no				
1	2	9	10	25
2	2	5	8	6
3	0	0	0	1
4	0	0	0	1
5	4	6	8	9
6	16	26	27	25
7	11	10	15	24
8	5	14	13	11
9	4	9	11	15
10	1	6	9	6
11	21	25	26	26
12	2	0	0	2
Mean	5.6	9.2	10.6	12.6

Table 2. Amount of *Sclerotinia* stem rot recorded in parts of western Sweden during 1983-1984.

% dis. plants	0	1-2	3-5	6-10	11-20	21-50	51-100
	Per cent fields in different classes of disease						
Year & Area							
1983							
Halland	61	17	6	11	5	0	0
Älvsborg	38	10	21	14	10	7	0
Skaraborg	58	23	9	3	4	3	0
Värmland	81	12	0	2	5	0	0
1984							
Halland	33	29	29	9	0	0	0
Älvsborg	20	35	10	10	20	5	0
Skaraborg	35	12	4	13	8	7	1
Värmland	21	32	16	0	26	5	0

Table 3. Amount of *Sclerotinia* stem rot recorded in parts of eastern Sweden during 1979-1985.

% dis. plants	0	1-10	11-20	21-40	41-100	Mean
	Per cent of the fields in different classes					
Year & Area						
Uppland, north Södermanland						
1979	90	0	10	0	0	2
1980	60	30	10	0	0	3
1981	23	70	7	0	0	5
1982	80	18	2	0	0	2
1983	62	33	0	3	2	4
1984	0	30	25	25	20	20
1985	22	74	2	2	0	3
Västmanland						
1979	55	10	25	5	5	9
1980	30	60	10	0	0	5
1981	15	35	20	20	10	16
1982	80	18	0	2	0	2
1983	25	60	10	5	0	6
1984	5	45	20	15	15	20
1985	0	95	5	0	0	4
Södermanland						
1984	24	35	18	15	8	8
Örebro län						
1984	23	46	12	13	6	10
Östergötland						
1980	55	35	8	2	0	3
1981	20	65	10	3	2	6
1982	31	62	5	2	0	2
1983	63	37	0	0	0	1
1984	8	30	10	28	24	24
1985	13	54	22	9	2	9
Southeast Götaland						
Spring sown oilseed crops						
1982	81	17	1	1	0	1
1983	93	17	0	0	0	1
1984	72	26	1	1	0	2
Winter sown oilseed crops						
1982	56	39	5	0	0	2
1983	82	16	2	0	0	1
1984	74	21	5	0	0	2

CURRENT RESEARCH ON SCLEROTINIA SCLEROTIORUM IN SWEDEN

K.NORDIN and C.SVENSSON
Swedish Univ. of Agricultural Sciences
P O Box 7044, S-750 07 Uppsala, Sweden

Summary

Field experiments with different seeding rates and nitrogen levels were carried out in spring rape for three years in the central parts of eastern Sweden. Bags with sclerotia were placed in the experimental fields and counts of apothecia were made weekly. The importance of the amount of rain was illustrated clearly. It was not possible to detect any influence of the crop densities due to various seeding rates on the development of apothecia or on the development of *Sclerotinia* stem rot. In one of the experiments, where disease incidence was about 80 %, seed yield doubled after spraying the crop with Ronilan (1.5 l/ha) about one week after the beginning of flowering.

Field experiments

Since 1983 the Dept. of Plant and Forest Protecton and the Research Information Center/Plant Protection have received funds from the Swedish Oil Plant Growers Association to develop a forecasting method for *Sclerotinia* stem rot on spring sown oilseed crops. Field experiments involving three seeding rates and two nitrogen levels were a major part of this work. The aim of these experiments was to study the influence of crop density on the development of apothecia and on the development of the disease. We also wanted to study the importance of rain on the development of apothecia and to estimate the crop losses due to disease. Half of the plots were sprayed with a fungicide (Ronilan 1.5 l/ha).

Bags, each containing between 25-100 sclerotia, were stored in soil (ca 20 cm depth) during the winter and buried in the experimental fields as soon as possible after sowing. The numbers of apothecia were counted each week during June,July and August.

Development of apothecia

It is wellknown that the amount of rain during the summer is of great importance for apothecia formation and the development of *Sclerotinia* stem rot. Figure 1. shows the numbers of apothecia produced during three different years and the total amount of rain from June 1 - July 20, measured in or near the experimental fields. In 1985, June and the first half of July were extremely dry . During the second half of July onwards the amount of rain was about normal and the first apothecia were detected during the first week of August. This, however, was too late to cause a serious infection of *Sclerotinia* stem rot. In 1983 and 1984, when apothecia appeared during the flowering period, the infection by *Sclerotinia* was severe.

It was not possible to detect any difference in the time of appearance of apothecia or in the numbers of apothocia in the plots with different seeding rates. Because of the greater numbers of lateral shoots produced in plots sown with the low seeding rate (4 kg seed/ha) than in plots sown with the high seeding rate (16 kg seed/ha) the difference in crop density is not as large as the difference in seeding rate. In addition, it was not been possible to show any consistent effect of the different nitrogen levels (difference equals 50 kg N/ha) on the development of apothecia.

Development of Sclerotinia stem rot

In the field experiments, the level of disease was assessed several times during July and August. 200 plants in unsprayed and sprayed areas were inspected and the proportion of diseased plants recorded. One of the experiments was chosen to illustrate the development of the disease.

As can be seen in Figure 2. the development of *Sclerotinia* stem rot in this particular experiment was extremely rapid between July 10 and 25. The number of apothecia in this experiment is shown in Figure 1, by the curve illustrating the development of apothecia in 1984. In the plots with low seeding rate the number of plants was about 55/m^2, in the normal about 110/m^2 and in the high seeding rate plots about 175/m^2. Plants in the plots with low seeding rate were much larger than those in the other plots and this partially explains why the disease incidence was higher in the plots with low seeding rate.

At the end of August there was no longer a great difference in disease incidence in plots sown with different seeding rates. Figure 2 illustrates the problem in estimating the importance of *Sclerotinia* by counting the proportion of diseased plants. In 1985 there was hardly any *Sclerotinia* stem rot in the field experiments.

Yield and effect of spraying

The yield in experiment B84 is shown in Table 1. The effect of spraying when the disease incidence was about 80% in unsprayed plots, was 420 kg crude fat/ha in plots with "normal" nitrogen level and 600 kg at the higher nitrogen level (normal + 50 kg N/ha). The later yield was twice the yield obtained from the unsprayed plots. This experiment was sprayed July 9, about one week after the beginning of flowering and at a time when there were still not many apothecia (Figure 1). The spraying was extremely effective and only a few diseased plants were subsequently found in the sprayed plots (Table 1).

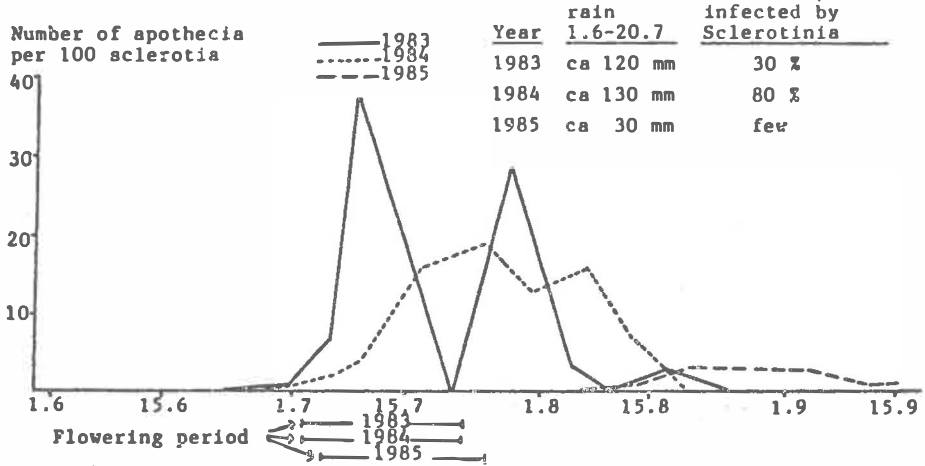
In experiment B84, counts were made of the numbers of sclerotia per kilogram of harvested seed. The number of sclerotia ranged from 720-1190 per kg seed in the unsprayed plots (mean=1030). This represents of course only a small proportion of the enormous numbers of sclerotia produced per hectare. The majority fall to the ground and become an important source of infection for several years ahead.

In experiment H85 the spray had no positive effect on yield (Table 1). This result was not unexpected since there were very few diseased plants in this experiment.

Table 1. Yield (kg crude fat /ha) and per cent diseased plants in 1 field experiment in 1984 and in 1 field experiment in 1985.

	Yield,kg crude fat/ha		Per cent diseased plants	
	I[1])	II[1])	I[1])	II[1])
Experiment B84				
Unsprayed area	687	588	81	83
Sprayed area	1106	1192	few	few
Experiment H85				
Unsprayed area	874	1054	few	few
Sprayed area	816	960	few	few

[1]) Mean of three different seeding rates.
I="normal" nitrogen-level II="normal" nitrogen level + 50 kg N/ha.



Year	Amount of rain 1.6-20.7	Per cent plants infected by Sclerotinia
1983	ca 120 mm	30 %
1984	ca 130 mm	80 %
1985	ca 30 mm	few

Figure 1. Development of apothecia from 1 year old sclerotia of about the same size. Each curve illustrates 1 experiment in 1 year.

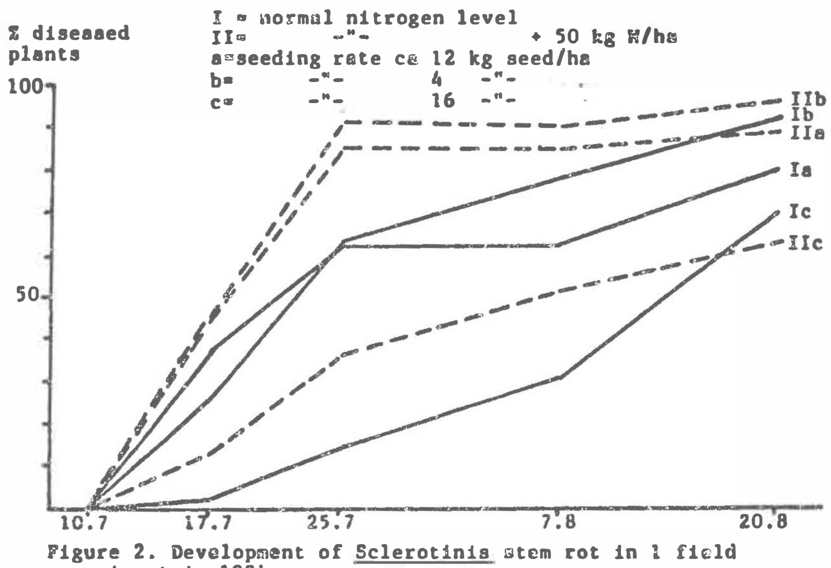


Figure 2. Development of <u>Sclerotinia</u> stem rot in 1 field experiment in 1984.

THE ROLE OF FLOWERING IN INFECTION BY SCLEROTINIA SCLEROTIORUM (WHITE MOULD)

M. Gerlagh
Research Institute for Plant Protection,
P.O.Box 9060, 6700 GW Wageningen,
The Netherlands

Summary

Infection of many crops by *S. sclerotiorum* is assisted by the presence of wilted petals during flowering. Nevertheless infection can also take place at other times. This occurs when tissues decrease in vigour, such as when older leaves are shaded under a closed canopy. Loss of vigour also explains why the symptoms of the pathogen sometimes only become apparent several weeks after infection. The fungus is often limited to a few cells until loss of vigour exposes the plant tissue to rapid invasion. The possibility of infection in periods other than during flowering makes the accurate timing of fungicidal sprays difficult.

1. Introduction

Of the three species of *Sclerotinia* commonly encountered, *S. sclerotiorum* and *S. trifoliorum* are disseminated mostly by ascospores, whereas *S. minor* infects through mycelia germinating from sclerotia. It is generally accepted that infection of rapeseed, beans, sunflowers and many other crops takes place when ascospores infect wilted petals. These petals stick to fruits, leaves or stalks and enable the fungus to attack the healthy tissues beneath, which it otherwise would not be able to do.

The conclusion from this sequence of events is that infection should become apparent a few days after the beginning of flowering, when weather conditions favour the disease. However, it is known that in many cases symptoms of the disease appear only weeks or even months after conditions favourable for infection (1, 2). Another question is how crops like carrots and celeriac which normally do not flower in culture become infected. This paper deals with experiments and observations that answer some of these questions.

2. Is flowering necessary for infection?

2.1 Crops which usually flower during culture

In 1984 and 1985 inoculation experiments were carried out in fields of oilseed rape free from infection by *S. sclerotiorum*. The experiments consisted of placing pots with sporulating apothecia in the oilseed rape crops from the beginning of flowering onwards. Each pot was left at a given position for one week. It was then removed and another pot was placed at a new position at least 10 m away. This procedure was repeated for 8 weeks.

The presence of diseased plants was scored when the crop reached maturity. Numbers of diseased plants were found around all of the places where the pots had been. However, neither the numbers of diseased plants nor the severity of disease were clearly related to any specific period of exposure. Therefore infection can take place at times other than flowering.

2.2 When does infection take place in non-flowering crops?

Carrots, celeriac, chicory and potatoes are among the crops that normally do not flower, or only flower occasionally during culture.

Nevertheless these crops are all susceptible to *S. sclerotiorum*, and for some of them white mould is their most serious pathogen. If wilted petals are essential for infection by ascospores, these crops should not suffer from attack by *S. sclerotiorum*, but they do. However, attack by *S. sclerotiorum* is not evident on young and vigourously growing plants in such crops. Only old plants become infected. Therefore, since the precise timing of infection is much more difficult to predict in ageing than in flowering crops, fungicidal treatments in ageing crops also tend to be less effective.

3. Reduced plant vitality as a criterion for infection and disease development

In the experiments described under 2.1 in 1985, leaves of oilseed rape plants at one and two metres distance from where the pots had been positioned, were sampled every week. At both distances two leaves were collected from one plant, one old leaf, and one younger leaf from higher up the plant. The leaves, which never showed signs of infection by white mould, were each cut in half. One half was surface sterilised with sodium hypochlorite, the other half was just rinsed with sterile water. The leaf halves were then incubated on moist filter paper or cherry agar in petri dishes and observed for the appearance of mycelium and sclerotia of *S. sclerotiorum*. Though they did not produce sclerotia abundantly, *S. sclerotiorum* was shown to be present on at least one of the leaves sampled for each exposure period (one week). Also both surface-sterilised and non-sterilised leaves produced sclerotia. It was concluded that leaves contained latent infections by *S. sclerotiorum*. After collection, the leaves started to decay and the fungus began to show its presence. Sutton & Deverall (1983) mentioned the possibility of infection of healthy tissue by ascospores, followed by a hypersensitive reaction which halts further development of the pathogen. It is clear that hypersensitivity is correlated with vigour. Thus when the tissues begin to senesce the resistance will decrease and the pathogen might accelerate its growth. Exactly the same seems to happen in clover infected by *S. trifoliorum*, where infection in autumn leads to restricted brown lesions on the leaves. Frost damage during winter then leads to complete rotting of the plants early in spring (1, 3). This situation also exists with other host-pathogen relationships such as *Colletotrichum musae* in bananas and *Botryris cinerea* in strawberries (6). In both examples the fungus is refrained from developing in the unripe fruit; the symptoms only beginning to appear when the fruit starts to ripen.

The suggestion that vitality of the tissues opposes development of the pathogen also explains why symptoms only appear several weeks after flowering of crops like sunflowers and oilseed rape. It seems in such cases that even the availability of suitable food is not sufficient to permit S. sclerotiorum to spread through the vital tissues of the host. Maturation of the crop is accompanied by the loss of this disease opposing vitality. With beans, young pods, infected through petals adhering to their tips, may rot completely without the fungus entering their petioles. Such petioles therefore must possess a high degree of resistance, particularly when they are required to continue transporting food to a second pod on the same petiole.

With crops which normally do not flower, such as carrots, chicory and celeriac, rotting leaves can be found soon after the crop canopy closes. At this time the oldest leaves no longer receive sufficient light to be photosynthetically active and hence begin to senesce. This assists infection by ascospores and the spread of the pathogen (Cf Purdy (1958) on infection of lettuce). The subsequent rotting can proceed to the crown of the plant, but normally does not kill the growing point nor cause rotting of the root. (For comparison: Loveless (1951) reports clover plants to start regrowth from the heart of completely rotten plants). This implies that apparently healthy roots stored during the winter may already contain a quiescent fungal infection in the crown. Depending on the conditions of storage, the roots will rot sooner or later and develop sclerotia of S. sclerotiorum. The gradual loss of vitality in the stored roots would again explain why the fungus does not show up earlier.

4. Implications for preventative spraying

Experiments with fungicidal sprays have shown that spraying during full bloom is generally the most satisfactory way to limit damage by S. sclerotiorum in oilseed rape and other crops. This indicates that infections during flowering have the most important effects on yield, even if they do not spread actively until much later. Possibly the rapid maturation of spring-sown oilseed rape in Northern countries, compared to the slower development of winter-sown oilseed rape grown in most countries (e.g. the Netherlands) may help further to reduce the difference between infection during flowering and later. It seems clear that S. sclerotiorum can infect the crop over extended periods of time. The economic importance of this can only be assessed through careful monitoring. For the success of predictive spraying based on a combination of an appropriate inoculum (apothecia) during full flowering and climatic conditions favourable for infection, it is crucial to know whether late infections can occur on an appreciable scale when infection does not occur during flowering.

References

1. DIJKSTRA, J., 1966. Rotting by spread of mycelium from ascospore lesions of Sclerotinia trifoliorum. Neth. J. Pl. Path. 72: 279-283.
2. LAMARQUE, C. & RAPILLY, F., 1981. Conditions nécessaires a la contamination du tournesol par les ascospores de Sclerotinia sclerotiorum (Lib.) de Bary - Application à la prévision des épidemies locales. Informations Techn. CETIOM, no. 75: 4-6.
3. LOVELESS, A.R., 1951. Observations on the biology of clover rot. Ann. appl. Biol. 38: 642-664.
4. PURDY, L.H., 1958. Some factors affecting penetration and infection by

Sclerotinia sclerotiorum. Phytopathol. 48: 605-609.
5. SUTTON, D.C. & DEVERALL, B.J., 1983. Studies on infection of bean (Phaseolus vulgaris) and soybean (Glycine max) by ascospores of Sclerotinia sclerotiorum. Plant Pathol. 32: 251-261.
6. VERHOEFF, K., 1974. Latent infections by fungi. Ann. Rev. Phytopath. 12: 99-110.

EINIGE ERGEBNISSE ÜBER DIE EPIDEMIOLOGIE DES ERREGERS DER WEIßSTENGELIGKEIT (RAPSKREBS/SCLEROTINIA SCLEROTIORUM)

W. KRÜGER
Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für Pflanzenschutz in Ackerbau und Grünland, Braunschweig

Summary: Some results about the epidemiology of Sclerotinia sclerotiorum, causing stalk rot of oil seed rape

The speed of development of apothecia of Sclerotinia sclerotiorum (Lib.) de Bary was dependend on the time of appearance. Early formed apothecia needed some more time to reach their maximum size. The growth rate per day was higher in the first days (0,6 mm/day) than later (0,3 to 0,1 mm).

The spore flight of the fungus took place during and after rains, but only when the rainfall was not too heavy. Two early rain periods in the beginning of May 1985 did not seem to have initiated infection, due to the fact that no or only very slight petal falling was present at that time.

The infection of rape seems to be not so much dependend on the numbers of spores present in the air, but more on the microclimate present when spores are discharged, as can be followed from dew measurements.

Yield, 1000 kernel weight and the number of bursted pods were more reduced on early infected plants than on those infected later after flowering. There seem to be some differences between cultivars, expecially with respect to pod bursting. More data are necessary.

It was tried to find a correlation between the degree of infestation of a field and the number of sclerotia recovered from the soil by washing soil samples. Only very few sclerotia were found in both, the heavy infected fields and in those with only a few plants diseased.

1.1 Einleitung

Die Arbeit wurde mit dem Ziel ausgeführt, einige weitere Daten über die Biologie des Pilzes zu erhalten, um die Vorhersage über einen zu erwartenden Befall genauer präzisieren zu können. Diese Untersuchungen schlossen daher Beobachtungen über die Entwicklung der Apothezien, das Ausschleudern der Sporen bei bestimmten Witterungskonstellationen und die Auswirkung auf den Ertrag ein.

1.2 Methoden

1. Sklerotien wurden 2 cm tief mit einem Abstand von 3 cm zwischen Rapsreihen

im Freiland ausgelegt und im Frühjahr auf Entwicklung der Apothezien beurteilt.

2. Sklerotien wurden im Herbst am 18. 9. 1984 auf zwei Flächen mit einem Durchmesser von 10 m inmitten eines Rapsfeldes oberflächlich eingearbeitet. Die Sklerotienmenge betrug 50 g/Fläche.

3. In stehenden Beständen wurden kurz vor der Ernte die Auswirkung des Befalls auf die Anzahl geplatzter Schoten, den Ertrag und das TKG bei Einzelpflanzen bestimmt. Die Pflanzen wurden äußerst vorsichtig von benachbarten Pflanzen getrennt, so daß die Schotenanzahl erfaßt werden konnte. Beim Freistellen der zu beurteilenden Pflanzen geplatzte Schoten wurden nicht als gepflanzt gewertet.

1.3 Ergebnisse

a. Entwicklungsgeschwindigkeit der Apothezien

Der Durchmesser der Apothezien wurde in zeitlichen Abständen an Einzelapothezien gemessen. Es wurden 4 Gruppen gebildet, die jeweils etwa 4 Tage später mit ihren Stielchen erschienen waren. Die Ergebnisse sind in Abbildung 1 dargestellt. Aus den Kurven ist zu entnehmen, daß 1. die zuerst gebildeten Apothezien etwa 35 Tage bis zur vollen Entfaltung benötigt hatten; 2. die später erschienenen Apothezien kürzere Zeit bis zur Maximalgröße brauchten und zwar 29, 23 und 22 Tage; 3. die beiden mittleren Gruppen etwa 1,5 mm kleinere Apothezien entwickelt hatten. Außerdem wurde die durchschnittliche Wachstumszunahme je Tag errechnet. Während neu gebildete Apothezien in den ersten 5 Tagen etwa 0,6 mm am Tag wuchsen, reduzierte sich der Zuwachs danach auf 0,3 bis 0,1 mm.Es ist somit damit zu rechnen, daß später gebildete Apothezien schneller und intensiver Sporen entwickeln und ausschleudern.

