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WORKING GROUP "INTEGRATED CONTROL IN OILSEED CROPS"

GROUPE DE TRAVAIL "LUTTE INTEGREE EN CULTURES D'OLEAGINEUX"

ROTHAMSTED (UNITED KINGDOM), 1-3 MARCH 1990
PADERBORN (GERMANY), 19-20 APRIL 1990

EDITED BY
EDITE PAR
V.H. PAUL AND C.J. RAWLINSON

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

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IOBC WPRS OILB SROP

WORKING GROUP

"INTEGRATED CONTROL IN OILSEED CROPS"

PROCEEDINGS OF THE MEETINGS AT
ROTHAMSTED (UNITED KINGDOM), 1-3 MARCH 1990 AND
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"LUTTE INTEGREE EN CULTURES D'OLEAGINEUX"

COMPTES-RENDUS DES REUNIONS A
ROTHAMSTED (ROYAUME UNI), 1-3 MARS 1990 ET
PADERBORN (ALLEMAGNE), 19-20 AVRIL 1990

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Preface

The fifth meeting of the working group on integrated control in oilseed rape was held at Rothamsted Experimental Station in Harpenden, United Kingdom, 1 - 2 March 1990.

At the meeting the members of the group decided to expand its remit from rape to other oil crops and to change its title to the 'working group on integrated control in oilseed crops'.

The main subjects of the meeting were: occurrence and distribution of pests and diseases, monitoring, forecasting, establishment of damage thresholds, parasitoids, plant resistance, crop rotation and, use of bait plants for pest control. In order to develop closer collaboration in the working group a joint field experiment in different countries to study the interaction between varietal resistance and disease control in order to minimize fungicides in rape cropping started in autumn 1990. Another new joint project of the working group to study possible control of the pollen beetle by entomophagous fungi started in spring 1990.

In order to obtain a clear picture of the priorities for fundamental and applied research in the biology of pathogens and pests and integrated control in oilseed rape an IOBC/WPRS conference on diseases, weeds, pests and integrated control was held at Paderborn on 19 to 20 April. More than 110 rape specialists from 12 countries and, for the first time from Eastern Europe especially from Poland and Çechoslovakia and from Canada attended.

We are pleased to acknowledge financial support from the german breeding companies Deutsche Saatveredelung Lippstadt (DSV) and Norddeutsche Pflanzenzucht Hohenlieth (NPZ) and thank the chancellor of the university of Paderborn for technical help.

We thank Dr. Ingrid H. Williams and Dr. Peter Gladders for their thorough criticism and correction of manuscripts.

V. H. Paul
convenor

Ch. J. Rawlinson

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SESSION 1

Priorities for Research and Development

PRIORITIES FOR RESEARCH AND DEVELOPMENT OF DISEASES OF OILSEED RAPE IN THE UNITED KINGDOM

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Summary

There is increasing pressure to reduce the use of pesticides and nitrogen on oilseed rape and other arable crops. Research priorities will be set to support the Government policy rather than to increase production. A voluntary levy will be raised on oilseeds so that "near market" R & D can continue (eg cultivar evaluation). Fundamental studies of pathogen biology, epidemiology and disease-yield loss relationships are still required particularly for Pyrenopeziza brassicae. For advisory purposes it is necessary to refine factors used in risk assessment and if possible, to develop and evaluating disease forecasting systems. Developments from biotechnology and biological control may well be forthcoming and could lead to re-evaluation of disease control strategies.
The past 2 decades have seen major increases in both the diversity and the use of agrochemicals in arable farming systems in an era when maximising yields by using high inputs was economocially sound. Sustained pressures from environmentalists and politicians are being brought to the fore and are likely to limit the use of pesticides and nitrogen fertilisers on oilseed rape and other arable crops. Efforts are being directed at farming systems rather than at individual crops or individual pesticides.

The Boxworth Project in Cambridgeshire, England has received considerable attention in the UK and internationally. It was established in 1981 and compared 3 regimes of pesticide use: "full insurance" (comprehensive protection against pest diseases and weeds), "supervised" (sprays applied according to thresholds) and "integrated" (modifications to sowing date, variety and pesticide product). One third (120 hectares) of the experimental husbandry farm at Boxworth was used for this project and treatments were applied to winter wheat, break crops of oilseed rape from 1984-1988 in separate blocks of fields. Detailed monitoring of flora and fauna in the crop and adjacent areas has been carried out and the results will be published in a book in 1990. Some of the work is continuing to monitor the recovery of insects which were reduced in number by the "full insurance" programmes.

A number of further studies are now taking place following the initial results from Boxworth. Two of these have the acronyms SCARAB (Seeking Confirmation After Research At Boxworth) and TALISMAN (Towards A Low Input System, Minimising Agrochemicals and Nitrogen). SCARAB is a 6 year study comparing a commercial pesticide programme with reduced inputs on 3 experimental husbandry farms. It seeks to establish if the trends observed at Boxworth are a general phenomenon. TALISMAN is also a 6 year investigation and compares all input costs and economics of a standard rotation with both commercial and reduced inputs of agrochemicals within a "friendlier" arable rotation using reduced inputs. TALISMAN is being undertaken at 4 sites.

A range of environmental issues are likely to have direct and indirect effects on oilseed rape production. Nitrogen fertiliser applications are being modified in parts of the UK as part of a programme to ensure that the EC statutory maximum limit of 50 mg/l of nitrate in drinking water is not exceeded. A ban on straw burning is scheduled to take effect after harvest in 1992. Both these initiatives may affect diseases of oilseed rape.

There is increasing interest in reducing or avoiding pesticide treatments to field margins in order to foster uncommon plant species and weeds and to promote beneficial insects and other fauna. Monitoring will be needed to identify the benefits of this approach to oilseed rape.

Priorities for traditional aspects of plant pathology and crop protection now also need to be viewed from the environmental standpoint. Most topics can be considered as contributing to minimising the use of pesticides. Clearly evaluation of varieties, their susceptibility to pest and diseases and their management requirements will underpin much of the research activity.

Further investigations of damage thresholds are still required for most pathogens and these may need to be updated if control stratagies are changed. These investigations should be linked to detailed studies of spray timing which is aimed at minimising the quantity and number of applications of agrochemicals. Disease-yield loss relationships are not well established for many of our common fungal diseases. This is particularly apparent for Pyrenopeziza brassicae which remains the most important disease in the UK. Linked to this is a shortage of fundamental studies on infection and disease development. The recent discovery of the perfect stage of P. brassicae at Rothamsted established a new component of the disease cycle whose significance has not yet been established. Although priority has been given to P. brassicae fundamental studies of most other pathogens are far from complete. It is hoped that some of these will receive detailed attention elsewhere in Europe where they are of local or national significance (eg Sclerotinia, white leaf spot and Verticillium).

Crops which warrant pesticide application in future may need to be clearly identified especially if prophylactic use of agrochemicals becomes unacceptable. A disease risk assessment will need to be carried out for many crops and this will necessitate the identification of useful criteria (eg quantifying the effects of sowing date, proximity to previous crop, local history of disease, weather factors etc). The build-up of soil-borne diseases in rotations also requires long-term studies and would contribute to risk assessment. For example what level of Sclerotinia infection in a crop and what level of soil infestation would constitute a high risk threshold for the next susceptible crop?

Diagnostic kits are available already for some plant pathogens. A number of oilseed rape diseases could be amenable to development work in this area. This will be particularly appropriate where diseases have long latent periods or initial infections are difficult to identify. In the UK a good case could be made for early diagnosis of P. brassicae which appears to invade crops in the Autumn but is rarely detectable on plants in the field until January. Rapid diagnosis of Sclerotinia infection of petals would enable spray treatments to be targeted more effectively and for spray timing to be optimised.

Novel methods of disease control may be forthcoming and these could include genetic manipulation of host pathogen or antagonist. Other techniques could be used to modify or manipulate any of these three elements either directly or indirectly to give disease suppression. In this context the role of petals warrants fundamental study in terms of pathogen biology and host physiology. What exactly are the conditions required for petals to adhere to leaves - this would appear to be a critical element of forecasting Sclerotinia attacks. Are apetallous varieties in the same genetic background as petallous varieties higher yielding?

Monitoring of pests and diseases should retain its prime position in future work. Biologists have struggled to predict accurately the consequences of changes in husbandry practice or in varieties. Monitoring therefore remains the most effective way of detecting changes in pest and pathogens and ultimately in safeguarding the crop from major attacks of pest or disease. Studies in future should be established to ascertain the effects of major changes in husbandry and variety and to establish a distribution of fungicide resistant strains and pathogen virulences.

Recent investigations on disease control have often included comparisions of new and existing commercial products. This activity is now considered "near market" and will not be supported directly by Government sources. In future such comparisions are likely to be funded by growers from levey funds and by the agrochemical companies.

There is still a significant role for plant pathologists in R & D on oilseed rape but new environmental pressures are rapidly bringing about changes in priorities. Disease control now needs to be examined as part of the whole farming system which faces modifications of its cropping, fertiliser, straw disposal and pesticide policies. The consequences of these changes cannot be accurately predicted and close monitoring of interactions will be required. Fundamental studies of many pathogens are still needed if efforts to minimise applications of pesticides are to succeed. Whilst this paper has drawn on experiences in the UK many of the principles will undoubtedly apply to other European countries and hopefully provide some opportunities for further discussion and integration of research programmes.

SESSION 2

Monitoring Pests and Diseases

MONITORING OF OILSEED RAPE PESTS IN ENGLAND AND WALES

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Abstract

Since the early 1980s Advisory Entomologists in MAFF/ADAS have regularly monitored winter oilseed rape crops and recorded the incidence and severity of establishment pests in autumn and of the main pests attacking buds, flowers or pods in spring and early summer. Extensive damage assessment trials have been conducted to develop and validate economic thresholds and to improve the methods used by advisers and farmers to decide the need for control measures. The distribution of the major autumn/winter pest, cabbage stem flea beetle (*Psylliodes chrysocephala)*, has expanded northwards and westwards. There is an established autumn economic threshold for larvae but the significance of later hatching larvae (late winter/early spring) is also under investigation. A simplified method of assessing larval infestation, based on external damage symptoms on leaf stalks, shows great promise as an alternative to plant dissection. Numbers of pollen beetles (*Meligethes* spp.) have risen dramatically since 1986 prompting a reassessment of existing thresholds. Improved field assessment and thresholds for cabbage seed weevil (*Ceutorhynchus assimilis)* are also under development as part of a general strategy to reduce unnecessary spraying of crops.

1. Introduction

In the UK, winter oilseed rape increased dramatically in importance as a break crop in cereal rotations during the 1970s and 1980s and it now occupies the largest arable area after wheat and barley. In recent years the area has exceeded 300,000 ha, with a peak in 1987 at 388,000 ha (Anon, 1988). The expansion of the crop initially in eastern England and subsequently into more northern and western areas led to increased concern over pests and to widespread spraying of crops during or after flowering in the summer and, more recently, in the autumn too. ADAS Entomologists have regularly monitored winter oilseed rape crops to record the spread of establishment pests in autumn and the importance of pests attacking buds, flowers and pods in spring and early summer (John and Holliday, 1984; Lane and Cooper, 1989). Insecticides applied to flowering oilseed rape crops presented a serious risk to honeybees or other foraging or beneficial insects in the crop. ADAS research and development work has been concerned with improving effective control methods to reduce this risk and with investigating the biology of the major pests of oilseed rape in the UK and their effect on yield to develop economic thresholds and reduce the unnecessary spraying of crops. Currently, work is continuing to improve methods used by advisers and farmers to monitor crops and the thresholds and forecasts on which spray decisions are then made.

2. Common Pests of Oilseed Rape

The most important autumn/winter pest is the cabbage stem flea beetle (*Psylliodes chrysocephala*). The adult beetles which move into emerging crops in late August to early September can damage developing leaves. However, the larvae which feed inside the leaf stalks and stems throughout the winter, from October onwards, are usually more serious. Peach-potato aphid (*Myzus persicae)* the main vector of a virus which commonly occurs in rape, beet western yellows virus, can often be found on rape plants during early autumn. In some mild winters it has persisted in substantial numbers until January. Cabbage aphid (*Brevicoryne brassicae)* may also be present and in the autumn of 1989 was numerous enough to cause direct damage to young plants. This species is more usually evident as a minor pest of developing racemes in hot dry summers (including 1989), particularly on spring rape. Slugs may damage rape seedlings in the autumn and leaf shredding or holes in leaves can appear similar to damage by adult cabbage stem flea beetle. The larvae of cabbage leaf miner (*Phytomyza rufipes)* mine the stalks, usually of only the lower leaves. Neither this, nor the species of leaf blotch miner are considered of economic importance. Mining or severing of roots by larvae of cabbage root fly (*Delia radicum)* is more common in August-sown crops. Damage is generally important only where the pest is locally very abundant and where dry weather delays new root growth. The rape winter stem weevil (*Ceutorhynchus picitarsis)* remains a local, but potentially serious pest, in parts of eastern England; the many larvae present inside a main stem can destroy the terminal bud or kill the plant.

The major pests during the flowering and pod development stages are pollen (blossom) beetles (*Meligethes* spp.) which attack buds and flowers both as adults and larvae; cabbage seed weevil (*Ceutorhynchus assimilis)* the larvae of which feed on developing seeds in the pods and brassica pod midge (*Dasineura brassicae)*. Egg laying in pods by the midge is dependent on prior damage to the pod, mainly the feeding punctures made by adult weevils. Midge larvae feed on the walls of the pod causing premature shattering. For this reason pod midge can be a very serious pest although in most crops it may not be abundant, except on headlands. The cabbage stem weevil (*Ceutorhynchus quadridens)* is often present in winter rape but is of minor importance. On spring rape, damage from larvae tunnelling in leaf stalks and stems can reduce plant vigour and yields.

The economic thresholds currently in use in the UK are shown in Table 1.

3. Cabbage Stem Flea Beetle Distribution

The cabbage stem flea beetle distribution map produced by John and Holliday (1984) has been updated from subsequent ADAS advisory and survey records (Lane and Cooper 1989) (Fig 1). Since 1984 the distribution of this pest has extended largely westward into the West Midlands and Welsh Borders and northwards into Humberside and Yorkshire. Although the pest now occurs in most areas of England and Wales where rape is widely grown, infestation levels generally remained low during the mid 1980s but have increased again during the last two years.

FIG 1.DISTRIBUTION OF CABBAGE STEM FLEA BEETLE ON WINTER OILSEED RAPE IN ENGLAND AND WALES

○ To 1984 ● 1985-1988

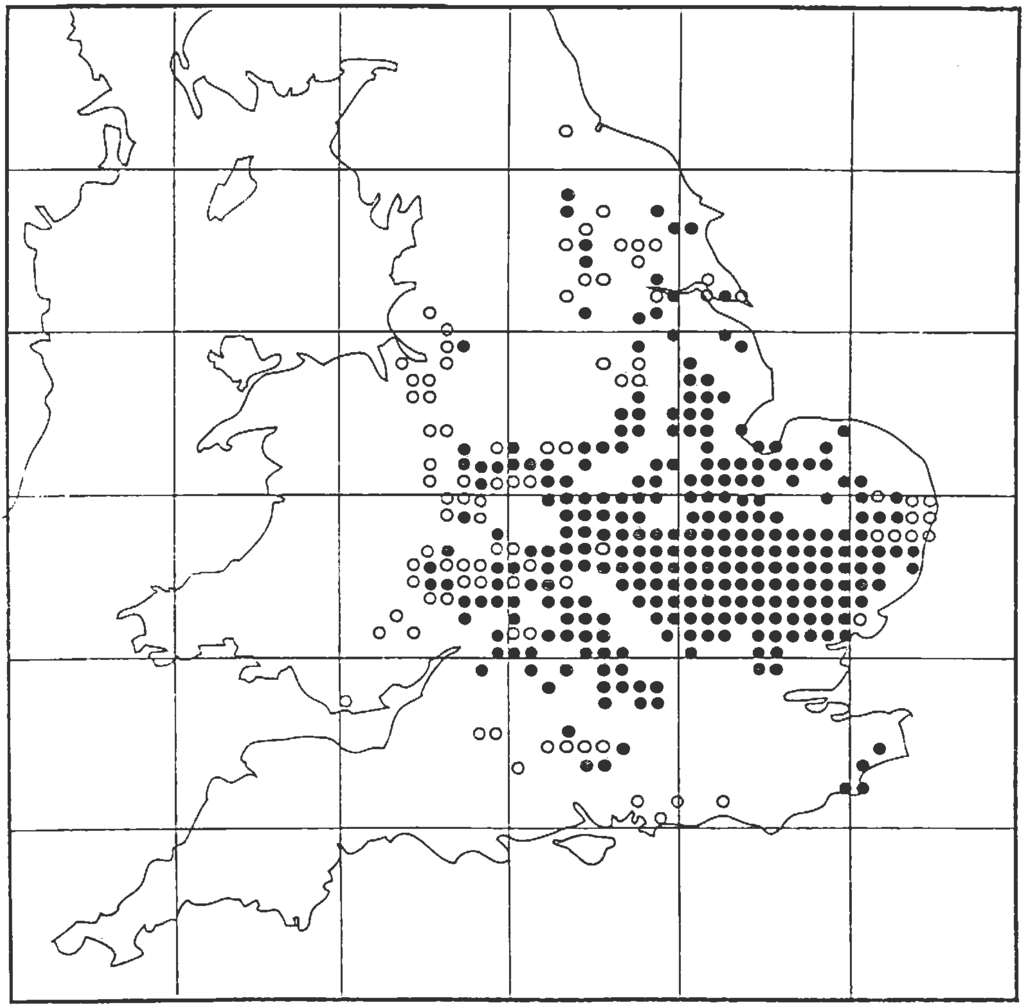


Table 1. Thresholds in use for major oilseed rape pests in UK.

Pest	Time/growth stage	Threshold Mean no./plant
Cabbage stem flea beetle larvae (*Psylliodes chrysocephala)*	October-December	5
Pollen beetle (*Meligethes* spp.)	Winter oilseed rape; green-yellow bud	15-20
	Winter oilseed rape; backward crop	5
	Spring oilseed rape;	
	green bud	3
	re-invasion before late yellow-bud	3
Seed weevil (*Ceutorhynchus assimilis)*	Winter oilseed rape; During flowering: Crop sampled three times	
	on a single occasion	1
	on two occasions	0.5
	Spring oilseed rape; before flowering	1

Pod midge (*Dasineura brassicae)* - no threshold but spray decision made on numbers of seed weevil present and farm history of pod midge damage.

4. Cabbage Stem Flea Beetle Thresholds

Many fields are sprayed merely because cabbage stem flea beetle is known to be present. At current insecticide prices an autumn pyrethroid spray represents a cheap insurance option also giving incidental control of aphids/virus and other pests. However advice on the need for control of the larvae is based on regular crop inspection from October. Leaf stalks from a sample of 20-25 plants per field are split open and treatment recommended above a mean of 5 larvae per plant (Table 1). An evaluation of insecticide trials data (Purvis 1986) confirmed that this threshold was applicable in autumn and early winter to well grown and otherwise healthy crops. However in some seasons, hatching of eggs and invasion of plants by larvae continues until early spring. The importance of these later hatching larvae is still under investigation but preliminary results suggest that the larger plants present in early spring are able to withstand a higher level of infestation than the autumn threshold but the more backward crops are still susceptible to damage.

Currently the assessment of larval numbers is based on plant dissection. An assessment of externally visible symptoms of larval tunnelling in leaf stalks offers a less laborious alternative more likely to be used by advisers and farmers. Initial work, albeit when larval populations were fairly low, suggested a good correlation between the mean number of larvae per plant and the percentage of leaf stalks showing 'scarring', indicating the internal tunnelling. Recent data confirm this relationship (Fig 2) and suggest that just below 60% of leaf stalks scarred equates with the 5 larvae per plant threshold. This incidence count may therefore have great potential as a quick and straightforward monitoring method which could help to reduce insurance spraying.

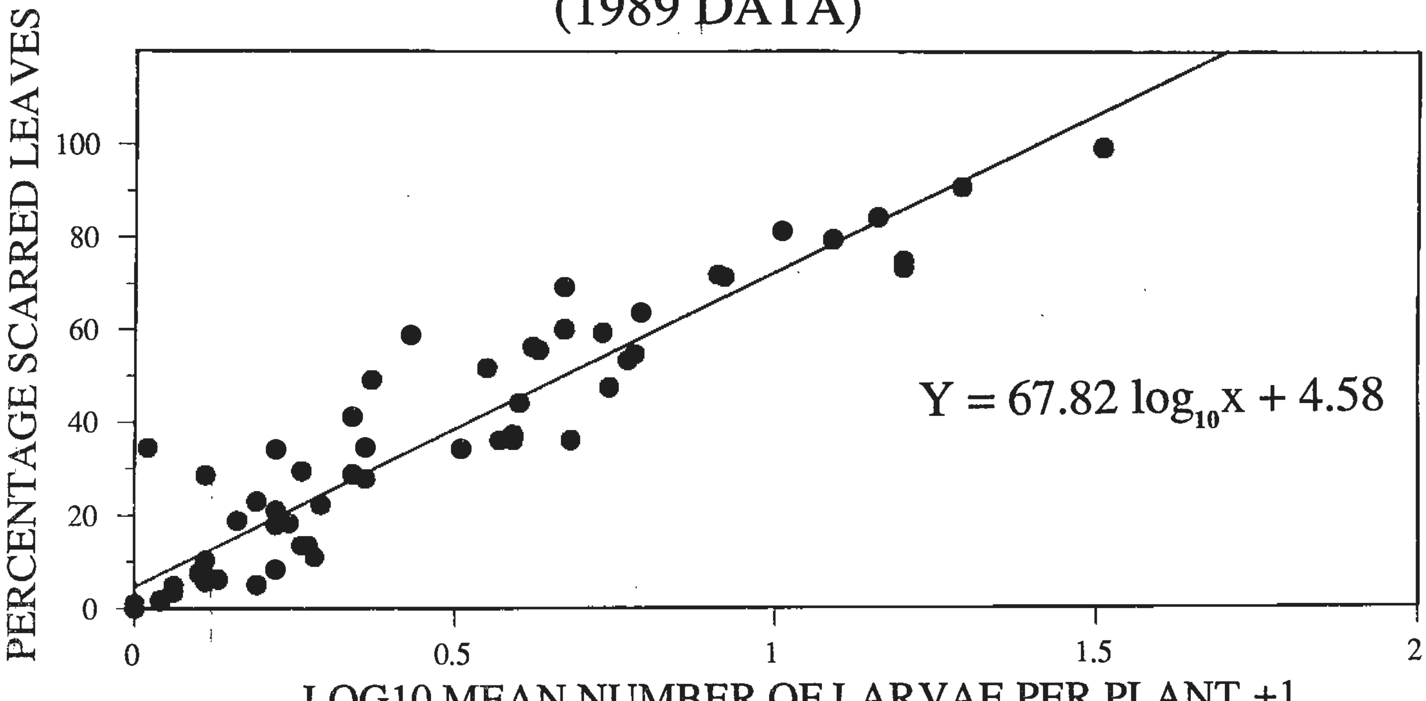
5. Annual Surveys of Flower/Pod Pests

Each year since 1981 a minimum of 50 unsprayed crops, forming a representative sample from the main oilseed rape growing areas, were monitored during the flowering period. Pollen beetles and seed weevils were beaten onto a white tray from the main flowering racemes of 20-25 plants and numbers per plant recorded. Mean counts from samples taken at full flowering of the crop each year are shown in Table 2.

Table 2. Incidence of pollen beetles and seed weevil on unsprayed crops during flowering 1981-89

	No fields	Mean No. beetles/plant	Mean No. weevils/plant	% fields over weevil threshold
1981	51	0.64	0.23	2
1982	70	0.55	0.27	6
1983	76	0.65	0.48	12
1984	74	0.44	0.35	8
1985	65	0.74	0.65	26
1986	63	0.75	0.34	5
1987	52	4.61	0.31	10
1988	92	3.27	0.26	4
1989	76	5.87	0.58	16

FIG 2. WINTER OILSEED RAPE-CABBAGE STEM FLEA BEETLE LEAF SCARRING INDEX
(1989 DATA)



6. Status of Pollen Beetles on Winter Oilseed Rape

The incidence of pollen beetles remained fairly static from 1981 to 1984 with a slight increase in 1985, sustained in 1986. However, in 1987 numbers increased substantially and remained high in 1988. In 1989 a new peak of almost 6 beetles per plant was reached. Winter oilseed rape is usually past the susceptible green to yellow bud stage before large numbers of pollen beetles invade crops in the spring. In these monitored crops the current ADAS threshold (Table 1), applicable at this susceptible stage, was not reached by that time. Occasionally, in a few crops numbers exceeded this value later, at the peak of beetle activity during full flowering.

Pollen beetles have been particularly numerous in recent years (Table 2). Since 1988, there has been a major change to 'double low' varieties (low in erucic acid and glucosinolates). Observations of pest numbers on different varieties suggested that some pests may show a preference for certain double low varieties. It is interesting to note however that the increase in pollen beetle populations began before the new varieties were important commercially; the area of double lows was insignificant in 1987, 20% in 1988, rising to over 90% in 1989.

The recent increases in numbers, and warm springs which have favoured the beetles' reproduction, have led to many reports of large numbers of newly emerged adults in summer flying from oilseed rape and causing an annoyance to householders and gardeners. There have even been suggestions that farmers should spray the flowering crop to control this 'nuisance pest' (even though it does not present a risk to the crop at that stage) despite any adverse effect on beneficial insects present.

The increased incidence of pollen beetles has prompted new damage assessment work, scheduled to begin in 1990. Previously little experimental work was done on winter oilseed rape because few crops were heavily infested at the susceptible green-bud stage. Thresholds were largely developed from advisory experience on mustard and spring rape (Winfield 1961) and survey data (Gould 1975). With greater numbers of pollen beetles active in early spring more winter rape may now be at risk and current varieties may be more severely damaged.

7. Seed Weevil

Numbers of seed weevil reached a peak in 1985 with a mean of 0.65 weevils per plant (Table 2) and with 26% of monitored crops above the threshold of one weevil per plant during flowering. Populations remained low from 1986 to 1988 but in 1989 increased again with a national mean of 0.58 weevils per plant and 16% of monitored crops above the treatment threshold.

The one weevil per plant threshold during flowering (Table 1) has sometimes proved unreliable, particularly in Northern England. A number of alternative assessment methods to provide a forecast of subsequent larval damage have been investigated. However the beating tray count to assess the numbers of active weevils proved to be the most accurate and convenient method provided that the highest value from a series of at least three assessments made during flowering was used. Generally a count of one weevil per plant equated with subsequent damage to about 15% of pods, where treatment would have been worthwhile; but in some situations this level of damage was associated with counts of 0.5 weevils per plant (recorded in most cases on more than one sampling occasion c.f. Table 1). Weather conditions at the time of sampling affect the activity of weevils at the top of plants and hence may account for some lower counts than might be expected, particularly in the cooler climate of Northern England. Consequently recent work has investigated the effect of weather, particularly prevailing temperature. Temperatures between 15°C and 22°C appear to give the most consistent estimate of weevil numbers. However it is not always possible to sample, throughout the critical phase of weevil movement into crops, in suitable conditions. Work is therefore continuing to develop correction factors which can be applied to counts necessarily made under sub-optimal conditions and so improve the reliability of the threshold.

Without a reliable monitoring method there is likely to be an increase in routine spraying; insecticides are frequently tank-mixed with scheduled fungicides when seed weevils are known to be present. Pyrethroids applied during flowering are increasingly used for seed weevil control. Although they do not present a field hazard to foraging honeybees their routine application may have detrimental effects on seed weeevil parasites. In the damage assessment trials series the main parasite, the chalcid *Trichomalus perfectus*, has generally occurred in very low numbers. There have been occasional crops with up to 30% of weevil larvae parasitized but even in unsprayed fields the parasite does not appear to be as common as in the 1970s. In recent trials pod midge damage has also been low, usually less than 5% of pods infested but higher levels have occurred in some small fields with very high seed weevil populations.

8. Prospects

ADAS surveys have indicated that while pest numbers vary greatly from season to season there has been a resurgence in populations of several major pests in recent years. If it continues, this trend is likely to encourage the wider use of routine autumn and spring/summer insecticides. It therefore remains imperative that the incidence of major pests and the spread and importance of minor pests are kept under surveillance. Greater routine use of insecticides would be environmentally detrimental generally and could in particular affect populations of natural enemies of major pests, including the parasites of flower/pod pests in summer and ground-dwelling polyphagous predators in autumn. The latter aspect has been primarily investigated in cereals with little work in oilseed rape. Observations in rape will be made within a new 6-year MAFF environmental project in arable rotations but there may also be a need for more specific studies in future. Widespread autumn pyrethroid use could, for instance, increase insecticide resistance in *Myzus persicae*. Where rape constitutes an important overwintering host, build up of resistant populations could ultimately affect control of this aphid on other crops.

There is now a succession of new double low varieties of winter oilseed rape and it will be necessary to continue to assess their attractiveness and susceptibility to insect pests. On-going work on pollen beetle and seed weevil and the improvement of methods for advisers and farmers to monitor crops and assess risks to individual fields have a vital role in minimising the unnecessary use of pesticides in the future.

Acknowledgements

We thank ADAS colleagues for crop monitoring and pest assessment and the farmers who allowed us to survey their fields.

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OILSEED RAPE IN AUSTRIA - PEST PROBLEMS

by
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Summary

The area of oilseed rape grown in Austria increased from about 3,000 ha in 1984 to 35,275 ha in 1989 - and is still increasing. Only double low varities are grown in Austria.
The main pest is _Ceutorhynchus napi_ (Gylh.) and to a lower extent _C.quadridens_ (L.). Control can be difficult as low temperatures occur when insecticide application is necessary. Monitoring of _C.napi_ and _C. quadridens_ is done by yellow water traps. _Meligethes aeneus_ (Fabr.) is a pest which occurs occasionally and can controlled easily.
A very efficient monitoring system for _Psylliodes chrysocephala_ (L.) is operated, and seed treatment is advised only when pest numbers warrant it.

Oilseed Rape Growing in Austria

The area of oilseed rape grown in Austria increased from about 3,000 ha in 1984 to more than 35,000 ha in 1989 and is still increasing (Table 1). The increase has been stimulated a change in agricultural policies.

Since the early seventies Austria has been a cereal-exporting country but price for cereal and cereal products has fallen because cereals had to be supported both by the government and the farmers. On the other hand, large quantities of fodder crops - mainly protein crops, but also oil crops - were being imported.

Therefore the government suggested a switch to fodder crops instead of supporting exports. Since this decision the amount of oilseed rape area as well as that of other "alternative crops" has increased rapidly.

TABLE 1: Oilseed Rape in Austria

Year	Area in ha	Average yield kg x 100 / ha
1970	3.960	20.0
1975	2.205	22.5
1980	3.941	21.1
1985	6.324	27.3
1987	22.703	28.9
1988	32.126	27.1
1989	35.275	23.9

Other decisions by the government have at the same time also helped to reduce the area of conventional crops such as winter wheat and maize.

TABLE 2: Area of Conventional Crops 1951–1989

WINTER WHEAT: Year	Area in ha	MAIZE : (Grain corn) Year	Area in ha
1951	178.863	1951	58.065
1960	264.239	1960	58.324
1970	258.891	1970	123.927
1980	247.024	1980	192.947
1985	296.256	1985	207.785
1986	298.804	1986	216.655
1987	294.804	1987	207.272
1988	269.428	1988	200.524
1989	255.292	1989	194.181

Governmental Regulations

To reduce the cereal acreage other regulations - besides supporting alternative crops as oilseed rape, fodder beans, fodder peas, soya beans - have been introduced:

A special duty on mineral fertilizer has been imposed:

Nitrogen	Ash	5.--	/ kg pure nutrient
Phosphorus	Ash	3.--	/ kg -"-
Potassium	Ash	1.50	/ kg -"-

e.g.:"Nitramoncal"(26 - 28 % N) : Ash 250.--/100 kg +duty +tax
= + 125.-- + 50.-- = 425.-- (+ 58 %)
"Superphosphate"(19 % P_2O_5) :Ash200.--/ 100 kg -"-
= + 57.-- + 40.-- = 297.-- (+ 67 %)
"40-er Kali" (40% K_2O) : Ash 180.--/ 100 kg -"-
= + 60.-- + 36.-- = 276.-- (+65 %)

Also a seed-tax for maize has been introduced:

Each farmer has to pay this extra tax of Ash 300.-- for a package of 50.000 kernels (which is the amount of seed you need for about 1/2 ha).

All these changes have led to the increase in oilseed rape area. Parallel to this increase an increase in pest problems was also noted.

The varieties grown in Austria were of the single low type since 1981 and of the double low type since 1986 . Nearly all of the area is sown with winter varieties. Spring rape is sown only very rarely and only for green manure.

Pest Problems

Psylliodes chrysocephala (L.), a pest which was also previously controlled in Austria, has become more important. Our institute is monitoring this pest by taking samples in rape fields twice a year (late autumn and early spring) to set up a warning programme for the need for seed treatment. The average number of larvae found in plants is 1.0 - 1.5 larvae / plant. Only in one growing area (Upper Austria) has the number of larvae/plant increased to over 3.0. Only there do we suggest that seed be treated with a registered pesticide (i.e. in Austria : lindane). At lower pest levels seed treatment is not considered economically worthwhile.

Together with P. chrysocephala we monitor Ceutorhynchus pleurostigma (Marsh.). The occurence of this pest is rather low and does not cause economic loss. It is also controlled by seed treatment applied to control P.chrysocephala .