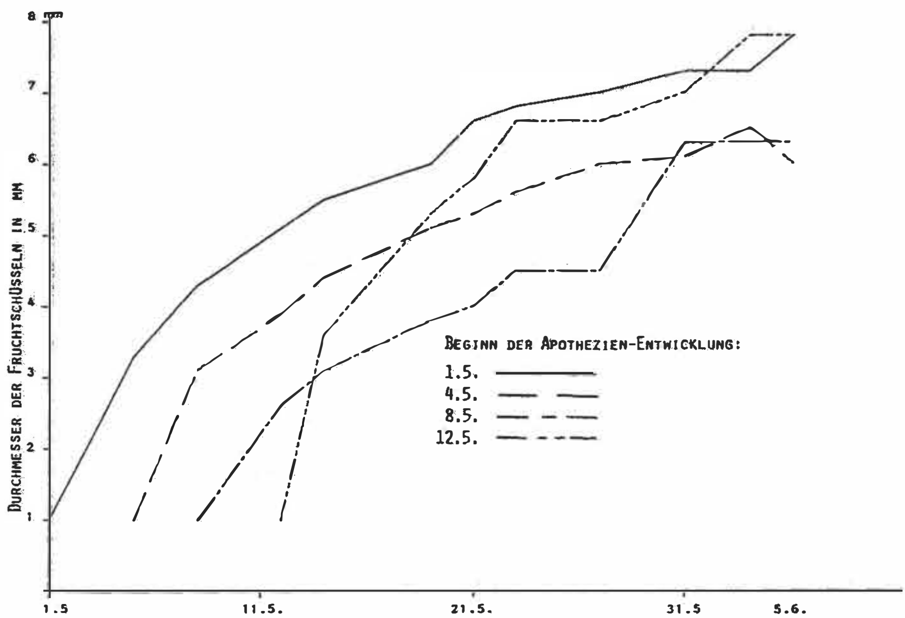


Abb. 1. Wchstumsgeschwindigkeit der Apothezien von Sclerotinia sclerotiorum

b. Ausschleudern der Sporen

Die Apothezien bildeten sich Anfang Mai. Ein Sporenflug konnte am 17.5.1985 beobachtet werden (Abb. 2). Kurz vor und zu diesem Zeitpunkt fielen die ersten geringen Niederschläge. Danach war es für 6 Tage niederschlagsfrei. Erneute 2 mal 0,9 mm führten zu einem weiteren Sporenflug. Beim ersten Sporenausstoß begann gerade die Blüte, und auch bei der zweiten Phase war die Anzahl der abgefallenen Blütenblätter in den Blattgabeln noch gering. Zwischen diesen Perioden war keine meßbare Taubildung vorhanden, so daß ein Befall durch diese zwei Niederschlags- und Sporenflugperioden kaum in Betracht gezogen werden kann.

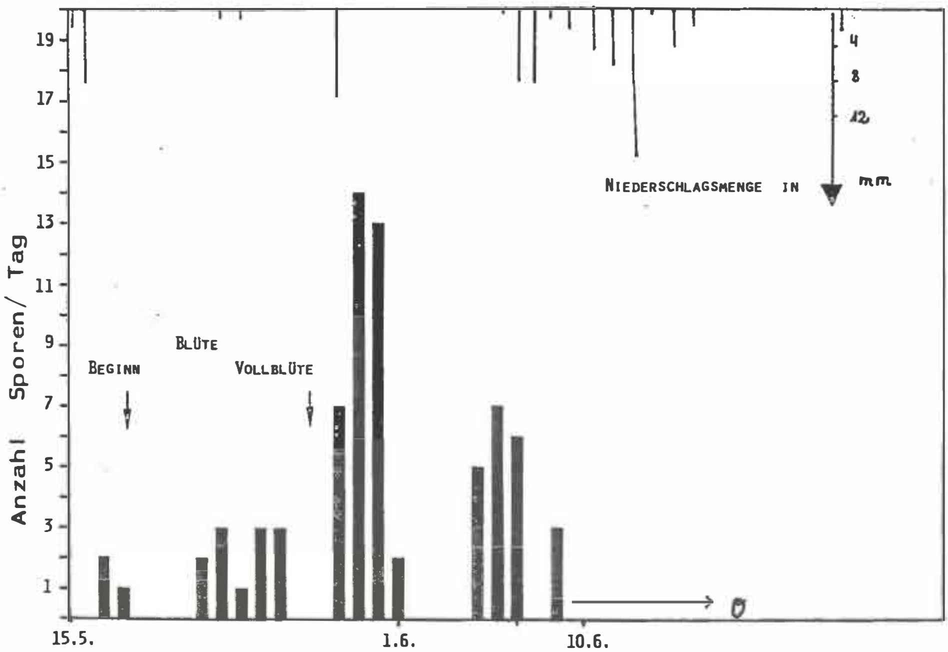


ABB. 2: SPORENFLUG VON SCLEROTINIA SCLEROTIORUM IN ABHÄNGIGKEIT VON DEN NIEDERSCHLÄGEN (1985)

Erst am Ende des Monats nach der Vollblüte, die am 26./27. 5. war, bildete sich eine feuchte Periode, die auf Feld H zu einer kurzen und Feld Sch zu einer längeren Taubildung führte (Abb. 3). Die Durchschnittstemperatur war mit etwa 14° C in 20 cm Höhe im Bestand für einen Befall relativ günstig. Zu dieser Zeit sind im Feld Sch die Infektionen gesetzt worden, wie spätere Beobachtungen an Blättern und Stengel zeigten. Im Feld H betrug die Tauphase nur die Hälfte der Zeit und führte, trotz des intensiven Sporenfluges, zu keinem nennenswerten Befall. Nach dieser Sporenflugperiode stiegen die Temperaturen für 6 Tage etwas an. Es folgte eine längere Regenperiode, in der nur in den ersten 4 Tagen Sporen gefangen wurden. Dieser erneute, wenn auch mäßige Sporenflug hat auf Feld Sch zu einer weiteren Infektion geführt, die aber infolge des bereits eingetretenen Blattabfalles nur noch Pflanzenteile im oberen Bereich erfaßte.
Auf Feld H wurde trotz des Sporenfluges nur noch ein geringer Befall beobachtet, der sich ebenfalls hoch an den Stengeln befand.

Die Ergebnisse auf den beiden an verschiedenen, aber dicht beeinander liegenden Standorten zeigten, daß trotz einer guten Apothezienbildung auf beiden Feldern auf Feld H kaum Befall (etwa 6 %) vorhanden war, obwohl 4 Sporenausstöße beobachtet worden waren. Die ersten zwei waren zeitlich etwas früh, der dritte genau richtig und der vierte etwas verspätet gewesen. Die offene Lage des Feldes H bewirkte weniger Taubildung und dadurch auch wahrscheinlich weniger Befall. Feld Sch in einer windgeschützten Senke hatte somit günstigere Infektionsvoraussetzungen.

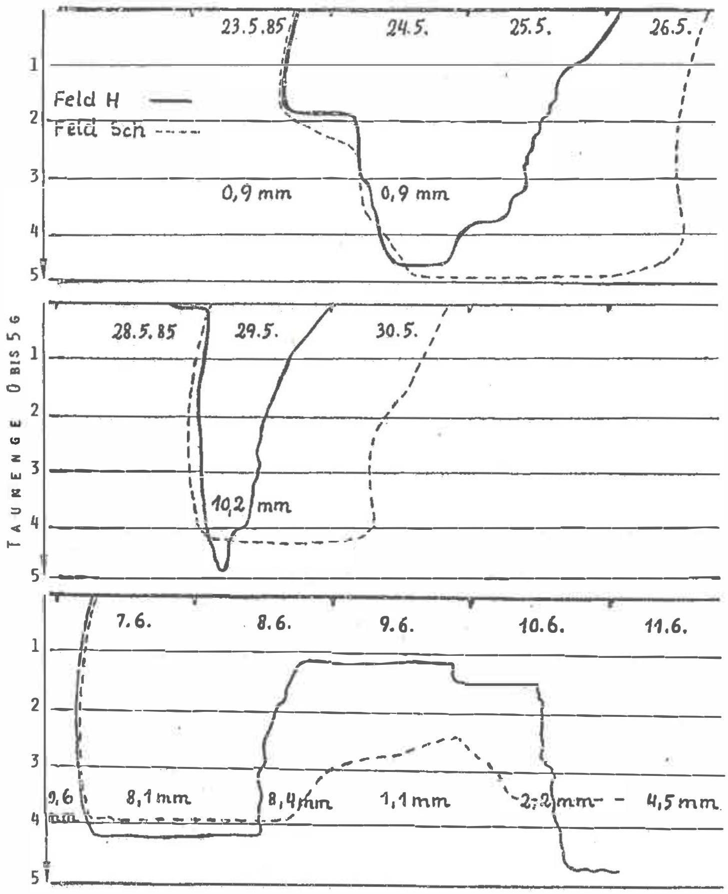


ABB. 3: TAUBILDUNG UND NIEDERSCHLAGSMENGE WÄHREND DREI FEUCHTPERIODEN IN ZWEI RAPSFELDERN (1985)

Die Daten zeigen somit erneut, daß die Anwesenheit von Apothezien und auch das Ausschleudern der Sporen keine guten Maßstäbe für eine Vorhersage eines zu erwartenden Befalles sind. Wenn die Witterung und der physiologische Zustand der Pflanzen für einen Befall nicht günstig sind, bleibt auch bei positiver Analyse der beiden oben genannten Faktoren der Befall gering.

c. Einfluß eines frühen und späten Befalls auf Ertrag, TKG und Schotenplatzen bei Raps.

Der oben erwähnte frühe und späte Befall des Rapses gab Anlaß, die Auswirkungen auf Ertrag, TKG und Schotenplatzen zu analysieren. In 2 Schlägen wurden an 3 Stellen je 10 Pflanzen beurteilt, die a) nicht befallen, b) spät und c) früh infiziert worden sind. Die Ergebnisse sind in Abbildung 4 dargestellt. Wie aus den Säulen ersichtlich, war der Anteil geplatzter Schoten nach Frühbefall deutlich höher als nach spätem, weil allgemein nur Zweige einer Pflanze befallen waren und außerdem die Notreife nach spätem Befall weniger ausgeprägt war. Die Schoten hatten vor der Reife nur eine gelbliche Verfärbung, während sie nach Frühbefall bereits braun und trocken waren. Allgemein nahm nach Frühbefall das TKG und der Ertrag der Pflanzen ab. Feld A mit Sorte C unterschied sich von Feld B mit Sorte D, das etwa 1 km weit entfernt war, besonders im Hinblick auf die Anzahl geplatzter Schoten. Wie weit eine Sorteneigenschaft vorliegt, kann noch nicht beurteilt werden, da keine weiteren Daten vorliegen.

d. Anzahl von Sklerotien in stärk und schwach befallenen Feldern

Von drei Feldern mit unterschiedlichem Befall des Rapses mit S. sclerotiorum wurden Erdproben (20 x 20 x 25 cm) von mehreren Stellen entnommen und gewaschen. Die Anzahl der wiedergefundenen Fruchtkörper war bei allen drei Feldern sehr gering (0 bis 3) und ist als Entscheidungshilfe für einen zu erwartenden Befall nicht geeignet, zumal die Methode sehr arbeitsaufwendig ist.

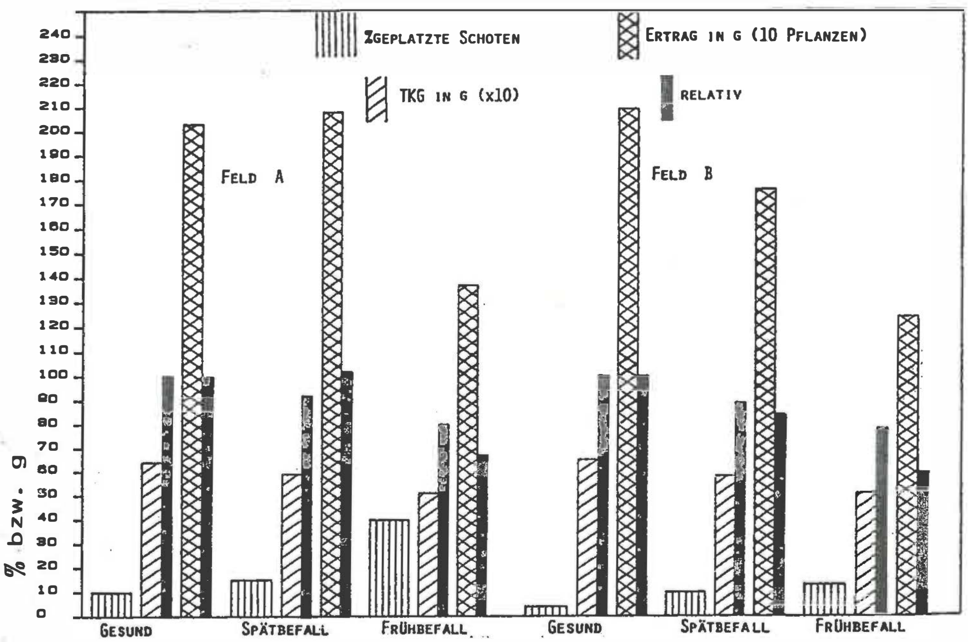


Abb. 2: Einfluß einer frühen und späten Infektion durch Sclerotinia sclerotiorum (Rapskrebs) auf Schotenplatzen, TKG und Ertrag der Einzelpflanzen

AN INVESTIGATION ON THE EFFECT OF VERTICILLIUM WILT (VERTICILLIUM DAHLIAE KLEB.) ON OILSEED RAPE

CH. SVENSSON and C. LERENIUS
Swedish University of Agricultural Sciences
Department of Plant and Forest Protection
P.O. Box 7044, S-750 07 Uppsala SWEDEN

Summary

Verticillium wilt caused by *Verticillium dahliae* (Kleb.) is common in some oilseed rape growing areas in Sweden. Infected plants ripen prematurely and seed scattering can be considerable. In a small plot experiment, the effect of *V. dahliae* and its supposed interaction with beet cyst nematodes were investigated. *V. dahliae* reduced seed yield to 50% of that recovered from the control plot. The 1000-kw and oil content were also markedly reduced. The yield from plots with beet cyst nematodes were reduced by about 25%. No visible differences were detected between plants from the control and the nematode-infected plot. In the three experiments with various crop rotations, the numbers of plants infected by *V. dahliae* were recorded. Highest numbers were found after monoculturing oilseed rape. A break crop (barley) gave a lower frequency of infected plants. The inoculum of *V. dahliae* can survive on alternative hosts and also in the soil for many years as microsclerotia.

1.1 Introduction

Verticillium dahliae (Kleb.) is a common soil-borne pathogen in some oilseed crops growing areas in Sweden (1). The fungus infects the plant through the roots and grows upwards in the vessels. At the early stage of infection, the symptoms on the plant are difficult to separate from senescence. The symptoms are often visible only on one side or part of the plant. Infected plants loose leaves early, ripens prematurely and seed loss can be great. It is difficult, therefore, for the farmer to decide on the best time to harvest. The difference in ripening time between infected and healthy plants can be more than fourteen days.

In this paper results are presented (i) from a small plot experiment with winter oilseed rape, where the effect of *V. dahliae* and the interaction of *V. dahliae* and beet cyst nematode (*Heterodera schachtii*) was studied, (ii) from crop rotation experiments with spring sown oilseed rape. The benefit of break crops in lowering infection in oilseed rape crops is demonstrated.

1.2 Winter rape/Verticillium wilt/beet cyst nematode (*Heterodera schachtii*) - results from a small plot experiment

In the experiment the following treatments were included:

A. Untreated control
B. Beet cyst nematode (*Heterodera schachtii*)
C. *V. dahliae* (Kleb)
D. *V. dahliae* + beet cyst nematode

The experiment consisted of three randomized blocks. The size of each plot was 0.94 m^2. In each plot 3x15 plants (Jet Neuf) were planted. Before planting, the soil was inoculated with nematodes and *V. dahliae*-infected stalks (350 g per plot). The stalks were chopped into small pieces. The plots were separated by boards placed 15 cm below, and 40 cm above the soil surface. Wilted leaves collected before winter from all treatments were incubated in a humid chamber. Microsclerotia were only recovered from leaves from treatments C and D.

Throughout the growing season, the experiment was inspected weekly. Wilt symptoms, premature ripening and occurence of microsclerotia were recorded. The treatments C, D and A, B were harvested on July 26 and Aug 6, respectively.

Seed yield and seed weight were determined in each plot and oil content and chlorophyll (ppm) in each treatment. The stalk diameter (mm) and an assessment of the degree of wilt were determined for each plant.

1.3 Results and discussion

The results were analysed with Duncan's test (P = 0.05). Mean values followed by the same letter are not significant.

Table I. Effect of *Verticillium* wilt and beet cyst nematodes on winter oil seed rape. Duncan's test (P = 0.05).

Treatment	Seed yield (10% H_2O) Rel. no.	Crude fat yield Rel. no.	Oil content (% of dry w.)	Chlorophyll ppm	1000 kw Rel. no.
A Untreated	100 a (=320g/plot)	100 (=130g/plot)	45	15	100 a (=5.0g)
B Beet cyst nem.	78 b	78	45	14	98 a
C *V. dahliae*	56 c	52	42	23	76 b
D *V. dahliae* + beet cyst nem.	50 d	47	42	25	76 b

In this experiment the seed yield was reduced by about half in treatments involving *V. dahliae* (Table I). Negative effect were also found on both percent oil content and seed weight. The content of chlorophyll (ppm) was higher in treatments with *V. danliae*. The chlorophyll may be encapsulated in the seed during premature ripening. The stalk diameter was significantly reduced (Table II).

Table II. Effect of V. dahliae on diameter (mm) of plants' stalk. Duncan's test (P = 0.05).

All treatments	Relative stalk diameter (mm)
Healthy plants	100 a (=9.3 mm)
Lightly infected plants	95 b
Heavily infected plants	89 c

Table III. Percentage of plants infected by Verticillium at harvest. Duncan's test (P = 0.05).

Treatment	% of plants infected by Verticillium wilt			
	Healthy plants	Lightly infected plants	Heavily infected plants	Total infected plants
A Untreated	75 a	12 b	13 b	25 b
B Beet cyst nematode	70 a	15 b	15 b	30 b
C V. dahliae	4 b	41 a	55 b	96 a
D V. dahliae + beet cyst nematode	4 b	43 a	53 b	96 a

Even in treatments A and B some plants were infected by V. dahliae (Table III). The reason may be that small pieces of epidermis with microsclerotia fell onto these plots during inoculation of treatments C and D. Wilted leaves from the treated plots may also have dropped onto plots A and B during the summer, and infected some of the plants. The wilt symptoms in treatment A and B only became visible late in the season, and the infection was of minor importance compared to the early high infections in treatments C and D.

The nematode density was assessed twice during the experiment; once after incorporation into the soil and once after harvest. The number of nematodes was low. In spite of this, there was a clear negative effect on seed yield in treatment B. The question is whether the nematodes were so unevenly distributed in the soil that they were missed when soil samples were taken or whether the small number of nematodes could be the reason for the low seed yield in treatment B. No visible differences were observed between plants in treatment A and B during the growing season.

It is known that Brassica spp are good hosts for beet cyst nematodes. Investigations in Sweden have shown that oilseed rape probably are more negatively affected by nematodes than previously thought (2), (3). Interactions between nematodes and V. dahliae and their effects on oilseed rape are being investigated in another research program (4).

Seeds from this experiment are presently being tested for evidence of seed borne inoculum of V. dahliae. Preliminary results have shown that V. dahliae can be seed borne. Analysis of seeds from treatment C and D have revealed 5-10% infested kernels. Whether the seed borne inoculum can also produce infection in the field is now being tested.

2.1 Influence of break crops in crop rotation experiments on the percentage of plants infected in oilseed rape crops

In three crop rotation experiments (Department of Plant Husbandary) we monitored the growth of spring sown oilseed rape with respect to infections of V. dahliae. Two of the experiments were situated in fields known to contain Verticillium wilt, the third was not.

The results from the following three crop rotation program are presented here:

A. Oilseed rape, monoculture
C.1,2 Oilseed rape, every second year
D.1,2,3 Oilseed rape, every fifth year

The break crop is barley. All combinations are represented each year.

Table IV. Percentage plants infected by V. dahliae. (2x100 plants assessed per treatment.)

Exp. year	A	C1	C2	D1	D2	D3
Vreta kloster						
1982	ca 10		ca 10			
1983	11/10	11/2		10/5		
1984	46/63		45/33		13/17	
1985	52/52	39/32				20/10
Lönnstorp						
1983	6/6		8/14			
1984	77/66	20/31		24/25		
1985	87/77		46/46		35/40	

In the third crop rotation experiment we did not find any plants infected with V. dahliae. The very low infection level recorded during the first year might be an underestimation due to initial difficulties in recognizing the symptoms. The numbers of infected plants recorded in a particular year were higher in monoculture than after a break crop. In crop rotations C and D the levels were relatively constant, indicating survival of inoculum of V. dahliae for several years (Table IV).

3.1 Closing remarks

V. dahliae has been recognized as a serious pathogen in oilseed rape in Sweden since 1960. This paper is probably the first showing a reduction in both quantity and quality of the oilseed rape crop caused by the fungus V. dahliae.It is considered a "Swedish problem". In all other countries the fungus is reported as a pathogen of only minor importance.

From our point of view the Verticillium-complex needs much more research, including biology, epidemiology, damage threshold, chemical and/or biological control. There is, at present, no realistic way for farmers to control V. dahliae using fungicides. Farmers also need the oilseed rape as a break crop in their cereal rotations. Field surveys have shown that high numbers of infected oilseed rape were found even when there was 10 years between subsequent oilseed crops (1). How does the fungus survive? What role do other crops and weeds play for the survival and reproduction of the fungus? Luckily, in respect to controlling this pathogen, the plant breeders at the Plant Breeding Institute, Svalöv and Weibulls have produced promising lines with some resistance to this pathogen.

REFERENCES

1. BERG, G. 1984. Undersökning av rotskador i höstoljeväxter. (An investigation of root injuries in winter oil seed crops). Inst. för växt- och skogsskydd, Examensarbeten, Uppsala 1984:2, 32 pp (with english summary).

2. INSUNZA, V. & ERIKSSON, B. 1981. Betcystnematod/kransmögel/oljeväxter. Exempel på markbiologiska samspel. SLU Växtskyddsrapporter, Jordbruk, 16, 90-95.

3. PRESTE, P.S. 1982. Betcystnematoder (Heterodera schachtii) och oljeväxter (Brassica spp) - ömsesidig påverkan. SLU Inst. för växt- och skogsskydd, Examensarbeten, Uppsala 1982:5 (with english summary).

Pers. communication:

4. MAGNUSSON, C. Department of Plant and Forest Protection, Uppsala.

SCHWIERIGE DIAGNOSE BEI BEFALL VON RAPS MIT VERTICILLIUM DAHLIAE UND PHOMA LINGAM

W. KRÜGER
Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für Pflanzenschutz in Ackerbau und Grünland

Summary: Difficult diagnosis of symptoms caused by Verticillium dahliae and Phoma lingam on oil seed rape

As a report on this subject was published in RAPS (4, (1986), 14-19), only a brief summary is supplied here.

Due to the appearance of Phoma lingam (Tode) Desm. late in the season in 1985 and forming many pycnidia in the stalks above soil level and because of dark discoulorations of the stalks by this fungus, difficulties were probably encounterened with the identification of Verticillium dahliae Kleb., a fungus forming microsclerotia mainly at the end of the season. The dark discouloration of roots, due also to P. lingam infection may perhaps have even more contributed to further misunderstanding.

For an exact visual identification it is suggested to remove plants with their roots from the soil and inspect them with the help of a hand lense (or even a stereo-microscope). In some cases, plants may have to be cut length wise to look for microsclerotia inside the stalks. Generally the plants should be inspected at stage 87 (time of wind rowing), but from the point of view to have a survey on the general appearance of the fungus, a later date (at harvest) may be suitable, as microsclerotia may have increased during the last 10 days.

In der Zeitschrift RAPS (4. 1986, S. 14 - 19) wurde über die schwierige Diagnose und das Auftreten von Verticillium dahliae Kleb. in Schleswig-Holstein berichtet. An dieser Stelle soll daher nur eine Zusammenfassung der Ergebnisse erfolgen.

Im Jahre 1985 entwickelten sich spät in der Vegetationsperiode viele Pyknidien von Phoma lingam (Tode) Desm. im Stengelbereich, die dort dicht bei dicht lagerten. Außerdem waren die Stengel im Befallsbereich dunkel verfärbt. Weiterhin schaffte eine schwarze Verfärbung der Wurzeln Verwirrung, die sowohl nach Befall mit V. dahliae als auch nach P. lingam auftreten kann. Erneute Isolationen gaben Aufschluß darüber, daß, sofern in den dunklen Verfärbungen keine Mikrosklerotien vorhanden waren, fast nur P. lingam isoliert werden konnte. Waren in bestimmten Wurzelregionen jedoch Mikrosklerotien zu sehen, dann wurde V. dahliae aus den Befallsstellen isoliert. Pyknidien waren in den dunklen Wurzelabschnitten nicht zahlreich vorhanden. Dieses ist auf die Zerstörung der Rinde zurückzuführen, in der sich die Pyknidien befinden und die bei der späten Analyse bereits abgefallen waren (Abb. 1 - 3).

Eine regionale Befallserhebung zeigte, daß im Norden des Landes Schleswig-Holstein fast kein Befall vorlag, der zum Süden hin aber zunahm und maximal einen Befall von 29 % erreichte. Der Befallsgrad war bei diesem am stärksten befallenen Schlag mit 2,3 (Skala 1 - 9) jedoch noch als schwach zu bezeichnen.

Die Beurteilung des Befalls sollte an aus dem Bestand entnommenden Pflanzen und mit einer Lupe erfolgen, um P. lingam und V. dahliae besser trennen zu können. Im Zweifelsfall sollten die Pflanzen auch aufgeschnitten werden. Durch diese genaue Untersuchung wird der Anteil befallener Pflanzen wesentlich höher als nach visueller Beurteilung im stehenden Bestand, bei dem meistens nur die Mikrosklerotien im oberirdischen Bereich gesehen werden können. Außerdem ist es möglich, den Befallsgrad zu schätzen, der bei Sortenbeurteilungen wichtig sein könnte.

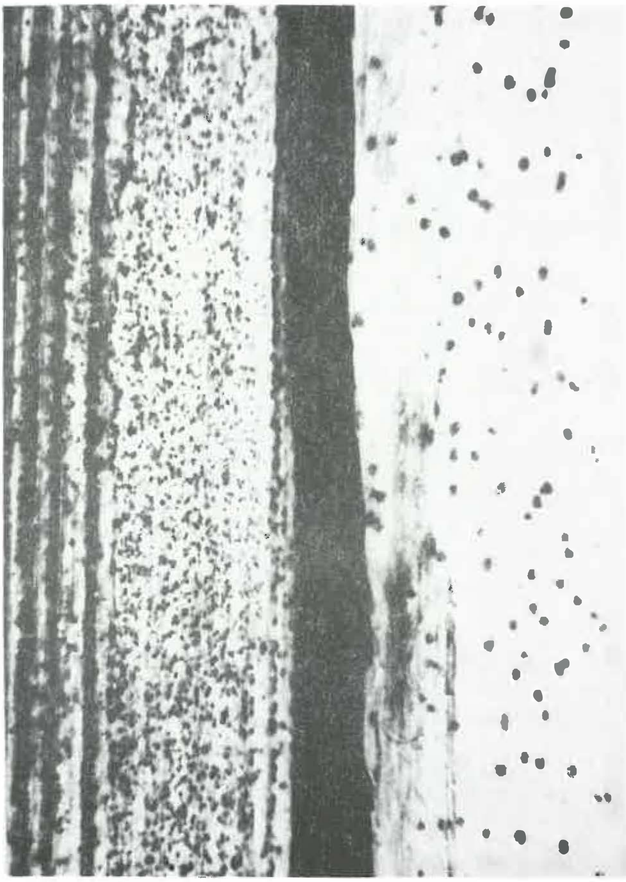


Abb. 1: Symptome der durch Verticillium dahliae (l) und Phoma lingam (r) hervorgerufenen Stengelfäule

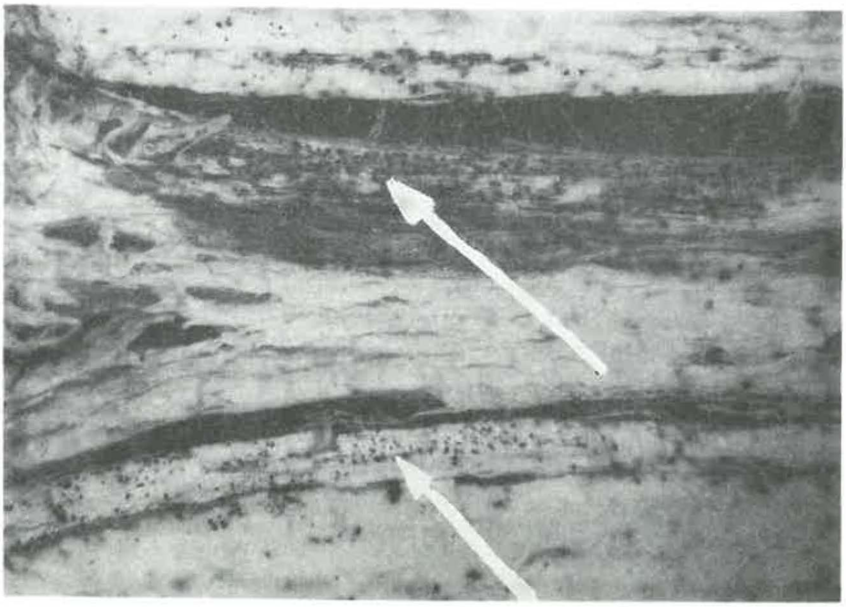


Abb. 2: Mikrosclerotien im Wurzelbereich

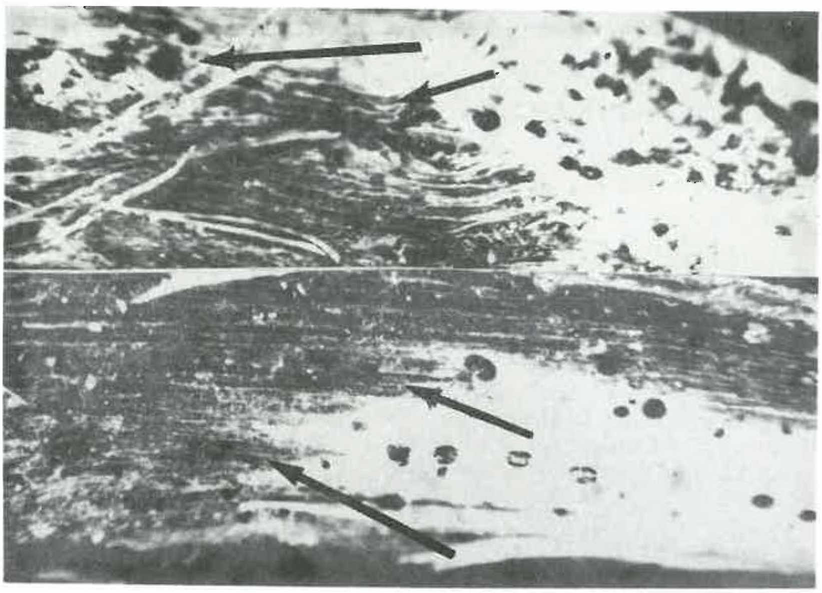


Abb. 3: Pyknidien von Phoma lingam im Wurzelbereich. Es sind Pyknidien im hellen und dunklen Bereich (Pfeil) zu sehen.

INVESTIGATION OF THE INFECTION OF WINTER OILSEED RAPE BY *PHOMA LINGAM*

V. H. Paul

Universität-GH-Paderborn, Fachbereich Landbau
Windmühlenweg 25, D 4770 Soest, Deutschland

Summary

The increases incidence of *Phoma lingam* (stat. gen. *Leptosphaeria maculans)* on rape cultivars free from erucic acid warrants the search for mor resistant cultivars.
In preparation for tests on disease resistance, the mode of infection of the root collar and stem rot pathogen was investigated. *P. lingam* entered stems of winter rape plants through stomata and fracture sites of fallen leaves. Direct penetration into the stems did not occur. After infection *P. lingam* hyphae developed first intercellularly and than intracellulary. The cortex, phloem, xylem and pith of the rape stem were all infected by the pathogen.

1.1 Introduction

The main reason for the increased incidence of root collar and stem rot in oilseed rape crops is the increase in cultivation of winter rape cultivars free from erucic acid. The disease is caused by *Phoma lingam* (Tode ex. Fr.) Desm. (state gen. *Leptosphaeria maculans* (Desm.) Ces. et de Not.) Although many papers have been published on measures for controlling *P. lingam* on rape (2, 3, 4, 5, 6, 8) little is known about the pathogens mode of infection (1, 7). The aim of this investigation was, to demonstrate how *P. lingam* infects winter oilseed rape.

1.2 Materials and Methods

Rape (cv. Jet Neuf) plants infected by *P. lingam* were studied at the six-leaf stage (EC 23) at the beginning of flowering (EC 61) and at maturity (EC 81).
At such times parts of the hypo- and epicotyl were specially prepared for histological and cytological investigations.
The stem specimens were examinend both with a light microscope (Leitz Orthoplan) and a scanning electron microscope (Hitachi H - 300). Photographs were taken, either with a Leitz camera (Orthomat W), or a Mamiya camera (RB 67 Professional S).

1.3 Results

P. lingam enters into rape plants either through stomata (Fig. 1 b, 1 c and 2 a) or via fracture sites of fallen leaves. Direct penetration through the surface of the stem was not observed.

After infection, the hyphae of *P. lingam* initially move intercellularly through the epidermis and the interior layers of the cortex (Fig. 2 b). Subsequently the hyphae actually penetrate into cells (Fig. 2 b and c) causing initially single cell necroses and later tissue necroses. At this stage many hyphae of *P. lingam* can be found in the infested (Fig. 3 a) cells. The pathogen eventually infects the cortex, the phloem, the xylem and the pith of the plants (Fig. 3 b).

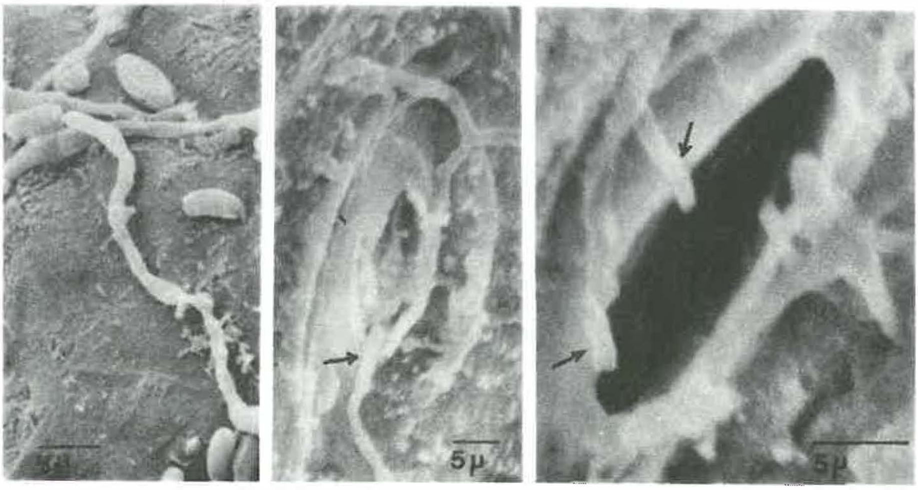


Fig. 1 a   Fig. 1 b   Fig. 1 c

Conidia of *P. lingam* on the surface of a stem of winter rape. Some of the conidia have germinated and show the long germ tubes that seek a stoma (Fig. 1 a). Single hyphae have reached a stoma (Fig. 1 b, arrow) and can be seen entering (Fig. 1 c).

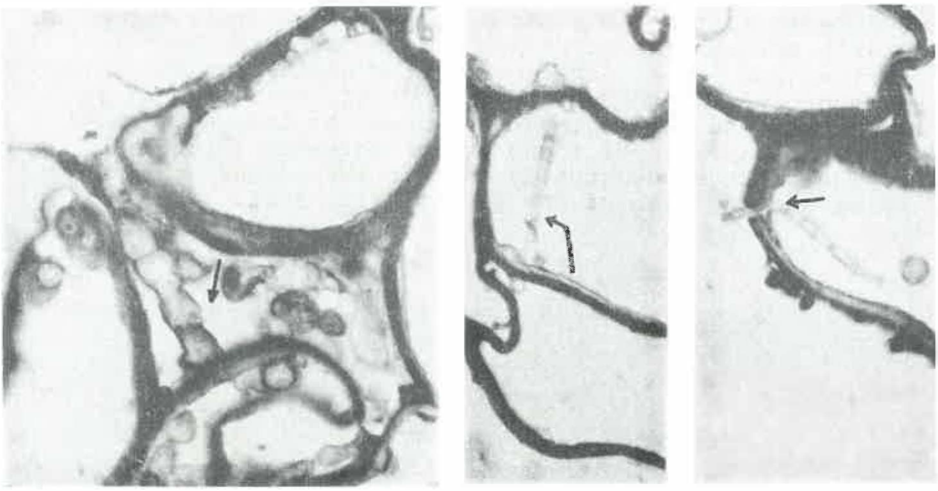


Fig. 2 a X 200 Fig. 2 b X 1100 Fig.2 c X 1100

A penetration hypha (arrow) of *P. lingam* has passed the stoma and reached the substomatal chamber (Fig. 2 a). A hypha has changed from moving intercellularly (arrow) in the cortex and can be seen penetrating a host cell (Fig. 2 b). *P. lingam* penetrating from one cortex cell to another (Fig. 2 c, arrow).

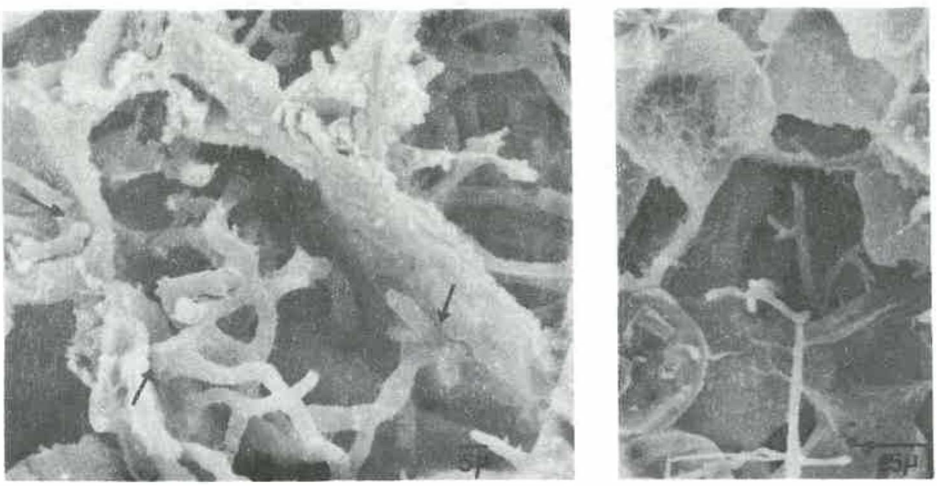


Fig. 3 a Fig. 2 b

Mycelium of *P. lingam* in the cortex of rape. Single hyphae can be seen (arrows) piercing the cell walls of the host (Fig. 3 a) Intercellular mycelia can be seen in the pith (Fig. 3 b).

References

1. ABADIE, M. and BOUDART, G. (1982). Etudes cytologique et ultrastructurale de la necrose des crucifères due à *Leptosphaeria maculans*, forme conidienne *Phoma lingam*. Annales des Sciences Naturelles. Botanique et biologique végétale, Paris 13, (4), 53 - 72.

2. BARBETTI, M. J. (1975). Benomyl and carbendazim fail to provide effective control of blackleg in rape. *(Leptosphaeria maculans)* on Brassica campestris and B. napus). Aust.Plant Path. Soc. Newsletter 4 (2), 11 - 12.

3. BROWN, A. G. P., BARBETTI, M. J. and WOOD, P. M. (1976) Effect of benomyl on 'blackleg' disease of rape in Western Australia. Aust. J. Exp. Agric. and Animal Husb. 16 (79), 276 - 279.

4. GLADDERS, P. and MUSA, T. M. (1979). The development of *Leptosphaeria maculans* in winter oilseed rape and its implications for disease control. Proc. Brit. Crop. Conf.- Pests and Diseases 1979, 129 - 136.

5. KRÜGER, W. (1982). Die Wurzelhals- und Stengelfäule des Rapses, verursacht durch *Phoma lingam* (stat. gen. *Leptosphaeria maculans)*, eine schwer bekämpfbare Krankheit. Z. für Pflanzenkrankheiten und Pflanzenschutz 89,498-507.

6. KRÜGER, W. (1983). Bekämpfung von Rapskrankheiten 1. Verringerung des Befalls mit *Phoma lingam* und Methoden zur Bestimmung der Anfälligkeit von Sorten. Phytopath. Z. 108, 106 - 113.

7. PAUL, V. H. (1985): Mecanisms of Penetration and Development of *Phoma lingam* in Oil Rape. XXXVII International Symposium on Crop Protection Gent. Summeries of the Papers, 71.

8. WITTEN, I. (1984). Untersuchungen zur Erfassung der Resistenz von Winterraps (Brassica napus L. var. oleifera Metzger) gegenüber *Phoma lingam* (Tode ex. Fr.) Desm. und zu der durch den Erreger verursachten Wurzelhals- und Stengelfäule. Diss. Georg-August-Universität Göttingen, 149 S.

The author thanks Dr. G. Masuch and Mr. U. Niemann from the Fachbereich Naturwissenschaften II - Biologie for technical assistance.

EINJÄHRIGE ERGEBNISSE ÜBER DIE INTERAKTION ZWISCHEN BESIEDLUNG DES RAPSES MIT LARVEN VON PSYLLIODES CHRYSOCEPHALA UND BEFALL MIT PHOMA LINGAM

W. KRÜGER
Biologische Bundesanstalt für Land und Forstwirtschaft, Institut für Pflanzenschutz in Ackerbau und Grünland, Braunschweig

Summary

An experiment was carried out with 10 cultivars and sprayed and non sprayed plots against the Cabbage stem flea beetle (Psylliodes chrysocephala L.) generally the infestation of rape with P. chrysocephala was slight but reduced after control measures. The degree of infection of rape with Phoma lingam (Tode) Desm. in non sprayed plots resulted in no significant increase. The experiment has to be carried out again under heavier infestation pressure with P. chrysocephala.

1.1 Einleitung

Der vor mehreren Jahren beobachtete stärkere Befall von Raps mit Phoma lingam, nachdem Larven von Psylliodes chrysocephala die Pflanzen besiedelt hatten (1), wurden mit Sorten durchgeführt, deren Befallsniveau wesentlich höher lag als es bei den zur Zeit verwendeten der Fall ist. Es wurde daher ein Versuch mit neuen Sorten angelegt.

1.2 Methoden

Die Sorten wurden zufällig verteilt in 8 Blöcken angelegt, von denen 4 mit dem Insektizid E 605 behandelt worden sind und zwar 3 mal im Verlauf der Vegetationsperiode am 28. 9. (580 ml/ha), am 4. 10. (210 ml/ha) und am 5. 11. 1984 (210 ml/ha). Beurteilt wurde zur Zeit des Schwadlegens, das ist Stadium 85. Die Stengel wurden aufgeschnitten und a. auf Befall mit Phoma lingam und b. auf die Anwesenheit von Fraßgängen nach einer Skala 1 - 9 beurteilt. Je Sorte und Wiederholung sind 30 Pflanzen untersucht worden. Der mittlere Befallsgrad für jede Sorte wurde für die statistische Verrechnung verwendet. Da es sich um einen einjährigen Versuch handelt, werden die Namen der Sorten nicht angeführt.

1.3 Ergebnisse

Die Ergebnisse sind in der Tabelle 1 zusammengestellt. Wie aus den Daten ersichtlich, war bei der geringen Besiedlung mit Rapserdflohlarven, die in den behandelten Parzellen einen Befallsgrad von 1,7 und in der nächst-behandelten Parzelle einen von 2,5 hatten, der Befall mit Phoma lingam kaum erhöht worden. Sortenunterschiede waren wohl allgemein, nicht aber auf Grund des etwas höheren Befalls mit Larven des Rapserdflohes (Interaktion) vorhanden. Die Versuche müssen bei stärkerem Befallsdruck fortgesetzt werden.