In autumn Athalia rosae (L.) can be found on rape. This pest infests rape frequently not only in seed crops, but also where rape is sown for green manure. As there is naturally no control where rape is sown for green manure, new infestation originates from these fields. Where rape is sown as a seed crop, control is easily attained with pyrethroids or organophosphate insecticides.

The pest problem of greatest importance in Austria is certainly Ceutorhyncus napi (Gylh.) and to a lesser extent Ceutorhynchus quadridens (L.) . Both pests occur frequently in most of the rape growing area. They are monitored by yellow water traps. The beetles appear in early March depending on temperature. We suggest that control should begin when 10 beetles are caught within 3 days or 3 beetles on one day if the temperature is likely to increase. The problem is, that in many cases fields are not accessible due to wetness. Even if they are accessible temperature might in the meantime drop so low that there is no flight and the efficiency of the pesticide - esp. pyrethroids - is very low. For that reason a treatment may need to be repeated. (Table 3)

TABLE 3: Control of C.napi ; One or two Treatments

Pesticide		Infestation in %	Length of Tunnel in cm
Deltamethrin	1 x	53.0	21.2
Untreated		55.0	19.8
Deltamethrin	1 x	54.9	15.6
Deltamethrin	2 x	12.0	5.0
Untreated		58.0	57.9

The first treatment was applied on 12 March according the appearence of beetles in yellow traps, the second one 8 days later.

Determination of the right time for spraying can be rather complicated, due to the weather situation , the date of appearance of the beetles and the economic situation. (i.e. price of pesticide).

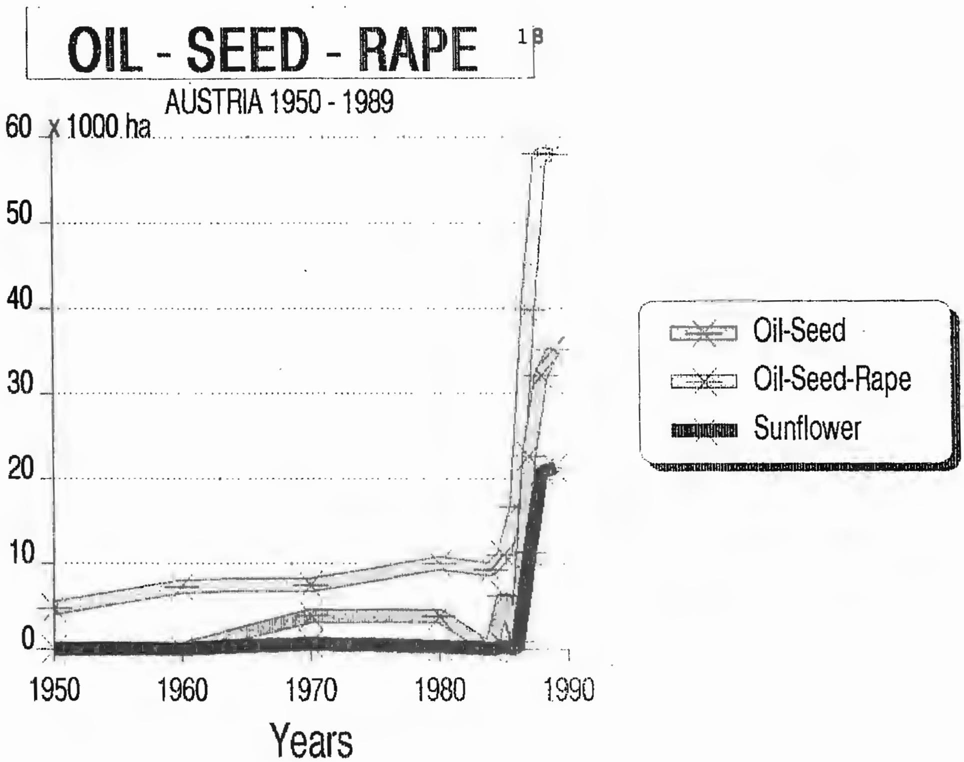
Meligethes aeneus (Fabr.) is a pest which occurs nearly every year and is also controlled by the farmer - normally with pyrethroids. We determined the economic threshold to be 4-5 beetles on the main stem on the field edge and 2-3 beetles on the main stem in the middle of the field. These thresholds proved to be effective guides for the need to the control this pest.

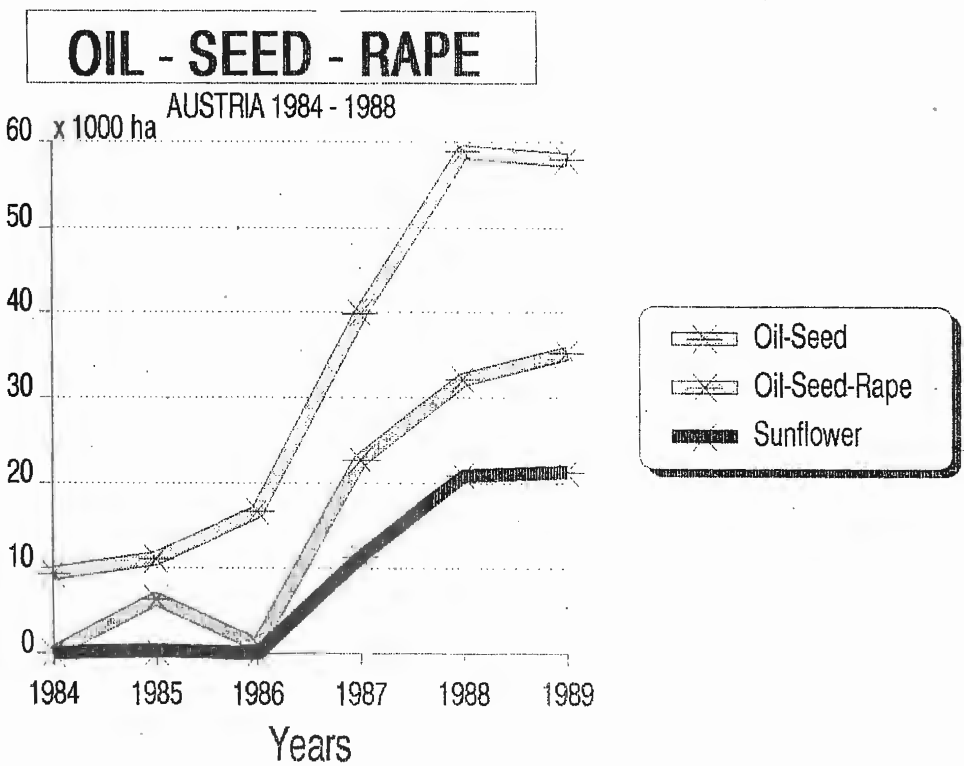
Thus P .chrysocephala (L.) C . napi (Gylh.) C. quadridens (L.) and M . aeneus (Fabr.) are the most important pest of oil seed rape in Austria. Ceutorhynchus assimilis (Payk.) and Dasineura brassicae (Winn.) are of less importance because neither occur very often in Austria and can be controlled with an application against M . aeneus . Brevicoryne brassicae (L.) is seen on oilseed rape from time to time after the beginning of June, but is not controlled. Its late appearance as well as the difficulties in applying insecticide at this late stage make it not worth to carrying out control measures.

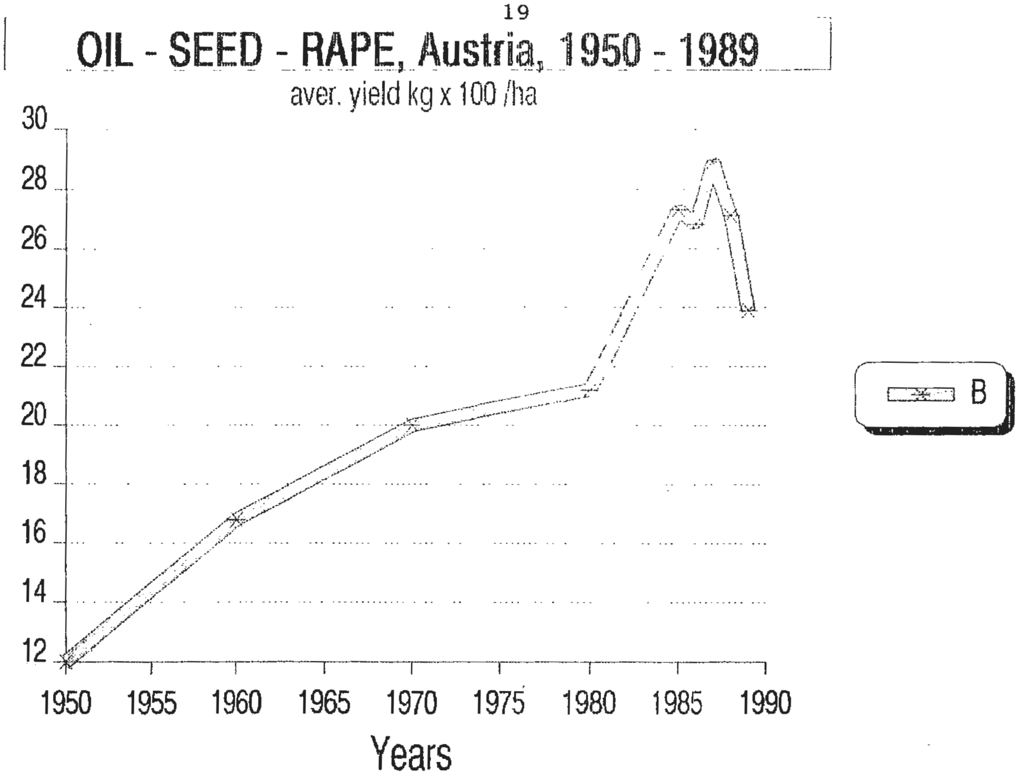
Reference :

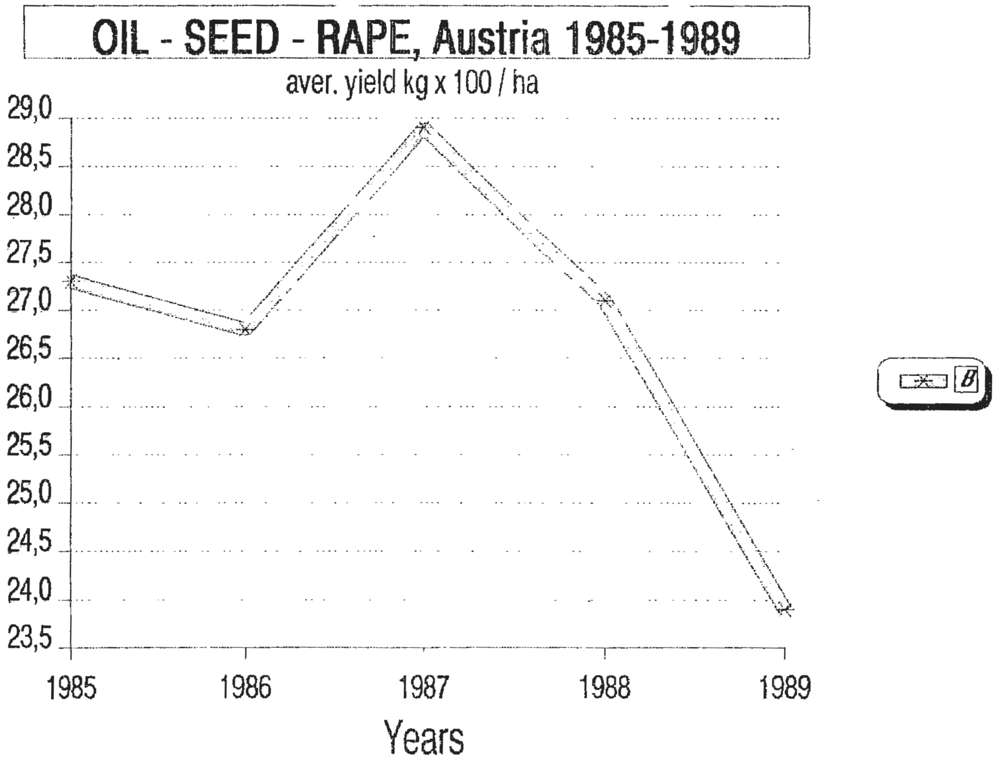
BERGER,H.K., 1987, Richtlinien für die Rapsstengelrüßlerbekämpfung Pflanzenschutz, 3,7/8 : 8-9

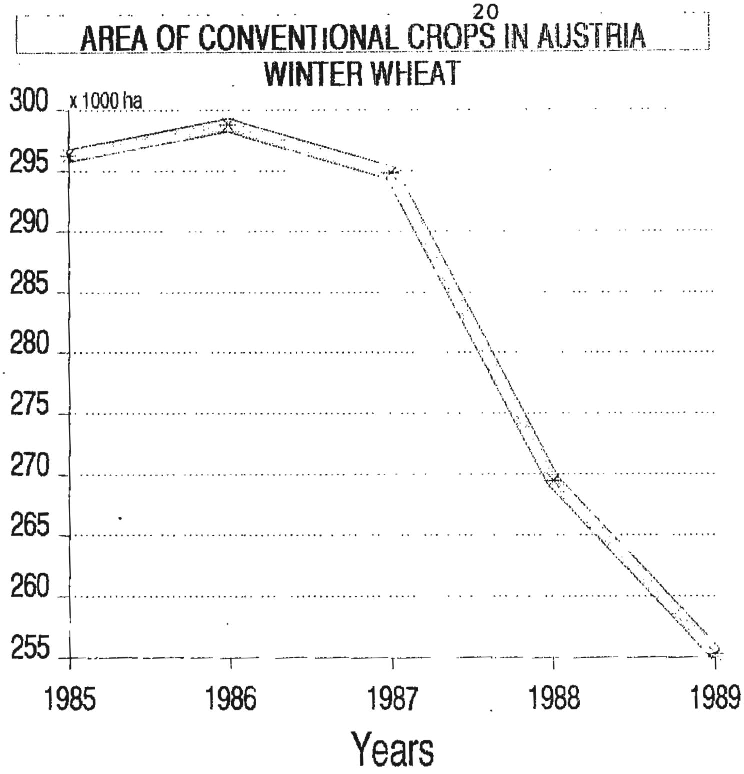
BERGER, H.K., 1989, Altbekannte und neue Schädlinge an Raps Der Pflanzenarzt , 42; 11/12 : 233-235

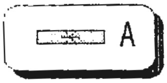

OIL - SEED - RAPE
1B
AUSTRIA 1950 - 1989
60 x 1000 ha
50
40
30
20
10
0
1950
1960
1970
1980
1990
Years
Oil-Seed
Oil-Seed-Rape
Sunflower

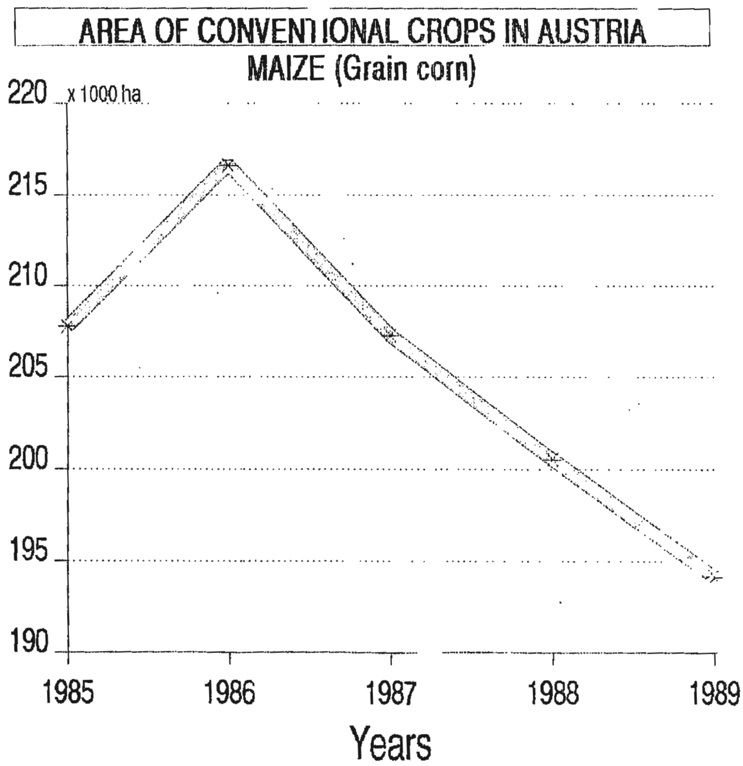

OIL - SEED - RAPE
AUSTRIA 1984 - 1988
60 x 1000 ha
50
40
30
20
10
0
1984
1985
1986
1987
1988
1989
Years
Oil-Seed
Oil-Seed-Rape
Sunflower


OIL - SEED - RAPE, Austria, 1950 - 1989
aver. yield kg x 100 /ha
30
28
26
24
22
20
18
16
14
12
1950
1955
1960
1965
1970
1975
1980
1985
1990
Years
B


OIL - SEED - RAPE, Austria 1985-1989
aver. yield kg x 100 / ha
29,0
28,5
28,0
27,5
27,0
26,5
26,0
25,5
25,0
24,5
24,0
23,5
1985
1986
1987
1988
1989
Years
B


AREA OF CONVENTIONAL CROPS IN AUSTRIA
WINTER WHEAT
x 1000 ha
300
295
290
285
280
275
270
265
260
255
1985
1986
1987
1988
1989
Years


A


AREA OF CONVENTIONAL CROPS IN AUSTRIA
MAIZE (Grain corn)
x 1000 ha
220
215
210
205
200
195
190
1985
1986
1987
1988
1989
Years

THE EFFECT OF ABIOTIC AND BIOTIC FACTORS ON FLEA BEETLE POPULATIONS IN SPRING RAPE IN SWEDEN

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Abstract

Populations of flea beetles (*Phyllotreta undulata*) monitored in Uppsala, Sweden from 1986-1989 showed differences from year to year. The population fell after the cold-wet summer of 1987. Mortality due to parasitoid attack was low in 1987 and 1988 but began to increase in 1989. Weather seems to be an important factor in determining population levels while biotic mortality factors seem marginal.

1. Introduction

Flea beetles of the genus *Phyllotreta* are a major economic problem on spring grown oilseed crops in middle Sweden (Ekbom, 1988). Seed dressing is routinely used to control the pests. However, attack rates are unpredictable, some years and some localities will escape damage. It is not presently known which factors determine population levels of flea beetles. This study was begun in order to better describe the biology of *Phyllotreta undulata*, the most abundant species of flea beetles in spring sown oilseed crops. Possible mortality factors, both abiotic and biotic were also studied to explore possibilities of enhancing natural control.

2. Materials and Methods

In 1986-1989 rape (*Brassica napus*), turnip rape (*B. campestris*) and white mustard (*Sinapis alba*) (the last only 1987,88,89) plots were sown in a field in Uppsala. In each of the plots 4 petri dishes (diameter 14 cm) filled with detergent and water were used as traps. The traps were emptied 5-6 times each week. Flea beetles were preserved in a fixative (Weaver & Thomas 1956). All flea beetles in each plot were counted and identified. From dates with more than 50 flea beetles a random sample of 50 beetles was removed. The samples were later dissected to determine sex, count eggs and check for parasitization.

3. Results

The dominant species in all years was *Phyllotreta undulata* (more than 95% of the catch). Other *Phyllotreta* species were found but only in small numbers.

Abundance: Number of beetles caught, divided by sex is shown in Figs. 1, 2 and 3. Spring abundance was highest in 1986. More than 1500 beetles were caught each week during the first three weeks of June. No weekly catch in 1987 exceeded 1000 beetles. In 1988 weekly numbers in June never went above 400. Numbers of beetles for the new generation in 1986 were very high (over 3000) compared to much lower counts in 1987 and 1988. More males were trapped in the spring.

Phenology: No females with eggs were trapped after 21 July 1986, 3 August 1987 and 18 July 1988. This would indicate that all beetles caught after these dates belong to the new generation.

Mortality factors: Fig. 4 shows the proportion of beetles parasitized by parasitoids or nematodes for 1986 to the spring of 1989. The proportion of beetles containing nematodes was usually larger than those with parasitoid larvae except for the spring of 1989. The proportion of beetles with parasitoids is increased each year from 1987 through 1989. The highest percentage of parasitoid parasitization was 23%, in the first week of June 1989.

4. Discussion

Abundance: The trapping method used must be considered as a relative measure of abundance as the activity of the beetles is regulated by temperature. However, the lower numbers of beetles in the spring of 1988 is probably a result of the cold, wet summer of 1987 (Tables 1 & 2).

Table 1. Mean monthly temperature. Uppsala, Sweden

	May	June	July	August	September
Normal	9.6	15.0	16.3	15.3	10.9
1986	12.7	16.2	16.5	13.1	8.0
1987	8.3	12.2	15.8	12.6	9.7
1988	11.9	15.7	17.7	15.3	12.2
1989	11.9	15.2	17.4	15.1	12.2

Table 2. Monthly precipitation (mm). Uppsala, Sweden

	May	June	July	August	September
Normal	32	44	71	66	53
1986	68.9	38.9	67.6	158	43.6
1987	42.8	61.1	67.7	102.2	48.1
1988	34.5	45.8	109.9	99.5	20.3
1989	30.4	40.9	9.8	54.1	17.1

Phenology: The appearance of the new generation of flea beetles was considerably later in 1987 than in 1986 and 1988. The oviposition period was about 2 weeks longer in 1987 than in the other years. Low numbers of beetles occurring in the fall may indicate poor population development because of weather.

Mortality factors: Nematodes do not kill their host and do not considerably reduce egg development. Any sublethal effects have not been studied. It is not possible to say if the nematode infections can have any impact on population levels.

Mortality caused by parasitoids was very low. Parasitoids both kill the host and stop reproduction by the host. Parasitoid levels are probably best measured during the first weeks after the crop is sown. It may be that parasitized flea beetles leave overwintering localities earlier than non-parasitized beetles. The proportion of parasitized beetles has increased during the last three years. This may be due to better weather or the fact that the fields used have not been treated with pesticides for the past 5 years.

5. References

EKBOM, B., 1988. Flea beetles in summer oilseed rape. Proceedings 7th International Rapeseed Congress, Poznan, Poland, 11-14 May 1987 5, 1104-1108.

WEAVER, N. & THOMAS, R.C., 1956. A fixative for use in dissecting insects. Stain Technology 31, 25-26.

FIG. 1

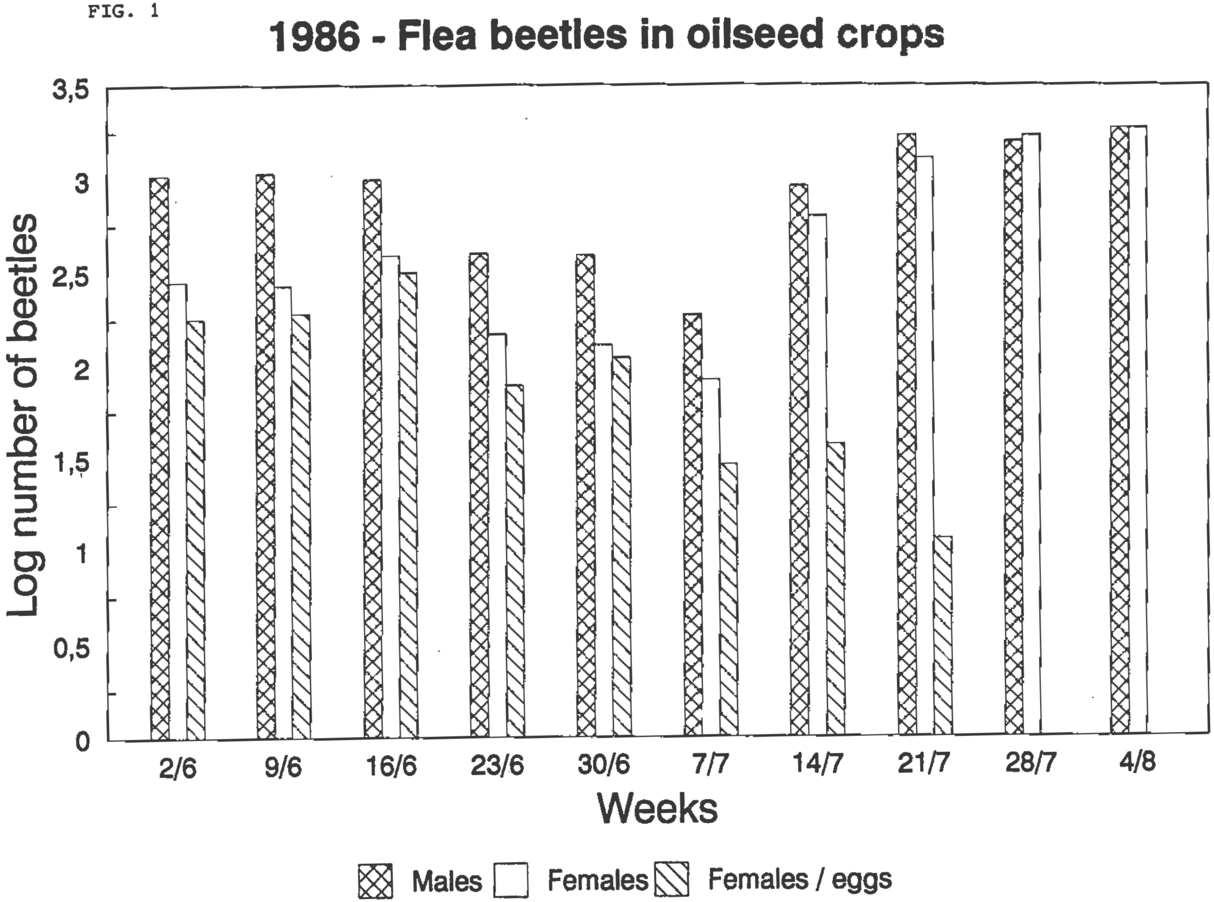

1986 - Flea beetles in oilseed crops
3,5
3
2,5
2
1,5
1
0,5
0
Log number of beetles
2/6
9/6
16/6
23/6
30/6
7/7
14/7
21/7
28/7
4/8
Weeks
Males
Females
Females / eggs

FIG. 2

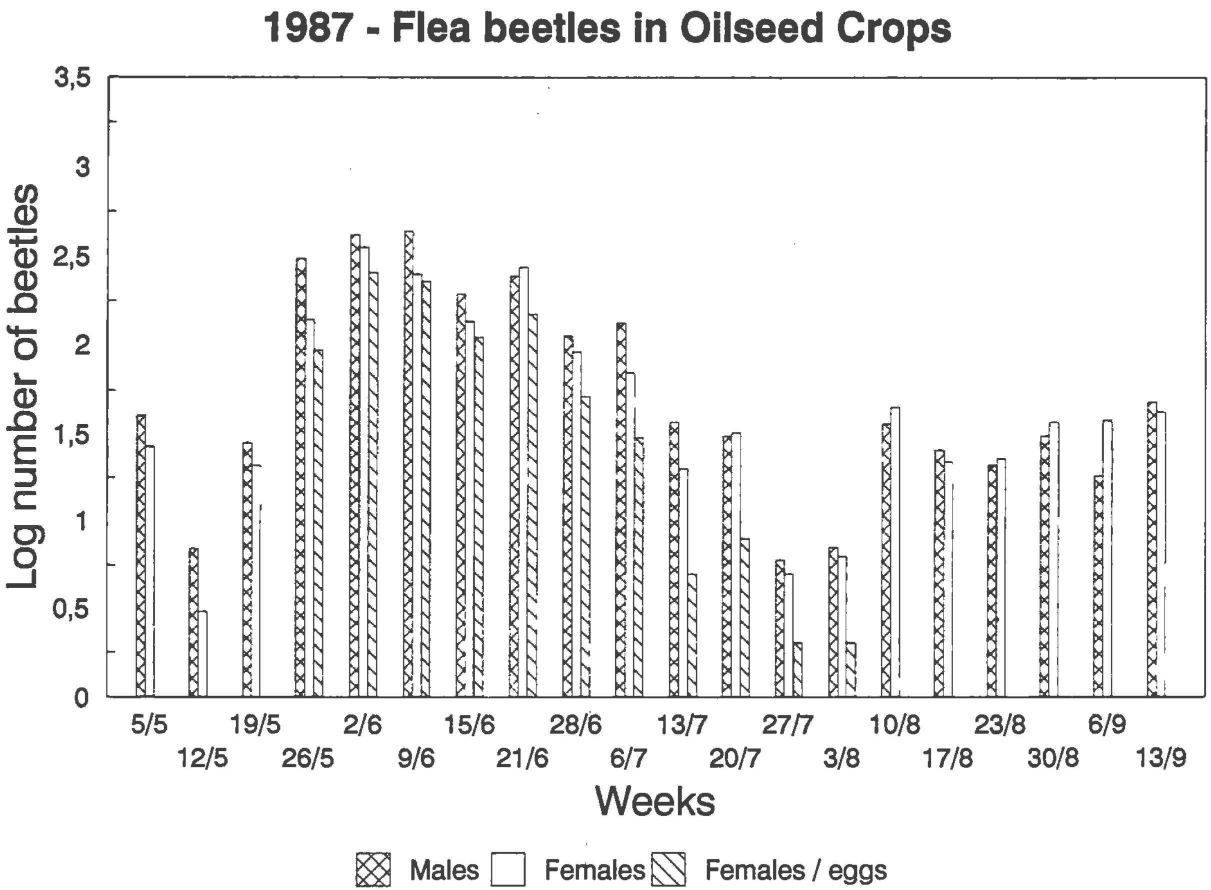
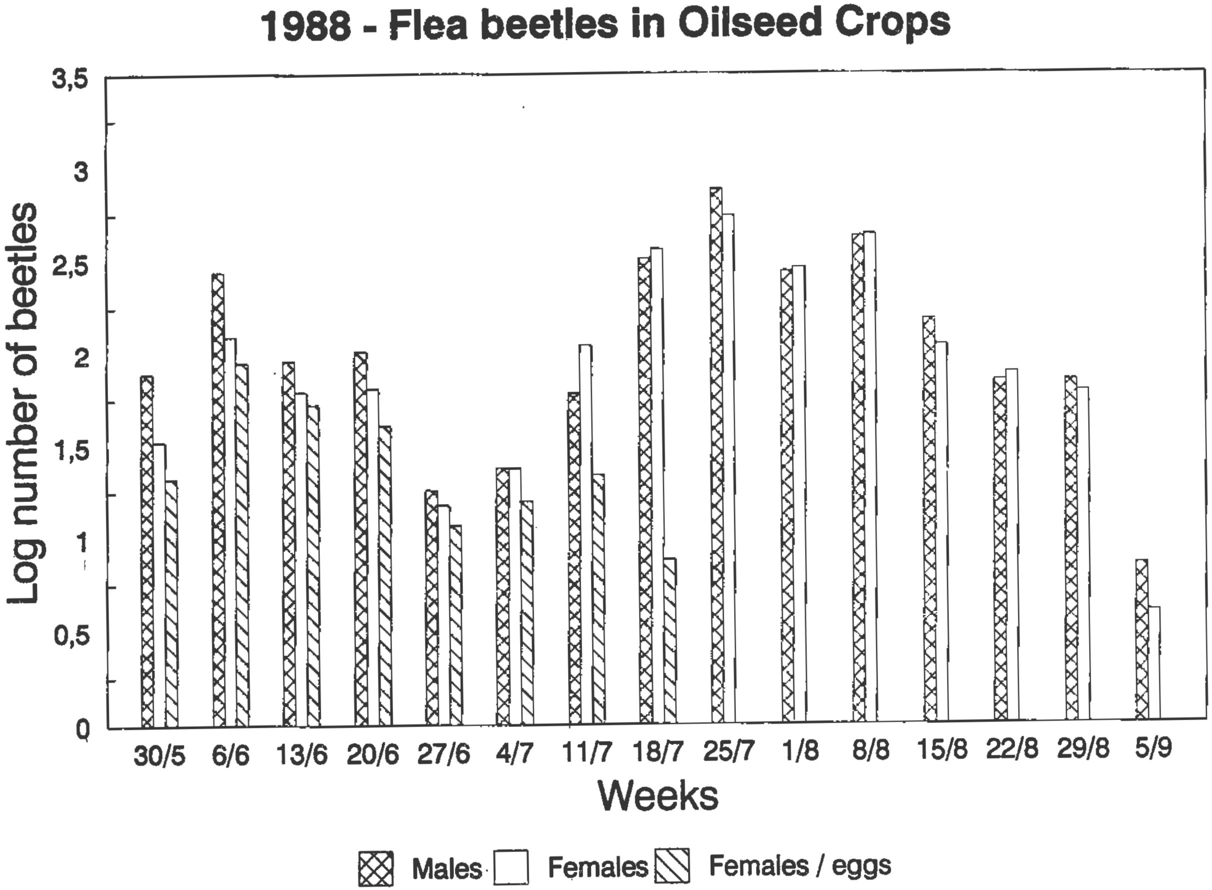
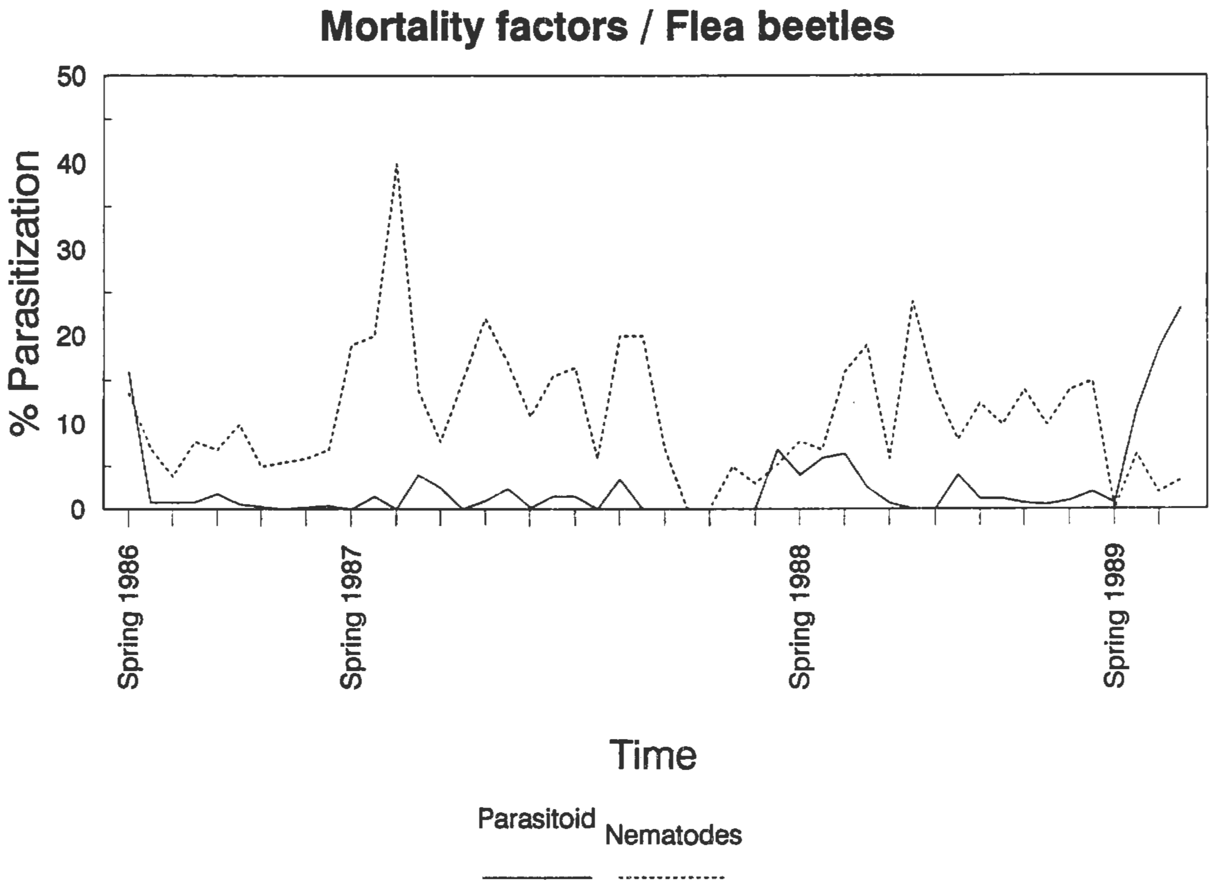

1987 - Flea beetles in Oilseed Crops
Log number of beetles
3,5
3
2,5
2
1,5
1
0,5
0
5/5
12/5
19/5
26/5
2/6
9/6
15/6
21/6
28/6
6/7
13/7
20/7
27/7
3/8
10/8
17/8
23/8
30/8
6/9
13/9
Weeks
Males
Females
Females / eggs

FIG. 3



1988 - Flea beetles in Oilseed Crops
Log number of beetles
3,5
3
2,5
2
1,5
1
0,5
0
30/5
6/6
13/6
20/6
27/6
4/7
11/7
18/7
25/7
1/8
8/8
15/8
22/8
29/8
5/9
Weeks
Males
Females
Females / eggs

FIG. 4


Mortality factors / Flea beetles
50
40
30
20
10
0
% Parasitization
Spring 1986
Spring 1987
Spring 1988
Spring 1989
Time
Parasitoid
Nematodes

BIOLOGY of Baris coerulescens SCOP., A PEST OF WINTER RAPE

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Summary

Baris coerulescens Scop. (Coleoptera Curculionidae) is a pest of winter oilseed rape which lays its eggs in the root crown or the first 2 cm of the upper part of the root. There are 4 larval instars before nymphosis. The whole development takes place in the root including a estivation of the new generation.
There is only one generation per year. In the conditions of the centre-west of France the insects invade the fields at the beginning of April except when unusual warm weather occurs earlier.
The mean fecundity in controlled conditions can reach more than 350 eggs per female. Parasitism of the adults is low leading to high population levels in Poitou-Charentes. Though roots can be completely destroyed by the pest this usually occurs only after harvest. The status of the insect as a pest of economical significance has yet to be confirmed.

1. Introduction

Baris coerulescens Scop., is a weevil (Coleoptera Curculionidae) which lays its eggs in the root of winter oilseed rape during spring. The larva mines the root causing considerable damage. As it was first studied on oilseed rape in France in the seventies it hardly can qualify as a NEW pest. But until its recent outbreak in the centre-west of France its effect on yield was regarded as negligible as the larva usually completes its development long after harvest in the stubble left in the fields. Since 1985 however the population has steadily increased and it is difficult to find fields with less than 50 % of plants attacked by the pest at the time of harvest. A vast majority of rape fields exhibit levels of attack as high as 80-90 %, as shown by surveys made by the "Service régional de la Protection des Végétaux". Such levels are significantly higher than previously found in other regions and correspond to more than 5 larvae per root. Therefore the problem of damage had to be reassessed. Reviewing the available literature was quickly done as the most recent work on this pest was published by Obarski in 1968. The work done between 1969 and 1973 by French agronomists has never been published in a formal way : it showed that in the eastern part of France, populations were well regulated by entomophagous nematodes on a 4 year cycle.

Other references included old papers written at the beginning of the century or recent papers dealing with other species of Baris like Baris lepidii (Sherrod et al., 1982, 1984). Obarski (1968) gave a fairly accurate synopsis of the life cycle of the pest but such information as time of reproductive maturity, potential fecundity, or rate of development of the larvae was lacking. Furthermore as these biological data depend highly on agrometeorological conditions it was necessary to start a complete investigation. The first results collected during 1988 and 1989 are presented in this paper.

2. Methods and results

Field infestation

The date of the first captures in yellow water traps - placed in fields above the plants - are shown in Figure 1. Data were available since 1979 except for 1986 because a very serious drought impeded sowing in Poitou-Charentes. As can be seen on the figure, infestation of the fields occurs mainly in April except for 3 years where it happened in late February or beginning of March. The conditions for early flights are warm air temperatures - more than 15°C for a few hours - and soil temperature at -10 cm of at least 10°C. As usual with most rape pests there must be no strong wind and no rain.

Once on the fields the insects are not captured anymore by yellow traps suggesting that the pest does not fly but crawls from one plant to another at ground level.

On the first day of captures about one third of the females caught were mature with eggs present in the ovaries, and one third with no visible segmentation in the ovaries. The rest was in an intermediate stage. This has been confirmed during 2 consecutive years (1988, 1989).

The evaluation of insect density has to be assessed through soil samples as the pest is seldom seen on the upper part of the plant.

Each soil sample taken on the sowing lines, which were 18 cm apart, was 40 cm long, 10 cm wide and 10 cm deep.

In 1988, 18 such samples were examined on 5 May giving a density of 3.9 insects per m. In 1989, 25 samples were taken on 24 April followed by 24 on 17 May : the first estimation gave 3.9 insects/m, the second 3/m. These densities are very high and explain why so many plants can be infested by larvae. Insects did not distribute evenly as the range of counts per sample was 0 to 13. But from one sampling date to the other there were no common structures in the repartition of densities. This indicates that the insects move within the field.

Life cycle

Table 1 gives the percentages of the different immature stages found in plants at different sampling dates. The sum for one date is therefore 100 %. The 2nd column gives the number of plants examined on each occasion.The absolute number of "insects" per plant is given in the 4th column. Egg laying must have begun a few days before the first sampling date - 20 April - as already 33 % of the plants collected were infested, and continued until 26

June. The first hatched larvae have been noticed about 1 month after laying began. The 3rd and 4th instars became the majority between 12 June and 26 June only one month before harvest. At this time plants contained about 7 to 8 such larvae and the damage to the roots was quite considerable. Nevertheless plant physiologists were unable to predict any adverse effect on yield as the root does not seem to have a major role in the establishment of yield components at such a late stage in the plant's life. From Table 1 it can also be seen that the new generation of adults is almost complete one month after harvest.

These insects spent the summer in the roots left standing in the fields. During October and November a vast majority left the roots and proceeded to fly towards wintering sites which are said to be hedges or woods (Obarski, 1968). A few captures could be made in yellow traps placed in the newly sown rape fields. About 35 samples of soil were examined during winter (1989-1990) but we were able to retrieve only 10 insects of which 7 were live males and 3 were dead females. It is therefore concluded that the main population does not overwinter in new rape fields and that the mass flight at springtime is actually an immigration flight. A few insects stay in the decaying roots in the old rape fields even after they have been ploughed.

Reproductive maturity in controlled conditions

Several conditions have been tested to see whether there is an effect of temperature or photoperiod on the acquisition of reproductive maturity, defined as the ability to lay eggs. This stage can be reached in all conditions but warm temperatures (18 to 22°C) and long photoperiods (16 hours) hasten the process. The phenological stage reached by the plants, given as food to females being reactivated after 2 months of overwintering, seems to be very important but further experiments are needed to determine the plant factor involved. In the best conditions devised until now it took 70 days after emergence from the roots to obtain about 50 % of females with fully developed ovaries containing eggs.

Potential fecundity in laboratory conditions

Eleven weevil couples were each enclosed in a small plastic cage. Each couple was given 2 roots of winter rape stuck in artificial soil. The roots were changed every 3 or 4 days and dissected to count the number of eggs laid.

The cages were placed in a growth chamber with a photoperiod of 16 h and temperatures varying from 16° - 20°C (night/day). The experiment was done on 2 varieties, Darmor and Bienvenu. The results are shown on figure 2.

Egg laying lasted 144 days on Darmor and 122 days on Bienvenu. The difference is attributed to the fact that Darmor is a late maturing variety. The mean number of eggs laid per female was 351 on Darmor and 281 on Bienvenu. After the first 14 days each female laid for 2 - 4 eggs per day for 3 months. There is no statistical difference between the 2 varieties during this period.

Behavioural observations

Most of the eggs are laid in the root crown or the upper first 2 cm of the root. The behaviour of the female is quite interesting during egg laying. First it chews oblong holes along a circular arc then bores a smaller hole toward the centre of the circle into which the egg is laid. This behaviour protects the egg from being expelled by the strong reaction of damaged tissues.

Numerous dissections of roots show that the first 2 larval instars mine just under the surface leaving vascular bundles intact. During the 3rd instar the larva makes its way toward the pith of the root where it completes its development. At the end of the 4th instar it moves again toward the periphery where the nymphal room is made. When insect density is high, nymphosis can also take place in the pith in a chamber made of frass.

Each new adult makes its own exit hole.

3. Discussion and conclusions

These first results show that Baris coerulescens can reach high density levels in the conditions of the centre-west of France. Very few adults (less than 6 %) harbour nematodes and we have not found any other parasite at this stage. This may explain why the populations seem to have increased since 1985.

Larval development can be highly damaging to roots just before harvest. The actual effect on yield has not been quantified yet because of experimental problems caused by insufficient knowledge of the biology of the insect and lack of chemical methods to control it even in cages. Foliar applications of pesticides are completely inefficient as shown by several field trials. A priori considerations lead to the idea that the pest could be of economic importance only if the larvae develop early or quickly enough to reach the 3rd instar at least 5 or 6 weeks before harvest.

A drought before harvest or opportunistic infestations by other pests like fungi can certainly aggravate the direct effect of larval infestation, if any. Conditions speeding larval growth can be met in north Africa where several species of Baris have been reported on spring cultivars of rape grown as winter crops, Baris coerulescens being one of them.

4. References

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SHERROD, D.W., EASTMAN, C.E., RUESINK, W.G., RANDELL, R., 1984. Sampling populations of the imported crucifer weevil, Baris lepidii (Coleoptera Curculionidae) in commercial horseradish. Can. Ent., 116, 159-163.

Figure 1. Date of first captures from 1979 to 1989.

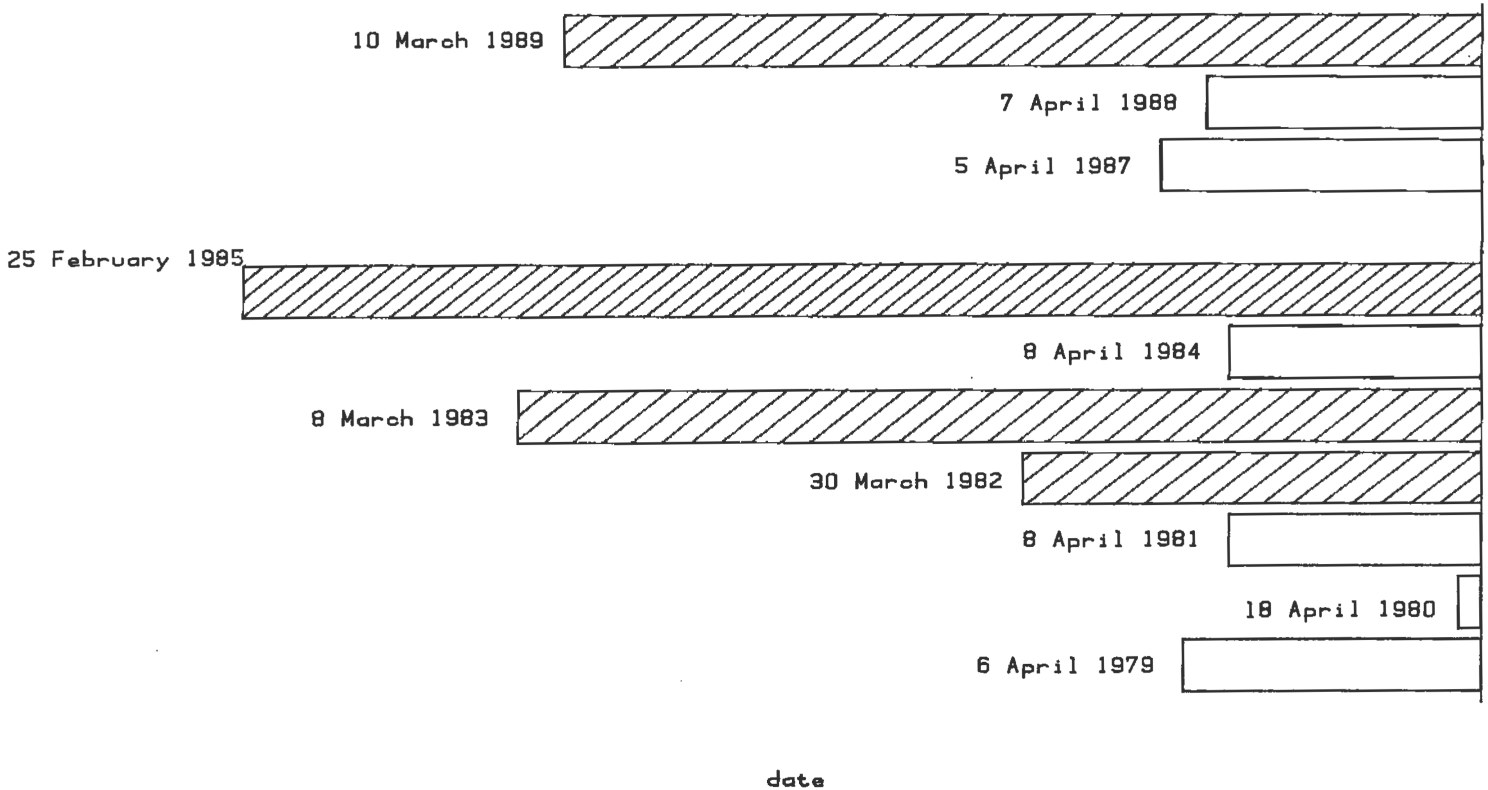

Figure 2. Mean number of eggs per female and per day.

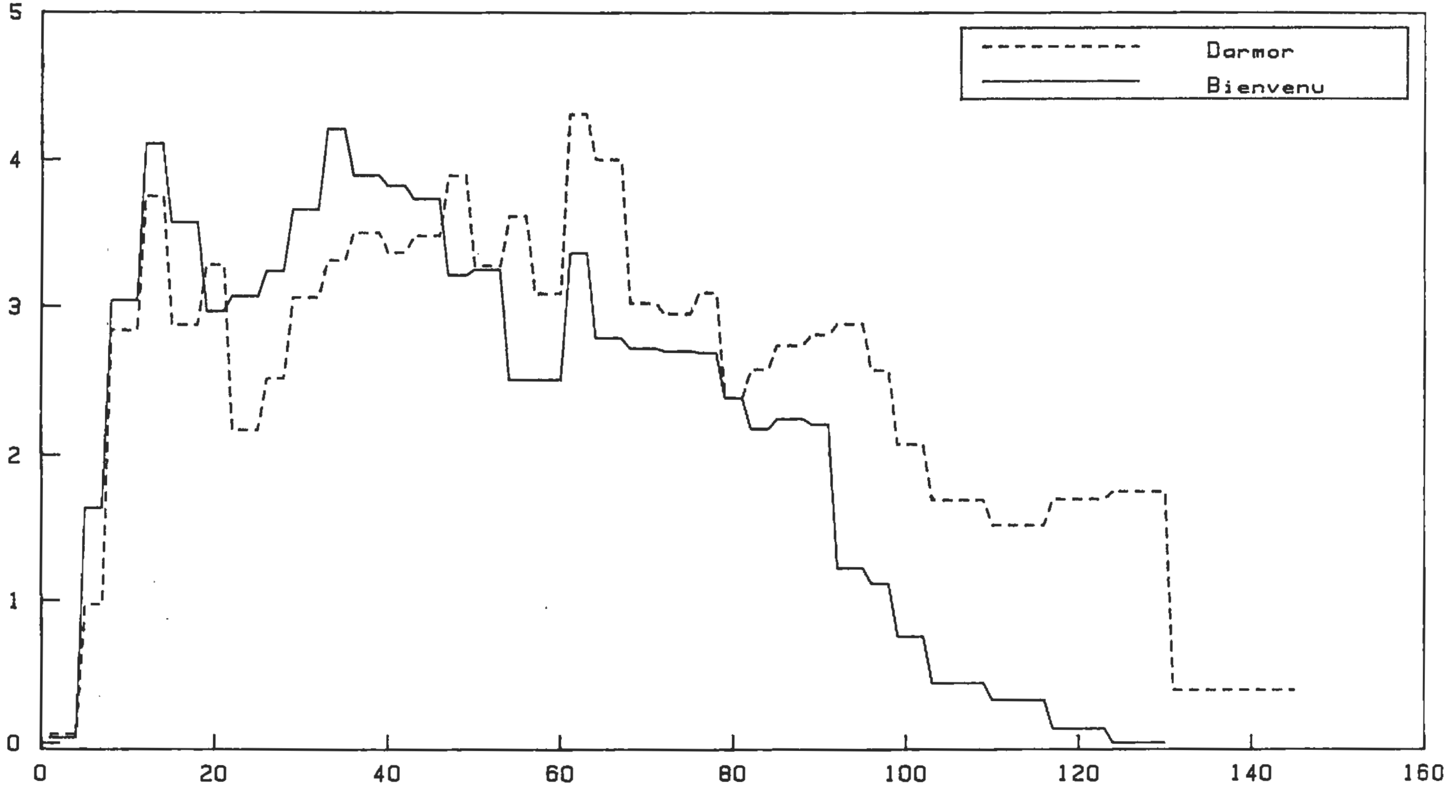

Table 1. Evolution of immature stages of *Baris coerulescens* in natural conditions.

number = number of plants in the sample
% att. = percentage of plants attacked by the weevil
total = number of 'insects' per plant (all stages)

date	number	% att.	total	eggs	L1	L2	L3	L4	nymphs	adults
				percentage of each stage per date						
20-4	24	33	0.9	100						
24-4	28	68	1.9	100						
2-5	59	76	2.4	100						
17-5	56	86	6.6	94.3	5.7					
29-5	17	100	10.4	62.0	29.0	0.6	0.3			
12-6	19	100	13.4	50.0	21.0	21.0	8.0	0.4		
26-6	22	100	9.6	13.0	2.0	9.0	30.0	45.0		
20-7	17	100	7.1				6.0	72.0	22.0	
harvest										
3-8	21	100	7.1					12.7	74.7	12.7
22-8	20	100	9.1					2.0	6.0	92.0

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date	number	% att.	total	eggs	L1	L2	L3	L4	nymphs	adults
				percentage of each stage per date						
20-4	24	33	0.9	100						
24-4	28	68	1.9	100						
2-5	59	76	2.4	100						
17-5	56	86	6.6	94.3	5.7					
29-5	17	100	10.4	62.0	29.0	0.6	0.3			
12-6	19	100	13.4	50.0	21.0	21.0	8.0	0.4		
26-6	22	100	9.6	13.0	2.0	9.0	30.0	45.0		
20-7	17	100	7.1				6.0	72.0	22.0	
harvest										
3-8	21	100	7.1					12.7	74.7	12.7
22-8	20	100	9.1					2.0	6.0	92.0

THE INCIDENCE AND IMPORTANCE OF BEET WESTERN YELLOWS VIRUS IN OILSEED RAPE

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Summary

Stratified surveys of oilseed rape crops carried out over the years 1986 to 1989 showed infection with BWYV to be widespread. Incidence was generally lower in the north and east and higher following mild autumn weather. Replicated plot trials over three years showed that virus incidence could be significantly reduced by autumn insecticide applications to control the aphid vector Myzus persicae. Repeated applications of specific aphicide gave best control of virus, but resulted in significant yield responses in only four of nineteen trials. Single or double deltamethrin sprays also gave good control of virus and gave significant yield responses in five of nineteen and six of nineteeen trials respectively, but other pests may have been controlled. However, even when yield increases were not significant, there was a trend towards higher yield suggesting a treatment effect. The work suggested that oilseed rape provided a good host for BWYV, and may provide inoculum for other crops. Insecticide applications specifically for virus control alone may be difficult to justify, but valuable yield benefit may result from sprays applied as part of a broader managed pest control strategy.

1. Introduction

The significance of beet western yellows virus (BWYV) as a pathogen of crop plants in UK has been unclear for many years. In western USA the virus is clearly defined as an economically significant pathogen of sugar beet causing yellowing of the leaves of affected plants. Studies have shown the same virus to be able to infect other important crop plants such as lettuce as well as weed hosts (Duffus, 1961). By contrast isolates of BWYV originally investigated in UK (Duffus & Russell, 1970) were apparently unable to infect sugar beet in glasshouse tests, yet were able to infect lettuce and the range of weed hosts susceptible to US isolates. Yellows disease of sugar beet in UK is largely due to infection by what is commonly regarded as the distinct mild yellowing virus (BMYV),which shares some of the weed hosts of BWYV but does not infect lettuce.

The report of BWYV infection in oilseed rape in 1980 (Gillingan, Pechan, Hill and Day (1980)) suggested that the virus may be of greater importance than had formerly been recognised. Such infection might be widespread and severe enough to cause damaging disease in the oilseed rape crop itself, but also, since BWYV and BMYV are closely related members of the luteovirus group, the oilseed rape crop may provide a source of virus inoculum for disease spread to sugar beet.

Smith and Hinckes (1984, 1985) undertook studies to investigate oilseed rape as a potential overwintering host for the sugar beet yellowing viruses (beet yellows virus and BMYV). Using antiserum specific to BMYV in ELISA tests they were able to detect a virus at high incidence in 78 of 80 crops surveyed throughout England and Scotland. In glasshouse studies they investigated the host range of the virus they isolated from oilseed rape and found that it was able to infect the same range of weed hosts as BWYV, however, it also infected sugar beet, albeit inefficiently. In aphid transmission tests using Myzus persicae, 10% of oilseed rape virus isolates of BWYV infected beet, whilst by contrast, 10% of BMYV isolates from sugar beet infected oilseed rape. When the oilseed rape isolate was first passaged through Capsella bursa-pastoris it became better able to infect beet, 40% of inoculated plants becoming infected. These results suggested that oilseed rape might form an overwintering host for virus to infect sugar beet. In work using the same BMYV antiserum Govier and Woods (1982) showed that BWYV and BMYV were very closely related.

The apparent widespread occurrence of BWYV in oilseed rape crops led Smith and Hinckes to investigate the development and significance of the virus to the oilseed rape crop itself. In crop observations in the winter of 1983/84, populations of M.persicae, the principal vector of BWYV, built up quickly after the rape emerged, and by the end of November all plants were infested. These rates of increase were more rapid and the aphid infestation and virus infection levels reached were higher than in the previous year, although the timing of their development was similar. Seed yields from plots regularly sprayed with insecticide in the 1983/84 winter were 10% greater than those from unsprayed plots and overall oil yield was 13.4% greater.

In separate studies, Smith and Hinckes (1985) were unable to correlate the occurrence of BWYV in plants with specific virus symptoms. Infection did not appear to be the cause of the frequently occurring lower leaf reddening, although this would be the kind of symptom which might be expected from luteovirus infection.

The work of Smith and Hinckes raised a number of questions on the importance of BWYV both to the oilseed rape crop and to sugar beet. The suggestion that an apparently symptomless virus infection could cause such significant yield effects caused concern not only related to BWYV infection itself, but also in the interpretation of oilseed rape pest control studies which had formerly taken no account of incidental virus control.

To see if the widespread occurrence of the virus was a regular phenomenon, and to establish its significance to the oilseed rape crop itself, ADAS instigated two investigations. In the first, tests to detect BWYV infection were added to the existing studies of the incidence and severity of foliar disease of oilseed rape, in the second, trials to investigate the control of aphid populations and thereby control virus infection were set up to demonstrate yield effects so far as possible independently of the effects of control of other pests such as cabbage stem flea beetle.

2. Materials and Methods

ELISA testing - BWYV was detected in selected leaves by an ELISA procedure essentially similar to that described by Hill (1984), with an antiserum prepared to an isolate of BMYV by Dr D A Govier at Rothamsted Experimental Station using a method described by Govier and Woods (1982). Coating and conjugate globulin concentrations were lug/ml. Leaf extracts were prepared using a Pollahne press and diluted to 1:20 in phosphate buffer (0.02M phosphate bufffer pH 7.4 containing 0.15M NaC1, 0.05% Tween 20, 2% polyvinyl pyrollidone and 0.2% ovalbumen).

Leaf extracts from six virus-free oilseed rape plants were included in each microtitre plate and a positive result recorded in a test sample only if the value of A405 was greater than twice the mean for virus free extracts. Leaf extracts from glasshouse-grown oilseed rape plants infected with BWYV were included in each plate to confirm the efficiency of virus detection.

Monitoring the incidence of virus in commercial crops - Crops were sampled on farms chosen from selected holdings to provide as representative a sample for each of the six ADAS Regions as possible (Hardwick et al). The number of crops monitored per Region was adjusted to be proportional to the area of oilseed rape grown (except in Wales). Chosen crops were sampled in spring when plants were between growth stage 2.0 (one internode detectable) and 3.3 (green bud) according to the key of the National Institute of Agricultural Botany (Anon, 1979), by taking twenty-five plants singly and at random. A sub-sample of ten randomly selected plants was retained for virus test. From each of the ten plants the lowest non-senescent leaf was removed to be individually tested for BWYV by ELISA.

The effect of BWYV infection on yield of oilseed rape - In preliminary studies, specific aphicide treatments were added to existing trials in which the effectiveness of pyrethroid sprays against cabbage stem flea beetle were being evaluated. These indicated that the application of aphicides in the autumn would control *M. persicae*, but it was difficult to seprate the effects of aphid and virus control from those resulting from control of cabbage stem flea beetle. Beginning in 1986, trials specifically designed to investigate the yield consequences of BWYV control were undertaken. In 1986 and subsequent years the same basic design was used at a number of sites chosen in areas less prone to cabbage stem flea beetle, rape winter stem weevil or cabbage root fly attack.

Experiments located within commercial crops of winter oilseed rape were of a randomised block design with four replicate blocks. Treatments were, untreated, Aphox (50% soluble pirimicarb grains) at 0.21 kg ai/ha applied weekly from crop emergence until the end of October, Decis (deltamethrin 2.5% ec) at 0.005 kg ai/ha applied at 2-true leaf stage (late Sept/early Oct), Decis (deltamethrin) as before but applied in mid to late October and Decis (deltamethrin) applied on both the above occasions. Other than the experimental treatments, husbandry was as per farm practice.

Plots were assessed at regular intervals for aphid infestation, 20 to 50 plants per plot being examined to determine the number of aphids per plant and/or the percentage of plants infested.

Samples of individual oldest non-senescent leaves from ten randomly chosen plants in each of the four unsprayed plots were taken in mid-December and individually tested for BWYV by ELISA.

In early years only the trials with high virus incidence in unsprayed plots when tested in December were resampled for further testing of all treatments in spring because of limited resources. However, latterly, all treatments in all trials were resampled, this time taking leaves from 20 plants in March before flowering occurred for test for BWYV by ELISA.

Plots were combine-harvested and yields corrected to 92% dry matter. Seed oil content and glucosinolate levels were determined.

3. Results

The incidence and severity of BWYV infection - The four years of survey data summarised in Table 1, confirm the widespread occurrence of BWYV in oilseed rape.

Table 1. The incidence and distribution of BWYV

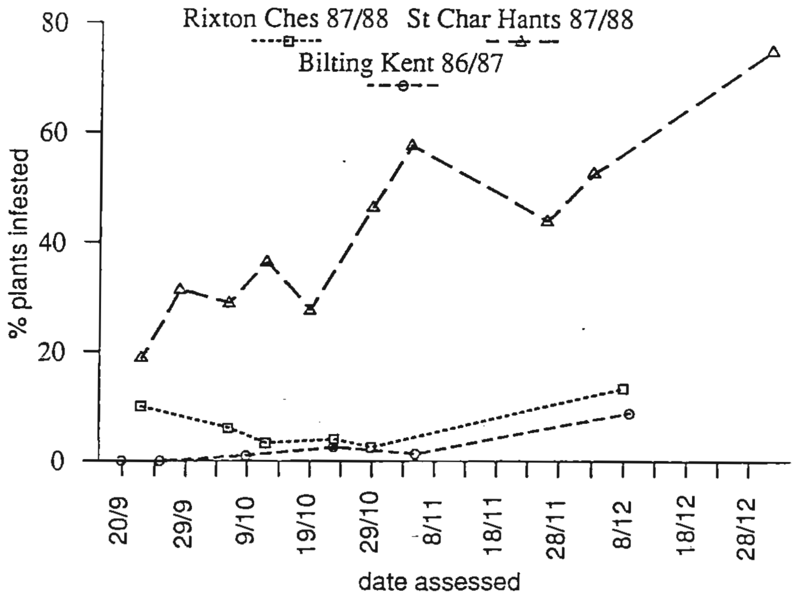
Region (ADAS)	Mean % virus infection 1986	1987	1988	1989
N (Leeds)	11.6	12.6	6.9	59.3
N (Newcastle)	-	1.4	1.6	40.0
M&W (Wolverhampton)	22.5	14.6	8.5	31.3
M&W (Evesham)	-	2.5	20.0	20.0
E (Cambridge)	21.1	3.2	12.2	24.1
E (Kirton)	-	5.4	2.7	34.6
SE (Reading)	11.3	12.0	10.0	-
SE (Wye)	54.0	0	22.0	27.1
SW (Bristol)	10.8	25.0	46.0	44.4
W (Trawsgoed)	6.6	-	10.0	13.3
W (Cardiff)	-	45.0	50.0	-
% crops infected	55	36	44	75
mean % infection	19	12	17	33

In general a greater proportion of the crops surveyed in the south were infected than were infected in the north, and the incidence of virus in individual crops showed a similar geographical trend. The data for 1989 suggests that after mild winters such as that of 1988/89 which encouraged the multiplication and spread of the virus vector M.persicae, the virus occurs more widely and attains a higher incidence in individual crops. The survey data suggested a trend towards higher incidence in individual crops. The survey data suggested a trend towards higher incidence in more crops in the south and south-west of the country, but following a mild winter, virus was more widespread and levels increased in most areas.

Control of aphids and BWYV infection - Data was available from 20 separate trial sites at which the experiment described above was undertaken.

Aphid control - aphid numbers were low at many sites during 1986/87 and 1987/88, with usually fewer than 5% of plants infested in the autumn. Populations were noticeably higher however, during the mild autumn of 1988/89. At some sites large infestations developed, typically at sites in Hants and Essex, and infestation was progressive throughout the autumn. Data from unsprayed plots in three trials done in 1986/87 and 1987/88 are presented in Figure 1 as illustration. Aphids, especially M.persicae were difficult to find in crops and not surprisingly at several trial sites BWYV infection was found in plots in which aphids had apparently been absent throughout the autumn. Consequently, the relationship between aphid infestation levels and subsequent BWYV infection was poor. However, where aphids were present in sufficient numbers to allow meaningful assessment, all of the insecticide treatments gave good control with little evidence of reinvasion.

Figure 1 - Aphid development on unsprayed plots at three sites in the autumn



Virus control - As expected, pirimicarb sprays applied weekly to provide complete control of aphids gave the greatest reduction in virus infection (Table 2). Deltamethrin applied at about the two true-leaf stage gave almost equal control and was generally more effective than the later application. Two spray applications of deltamethrin provided comparatively little additional control.

Table 2 - The effect of treatment on BWYV incidence

	Mean % reduction in BWYV incidence		
Treatment	1986/87 6 sites	1987/88 8 sites	1988/89 6 sites
carbamate - weekly	95	82	85
deltamethrin - Sept	83	78	65
deltamethrin - Oct	83	44	60
deltamethrin - Sept + Oct	86	83	64
unsprayed - mean % virus in March	58	44	33

The effect of insecticide treatments on yield - Over the three years, in only four of the 19 trials which were taken to yield were significant yield responses (P, 0.05) to carbamate treatments achieved. Two of these occurred in trials in the south east of the country and two were in the south-west, and two occurred in 1989 when virus incidence was generally high (Table 3).