Tabelle I: Befall von Rapssorten mit Phoma lingam nach Besiedlung der Stengel mit Rapserdflohlarven

Sorte	Phoma-Befall (1 - 9) Behandlung gegen Erdfloh			Besiedlung mit Rapserdflohlarven (1-9) Behandlung gegen Erdfloh		
	ja	nein	$\bar{x}$	ja	nein	$\bar{x}$
A	4,0	4,5	4,3 o	2,5	2,8	2,7
B	3,7	3,5	3,6++	1,7	2,1	1,9
C	4,1	4,1	4,1 o	1,9	2,3	2,1
D	4,5	4,2	4,4-	1,6	2,6	2,1
E	3,8	3,6	3,7+	1,6	2,7	2,2
F	4,4	4,8	4,6=	1,3	2,9	2,1
G	3,7	4,5	4,1 o	1,7	2,6	2,1
H	4,0	4,5	4,3 o	1,2	2,8	2,0
J	3,8	4,3	4,1 o	1,8	2,3	2,1
K	3,8	3,7	3,8+	1,3	1,9	1,6
$\bar{x}$	4,0	4,2	4,1	1,7++	2,5=	2,1

Bemerkungen: ++, +, o, -, = sind Beurteilungssymbole (2)

REFERENCES

1. KRÜGER, W. (1982): Die Wurzelhals- und Stengelfäule des Rapses, verursacht durch Phoma lingam (stat. gen. Leptosphaeria maculans) , eine schwer bekämpfbare Krankheit. Z. Pflanzenkrh. Pflanzensch. 89, 498 - 507.

2. KRÜGER, W. (1983): Bekämpfung von Rapskrankheiten I. Verringerung des Befalls mit Phoma lingam bei Raps und Methoden zur Bestimmung der Anfälligkeit von Sorten. Phytopath. Z. 108, 106 - 113.

DISPOSITIF EXPERIMENTAL MIS EN PLACE POUR L'ETUDE DE LA CONDUITE DU COLZA D'HIVER

E. CHOPPIN de JANVRY - A. POUZET

CETIOM, 174, Avenue Victor Hugo, 75116 - PARIS

PRINCIPES

La plupart des travaux et essais menés jusqu'à présent sur le colza d'hiver cherchaient à étudier et à caractériser un problème précis, un facteur unique et à analyser son influence dans des milieux divers.

Le dispositif mis en place par le CETIOM est d'une conception totalement différente ; il s'agit de cerner, dans des conditions bien déterminées, l'influence de chaque technique et des successions de techniques constituant des itinéraires sur le rendement du colza.

Pour cela, on opère une combinaison des différentes techniques culturales envisageables, en tenant compte des types variétaux, des conditions pédo-climatiques, des contraintes ressenties, exprimées ou diagnostiquées par les producteurs. S'y ajoutent des analyses permettant de caractériser le plus finement possible le milieu (analyses de sol, recueil de données climatiques précises grâce à une station météo automatique placée sur le dispositif...).

LOCALISATION

A l'automne 1984, nous avons mis en place trois essais : dans la Meurthe et Moselle, le Cher et l'Indre ; ceci en parallèle avec nos collègues de ROTHAMSTED (Grande-Bretagne), avec qui nous avions confronté nos conceptions, et prévu, d'échanger nos résultats et de discuter nos méthodes dans un excellent esprit de coopération stimulant et enrichissant. La conception du dispositif et le traitement des résultats sont effectués en collaboration très étroite avec le Laboratoire de Biométrie de l'Université Claude Bernard de LYON.

DISPOSITIF ET TRAITEMENTS

Le dispositif ne comprend qu'une parcelle par itinéraire technique, aussi, les essais sont-ils placés dans une zone homogène et l'on peut disposer les parcelles en fonction des contraintes propres à chaque situation : largeurs de travail, nécessité d'irriguer un secteur, type de matériel disponible...

On cherche à regrouper les traitements identiques de façon à limiter les interactions entre parcelles. Il n'y a pas de répétition dans le dispositif mais des parcelles témoins sont incorporées pour mieux caractériser l'influence de l'environnement sur la culture. L'analyse statistique est d'un type particulier dite "écologique".

L'ensemble d'un essai regroupe environ un hectare avec un centaine de parcelles. Chaque parcelle mesure 4 à 5 mètres de large sur 30 à 40 mètres de long + une partie de 10 mètres de long pour les observations. Le précédent est une céréale : orge ou blé.

Les traitements qui entrent en combinaison sont :

- A l'automne

. Les variétés : Bienvenu et une variété à basse teneur en glucosinolates (Darmor).

. Deux dates de semis : plutôt précoce et plutôt tardif.

. L'azote à l'automne : 80 unités pour les parcelles du premier semis et 40 unités pour le second semis dans la zone Centre. Dans l'Est, on garde des parcelles sans azote.

Pour ce qui est du semis, il est effectué au semoir de précision (70 à 80 graines au m2) avec des graines traitées fongicides. La protection insecticide d'automne est faite sur tout le dispositif avec du Curater à 15 kg/ha, le désherbage de pré-semis avec éventuellement antigraminées de post-levée sur toutes les parcelles. On n'applique pas de fongicide à l'automne.

- Au printemps

. Traitement insecticide sur une moitié des parcelles, l'autre ne recevant rien. On appliquera, en respectant les seuils d'intervention préconisés par le CETIOM :

.. du Decis contre *Ceuthorrhynchus napi*, méligèthes et *Ceuthorrhynchus assimilis*,

.. du Pirimor contre les pucerons.

. La fertilisation minérale de printemps : niveau faible (160 N+30 S) et niveau faible (220 N+50 S) en deux apports.

. Fertilisation tardive : deux conduites, un niveau sans apport tardif et un niveau avec apport de (60N+20S) entre les stades E et F1.

. Régulateur de croissance : deux traitements avec ou sans régulateur.

. Fongicide : protection complète (un traitement Sclerotinia + Cylindrosporiose et un traitement Alternaria), comparée à une absence de protection fongicide.

. Irrigation : concerne uniquement l'implantation dans l'Indre. On considèrera un niveau sans irrigation et un niveau avec une ou deux irrigations selon les conditions climatiques (la première entre le stade E - F1 et la seconde fin floraison). Chaque irrigation visera à recombler les réserves du sol.

Bien entendu, toutes les combinaisons ne sont pas étudiées (cela ferait 2^9 , soit plus de 500 combinaisons), mais les plus importantes pour la zone considérée ont été conservées.

MESURES ET CONTROLES

Ceux-ci sont très nombreux de façon à bien suivre le développement de la plante et l'état du milieu tout au long de la culture.

En particulier, on peut indiquer :

- Analyses de sols très précises pour contrôler l'homogénéité du dispositif.

- Données climatiques journalières à proximité de l'essai : pluie, températures mini et maxi, rayonnement et humidité de l'air.

- Peuplement à la levée, à l'entrée de l'hiver, à la reprise de végétation et à la récolte.

- A l'entrée de l'hiver, puis au rythme de deux prélèvements par mois de la reprise de végétation à l'entrée de l'hiver, on notera l'état sanitaire, le diamètre au collet, et le poids sec des différents organes sur certaines parcelles ; des prélèvements de sol seront également effectués pour le dosage de l'azote minéral.

- Récolte mécanique de toutes les parcelles après détermination des composantes du rendement et appréciation de l'état sanitaire.

Toutes ces différentes mesures sont effectuées sur des placettes de 2 mètres linéaires, prélevées dans la partie réservée aux observations. Une analyse économique des différents itinéraires est également réalisée.

PREMIERS RESULTATS

L'ensemble des résultats est encore en cours d'analyse et n'aura de vraie signification qu'après avoir réuni plusieurs années d'observations.

Si nous prenons, en 1985, le dispositif de l'Indre on peut néanmoins indiquer que l'apport d'azote au printemps n'a eu aucun effet sur Darmor, par contre, il permet une vigueur plus importante en sur Bienvenu.

D'une façon générale, on s'aperçoit que ces deux variétés doivent avoir un mode de conduite très différent : Bienvenu "répond" aux traitements de début de printemps (fertilisation azotée) alors que Darmor "répond" surtout aux traitements de fin de cycle (fongicide avec azote tardif, irrigation...). Cette différence de comportement est illustrée par l'indice de récolte (rendement en graines par rapport à la quantité de matière sèche maximum accumulée) ; l'indice est de 0,45 pour Bienvenu et de 0,35 pour Darmor.

CONCLUSIONS ET PERSPECTIVES

Ces essais seront poursuivis sur au moins trois ans et devraient fournir un nombre considérable de données qu'il sera intéressant de confronter avec les résultats de nos collègues britanniques et peut être d'autres pays européens intéressés par la culture du colza.

La comparaison de ces itinéraires permettra de déduire pour les producteurs des modes de conduite de la culture bien adaptés techniquement et économiquement.

MULTIDISCIPLINARY, MULTIFACTORIAL TRIALS ON WINTER OILSEED RAPE: PEST AND DISEASE FACTORS LIMITING YIELD IN 1984-85.

C. J. RAWLINSON
Rothamsted Experimental Station, Harpenden, Herts. U.K.

Summary

Factors affecting the yield of winter oilseed rape are being studied by a multidisciplinary research team at Rothamsted. The effects of several main inputs into a crop production system are being compared separately and in combination in multifactorial field trials. The purpose is to identify and measure those factors and their interactions that affect yield and can be manipulated by the farmer. Studies on pests and diseases are integrated with research on agronomy, microbiology, nutrition and physiology. The aim is to provide information whereby the likely benefits of each input can be assessed singly and in combination, to ensure their efficient and effective use to best meet the demands of a chosen cropping system.

Results from the first trial, completed in 1985, showed that the advantage of better growth and increased leaf area from early sowing (16 August) rather than later sowing (6 September) was counteracted by smaller plant populations, much increased damage by larvae of *Psylliodes chrysocephala* and increased incidence of diseases. Yield was increased by later sowing, autumn insecticide and spring + summer application of fungicides, although the interpretation of yield responses to treatment combinations was complicated by a late harvest under wet conditions with much shedding of seed.

1.1 Introduction

The International Organisation for Biological Control (IOBC) recently emphasised the need to broaden its activities to include more work on plant pathogens. IOBC has also begun to examine programmes of research where integrated pest management practices are studied as part of crop production systems. The activities of a multidisciplinary team at Rothamsted, working on factors limiting yield of oilseed rape, contribute to these IOBC objectives. This paper summarises the origin of the team approach and presents selected data from the first year of work on a series of large multifactorial field trials.

Personal research on the pathology of oilseed rape over the past decade led to the conviction that there should be close collaboration between pathology and other disciplines. Information on the incidence and severity of disease regressed against yield (7) indicated the end result of infection, but contributed little to an understanding of the mechanisms involved in yield loss. Crops respond to natural complexes of many environmental, agricultural and management inputs and detailed information is required to adequately interpret the data. Later experiments (8) emphasised the value of measurements of crop growth (e.g. leaf area index, leaf number, crop growth rate, height, flowering time, pod and branch number) and plant density to an understanding of the effects of disease and fungicides. These measurements revealed the effects of controlling disease more clearly than assessments based solely on randomly selected plants or subjective visual estimates. Other work examining the effect on disease of growth regulators (6), some of which could increase the effect of splash dispersed pathogens by shortening plants and altering crop microclimate or by allowing greater use of nitrogen, also required measurements of crop growth to quantify plant development in relation to disease progress. These considerations, and an awareness of the importance of certain pest/pathogen interactions (3) and pathogen/crop nutrition interactions, indicated a need for close liaison between the disciplines of pathology, entomology, crop physiology and nutrition.

Concurrent with the work on diseases other research was done at Rothamsted on rape pollination, insect pests, insecticide toxicity to bees and beneficial insects, fertilizers and nitrification inhibitors, nematodes, and suitability of soil type; much was done in separate independent experiments. The value of independent enquiries can sometimes be limited by ignorance of, or inability to measure, crop responses to factors outside the competence of one discipline. This can restrict understanding and the useful application of results to current agricultural practice. This realisation, and because much research on rape done elsewhere had concentrated on selected problems of interest to single scientific disciplines, led to the formation of a multi-disciplinary team. Our research aims to investigate and understand factors limiting the achievement of full yield potential by across-discipline collaboration in multifactorial field trials. The methodology for such an approach had already been established on cereals (2,4). It was judged to be even more necessary for rape because of the relatively recent expansion in crop area in Britain and consequent lack of integrated knowledge about its responses to limiting factors. The merits of a co-ordinated approach to research were further emphasised by the heterogeneity of the crop and its ability to compensate for some types of damage.

There is a need to identify, define and rank the importance of insect pest, nematode and disease constraints to rape yield so that they may be avoided, manipulated or controlled efficiently. From a co-ordinated study of the effects of individual crop treatments, combinations of treatments, and natural limiting factors we hope to determine whether such effects are additive, synergistic or interactive. This should enable not only a thorough evaluation of the factors influencing yield but also a better understanding of inter-relationships between pests, pathogens, their host plant and current agricultural practices. Information and understanding derived from this team-study is needed by growers to know whether and when to use inputs under different production systems. For research workers this approach should also give greater insight into problems beyond the specialist interests of individuals and make them better able to meet future challenges arising from changes in the status of certain pests and diseases, new cultivars and agrochemicals or new growing systems.

1.2 Experimental design, treatments and measurements

The series of experiments was begun on cv. Bienvenu winter oilseed rape which followed winter barley on a deep flinty loam. The seven treatments shown in Table I were tested in factorial combinations in a half replicate design of 2^7 on 64 plots. Thirty-two extra plots were included to test;

a) an extended range of nitrogen applications up to 325 kg/ha
b) no treatments other than seedbed nitrogen
c) a seedbed nematicide (5 kg/ha oxamyl)
d) for detailed physiological studies
e) for root growth measurements
f) for nitrogen uptake and post-harvest residues using ^{15}N.

The total of 96 plots, each 3 x 17m (with 3 x 6.7m sampling area and 3 x 9.7m yield area per plot), covered 0.8 ha set within 6.7 ha also sown with rape. Basal treatments were straw burning and paraquat after winter barley, shallow cultivation, 50 kg/ha nitrogen to the seedbed, 8 kg/ha seed rate, 17 cm row width row width and 'Matri-kerb' herbicide on 30 October 1984. The experiment was netted from 5 December to 3 April to prevent pigeon damage. Diquat desiccant was applied on 25 July and plots combine harvested on 12 August 1985.

The disciplines involved in the experiment were agronomy, entomology, microbiology, nematology, nutrition, pathology, physiology, root studies, soil physics and statistics.

Measurements made included emergence and establishment counts, dry matter, leaf area, growth stage, plant structure and development, detailed growth analysis, light interception and quality, soil water, nitrogen analyses of dry matter samples and frequent petiole nitrate tests on selected plants, nitrogen uptake and loss on root study and ^{15}N plots, root growth quantity and distribution in relation to nutrient uptake, development and identification of leaf surface and seed microflora in relation to spray treatments, pest and disease assessments, soil nematode infestation, components of yield, total yield and oil content of seed. Weather and crop microclimate were monitored and daily records stored on computer file. After harvest, plots given ^{15}N were marked and succeeding crops will be monitored to measure the residual value to these crops of nitrogen applied to rape. Further details of the experiment are recorded elsewhere (5,9,10) and will be published fully at a later date.

1.3. Main features of crop growth, treatment effects, pests and diseases.

Many data from the experiment still await processing; some are presented elsewhere (9,10) but most must await full interpretation until seen in the context of further results from future work. Nevertheless, in 1984-85 it was clear that sowing date and attack by cabbage stem flea beetle (*Psylliodes chrysocephala*) had most effect on crop growth and yield.

Despite emergence within 7 days, early-sown (E) plots established fewer plants than later-sown (L) plots and this difference was maintained up to maturity when L plots had nearly twice the number of plants (45 v. 87 plants/m²). Rapid early growth on E plots produced a much more dense leaf canopy than on L during autumn (2.7 v. 1.1 leaf area index in November). However, E plots were much more severely damaged than L by adults and larvae of *P. chrysocephala* (98 v. 37% plants damaged, 76 v. 12% petioles damaged, 11.5 v. 0.8 larvae/plant in March where no autumn insecticide had been applied). Autumn insecticide gave good control of larval damage, decreasing the numbers of plants and petioles damaged and on L plots to 3%, 1% and 0 respectively. Autumn insecticide on E plots maintained greater plant population, dry matter and leaf area up to maturity. More plants and leaf area was lost from E than from L plots during the winter, when temperatures reached -18°C. Autumn insecticide decreased the incidence of beet western yellows virus (BWYV), presumably by control of the vector *Myzus persicae*, and decreased the incidence of *Botrytis cinerea* on stems, presumably by lessening the damage to tissues by exit holes of *P. chrysocephala* larvae. On untreated plots (both E and L) mean incidence of BWYV was 60% and *B. cinerea* 22%; incidence of both diseases was decreased to 7% by autumn insecticide.

During April and early-May the growth stage of E plots was more advanced than L, and plots given autumn insecticide more advanced than those untreated. However, subsequently after a period of rapid growth, L plots soon equalled E in development and had greater leaf area. Canopy structure in E plots was distinctly different from L; the fewer plants in E plots developed many more branches than those in L (10.0 v. 4.7/plant on 30 April). More branches developed later in L plots and by June these had 15% more fertile pods per unit area and by July 15% greater pod dry weight per unit area than E plots.

Insect pests were few during flowering and maturation. The numbers of *Meligethes aeneus* did not exceed 0.3 per plant, *Ceutorhynchus assimilis* and *Dasineura brassicae* were rare. Thus pest numbers were well below the threshold levels which would have justified the use of summer insecticide in this experiment.

Oxamyl applied to the seedbed decreased numbers of *Pratylenchus* (mainly *P. neglectus* with a few *P. thornei*) in May (7 v. 16/g of root, 4680 v. 9200/l of soil). Total ectoparasite nematode numbers were also decreased (11800 v. 22440/l of soil). Although the population densities in soil were considerable, no species was present in numbers likely to cause damage in the wet summer of 1985. In addition to controlling nematodes oxamyl also decreased the number of *P. chrysocephala* larvae in plants from 29 to 6 larvae/100 petioles and decreased the percentage of petioles damaged from 26 to 11%. Oxamyl did not significantly affect combine harvested yield (untreated plots 3.81 and oxamyl plots 3.67 t/ha).

Fungal diseases were never severe during the season, but incidence was always greater on E than on L plots except for *Pyrenopeziza brassicae* which after April was more prevalent on leaves in L plots (Table II). It was noteworthy that incidence of BWYV was fourfold greater on E than on L plots, possibly because of the earlier emergence and greater leaf area on these plots in autumn attracting larger numbers of aphid vectors. All diseases except *Peronospora parasitica* were lessened in autumn by seed treatment with fenpropimorph. Prochloraz applied in autumn or in spring decreased the incidence of *P. brassicae* and *Leptosphaeria maculans* (Table III). The incidence and severity of both diseases was least on plots given sprays on both occasions (Table IV); the greatest contribution to control was from the autumn spray. A few plants (< 0.1%), scattered throughout the experiment, were infected with *Sclerotinia sclerotiorum* initial inoculum of which was thought to come from susceptible weeds because, prior to the rape, the site had grown cereals continuously for 20 years. *Alternaria* lesions were very few on pods in July (< 0.1% pod area infected on only 6 of 96 plots). Seeds were colonized by *Alternaria* spp. and to a lesser extent by *Cladosporium* sp. when they were almost mature but not before. Iprodione applied on 17 June had little permanent effect on the superficial microflora of the pods or on seed infection.

1.4 Yield at maturity and at combine harvest

Strong winds and much rain during the interval between crop desiccation on 25 July and combine harvesting on 12 August caused much seed to be shed. Table I therefore gives yields obtained from a hand harvest (0.85 m^2 per plot, 3.7% of the combine harvest area) on 22 July before shedding started as well as combine harvest yields so that treatment effects may be compared. These data show a mean loss of 1.3 t/ha from shedding, greatest on E plots and on those plots given treatments which advanced crop development and hastened maturity (deltamethrin, spring nitrogen @ 175 kg/ha, spring prochloraz, ethephon). Consequently even the large benefit from insecticides (0.96 t/ha) and from spring + summer fungicides (0.58 t/ha) was lost by the later harvest date. Both sets of data showed the significant benefit from the later sowing date (0.76 and 0.65 t/ha from hand and combine harvest respectively). Table V shows the components of yield which contributed to these benefits.

The effects from controlling *P. chrysocephala* were greatest on E plots where by 22 July deltamethrin had increased dry matter from 1390 to 1600 g/m^2, number of plants from 36 to 55/m^2, number of fertile pods from 4548 to 6699/m^2, harvest index from 26.2 to 32.1 and increased hand harvest yield by 1.60 t/ha. By comparison the hand harvest yield benefit from deltamethrin on L plots was 0.32 t/ha.

Greatest hand harvest yield benefits from combinations of treatments were : a, spring + summer fungicide on either E plots (0.88 t/ha), or those given a single application of spring nitrogen (0.88 t/ha), or a high rate of nitrogen @ 275 kg/ha (0.67 t/ha), or those previously sprayed with autumn fungicide (0.69 t/ha); b, high rate of nitrogen on L plots (0.74 t/ha); c, growth regulator on L plots (0.60 t/ha).

Combine harvested yields on single plots ranged from 2.68 to 5.27 t/ha and the two plots sown early or later without further treatments yielded 2.71 and 3.27 t/ha respectively. E and L plots used to test response to rates of spring nitrogen (all plots had been given full pest and disease control and growth regulator) showed optimum yield response at 225 kg N/ha. Combine yields at this rate of nitrogen on E and L plots were 3.76 and 4.50 t/ha respectively. There was no yield benefit from further increases in nitrogen up to 325 kg/ha. This may have been because prior to sowing the soil already contained much nitrogen, estimated at 90 kg N/ha. Approximately 50% of ^{15}N-labelled ammonium nitrate applied at 254 kg N/ha to plots in spring was recovered in crop residues and soil after harvest.

1.5 Modifications to future multidisciplinary trials

The choice of cultivar and treatments used in 1984-5 reflected a compromise between research and farmers' needs, short and long term objectives, practicality and resources. It was anticipated that, where appropriate, the results from other independent research on rape at Rothamsted (5) or elsewhere would be used to complement or modify future multidisciplinary trials. Conversely, any important interaction revealed in multidisciplinary work should be the subject of further independent study. As the research programme continues the range and justification for treatments should be validated or questioned.

Table I. Treatments tested and their effects on yield of Bienvenu winter oilseed rape. Yields meaned over all other treatments and for treatments 2-7 analysed to show response on early and later sown crops.

(Hand harvest yields from 0.85m² per plot on 22 July, combine yields on 12 August).

	Yield (t/ha at 90% D.M.)			
Harvested by	Hand	Combine	Combine	
			Sown 16 Aug.	Sown 6 Sept.
1. Sowing date				
16 August	4.87	3.63	-	-
6 September	5.63	4.28	-	-
2. Spring nitrogen rate (kg N/ha)				
175	5.00	3.94	3.69	4.18
275	5.50	3.97	3.57	4.38
3. Spring nitrogen timing				
All on 25 February	5.27	3.97	3.72	4.23
1/3 on 25 February + 2/3 on 25 March	5.23	3.94	3.54	4.34
4. Insecticide *				
Without	4.77	3.93	3.64	4.23
With	5.73	3.97	3.62	4.33
5. Autumn fungicide **				
Without	5.22	3.96	3.66	4.26
With	5.28	3.95	3.60	4.30
6. Spring & summer fungicide ***				
Without	4.96	3.95	3.64	4.27
With	5.54	3.95	3.62	4.29
7. Growth regulator ****				
Without	5.19	4.03	3.87	4.19
With	5.31	3.88	3.38	4.37
(SED)	(0.269)	(0.065)	(0.092)	(0.092)

* Deltamethrin as 'Decis' on 4 October and 28 November plus triazophos as 'Hostathion' on 17 June.

** Fenpropimorph seed dressing and prochloraz as 'Sportak' on 26 November.

*** Prochloraz as 'Sportak' on 4 April plus iprodione as 'Rovral Flo' on 17 June.

**** Ethephon as 'Cerone' on 23 May to early sown and 29 May to late sown

Table II. Influence of sowing date (meaned over all other treatments) on incidence of disease

Date	Diseases	% plants (% leaves) infected: Early sown 16 August	% plants (% leaves) infected: Later sown 6 September
12 November	*Peronospora parasitica*	86* (21*)	71 (17)
	Botrytis cinerea	34 (7)	24 (5)
	Alternaria spp.	4 (0.5)	2 (0.3)
31 January	*Pyrenopeziza brassicae*	7* (2*)	1 (0.2)
26 February	*Pyrenopeziza brassicae*	7* (1*)	1 (0.2)
22 April	*Pyrenopeziza brassicae*	28 (5)	21 (4)
	Leptosphaeria maculans (leaf spot)	17* (2*)	2 (0.1)
	Peronospora parasitica	100 (26*)	100 (19)
11 June	*Peronospora parasitica*	39* (18*)	12 (3)
	Pyrenopeziza brassicae	34 (6*)	45 (10)
	Beet western yellows virus	44	11
	Botrytis cinerea (on stems)	21*	8
	Leptosphaeria maculans (on stems)	13*	4
17 July	*Pyrenopeziza brassicae* (% pod area infected)	1.3	0.7

(* indicates values significantly greater than corresponding values on later-sown plots at P< 0.05)

Table III. Effect of fungicides (meaned over all other treatments) on incidence of disease

Date	Disease	% plants (% leaves) infected: Untreated	Autumn prochloraz	Untreated	Spring prochloraz + summer iprodione
31 Jan	*P. brassicae*	6(2)	2 (0.7)	-	-
26 Feb	*P. brassicae*	7(1)	1*(0.1*)	-	-
22 April	*P. brassicae*	45(9)	4*(0.5*)	31(6)	18*(3*)
	L. maculans (leaf spot)	16(2)	2*(0.2*)	14(1)	4*(0.4*)
11 June	*P. brassicae*	55(12)	24*(4*)	49(11)	30*(5*)
	L. maculans (canker)	11	5	10	6
17 July	*P. brassicae* (% pod area infected)	1.7	0.3*	1.8	0.2*

(* indicates values significantly less than corresponding values in untreated plots at P<0.05).

Table IV. Effect of prochloraz applied in autumn and spring and on both occasions on incidence of disease (meaned over all other treatments).

Date	Disease	% plants (% leaves) infected			
		Untreated	Spring	Autumn	Spring + autumn
22 April	*P. brassicae*	55(12)	34(6)	6(1)	2(0.2)
	L. maculans (leaf spot)	24(3)	7(1)	4(0.3)	1(0.1)
11 June	*P. brassicae*	66(16)	45(8)	32(6)	15(1)
	P. brassicae (% plants with pods infected)	11	2	4	1

(All values given for fungicide treatments were significantly less than those for untreated plots at $P < 0.05$)

Table V. Components of yield analysis for treatments which gave significant yield increases (data from 22 July hand harvest, means over all other treatments)

Treatments.....	Sowing date		Insecticide		Spring + summer fungicide	
	Early	Later	Without	With	Without	With
No.plants/m²	45	87*	61	71*	62	70
Pod dry weight (g/m²)	895	1029*	913	1011*	917	1007
1000 seed weight (g)	4.47	4.09*	4.31	4.26	4.25	4.32*
Harvest index	29.1	30.5*	28.0	31.6*	29.4	30.3
No. ($\times 10^3$) fertile pods/m²	5.97	8.89*	6.87	7.99*	7.10	7.76

(* indicates values significantly different from corresponding values within each treatment at $P < 0.05$)

In 1985-86 the same treatments were tested again on cv. Bienvenu using the same design, but instead of a randomised layout a blocked layout of larger plots (3 x 20m) was chosen. Also extra plots were included to test late foliar application of nitrogen with and without micro-nutrients and sulphur.

In 1986-87 the trial will include a comparison of the cultivars Bienvenu and Ariana (recently recommended for cultivation in Britain) to reflect the need for more research on low glucosinolate cultivars. Difficulties with the accurate timing of a growth regulator at late flowering, and the inclusion of cv. Ariana (a taller, later maturing cultivar than Bienvenu), indicate a need to change the type and timing of growth regulator. A spring application of one of the new triazole types (1) will replace ethephon.

The spectrum and severity of pest and disease attack, and other constraints to yield, may change with the widespread cultivation of low glucosinolate cultivars in Europe. Multidisciplinary trials offer a comprehensive means to prepare researchers and farmers for any changes needed in agronomy and crop protection. This type of trial has been adopted, with modifications, by the CETIOM organisation in France; the concept could with advantage be extended elsewhere in Europe.

REFERENCES

1. CHILD, R.D. et al. (1985). Effects of some experimental triazole retardants on yield of oilseed rape. *Proceedings 1985 British Crop Protection Conference - Weeds*, 2, 561-567.
2. LESTER, E. & PREW, R.D. (1983). A multidisciplinary approach for evaluating the factors that affect cereal yields. In : *The yield of cereals, Proceedings of an International Seminar, Cambridge and Stoneleigh, 1983.* Ed. D.W. Wright. London: Royal Agricultural Society of England, pp. 79-84.
3. NEWMAN, P.L. (1984). The effects of insect larval damage upon the incidence of canker in winter oilseed rape. *Proceedings 1984 British Crop Protection Conference - Pests and Diseases*, 2, 815-822.
4. PREW, R.D. et al. (1985). Some factors limiting the growth and yield of winter wheat and their variation in two seasons. *Journal of Agricultural Science, Cambridge*, 104, 135-162.
5. RAWLINSON, C.J. (1985). Multidisciplinary research on oilseed rape at Rothamsted. *Groupe Consultatif International de Recherche sur le Colza. Bulletin*, 2, 84-85.
6. RAWLINSON, C.J. & CAYLEY, G.R. (1984). Spray treatments, methods and timing for control of light leaf spot on oilseed rape. *Proceedings 1984 British Crop Protection Conference - Pests and Diseases*, 2, 735-742.
7. RAWLINSON, C.J. et al. (1979). Diseases of winter oilseed rape : occurrence, effects and control. *Journal of Agricultural Science, Cambridge*, 93, 593-606.
8. RAWLINSON, C.J. et al. (1984). Fungicide effects on light leaf spot, canker, crop growth and yield of winter oilseed rape. *Journal of Agricultural Science, Cambridge*, 103, 613-628.
9. ROTHAMSTED EXPERIMENTAL STATION (1985). Winter oilseed rape, factors limiting yield. *Yields of the Field Experiments 85/R/RA/1.*
10. ROTHAMSTED EXPERIMENTAL STATION REPORT FOR 1985 (1986). Multidisciplinary agronomy : Factors limiting yield of winter oilseed rape, pp. 27-30.

COMPENSATION IN WINTER RAPE FOLOWING SIMULATED POLLEN BEETLE DAMAGE

Jacques LERIN
INRA, Centre de Poitou-Charentes, Laboratoire de Zoologie, F. 86600 Lusignan, France

Summary
Pollen beetle damage was simulated on about half of the buds on the terminal racemes of rape plants, cv Jet Neuf, growing in a field. This damage reduced seed production on the main shoot by about 38 %. However, seed loss on the terminal raceme was compensated for by the rest of the plant producing an increased number of productive racemes and increasing both the numbers of pods and the numbers of seeds/pod in such racemes. This compensation occurred under conditions of partial water stress. The type of damage inflicted by certain pests and their possible effects on yield are discussed.

1. Introduction

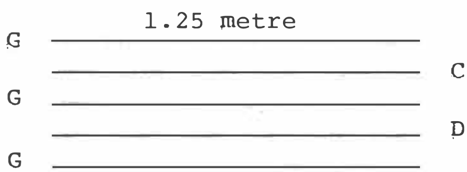
There are still difficulties in quantifying the loss in yield in oilseed rape crops that occur as a result of attack by pollen beetles (Meligethes aeneus L.). In France, 1 pollen beetle/plant at the "small green buds close together" stage, or 2-3 beetles/ plant at the "green buds separated" stage, are considered worth spraying, even though Pouzet & Ballanger (8) only found a reduction in the number of pods on terminal racemes when 9 pairs of beetles were present/plant at this stage. In England, ADAS leaflets indicate that at the "green bud" stage only beetle populations in excess of 15-20 beetles/plant are worth spraying. In East Germany, Daebeler et al. (3) proposed a threshold of 8-10 beetles/ plant "under very favourable growing conditions" and 5-6 "under less favourable conditions". Finally, in Sweden, Sylven & Svensson (9) found no loss of pods during a 4-year period, when 6 beetles/ plant were introduced under field-cage conditions.

Though the number of podless stalks is the usual criterion for assessing the severity of pollen beetle damage, it is well known that this variable is positively correlated with plant size, even when plants are free of insects. For this reason, control plants without insects are essential for assessing the number of podless stalks that result directly from pollen beetle activity.

The high numbers of pollen beetles mentioned above did produce podless stalks, but this rarely resulted in yield losses because of the considerable capacity of the rape to compensate for bud injury. This phenomenon has been documented thoroughly for several brassica crops (4, 12, 11, 10). For example, Williams & Free showed that removal of up to 60 % of the buds caused no loss in yield. Therefore, the aim of this study has not been to see *if* plants compensate, but to see *how* they compensate. Tatchell (10) carried out a study, similar to this study, on spring rape, but unfortunately failed to take into account the numbers of seeds produced/pod.

2. Materials and Methods

Five plots of Jet Neuf, the commonest cultivar grown in France in 1984, were selected at random, approximately 10 m in from the edge of a rape field. Each plot was set out as shown below :



G : guard rows C : control rows D : damage rows

Damaged plants were produced by using special tweezers with a "tooth" that would crush rather than remove the buds. Since the crushed buds stayed on the plants for some time before falling, they closely resembled buds actually damaged by pollen beetles. Damage was inflicted on two occasions, separated by an interval of 4 days, until about half of the developing buds on the main raceme were damaged. At this time, the plants had inflorescences of about 1.5 - 2 cm in diameter and all of the buds were green. No pollen beetles were seen on the plants before flowering and the population remained low after flowering (less than 2 beetles/plant). On each of the "control" and the "damaged" rows, 1 m of row was harvested. Plant measurements recorded included the numbers of podless stalks on the terminal raceme, the number of pods, the number of seeds from each raceme, the weight of seed from each raceme, the total number of racemes initiated (including aborted ones), the number of productive racemes and finally the stem diameter 5 cm above soil level. For several years, measurements of this last variable have indicated that stem diameter is unaffected by insect pests in the spring, except for *Ceuthorrhynchus napi* Gyll., and that stem diameter is a good relative indicator of plant vigour in rape (5).

3. Results

The number of plants, the mean stem diameter, the number of axillary racemes initiated (both aborted and productive), the numbers of productive racemes and the yield from 1 metre of crop row are shown in Table 1. Analysis of Variance indicated no differences between yields of blocks or treatments (Table 1). Nevertheless, there were differences between the number of plants subjected to the two treatments and this in turn affected stem diameter. When the different numbers of plants were taken into account in a covariance analysis, the previous difference disappeared. Therefore, plant density was the major factor affecting stem diameter and subsequent plant vigour. Although the numbers of racemes initiated were similar for both treatments, the numbers of productive racemes were different. This resulted partly from the different numbers of plants in the two treatments and partly from the compensatory growth produced by the damaged plants. Since plant density was lower in the damaged rows (Table 1), each plant tended to produce more racemes than in the control rows. In contrast, the higher plant density in the control rows resulted in many plants with a stem diameter of less than 1.1 cm. Such plants had no axillary racemes and this adversely affected all yield components related to plant vigour. Direct comparison of the treatments, therefore, tended to overestimate plant compensation.

Table 1. **Plant parameters recorded from 1m-row length of crop harvested from the 5 experimental blocks.**

Blocks		B1	B2	B3	B4	B5	Mean	(1)
number of plants	C	18	20	16	20	17	18	*
	D	12	13	16	11	11	15	
mean stem diameter	C	1.1	1.1	1.1	1.1	1.2	1.1	*
	D	1.4	1.3	1.2	1.2	1.4	1.3	
racemes initiated	C	61	81	59	85	71	71	NS
	D	75	74	71	57	69	69	
productive racemes	C	38	46	23	50	45	40	*
	D	72	66	61	48	58	61	
Yield (g)	C	105	129	95	149	127	121	NS
	D	152	124	134	84	133	125	

C control D damaged

(1) significance of the differences between treatments :
NS not significant ; * 5 % level ; ** 1 % level

There are no significant differences between blocks.

As the aim of this study was to show how compensation occurs in winter rape plants, a more homogeneous subsample was obtained by selecting, from both treatments, only plants with stem diameters between 1.2 - 1.4 cm (inclusive). The results from this subsample (Table II) showed that the yields from the terminal racemes were reduced considerably by the damage inflicted, that about 41% of the pods were lost and that there was little compensatory growth, since the weight of seeds/pod was similar for both the control (109 mg) and the damaged (115 mg) plants. The numbers of aborted racemes were reduced considerably on the damaged plants and this induced a higher number of both productive shoots and pods on the axillary racemes. The usual relationship between the number of productive racemes and the number of pods/raceme was significant for the control (plants (r = 0.513) but not for the damaged plants (r = 0.136). Hence, the usual intra-plant relationships among yield components were modified considerably by damage. Therefore, the increase in the number of pods produced on each raceme is biologically important in the process of compensation even if it is not statistically significant at the 5 % level in the analysis of variance.

Another way compensation occurred was that the number of seeds/pod increased by about 35 % on the damaged plants. The compensatory effect of this increase was diminished slightly by the small, though significant, decrease in the weight of 1000 seeds.

Table II. **Measurements of various parameters from the plants included in the sub-samples.**

	Control	Damaged	Significance
Number of plants	29	24	
Stem diameter	1.31	1.30	NS
Terminal raceme			
podless stalks	4	34	**
pods	61	35	**
seeds per pod	20	22	NS
1000 seed weight (g)	5.5	5.4	NS
productivity	6.5	4.1	**
Axillary racemes			
aborted racemes	1.2	0.6	**
productive racemes	4.1	5.2	**
number of pods	59.2	87.0	**
pods per raceme	13.8	16.6	NS
seeds per pod	9.4	12.6	**
1000 seed weight (g)	6.1	5.7	**
yield	3.5	6.3	**
pods per plant	120	122	NS
yield per plant	10.1	10.4	NS

Oilseed rape plants can therefore compensate for damage :

1) by increasing the numbers of productive axillary racemes,
2) by increasing the numbers of seeds/pod and, to a lesser extent,
3) by increasing the numbers of pods/raceme.

4. Discussion and conclusion

These results can be compared with those obtained in an experiment carried out on the same cultivar in 1980 (6). In the 1980 experiment, the rape plants were either pollinated by bumble bees or left unpollinated. Good pollination resulted in an increase in both the numbers of pods on the main raceme and in the number of seeds/pod on the whole plant. In the 1980 experiment, fewer racemes and fewer pods were produced on the pollinated than on the unpollinated plants.

Hence, a winter rape plant that can produce n grams of seed, (n depending on the growing conditions of the particular year), will achieve this result under a wide array of conditions as long as damage does not impede the exchange of metabolites within the plant. Several authors have suggested that compensation cannot occur under stress conditions. The present experiment was carried out under extremely dry conditions, since it rained only 6.2 mm in April prior to flowering (first flowers on the 20th) and during the first 10 days of flowering there was no rain. The water deficit lasted from April to August, that is throughout the complete period that plants are considered sensitive to water stress. Despite this stress, yields were good (3.5 tons/ha) and complete compensation occurred in this experiment.

Plant physiologists have shown that two-thirds of the metabolites that enter the seeds come from the leaves and stems, with the other third being produced locally by the walls of the seed pods (1, 7 & 2).

Although the metabolites from the walls of the seed pods cannot migrate to other pods, the metabolites from the leaves and stems can be re-distributed along different pathways within the plant. Usually, the main metabolic sink is the terminal raceme, but when this fails to absorb all of the metabolites produced, the excess moves into the axillary racemes. It is still not certain that compensatory growth always occurs in the same way. The ways for redistributing the metabolites within a plant can change under different agronomic conditions. Nevertheless, it seems certain that some kind of compensation occurs under all conditions. Since damage by *Meligethes aeneus* or *Ceuthorhynchus assimilis* do not impedethe exchange of metabolites within the plant, losses in yield will result only from very severe levels of attack by these insects. In contrast, infestations of the weevil *Ceuthorhynchus napi*, whose larvae mine in the plant's stems, or fungal diseases, which interact with photosynthesis, should result in greater losses in yield. The capacity of Jet Neuf to compensate for damage, by decreasing the number of seed abortions on its axillary racemes, is interesting, since this method of compensation does not alter the plant's architecture. The alternative strategy of carrying out compensatory growth by increasing the number of racemes is usually deleterious, since it can lead to delayed maturity and uneven ripening which cause problems at harvest.

It is essential to stress that if the plant has been attacked during any earlier stage of growth by winter flea beetles or any species of stem weevil, then its potential to compensate for any subsequent attack might already be considerably reduced.

Experiments to determine the relative effects of the various pests, and their interactions, were started in 1985.

Acknowledgements

This study was carried out with technical collaboration by **Erick RIVAULT.** I am deeply indebted to **Stan FINCH** for his thorough work on the English of the manuscript.

References

1. BRAR G., THIES W. (1977). Contribution of leaves, stem, siliques and seeds to Dry Matter Accumulation in Ripening Seeds of Rapeseed, Brassica napus L. **Z. Pflanzenphysiol 82,** 1-13.

2. CHAPMAN J.F., DANIELS R.W., SCARISBRICK D.M. (1984). Field studies on C14 assimilate fixation and movement in oil-seed rape (B. napus). **J. agric. Sci. Camb. 102,** 23-31.

3. DAEBELER F., RÖDER K., HINZ B., LÜCKE W. (1980). Schadwirkung des Raps glanzkäfers bei unterschiedlich hohen Stickstaffgaben. **Nachrichtenbl. Pflanzenschutz** DDR, Berlin, **1,** 13-15.

4. KAUFMANN Von O. (1942). Die Gesunderhaltung der Rapspflanze als Mittel zur Vermeidung starker Rapsglanzkäferschäden. **Mitt. biol. Reichsanst.** Berlin **66,** 1-36.

5. LEFORT-BUSON Marianne (1979). Hétérosis et paramètres génétiques de quelques caractères agronomiques chez le colza oléagineux (Brassica napus L.). Thèse de 3ème cycle. **Université Pierre et Marie Curie,** Paris VI.

6. LERIN J. (1982). Effets de la pollinisation entomophile sur colza dans une expérience en cage. **Agronomie 2** (3), 249-256.

7. MAJOR D.J., CHARNETSKI W.A. (1976). Distribution of C14-labelled Assimilates in rape plants. **Crop Science 16,** 530-532.

8. POUZET A., BALLANGER Y. (1983). Etude de la nuisibilité du méligèthes des crucifères (Meligethes aeneus F.) sur colza d'hiver (Brassica napus L.) en conditions contrôlées. **Informations techniques CETIOM 84,** 3-10.

9. SYLVEN E., SVENSSON G. (1976). Effect on yield of damage caused by Meligethes aeneus F. (Col.) to winter rape, as indicated by cage experiments. **Ann. Agric. fenn. 15,** 24-33.

10. TATCHELL G.M. (1983). Compensation in spring sown oil seed rape (Brassica napus L.) plants in response to injury to their flower buds and pods. **J. agric. Sci. Camb. 101,** 565-573.

11. WILLIAMS Ingrid, FREE J.B. (1979). Compensation of oil seed rape (Brassica napus L.) plants after damage to their buds and pods. **J. agric. Sci., Camb 92,** 53-59.

12. WINFIELD A.L. (1962). Effect of early flower-bud removal on subsequent development of some brassica seed plants. **Plant Pathol. 11,** 17-22.

Parasitoids and predators attacking pollen beetles (Meligethes aeneus F). in spring and winter rape in southern Sweden.

Christer Nilsson and Britt Andreasson
Swedish University of Agricultural Sciences
Box 44
S-230 53 Alnarp, Sweden

Summary

Predators and parasitoids of the pollen beetle (Meligethes aeneus F.) were studied in spring and winter rape during 1976-1978. Very few predators were found on the plants. Predators living on the soil surface had little effect on the survival of pollen beetle larvae. Six hymenopterous parasitoid species were caught of which Tersilochus heterocerus (Thomson) and Phradis morionellus (Holmgren), were the most common. The degree of parasitization varied greatly between years and was not correlated with the density of the host population. T. heterocerus females laid their eggs at random. Insecticide treatments during the bud stages of rape had no apparent impact on parasitization rates. Crop rotation can strongly affect the density of the parasitoid population. Where spring barley or spring oats follow spring rape, early insecticide treatments can sharply reduce parasitoid populations.

In Sweden winter rape is grown on ca. 50,000 ha, while spring and turnip rape are cultivated on ca. 110,000 ha. Pollen beetles (Meligethes spp; Coleoptera: Nitidulidae), M. aeneus F. in particular, are pests of great economic importance attacking these and other cruciferous crops in Sweden. The economic threshold above which chemical control should be implemented is about 0.8 beetles per plant during the bud stages (Nilsson 1986). Winter rape crops, which usually are invaded during a later growth stage (GS), are not damaged to the same extent as spring oilseed crops (Nilsson 1980). Consequently, almost every field of spring rape and spring turnip rape in Sweden is sprayed at least once every year with either fenitrothion or a pyrethroid.