Table 3 - Effect of insecticide treatments on yield

	Mean yield (t/ha) (% response)		
Treatment	1986/87 6 sites	1987/88 8 sites	1988/89 5 sites
unsprayed	4.15	2.89	2.80
carbamate - weekly	4.22 (1.6)	3.05 (5.5)	3.15 (12.5)
deltamethrin - Sept	4.28 (3.1)	3.07 (6.2)	3.12 (11.4)
deltamethrin - Oct	4.30 (3.6)	3.07 (6.2)	3.19 (13.9)
deltamethrin - Sept + Oct	4.34 (4.6)	3.09 (6.9)	3.21 (14.6)

Significant yield responses to deltamethrin treatment ($P < 0.05$) were more frequent, in six trials to two sprays, in five to the late spray and in four to the early spray. At other sites the general order of responses showed a clear trend. Whilst the single early deltamethrin application generally gave better virus control, there was no difference between the two single sprays in the extent of yield response, and there was little benefit from applying two sprays. Little or no effect of aphid and/or virus control on oil content and glucosinolate levels could be detected, and there appeared to be no consistent relationship between symptom development and virus control.

4. Discussion

The effect of BWYV infection has been investigated by a number of workers in addition to the work presented here.

At Rothamsted Experimental Station, disease incidence was similar in plots in 1985 and 1986, and in both years before and after flowering (Njuguma, Govier and Cockbain (1986), Nagarajan, Govier and Cockbain (1987)). In one year the date of sowing of the crop affected virus incidence. As with the work described here, application of autumn insecticide significantly reduced virus infection but yield data were not presented.

Read and Hewson (1988) carried out plot trials at 48 sites between 1986 and 1988 using deltamethrin sprays and were consistently able to demonstrate effective virus control. Yield responses were reported but since the trials were largely unreplicated, data analysis was limited.

Walsh, Perrin, Miller and Laycock (1989) found BWYV in 13 of the 16 crops they sampled, with incidence of virus infected plants in one crop as high as 85%. Significant increases in seed and oil yield were obtained following single or double sprays of an experimental insecticide, lambda-cyhalothrin (PP321), which effectively controlled BWYV, but there was no correlation between the seed yield and the amount of virus in the experimental plots.

The experiments described in this study have clearly shown that at sites where the confusing effects of other oilseed rape pests were largely avoided, and where specific aphicides with no action against other pests were used, aphid and virus control resulted in a significant yield response in 21% of trials. Such responses were obtained using deltamethrin sprays in32% of trials where two sprays were used and in 24% of trials with one spray. This better control may be partly due to the suggested anti-feedant activity of the material (Rice, Sawicki, Stribley, Tuckett and Gibson, 1982) or to the incidental control of low levels of other pests. Whilst at some sites, responses to low levels of virus and the apparent absence of aphids were difficult to explain, the generality of data suggested a trend which implied that aphid colonisation and virus infection did affect the performance of the oilseed rape crop. Further, there was a clear indication that the trend was more pronounced in years when early and continuous aphid colonisation led to higher incidence of virus infection. The study provided support for the work of Smith and Hinckes whilst demonstrating that generally lower incidence of aphids and virus infection was more usual than the levels they reported. The low cost of a pyrethroid spray application (ca £10/ha) was often easily repaid by the increased yield resulting from such sprays in many of the trials.

Further, the results suggested that the timing of application of sprays in the autumn was not critical provided they were not applied too late. Thus whilst it would probably be cost-effective to apply an autumn spray for virus control alone, it may be more appropriate to consider the control of pests (and incidentally,virus) as part of an overall autumn strategy. Potentially damaging populations of cabbage stem flea beetle now appear to occur in most areas where oilseed rape is grown. Where deltamethrin sprays are applied in early autumn for control of this pest, virus control will be an incidental bonus. Where such early autumn sprays are not warranted, for example, in more southerly areas where cabbage stem flea beetle populations are lower, virus incidence seems generally higher, especially in mild autumns, and sprays for virus control may more often be justified.

It is difficult to predict years when aphid populations will be sufficient to warrant sprays for virus control alone. Further work is needed to see if the build up of such populations can be forecast so that the need for sprays can be judged more effectively.

The oilseed rape crop appears to provide an ideal host for BWYV and where the virus vector overwinters, appears to present a threat to other crops. Investigations suggest that the adaptation of the virus to different hosts may limit the efficiency with which it passes from oilseed rape to sugar beet, but other brassica crops may be at greater risk. There is need for further clarification of the relationship between the two viruses BWYV and BMYV,in particular for studies of their hosts and vector relations.

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MONITORING DOUBLE LOW VARIETIES FOR DISEASE ATTACKS

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Summary

Double low cultivars were screeened in Germany as routine work on several Test Stations. The results are discussed with regard to Phoma lingam, Verticillium dahliae and Cylindrosporium concentricum. Only a few results were obtained for Alternaria and none for Sclerotinia sclerotiorum. The latter disease did not develop because of the severe drought experienced in the northern parts of Germany, where the scorings are usually carried out.

The results indicated, that there are double low cultivars, which are infected to a slight degree by P.lingam. The scores can be compared with the resistant standard cultivar Jet Neuf.

There were also differences between cultivars in susceptibility to V. dahliae but further work is needed to confirm these results using various methods to establish infection. Different reactions were also observed after infection by C. concentricum:

Results

Double low cultivars were screened for the following diseases:

A. Phoma lingam (Tode) Desm.
B. Cylindrosporium concentricum Grev.
C. Verticillium dahliae Kleb.

A. Phoma lingam: In Table 1 the results are presented on one cultivar-set which was tested at three Test Stations. Generally the incidence of P. lingam was slight in 1989 and at one Station (B) no significant differences could be observed. According to the statistical analysis and the respective scoring (++, +, o, -, =) there were variations between the cultivars which ranged from very susceptible (=) to very resistant (++). The reaction of the cultivars was not always the same at each Test Station as can be seen from cultivars Lirakota, F, J, T and BB. This variation has to be expected with a fungus, whose virulence is governed in all probability by several genes. To get a true picture of the reaction of a cultivar, observations have to be carried out at several sites over several seasons.

In Table 2 the results of some years are compiled. In this Table the classification of the cultivars is compiled according to the 1- 9 scale and these relative values are used in order to give each cultivar a "score". By this way it is possible to use the results of many Test Stations and seasons, without being afraid of "levelling" the results because of the differing levels of infection being present (Krüger (1983), Phytopath. Z. 108, 106- 113).

In Table 2 it can be seen, that there are cultivars which cover the whole range (1- 9) of susceptibilities, e.g. Lictor and Lirabon and others, which had a more consistant susceptibility level as e.g. Diadem and Libraska which were less susceptible and Ceres and Libravo which were moderate susceptible. Cobra tended to be more susceptible. By presenting the results in this way, the behaviour of the cultivars can be recognized.

From the results is also visible, that there are now again some cultivars which are only slight susceptible to P.lingam.

Table 1: Resistance testing of double low-oil seed rape cultivars against *Phoma lingam* in 1989 in der Federal Republic of Germany

Cultivar or No.	Station A	Station B	Station C	Mean
Lirabon	3.3- *	3.1	3.2o	3.2o
Ceres	3.2o	2.8	3.6o	3.2o
Arabella	3.5-	2.9	3.0+	3.1o
Lirakotta	2.4++	3.1	3.2o	2.9+
Jet Neuf	2.5+	2.6	2.8+	2.7++
Belinda	2.7o	3.0	3.8o	3.1o
A	2.5+	2.6	3.5o	2.8+
B	2.8o	2.6	3.2o	2.9+
C	3.3-	2.9	3.6o	3.3-
D	2.8o	2.7	3.5o	3.0o
E	3.2o	2.7	4.3-	3.4=
F	2.9o	2.8	4.8=	3.5=
G	3.2o	2.8	4.0o	3.3-
H	3.2o	2.8	3.5o	3.2o
I	2.4++	2.5	2.3++	2.4++
J	3.6=	3.3	3.5o	3.5=
K	2.8o	2.6	3.2o	2.9+
L	2.8o	2.8	3.4o	3.0o
M	2.6+	2.7	3.1o	2.8++
N	2.5+	2.5	2.8+	2.6++
O	3.0o	3.0	4.1o	3.3-
P	3.6=	2.8	4.3-	3.5=
Q	3.1o	2.8	3.3o	3.1o
R	3.1o	3.0	3.4o	3.1o
S	3.1o	3.8	3.5o	3.1o
T	3.2o	2.8	4.6=	3.5=
U	3.6=	3.3	5.3=	4.1=
V	2.3++	2.6	2.4++	2.4++
W	3.1o	2.9	4.0-	3.3o
X	3.3-	3.0	3.8o	3.4=
Y	3.1o	2.9	4.0-	3.3-
Z	2.7+	2.7	2.7+	2.7++
AA	2.6+	2.4	2.4++	2.5++
BB	2.5+	2.8	4.0-	3.1o
Mean	3.0	2.8	3.5	3.1
LSD (P = 0.05)	0.6	n.s.	0.8	0.3

Cultivar means:	0.34
Stations:	0.1
Interaction:	0.8

*) Rating

++	very resistant	(1)
+	resistant	(3)
o	moderate susceptible	(5)
-	susceptible	(7)
=	very susceptible	(9)

Table 2: General susceptibility of double low-oilseed rape cultivars for Phoma lingam in course of many seasons and on various Test Stations

cultivar	Number of experiments in which the cultivars were classified according to 1 - 9 scale					Number of experiments	Mean susceptibility
	1	3	5	7	9		
Arabella		1	13	3	2	19	5.6
Ceres		1	15	3		19	5.1
Cobra		2	5	3	4	14	6.3
Diadem	4	5	4			13	3.0
Elena		2	7	3	2	14	5.7
Liborius			7	6		13	5.9
Libraska	3	5	5			13	3.3
Libravo		4	10			14	4.4
Libritta	3	3	6	2		14	4.0
Lictor	1	2	7	4	4	18	5.9
Lindora	1	6	5		2	14	4.4
Liporta	2	6	4			12	3.3
Liquanta	1	5	8			14	4.0
Lirabon	3	5	10	1	1	20	4.2
Liradonna	1	4	8			13	4.1
Lirajet	5	3	3			11	2.6
Lirakus		4	6	1	1	12	4.8
Panter	1	3	6	3		13	4.7
Rubin	4	8	21	4		37	4.4
Santana		1	9	2	1	13	5.5

3. <u>Cylindrosporium concentricum</u>

On six Test Stations 34 cultivars were screened for susceptibility.The results have been collated by the author but have not been statistically analysed. Only the mean, the maximum and the the minimum values are compiled in Table 3. The differences between the most severely and least affected cultivars are also given.

Table 3. Susceptibility of oilseed rape cultivars to *Cylindrosporium concentricum* (scale 1- 9) at various Test Stations (A- F) 1989

Cultivar	Test Stations						
1- 34	A	B	C	D	E	F	Mean
Mean	3.9	2.6	3.7	2.5	1.7	3.6	3.0
Maximum	5.0	5.0	7.0	3.5	3.0	7.0	5.1
Minimum	3.0	1.8	2.0	1.3	1.0	2.0	1.9
Difference	2.0	3.2	5.0	2.2	2.0	5.0	3.2

There were large differences between the Test Stations. E, O and B had tha least and C, F and A the largest range of infection. Generally the severest infection was observed at those Stations, which also had a high mean infection.

The largest difference between cultivars was 5.0 at Stations F and C, where the highest score applied to one cultivar.

It may be concluded, that there are differences between the cultivars and that observations should be carried out in districts, where a severe infection is anticipated. In Germany the disease is not yet present in many districts, but recent warm winters may encourage spread of C. concentricum to new areas.

C. Verticillium dahliae

Verticillium dahliae is not present in many districts and consequently, the chances of scoring susceptibility to this disease were slight. Moreover the development of the symptoms takes place very late and interferes with other agricultural practices, because plants have to be removed from the plots (at least the lower part), thus creating difficult problems with the harvest of such plots.

Screening of the cultivars in the field and in the greenhouse revealed that there was a general agreement in the reaction of the cultivars, but variations have to be expected as was the case with the other two fungi discussed earlier. A comparison of the methods is tabulated (Table 4). It can be seen, that the infection was very high after inoculation of the greenhouse soil, averaging an index of 7.0. In the field and the glass bed the disease symptoms were less visible, in spite of the fact, that there was an inoculation of the soil in the glass bed with 25 g infested oat kernels per meter row. These 25 g were mixed with the soil in the furrow and the seed placed into this infested soil. The oat kernels were not dried; if dried kernels are used, about 1/3 of that quantity is sufficient.

The results with artificial inoculation in the field were not always as successful as those just presented. The results from 1987/1988 are presented in Table 5. From these dates can be seen, that there were no statistical differences between the cultivars; either with a low level of infection or with a high level. Under natural infection, only two out of three experiments gave significant differences between cultivars.

If these results are compared with respect to the number of cultivars placed into the various susceptibility classes, an impression can be obtained about the reaction of the cultivars. The values are compiled in Table 6 accordingly.

Table 6. Number of cultivars in each "susceptibility class"* when tested by three methods in 1989 (V. dahliae)

Susceptibility-class	Field (S.dorf)	Glass bed	Green house
9(=) Very susceptible	3	2	2
7(-) Susceptible	7	4	11
5(o) Moderate susceptible	13	23	10
3(+) resistant	9	3	5
1(++) very resistant	0	0	4

*) Classification according to Krüger (1983), Phytopath. Z. 108, 106- 113.

Table 4: Susceptibility of oil seed rape cultivars to Verticillium dahliae (Scale 1 - 9) - using three methods: field, glass bed, and greenhouse *)

Cultivar No.	Field	Screening Method Glass bed	Greenhouse
1	4.3-	3.0o	8.0-
2	4.2-	2.1o	6.7o
3	3.4o	3.0o	7.7-
4	4.4-	4.0-	8.0-
5	4.2-	2.3o	8.7=
6	4.3-	2.6o	8.0-
7	2.8+	2.1o	7.9-
8	4.6=	2.4o	5.3++
9	3.8o	3.3o	7.6-
10	3.2o	1.8+	7.3o
11	3.0+	2.6o	7.3o
12	3.9o	2.3o	4.7++
13	3.6o	2.9o	6.3+
14	3.6o	2.1o	6.4+
15	2.8+	2.9o	6.2+
16	3.7o	2.6o	7.5o
17	5.5=	5.9=	8.2-
18	2.7+	2.6o	7.6-
19	3.0+	2.2o	8.2o
20	3.9o	2.6o	4.7++
21	3.6o	3.6o	6.6o
22	2.9o	2.6o	8.7=
23	2.2+	1.4+	7.0o
24	4.4-	4.3-	8.2-
25	3.6o	2.6o	7.4o
26	3.3o	4.5-	6.8o
27	2.4+	3.0o	6.2+
28	4.5-	4.6=	8.2-
29	2.5+	-	-
30	2.9+	1.6+	5.2++
31	2.9+	-	-
32	4.9=	4.0-	7.8-
33	3.4o	2.4o	5.6+
34	3.0+	3.5o	6.0o
Mean x	3.6	2.9	7.0
LSD (P = 0.05)	1.0	1.7	1.2

*) Rating as given in Table 1

Table 5: Comparison of results of artificial inoculation methods with the incidence of *V. dahliae* in the field 1987/88

Cultivar	Control	Inoculation-Method			Natural Infection		
		Infested stalks	Bad kernels*	Rough ground oat kernels*	Friedrichs-thal (1 - 9)	Sartjen-dorf (1 - 9)	Bojen-dorf % **
Korina	1.0	2.3	-	-	2.7-***	1.6	
Jet Neuf	1.2	2.2	-	-	1.4+	1.4	
Cobra	1.1	2.1	7.1	6.1	2.6-	2.0	53.3=
Konstanze	1.5	1.9	7.2	7.2	3.5=	1.9	43.5-
Liborius	1.0	1.4	6.7	6.7	1.5+	1.2	23.3++
Libranco	1.1	2.1	6.9	6.4	2.1o	1.7	38.6o
Libravo	1.1	1.6	4.9	5.9	1.3+	1.2	21.6++
Libritta	1.0	1.7	6.2	6.8	2.1o	1.8	43.9-
Licantera	1.1	2.0	6.7	7.3	-	-	
Lirabon	1.1	1.5	6.9	7.2	1.8o	1.3	32.3o
Liradonna	1.0	1.5	6.1	6.2	1.7o	1.5	40.2o
Lirabus	1.0	1.6	6.2	6.8	-	-	
Liporta	1.1	1.5	6.2	6.8	1.2++	1.5	27.0+
Rubin	1.0	2.0	6.8	7.0	2.5-	1.4	46.1-
Santana	1.1	1.8	6.4	6.8	2.0o	1.4	41.7-
Ceres	1.0	1.7	6.6	6.1	1.4+	1.4	34.2o
Arabella	1.0	1.6	7.8	6.9	2.1o	2.0	34.8o
Mittelwert	1.1	1.8	6.6	6.7	2.0	1.5	35.8
LSD (P=o.o5)	n.s.	n.s.	n.s.	n.s.	0.8	n.s.	11.6

*) infected oat kernels respectively the rough ground ones were mixed with soil at a quantity of 3 % and applied at a rate of 25 g moist infested oat kernels for 1 m row

**) as it was only possible to make the records on short stubble, % plants infected was preferred.

***) Rating: see Table 1 for definitions

Differentiation between cultivars was most pronounced when the tests were carried out in the greenhouse, but unfortunately the infection level was rather high.

To get a general impression on the classification of the cultivars hitherto carried out, the results are compiled in Table 7. Unfortunately the number of tests with double low cultivars was limited. A mean level of infection can be calculated with some cultivars which have been tested several times. - From these numbers it is obvious that there was only one cultivar which could be classified as slightly more suceptible (Cobra). The others had a susceptible degree of about 5.

Table 7. Susceptibility of double low oilseed rape cultivars for <u>Verticillium dahliae</u>

Cultivars	Number of experiments in which the respective cultivar was scored (1- 9)					Number of experiments	Mean score
	Susceptibility class						
	1	3	5	7	9		
Arabella		3	9	2	1	15	5.1
Ceres	1	3	11	2		17	4.6
Cobra			6	2	2	10	6.2
Diadem	1				1	2	5.0
Elena						0	
Liborius		1				1	
Libraska		1	1			2	4.0
Libravo		1	1			2	4.0
Libritta				1		1	
Lictor						0	
Lindora						0	
Liporta	1	3	5		1	10	4.4
Liquanta		1				1	
Lirabon			12	2		14	5.3
Liradonna						0	
Lirakus						0	
Panter						0	
Rubin		1	8	2		11	5.2
Santana			4	1		5	5.4

SESSION 3

Biological Control of Pests

MONITORING OF PARASITOIDS IN OILSEED RAPE PESTS DURING 1989 IN SWITZERLAND

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Summary

In 1989 in different regions of Switzerland the rate of larval parasitism of the following rape pests was monitored: Ceuthorhynchus napi, Ceuthorhynchus quadridens, Meligethes spp., Ceuthorhynchus assimilis and Dasineura brassicae. In C. napi and D. brassicae larvae no parasitoids were found. The rate of parasitism in Meligethes spp. larvae in general was less than 10 %, but in one region rates of parasitism between 27 % and 85 % were found. Four different species of parasitoids parasitised Meligethes spp. larvae. The ectoparasitoid Trichomalus perfectus occurred in ranges from 37.5 % to 80 % on C. assimilis larvae.

1. Introduction

Oilseed rape is threatened by many insect pests. In Switzerland, 10 different pest species can cause economical damage. However, one would assume that there are also many parasitoids present. From other countries there are considerable data published about parasitoids. Osborne (1960) described the larval instars of parasitoids in Meligethes spp. larvae. Nilsson and Andreasson (1987) monitored parasitoids of the pollen beetle (Meligethes spp.) on winter and spring rape in southern Sweden. Von Rosen (1964) described the morphology of two pteromalid species which parasitise the cabbage seed weevil C. assimilis. An extensive work about many parasitoids in different rape pests was published by Jourdheuil (1960). Laborius (1972) gives a list of parasitoids of the Brassica pod midge D. brassicae in Germany.

Unfortunately the literature on parasitoids of different rape pests in Switzerland is very poor. Forel (1866) mentioned two Platygaster species as parasitoids in D. brassicae. Günthart (1949) found 30 - 40 % of the cocoons of C. napi parasitised by Tersilochus gibbus and 35 - 75 % of cocoons of C. quadridens parasitised by Tersilochus melanogaster. Günthart also mentioned the occurrence of T. heterocerus and Diospilus capito as parasitoids of Meligethes but the rate of parasitism was not recorded. Nothing has been published since 1949, so it is not known what impact the intensive use of insecticides in rape fields has had on the parasitoids.

2. Methods

Between full flower and the end of flowering of oilseed rape larvae of the pollen beetle (Meligethes spp.) were collected at one to three dates in different regions of Switzerland. The larvae were dissected under the microscope and the eggs and the larvae of parasitoids were recorded.
Also larvae of the weevils C. napi and C. quadridens were collected by cutting stems and the rates of parasitism were registered by dissection. For the cabbage seed weevil (C. assimilis) infested pods were harvested and inspected for larvae and ectoparasitoids.

3. Results

3.1 C. napi and C. quadridens

From two rape fields, one at Bad Ragaz and one at Zurich-Reckenholz stems were cut open and larvae of the stem weevil C. napi were removed. Under the microscope 200 larvae were dissected and checked for presence of parasitoids. No parasitoids were found.
In the same way 200 larvae of C. quadridens were inspected for parasitism. The rate of parasitism was 6 % at Bad Ragaz and 0 % at Zurich-Reckenholz. The species of the parasitoid is unknown.
No further larvae of these species were examined for parasites from other regions of Switzerland.

3.2 Meligethes spp.

The rate of parasitism of pollen beetle larvae from different regions in Switzerland in 1989 were very variable ranging from 0 to 83.9 % (Table 1).

Four different species of parasitoids were found: Tersilochus heterocerus, Phradis morionellus, Diospilus capito and an unknown species. The unknown species was very rare and we could not identify it from the larval stage. It was only found at Bad Ragaz.

<u>Table 1.</u>: The occurrence of 4 different parasitoids in L_3-larvae of <u>Meligethes</u> spp. in different regions in Switzerland, 1989. At each site, 200 larvae were controlled.

Site	Date of samp-ling	Rate of parasitism in L_3-larvae in %				Total rate of para-sitism in %
		Tersilochus heterocerus	Phradis morionellus	Diospilus capito	unknown species	
Bad Ragaz I	12 May	79.6	2.2	-	-	81.8
Bad Ragaz II	12 May	83.9	-	-	-	83.9
Bad Ragaz III	12 May	79.9	-	-	-	79.8
Vilters	12 May	67.2	1.0	-	-	68.2
Trübbach	15 May	35.6	2.4	-	-	38.0
Bülach	16 May	-	-	0.5		0.5
Buchberg	16 May	-	2.7	-	-	2.7
Adlikon	16 May	0.5	-	0.5	-	1.0
Oberkulm	16 May	8.5	-	-	-	8.5
Lotzwil I	18 May	7.3	-	-	-	7.3
Lotzwil II	18 May	1.2	-	-	-	1.2
Kleindietwil	18 May	3.4	-	-	-	3.4
Rohrbach	18 May	1.8	-	-	-	1.8
Langenthal	18 May	0.8	0.8	-	-	1.6
Bad Ragaz I	19 May	63.7	1.9	3.8	-	69.4
Bad Ragaz III	19 May	69.9	5.8	1.9	-	77.6
Bad Ragaz III	23 May	21.1	-	2.7	1.1	24.9
Huttwil	30 May	0.6	16.3	3.8	-	20.7

The rate of parasitism did vary with date of sampling. The results in table 2 give an example of this variation.

Table 2.: Varying rate of parasitism with date of sampling in L_3-larvae of Meligethes spp. at several sites 1989.

Site	Rate of parasitism in L_3-larvae in %				
	12 May	18 May	19 May	23 May	30 May
Bad Ragaz I	81.8		69.4		
Bad Ragaz III	79.8		77.6	30.5	
Huttwil		3.1			20.7

Meligethes spp. have three larval instars (Fritsche, 1955). We found in L_3-larvae much more parasitoids than in L_2-larvae as shown in Table 3.

Table 3.: Rate of parasitism in L_2- and L_3-larvae of Meligethes spp. at different sites 1989.

Site	Date of sampling	Rate of parasitism in %	
		L_2-larvae	L_3-larvae
Buchberg	9 May	0	4.8
Bad Ragaz I	12 May	33.3	81.8
Huttwil	18 May	0	3.1
Huttwil	30 May	17.1	20.7
Bad Ragaz III	19 May	23.8	77.6
Oberkulm	16 May	0	8.5

In Bad Ragaz T. heterocerus was the most important parasitoid. There was a high degree of superparasitism. We found up to six eggs in one larvae. Fig. 1. shows the results.

3.3 Ceuthorhynchus assimilis

The rate of parasitism in larvae of C. assimilis was recorded in different regions of Switzerland. Table 4 shows the results. The ectoparasitoid was most probably Trichomalus perfectus. The population of C. assimilis in summer was very low. We hardly found a sufficient number of infested pods.

FIG. 1 Frequency of L_3-larvae of <u>Meligethes spp.</u> with 0,1,2,... 6 eggs of the parasitoid <u>T. heterocerus</u> at Bad Ragaz.

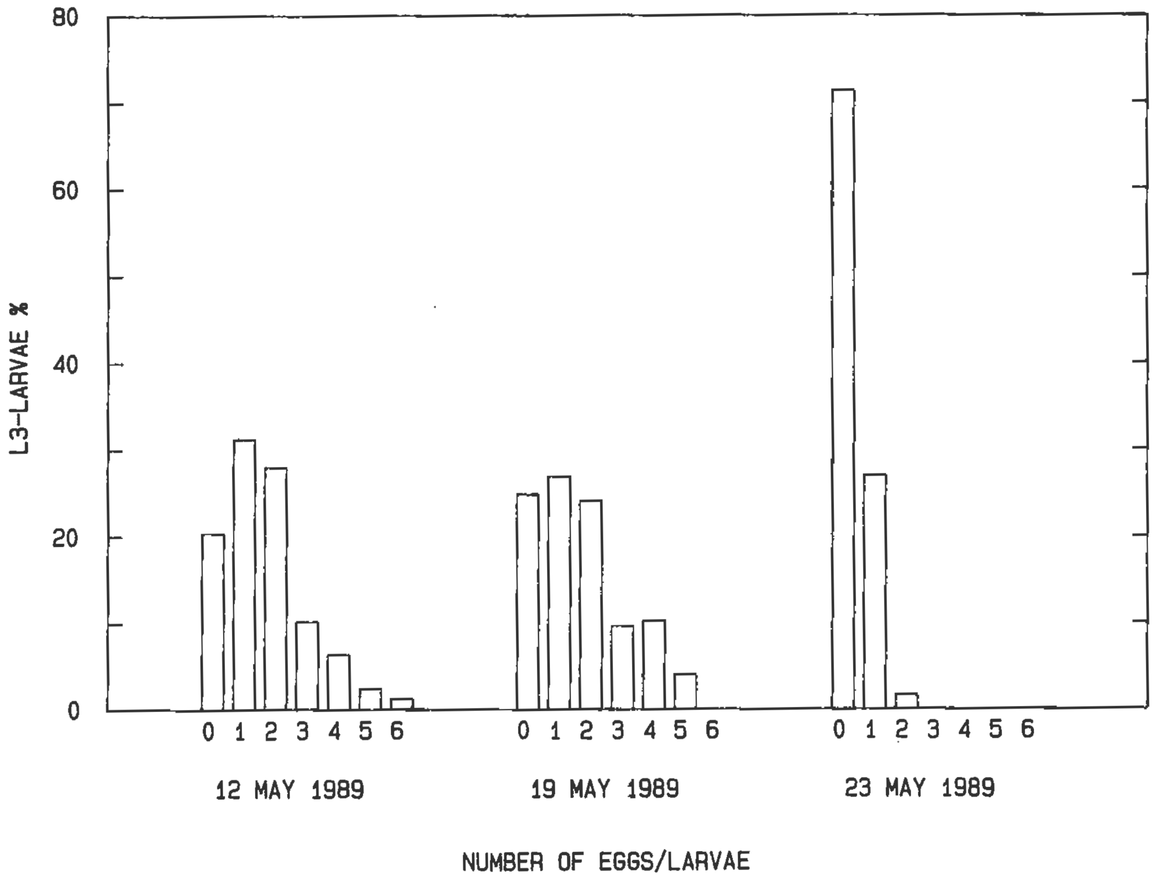

Table 4.: Rate of parasitism in C. assimilis larvae in different regions of Switzerland 1989. Parasitoid: most probably Trichomalus perfectus

Site	Date of sampling	Number of larvae of C. assimilis	T. perfectus	Rate of parasitism in %
Bad Ragaz I	6 June	8	3	37.5
Bad Ragaz III	6 June	13	6	46.2
Zollikofen	13 June	10	7	70.0
Oberkulm	13 June	12	9	75
Buchberg	13 June	62	35	56.5
Reckenholz	23 June	10	8	80

4. Discussion

This small survey shows that in Switzerland parasitoids in Meligethes spp. are rare except at Bad Ragaz. But that the ectoparasitoid in cabbage seed weevil is abundant.

Jourdheuil (1960), pointed out that the rate of parasitism varies greatly from year to year. Further investigations are needed to record the rate of parasitism in the next years at Bad Ragaz. Superparasitism would perhaps reduce the population of parasitoids. Jourdheuil (1960), states that in superparasitised larvae only one parasitoid is able to develop, namely the first one, and all others die. However, sometimes the host larvae can kill the eggs of the parasitoids.

The three parasitoid species Tersilochus heterocerus, Phradis morionellus and Diospilus capito could be determined after drawings and descriptions in Osborne (1960). One species could not be identified from the larval stage. Because this species was rather rare we could not find its cocoons in soil samples.

The composition of the Meligethes spp. population on oilseed rape in Switzerland has not been determined. In southern Germany Scherney (1953) reported the occurrence of four different Meligethes species (M. aeneus, M. viridescens, M. coeruleovirens, M. coracinus). Although M. aeneus was always the most frequent, the other three species could represent more than one third of the Meligethes population. In spring, M. aeneus is the earliest species to appear and is therefore the most damaging one, because it infests when rape is still in the bud stage. After Fritsche (1956) the rate of parasitism in M. aeneus larvae is lower than in other species. It is clear that for the evaluation of the economic importance of the parasitoids in Switzerland a survey is also needed to determine the frequency of Meligethes species with the population.

The ectoparasitoid T. perfectus of C. assimilis is very abundant and probably is therefore an important influence on the population dynamics of C. assimilis. T. perfectus was abundant in the western part of Switzerland in 1955 at a rate of 40 - 75 % of C. assimilis larvae (R. Murbach, pers.

comm.). Nowadays, we found a similar rate of parasitism in the northeastern part of Switzerland. The effect of insecticides on the population of T. perfectus is unknown.
Further investigations are needed to determine the regional distribution of parasitoids in rape pests in Switzerland more thoroughly.

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OCCURRENCE OF *Nosema meligethii* I. & R. IN POPULATIONS OF *Meligethes aeneus* L. IN FINLAND

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Abstract

Populations of *Meligethes aeneus* were sampled and inspected for the occurrence of the microsporidian disease *Nosema meligethii* over the whole of southern Finland during the autumn of 1989. From a total of 47 sampling locations, *N. meligethii* was found at only 8 sites. Out of 1575 inspected beetles only 20 were infected, giving an overall infection rate of 1.3%. The highest infection rate was 17% from a sample from Eastern Finland. All the 8 locations of occurrence of *N. meligethii* were outside the main growing area of oilseed crucifers, mainly originating from areas far from oilseed cultivations; i.e. they represented populations of *M. aeneus* that subsist on cruciferous weeds. These findings may have important ecological and management implications.

1. Introduction

Protozoan diseases of insects occur very commonly in natural populations (Brooks 1988). They often cause dramatic declines in population size, but since they produce no external symptoms, and are of a very small size (1.5 - 8 μm), they remained long unknown. First known microsporidian diseases of insects were *Nosema apis* and *Nosema bombycis*, serious diseases of the honey bee and the silk worm, respectively (Brooks 1988).

Nosema meligethii was first described in 1979 infecting rape blossom beetle *Meligethes aeneus* from the Leningrad area, USSR (Issi & Raditscheva 1979). Infection levels of 35% were reported from that area, and over 90% of the infected beetles died during the winter (Issi & Raditscheva 1979). The beetle host populations in the Leningrad area reproduce on cruciferous weeds, because no oilseed crucifers are grown in that area.

The presence of *N. meligethii* in Finland was first observed by Hokkanen et al. (1988), in a sample of *M. aeneus* collected in Pieksämäki, Central Finland. Since this microsporidian may play an important role in the natural control of *M. aeneus*, a thorough survey was made of the occurrence and the infection level of *N. meligethii* in the populations of the blossom beetle in Finland. So far *N. meligethii* has been reported only from the Soviet Union (Issi & Raditscheva 1979, Lipa, unpublished), Finland (Hokkanen et al. 1988), Hungary, Czechoslovakia, and Poland (Lipa, unpublished).

2. Material and methods

During 5 to 13 September 1989 a sample of the new generation adults of *M. aeneus* were collected at 47 different localities in the south western and south-central parts of Finland (Fig. 1, Table 1). The sampling covered practically the whole rape growing area, and in addition 15 samples were collected in areas where no oilseed crucifers are grown within at least 10 km of the sampling site. Adult beeetles were collected by hand from the flowers of *Sonchus arvensis* L., *Leontodon autumnalis* L., (Asteraceae), and *Raphanus raphanistrum* L. (Cruciferae), on which the beetles aggregate at this time of the year. In most cases 50-100 beetles could easily be collected in a reasonable period of time.

Beetles with the flower heads were transported to the laboratory in plastic cups and were kept at 8 ^{o}C until microscopical examination (within one week). Live beetles were individually put into a small drop of water on a microscopic slide and their bodies crushed (ground) with a rounded glass stick in order to release the parasite spores from infected tissues. On each microscopic slide 8 beetles were treated in this way. Then the slide was examined with a compound microscope at the magnification from 100x to 400x. In total 1575 beetles were examined, averaging about 33 beetles per population sample.

For a reference, two samples collected at the beginning of the summer from the sampling locations # 36 and # 40 were examined. These were air-dried individuals, and represented the old, overwintered generation of *M. aeneus*. The spores of microsporidia are readily recognizable in such samples also.

The pattern of rape cultivation at the county level was compiled and calculated based on the data obtained from the National Board of Agriculture, Statistical Office, Helsinki.

3. Results

Occurrence of *Nosema meligethii*

The parasite was found at eight of the 47 sampled localities (Fig. 1, Table 1). All these localities were outside of the main rape growing area (defined as areas where less than 5% of the cultivated area was sown to oilseed crucifers). The sample sites 22, 24, and 25 (Kangasala, Urjala, Forssa), where the parasite was found, were at the very edge of the main growing area (Fig. 1), but within that border area represented counties where turnip rape was less extensively grown than in the neighbouring counties. The other five localities, where *N. meligethii* was found, lay clearly outside the main growing area for oilseed crucifers (Fig. 1).

Half (4/8) of the samples which yielded the parasite were collected from "wild" *M. aeneus* populations, i.e. from localities where no oilseed crucifers were grown at least within some 10 km (sites 31, 33, 35, 36). These beetles subsisted on cruciferous weeds. Of the 47 sampling localities 15 were of this type; at the 31 other localities the beetles were collected close to turnip or oilseed rape fields. The infection rate of *M. aeneus* in the wild populations, however, was on the average 2.5% (11/448), compared with 0.8% (9/1127) in the populations from rape cultivations. This three-fold difference was statistically significant ($X^2 = 6.795$, $p < 0.01$).

The total number of infected *M. aeneus* individuals found in this survey was 20, which out of the total of 1575 examined individuals gives an overall rate of parasitism 1.3%. The highest observed rate of 17% was at location 35, Haukivuori, whereas the overall infection rate in those populations of *M. aeneus* where the parasite at all was detected, was 7.9%.

4. Discussion

This report confirms the occurrence of *N. meligethii* in the populations of *M. aeneus* in Finland, earlier briefly mentioned by Hokkanen et al. (1988). This is the first paper that examines the occurrence of *N. meligethii* in areas where oilseed crucifers are grown, because the only other paper known to the authors, the original description of the species (Issi & Raditscheva 1979), deals only with wild host populations.

The infection rate observed in this study, 1.3% on the average, and maximally 17%, was very low. Issi & Raditscheva (1979) reported parasitism from 10 to 35 % in the new generation beetles in the Leningrad area, and similar data has been obtained from Czechoslovakia (23 %) and Hungary (20 %) (Lipa, unpublished).

Occurrence of *N. meligethii*

The pattern of the occurrence of *N. meligethii* in Finland is peculiar. No infections were found in the samples from the main rape growing area, although certainly the vast majority of all the beetles occupy this area, and the horizontal transmission of the parasite would appear easiest.

It can be speculated that *N. meligethii* is slowly spreading into the country, obviously from the east, and has not yet reached the west coast. An alternative hypothesis would be that the disease has always been here, but for some reason is now confined to the central-eastern parts of the country.

A difficulty with the first hypothesis is the question why *N. meligethii* is not spreading along the southern coastal areas, where there are plenty of host beetles. The second hypothesis has two difficulties: how can one explain the very low disease incidence in comparison with for example the nearby Leningrad area (cf. Fig. 1), and why are there such large regions where *N. meligethii* could not be found at all?

The possible sensitivity of *N. meligethii* to the regular use of insecticides appears to answer most of the above questions. If the disease is spreading, its spread may be hampered by the intensive use of insecticides in virtually all rape fields in Finland (See Hokkanen et al. 1988), and therefore it cannot spread along the southern coastal areas. Due to the low density and the geographical isolation of the *M. aeneus* populations outside the main rape growing areas, the spread of *N. meligethii* is not very fast and therefore it has not yet reached the western parts of the country. To verify this hypothesis the areas along the eastern border of Finland need to be sampled more intensively.

Assuming that *N. meligethii* has existed in Finland for a long time, the pesticide-sensitivity hypothesis would mean that the disease has been virtually wiped out from the main rape growing areas through the intensive use of insecticides. In that case, however, there should be some positive finds from the western parts of Finland, and one would also expect higher disease incidence in the wild populations.

N. meligethii in biological control

Microsporidia can sometimes be very effective in the biological control of their host insects (Brooks 1988). *N. meligethii* has such potential, because Issi & Radistheva (1979) report relatively high infection levels and very high winter mortality of infected *M. aeneus*. Such parasites have a very good stabilizing effect in the population dynamics of the host insect, in addition to lowering the average densities (Anderson 1982).

It might be worthwhile to spread *N. meligethii* artificially into the populations of *M. aeneus* in Finland, and at the same time to try to minimize the use of insecticides in the target area, for example along the suggestions by Hokkanen et al. (1988). Such inoculative releases of microsporidia have rarely been attempted (Brooks 1988), but in this case the setup and outlook are promising.

SESSION 4

Host Resistance and Integrated Control of Diseases

A METHOD TO ESTIMATE THE LEVEL OF RESISTANCE IN OILSEED RAPE TO *PSEUDOCERCOSPORELLA CAPSELLAE*

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Summary.
Pseudocercosporella capsellae, responsible for white leaf spot disease, infects all parts of the plant. Cultivar resistance can be estimated at early stage.
Four drops of spores suspension are put on cotyledons and plants are incubated at 10°C and high humidity for 24 hours. The cultivars ranking obtained with this method is the same as field assessment.

1.Introduction.

Pseudocercosporella capsellae causes the white leaf spot disease on rapeseed (Petrie and Vanterpool, 1978). It has been known as pathogen on leaves for a long time in France. In 1985 the symptoms were visible on pods and this resulted in yield reductions of several quintaux.
It is difficult to assess the resistance of genotypes in the field, mainly because the symptoms may be confused with symptoms of *Phoma lingam* and *Peronospora parasitica* on leaves and *Alternaria brassicae* on pods.
For this reason we have developed a method using artificial conditions to test the level of resistance in *Brassica* at an early stage of growth.

2.Materials and methods.

Plants used in this study were grown for 7 days under growing chamber conditions at 20°C with 16 hours of light. Three canola type cultivars of rapeseed used in this study included Jet Neuf, Darmor and Bienvenu. The other crucifers used were accessions of *B.nigra* (black mustard) cultivar Junius and *B.juncea* (brown mustard) cultivar Picra.

The spores of *P.capsellae* were obtained by washing leaves with natural field infection with sterilized water. The spores suspension was gauged at $2x10^5$ spores/ml and $5x10^4$ spores/ml. Four drops of spores suspension,10 ul per drop, are deposited on cotyledons of each plant.

Each variety had 12 plants and were put at three temperatures : 10°C, 15°C and 20°C, after inoculation. A high level of relative humidity was maintained for either 24 hours or 4 days by covering pots with a plastic cover.

The symptoms are assessed from 0 (no symptom) to 9 (brown necrosis on whole of drop area) four or five days and twelve days after inoculation.

This assay was repeated three times.

Table 1 - Reaction of cultivars to *P. capsellae* contamination at different temperatures. Spores suspension gauged at $5x10^4$ spores/ml and 24 hours of high humidity.

	DISEASE INDEX (0 to 9)					
Temperatures	10°C		15°C		20°C	
Days after inoculation	4	12	4	12	4	12
Varieties						
BIENVENU	0,7	2,6	1,3	3,4	0,0	6,5
PICRA	0,0	1,1	0,2	1,6	0,0	5,6
JET NEUF	0,0	1,2	0,0	2,3	0,0	8,8
JUNIUS	0,0	1,2	0,0	1,8	0,0	6,1
DARMOR	0,0	0,1	0,0	0,6	0,0	7,3

Table 2 - Reaction of cultivars to *P.capsellae* contamination at different temperatures. Spores suspension gauged at $2x10^5$ spores/ml and 24 hours of high humidity.

	DISEASE INDEX (0 TO 9)					
Temperatures	10°C		15°C		20°C	
Days after inoculation	4	12	4	12	4	12
Varieties						
BIENVENU	6,6	6,4	3,2	7,5	4,3	9,0
PICRA	2,5	2,0	3,0	3,0	3,1	7,2
JET NEUF	2,3	2,4	1,6	6,8	2,3	9,0
JUNIUS	1,6	2,3	1,5	6,3	2,0	8,6
DARMOR	0,0	0,0	0,0	2,5	0,0	9,0

Table 3 - Reaction of cultivars to *P. capsellae* contamination at different temperatures. Spores suspension gauged at $2x10^5$ spores/ml and four days of high humidity.

	DISEASE INDEX (0 to 9)					
Temperatures	10°C		15°C		20°C	
Days after inoculation	5	12	5	12	5	12
Varieties						
BIENVENU	3,6	7,0	7,5	8,7	0,0	6,8
PICRA	0,0	6,2	3,5	5,3	4,3	8,0
JET NEUF	0,0	2,7	1,2	4,5	0,0	5,8
JUNIUS	2,8	3,9	4,6	6,8	7,2	7,5
DARMOR	0,0	1,1	0,0	1,5	0,0	6,3

Table 4 - Reaction of cultivars to *P. capsellae* contamination at different temperatures. Spores suspension gauged at $5x10^4$ spores/ml and four days of high humidity.

	DISEASE INDEX (0 to 9)					
Temperatures	10°C		15°C		20°C	
Days after inoculation	5	12	5	12	5	12
Varieties						
BIENVENU	6,2	3,6	2,1	4,1	2,2	8,6
PICRA	6,4	1,2	0,9	4,3	4,1	7,2
JET NEUF	1,7	0,1	0,2	3,1	1,9	6,6
JUNIUS	1,8	3,7	4 0	5,4	5,2	8,0
DARMOR	0,0	0,0	0,0	1,5	0,0	2,5

3.Results.

Spores concentration.

The symptoms obtained with 5x10⁴ spores/ml were weak and the variation coefficient is very high. There was not a good discrimination between varieties when there were only 24 hours of high humidity (Table 1). In contrast, when 2x10⁵ spores/ml were used the symptoms were pronounced on the susceptible variety Bienvenu and there was a good discrimination between varieties (Table 2).

Period of high humidity.

For 2x10⁵ spores/ml an incubation period longer than 24 hours was not necessary (Table 3). The symptoms were not better developed and the differentiation between varieties did not change after longer incubation.

Temperatures.

At 20°C it was often not possible to separate the varieties.

4.Conclusion.

The best conditions to obtain a good discrimination are :

- 2x10⁵ spores/ml.
- 24 hours of high humidity.
- 10°C or 15°C.

The cultivars ranking obtained with this method for Bienvenu, the most susceptible variety, Jet Neuf moderately susceptible variety, Darmor with good resistance is the same as field assessment. The variation of Junius and Picra ranking is probably because they are population cultivars. The *B. napus* varieties are lines.

This method is easy to practice and the results are product very quickly.

This work was supported by PROMOSOL and CETIOM.

5.Reference.

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RESISTANCE OF DOUBLE LOW WINTER RAPE CULTIVARS TO STEM CANKER AND THEIR YIELD RESPONSE TO FUNGICIDE TREATMENT

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Summary

Stem canker on winter rape caused by Phoma lingam (teleomorph: Leptosphaeria maculans) is in Germany one of the major diseases in oilseed rape production. Controlling the disease by fungicides in 1986/87, 1987/88 and 1988/89 showed, that most of the treatments were not economic when stem canker occurred at a moderately severe degree. Double low cultivars with a very low degree of susceptibility to stem canker showed no positive response on yield to fungicide treatment. Leaf attack by the fungus in autumn did not seem to correlate with the intensity of stem canker at harvest.

1. Introduction

Stem canker caused by Phoma lingam (teleomorph: Leptosphaeria maculans) is one of the major diseases of winter oilseed rape in Germany. It has increased in importance as the area of double low varieties has increased over the last 6 years because most of them are far more susceptible than the old single low varieties such as Jet Neuf which is rather resistant to stem canker. For this reason the need to evaluate fungicides for control of canker in rape production has become very important. However, from the point of view of biology, the pathogen is rather difficult to control because the fungus attacks the rape plant from onset up to harvest. Leaf attack in autumn seems to play an important role for the severity of the disease (Hoffman and Schramm, 1987) as the fungus grows after leaf infection downwards via petiole to the root neck causing stem canker in spring and later premature lodging and ripening.

Aim of these trials was to find out if fungicide treatments are effective against Phoma lingam and increase yield with special regard to some new double low cultivars.

2. Material und methods

Double low winter rape cultivars

The cultivars Ceres, Liporta and Diadem were used.The first two are susceptible whilst Diadem is resistant to stem canker (Table 1). At present the susceptible cv.Ceres is grown on about 30-40 % of the winter rape area in Europe.

Table 1 Susceptibility of double low winter oilseed rape cultivars to stem canker (Phoma lingam)

Cultivar	Degree of susceptibility*
Ceres	5
Liporta	5
Diadem	2

*Classification of the official Variety List by the scale used in Bundessortenamt (1989), from 1 = not susceptible to 9 = very strongly suscesptible.

Fungicides

The fungicides Sportak (40 % a.i. prochloraz, ec applied at 1.5 l product/ha) and Folicur (25 % a. i. tebuconazole, ec applied at 2.0 l product/ha) were used. Sportak has a certain local systemic action and Folicur a systemic action in herbacous but not in woody plants. Their fungicidal activities on P. lingam was investigated in the greenhouse. Application times in the field were autumn (leaf development) spring (stem elongation) and full flowering of winter rape as single, double or triple treatments.

Trial design

The experiments started in1986 were carried out as field plots with a size of 10 - 20 m² as a randomized block design with 3-4 replicates for each experimental variant.

Desease assessments

Stem canker was assessed by estimating the degree of leaf attack and of root neck attack before harvest and, after harvest. The latter ones were evaluated after the scoring scale of Krüger (1982). For reason of comparing, the scale -1 means no disease attack, 9 very high diseased - was transformed to percent of symptoms as shown in Table 2.

Table 2: Transformation of disease index to percentage plants affected

Scale	Degree of symptoms in %	x (%)
1	no disease attack	0
3	1 - 10	5,5
5	11 - 25	18
7	26 - 44	35
9	45 - 100	72,5

Yield

Yield of the plots was calculated on yield/ha at 91 % dry matter

3. Results

Severity of stem canker on winter rape in the field experiments carried out in Westphalia in 1987/88 and 1988/89 was 30 - 38 % during both years. The disease reached, 38 % in 1987/88 at ripening stage (EC 83) on the cvs Ceres and Liporta whilst Diadem had 10 % less attack. After harvest the disease situation on the different cultivars remained similar. In 1988/89 the degree of stem canker at harvest time (EC 90) was on Ceres at 35 %, Diadem was less affected whilst Liporta had significantly more canker. After harvest disease situation was similar except that on Diadem there was no further development (significantly less than on Ceres and Liporta). The different susceptiblity of the 3 cultivars to stem canker could be compared with the scores of the official variety list (Bundessortenamt,1989). Leaf attack of rape by P. lingam (L. maculans) scored in autumn was different: Ceres was more susceptible than Diadem and Liporta. Leaf attack by the fungus in autumn (EC 26/27) 1988/89 was on Ceres about 36 %, Liporta 21 % and on Diadem 13 % (Table3).

There was no correlation between leaf and root neck attack on Liporta,Ceres and Diadem (Table 3).

Fungicide treatments in 1987/88 against stem canker (Sportak 1,5 l/ha autumn; Sportak 1,5 l/ha autumn and 1,5 l/ha flowering; Folicur 0,5 l/ha autumn and 2,0 l flowering) gave no significant control on any of the cultivars.

In 1988/89 all fungicide treatments (autumn: EC 23, spring: EC 37) with Sportak (1,5 l/ha) and Folicur (2,0 l/ha) reduced significantly disease attack by stem canker. However, fungicide application significantly reduced leaf attack on Ceres and Liporta but not on Diadem. (Table 4) The results from 3 years'plot trials (1986-1989) showed that all single (autumn, spring, flowering),double(autumn and spring) as well as triple sprays (autumn and spring and flowering) over all investigated double low-cultivars of different susceptibility to stem canker did not significantly increase yield when stem canker was moderately severe (Table 5). However, single sprays in autumn or in spring as well as double treatments (autumn and spring) increased yields between 5-9 %. Within the cultivars Diadem showed no positive reaction to fungicides on yield, whilst Liporta showed highest response, Ceres gave an intermediate response.

4. Discussion

Stem canker can be reduced by using fungicides such as Sportak and Folicur. However, the results were very variable. Most of the treatments were not economic under moderately severe disease attack. Controlling leaf attack in autumn did not effect a reduction in stem canker.The correlation between the susceptibility of leaves and root necks of double low cultivars to Phoma lingam remains to be demonstrated.

There seems to be no correlation on the cvs Liporta and Ceres. Amongst the new double low winter rape cultivars there are certain which have a very low susceptibility to stem canker, e. g. Diadem,which seems to be sufficient for controlling the disease at least when it occurs at a moderate severe intensity. Diadem also reacted negatively on fungicides in regard to yields. Chemical control of stem canker does not seem to be necessary at a low and moderately severe incidence of the disease. At a very severe occurrence one single spray on susceptible cultivars may be economic. Further investigations on new double low cultivars with a low degree of suscesptibility to stem canker are necessary.

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Table 3. SUSCEPTIBILITY OF DOUBLE LOW WINTER RAPE CULTIVARS TO STEM CANKER (*Phoma lingam*) IN REGARD TO LEAF ATTACK AND DISEASE DEVELOPMENT

YEAR	1987/88		1988/89		
TRIAL TYPE	plots		plots		
ASSESMENT					
ORGAN	Root neck		Leaf	Root neck	
STAGE	harvest			harvest	
	before (EC 83)	after	(EC 26/27)	bevore	after
DATE	10-8-88	27-9-88	30-11-87	14-7-89	21-7-89
CULTIVAR					
CERES	100	100	100	100	100
Disease scoring	(38)	(22)	(36)	(34)	(39)
DIADEM	74	92	36	95	80
LIPORTA	103	102	58	115	113
LSD (P = 0.05)	8	10	15	12	10

* BSA-Note 1989: 1 - 9 scale, 1 = no disease attack ($\bar{x}$ = 0%), 3 = 1 - 10 % disease attack ($\bar{x}$ = 5 %), 5 = 11 - 25 % ($\bar{x}$= 18 %), 7 = 26 - 44% ($\bar{x}$ = 35 %), 9 = 45 - 100 % ($\bar{x}$ = 72,5 %), ( ) = estimated relative value in %

Table 4. RESPONSE OF DIFFERENT DOUBLE WINTER OILSEED RAPE CULTIVARS TO FUNGICIDE TREATMENTS ON STEM CANKER (Phoma lingam)

YEAR	1988/89								
TRIAL TYPE	plots								
TRIAL-No.	Ra9 Fu3								
ASSESSMENT									
ORGAN	Leaf			Root neck					
STAGE	(EC 26/27)			before harvest (EC 90)			after harvest		
DATE	30-11-88			14-07-89			21-07-89		
CULTIVAR	Diadem	Ceres	Liporta	Diadem	Ceres	Liporta	Diadem	Ceres	Liporta
TREATMENTS									
Sportak (1,5 l/ha)									
autumn	101	30	67	80	50	81	74	52	71
autumn + spring	--	--	--	--	--	--	--	--	--
Folicur (2 l/ha)									
autumn	86	30	43	68	60	69	64	79	69
spring	--	--	--	42	55	77	73	43	56
UNTREATED CONTROL	100	100	100	100	100	100	100	100	100
scoring value (%)	(12)	(36)	(21)	(33)	(34)	(40)	(31)	(39)	(41)
LSD P (= 0.05)	41	15	25	29	27	24	20	16	14

Table 5. RESPONSE OF DOUBLE LOW WINTER RAPE CULTIVARS OF DIFFERENT SUSCEPTIBILITY TO FUNGICIDE TRETATMENTS AGAINST STEM CANKER ON YIELD FROM 1987-1989

YEAR	1986/87	1987/88			1988/89			MEAN	
TRIAL TYPE	plots	plots			plots				
TRIAL - No.	07.1	Fu. 88			Ra 9 Fu 3			1986-88	1986-89
CULTIVARS	Ceres[1]	Ceres[1]	Diadem[2]	Liporta[3]	Ceres[1]	Diadem[2]	Liporta[3]		
TREATMENTS									
Sportak (1,5 l/ha)									
1) autumn	119	106	103	116	98	96	110	111	106
2) autumn + spring	--	--	--	--	--	--	--		
3) autumn + full flowering	116	106	113	107	--	--	--	111	
4) full flowering	101	--	--	--	--	--	--		
Folicur (2,0 l/ha)									
1) autumn	97	--	--	--	96	90	115		99
2) spring	101	--	--	--	111	106	119		109
3) full flowering	103	97	104	105	--	--	--	103	
4) autumn + full flowering	--	--	--	--	--	--	--		
5) autumn + full flowering*	114	103	105	112	--	--	--	109	
6) spring + full flowering	106	--	--	--	--	--	--		
7) autumn + spring + full flowering**	--	101	112	102	--	--	--		
UNTREATED CONTROL	100	100	100	100	100	100	100	100	100
YIELD dt/ha	37.2	33.7	39.9	32.0	46.5	47.5	36.2	35.7	41.9
LSD$^+$ (P = 0.05)	5	13	11	13	14	14	18	10	12
	n.s.	n.s.	n.s.	ns.	s.	s.	s.		

* dosis: 0.5 + 2.0 l/ha ** dosis: 0.5 + 1.5 l/ha [1]Ceres [3]Liporta: moderately susceptible [2]Diadem: resistant

$^+$ comparison within the treatments

PESTS, DISEASES AND EFFECTS OF CROP PROTECTION ON SINGLE- AND DOUBLE-LOW WINTER RAPE

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Summary

Double-low cultivars (Ariana, Capricorn, Cobra, Corvette, Cosmic, Libravo, Tapidor)of winter oilseed rape were not consistently more or less susceptible to diseases or infested by pests than the single-low cultivar Bienvenu, but were less tolerant of damage. When *Pyrenopeziza brassicae* and *Alternaria* spp. were prevalent and severe, fungicides increased yield by a greater amount (+0.96 to 1.58 t/ha) on all double-lows tested than on Bienvenu (+0.16 t/ha). Oil content, seed mass and oil yield were also increased by greater amounts in some double-lows than in Bienvenu. When *Psylliodes chrysocephala* was the principal pest species, insecticides increased yield by a greater amount (+0.30 to 1.49 t/ha) on all double-lows tested than on Bienvenu (-0.25 t/ha). Glucosinolate concentration in seed of some cultivars was decreased by fungicides and increased by insecticides. Symptoms of *P. brassicae* and *Alternaria* spp. and damage by *P. chrysocephala* were negatively correlated with yield; *P. brassicae* incidence and severity was positively correlated and damage by larvae of *P. chrysocephala* was negatively correlated with glucosinolate concentration in harvested seed.

1. Introduction

The recent replacement of single-low (low erucic, high glucosinolate) winter oilseed rape cultivars with double-low (low erucic acid, low glucosinolate) types in much of Europe has been accompanied by concern that lowering the glucosinolate content of rape cultivars may increase both their attractiveness to insect pests and their susceptibility to diseases. The concern arose because glucosinolates and their hydrolysis products, including volatile isothiocyanates which are released primarily by tissue damage but also during normal growth (Cole & Finch, 1978), are generally considered to be active in plant defence mechanisms, protecting crucifers from insect and pathogen attack by their toxicity. A general increase in susceptibility of new cultivars, if substantiated, implies that their crop protection requirements may be greater, with consequent impact on the environment.

Indirect evidence supporting the concern about pest damage came from Jonasson (1982) who reported that flea beetles (*Phyllotreta* sp.) caused more feeding damage to the cotyledons of a double-low spring rape than to those of a single-low cultivar, although the findings of others (Larsen *et al.*, 1985; Lamb, 1988) do not confirm this relationship. Slug (*Deroceras reticulatum*) damage at emergence has been negatively correlated with glucosinolate content in seed (Moens, 1989) and in seedlings (Glen *et al.*, 1989) and Milford *et al.* (1989a) reported that pollen beetles (*Meligethes aeneus*) were more numerous on a double-low than two single-low cultivars.

Glucosinolate hydrolysis products can be toxic (Ahman, 1986) to eggs of pod midge (*Dasineura brassicae)*. In contrast, some pests have become adapted metabolically and behaviourally to these compounds and utilise them as host specific cues. Some pests are stimulated to feed by glucosinolates (Nayar & Thorsteinson, 1963; Nault & Styer, 1972; Hicks, 1974; Neilsen, 1978; Larsen *et al.*, 1985; Bartlet & Williams, 1989), and some to oviposit by them (Nair & McEwen, 1976). Several rape pests have also been shown to be attracted to field traps baited with allyl isothiocyanate (Finch & Skinner, 1982; Free & Williams, 1978; Lerin, 1984).

The evidence for a toxic effect of glucosinolate hydrolysis products on pathogens is less equivocal, some are known to be toxic to a range of pathogens *in vitro* (Hooker *et al.*, 1943; Drobnica *et al.*, 1967; Hartill, 1978; Rawlinson, 1979; Mithen *et al.*, 1986; Milford & Rawlinson, 1989) *in vivo* (Greenhalgh & Mitchell, 1976; Mithen *et al.*, 1987) and when applied as formulations in the field (Rawlinson *et al.*, 1985; Doughty *et al.*, 1990). Moreover, recent work has shown that certain glucosinolates which yield toxic hydrolysis products can occur in sufficient quantity in vegetative tissue to influence pathogenesis (Milford *et al.* 1989b). Such evidence indicates that downy mildew (*Peronospora parasitica*), light leaf spot (*Pyrenopeziza brassicae*), dark leaf spot (*Alternaria brassicae*), grey mould(*Botrytis cinerea*) and canker (*Leptosphaeria maculans*) could all be influenced by any changes in glucosinolates in vegetative tissue that may occur in the new double-low cultivars.

Despite the interest and concern about double-low cultivars little has been formally published providing direct, contemporary evidence of their reaction to pests and diseases or their performance when given full crop protection in appropriate field experiments. Most currently available double-low cultivars, when not treated with pesticides, yield less than the single-low types grown hitherto (Anon., 1988), but it is not known whether pests and diseases are the primary factors limiting yield or whether seed glucosinolate content is affected by infection, infestation or crop protection measures. The profitability of the crop to growers in Europe may soon depend entirely on an ability to meet a new quality standard of < 20 µmol glucosinolates/g seed; factors that increase seed quantity without impairing quality will then be vital to the continued successful cultivation of the crop. This paper reports the incidence of the principal pests and diseases in the United Kingdom and the responses to their control on a range of double-low cultivars and the single-low cultivar Bienvenu, in two seasons, one favouring disease (1987-88), and one pest attack (1988-89).

2. Materials and Methods

Two field experiments, in 1987-88 and 1988-89, tested separate and combined treatments of insecticides and fungicides (Table 1) or none on six cultivars in plots arranged as 2 randomised blocks of 6 x 2 x 2 sown on 17 September 1987 and earlier, to encourage cabbage stem flea beetle (*Psylliodes chrysocephala*) infestation, on 22 August 1988. Plots were combine harvested after desiccation on 1 August 1988 and 15 July 1989. Full details including all basal treatments and agronomy are given elsewhere (Rothamsted Experimental Station, 1988, 1989).

Diseases on leaves and stems were assessed as described by Rawlinson, Muthyalu & Cayley (1984). Visual scores for disease severity on pods were

Table 1. Treatments applied to cultivars

Treatments		Application dates 1987-88	1988-89
Fungicides:	prochloraz	18 November	7 November
	prochloraz	11 April	29 March
	iprodione	16 June	2 June
Insecticides:	deltamethrin	13 November	1 Oct. + 7 Nov.
	'Gusathion MS'*	18 April	29 March
	triazophos	16 June	2 June

* a.i = azinphosmethyl plus demeton-s-methyl sulphone

made on six 1 m^2 areas per plot using a key devised by the National Institute of Agricultural Botany.

Cabbage stem flea beetle feeding damage to cotyledons and first leaves was assessed on 100 plants per plot in September; before stem extension in early March, larvae were counted in ten plants from each plot sampled and their exit holes were assessed in April. Pollen beetles were counted on ten plants per plot sampled, from mid- to late April when plots were from 'in green bud' to 'early flower'. Seed weevil and pod midge larvae were counted in 100 pods from each plot sampled in mid-July when early pods had full-size seeds.

Oil analyses on seed were made using low resolution nuclear magnetic resonance on a 'Newport 4000' (Oxford Analytical Instruments). Total glucosinolates in seed were measured by the glucose release method as described by Milford *et al.*, (1989).

3. Results

3.1 Pest incidence in 1987-88 and 1988-89

Cabbage stem flea beetle was the principal pest in both seasons. Early feeding damage by adult beetles to cotyledons (9 September) of Bienvenu and the double-low cultivars was similar; Tapidor was damaged most and significantly more than Cobra, Capricorn and Libravo (Table 2). A week later (15 September), cotyledon damage on Bienvenu was significantly greater than that on Capricorn only; Tapidor remained the most

Table 2. Cabbage stem flea beetle damage scores to cotyledons and first leaves in 1988-89

	9 September Cotyledons	15 September Cotyledons	15 September Leaves
Bienvenu	111	116	154
Tapidor	123	123	155
Ariana	111	106	148
Cobra	109	104	157
Capricorn	109	99	126
Libravo	104	101	130
SED	6.5	7.4	12.0

damaged, significantly more than all other cultivars except Bienvenu. Bienvenu, Cobra and Tapidor had significantly more feeding damage to their first leaves than Capricorn and Libravo.

Larval infestation was low in 1987-88 (overall mean 0.3/plant) and very high in 1988-89 (overall mean 20.0/plant). In both years infestation differed with cultivar (Table 3). In 1987-88 and 1988-89, on insecticide-free plots, the most infested cultivar had 17 and 2.4 times more larvae/plant respectively than the least infested. In 1987-88, all five double-low cultivars were more infested than Bienvenu, but the differences were significant only for Corvette and Cobra. In 1988-89, all five double-low cultivars except Capricorn were more infested than Bienvenu, but the difference was significant only for Cobra and Cobra was more infested than Tapidor and Capricorn. The four cultivars tested in both years ranked in the same order each year except that in 1989 Capricorn was relatively less infested than in 1988. Insecticides significantly diminished numbers of larvae on all cultivars.

Table 3. Mean number of cabbage stem flea beetle larvae per plant on Bienvenu and double-low cultivars grown without (-) and with (I) insecticides in two seasons

	1987-88				1988-89		
	-	I	Mean		-	I	Mean
Bienvenu	0.07	0.00	0.04	Bienvenu	32.3	1.3	16.8
Corvette	1.13	0.08	0.60	Cobra	57.5	2.6	30.0
Cobra	0.65	0.02	0.34	Ariana	41.0	1.4	21.2
Capricorn	0.55	0.00	0.27	Libravo	40.4	1.2	20.8
Cosmic	0.35	0.15	0.25	Tapidor	34.5	2.4	18.5
Ariana	0.20	0.00	0.10	Capricorn	23.6	1.9	12.7
SED	0.118		0.118	SED	7.30		5.16

In 1988, the incidence of stems damaged by larval exit holes in April was significantly greater on all insecticide-free double-low cultivars than on Bienvenu (18, 38, 50, 68, 70 and 78% stems damaged in Bienvenu, Ariana, Cosmic, Corvette, Capricorn and Cobra, respectively, SED 9.0) but, in 1989, when Capricorn had least stems damaged (88%), differences between other cultivars (92-100%, SED 7.5) were not significant. Insecticides significantly decreased the incidence of damage in both years, from a mean of 53 to 4% (SED 3.7) in 1988 and from 96 to 17% (SED 3.1) in 1989.

Pollen beetles were scarce in 1988 but more numerous in 1989 (means of 0.2 and 2.5/plant, respectively). Ariana was most infested, but differences between cultivars were not significant and infestation was not correlated with the stage of flowering of any cultivar. For example, in 1989, the mean number (SED 1.39) of pollen beetles per plant and percentage of plants in flower (given in parentheses) on Ariana was 4.3 (5), Cobra 3.3 (28), Bienvenu 1.9 (66), Tapidor 1.9 (26), Capricorn 1.9 (4) and Libravo 1.8 (19); insecticide decreased mean infestation from 4.7 to 0.3 per plant.

Infestation of pods by seed weevil (*Ceutorhynchus assimilis*) larvae was less in 1988 than 1989 (overall means 3.5 and 6.5% respectively). In

1988, all double-low cultivars except Cobra were more infested than Bienvenu, but only Corvette was significantly more infested (Table 4). By contrast, in 1989, all double-low cultivars except Libravo were less infested than Bienvenu, but this was only significant for Ariana. Insecticide decreased mean infestation in both years, from 6.0 to 0.9% (SED 0.10) in 1988 and from 7.1 to 5.9% (SED 0.86) in 1989.