The beetles mainly attack the small or medium-sized buds, where they lay eggs and eat pollen. The larvae develop inside the buds but often move to new buds or to flowers if all pollen within a bud is consumed. Last-instar larvae are usually found in flowers and most of them drop to the ground at petal-fall. Pupation takes place a few centimeters below the soil surface, and the new generation hatches about a month later. Development from egg to adult takes about 2 months. Adults overwinter in woodland litter and invade winter rape fields when temperatures rise above 12-15° C during spring. At flowering, during late May, they migate to spring oilseed crops or to other crucifers, where they continue egg-laying.

Natural enemies, especially parasitoids, can substantially reduce beetle populations. All parasitoids attack the larval stage. Very little is known about predation on adults. Nine species of hymenopterous parasitoids have been reported attacking the larvae in buds or flowers (Jourdheuil 1960, Osborne 1960, Horstmann 1967, 1971, Haeselbarth 1973). Herrström (1964) reported 7 parasitoid species from southern Sweden. Three species accounted for 96.1 % of his material, which has been reared from about 8000 pollen beetle larvae. The univoltine Tersilochine species dominated, but during certain years Diospilus capito (Nees) was also abundant in spring oilseed crops. Although both Phradis morionellus and P. interstitialis parasitize pollen beetles in southern Sweden, Herrström did not distinguish between them; thus there should be at least 8 species in southern Sweden, of which 4 are much more common than the other 4.
Many carabids prey upon pollen beetle larvae and pupae on and under the soil surface (Basedow 1973). Coccinellids and Malachius spp. also prey on larvae, mostly in the flowers (Friederichs 1920).

From 1976 until 1979 we investigated the ecology and biology of pollen beetles in southern Sweden (Scania). An attempt was made to measure the impact of predators and hymenopterous parasitoids on larval populations of pollen beetles. The results are reported below.

Methods

All trials were located at Alnarp, near Malmö in southern Sweden, in private fields or in fields sown at the university farm. The varieties Gulliver and Brink were used. Winter rape crops were investigated from 1976-1978, and spring rape was studied in 1977 and 1978. Since only winter rape was cultivated by the farmers in this area, the pollen beetle population consisted exclusively of M. aeneus.

Genera and species were determined with the aid of a demonstration collection verified by Dr K. J. Hedqvist, Stockholm. Tersilochinae (Ichneumonidae) were determined according to Horstmann (1971, 1967), and the identification of a few specimens were verified by Horstmann.

Hymenopterous parasitoids and predators on plants were sampled in sweep nets (32 cm diam) twice weekly. A sample consisted of the material from 5 single sweeps. The same person did all the sweeping with very few exceptions.

Catches have been transformed to no. beetles/m^2 by comparing numbers of pollen beetles counted per square meter on each occasion with the number of pollen beetles caught with the sweep-net. The relationship between these two variables during the last bud stage (GS 3.3; Harper & Berkenkamp 1975) and during flowering was usually linear. The number of beetles caught on wet plants was much lower than the number caught on dry plants, probably because the beetles had moved to lower levels in the canopy on the wet plants. This tendency to move down the plants was very evident when catches from sweeps made every 6th hour were compared. Twice as many beetles were caught at 3 a.m. than at any other time and this difference was statistically significant (P=0.001, ANOVA). It is not known whether parasitoids show a similar response, but our observations indicate that they are most active around noon. All sampling was conducted between 8 and 12 a. m. and since parasitoids are active during this period, collections should generally reflect their true abundance.
The correlation between pollen beetle counts and sweep-net catches in the five crops (21 dates) was 0.96. The regression-coefficient (5.4) was used

to transform parasitoid numbers in sweep-net catches to density estimates. It was estimated that the outswing of the net in the crop was about 1.45 m, which means that if 5.4 m^2 was to be covered in 20 sweeps, the width of the net in the crop should be 0.19 m.

Predators on the plants were estimated in the same way. To determine whether predators ascend the stems at other times of the day, glue-rings were used on a few occasions, but they never caught any predators. Plants were sampled twice weekly and larvae found in buds and flowers were examined to determine whether they contained parasitoid eggs or larvae.

Pollen beetle larvae dropping to the soil surface during petal-fall were collected in square trays (0.098 m^2) with water and detergent.
The heads of all parasitoid larvae and the eggs of Tersilochus heterocerus, which are black, can be seen through the host cuticle. Eggs laid by the other parasitoids are transparent and are generally very hard to detect, even when host larvae are dissected. It was possible, however, to detect these eggs by staining larvae with acetocarmine before dissecting them.

Wooden hatching boxes (0.11 m^2) fitted with a small glasstube covered by gause at its distal end, were used to estimate the numbers of pollen beetles and multivoltine parasitoids in the new generation.
The boxes were painted white and had such dimensions that they gave a representative sample from fields with different row spacings. The boxes were moved once just after the first pollen beetles hatched to minimize the impact of the box on the population. Between 0.5 and 1.8 m^2 soil surface was covered in each treatment.

Predators on the soil surface, such as carabids, were caught in pitfall traps. Wooden frames without a bottom or top were sunk into the ground in two trials (winter and spring rape 1978) 1-2 weeks before the larvae started migrating to the soil surface. These frames had the same dimensions as the hatching boxes. Half of them were sunk into the ground to just cover the upper rim (low frames), the other half were sunk 5 cm, leaving 10 cm above the soil surface (high frames). These latter frames were fitted with a pitfall trap to exclude predators. Hatching boxes were placed on top of the frames as soon as hatching began about 6 weeks later.

Results

Sweep-netting did not catch many predators. A few Tachyporus, Amara and Malachius were occasionally caught, as well as some Coccinella septempunctata (Coccinellidae) and Neuroptera spp. (adults and larvae). Ladybeetles and lacewings were abundant only in winter rape 1977 and in spring rape 1978, respectively, where they reached a maximal density of about 0.75 animals/m^2.

Table 1. Predators caught in pitfall traps. Numbers caught per trap during a 3-day period.

	Winter rape May 24-June 7 1978	Spring rape July 7-July 18 1977	June 22-July 31 1978
Carabidae	6.3	8.4	7.0
Staphylinidae	6.0	20.6	3.8
Araneidae	3.5	25.2	7.9

Predators on the soil surface were more numerous than those on the plants (Table 1). Ground beetles belonging to the genera Amara, Agonum, Harpalus, and Pterostichus were occasionally common. Staphyliniids and spiders (Linyphiidae) were also caught in high numbers, especially in spring rape 1977. Many spiders and rove beetles were caught in the pitfall traps placed inside the high frames. These animals flew or climbed over the barriers; in contrast most carabids remained on the soil surface and could not cross the barrier. Compared with the surrounding soil, 25 % more pollen beetles hatched within the high frames in winter rape (P=0.004, ANOVA) and 25 % less hatched within them in spring rape (not a significant difference). The low frames gave both predators and pollen beetle larvae free access to the soil inside the frame. In both winter and spring rape more pollen beetles hatched within these low frames (80 and 23 %) than in the surrounding soil (Table 3.).

Six hymenopterous parasitoid species were caught in either sweep-nets or hatching boxes:

Braconidae
Blacus nigricornis Haeselbarth
Diospilus capito (Nees)
Ichneumonidae
Phradis interstitialis (Thomson)
P. morionellus (Holmgren)
Tersilochus heterocerus (Thomson)
Proctotrupidae
Brachyserphus parvulus (Thomson)

Another ichneumonid, Aneuclis incidens (Thomson), has also been reported from Sweden; it was taken by Thomson in 1884. The ichneumonids are univoltine while the other parasitoids are multivoltine. Ichneumonids were found in all crops and the dominating species were T. heterocerus in winter rape and P. morionellus in spring rape (Table 2). P. interstitialis was quite common in winter rape and a few specimens were also taken in spring rape during the early bud stages. These individuals had apparently migrated in from nearby winter rape fields.

Table 2. Peak density/m^2 during flowering of hymenopterous parasitoids of pollen beetles

	Winter rape 1976	1977	1978	Spring rape 1977	1978
Tersilochus heterocerus	0.4	5.4	4.3	0.9	0.2
Phradis morionellus	0.6	1.7	0.4	34.1	3.2
P. interstitialis		0.6	0.2		
Diospilus capito				0.7	0.2
Blacus nigricornis					0.2

Multivoltine parasitoids were almost exclusively found in spring rape. D. capito was common in 1978, when relatively high numbers hatched during August. During both 1977 and 1978, B. parvulus was also very numerous in spring rape where 22 and 10 parasitoids/m^2 respectively were recorded from hatching boxes. Corresponding figures were 1 and 3 parasitoids/m^2 for B. nigricornis and 8 and 49 parasitoids/m^2 for D. capito. In

all, 31 and 60 parasitoids/m^2 hatched, representing only a few per cent of the pollen beetle population (Table 3).
Many other hymenopterous species were also taken in sweep-nets or hatching boxes in the five crops. Between 50-100 species were usually taken in each crop. Dominating genera included Dacnusa (Braconidae), Lysaphidus (Aphidiidae), Halticoptera (Pteromalidae), Eucoila (Eucoilidae) and Cyrtogaster (Pteromalidae). Sweep-netting also caught several proctotrupid parasitoids of Dasineura brassicae (Dipt., Cecidomyiidae), such as Platygaster (which was most common), Synopeas, Isostasius, and Inostemma. Omphale (Eulophidae) was also common.

Table 3. Emergence densities of pollen beetles and polyvoltine parasitoids/m^2. The spring rape was sprayed once with azinphos-azinphosmethyl and methoxychlor in 1977 and with permethrin (once) and methoxychlor (twice) in 1978.

		Meligethes aeneus	Diospilus capito	Blacus nigricornis	Brachyserphus parvulus
Winter rape					
1976		1,180		1.6	
1977		1,240			
1978		50 a 1/			
	low frame	180 b			
	high frame	130 b			
Spring rape					
1977		640 a	8.3	1.1	22.0
	insecticide	90 b	0.0	0.0	0.0
1978		2,510 a	38.6	3.3	1.1
	low frame	3,090 a	23.1	2.2	13.2
	high frame	1,860 a	38.6	0.0	8.8
	insecticide	330 b	17.6	4.4	0.0

1/ Within-year values followed by the same letter are not statistically different (P 0.05, ANOVA).

The most abundant species, T. heterocerus, is also the one for which parasitization is easiest to measure because of its black eggs. A few eggs can be hidden inside the body and therefore overlooked, but dissections we have made have shown this source of error to be negligible. The parasitoid females prefer large Meligethes larvae (Table 4), possibly because they mainly search for hosts in open flowers where the larger larvae are most numerous (Friederichs 1919, 1920; Lehmann 1965). The degree of parasitization varied greatly between years, and there was no apparent correlation between parasitization rate and density of the host population. The number of parasitoid eggs found in a single larvae increased as the percentage of parasitizised larvae increased (Table 5). The probability of finding a certain number of T. heterocerus eggs in a host larvae is described well by the Poisson-distribution, i.e. the eggs are layed at random. Insecticide treatments in spring rape 1977 and 1978 during the bud stages did not have any observable impact on the parasitoids; i.e. the rates of parazitization in these plots were similar to those in the untreated plots (Tables 3 and 4).

It was much more difficult to estimate the degree of parasitization due to the species with transparent eggs. The staining technique was laborious; consequently, only a limited number of larvae were subjected to this treatment. The results are shown in Table 5 (see 'Other parasitoids'). Between 70 and 190 larvae were examined each year, except during 1976 when no material was available. Eggs and larvae of these other parasitoid species were usually not found in more than 2 % of the parasitized hosts. In spring rape 1977, however, nearly 30 % of the pollen beetle larvae contained parasitoid eggs (mostly P. morionellus).

Tabel 4. Proportion (in %) of the pollen beetle larvae dropping to the ground at petal-fall that were parasitized by Tersilochus heterocerus (i=two insecticide treatments during the bud stages with permethrin and methoxychlor)

	First instar	Second instar small	large	Larval density (larvae/m^2)
Winter rape				
1977	6.8	10.7	24.6	4,800
1978	14.9	36.2	50.8	1,600
Spring rape				
1978	2.1	6.2	11.9	20,600
1978 i/	3.2	6.9	14.1	1,600
1979	0.0	0.8	0.0	1,000

Discussion

Basedow (1973) showed that 39 % of the pollen beetle larvae reaching the soil surface were preyed upon. The larvae only remain on the soil surface for a short time. Moreover, the emergence data from the low frames indicated that compaction of the soil surface was at least as important as predation in determining the percentage of larvae reaching pupation. The larvae tend to aggregate at spots where the soil can be easily penetrated. Compact soils, such as those containing clay, often form cracks during longer periods of warm weather. These cracks can be utilized by the larvae. When cracks don't develop, the importance of predation should increase since larvae have to spend more time on the soil surface where they are exposed to predators. Leuchs (1956) found a positive correlation between clay content and mortality, which could have many explanations, differential predation rates being one.

The sweep-nettings showed that predators living on plants were more scarce than surface predators. The farmer have many alternative food sources (e.g. pollen and nectar). Thus they probably had little effect on populations of pollen beetle larvae.

Multivoltine parasitoid species were less efficient than univoltine species in parasitizing pollen beetle populations. The total level of parasitization by multivoltine species was less than 5 % in spring rape and parasitism in winter rape was insignificant.
Univoltine species were present in measurable numbers in both spring and winter rape every year. These species oviposit in hosts with no regard to

their parasitization status, similar to the behaviour of D. capito as described by Jourdheuil (1960). When they are abundant, a substantial proportion of the eggs are laid in hosts already containing parasitoid eggs. Based on this behaviour, Jourdheuil (1960) calculated that the number of eggs laid must be 2-4 times the number of host larvae to attain parasitization levels of 60-100 %. Such ratios are rarely, if ever, found under field conditions. According to Fritzsche (1957) a female univoltine parasitoid lays 25-50 eggs during her lifetime. Thus the parasitoid density estimated through sweep-net sampling was apparently too low to produce the parasitization levels shown in Tables 4 and 5. However some of the parasitization rates given in these tables are based on several thousand larvae and should be reliable.

Sweep-net samples were taken at the time of the day and during the growth stages of the crop (flowering) when numbers of parasitoids and beetles in the upper parts of the plants should have been near their maxima. In winter rape parasitoids are usually not caught before flowering (Nilsson 1985). In spring rape large numbers of parasitoids (P. morionellus) were caught during bud stages only in 1978. Moreover, the estimated depth to which the sweep-net penetrated the foilage is very reasonable. Thus the large difference between the estimated density of parasitoids and subsequent parasitization rates is most likely attributable to the behaviour of the parasitoids or due to an underestimation of their egg-laying capacity.

Most of the variation in parasitization between years (Tables 4 and 5) was probably due to fluctuations in the host population. When the population of pollen beetle larvae in winter rape 1978 dropped below the 1977 level, the parasitization rate increased correspondingly. The estimated number of parasitoid eggs laid both years in winter rape and during 1978 in spring rape (Tables 4 and 5) are similar in spite of the large between-year differences in host populations. In 1979, however, parasitoids were rare.

Jourdheuil (1960) concluded that several factors limited rates of parasitization by Tersilochus and Phardis spp.: the low degree of synchronisation between host and parasitoid, competition between parasitoid larvae, encapsulation of parasitoid eggs, and high mortality during winter. Adult parasitoids hatch during the bud stage of winter rape if they developed in pollen beetle larva from winter rape and hatch during the bud stages of spring rape if they developed in spring rape. All species overwinter in the soil at the site of the previons rape crop. Thus they are very easily killed by soil preparation procedures, such as ploughing or harrowing. Rape is normally followed by cereals in Sweden. If direct drilling is used instead of ploughing, up to 4 times as many parasitoids will emerge the following spring (Nilsson 1985).

The cereal crop following spring rape is likely to be either winter wheat or spring barley. Both of these crops are often sprayed with insecticides, mainly against aphids during July or the last half of June. The pollen beetle parasitoids will also emerge during the last half of June and could be killed by these insecticides. If economic thresholds for aphid control are used, spraying will normally be done later in June or in July and parasitoids will not be affected. In barley a fungicide is often sprayed in mid-June. A tank-mix with an insecticide offers inexpensive protection against aphids in some years. This kind of prophylactic spraying has recenty become more common. As a result of these pesticide applications a substantial number of parasitoids are probably killed. To minimize parasitoid mortality, economic thesholds should be used to decide

Table 5. Parasitization of 2nd-instar pollen beetle larvae.

	Sample	*Tersilochus heterocerus* % larvae containing eggs. No. eggs				% parasitization	% parasitization calculated using a Poisson distribution	Other parasitoids % parasitization	No. examined larvae
		1	2	3	4				
Winter rape									
1976	Plants	3.2				3.2	3.1		961
1977	Plants	13.9	0.7			14.6	14.2		589
	Tray					23.1	-		3,981
	Tray 1/	22.9	4.2	0.4	0.2	27.6	28.2		525
	Tray 1/	35.6	7.8	3.3		46.7	45.7	2.2	90
1978	Plants	42.9	13.1	0.9	0.5	57.4	52.2		434
	Tray					47.6			1,217
	Tray 1/	42.0	10.1	1.5		53.6	48.7	0.0	69
Spring rape									
1977	Plants					5.0			802
	Plants 1/	8.9	2.2			11.1	12.5	28.9	90
1978	Plants	1.2				1.2	1.1		4,761
	Plants 1/					0.0		0.0	40
	Tray					10.5	-		11,795
	Tray 1/					1.3		2.0	150

1/ Subsamples from several dates

if and when insecticides are needed to control aphids in cereals. Parasitoids emerging in mid-May from the previous years winter rape fields, which have usually become winter wheat fields, do not run the risk of insecticide exposure but will probably have difficulties in finding food since no flowering plants are allowed to grow in or around the wheat field.

Parasitoids fly into the new rape crops from the previous year's fields. In winter rape they seldom arrive before the crop flowers (Nilsson 1985). Pollen beetle control is only economically justified during the bud stages, primarily the early ones. If farmers refrain from using pesticides during the last bud stage and during flowering, most of the parasitoids will remain unharmed. P. interstitialis, which often emerges 1 or 2 weeks before T. heterocerus, could, however, be affected.

After petal-fall in winter rape the parasitoids migrate to spring rape if this crop is available. Since they arrive during the early bud stages, they are often killed by insecticides applied for pollen beetle control. Thus parasitization of pollen beetles in spring rape crops is mainly dependent on those parasitoids that fly from the previous year's spring rape fields.

It should be possible to increase the degree of parasitization in both spring and winter rape by not using insecticides in rape during flowering, by direct drilling instead of ploughing when sowing cereals in rape stubble, and by delaying the combined insecticide-fungicide spray in spring barley as long as possible. Ideally, insecticide applications in wheat and barley should only be made when aphid populations reaches economic threshold levels.

Acknowledgments

We wish to express our gratitude to Prof. L. Caltagirone for help with the egg-staining method and to Drs K.-J. Hedqvist and K. Horstmann for parasitoid determinations.

References

Basedow, T., 1973. Der Einfluss epigaischer Raubarthropoden auf die Abundanz phytophager Insekten in der Agrarlandschaft. Pedobiologia, 13, 410-422.

Friederichs, K., 1919. Der Rapsglanzkäfer als Schädling. Der Landw. Presse, 46

Freiderichs, K., 1920. Untersuchungen über Rapsglanzkäfer in Mecklenburg. Z. ang. Ent., 7, 1-36.

Fritzsche, R., 1957. Beeinflussung der populationsdichte verschiedener Meligethes-arten von gleichen Wirtspflanzen durch Parasiten. Bericht über die Hundertjahtfeier der Deutschen Entomologischen Ges. Berlin, 1956. Akad.-Verl., Berlin, 141-145.

Harper, F.R. & Berkenkamp, B., 1975. Revised growth-stage key for Brassica campestris and B. napus. Can. J. Plant Sci., 55, 657-658.

Haeselbarth, E., 1973. Die Blacus-Arten Europas und Zentral-Asiens. Veröff. Zool. Staatssamml. München, 16, 69-170.

Herrström, G., 1964. Untersuchungen über Parasiten von Ölfruchtschädlingen in Schweden. Meddn. St. VäxtskAnst., 12 (99), 443-448.

Horstmann, K., 1967. Bemerkungen zur Taxonomie der Tersilochinen (Hym. Ichneumonidae). Opusc. Ent., 32, 123-130.

Horstmann, K., 1971. Revision der europäischen Tersilochinen I. Veröff. Zool. Staatssamml. München, 15, 45-138.
Jourdheuil, P., 1960. Influence de quelques facteurs écologiques sur les fluctuations de population d'une biocénose parasitaire: étude relative à quelques hyménoptères (Ophioninae, Diospilinae, Euphorinae) parasites de divers coléoptères inféodès aux crucifères. Ann. Epiphyt., 11, 445-658.
Lehmann, W., 1965. Der einfluss chemischer Bekämpfungsmassnahmen auf einige Parasiten von Rapsschädlingen. Mitt. Biol. Bundesanst. Land-u. Forstw., 115, 35-42.
Leuchs, F., 1956. Uber die Ursachen des Massenwechsels von Meligethes aeneus F. und einige anderen Ölfruchtschädlingen. Unveröff. Diss. Bonn.
Nilsson, C., 1980. Rapsbaggens Meligethes aenens F. (Col.), inverkan på höstrapsens avkastning. Fältförsök 1969-1971. Växtskyddsnotiser 44, 109-114.
Nilsson, C., 1985. Impact of ploughing on emergence of pollen beetle parasitoids after hibernation. Z. ang. Ent., 100, 302-308.
Nilsson, C., 1986. Yield losses in summer rape caused by pollen beetles (Meligethes spp). (In prep.).
Osborne, P., 1960. Observations on the natural enemies of Meligethes aeneus (F.) and M. viridescens (F.) (Col., Nitidulidae). Parasitology, 50, 91-110.

A SHORT BIBLIOGRAPHICAL REVIEW OF TRICHOMALUS PERFECTUS WALKER, A PARASITE OF THE SEED POD WEEVIL, CEUTHORRHYNCHUS ASSIMILIS PAYK.

Jacques LERIN
INRA, Centre de Poitou-Charentes, Laboratoire de Zoologie,
F. 86600 LUSIGNAN

Summary

The larval ectoparasite Trichomalus perfectus Walker is the commonest parasite of the seed pod weevil. Monitoring its numbers, therefore, may be one way of obtaining a good indication of whether pyrethroids applied to kill insect pests of rape also kill the natural enemies of these pests.

1. Introduction

The aim of this study was to find information on parasites of the seed pod weevil in order to assess the impact of pyrethroids on the levels of parasitism recorded throughout northern Europe.

The parasite name which appears most frequently in the papers reviewed (see references) is Trichomalus perfectus Walker, an ectoparasite, belonging to the family of the Hymenoptera called the Pteromalidae.

The analysis of earlier papers is complicated because this species has the following synonyms : Trichomalus perfectus Walker = T. fasciatus Thomson = T. herbidus Walker = T.laevinucha Thomson = Pteromalus decorus Walker = P. decisus Walker (4, 22). The several synonyms from the same two authors indicate that polymorphism is common.

Nevertheless T. perfectus is nearly always the most abundant ectoparasite of the seed pod weevil : infesting from 80 % to 90 % of weevil larvae in the USA (25), Poland (5, 6, 7, 8) and Germany (32). Among the other ectoparasites of the pest is Xenocrepis pura Mayr (= Mesopolobus morys Walker) which occurs quite frequently (5, 18) and also belongs to the Pteromalidae.

2. Some basic facts on the biology of T. perfectus

A description of this small greenish hymenopteran can be found in the paper by DELUCCHI & GRAHAM (4).

The major immigration of this parasite into the crop occurs 3 to 4 weeks after the pods become infested by the seed pod weevil (6, 22). The parasite lays its eggs, usually one per pod, preferentially in pods containing well developed weevil larva. It seems that odours from the frass of the final instar of C. assimilis enable female parasites to find their hosts (9). The parasite larva feeds externally and completes its development on one weevil larva. Pupation occurs in the pod without any cocoon. The new adult hymenopteran leaves the pod before the crop is harvested by boring an exit hole that is smaller than those bored by healthy seed weevil larvae. Complete developement of one generation lasts about 18 days : egg stage 3 days, larval stage 7 days, pupation 8 days (7).

The adult females can also kill some seed pod weevil larvae without laying, apparently to use the dead larvae as food (33).

Parasited seed pod weevil larvae stop feeding during the third instar and cause less damage than healthy larvae. The percentage of parasited larvae differs considerably between fields and between years. Up to 95 % of seed pod weevil can be parasited. Personal observations, in 1980, indicate that, even with extremely low population of C. assimilis, the parasites can be highly effective. Of 127 plants examined in 1980 although, only 0.95 seed pod weevil larvae were recorded per plant, 69 % of them were parasited.

3. Conclusion

Conservation of ectoparasites of the seed pod weevil is important since such parasites help to stabilize C. assimilis populations. The impact of pyrethroids sprays on the parasite Trichomalus perfectus is worthy of further study since the parasite is common everywhere in Europe. Since a major aim of this study was to establish a list of references, although many of the 34 references listed below have not been cited in the text, they have nevertheless been included for completeness.

REFERENCES

1. ANKERSMIT G.W. (1956). The biology and control of the colza seed-pod weevil (Ceuthorrhynchus assimilis Payk.) and the brassica pod midge (Dasyneura brassicae Winn). Versl. Landbouwk. onderz., 62 (9), 59 pp.

2. BONNEMAISON L. (1957). Le charançon des siliques (Ceuthorrhynchus assimilis Payk.). Biologie et méthodes de lutte. Ann. Epithyties 4, 387-543.

3. CARLSON E.C., LANGE JR W.M., SCIARONI R.H. (1950). Brussels sprouts seed loss in California caused by the cabbage seedpod wevil. J. econ. Entomol. 4, 389-390.

4. DELUCCHI V., de GRAHAM V.M.W.R. (1956). La révision du genre Trichomalus Thomson (1878) (Chalcidoidea, Pteromalidae). Beit. Z. Ent. 6, 543-576.

5. DMOCH J. (1975). Study on the parasites of the cabbage seed weevil (C. assimilis Payk.). I. Species composition and economic importance of the larval ectoparasites. Rocz. Nauk Roln. 5 (1), 99-112 (in polish).

6. DMOCH J. (1975). Study on the parasites of the cabbage seed weevil (C. assimilis Payk.). II. Relation between the times of occurrence and development of the cabbage seed weevil and those of its parasites on winter rape. Rocz. Nauk Roln. 5 (1), 113-124 (in polish).

7. DMOCH J., KLIMEK G. (1975). Study on the parasites of the cabbage seed-pod weevil (C. assimilis Payk.). III. Observations on the biology of Trichomalus perfectus (Walker). Rocz. Nauk Roln. 5 (1), 125-136 (in polish).

8. DMOCH J.(1978). Biological principles of the protection of winter rape against pests. Proceedings of the XVII Conference of the Scientific Institute for plant Protection, 333-345 (in polish).

9. DMOCH J., RUTKOWSKA-OSTROWSKA Z. (1978). Host finding and host acceptance mechanism in Trichomalus perfectus Walker (Hymenoptera, Pteromalidae). Bulletin de l'Académie polonaise des sciences C II vol. 26 (5), 317-329.

10. DOUCETTE C.F. (1951). Distribution and control of the cabbage seed-pod weevil in California. J. Econ. Entomol., 44, 958-965.

11. DOUCETTE C.F. (1948). Field parasitization and larval mortality of the cabbage seed-pod weevil. J. Econ. Entomol., 41, (5), 763-765.

12. GAMAN A.B. (1941). A revision of the parasitic wasps of the genus Necremmus Thomson (Eulophidae, Hymenooptera). J. Wash. Acad. Sci. 31, 196-303.

13. GODAN D. (1959). Mymar autumnalis (Foerst.) (Anaphes autumnalis Foerst.) (Chalcidoidea Mymar.) ein bisher unbekannter Eiparasit des Kohlschottenrüsslers. Nachrichtenbl. dtsch. Pflanzenschutzdienstas 11, 161-164.

14. GUNTHART E. (1949). Beiträge zur Lebenweise und Bekämpfung von Ceuthorrhynchus quadridens Panz. and Ceuthorrhynchus napi Gyll. mit Beobachtungen an weiteren Kohl-u. Rapsschädlingen. Mitt. schweiz. entomol. Ges. 22, 443-591.

15. HERRSTROM G. (1964). Untersuchungen über Parasiten von Olfruchtschädlingen in Sweden. Meddn. St. Wäxtsk. Anst. 12, 433-448.

16. HEYMONS R. (1922). Mitteilungen über den Rapsrüssler Ceuthorrhynchus assimilis Payk. und seinen Parasitten Trichomalus fasciatus Thoms. Z. angew. Entomol. 8, 93-111.

17.JOURDHEUIL P. (1957). Observations sur les ennemis naturels des coléoptères vivants sur les crucifères oléagineuses. C.R. Acad. Agric. Fr. 43, 593-596.

18.JOURDHEUIL P. (1961). Influence de quelques facteurs écologiques sur les fluctuations de population d'une bioceonose parasitaire. Ann. Epiphyties 11, 445-658.

19.JOURDHEUIL P. (1963). Les phénomènes de compétition parasitaire et la dynamique des populations. XI Int. Kongr. Ent. Wien 1960, 703-705.

20.JOURDHEUIL P., COUTIN R., LACOTE J.P. (1974). Evolution du niveau des populations de Ceuthorrhynchus assimilis Payk. dans le Lauragais. Informations techniques CETIOM 38, 11-13.

21.KAUFMANN O.,(1925). Beobachtungen und Versuche zur Frage der Uberwinterung und Parasitierung von Olfruchtschädlingen aus den Gattungen Meligethes, Phyllotreta, Phylliodes und Ceuthorrynchus. Arb. biol. Reichsanst. Land.-Forstw. 12, 109-169, Berlin.

22.LABORIUS von A.(1972). Untersuchungen über die Parasitierung des Kohlschotenrüssler (C. assimilis Payk.) und der Kohlschotengallmücke (Dasyneura bassicae Winn.) in Schleswig-Holstein. Z. angew. Zool. 1, 14-31.

23.LEHMANN W.(1965). Einfluss chemischer Bekämpfungmassnahmen auf einige Parasiten von Rapsschädlingen. Mitt. biol. Bundesanst. Land Forstwirtsch. Berlin, Dahlem 115, 35-42.

24.MACELJSKI M., BALARIN I., DANON V. (1980). Results of long term investigations on the occurrence and harmflulness of insects on oil seed rape. Zast. Bilja 31(4), 317-324.

25.Mc LEOD J.H. (1962). Notes on the cabbage seed-pod weevil, Ceuthorrhynchus assimilis Payk. (col. Curculionidae) and its parasites. Proc. Entomol. Soc. B.C. 49, 11-18.

26.REGNAULT Y., BALLANGER Y., JOURDHEUIL P. (1979). La lutte intégrée en culture de colza. Proc. of the International Symposium of IOBC/WPRS on integreted control in agriculture and forestry. Vienna 8-12th Oct. 1979, 205-210.

27.RISBEC J. (1953). Contribution à l'étude des parasites du charançon du colza, Ceuthorrhynchus assimlis Payk. Rev. Pathol. veg. Ent. Agric. 32, 37-43 (F).

28.ROSEN H.V. (1964). Untersuchungen über die Verbreitung und Biologie von zwei Pteromaliden in Rappsschotten (Hym. Chalcidoidea). Stat. Växtskyddsanstalt Medd. 12, 453-465.

29.SKROCKI C. (1972). Biology of the turnip seed weevil (Ceuthorrhynchus assimilis Payk.). Rocz. Nauk Roln., E. 2 (2), 7-20. (in Polish).

30.SPEYER W. (1925). Kohlschotenrüssler (Ceuthorrhynchus assimilis Payk.), Kohlschotenmücke (Dasyneura brassicae Winn.) und ihre Parasiten. Arb. biol. Reichsanstalt Land-und Forstwirtschaft, Berlin-Dohlem 12, 79-108.

31.SZCZEPANSKI H. (1972). The rape Pteromalid Trichomalus perfectus Walk. (Hym. Pteromalidae) in forest biocenosis and the problem of biological protection of rape. Pol. Pismo entomologiczne 4, 865-871. (in Polish)

32.THIEM E.(1970). Die Bedeutung der Feldrandbehandlung für die Bekämpfung von Dasineura brassicae Winn. und Ceuthorrhynchus assimilis Payk. in blühenden Raps und der Einfluss dieser Insektizidmassnahme auf das Vorkommen von Trichomalus perfectus Walker an den Larven des Kohlschotenrüsslers. Arch. Pflanzenschutz 2, 83-98.

33.WALZ A.J. (1956). Observations on the biologies of some hymenopterous parasites of the cabbage seed pod weevil in Northern Idaho. Ann. Entomol. Soc. Am. 60, 219-220.

34.WEISS H., 1940. Beiträge zur Biologie und Bekämpfung wichtiger Oelfruchtschädlinge. Zur Biologie und Bekämpfung von Ceuthorrhynchus assimilis Payk. und Meligethes aeneus. Beiheft Z. Zeitschr. Angew. Ent. 26, n° 14.

RAISONNEMENT DE LA LUTTE CONTRE LE GROS CHARANCON DE LA TIGE DU COLZA (Ceuthorrhynchus napi GYLL).

Y. BALLANGER - CETIOM*.
(* CEntre Technique Interprofessionnel de Oléagineux Métropolitains)

En France, le Charançon de la tige (Ceuthorrhynchus napi GYLL.) est un ravageur important des cultures de Colza d'hiver. Une surveillance vis à vis de cet insecte est mise en oeuvre dans toutes les régions de production. Chaque année, des dégâts importants sont cependant enregistrés, comme - par exemple - en région Midi-Pyrénées, en Lorraine et dans le Sud-Est en 1985 (De la TAILLE - 1985 ; WIMMER - 1985).

1 - Rappels -

Les adultes ne sont pas directement nuisibles. Pour l'essentiel, les dégâts occasionnés par ce Ceuthorrhynque sont liés à la désorganisation des tissus des tiges en croissance en réaction aux dépôts d'oeufs par les femelles. Aprés la ponte, on peut considérer que le développement des larves dans les tiges ne contribue guére à l'aggravation des dégâts. Des nécroses, dûes en particulier au Phoma (Phoma lingam), se développent souvent sur les tiges attaquées.

2 - Principes du raisonnement de la lutte -

Pour lutter contre les ravageurs du Colza d'hiver en général et contre le Charançon de la tige en particulier, le CETIOM préconise une bonne surveillance de la culture et des ravageurs afin de définir dans chaque cas (CETIOM - 1979 ; CETIOM - 1985) :
- "le stade sensible" du Colza (En dehors de la période sensible, les risques de dégâts sont moindres, même si le ravageur est présent) ;
- "le seuil de traitement" (Il ne devient rentable de traiter que si la population du ravageur - au stade sensible - dépasse une certain niveau).

Le choix de la méthode de contrôle est également discuté.

3 - Etudes réalisées -

Pour préciser le stade sensible des cultures et apporter des éléments pour l'élaboration d'un seuil de traitement, des études de plein-champ ont été menées : dans la région de Bourges (Centre), de 1974 à 1981 ; dans la région de Valence (Sud-Est), de 1981 à 1985.

On a d'abord cherché à décrire avec précision tous les paramétres des attaques observées chaque année - Dans le cadre d'études de dynamique de populations, on a largement pratiqué : le piégeage à l'aide de cuvettes jaunes, les estimations de populations imaginales, embryonnaires et larvaires, le suivi de cultures, les descriptions de dégâts, ...

Les essais proprement dits ont d'abord consisté en des introductions d'insectes sous cages (1976, 1978). Dans le même temps et par la suite, on a développé des essais strictement de plein-champ dont la méthodologie a évolué progressivement avant de produire de résultats (1976 à 1984). Sur le principe, il s'agit, au sein de cultures non protégées, de préserver des placettes indemnes de tous dégâts (Témoins sains) en recourant à des protections insecticides localisées (BALLANGER - 1981). L'évolution s'est faite dans le sens de la réduction de la taille des parcelles élémentaires (Pour limiter l'importance relative des surfaces traitées et permettre des récoltes manuelles), de l'éclatement du dispositif expérimental (Pour éviter toutes incidences sur la répartition des insectes en conséquence des traitements insecticides localisés), du choix de l'insecticide appliqué sur les témoins (Un pas décisif a été franchi avec l'utilisation d'un pyréthroïde - le Décis dans ce cas - qui a toujours permis de protéger trés efficacement des placettes de 6 mètres sur 6, même au sein de cultures trés attaquées), puis de la réduction du nombre de parcelles par essai (Au profit d'un plus grande nombre de situations d'essais).

4 - Le stade sensible de la culture -

On a longtemps considéré que le stade sensible de la culture allait du stade "C2" (Entre-noeuds visibles, on voit un étranglement vert-clair à la base des nouveaux pétioles : c'est la tige) au stade "D2" (Inflorescence principale dégagée, boutons accolés, inflorescences secondaires visibles) dépassé, lorsque la tige atteint la hauteur de 20 cm (CETIOM - 1979) - Nos résultats conduisent à remettre en cause les deux bornes de ce stade sensible.

a - Au début du stade sensible, à Valence, les vols d'envahissement des cultures sont trés précoces et les femelles sont souvent aptes à la ponte avant que l'allongement des tiges ne s'engage. Dans ces conditions : on observe des dépôts d'oeufs atypiques, en dehors des tiges ; l'attaque sur tige est déjà bien engagée avant que le stade "C2" ne soit atteint.

- A la reprise de végétation, le Colza se redresse et les pétioles des feuilles gainent l'axe de la plante qui commence à s'allonger. Les femelles ne pouvant accéder à la tige perforent les pétioles par la face inférieure. On dénombre alors : une majorité d'oeufs déposés dans l'épaisseur du pétiole (En réaction à la ponte, les tissus végétaux prennent un aspect cotonneux, le pétiole tend à s'aplatir, l'épiderme supérieur éclate, ... le processus est trés comparable à ce que l'on observe avec les tiges) ; quelques oeufs abandonnés à la face supérieure du pétiole ; de rares oeufs peu profondément enfoncés dans la tige, la ponte ayant été effectuée au travers d'un pétiole. Ces premiers dépôts d'oeufs ne sont jamais trés importants, on peut sans doute considérer qu'ils n'ont pas d'incidences défavorables.

- Dés que les plantes commencent à s'allonger, les femelles précocément aptes à pondre s'insinuent entre la base des jeunes feuilles terminales dressées et commencent à pondre dans l'axe des plantes. Ceci est possible avant que la tige ne soit directement visible, au niveau de la plante (Entre-noeuds visibles), et surtout au niveau de la culture (Un stade est atteint lorsque 50 p.cent des plantes sont à ce stade).

b - A la fin du stade sensible, à Bourges, si les charançons investissent plus ou moins tôt les cultures à la fin de l'hiver, la ponte n'est jamais bien engagée avant que les tiges n'atteignent 20 cm de hauteur.

- Dans cette région, les attaques observées sont plutôt faibles. Mais cette constatation est à mettre en relation avec la faiblesse générale des niveaux d'infestation, elle même vraissemblablement liée à la briéveté de la période de ponte qui limite le potentiel de multiplication de l'espèce (Les dépôts d'oeufs ne sont plus guère possibles aprés la mi-floraison). Mais, sur la période 1974-1980, des attaques assez généralement fortes ont été observées en 1979 : cette année-là, les insectes ont dû se répartir sur des emblavements ne représentant guére que le tiers de ceux des années précédentes, aprés les difficultés de mises en place des cultures liées à la sécheresse de l'automne 1978.

- Quoi qu'il en soit, et même si les capacités de ponte des femelles sont réduites lorsque l'allongement des tiges est bien avancé, la nuisibilité du Charançon de la tige est loin d'être nulle lorsque la ponte est déposée dans des tiges de plus de 20 cm. Ainsi, par un essai de plein-champ réalisé en 1980 - par exemple, on a pu mettre en évidence une perte de rendement moyenne de 12 % (Témoin-sain : 36 qx/ha de "Grain propre et sec"). Dans ce cas : chaque plante a reçu - en moyenne - 7,5 piqûres de ponte, déposées entre le stade "Tige 20 cm" et la mise à fleur (Culture alors traitée) ; 25 p.cent des plantes récoltées ont été classées "Plantes à tiges nettement déformées" (Seulement 2 p.cent de tiges éclatées) - (BALLANGER - 1981).

5 - Bases d'un seuil de traitement -

a - Pour élaborer un seuil de traitement, on n'a jamais cherché à prendre comme référence le niveau d'infestation de la culture par les adultes.

Ces derniers sont peu visibles et occasionnent des dégâts à faible densité de population (Quelques individus par m2). A plusieurs occasions, avec des coffres à épuisement ("Boites noires" couvrant 1 m2 au sol, les insectes étant capturés avec un piège à eau adapté sur un trou de sortie laissant passer la lumière), on a obtenu - environ - 2 fois plus de charançons qu'en opérant des comptages minutieux et répétés sur les plantes et le sol.

b - On a longtemps cherché à utiliser l'importance des captures réalisées avec des cuvettes jaunes maintenues comme posées sur la végétation.

Sur le plan qualitatif, on s'accorde aujourd'hui pour penser qu'un "Réseau de piégeage" permet de repérer de façon satisfaisante les périodes de vol du ravageur et donne ainsi des éléments de raisonnement de la lutte (Présence - absence dans les cultures).

Sur le plan quantitatif, on a - à la fois : démontré qu'il n'y a pas relation simple entre l'importance des captures réalisées pendant la période d'envahissement de la culture par les insectes (Charançons capturés avec une cuvette jaune placé à 10 mètres de la bordure du champ de Colza en regard de l'ancien Colza le plus proche) et le niveau d'infestation de cette culture (Nombre de charançons présents par m2) ;

échoué dans des tentatives d'utilisation de seuils empiriques (Par exemple : des captures supérieures à 10 charançons en 24 heures sont un seuil d'alerte, traitement sous 8 jours, si les captures dépassent nettement 10 insectes par jour).

En expérimentation, on a fréquemment observé des attaques insignifiantes succédant à des captures relativement abondantes (Plus de 50 charançons capturés, parfois plusieurs centaines) ; dans la pratique agricole, les observateurs signalent souvent des attaques graves alors que la cuvette jaune n'a pas fonctionné.

c - Aujourd'hui, et la remarque concerne également les autres ravageurs du Colza d'hiver, on tend plutôt à préserver les plantes qu'à limiter l'importance de la menace causée par la présence du Charançon en rattachant le "seuil de traitement" à un "seuil de dégâts".

- Cette démarche vient en conclusion logique des enseignements tirés des observations réalisées dans la région de Bourges.

Lorsque la ponte s'engage sur des plantes déjà bien développées (Tiges d'au moins 20 cm), on observe une tolérance aux faibles attaques. Ainsi, tant que les dépôts d'oeufs moyens - estimés au terme de la ponte - ne correspondent pas à plus de 2 à 3 piqûres de ponte par tige, on n'observe pas de limitation de la production de graines. A l'inverse, on dégage une tendance à la surcompensation, observée à la fois pour les essais d'introductions sous cages et les essais de plein champ - Figure 1. Dans ce contexte, on peut donc proposer de tester le caractère opérationnel d'un seuil de traitement basé sur la surveillance du niveau des dégâts observés sur les plantes, dans la culture : "Ne pas traiter tant que le seuil de 1 piqûre par plante n'est pas atteint".

- Les résultats obtenus ultérieurement dans la région de Valence ne permettent pas d'envisager une simple généralisation de cette démarche.

Lorsque les femelles sont prêtes à pondre avant même que l'élongation des tiges ne s'engage, la nuisibilité du Charançon de la tige devient beaucoup plus forte et la culture de Colza d'hiver ne présente plus aucune tolérance aux attaques du ravageur.

En première analyse, on dégage une relation "Pertes de rendement - Intensité de l'attaque (Ponte)" quasi-linéaire, la pente de la droite de régression étant forte. Ainsi, pour une attaque faible, de l'ordre de 1 piqûre de ponte par plante au terme de la ponte, on peut s'attendre à une perte de rendement de l'ordre de 3,8 % (En conditions favorables à la plante : printemps humide) à 8,7 % (En conditions difficiles pour la plante : printemps sec) - Figure 1.

Sur 17 cultures étudiées en 1982, 1983 et 1984 - conduites en l'absence de protection insecticide visant le Charançon de la tige et abritant un essai destiné à mettre en évidence la nuisibilité de ce ravageur - dans 17 cas, on a observé au moins 0,7 piqûres de ponte par plante ; dans 12 cas, au moins 1,0. Autrement dit, chaque année, des mesures de contrôle quasi-systématiques seraient justifiables (Sur la base d'une simple confrontation du coût de l'intervention insecticide et de la préservation minimale attendue du rendement).