Infestation of pods by pod midge larvae was small in both years (mean 2.7% in 1988, 1.5% in 1989). In 1988, three double-low cultivars were more infested than Bienvenu, but this was significant only for Cobra and two cultivars were less infested (Table 4). In 1989, only one double-low cultivar was more infested while four were less infested than Bienvenu, but no difference was significant. Insecticides significantly decreased mean infestation in both years, from 4.5 to 0.9% (SED 0.86) in 1988 and from 1.9 to 1.0% (SED 0.44) in 1989.

Table 4. Pod infestation by seed weevil and pod midge larvae

	1988 Mean % pods with			1989 Mean % pods with	
	Seed weevil	Pod midge		Seed weevil	Pod midge
Bienvenu	1.6	2.2	Bienvenu	8.4	1.8
Corvette	6.3	3.1	Libravo	8.4	1.1
Capricorn	5.0	2.5	Capricorn	6.5	1.1
Ariana	4.1	1.3	Cobra	5.9	1.5
Cosmic	2.2	1.0	Tapidor	5.6	0.9
Cobra	1.6	6.3	Ariana	4.3	2.4
SED	1.73	1.49		1.49	0.77

3.2 Disease incidence and severity in 1987-88

A mild, wet winter and spring encouraged disease. Mean monthly screen temperatures from December to March were > 1°C greater and rainfall in October and January more than double the thirty year average at Rothamsted.

Downy mildew occurred in autumn on 94% of plants and a little infection by dark leaf spot (*Alternaria* spp.) and the *Phoma* leaf spot stage of canker (*Leptosphaeria maculans*) was recorded on all cultivars in December (overall means 0.1 and 2.0% plants infected respectively); incidence was unaffected by treatments or cultivars. Downy mildew remained prevalent, with more on Bienvenu than other cultivars (range 25 to 50% leaves infected in April, SED 4.0; 13 to 56% in June, SED 14.6). There was a low incidence of grey mould, white leaf spot (*Pseudocercosporella capsellae*), stem rot (*Sclerotinia sclerotiorum*) and of very slight canker lesions on stems; all were too little, sporadic or slight to assess accurately the susceptibility of cultivars or effects of treatments.

Light leaf spot and subsequently dark leaf spot were the principal diseases. They were not consistently or significantly more prevalent or severe on all double-low cultivars than on Bienvenu (Table 5). Both were well controlled by fungicides on all cultivars. From April, the incidence of light leaf spot on plants was uniformly large and on leaves was greater on some cultivars, but significantly less on others, than on Bienvenu. In

Table 5. Incidence of light leaf spot (LLS) and dark leaf spot (DLS) assessed on five dates, on plants (%P) and leaves (%L) and severity on pods (% pod area*) of Bienvenu and double-low cultivars grown without (-) and with fungicides (F) during 1988

		Bienvenu		Ariana		Cosmic		Corvette		Cobra		Capricorn		SED		Mean (SED)	
		%P	%L	%P	%L	%P	%L	%P	%L	%P	%L	%P	%L	%P	%L	%P	%L
23 February																	
LLS	-	10	2	20	6	5	1	48	26	65	27	3	1	9.2	6.8	25	10
	F	10	2	3	1	0	0	5	1	0	0	3	1			3	1
																(3.8)	(2.8)
26 April																	
LLS	-	100	65	95	59	90	45	100	74	100	85	100	69	7.7	3.5	98	66
	F	30	4	28	4	10	1	58	10	38	7	15	3			30	5
																(3.2)	(1.4)
6 June																	
LLS	-	98	30	100	59	98	32	100	59	100	77	100	31	14.0	8.0	99	48
		50	0	55	3	39	2	55	2	20	3	23	2			40	2
																(5.7)	(3.3)
DLS	-	45	47	53	18	45	32	57	39	73	53	78	56	10.3	8.0	58	41
	F	39	39	48	15	64	29	58	42	63	30	90	51			60	34
																(4.2)	(3.3)
30 June*																	
LLS	-	0.06		0.14		0.05		0.32		0.07		0.07		0.081		0.12	
	F	0.01		0.04		0.0		0.03		0.03		0.02				0.02	
																(0.033)	
DLS	-	0.08		0.05		0.22		0.32		0.66		1.48		0.487		0.47	
	F	0.02		0.04		0.01		0.03		0.06		0.03				0.03	
																(0.199)	
12 July*																	
LLS	-	0.06		0.39		0.25		1.00		0.10		0.25		0.541		0.34	
	F	0.02		0.06		0.03		0.10		0.04		0.03				0.05	
DLS	-	3.92		1.26		8.25		6.08		8.92		4.58		2.291		5.50	
	F	0.07		0.04		0.01		0.07		0.08		0.06				0.06	
																(0.221)	

Table 6. Incidence of light leaf spot (LLS) and dark leaf spot (DLS) assessed on four dates, on plants (%P) and leaves (%L) and severity on pods (% pod area*) of Bienvenu and double-low cultivars grown without (-) and with fungicides (F) during 1989

		Bienvenu		Ariana		Cobra		Capricorn		Libravo		Tapidor		SED		Mean (SED)	
		%P	%L	%P	%L	%P	%L	%P	%L	%P	%L	%P	%L	%P	%L	%P	%L
27 February																	
LLS	-	55	19	40	14	60	9	45	14	28	9	16	6	18.4	7.6	41	12
	F	20	3	10	1	10	1	0	0	5	2	5	0			8	1
																(7.5)	(3.1)
DLS	-	100	64	100	58	100	72	95	31	100	60	100	66	7.9	11.6	99	59
	F	95	34	75	14	100	26	80	15	100	35	100	38			92	27
																(3.2)	(4.7)
4 April																	
LLS	-	70	28	84	20	90	40	75	17	40	11	60	16	16.9	9.4	70	22
	F	15	2	16	4	10	3	10	2	0	0	25	3			13	2
																(6.9)	(3.9)
DLS	-	100	40	100	31	100	40	100	35	100	30	100	43	5.6	5.9	100	37
	F	95	32	95	25	100	23	75	17	90	26	100	30			93	25
																(2.3)	(2.4)
10 May																	
LLS	-	60	19	30	13	75	41	80	33	60	13	75	25	18.3	10.0	63	24
	F	0	0	20	4	5	1	16	5	10	4	11	3			10	3
																(7.5)	(4.1)
DLS	-	100	39	50	9	75	15	70	15	65	16	85	28	10.9	3.3	74	20
	F	90	15	35	5	7	1	21	2	25	3	52	7			38	6
																(4.4)	(1.3)
28 June*																	
LLS	-	0.03		0.01		0.03		0.03		0.02		0.03		0.009		0.02	
	F	0		0		0		0		0		0				0	
																(0.004)	
DLS	-	1.13		0.18		1.52		0.47		0.10		1.20		0.146		0.77	
	F	0.03		0.04		0.02		0.03		0.03		0.03				0.03	
																(0.169)	

June it was similar on leaves of Bienvenu, Cosmic and Capricorn and significantly greater on other cultivars, notably Cobra. However, much infection on leaves was not always matched by greater severity on pods later in July when there was no significant difference between cultivars. Severity on stems was greater on Corvette (score 1.3) than on all other cultivars on which infection was similar (score range 0.3 to 0.6, SED 0.16).

By early June the incidence of dark leaf spot had increased considerably, notably on Cobra and Capricorn, but on others was similar or less than on Bienvenu. Severity (lesions per leaf) on all cultivars was low, with least on Ariana (0.3) and similar amounts on other cultivars (range 0.7 to 1.1, SED 0.24). By July infection was much increased on all cultivars except the later-maturing cv. Ariana; none was significantly more severely infected than Bienvenu, although infection was greater on Cosmic and Cobra than on others.

3.3 Disease incidence and severity in 1988-89

A very mild winter, with mean monthly screen temperatures from December to March generally > 2°C greater than average, hastened crop development and encouraged early establishment of diseases. But rainfall during this period and later, in May and June, was less than half the average so diseases although prevalent were not severe.

Downy mildew and dark leaf spot increased rapidly in autumn and light leaf spot and *Phoma* occurred earlier than usual. Downy mildew occurred on most plants (mean 92%) in December; incidence on leaves was least on Tapidor (19%), most on Capricorn and Libravo (40 and 42% respectively) but similar to Bienvenu on other cultivars (26 to 35%, SED 3.4). Incidence on leaves remained least on Tapidor (40%) until May, when it was greatest on Bienvenu (66%). *Phoma* and grey mould remained infrequent and canker lesions were few and slight. Light leaf spot and dark leaf spot were prevalent from February (Table 6). The number of dark leaf spot lesions in February was unusually large (mean 28/leaf) but decreased to 0.5/leaf in May. Severity of light leaf spot on leaves and stems remained low and neither disease became severe on pods. Although incidence of both diseases sometimes differed significantly between cultivars, the double-lows were not consistently more susceptible than Bienvenu. Fungicides effectively controlled both diseases, but the incidence and severity of light leaf spot was exacerbated by insecticides. This increase in light leaf spot had been recorded in previous years, but was particularly marked in 1989 when insecticides often more than doubled incidence and severity.

3.4 Effects of crop protection on yield and seed quality

Despite the lack of consistently greater susceptibility to pests and diseases among double-low cultivars, they gave consistently greater responses in yield than Bienvenu to fungicides and insecticides in both 1988 and 1989 (Table 7). The range of yield response to fungicides in 1988, when disease was severe, was +0.96 to 1.58 t ha^{-1} compared with +0.16 t ha^{-1} for Bienvenu and in 1989 from +0.12 to 0.66 compared with +0.06 t ha^{-1} for Bienvenu. Fungicides also increased oil content, oil yield and seed mass in 1988 (Table 8), but only oil yield (from 1120 to 1227 kg ha^{-1}, SED 52.3) in 1989.

Insecticides had less effect than fungicides on yield in 1988, when pests were few, but the range of response was similarly greater among double-lows (+0.09 to 1.03 t ha^{-1}) than for Bienvenu (+0.07 t ha^{-1}). In 1989, yield response was much greater to insecticides than to fungicides and again greater among double-lows (+0.30 to 1.49 t ha^{-1} compared with -0.25 t ha^{-1} for Bienvenu) when infestation by larvae of cabbage stem flea beetle was severe. Insecticides had no effect on oil content or seed mass and only slightly increased mean oil yield (from 1535 to 1656 kg ha^{-1}, SED 38.1) in 1988 and in 1989 decreased oil content, had no effect on seed mass, but significantly increased oil yield (Table 8).

In both years there were physiological effects of crop protection on crop growth in spring; fungicides increased leaf number in 1988 (from 8.8 to 9.7 leaves/plant, SED 0.31) and insecticides increased both leaf number and plant height in 1989 (13.5 to 15.2, SED 0.37 and 63 to 92 cm, SED 1.7, respectively).

Table 7. Yield response (t/ha @ 90% D.M.) to separate and combined fungicide (F) and insecticide (I) treatments in Bienvenu and double-low cultivars (C) in 1988 and 1989

Cultivar	None	F	I	F + I	Mean
1987-88					
Bienvenu	3.72	3.88	3.79	4.70	4.02
Ariana	3.02	4.16	3.36	3.64	3.54
Cosmic	2.83	3.79	3.40	4.22	3.56
Corvette	3.13	4.40	3.22	4.42	3.79
Cobra	2.68	4.20	3.71	4.22	3.70
Capricorn	2.89	4.47	3.31	4.65	3.83
Mean	3.05	4.15	3.47	4.31	
1988-89					
Bienvenu	3.36	3.42	3.11	3.70	3.40
Ariana	2.58	2.84	2.88	3.65	2.99
Cobra	2.58	2.70	3.33	3.59	3.05
Capricorn	2.54	3.20	4.03	4.01	3.45
Libravo	2.78	2.93	3.43	3.61	3.18
Tapidor	2.54	2.86	3.53	3.74	3.17
Mean	2.73	2.99	3.38	3.72	

SED:
1988: C = 0.154; F = 0.089; I = 0.089; F x I = 0.140; F x I x C = 0.243
1989: C = 0.163; F = 0.094; I = 0.094; F x I = 0.133; F x I x C = 0.325

3.5 Relationships between diseases, pest damage and yield

From February to July 1988 all measurements of light leaf spot incidence and severity were significantly negatively correlated with yield, with coefficients up to -0.68 ($P<0.001$). In late June and July the severity of dark pod spot was also significantly negatively correlated with yield, with coefficients up to -0.65 ($P<0.001$). Other diseases were often negatively correlated with yield, but values were either not significant or not consistent through the growing season. The incidence of damage to stems by larvae of cabbage stem flea beetle during April and June was significantly negatively correlated with yield, with coefficients up to -0.41 ($P<0.01$).

In 1989 all assessments of cabbage stem flea beetle damage by adults and larvae to leaves, petioles and stems from December were significantly negatively correlated with yield, with coefficients up to -0.66 ($P<0.001$). The incidence of dark leaf spot on leaves from December and severity on pods in June was also negatively correlated, with coefficients up to -0.34 ($P<0.05$). No other disease was consistently or significantly negatively correlated with yield.

Table 8. Responses in oil content, oil yield and thousand grain weight (TGW) to fungicides (F) in Bienvenu and double-low cultivars in 1988 and to insecticides (I) in 1989

		1988					
		Oil % @ 90% D.M.		Oil yield (kg/ha)		TGW (g)	
Treatment...		None	F	None	F	None	F
Bienvenu		43.2	44.2	1621	1895	4.46	4.73
Ariana		41.3	41.8	1318	1631	4.98	5.51
Cosmic		40.8	41.6	1269	1665	4.10	4.22
Corvette		42.0	42.8	1333	1888	5.10	5.38
Cobra		41.5	42.6	1328	1791	4.64	4.81
Capricorn		43.8	44.9	1360	2045	5.69	6.24
	SED	0.27		80.8		0.150	
Mean		42.1	43.0	1371	1819	4.83	5.15
	SED	0.11		38.1		0.071	
		1989					
		None	I	None	I	None	I
Bienvenu		41.9	40.6	1421	1386	3.75	4.02
Ariana		39.8	38.7	1078	1263	4.59	4.68
Cobra		39.4	38.7	1043	1335	4.20	4.25
Capricorn		41.6	41.1	1193	1650	5.24	4.45
Libravo		41.4	41.2	1180	1447	4.16	4.56
Tapidor		41.7	42.3	1127	1536	3.66	3.79
	SED	0.50		90.5		0.196	
Mean		41.0	40.4	1174	1436	4.27	4.29
	SED	0.21		37.0		0.080	

3.6 Effects of crop protection on concentration of glucosinolates in seed

In 1988, fungicides used separately significantly decreased glucosinolates in seed of Ariana and Corvette and, when combined with insecticides, of Ariana and Bienvenu (Table 9). Mean glucosinolate concentrations for cultivars given fungicides, with or without insecticides, were significantly less than in untreated cultivars (24.5 vs. 21.4 µmol/g, SED 0.85). Insecticides used separately had no significant effect on glucosinolates under conditions of severe disease and low pest incidence. In contrast, fungicides had no significant effect on seed glucosinolates in 1989 when disease did not become severe because of drought from flowering to pod maturity. Where infestation and damage by cabbage stem flea beetle adults and larvae was unusually severe, insecticides used separately significantly increased the mean concentration of seed glucosinolates from 22.6 to 28.8 µmol/g (SED 2.11). This effect was due mainly to a large increase in seed glucosinolates in cv. Ariana; other cultivars were little affected by insecticide. When Bienvenu was protected by fungicides and given additional insecticides, there was a significant increase in seed glucosinolates from 32.5 to 51.5 µmol/g (SED 7.32).

In both years there was considerable variation in these data which may indicate that greater replication is required to clarify the effects of fungicides and insecticides on seed glucosinolates. The trend toward lower concentrations following fungicides when disease is severe and to greater concentrations following insecticide, is supported by evidence from other experiments. However, the data are not conclusive and it is possible that drought stress in 1989 had a much greater influence than pests, diseases or crop protection treatments.

Table 9. Glucosinolate concentrations (µmol/g at 9% moisture) in the seed of Bienvenu and double-low cultivars grown with and without separate and combined fungicide (F) and insecticide (I) treatments in 1988

	Treatments				
Cultivar (C)	None	F	I	F + I	Mean
Bienvenu	48.5	51.9	54.1	41.5	49.0
Ariana	27.6	20.9	30.3	21.0	24.9
Cosmic	14.8	13.6	14.0	15.2	14.4
Corvette	19.7	13.4	16.8	18.6	17.1
Cobra	15.5	15.5	20.8	17.5	17.3
Capricorn	15.0	14.7	16.8	13.6	15.0
Mean	23.5	21.6	25.5	21.2	

SED: C = 1.47; F = 0.85; I = 0.85; F x I = 1.20; F x I x C = 2.32

3.7 Relationship between diseases, pest damage and total glucosinolates in seed

Analyses of disease data among double-low cultivars in 1988 showed that measurements of light leaf spot incidence and severity from April to July were all significantly positively correlated with glucosinolate concentration in seed, with coefficients up to 0.40 (*P*<0.01). Other diseases were either not correlated with glucosinolates or values were not consistent. In 1989, no disease was consistently or significantly correlated with seed glucosinolates. In both years, damage by larvae of cabbage stem flea beetle was negatively correlated with seed glucosinolates, but this was significant only in 1989 (coefficients up to -0.36, *P*<0.01).

4. Discussion

Double-low cultivars were not consistently more infected or infested than the hitherto dominant single-low cv. Bienvenu. Their consistently greater responses in yield to fungicides and insecticides are therefore difficult to ascribe solely to control of pests and diseases. When infection and infestation was severe these were clearly negatively correlated with yield, but yield responses of individual cultivars could not be related to differences in visible symptoms. The observable extent of infection, infestation or damage does not necessarily reflect the degree of physiological stress imposed on cultivars which may differ in their consequent yield loss. Although our results do not support the view that double-lows are generally more susceptible than Bienvenu, they indicate their inferior tolerance of infection and infestation and confirm their greater requirement for crop protection and the benefits in seed quantity and quality that can accrue. Physiological effects of fungicides and insecticides on plant growth were recorded here and have been noted before (Rawlinson *et al.*, 1988). Such effects and the alleviation of stress provided by crop protection chemicals may enhance green leaf and pod area or duration, and therefore assimilate production and yield, more in double- than single-low cultivars. These concepts are currently being investigated at Rothamsted.

Double-low and single-low cultivars differ in the glucosinolate content of their seed but it is not yet clear to what extent their vegetative, flowering and seed-producing organs differ in glucosinolate content. Information to date suggests that the glucosinolate content of the vegetative tissues is much lower than that of the seed, and that differences between cultivars are much less pronounced (Van Etten & Tookey, 1979; Larsen *et al.*, 1983; Milford *et al.*, 1989a; 1989b). Single- and double-low cultivars may therefore not differ greatly in the glucosinolate profiles they present to pests and pathogens. This would explain why none of the pests studied discriminated between them and why, as a group, the double-lows were not generally more susceptible to diseases than Bienvenu. Moreover, certain glucosinolates yielding toxic hydrolysis products can occur in sufficient quantity in vegetative tissue to influence pathogenesis, even in double-low cultivars (Milford *et al.*, 1989b). It is possible that screening cultivars for commercial production unwittingly selects those with amounts and types of glucosinolates in vegetative tissues that are biologically active. Their real effects on pests and diseases *in vivo* would be best investigated in isogenic lines which differ in the type and concentration of glucosinolates in vegetative tissue.

Milford *et al.* (1989a) found only small differences in glucosinolate types and concentration in inflorescences from Ariana, Bienvenu and Mikado and concluded that these could not account for the greater numbers of pollen beetles found on Ariana. The glucosinolate content of the cotyledons has been little investigated, but Glen *et al.* (1989) have shown that, unlike vegetative organs differentiated later, the concentrations of glucosinolates in seedlings tends to be highly correlated with those in the seed. This might explain why flea beetles (Jonasson, 1982) and slugs (Moens, 1989; Glen *et al.*, 1989) damaged the less toxic double-low cultivars more than single-low cultivars. Similarly, the very low glucosinolate cultivar Tapidor was the most damaged by cabbage stem flea beetle feeding at the cotyledon stage, but was not the most infested by larvae, which penetrate the plant later. As the four pests investigated here migrate to oilseed rape crops at different stages of its development and feed on different parts of the plant, it would be interesting to know in detail how the glucosinolate content of the different parts, and production of volatiles from them varies between cultivars throughout the growth of the plant. This need is being addressed by current research at Rothamsted (Milford *et al.*, 1989b; Blight *et al.*, 1989).

Light leaf spot incidence and severity among double-lows was positively correlated with seed glucosinolate concentration, and fungicides tended to decrease glucosinolate concentration in seed when disease was severe. Fungicides also significantly increased seed mass which might explain the decrease in proportion of glucosinolates to dry matter. It is not yet clear whether these effects are direct or interrelated, but any influence on the rate of dry matter accumulation in seed could be critical to glucosinolate concentration.

Alternative explanations for these effects involve the hypothesis that certain types of infection and infestation induce glucosinolate production in tissues as a defence mechanism (Koritsas *et al.*, 1989), so that control by crop protection should normally decrease glucosinolates in tissues. However, control by insecticides tended to increase rather than decrease glucosinolates in seed, but this may be related to the increase in light leaf spot caused by insecticides. By preventing larval induction of glucosinolates in tissues in autumn and winter (when light leaf spot infection is initiated) insecticides could have allowed greater initial infection by light leaf spot which then subsequently had the dominant effect on seed glucosinolates. Such speculation provides useful hypotheses to test in future work. At present, it seems likely that some types of infection, infestation, crop protection measures and interactions between these factors can influence the dynamics and accumulation of glucosinolates in tissues and seed. However, such influences may only modify the outcome of much greater effects caused by site, season and cultivar (Evans *et al.*, 1989).

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EFFICIENCY OF SPECIFIC FUNGICIDAL TREATMENTS IN AUTUMN AND/OR IN SPRING

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This experiment was carried out with large plots without replication, but within each large plot, six replicates were analysed. Five fungicides were used at recommended rates. Plots were sprayed in autumn, in spring, in autumn + spring and in autumn + spring + full flowering.

Prochloraz and iprodione increased yield only when applied in spring. None of the other treatments and interactions between fungicides and application times were significant. With the exception of prochloraz and iprodione the fungicides used did generally not affect the yield. Furthermore, the treatments reduced infection with Phoma only slightly and only when treated three times and when the plants were scored in July.

From these results may be concluded, that a treatment is not worthwhile when the disease levels are low.

Table 1: Effect of fungicides on Phoma lingam and yield of oilseed rape (Hemkenrode, 1989)

Fungicide	Yield dt/ha (92 % day matter) Treatments					P.lingam scoring (1-9) 11. 07. 89 Treatments					P.lingam scoring (1-9) 24. 05. 90 Treatments					P.lingam scoring (1-9) 17. 04. 89 Treatments				
	A*)	A+S	S	A+S+B	x̄	A	A+S	S	A+S+B	x̄	A	A+S	S	A+S+B	x̄	A	A+S	S	A+S+B	x̄
Prochloraz	32.74	34.20	36.08+	38.85	35.47	4.2	3.1	4.4	3.2+	3.7	2.1	2.3	2.3	2.3	2.3	2.4	2.2	2.9	2.9	2.6
Iprodione	32.81	34.52	34.31	35.71	34.34	4.4	3.6	4.4	3.6+	4.0	2.5	2.5	2.4	2.3	2.4	2.3	2.3	2.5	2.4	2.4
Vinclozolin	30.80	33.94	30.59	33.00	32.08	4.2	3.9	4.5	4.0+	4.2	2.1	2.5	2.2	2.7	2.4	2.6	2.3	2.4	2.7	2.5
Propiconazole	31.25	33.69	30.23	34.40	32.40	4.6	3.4	4.2	3.7+	4.0	2.3	2.1	2.6	2.2	2.3	2.4	2.2	2.6	3.2	2.3
Tebuconazole	32.91	38.06	31.73	34.70	34.35	4.5	3.6	3.9	3.5+	3.9	2.4	2.3	2.8	2.5	2.5	2.5	2.4	2.7	2.7	2.6
Untreated	31.65	36.47	30.14	34.38	33.16	4.6	4.2	4.0	5.0	4.4	2.4	2.6	2.8	2.8	2.7	2.4	2.7	2.7	2.9	2.7
Mean	32.03	35.15	32.18	35.18	33.64	4.4	3.6	4.2	3.9	4.0	2.3	2.4	2.5	2.5	2.4	2.4	2.4	2.6	2.8	2.7
Mean without Untreated	32.10	34.88	32.59	35.33	33.75	4.4	3.5	4.3	3.6	4.0										
LSD (P=0.05)	n.s.	n.s.	3.4	n.s.		n.s.	n.s.	n.s.	0.8		n.s.	n.s.	n.s.	n.s.		n.s.	n.s.	n.s.	n.s.	

*) A = Autumn; S = Spring; B = full flowering time

INTERACTION BETWEEN VARIETAL RESISTANCE IN DISEASES AND SPRAYING NEEDS

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An experiment was carried out in which six cultivars were sprayed with prochloraz (at recommended rate) at 3 timings in various combinations: autumn, spring, autumn + spring and autumn + spring + full flowering. There were hardly any differences between treatments except that the 3 spray programms resulted in a lower yield. Mechanical damage may have contributed to this effect. The interaction between cultivars and treatment time was not significant.

The reason for the slight effect may be seen in the late infection which was present mainly higher up on the stems. Disease assessments in April and at the end of May gave scores of about 2.5 on a 1 - 9 scale, indicating very slight disease incidence. Even the untreated and susceptible cultivars did not show higher infection rates at these early stages.

Table 1: Treatment of six oilseed rape cultivars with prochloraz for control of <u>Phoma lingam</u> (1989)

Cultivar	Yield in dt/ha						Scoring of <u>P.lingam</u> (1-9) on 16.07.89					
	Treatment						Treatment					
	control	Aut.*	Spr.	Aut.+ spr.	Aut.+ spr.+ flow.	Mean	control	Aut.	Spr.	Aut.+ spr.	Aut.+ spr.+ flow.	Mean
Libraska	44.2	40.2	38.2	42.2	40.2	40.9	4.1	3.8	4.1	3.3	3.1	3.7+
Diadem	40.9	44.2	40.2	38.9	34.8	39.5	3.8	3.4	3.7	3.5	3.0	3.5+
Ceres	36.2	34.2	38.9	35.5	36.9	36.2	6.0	5.0	5.2	4.6	4.9	5.1
Libritta	33.5	32.2	38.9	34.8	33.5	34.8	4.7	5.3	4.7	4.1	3.5	4.5
Arabella	38.9	37.5	38.9	39.5	30.8	36.9	4.3	3.9	3.8	4.3	3.6	4.0+
Cobra	44.2	46.9	43.6	43.6	38.2	43.6	5.6	5.1	4.8	5.1	3.9	4.9
Mean	39.3	38.7	39.3	38.7	35.3-	38.7	4.7	4.4	4.3	4.2	3.7+	4.3
LSD (P=0.05)												
Treatment:	0.23						0.4					
Cultivar:						0.3						0.5
Interaction:	not significant						not significant					

*) Aut.= autumn, Spr.= spring, flow.= during full flowering

SESSION 5

Methods of Disease Assessment

A REVIEW ON ASSESSMENT OF DISEASES IN OILSEED RAPE- COMPARISON OF VARIOUS METHODS

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Summary

The methods used to score diseases are compiled for the following diseases:

Root rot
Phoma lingam (Tode ex Fr.) Desm.
Sclerotinia sclerotiorum (Lib.) de Bary
Plasmodiophora brassicae Wor.
Alternaria spp.
Peronospora parasitica Pers. ex Fr.
General leaf spots (Mycosphaerella brassicicola (Fr. ex Duby) Lind., Alternaria spp., Pseudocercosporella capsellae (Ell. & Ev.) Deighton, Cylindrosporium concentricum Grev., Peronospora parasitica Pers. ex Fr., Erisyphe communis (Wallr.) Link.)

To limit space it was not possible to cite all the literature available in this respect. - In an Introduction the problems with scoring diseases are discussed in order to give a background on the methods used. It was stressed, that under certain circumstances it will not be possible to recommend only one methods. To meet the aims of the experiments it has to be decided whether a complicated method must be used, which is perhaps more accurate, or whether a rather simple one is sufficient.

There is the general trend to use a more accurate method with more steps (1- 9). It may be possible, that the methods are influenced by statistical recommendations and the technical equipment available.

1. Introduction

It is the aim of this compilation to present the various methods of disease assessment which have been used and to comment their advantages or disadvantages and to recommend a method for general use within the IOBC to make observations more comparable.

It may well be the case, that one method is suitable for all purposes. Generally it can be accepted, that a more detailed study has to be accompanied by a more accurate method. Thus a scale with only few categories seems to be less suitable than one with more detailter fundamental investigations. Furthermore, it should be taken into consideration, that the results have to be analysed statistically. As many diseases cannot be measured in kg or cm, the degree of a disease is assessed according to scales. In the past these scales often started with 0= no infection (healthy). From the mathematical and "computer" point of view, the zero value should be avoided. Therefor, new scales have started with 1 (healthy). In many cases it is possible to count the number of infected plants and to present the results as a percentage of plants and to present the results as a percentage of plants infected. The statistical calculation is again, from mathematical point of view, difficult, especially if there are large differences in disease incidence. In this case the values should be transformed to angles of sine. If the extreme values are not present, this transformation is not necessary.

In some cases it may be possible to use either percentage of infection or a scale which is based on percentage of infection. This is mainly the case with root rot, pod and leaf diseases. The scales are based on percentage of root system infected or percentage of the leaf area affected. Again, technique and time may force us to use the most suitable method. Our recording instruments in the laboratory and in the field are not designed to use very complicated values. It is easy to work with a scale 1 to 9. The computer multiplies the values and gives the "mean degree of infection" immidiately to the operator. Instead of these numbers 1 to 9 it is also possible to use the percentage of plants infected, but only in 9 steps as can be seen from the scale for root rot or leaf diseases in Fig. 1 with mean values of 0, 2, 7, 15, 27, 45, 65, 85 and 99 % for index 1 - 9 respectively. The 99 % has to be introduced instead of 100%, because only two digits can be used. This slight anomaly should be accepted. The "mean percentage of infection" can then be calculated accordingly as with the values 1 to 9.

The scales have the disadvantage, that the steps from one number to the next one are not equal (see Fig. 1). They are not arithmetic but more or less geometric (logarithmic). Originally, Bolle (1954) recommended such a scale (Fig. 1), but subsequently the scales have been slightly modified to fit in more observation possibilities. An example is given by Krüger (1985) who increased the values at lower and medium severities (Fig.1). The mathematical disadvantages or advantages are detailed in O'Svath, Peil and Geidel (1979).

It is also possible to leave the mentioned steps alltogether and put a percentage score into the computer as observed. Such a program is easy to elaborate. The disadvantage of this recording is, that it is not possible anymore to investigate into the distribution of the plants within the infection range as accurately as it was possible up to now.

There are, however, some diseases which cannot be related to fundamental values as numbers, g, cm or even as percentage area affected. Take for example Phoma lingam (Tode) Desm. or Verticillium dahliae Kleb., which are scored according to spreading of the disease on the plants, formation of fruiting bodies, depth of infection site, discolouration of the plants etc. For these symptoms recording using "values" (disease index) is the only quantitative methods available.

In this paper assessment of the main diseases of oilseed rape are discussed and illustrated using various published scales.

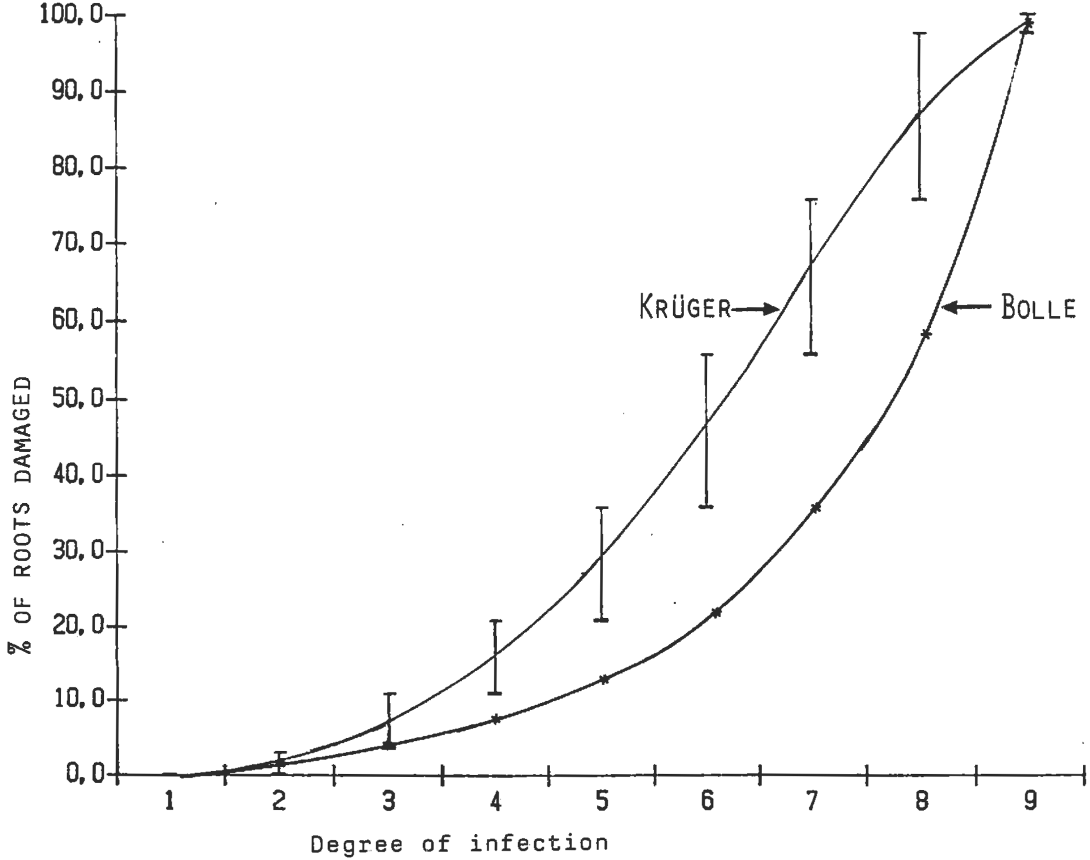


Fig. 1: Scheme for determination of the degree of root rot of plants

2. Methods

Root rot of oilseed rape

Investigations of root rot have been carried out with the aim of determining the fungi causing the disease. Surveys were carried out by Meier (1988), Weber (1987) and Krüger (1989) in Germany and Poland. Only two methods were used:
Weber used a 1- 5 scale on young plants after soil inoculation:

1= healthy plants
2= slightly)
3= moderately) infected plants
4= heavily)
5= no plants(shouts destroyed in the soil)

A general method was recommended by Krüger (1978) which can be used at all stages and which is based on the percentage of roots destroyed or infected of the whole root system present. This scale was also used by Meier (1988). The roots have to be removed from the soil and should be washed and scored immediately to avoid drying in the sun which makes accurate scoring impossible. The 1- 9 scale was described as follows:

Symptoms	% root system damaged
1: no symptoms	0
2: 1-2 small discoloured blotches	2
3: slight root rot; the roots have several infection sites	7
4: good visible root rot	15
5: moderate infection; root stumps can be present, many small roots are dead or decayed	27
6: about the half of the roots system is diseased or decayed	45
7: severe root rot; more than half of the roots are dead or decayed	65
8: most of the roots are dead, only few are still working	85
9: very severe root rot; the whole or nearly the whole root system is destroyed	98

Phoma lingam

P. lingam attacks various plant parts and accordingly several assessment methods have been used to cover the following symptoms:

a) Leaf spots on cotyledons
b) Leaf spots on leaves
c) Root collar infection
d) Root collar and stalk infection

a) Wittern (1984) scored the leaf spots according to recommendations of Kopraditskul (1981) using a 1- 9 scale.

1: cotyledons without visible symptoms
3: dark infection sites and/or starting grey-green discolouration
5: grey-green leaf spots, pycnidia present
7: expanded necrotic leaf spots, strong pycnidial formation, cotyledons severely damaged, wilted
9: cotyledons dead

The numbers 2, 4, 6, and 8 have to applied to symptoms in between the described ones.

b) A range of methods have been used to assess incidence and severity of leaf infection:

i) % plants infected) Gladders and Musa (1980)
ii) no.leaf spots/plant)
iii) no.infected leaves/plant)

Further methods were mentioned:

iv) no.spots/ 100 plants (van der Spek, 1981)
v) general scoring:
0= no infection) (Renard and Brun, pers. com.)
1= slight infection)
2= moderate infection)
3= severe infection)
vi) young leaves / older leaves — diameter of spots

young leaves	older leaves
0= no infection	0= no infection
1= 0- 1 mm Ø	1= 0- 2 mm Ø
2= 1- 2 mm Ø	2= 2- 4 mm Ø
3= 2- 5 mm Ø	3= 4- 8 mm Ø
4= larger + many pycnidia	4= 8- 16 mm Ø
	5= more than 16 mm Ø

(McGee and Petrie, 1970)

c) The affected stem base (canker) was scored using a scale 0- 6 with the following description (Gladders and Musa, 1980).
0= healthy
1= up to 11% circumference infected
2= 11- 25% circumference infected
3= 26- 50% circumference infected
4= 51- 75% circumference infected
5= 76- 100% circumference infected
6= plants severely infected and prematurely ripened or dead
The disease index for each crop was the mean severity score for plants.

d) Root collar and stalk infection (whole plant) was scored as percentage of plants infected by: McGee and Emmet (1977), Helm and Cruickshank (1979), and after soil inoculation by Gladders and Musa (1980). The degree of infection was recorded to various scales:
0= healthy
1= slightly cankered
3= severely cankered
This score was converted to a disease index (DI) ranging from 0-100 (McGee, 1973).

The scale was extended to 6 steps by Renard and Brun (pers. com.), to 7 steps by Frencel et al. (1987) and to 9 by Krüger (1978), Schuster et al. (1980), van der Spek (1980), Wittern (1984) and Daebeler et al. (1980). The last mentioned authors used, however, the opposite scoring: 9= healthy, 1= dead. Moreover, the score did not describe the symptoms but are stated as a percentage of the lower part of the stalk which had rotted:
9= healthy
7= up to 25% rotted
5= 26- 50% rotted
3= 51- 75% rotted
2= 76- 100 % rotted
1= plants dead

The scale developed by Krüger (1978, 1983) included the following:

1= healthy
2= few small, not deep flecks (only the epidermis affected) at the root collar and/or the stalk
3= not deep penetrating flecks on the stalks and/or few superficial corcy spots on the root collar
5= corcy spots readily visible: root collar girdled, but superficial or one sided deep penetration (about 50% of the root collar) and/or deeper infection sites on the stalk. The plants are still green at EC 85
7= root collar with severe and deep corcy penetrations and/or deep infection sites on the stalk, which caused necrosis and softening of tissue. Pycnidia usually present. At EC 85 (stage of windrowing) plants start yellowing
9= root collar deep corcy, only slight or no connection with the root and/or enlarged and deep penetrating infection sites on the stalk. Plants are prematurely ripe or dead already.

Note, that values 4, 6 and 8 should be applied to symptoms in between these described.

Usually 25 to 30 randomly collected plants should be used per plot. A somewhat more compilated scale was developed by Newman (1984) in which two symptoms were scored separately, a) lesion circumference and b) lesion length with scales 0- 6 and 0- 8 respectively. Both values were added to give the final score. - This scale was used when seedlings were artificially inoculated and scored 35 days later.

The scale used by Newman (1984) was described as follows:

Score	Lesion circumference (C)	Lesion length (L)
0	no infection	no infection
1	< 25% girdling	5 mm
2	25- 50% girdling	5- 10 mm
3	50- 75% girdling	10- 15 mm
4	75- 100% girdling	15- 20 mm
5	stem weak	20- 25 mm
6	plant dead	25- 30 mm
7	-	> 30 mm
8	-	plant dead

Plant score: S= C + L for each lesion.

General remarks

When results have to be used for statistical analysis, any zero values should be avoided. The scales should start with a value of "1". Furthermore, in commercial scorings and when larger experiments are used, a single score value is necessary to streamline the work.

Sclerotinia sclerotiorum (Lib.) de Bary

Sclerotinia stem rot was investigated many times and the effect of any treatment was usually expressed as percent plants infected (Krüger, 1973, 1975; Saur, 1983; Brun et al., 1983; Franke, 1986) to mention only few. A scale was used by the BASF (1981) and Milatz (1970) (see Franke and Hindorf, 1983). These scales were based on percent plants affected.

BASF (1- 9)	Milatz (1- 9)
1= no infection	no infection
2= 1.0- 2.5 %	1- 20%
3= 2.6- 5.0 %	21- 30 %
4= 5.1- 10.0 %	31- 40 %
5= 10.1- 15.0 %	41- 50 %
6= 15.1- 25.0 %	51- 60 %
7= 25.1- 35.0 %	61- 70 %
8= 35.1- 67.5 %	71- 80 %
9= 67.6- 100 %	81- 100 %

The scale used by the BASF is similar to that used by Krüger (1985) for root rot. As set out in the Introduction, it is doubtful, wether there is any advantage in determining the percentage of plants infected by counting, and then using a scale. From mathematical point of view it is preferably to do the calculations with percentage of plants infected. An angular transformation may be considered.

When the infection of the plants does not take place at the main infection time during flowering, but due to weather conditions also at later times, the infection sites may be high up, affecting only part of the plant.

In this respect it should be advisable to introduce a scale as proposed by Bauers et al. (1982) to determine the efficacy of fungicides. Only 4 steps (1- 4) were included. This method was used by Franke (1986):

1= no infection
2= up to 25 % plants affected
3= up to 50 % plants affected
4= more than 50 % plants affected

A more detailed disease assessment was recommended by Schütte (unpublished results) as illustrated in Fig 2.

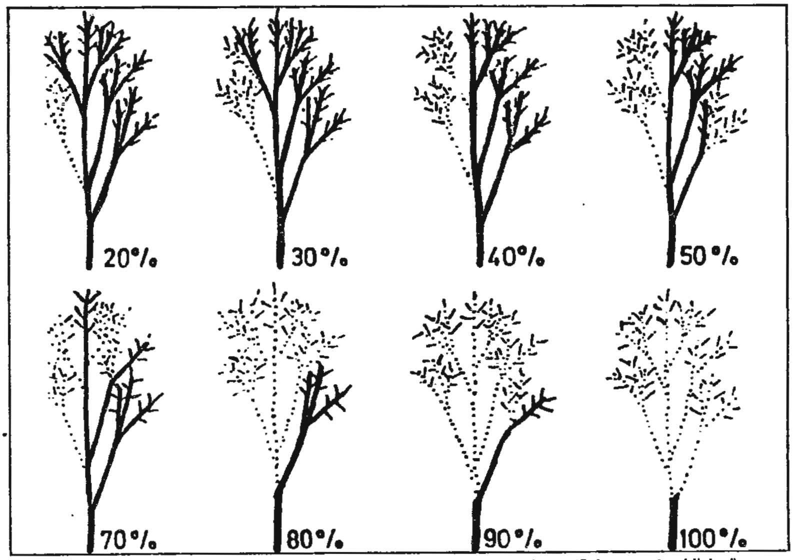


Fig.2: Diagram to estimate the plant parts affected by Sclerotinia sclerotiorum (Schütte, not published)

Depending on the aim of the experiment it should be suitable to use the method proposed by Schütte. When the plants are scored, it is possible to represent the data in three ways:
i) % plants infected
ii) degree of infection of all infected plants (on % basis)
iii) % plant parts of all plants damaged

For special determinations of S. sclerotiorum- spreading in the stalks, the extension of the discolouration (in cm) has to be recorded in intervals of 1 week for about 3- 4 weeks. This method is only suitable after artificial inoculation, when the fungus is inserted into the stalk or a piece of mycelium is placed into a leaf axil (Schüler, 1984).

Verticillium dahliae Kleb.

V. dahliae is a fungus better known in vegetables than in oilseed rape. Its distribution is limited at present to the more northern rape growing countries.

The first scoring was carried out by Nilsson (1977), but only on symptoms on the leaves. He used a 1- 5 scale without any specification for each degree. Further scorings were done by Scheibert-Böhm (1979) using a 1- 9 scale on whole plants but also without describing the symptoms.

A 1- 9 scale was used by Krüger (1986, 1989) according to the following description:
1= no infection
2= slight (1- 5 cm) one sided spreading of microsclerotia
3= still slight and one sided spreading of sclerotia (3- 10 cm), also inside the stalk
5= very good visible symptomas. The sclerotia have developed on 15- 20 cm long stalk pieces, also inside the stalks
7= more than half of the stalk shows sclerotia, which are spread on all parts, even inside on the pith
9= stalks completely covered with sclerotia and have died

Scores of 4, 6 and 8 are available for intermediate severities.

Furthermore, the percentage of plants infected were used by Svensson and Lerenius (1986) and Gröntoft (1987). Depending on the aim of the experiment it may be possible to use both: the percentage of plants infected and a scale 1- 9. For detailed resistance test studies the scale 1- 9 should be preferred. As V. dahliae occurs in the field late in the season, assessments have to be carried out just before harvest. Attention should be paid to the length of the stalks, they should be as long as possible (whole stalk), but if that is not possible from technical reasons, 50 cm of the lower part should be scored.

An early scoring at growth stage 85 results in much lower incidence and severity than in assessments made at harvest.

Leaf infections are generally only visible in greenhouse screening experiments.

Plasmodiophora brassicae Wor.

The disease caused by this fungus was generally assessed according to scales, which expressed the severity of gall formation and which included 4- 6 steps. The degree of infection was calculated by:

$$\frac{(n \times 0) + (n \times 1) + .. (n \times 3)}{\Sigma n \text{ (number of plants)}} = \emptyset \text{ degree of infection}$$

Exceptions were the proposals by Bochow (1958) and Seaman (1963) who used the degree of infections as well but they multiplied them by factors to get a "disease index" ranging from 0 to 100. These methods were used by several researchers. Unfortunately the factors were not the same, but they were "weighed", e.g. Williams and Seidel (1968): 0= 0 x 0

1= 1 x 10

2= 2 x 60

3= 3 x 100

The sum of these was divided by the number of plants to obtain the "index".

The scale 0- 3 was adopted by the EPPO (1982). This is a rather crude scale, because only 3 disease ratings are available. These ratings are also recommended to be used in connection with a "disease index" as set out below. When it comes to resistance tests a more detailed scale should be used. Therefore, some researchers increased the steps to 4 and 5 disease levels and even to 9 (Kühnel, 1974).

The extent of scoring should be determined for each experiment. If resistant tests are carried out, a scale should be used in which the lower scores (2- 6) represent a degree of infection which can be classified as very slight (2) to medium severe infection (6). The higher notes (7- 9) are reserved for severe infections up to dead plants (9).

To simplify the calculations, there is the question, whether it would not be more advantagous to increase the scale to 1- 9 and to use the value immediately for further calculation, instead of introducing "factors".

If for example the scale recommended by Channon and Keyworth (1960) is amended by 3 additional staps between 0 and 1, 1 and 2 and above 5, a sufficient scale could be used.

Description of scales:

Reyes, Davidson and Marks (1974):

0- no club
1= very small clubs on primary and secondary roots
2= slight clubbing on primary and secondary roots
3= moderate clubbing on these roots
4= severe clubbing
5= decayed roots

Channon and Keyworth (1960):

0= no disease
1= up to 6% of the root system clubbed , up to five small clubs. Many fibrous roots
2= 7- 12.5 %; two to three medium and several small clubs. Slight reduction of fibrous roots
3= 12.6- 25 %; one to two large and several medium clubs. Moderate number of fibrous roots
4= 26- 50 %; large and medium clubs coalesced. Few fibrous roots
5= more than 50 %; clubs coalesced, almost no fibrous roots

Recommended by Krüger:

1= no disease
2= up to 2 % clubbed
3= up to 12 % clubbed, up to five small clubs, many fibrous roots
4= up to 20 % clubbed, three to four medium and several small clubs. Slight reduction in fibrous roots

5= up to 35 % clubbed; two to three large and several medium clubs. Moderate number of fibrous roots
6= up to 50 % clubbed; large and medium clubs coalesced. Few fibrous roots
7= up to 75 % clubbed
8= up to 96 % clubbed, nearly no roots
9= plants died because of infection

EPPO (1982) recommended (Fig. 3)

Classes	Description	% root system affected
0=	no visible symptoms	0
1=	very small clubs on lateral roots	1- 10
2=	moderate clubs on lateral roots and/ or taproots	11- 50
3=	severe clubbing on lateral roots and/or taproots	51- 100

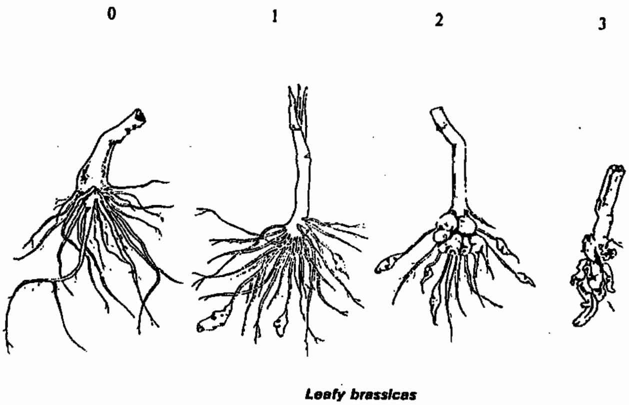


Fig. 3: Club rot degrees on leafy brassicas
To calculate the "Disease Index" (DI), the following formula is recommended:

$$DI = \frac{\Sigma(\text{class no. x no. of plants in each class}) \times 100}{\text{Total no. of plants} \times 3}$$

Summary of scales used for clubrot assessment:

Bilek (1987)	0- 3 + factors
Bochow (1958)	0- 4 + factors
Buczacki (1975)	0- 3
Channon and Keyworth (1960)	0- 5
Crete and Chian (1963, 1980)	0- 3 + factors
Datnoff and Lacy (1984)	0- 3
Dobson et al. (1983a)	0- 3
Dobson et al. 1983b)	0- 3 + factors
EPPO (1962)	0- 3 + factors
Heide (1970)	0- 4 + factors
Kühnel (1976)	1- 9 + factors
Reyes et al. (1974)	0- 5
Seaman et al. (1963)	0- 3 + factors
Williams and Seidel (1968)	0- 3 + factors

Alternaria spp. on oilseed rape

The classification of Alternaria on oilseed rape depends on the growth stage of the plants. A method was developed in France (Peres, 1987) to test resistance of leaves after spores have been sprayed onto the leaves. The work is quite laborious for routine testing as can be seen from the graphs; six plants have been analysed (Fig. 4).

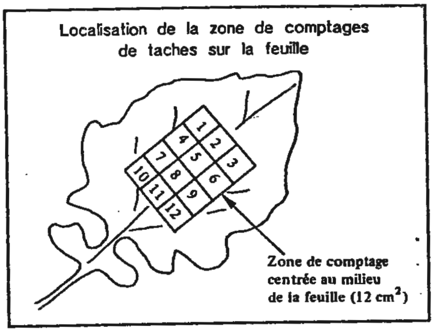


Fig. 4: (ex Peres, 1987): Localisation of observation zones on oilseed rape leaves

How the results are presented is set out in Table 1 (ex Peres, 1987).

This method is, however, only practicable for tests in the greenhouse after artificial inoculations. For outside observation, the incidence on stalks and predominantly on pods has to be carried out. In most reports, therefore, the disease was scored on pods, as they are the main source of damage.

A similar precedure was followed up with scoring the pods, but only 4 sections were used. Eight pods/plant and six plants were examinded. The results are presented as follows in Fig. 5 and Table 2.

Fig. 5: (ex Peres (1987)

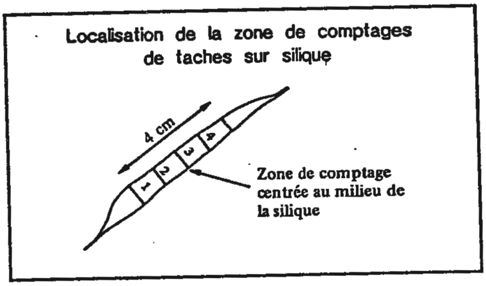


Fig. 5 (ex Peres, 1987): Localisation of observation zones on oilseed rape pods

Tableau 1: Nombre de taches par secteur de comptage pour chaque feuille et étude statistique

Table 1: Number of spots/counting area for each leaf, and statistical study

Feuilles (de la base vers le haut)	NOMBRE DE TACHES SUR LE SECTEUR												Moyenne	Variances feuilles
	1	2	3	4	5	6	7	8	9	10	11	12		
1ère feuille	14,3	27,5	17,2	20	18	18,7	16,7	16,2	11	10,5	15,2	14,8	16,7	87,5
2ème feuille	12,8	19,3	14,3	14	19,3	17	16	18,2	15,2	14,7	21,2	17,2	16,6	75,2
3ème feuille	9	21	21,7	12,8	14,2	19,8	14,3	13,7	13,8	14	12,2	14,8	15,1	63,6
4ème feuille	4,8	4,3	3,7	10,2	4,7	3	8	7,3	6,5	7,5	7,7	7	6,2	23,4
5ème feuille	6,3	8,2	6,7	5,2	5,7	7,5	4,7	6	8,8	6,3	9,7	14,1	7,4	65,4
6ème feuille	0,3	0,3	1,2	0,2	0,7	1,2	2,2	0,8	1	2,8	0,8	0,3	1	4,3
7ème feuille	1,8	1,2	0,7	1	1,2	1,8	3,7	1,8	2,2	1,8	1,2	2,8	1,8	9,6
Moyenne	7,1	11,7	9,3	9	9,1	9,9	9,4	9,1	8,4	8,2	9,7	10,2		
Effet "feuille"	HS 3,7	HS 13,4	HS 9,3	HS 6,5	HS 13,2	HS 7,2	HS 5,2	HS 5,5	HS 4,8	HS 3,9	HS 5,4	HS 3,4		
PPDS 0,05	7,9	8,5	7,9	8,3	6,3	8,9	7,8	8,3	7,2	7,3				
PPDS 0,01	10,7	11,5	10,6	11,1	8,5	12,1	10,5	11,2	9,7	9,9				
Effet bloc	Non significatif													
C.V.	95,4	61,9	71,8	77,3	58,8	77,4	70,8	76,8	73,1	75,6	79,5	86,4		

ex Peres (1987)

Tableau 2: Nombre de taches par secteur de comptage pour chaque silique et étude statistique

Table 2: Number of spots per counting area for each pod and statistical study

Siliques (du haut vers le bas)	Nombre de taches sur le secteur				Moyenne	Variances siliques
	1	2	3	4		
1ère silique (HP)	4	3,3	4,8	11,7	6	23,3
2ème silique (HP)	5,3	5,5	7,7	9,8	7,1	25,6
3ème silique (R1)	2,3	5,7	5	7	5	13,4
4ème silique (R2)	6	4,5	5,3	5,2	5,3	18,3
5ème silique (R3)	5,3	5,8	7,5	7,7	6,6	10,6
6ème silique (R4)	2	3,2	5	4,2	3,6	14,9
7ème silique (R5)	1,8	2,2	2,3	3,2	2,4	6
8ème silique (R6)	0,7	0,5	1,2	1,3	0,9	0,9
Moyenne	3,4	3,8	4,9	6,3		
Effet silique	NS	NS	S (2,3)	HS (3,7)		
PPDS 0,05			4,2	5,2		
PPDS 0,01			5,7	6,9		
Effet bloc	Non significatif					
C.V.	95,4	87,7	74,4	70,3		

HP: hampe principale - R1 à R6: ramifications , ex Peres, 1987

A slightly less laborious way was recommended by Choppin de Janvry (1982) and Regnault (1983), in which the percentage of pod area covered by <u>Alternaria</u> spots and the percentage of pods affected was taken into consideration as demonstrated below.

ECHELLE ALT. I		% de siliques tachées (FREQUENCE)				
		0	<25	<50	<75	>75
% moyen de suface	0	a	-	-	-	-
tachée par	0 à 5	-	b	c	d	e
silique	6 à 15	-	d	e	f	g
(GRAVITE)	16 à 30	-	e	f	h	j
	31 à 50	-	f	h	j	k
	51 à 75	-	g	j	k	m
	76 à 100	-	h	k	m	p

ex Regnault, 1983

$$ALT.I = \frac{1}{\Sigma n} (b + 10c + 20d + 30e + 40f + 50g + 60h + 70j + 80k + 90m + 100p)$$

$$\text{Alt.I.}^* = \frac{1}{\Sigma n}\,(b + 10c + 20d + 30e + 40f + 50g + 60h + 70j + 80k + 90m + 100p)$$

*) Alternaria Index.
That index varies from 0 to 100.

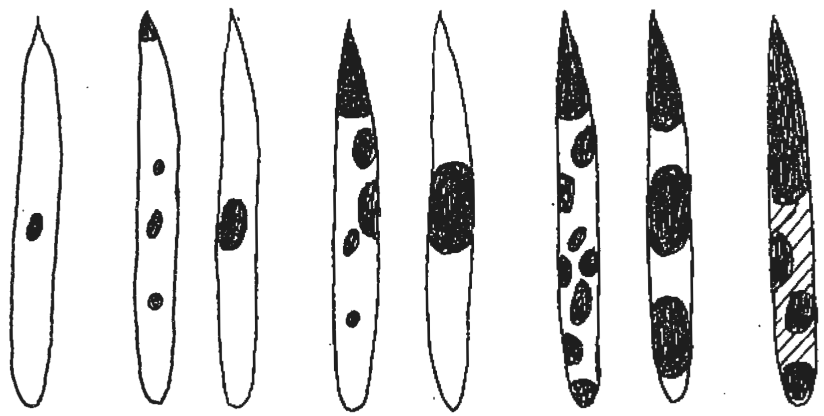
Some more scales were proposed ranging from 5 to 9 steps:

A) 0= no symptoms
   1= up to 10%)
   2= 11- 25%)
   3= 26 to 50%) pod surface blackened
   4= more than 50 %)

(Humpherson-Jones, 1983; Evans et al., 1983; Evens and Gladders, 1981)

A similar systems was presented by Babadoost and Gabrielson (1979)
0= no infection
1= trace, less than 10%)
2= slight, 10- 30%)
3= moderate, 30- 60%) plant surface area covered by flecks
4= severe, over 60%)

The steps were increaed by Cox and Swash (1981) to 6, similar to that by Humpherson-Jones (1983), but between o and 1 a "trace" was introduced. The next scale was one from 1- 9 (Daebeler and Amelung, 1988), which is opposite that one used in the FRG; 9= healthy - 1= severely damaged. To get an idea on the coverage by Alternaria, pods were drawn to illustrate the range of severeties of spotting. It is not possible to have a complete coverage for (9), but the tisssue in between the spots should not be regarded as healthy, it is yellow and shrivelled. For accurate scoring Krüger (not published) used a pattern in which the percentage of infection was demonstrated (Fig. 6):



Score	2	3	5	7	9
%Infected area	2	7	27	65	100

Fig. 6: Surface area covered by Alternaria- infection on oilseed rape pods

Peronospora parasitica Pers.ex Fries

Only few records could be found on the use of scales for classifying leaf infection by this fungus. Sadowski (1987) and Natti et al. (1967) used scales ranging from 0- 5:

0= no symptoms
1= spots, necrotic flecks or streaks, but no sporulation
2= spots, necrotic flecks or streaks, with sparse sporulation confinded to necrotic tissue
3=)
4=) systemic infection and sporulation in increasing degree
5=) (plants with ratings 0 to 2 were considered resistant)

Krüger (unpublished) used a 1- 9 scale as usually recommended when cultivars are scored for susceptibility. This is illustrated in Fig. 7. If larger leaves are concerned, those in Fig. 7 should enlarged by 2 to 5 times to get a comparable shape and size to the leaves found in the field.

General leaf spot assessment

To score leaf spots there are two possibilities.

i) the number of spots are counted per plant of per leaf as carried out byNelson and Pound (1959) with respect to Mycosphaerella brassicicola

ii) assessment according to affected area. Petrie (1973) scored Alternaria spots with steps 0, trace, 1, 2 and 3 = 0, 1, 1- 10, 11- 30 and more than 30% respectively. When it comes to ringspot (M. brassicicola) the following scale was used:
0= 0 %
1= 1- 20 %)
2= 21- 40 %)
3= 41- 60 %) leaf area affected
4= 61- 80 %)
5= 81- 100 ")

Furtherore, Pernaud (1986) used a scale 1- 9 for assessing P. capsellae on pods, but the surface area covered by each step was not stated.

To get a general recommendation, especially when cultivars are screened, the area affected should be estimated. That can be done according to percentage area affected, which is much more laborious, or by transforming the percentage area affected to an "index" ranging from 1 (healthy) to 9 (dead). A guide to severity for pods and leaves is demonstrated in Fig. 6 and 7 respectively. For the values 3, 5, 7 and 9 two leaves are drawn with differing spot sizes. The smaller ones may be used for M. brassicicola and P. capsellae, whilst the larger spots suit to mildew and C. concentricum.

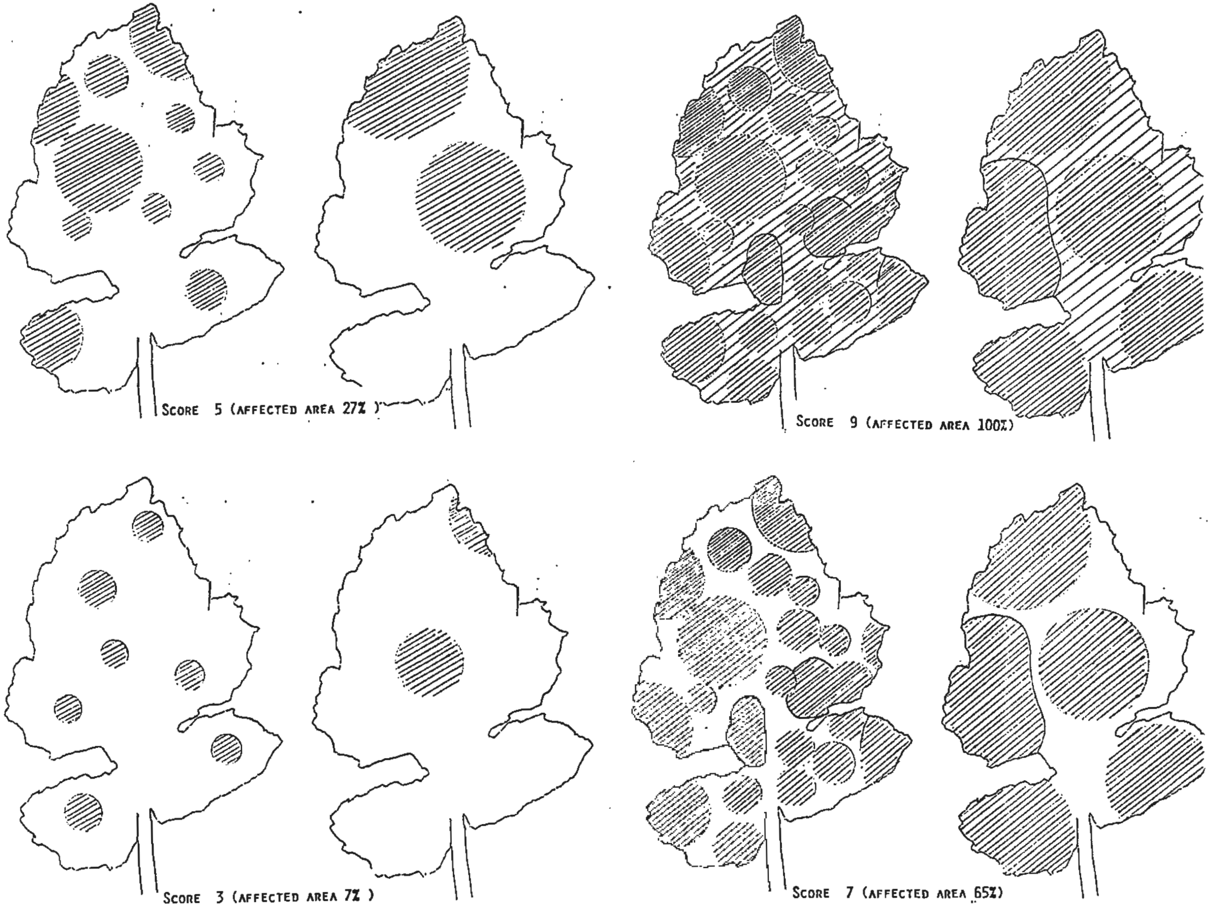


Fig.7: DISEASE ASSESSMENT (1 TO 9) ON LEAVES OF OILSEED RAPE

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Introduction

OPPORTUNITIES AND LIMITATIONS ON RAPESEED CULTIVATIONS IN THE 1990 s

H. PRIEW
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The work of the Ministry of Food, Agriculture and Forestry concerning oilseed rape is influenced by:
- the natural and structural conditions in the sector of agriculture
- the political framework conditions implemented by the administrative authorities
- the demands of the consumer
- the demands of the market which are also influenced by the quality standards of the raw materials processing industry
- the know-how available to the farmer
- the degree to which society accepts the agricultural production methods.

A deep analysis of all these points would take up too much time so I will just pick out a few subjects and look at them more closely. In the Federal Republic of Germany the discussion of modern methods of plant production takes place against a background of economic and ecological considerations and seems to be conducted in a fashion which is rather more intense or even more violent than in other countries. The dynamics of these processes are vital for an ongoing re-orientation in decision-making and opinion-forming in society and politics and are reflected in the legislation pertaining to agriculture. Therefore we depend more than ever on the availability of a great variety of cultivars in order to create some respite in the overly thight crop rotation schedules and to develop production methods that free the farmers from the coercions they face at present and allow them to reconcile the ecological and economic aspects of their activities.

For many years the Federal Government and the Federal Ministry have given financial support to the research activities of the German breeders in the area of variety breeding, particularly with respect to oilseed rape.

Nor was this pure coincidence, after all, oilseed rape has been cultivated for a long time in Europe and the far-sighted private breeders, who used to live in the central and eastern regions of Germany - among them Lembke, Dippe, Janetzki, to mention just a few - have never abandoned the plant even at times when breeding prospects were quite bleak. After the unfortunate war many private breeders who had been expropriated in the GDR came to Western Germany where they found new possibilities to work. The breeding stations in the GDR became state-owned institutions with scientific or practice-oriented tasks. I am stressing this point because we are very happy indeed to welcome among us members of these institutions who are here for the first time on account of their personal decision. The Federal Republic of Germany and the GDR are now called upon to develop sound structures which will carry both private and state-run breeding stations into the 1990s. I am convinced that these breeding institutions can give important incentives which reach across the borders. Allow me to point out in this - agriculturally relevant - context that today there are two wholly different agricultural systems in Germany: agriculture in the Federal Republic of Germany is characterised by private enterprise while state-owned and cooperative large-scale enterprises dominate agriculture in the GDR.