En tout état de cause, le raisonnement de la lutte prenant en compte la mise en évidence des premiers dégâts devient trés délicat.

- Plus que précédemment, il faut sans doûte considérer que les piqûres de ponte n'ont pas toutes la même incidence et que les piqûres les plus précoces sont certainement plus traumatisantes que les piqûres subies en dernier lieu.

- Dans un contexte de forte attaque, un accroissement du niveau moyen d'attaque de 1 piqûre de ponte par plante est observable en quelques jours.

- Il faut naturellement tenir compte des délais de mise oeuvre du traitement insecticide, aprés décision d'intervention en réponse à des observations ayant rarement une fréquence journaliére.

6 - Conclusions -

Il n'est donc pas vain de poursuivre les études sur les ravageurs déjà "bien connus" de la culture de Colza d'hiver, même si les enseignements tirés ne vont pas dans le sens de la simplification.

Dans le cas du Charançon de la tige rapporté ici, on est amené à préconiser un rallongement du stade sensible de la culture, en prenant en compte le début (Avant le "stade" C2) et la fin (Au delà du stade "Tige 20 cm") de la période de ponte, et à suggérer un raisonnement de la lutte différent mais adapté à chacune des deux modalités d'attaques observées, c'est à dire à chacune des deux zones de production considérées.

REFERENCES :

BALLANGER Y.. 1981 - Le Gros Charançon de la tige du Colza (Ceuthorrhynchus napi GYLL.) : Nouvelles bases d'expérimentation - C.R. 6émes Journ. Phyt. Phytoph. Circum-med. : 133-141.

CETIOM, 1979 - Cahiers Techniques Colza d'hiver n°4 : Insectes, limaces, pigeons - Document CETIOM - Paris, 40 pp.

CETIOM, 1985 - Cahiers Techniques Colza d'hiver : Insectes et autres ravageurs - Document CETIOM - Paris, 55 pp.

De la TAILLE G., 1985 - Bilan de la récolte colza 1985 - Bull. CETIOM, 91 : 10-15.

WIMMER F., 1985 - Caractéristiques de la campagne 1984-85 par le Service de la Protection des Végétaux - C.R. du Sous-comité technique culture "Colza", document CETIOM - PARIS, page 20.

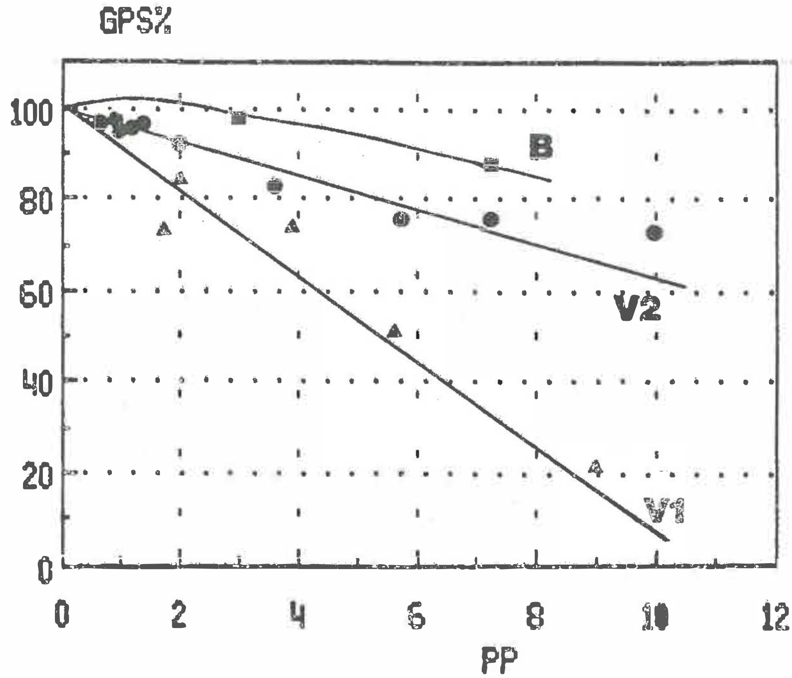
FIGURE 1 - Etude de la nuisibilité - au champ - du Charançon de la tige, essais réalisés en :

- 1980 et 1981 (B), dans la région de Bourges (Attaques tardives : la ponte s'engage alors que la hauteur des tiges avoisine 20 cm) ;

- 1981 (V1 : printemps sec) et 1982 et 1983 (V2 : printemps humides), dans la région de Valence (Attaques précoces : la ponte s'engage dès le début de formation des tiges).

GPS % : récoltes de graines (Grain propre et sec) -

PP : piqûres de ponte par plante (Estimation au terme de la ponte) -



FACTORS INFLUENCING THE SEVERITY OF CABBAGE ROOT FLY INFESTATIONS IN CROPS OF OILSEED RAPE

S. FINCH & T.H. JONES

Institute of Horticultural Research, Wellesbourne, Warwickshire, CV35 9EF

SUMMARY

During plant establishment, oilseed rape crops are highly preferred for oviposition by the cabbage root fly. The fly, however, prefers not to lay on plants growing in clay soils, particularly when such soils are wet. Survival of the insects is also lower in clay soils. Cabbage root fly populations must establish on oilseed rape crops in the autumn to produce sizeable infestations in the crop during the following spring. Infestations from oilseed rape crops, that could increase pest control problems in vegetable brassicas, are at present easy to contain by applying insecticide to autumn rape crops, but only on light soils in localities known to contain high populations of this pest.

INTRODUCTION

The area of oilseed rape in England and Wales has increased over ten-fold since 1974, from about 24,500 to about 300,000 ha. Meanwhile, the area of vegetable brassicas, totalling about 55,000 ha, has not changed appreciably and so vegetable brassicas are now overshadowed at least five-fold by the oilseed rape crop (Wheatley & Finch, 1984).

Some of the effects that this rapid expansion in the area of land sown with oilseed rape has had on populations of insect pests normally associated with cruciferous vegetable crops have been described in earlier studies (Wheatley & Finch, 1984; Skinner & Finch, 1987). The cabbage root fly, *Delia radicum* (L.), will be the only insect considered in this paper.

The earlier results showed that although all rape crops were not infested by the cabbage root fly, the populations in those that were gave cause for concern. For example, the cabbage root fly populations in fields near Wellesbourne apparently increased 16-fold in the 8-year period prior to 1984 (Wheatley & Finch, 1984). This paper describes experiments to determine the factors that predispose certain crops to attack by this pest, and explains why the rape crop in both 1985 and 1986 contributed only relatively small numbers of the fly to local vegetable crops.

MATERIALS & METHODS

Laboratory experiments were carried out to determine whether oilseed rape is as preferred by the fly for oviposition as some of the more preferred cultivars of vegetable brassicas. The work included experiments to show how plant preference was affected, in choice and no-choice situations, by the type of soil in which the plants were growing and by the wetness of the soil.

Production of plants
All plants were grown in loose-filled cells in Hassy trays and were fed solely on a solution of potassium nitrate. Using this technique, plant development could be arrested at the 3-4 leaf stage for protracted periods without the plants senescing. For all experiments, plants were potted into 7.5 cm diameter pots containing John Innes compost and were then allowed 1 week to establish before being tested. The three plant types used in these experiments were swede (Brassica napus L. var. napobrassica D.C. (L.) Reichenb.),cv. Acme; cauliflower (Brassica oleracea var. botrytis L.), cv. White Rock; and oilseed rape (Brassica napus L. var. oleifera (E.&G.)), cv. Jet Neuf.

EXPERIMENTAL

Laboratory experiments

All experiments were carried out in a test chamber consisting of three 65 x 65 cm and 45 cm high cages arranged one above the other (Ellis & Hardman, 1975). Each cage contained a 60 cm diameter turntable which rotated once every 4 minutes. Test plants were arranged regularly, though in random order, on the turntables. At any one time, either six or twelve plants were tested and equal numbers of 5-6 day-old male and female flies were released into each cage. Forty and eighty flies were released into the cages containing six plants and twelve plants, respectively. The flies were allowed to lay for one day and then the eggs were washed from around the base of each test plant and counted.

Effect of plant type

Plant preference - No-choice situation. Six plants of the same plant type were tested in one cage. The other two plant types were tested in a similar no-choice situation in the other two cages. The mean numbers of eggs recovered from the swede, oilseed rape and cauliflower after one day of oviposition were 37, 33 and 37/plant, respectively. These similar numbers of eggs indicate that if the fly found an isolated young crop of any of these plant types in the field, it would probably be considered suitable for colonisation.

Plant preference - Choice situation. In the first of these experiments, six plants of each of two plant types were placed in each cage to compare their relative effectiveness at stimulating cabbage root fly oviposition. The results (Table 1) show that swede was more stimulating than the other two plant types tested. The oilseed rape cultivar, Jet Neuf, was also more stimulating than the cauliflower cultivar, even though the latter was selected originally as being highly-preferred as an oviposition site by the cabbage root fly.

In a separate experiment when all three cultivars were tested at the same time, totals of 134, 234 and 310 eggs were recovered from the cauliflower, oilseed rape and swede plants, respectively, confirming the order of preference shown in Table 1.

Table 1. Mean numbers of eggs laid/plant/day (18 replicates) when cabbage root fly were provided with a choice of two different types of brassica host-plant

Host plant A	Eggs laid on A	Eggs laid on B	Host plant B
Swede	59	25	Oilseed rape
Cauliflower	13	48	Oilseed rape
Cauliflower	28	60	Swede

L.S.D. ($\underline{P}$ = 0.05) = 18

Effect of soil type

Soil preference - No-choice situation. Eighteen plants of each cultivar were potted in clay, loam or peat. Six plants of one type were then tested in each of the three cages of the test chamber. Similar numbers of eggs were recovered from all plant and soil types (Table 2), indicating that the fly does not retain its eggs even when the oviposition medium may not be optimal.

Table 2. Mean numbers of eggs laid/plant/day when cabbage root fly were provided with a no-choice situation of one of three host-plants growing in one of three soils.

	Soil type		
Plant type	Clay	Loam	Peat
Cauliflower	34	26	37
Oilseed rape	23	30	34
Swede	24	33	22

L.S.D. ($\underline{P}$ = 0.05) = 12

Soil preference - Choice situation. When the fly was provided with one plant type but with a choice of soil types, fewer eggs were laid around the plants potted in the clay soil than in those potted in either loam or peat (Table 3). The soil around the base of each plant was in a dry, crumbly condition at the time of the test.

Table 3. **Mean numbers of eggs laid/plant/day when cabbage root fly were provided with the choice of one cultivar growing in three different soils.**

	Soil type		
Plant type	Clay	Loam	Peat
Cauliflower	16	54	55
Oilseed rape	14	49	42
Swede	37	61	76

L.S.D. (P = 0.05) = 18

Comparison of wet and dry soils. Plants were potted in the three types of soil and one day before the start of the experiment half of the pots were immersed in water to bring the soils to a wetness approaching 'field capacity'. Whether the soil was wet or dry did not appear to deter the fly from ovipositing in loam and peat soils but, given a choice, the flies preferred not to lay in wet clay soils (Table 4).

Table 4. **Mean numbers of eggs recovered/plant when cabbage root fly were provided with a choice of wet and dry soils.**

	Soil status	
Soil type	Wet	Dry
Clay	13	58
Loam	52	60
Peat	63	62

L.S.D. (P = 0.05) = 12

Survival of larvae in different soil types. In this experiment, the roots of plants removed from Hassy trays were washed free of the potting compost before being re-potted in clay, loam or peat. All plants were allowed two weeks to re-establish and then each plant was inoculated with 40 cabbage root fly eggs from a laboratory culture (Finch & Coaker, 1969). Thirty plants of each type were inoculated and then maintained in a moist, but not wet, condition for 5 weeks to allow any developing insects to reach the pupal stage. The pupae were then washed from the various soils and counted.

Table 5. Mean number of cabbage root fly surviving to the pupal stage from eggs inoculated onto host-plants growing in three different soil types (40 eggs inoculated/plant).

	Soil type		
Plant type	Clay	Loam	Peat
Cauliflower	9	11	15
Oilseed rape	11	13	18
Swede	9	11	19

L.S.D. ($\underline{P}$ = 0.05) = 2

On all three plant types, fewer insects survived to the pupal stage in the clay than in the other two soils (Table 5). In addition, survival was also improved markedly when the plants were growing in peat rather than in loam soils. This confirms field results, which showed that pupae were more numerous around the roots of a particular cultivar grown in peat soils than around roots of the same cultivar grown in different soil types in neighbouring fields (Finch, unpublished data).

Field-cage experiments

To determine whether oilseed rape plants that had overwintered in the field could support similar numbers of cabbage root fly as transplanted spring crops, 36 oilseed rape plants were lifted in the spring from a crop that had not been damaged by the fly during the previous autumn. These plants and 36 cauliflower plants, cv Perfection, were transplanted 0.6m apart, in a 6m x 3m and 2m high field cages made of Tygan netting (Finch, 1971). Six of the oilseed rape and cauliflower plants in each cage were inoculated with 0, 10, 20, 40, 80 or 160 cabbage root fly eggs, respectively, and then the treatments were each replicated six times. In addition to the field-cage experiments, oilseed rape plants left undisturbed in the field in which they had overwintered, were also inoculated with 20, 40, 80 or 160 eggs. Eight weeks after inoculation, the numbers of cabbage root fly pupae around the roots of the experimental plants were determined by taking 15 cm diameter soil cores (Jarret Soil Sampler: Baird & Tatlock Ltd), each containing the main root system of one plant. The pupae were separated from the soil by stirring each sample into a 9-litre bucket of water. The water and floating material were then poured onto a 1.7 mm aperture sieve on which any pupae were rinsed clean, collected and counted (Finch, Skinner & Freeman, 1978).

The results in Table 6 show that undisturbed, previously-undamaged oilseed rape plants did not support cabbage root fly infestations in the spring. In contrast, plants from the same oilseed rape field that were transplanted into the field-cage supported similar numbers of cabbage root fly pupae as transplanted cauliflowers, a crop that generally supports high numbers of this pest. The transplanted oilseed rape plants supported the pest because their roots were damaged during transplanting. Once roots of brassica plants are damaged in any way, they invariably respond by producing an abundance of adventitious roots just below the surface of the soil. It is these tender roots that the small cabbage root fly larvae penetrate to establish themselves on this crop in the spring. Hence, for the cabbage root fly to establish on oilseed rape crops in the spring, it must damage the plants during the previous autumn when they are still small and tender. When this occurs, the plants produce an abundance of adventitious roots in the spring so that when the fly emerges from the overwintering pupae, the plants on which it developed are still highly favourable as host-plants for its offspring.

Table 6. **Numbers of cabbage root fly pupae recovered from transplanted cauliflower, transplanted oilseed rape and undisturbed oilseed rape plants inoculated with various numbers of cabbage root fly eggs in the spring of 1986.**

	Mean number of pupae recovered/plant		
Number of eggs inoculated	Transplanted cauliflower	Transplanted oilseed rape	Undisturbed oilseed rape
0	0	0	-
10	2	5	-
20	7	5	0
40	7	8	1
80	13	20	2
160	21	24	0

Field survey

In the 1984-85 crops of oilseed rape, fourteen fields were surveyed in the Wellesbourne area in November 1984 to estimate the root damage index (Rolfe, 1969) produced by the autumn infestation of cabbage root fly, and again in August 1985 to estimate the final numbers of insects that developed under the crops (Skinner & Finch, 1987). The highest infestation recorded was at Long Itchington where the root damage index was 45 in November 1984 and where an estimated 1080 pupae were recovered from each square metre of soil in August 1985. Similar damage and numbers of pupae were recorded in the same localities in the 1985-86 crop (Table 7). High infestations were not as common as previously, mainly because the summers of both 1985 and 1986 were cool and as a consequence permitted the development of only two generations of the fly. Hence, only the relatively small numbers of the fly that emerged towards the end of the second generation coincided with even the earliest of the autumn-sown oilseed rape crops.

Table 7. Assessment of overwintering root damage and cabbage root fly pupae/m² from thirty oilseed rape crops surveyed in the Wellesbourne locality during the 1985-86 season.

Locality		Soil type	Root damage index (Nov. 1985)	Mean pupae/m (Aug. 1986)
Long Itchington	)		29	900
Long Itchington	)	Light &	12	480
Eathorpe	)	sandy	8	360
Eathorpe	)		4	180
26 other sites		Mainly clay	0	8

DISCUSSION

The results and observations described in this paper indicate that, during its early stage of establishment, oilseed rape is as attractive a host-plant to the cabbage root fly as other highly-preferred brassica crops. This was not unexpected, however, since oilseed rape was selected from Brassica napus, the wild plant from which swede, the plant most preferred by the cabbage root fly, was also selected.

Laboratory results indicated that once the females were ready to lay, they laid similar numbers of eggs even on the less-preferred plant types. Hence, it seems likely that once the females locate a brassica crop their oviposition threshold falls relatively quickly, so that a crop that is far from preferred when the insects first arrive soon becomes acceptable.

In the present series of experiments, soil type exerted an influence comparable to plant type during selection of a suitable site for oviposition, provided a choice was available. The females preferred not to lay in clay soils particularly when such soils were wet. In addition, when eggs were laid in clay soils their relative survival to the pupal stage was considerably lower than in loam or peat soils.

With the vast hectareage of oilseed rape that is now grown, much of which is not treated to control insect pests normally associated with vegetable brassica crops, it seems somewhat surprising that pest problems in vegetable crops have not increased unduly. Probably the main reason why the cabbage root fly has not posed more of a threat is that most of the oilseed rape crop is now autumn-sown. As a result, when the fly population is out of synchronisation with the rape crop and fails to infest the crop in the autumn then, for all intents and purposes, such crops are not susceptible to attack by the fly in the spring. The fly was out of synchronisation with the crop in both 1985 and 1986 because the cool summers allowed the fly to complete only two generations. Although populations in the oilseed rape crop have declined in the last two years, this may not continue should 1987 be sufficiently warm to allow the fly to complete three generations. In theory, those years that permit the fly to complete three generations, so that a large autumn (third) generation coincides with the major period of establishment of the oilseed rape crop in early September, are those years when this crop will potentially pose the greatest threat to other cruciferous crops growing in the same locality.

In addition to the biological reasons why cabbage root fly populations from oilseed rape crops are not causing more problems in vegetable crops there are also three important cultural reasons. Firstly, in regions where oilseed rape is sown early and known to suffer considerable damage if not protected from root fly infestations, insecticide treatments are often applied at drilling. Secondly, even in those cases where no treatment is applied, if the pest severely damages the overwintering crop the grower has the option of ploughing the crop under since the pupal population beneath such a crop would be no higher than the population beneath a swede crop. Finally, and probably the most important constraint, is that oilseed rape is used as a break crop largely by cereal growers and, at present, is not grown in any great quantity in the traditional vegetable-growing localities. In the latter areas, the vegetable brassicas are used as the appropriate break crop in the rotation. Hence, considerable care may be required in vegetable-growing regions in future to ensure that growers who cannot produce vegetables at a competitive price do not upset the whole pest complex in the locality by using their land to grow oilseed rape.

REFERENCES

Ellis, P.R. & Hardman, J.A. (1975). Laboratory methods for studying non-preference resistance to cabbage root fly in cruciferous crops. Ann. appl Biol. 79, 253-264.

Finch, S. (1971). The fecundity of the cabbage root fly Erioischia brassicae under field conditions. Ent. exp. & appl. 14, 147-160.

Finch, S. & Coaker, T.H. (1969). A method for continuous rearing of the cabbage root fly Erioischia brassicae (Bouche) and some observations on its biology. Bull. Ent. Res. 58, 619-627.

Finch, S., Skinner, G. & Freeman, G.H. (1978). Distribution and analysis of cabbage root fly pupal populations. Ann. appl. Biol. 88, 351-356.

Skinner, G. & Finch, S. (1987). Oilseed rape as a source of cabbage root fly infestations for cruciferous vegetable crops. IOBC/WPRS Bulletin 1986 (in press).

Rolfe, S.W.H. (1969). Coordinated insecticide evaluation for cabbage root fly control. Proceedings 5th British Insecticide and Fungicide Conference, 238-243.

Wheatley, G.A. & Finch, S. (1984). Effects of oilseed rape on the status of insect pests of vegetable brassicas. 1984 British Crop Protection Conference - Pests and Diseases, 807-814.

x

Participants.

B. Bromand	National Research Centre for Plant Protection Institute of Pesticides Lottenborgvej 2 DK-2800 Lyngby, Denmark
L. Buchwaldt	National Research Centre for Plant Protection Institute of Plant Pathology Lottenborgvej 2 DK-2800 Lyngby, Denmark
M. Gerlagh	Research Institute for Plant Protection, IPO P.O.Box 9060 6700 GW Wageningen The Netherlands
P. Gladders	Agricultural Development and Advisory Service Ministry of Agriculture, Fisheries and Food Shardlow hall, Shardlow Derby DE7 2GN, U.K.
E. Choppin de Janvry	CETIOM 174, Avenue Victor Hugo 75116 - Paris, France
W. Krüger	Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für Pflanzenschutz in Ackerbau und Grünland, Messeweg 11/12 D - 3300 Braunschweig, BRD
J. Lerin	I.N.R.A. Centre de Lusignan Laboratorie de Zoologie 86600 - Lusignan, France
D. Martin	I.N.R.A. Station de Pathologie Vegetale - CNRA Route de Saint Cyr 78000 - Versailles, France
C. Nilsson	Sveriges Lantbruksuniversitet Försöksavd. för Skadedjur, Box 44 S - 230 53 Alnarp, Sverige
V. H. Paul	Universität-GH-Paderborn Fachbereich Landbau Windmühlenweg 25 D 4770 Soest, Deutschland
A. Pouzet	CETIOM 174, Avenue Victor Hugo 75116 - Paris, France
C. J. Rawlinson	Plant Pathology Department Rothamsted Experimental Station Harpenden Herts AL5 2QJ, U.K.

F. Schütte	Biologische Bundesanstalt für Land- und Forstwirtschaft, Institut für Pflanzenschutz in Ackerbau und Grünland Messeweg 11/12 D - 3300 Braunschweig, GRD
C. Svensson	Sveriges Lantbruksuniversitet Inst. for Växt- och Skögsskydd S - 750 07 Uppsala, Sverige
U. E. Tulisalo	Oljynpuristamo oy Niittaajankatu 1 SF-00810 Helsinki 81 Finland
L. Wouters	Rijksdienst Ijsselmeerpolders - K204 Smedinghuis P.O.Box 600, 8200 AP Lelystad, The Netherlands