Since 1966/67 oilseed rape has been included in the European Community's market organisation for fats, e.g. vegetable fats. This ist the outcome of a compromise between the Community's obligations under the GATT and the necessity to secure the incomes of the farmers. The market organisation comprises a system of subsidies which plays a very essential role for the cultivation of rapeseed in the Community. This refers not only to the element of income support but also to
the ecological relevance of oilseed rape as one part in a system of crop rotation. Another key task is the securing of the food supply. In this context we should not forget that it was the same market organisation which gave vital impulses for the successful production of oilseed rape in the European Community. it will retain its importance for rapeseed cultivation in the 1990s. The lack of upper limits within the Community's subsidy system put such an enormous burden on the budget - 7.9thousand million for oilseed rape in 1987 - that the overall market policies could no longer cope and the public would not accept justification of such a burden. In the financial year 1988 the European Council therefore introduced the so-called budget stabilisors according to which the price was automatically reduced as soon as a certain fixed quantity - 4.5 m.t. in the case of rapeseed - was exceeded. Today the price is reduced by 0.5 percent for each 1 percent in excess of the fixed quantity. Each agricultural enterprise had to undergo re-assessment with respect to the rapeseed crop in relation to other crops. The fact that the area of oilseed rape cultivation has expanded in the Federal Republic of Germany to a total of 550000 ha compared to other countries goes to show that there is a trend toward the better site and the better host country even though the product is still being subsidised.

During the last round of GATT negotiations in Uruguay the United States of America initiated an expert's opinion on the subsidies of the European community for oilseed rape. The document recommends that the Community harmonise its oilseed regulations with the rules of the GATT. The subsidies - this was the main criticism - not only benefited the agricultural producers but also profited the processing industry. It was further pointed out that the European oilseed growers were protected against movements on the world market and were thus given a competitive advantage over producers in third countries at the expense of these countries.

The Community accepted the conclusions of the GATT panel with the reservation that the USA should take no measures against the EC until the Community had an opportunity to adjust its regulations on rapeseed. At the moment it is hard to predict whether there will be decisive changes in the subsidy system for oilseed. We will have to await the end of the GATT negotiations. As adjustments are not likely to be started before the GATT negotiations are over the earliest possible changes can be expected to come about in the financial year 1991/1992.

The two factors described above, namely

1. Tieing the price to a certain production quantity, and

2. Possible changes of EC subsidy regulations following the current GATT negotiations

are important imponderabilities for the next decade of oilseed rape production. They also mean a new big challenge for all those involved with oilseed rape.

There are various ways in which this challenge can be met. One possibility is to lower the break even point by increasing the yield per unit, another is to create new markets by finding new uses for oilseed rape. Pessimism does not seem expedient here and would only jeopardise the great achievements made in the area of rapeseed cultivation.

May I remind you that it is not so long ago that the ugly duckling rape was transformed into a yellow beauty. Here is what Meyers Encyclopedia said about the processing products of rapeseed in 1890:

"Rapeseed oil is used as lamp oil, for soap making, machine lubrication, wool lubrication and the greasing of leather. The oil can be heated to the point of simmering after which one adds 1/32 of its weight as crushed potato starch and reheats until slightly sweet and one thus obtains an oil which can be used for cooking and baking."

In the past it was dire need and the lack of quality foods that encouraged the extended cultivation of oilseed rape which was grown exclusively for its unloved oil. Unitl the 1970s rapeseed oil was still seen as a low-quality product whose unfavourable composition of fatty acids made it unpopular with the food industry and whose by-products had limited uses.

The share that plant breeding had in the development of rapeseed cultivation after the war can not be overestimated. Only when the low erucic acid varieties, the so-called single low varieties, came up in the 1970s did it become possible for rapeseed oil, which had been limited to technical application, to gain access to the active profitable market for edible oils. The better quality was accompanied by an increased yield due partly to successful breeding but also to more sophisticated cultivation methods and a broad range of plant protection products which was extending all the time.

Cross-fertilization and weed problems which stood in the way of putting the breeders' achievements into practice could only be overcome because all parties concerned agreed to supply only low erucic acid varieties to the German farmers for the sowing period of 1974 (regional exceptions in Bavaria and Baden-Württemberg). The radical change-over to the brandnew low erucic acid varieties is a veritable model of an excellent, successful cooperation between science, industry, extension services and the farmers and their associations within a social market economy. Less spectacular but no less important for the further development of rapeseed cultivation was the fast-progressing change to low-glucosinolate varieties, the double-low varieties, which took place all over Europe. The change was made just in time to ward off the threatening problems of selling the rape meal produced in large quantitites, but lacking in quality, following the increase in the area under cultivation. The process of switching over went on gradually over a number of years.

Breeding for low-glucosinolate content at an early stage gained the German breeders a - temporary - advantage over their competitors in the Common Market. This was most clearly demonstrated by the rapid way in which German cultivars increased their market shares even in other countries of the European Community. This breeding success also upgraded the value of oilseed rape as animal feed: low glucosinolate extraction meal from double-low varieties was no longer restricted to use in cattle feed but could be employed for feed mixes for pigs and poultry.

It is quite obvious today that oilseed rape has not yet reached its qualitative or quantitative limits. Further breeding efforts are required in oder to avail rapeseed of the opportunities of the food market. Another opportunity we cannot afford to miss lies in the possibility of a 2-3% yield increase in the near future. This can be achieved by breeding for larger seed size at the expense of other plant organs. In view of the Community's price policy we must also attempt to breed for qualites that meet the needs of the market in order to open up new sales channels and fend off competition. Larger amounts of rape oil could be used in margarine production if breeding succeeds in increasing the content of linoleic acid and reducing the content of linolenic acid. The development of rapeseed varieties with fundamentally different oil qualities proves that modern breeding methods can adapt the composition of fatty acids to the exact demands of the consumer. There is, however, some room for improvement in the area of rape meal.

Some developments indicate that the cultivation of rapeseed in the European Community or even in the whole world has again come to a turning point where oilseed rape can be considered as "regenerative energy" for the non-food sector - these are the operative words. I realise that we must exercise great care in approaching this market and be sure not to damage the market in the food sector. Under the proper economic conditions the non-food market for rapeseed could give a boost to the demands for rape oil in the medium term. But this potential can only be realised if there is a broad political consensus in the Community. National solo performances are uncalled for at a time when we face the task of reducing the strains on the market and if possible on the budget as well. It is unfortunate that the EC-Commission should find it so hard to come up with an acceptable proposal and would rather cling to the once-accepted principle of excluding a product which is already subsidised from any further promotion measures.

This is the background against which we must assess the opportunities for rapeseed as a regenerative raw material in the various fields. The most interesting ones are:

lubricants
fuels
fatty acids.

At present the market for lubricants seems to be expanding most rapidly in the whole Community. The industry's quality demands for a basic oil correspond exactly to the composition of fatty acids in the oil from the double-low varieties. Other vegetable oils are less adequate or completely inadequate. Even at lower prices they cannot replace oil from rapeseed. Various lubricants which are already derived from oilseed rape combine advantages in the fields of ecology and human toxicology with surprisingly good lubricating properties. Lubricants derived from mineral oil do not meet such requirements at all and even synthetic oils are confined to uses within narrow limits.

There is a growing demand for lubricants and hydraulic fluids which are safe for man and the environment.

The first commodity to be produced was an environment-friendly lubricant oil for the chain of a power saw. Nowadays hydraulic oils are available for tractors, construction machinery and stationary aggregates. Further innovative products are being developed at high speed and there is fierce competition which pushes environmentally hazardous lubricants from the market. According to estimates by the industry it is not unrealistic to expect the new generation of environment-friendly lubricants to win 25 to 30% of the market in the medium term range. This would correspond to a Community-wide rape oil consumption of about 1 million tons or half of today's rape production in the EC or all of what is exported as surplus within the community (rape oil production in 1988: ca. 2.1m tons, export of rape oil: 1m tons).

Rapeseed oil is available at world market prices on the domestic market - it competes very well with its industrial rival products. The world market price of rape oil does not seem to play a very big role for the lubricant industry. The real net output of rape oil is large enough to withstand competition with highly processed mineral oil derivates and synthetic lubricants.

Lately, many political statements and scientific publications have been concerned with rape oil as a substitute for diesel oil. Like other regenerative raw materials "rape oil as fuel" has met with reservations which are of an economic rather than a technical nature.

The cheapest technical solution is to buy vegetable oil directly from the domestic oil mills whose crushing capacity is fortunately large enough. With only half the VAT rate and no mineral oil tax to pay one would arrive at reasonably realistic fuel prices in the area of 0.70DM/l to 1.00DM/l. A diesel engine which can run on vegetable oil would of course be needed but there are already severalengines which have undergone a series of tests with respectable success. They are not ready for serial production but the first fleet tests for tractor prototypes are in the pipeline. Still, it may take some more time until these plans become reality. At the moment an intensive discussion is going on in the EC agricultural price negotiations about the possible launch of a demonstration project to investigate whether rape oil can be a viable alternative to diesel fuel.

With respect to fatty acids we should note the following points: The industry is actually interested in oils with a high content of a certain fatty acid. Expensive technical processing could be avoided if the raw material already met most of the quality demands. The industry is specifically interested in:

- erucic acid,
- oleic acid, and
- fatty acids with shorter chains which cannot be obtained from oilseed rape.

High erucic acid rape varieties were the ones grown before the change in 1974. In the meantime systematic breeding has been taken up again. The potential sales to the industry could be increased, but within rather narrow limits (about 30.000 ha of oilseed rape in the Federal Republic of Germany).

Although the market for oleic acid is active and quite large a major share has already been conquered by the sunflower producers. We are not yet certain that the rape breeding efforts which are under way will yield positive results. Another aggravating factor is that oleic acid from rape or sunflower oil has to compete with beef suet which can be bought cheaply on the world market. The Federal Ministry of Agriculture hopes that some of the questions arising in conjunction with the role of rape oil in the food sector will be answered by an experts's colloquium on "Vegetable oils for chemical and technical uses" to be held at the end of this year.

Ladies and Gentlemen, cultivating large areas with newly bred varieties must be expected to carry some risks. Stronglights cast deep shadows! Shortly after the double-low varieties had reached a certain level of expansion we started getting reports, initially from Austria, about deer dying in the vicinity of or in oilseed rape fields. While deer died in Austria it was hares dying in

Germany. Scientists could neither confirm nor disprove these accusations. My Ministry launched extensive research whose consclusions agreed with the findings of other researchers: there is a high probability that the death of the hares was not caused by oilseed rape but by a virus disease which has spread all over Europe. With deer the situation is different. Oilseed rape was found to contain a certain amino acid which - and this has been known for some time - can cause the so-called cabbage anaemia in ruminants. We can therefore assume that in extreme winter weather when there is little or no grazing deer may overfeed on oilseed rape. This may exceed the tolerance limit of the deer and cause the symptoms described above which will eventually lead to death. My Ministry has made this information available to the Federal States governments which run the extension services and they have taken immediate measures of precaution.

We are presently trying to establish whether the problem can be overcome by breeding measures e.g. breeding out the amino acids which causes the problem, but we have not had a conclusive answer yet.

The continuous development of environmental legislation in the Federal Republic of Germany is also translated into rules and regulations of the laws on agriculture. The Water Act and the laws on fertilizers or pesticides may serve as cases in point. The Germans in the audience will surely be aware of the strict environmental standards that have to be met before chemical plant protection products can be approved and recall that many have not made it to approval or can only be used with restriction. But if we want to continue using pesticides we must not forget the agricultural aspects of rapeseed cultivation. Our aim must be to use them as sparely as possible. This challenges the breeders to work towards cultivars with good resistance to diseases. This demand is also underlined by the fact that the increasingly dense rape cultivation gives rise to an increased incidence of fungal pathogens.

I should not forget to mention that there are people who cast a sceptical eye on the concept of regenerative raw material for ecological reasons and this goes for some cultures more than for others. At the beginning I stressed the need to look at all aspects of our activities. Certain mistakes have been committed in the past and this is why the Ministry of Food, Agriculture and Forestry has commissioned a working group to develop "Strategies for an Environmentally and Socially Acceptable Agricultural Policy".

The opportunities and limitations on oilseed rape cultivation in the 1990s is the subject which will occupy you directly or indirectly in discussions over the next two days. The views one holds on this subject certainly depend on where one lives and works. I have tried to highlight some aspects from the viewpoint of the Federal Republic of Germany which is, of course, strongly influenced by the regulations of the Community. Though we must certainly not underestimate the necessity of further developing the cultivation of oilseed rape - I have made this point before -

the real opportunities for oilseed rape depend on whether variety breeding manages to meet the demands of a changing market and whether new uses for rapeseed and its byproducts can be discovered. Oilseed rape will certainly never be an easy or convenient plant! The "Yellow Beauty" will continue to challenge us! In her booklet "The development of bird rape and oilseed rape in the agriculture of Germany" Mrs. Schröder-Lembke quotes from a book written in 1570:
"Especially in Germany, where there is no olive oil the farmers earn good money with oilseed rape".
Let me conclude by expressing the wish that the statement "the farmers earn good money" may also apply to the production of oilseed rape in the 1990s.

SESSION 1

Occurrence and Biology of Pathogens

PREMATURE RIPENING IN OILSEED RAPE IN FRANCE : FIRST REPORT ON ASSOCIATED FUNGI.

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Summary

Premature ripening in oilseed rape has been observed for at least five years in France. In 1989, a considerable number of samples from different plots in the Lorraine region showed internal and external symptoms most frequently associated with the wilt of plants.

Phoma lingam, Verticillium dahliae and Fusarium roseum sp. were isolated in many cases and seem to be associated with blackening of tap-root and stem.

Résumé — Le dessèchement prématuré du Colza en France : Premier rapport sur les champignons associés.

Le dessèchement prématuré des pieds de colza est observé depuis au moins 5 ans en France. En 1989, des échantillons prélevés dans différentes parcelles de Lorraine ont permis de déterminer les symptômes internes et externes les plus fréquemment associés au dessèchement. Phoma lingam, Verticillium dahliae et Fusarium roseum sp. sont très souvent isolés à partir des noircissements des tissus du pivot et des fibres noircies de la tige.

1. INTRODUCTION

Over the last ten years premature ripening of oilseed rape plants has been observed in France, with precocity varying from a few days to six weeks before harvest, and with an intensity varying according to the climatic conditions in late spring. This phenomenon, commonly known locally as "pieds secs", generally appears suddenly and occurs in all the traditional oilseed rape-producing areas, but more particularly in eastern and northern France. It may give rise to considerable loss in yield.

Premature ripening has been most closely studied in Germany, where it was first observed in 1983. It is known there as pathological maturation. With no outward signs or intermediate stages brown stems appear during the two or three weeks preceding harvest. Some, though not all, affected plants are easily uprooted. Lateral roots are then seen to have disappeared wholly or partially, and the taproot shows signs of rot. HORNIG (1985) attributes these effects mainly to the separate or combined action of Phoma lingam and Verticillium dahliae. Their respective importance depends on climatic conditions during the preceding year (HORNIG, 1987). The effect on yield mainly appears as a reduction in 1,000-seed weight (HORNIG, 1985). The fungus or fungi in fact affects yield during formation, even before the appearance of visible symptoms.

German researchers have pointed out the difficulty of distinguishing symptoms provoked by P. lingam from those of V. dahliae since both cause blackening of stem and taproot tissues. Formation of the organs characteristic of the two fungi, pycnidiae in the case of P. lingam and microsclerotiae for V. dahliae, often occurs late, sometimes even after harvest. HORNIG, 1987, believes the phenomenon to be a disease linked to crop rotation. He points out that some crops (potatoes, clover, lucerne) have the effect of increasing the incidence of V. dahliae attack, whereas others reduce it (sugar beet, peas, oats).

AHLERS, 1987 points out the existence of wide varietal and regional variations.

In Sweden, V. dahliae has been considered since 1960 as a pathogen of oilseed rape liable to cause appreciable losses in yield (SVENSSON & LERENIUS, 1987).

Initial analysis of prematurely ripened plants carried out in the oilseed rape disease laboratory of the INRA-Le Rheu (FRANCE) over the last five years using samples from the different oilseed rape-procucing regions has demonstrated the frequent presence of several pathogens. P. lingam, V. dahliae and Fusarium roseum sp. were those most commonly isolated, mainly from blackened areas of the taproot and stem, and were found singly or in varying combinations according to the region and the year. However, it was not possible to assert on the basis of these results that their presence on dead plants implied their direct responsability as primary or secondary agents in premature ripening.

2. MATERIALS AND METHODS

No specific study has yet been carried out in France to further knowledge of premature ripening in oilseed rape and more particularly the symptomatology of V. dahliae and the evolution of the symptoms leading to premature ripening.

To permit such a study, regular observation of identified plants was carried out at different sites in Lorraine during the period from mid-May 1989 until harvest (18th July). Choice of plots was dictated mainly by the frequency of prematurely ripened plants previously noted in neighbouring plots. Sites were located at Demange aux Eaux (Meuse), Fresnes en Wöeuvre (Meuse), Flirey (Meurthe et Moselle) and Amance (Meurthe et Moselle).

Two varieties, Cérés and Samouraï, were chosen for their susceptibility to premature ripening and Darmor for its lower susceptibility. At Amance, Samouraï was replaced by the variety Tapidor. The number of repetitions varied from site to site : three at Flirey, Fresnes en Wöeuvre and Demange, one at Amance. Two series of 25 plants each from two continguous lines were studied in each repetition.

Externally visible symptoms were separately recorded for each plant, approximately every ten days. Seven plants of each variety were removed for examination. Internal symptoms and non-identified external symptoms were studied by isolation on two agar medi :

TABLE 1 - PERCENTAGE OF PLANTS SHOWING EACH TYPE OF SYMPTOM, BY VARIETY AND SITE.

	LOCATIONS	Demange		Amance			Flirey			Fresnes			
	VARIETIES	C	D	C	D	T	C	D	S	C	D	S	x̄
SYMP-TOMS	Nb of plants	90	90	50	50	50	90	90	90	50	50	50	
	% "pieds secs"	58	53	48	6	18	13	30	27	20	6	10	26,2
EXTERNAL	Weevil	0	2	12	20	12	2	1	1	10	12	8	6,66
	Cylindro.	20	27	0	4	24	48	24	32	36	90	76	31,75
	Phoma (c.n.)	18	9	26	10	14	8	18	9	6	2	16	11,33
	PGC	27	20	6	0	6	21	18	17	2	0	0	9,75
	Uni. Y	54	52	52	4	18	18	26	36	6	0	0	22,16
	Uni. D	57	51	44	0	10	10	20	19	10	0	0	18,40
	Microscl.	14	36	14	2	2	9	6	11	2	0	0	8,00
	GBP	14	38	18	0	4	11	12	22	4	0	6	10,58
	BBP	6	3	4	2	0	3	4	1	2	0	2	2,25
INTERNAL	TB	91	89	52	48	44	48	66	53	56	32	54	52,75
	SFB	69	50	52	32	20	28	41	39	16	12	8	30,50
	OPP	2	3	0	2	0	8	12	9	34	8	16	7,80
	HC	50	32	14	22	16	38	47	38	38	22	28	28,75

SYMPTOMS

EXTERNAL
- Weevil : Stem weevil
- Cylindro. : Cylindrosporiosis
- *Phoma* (c.n.) : *Phoma* (collar necrosis)
- PGC : Pale green colouring
- Uni. Y : Unilateral yellowing
- Uni. D : Unilateral drying
- Microscl. : Microsclerotiae
- GBP : Greyish-blue patches
- BBP : Beige-brown patches

INTERNAL
- TB : Tap-root blackening
- SFB : Stem fibre blackening
- OPP : Orange patches in pith
- HC : Hollow collar

VARIETIES

- C : Ceres
- D : Darmor
- T : Tapidor
- S : Samuraï

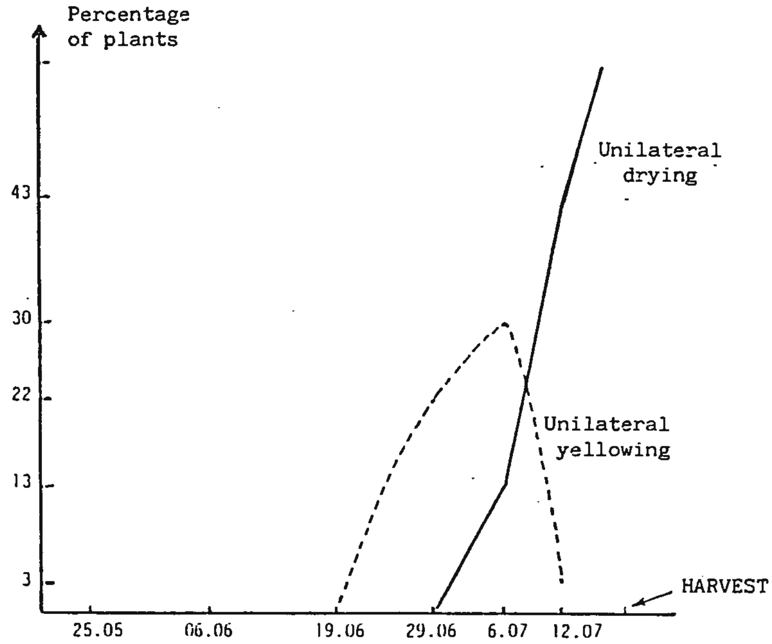

Fig. 1 - Appearance of unilateral yellowing and drying.
Variety CERES (DEMANGE).

TABLE 2 - FREQUENCY OF PREMATURELY RIPENED PLANTS AND PLANTS SHOWING BLACKENING OF TAP-ROOT AND VESSELS, ON HARVEST, VARIETY CERES.
RESULTS EXPRESSED AS % OF PLANTS ANALYZED.

Sample sites	DEMANGES	AMANCE	FLIREY	FRESNES
Number of plants analyzed	90	50	90	50
Premature ripening (%)	58	48	13	20
Blackening of tap-root (%)	91	52	48	56
Blackening of vessels (%)	69	52	28	16

<u>TABLE 3</u> - FREQUENCY OF PRINCIPAL PATHOGENS ISOLATED FROM ORGANS SHOWING BLACKENING OF TISSUES.

Symptoms	Blackening of tap-root	Blackening of vessels
Number of plants analyzed	56	42
V. dahliae (%)	45	50
P. lingam (%)	62	62
V. dahliae + *P. lingam* (%)	27	31
F. roseum (%)	20	12
Nothing	14	17

<u>TABLE 4</u> - FREQUENCY OF PLANTS SHOWING SYMPTOMS OF *V. DAHLIAE*. RESULTS EXPRESSED AS % OF PLANTS ANALYZED.

SAMPLE SITES	DEMANGES	AMANCE	FLIREY	FRESNES
Number of plants analyzed	90	50	90	50
Prematurely ripened plants (%)	58	48	13	20
Unilateral drying (%)	57	44	10	10
Microsclerotiae (%)	14	14	9	2

- Medium containing malt (2 %) and agar (2 %)
- Medium containing malt (2 %), agar (2 %), penicillin (500 ppm) and streptomycin (500 ppm).

The second medium is specific to the study of V. dahliae development.

On harvesting the selected plants were uprooted, and numbers of "pieds secs" and internal symptoms were recorded.

3. RESULTS

1. Description of symptoms

a - Symptoms of V. dahliae

External symptoms most commonly encountered include unilateral bands of yellowing and drying along the stem. These may affect only a single ramification. The symptoms appear suddenly (at mid-June in 1989 in Lorraine) and rapidly lead to premature ripening of entire plants (fig. 1).

The sub-epidermic microsclerotiae which form, sometimes late in the process, give the stem a greyish appearance. In this case the symptoms may easily be confused with those of Pseudocercosporella capsellae. However, when the symptoms are caused by V. dahliae, the epidermis may-easily be detached to reveal the sub-epidermic microsclerotiae and dissociated fibres, whereas those of P. capsellae are superficial and the epidermis difficult to remove. Greyish-blue patches are also commonly observed at the base of the stem.

The tap-root shows bands of blackening beneath a partially or totally affected cortex.

Internal symptoms consist in more or less general blackening of the tap-root and of stem vessels, with or without microsclerotiae. The pith remains present, and may be totally overrun by microsclerotiae which give it a greyish appearance.

b - Symptoms of Phoma lingam

The best-known symptom of this parasite's action on oilseed rape is a cork-like necrosis of the collar which in extreme cases may lead to wilting of the plant after flowering.

Grey or white patches of varying sizes, lightly speckled with black dots (pycnidae), may also be observed at different heights on the stem.

In the case of "pieds secs" the tap-root shows intense blackening usually associated with the disappearance of secondary roots and cortex.

c - Other possible causes of premature ripening

Severe attacks of light leaf spot (Pyrenopeziza brassicae) and white leaf spot (Pseudocercosporella capsellae) may also lead to premature ripening.

White mold (Sclerotinia sclerotiorum) also causes drying of plants but symptoms are frequently highly typical (white stem), and the presence of sclerotiae inside the stem makes identification easy.

2. Main phytosanitary problems encountered in Lorraine

The main symptoms encountered are shown in table 1. Presence only is recorded, without details concerning the severity of attack.

Collar necrosis due to P. lingam and the stem weevil was observed on all sites. Damage caused by C. concentricum was mainly evident at Flirey and Fresnes. Symptoms imputable to V. dahliae ranging from pale green discoloration to unilateral drying of the stem, as well as greyish-blue patches, were observed in varying degrees on the different sites.

Hollow collars, probably physiological in origin, were recorded in all the plots studied.

Blackening of tap-roots and stem vessels were the most common symptoms, and were to be found in plants not yet dry on harvest (table 1 and table 2).

Isolations from organs presenting this type of blackening (table 3) show the presence of V. dahliae and P. lingam in a large number of cases. These two fungi may be found simultaneously on the same symptom. Fusarium roseum sp. was isolated less frequently from both types of symptom. In a few cases a pathogen was not detected, either because it was absent or because its presence was masked by that of saprophytic fungi.

3. Relationship between premature ripening and Verticillium dahliae in Lorraine, 1989

Taking the variety Cérès (table 4) as an example, it is possible to establish a link between the percentage of prematurely ripened plants observed at harvest and the percentage of plants affected by V. dahliae in the 4 experimental sites. However, the occurence of microsclerotiae at harvest is relatively low on those plants affected by Verticillium wilt, and there is a danger that where observations are carried out after the unilateral drying stage it may be difficult clearly to attribute the responsability for premature ripening to this fungus, thus its effects are likely to be underestimated.

4. Varietal resistance

The results show the presence or absence of symptoms but give no account of their date of appearance or the severity of the attack (table 1).

This explains varietal behaviour which may appear surprising in the case of collar necrosis, particularly at Fresnes. Varieties such as Darmor express their resistance to P. lingam by a lower intensity of necrosis symptoms.

The percentage of prematurely ripened plants varied from one site to another. It was high at Demanges (over 50 %) and lower at Fresnes. This seems to argue a certain varietal variability, but in the context of these trials the same classification cannot be applied from one site to another.

4. CONCLUSION

The study of plants in the Lorraine region over the period from the month of May until harvest in plots where the percentage of prematurely ripened plants is generally high makes it possible to confirm the frequent presence of the three main fungi previously isolated from prematurely ripened plants.

Early symptoms of *V. dahliae* have been described for the first time in French growing conditions.

Following this study it appears that premature ripening in this year and this region is generally associated with *V. dahliae*, *P. lingam* or the complex *V. dahliae* - *P. lingam*.

These initial results indicate that the phenomenon is the same as that described by German researchers.

However it is not yet possible to state whether the fungi act as primary agents or as secondary pathogens on already weakened plants.

Although results in the field often show appreciable losses in yield associated with premature ripening, the extent of the phenomenon in normal growing conditions and its relative harmfulness in different situations remain to be determined.

A study covering a number of different sites and prolonged over several years is required in order to answer these questions.

Acknowledgements

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FIRST EXPERIENCES WITH ELISA FOR DIAGNOSIS OF *VERTICILLIUM DAHLIAE* IN OILSEED RAPE

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Summary

Commercially available antibodies against *V.dahliae* have been tested for their suitability in the early diagnosis of *Verticillium* on oilseed rape. Cross reactions with the most common pathogens of rapeseed were negative. Leaves of six week old artificially inoculated plants gave positive responses. The minimum quantity of fungal tissue detectable in a single well was less than 11 ng of fresh matter. This is the first report on the use of ELISA for detection of *Verticillium* in agricultural crops. The method is suitable for rapid and reliable processing of large numbers of samples from early stages of pathogenesis. Each individual sample covers relativeley large amounts of the plant so that "sampling problems" known in microscopy or in the isolation of funghi with low and discontinous distribution are not important.

1. Introduction

Early symptoms of *Verticillium dahliae* infections on winter oilseed rape are non-specific and easily mistaken for symptoms of other biotic or abiotic causes. Conventional methods of diagnosis (e.g. plating on selective media) are time consuming and not always reliable. Serological methods for example a specific ELISA - test, commonly used in virology and bacteriology, can be eminently suitable for an early diagnosis of fungal pathogens with long incubation periods.

2. Materials and Methods

Test principle

The ELISA-test used here works upon the double-antibody (sandwich) principle.

Buffers

We used the usual buffers (Clark & Adams, 1977) for coating and washing the plates eg.: coating buffer ($Na_2CO_3/NaHCO_3$; pH9.6) - conjugate buffer (PBS; pH 7.0) - substrate buffer (diethanolamine; pH 9.6) - washing buffer (PBS, Tween 20 1%, pH 7.4). Buffers were added with 0.02% sodium azide and stored at 4°C.

Microtitre Plates

Flat bottomed polystyrene microtitre plates (Dynatech M29AR) were used.

Sample processing

Samples were processed either in autoclaved mortars or in "homogenization bags" (Bioreba with sample buffer in an 1+9 (m/v) ratio.

Cross tests

These tests were carried out in order to verify the specificity of the *Verticillium* serum; pure cultures from the stock of the laboratory were used.

Plant Materials

The detection of *V.dahliae* in plant materials was carried out on naturally or artificially infected plants of different age and symptoms. Some of the material was fresh while the rest had been stored dry for over a year without any special precautions.

Detection limit

In order to determine the detection limit a six week old pure culture (mycelium and spores, no microsclerotia) of *V. dahliae* was prepared in sample buffer, in pressed leaves sap and in root sap in a series of diluitions. The first well contained 3mg of fresh fungal matter; the final dilutions contained 11ng of fresh fungal matter. Photometric evaluation was carried out with a normal spectrophotometer (Bausch & Lomb 501) at 405 nm in glass cuvettes (2mm x 10mm) after the enzyme reaction had been stopped by adding 50 1 of 1M NaOH. A measurement was rated "positive" if the condition $OD_{measurement} > OD_{blank}+3x(s.d._{blank})$ was fulfilled.

3. Results

The cross reaction tests (Table 1) with milligram amounts of pure cultures of other fungal pathogens of rape produced negative reactions in all cases. Pure cultures of *V. dahliae* of different geographical (France, Sweden, Germany) and botanical origin (Strawberry, hops) reacted positively.

Table 1. Specificity of the *V. dahliae* - ELISA test

Pure culture	Origin	no. of isolates	Reaction
Alternaria brassicae	*Brassica napus*	2	-
A. brassicicola	*B. napus*	2	-
Cylindrosporium concentricum	*B. napus*	1	-
Phoma lingam	*B. napus*	3	-
Sclerotinia sclerotiorum	*B. napus*	3	-
Typhula ishikariensis	*Bromus sp.*	1	-
V. dahliae	*Fragaria vesca*	1	+
V. dahliae	*Humulus lupulus*	1	+
V. dahliae	*B. napus*	1	+
V. dahliae (spores)	*B. napus*	1	+
V. dahliae (microscler.)	*B. napus*	1	+
V. dahliae (microscler.)	*B. napus* (France)	1	+
V. dahliae (microscler.)	*B. napus* (Sweden)	1	+
Xanthomonas campestris	*Festuca pratensis*	4	-

Naturally and artificially infected rape plants also produced a positive reaction. The detection limit for mycelium with spores in sample buffer and in leaf sap was below 11ng/well but considerably higher if root juice was used. Stubble material with microsclerotia which had been stored for over one year at room temperature responded positively to the test. Leaves of six weeks old artificially inoculated plants also gave positive responses in the absence of macroscopic symptoms of attack.

4. Discussion

The sensitivity of the test to spores or mycelium appears to be considerably higher than to microsclerotia. This makes the test a very useful instrument for detecting early stages of pathogenesis. Once sclerotia have been formed they are easily diagnosed with a lens or even the naked eye. The detection limit of less than 11ng corresponds to a quantity of less than five spores or mycelium mass respectively. It is therefore possible to detect spore concentrations of some ten spores per gram of plant, in leaves or stems irrespective of the other rapeseed pathogens in the sample. The ELISA test should prove superior to all conventional methods of analysis.

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CLUBROOT, PLASMODIOPHORA BRASSICAE, IN SWEDISH SOILS.

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Summary

In Sweden clubroot caused by Plasmodiophora brassicae Wor. has been given increased attention in recent years. The method for the detection of the fungus in soil samples is presented. In the years 1987-1989, 395 fields were tested for presence of clubroot prior to potential cropping with oilseed rape. 135 of the fields were infected. 228 fields were randomly chosen for testing and 38 (i.e. 17 %) of these were shown to be infected.

1. Introduction

In 1989, the area in hectares under cultivation with oleiferous plants was 169457. This was divided among winter rape 71322 ha, spring rape 52924 ha, winter turnip rape 9047 ha and spring turnip rape 36164 ha.

Clubroot disease of Cruciferae is one of the damaging diseases associated with intensive cultivation of Brassicas in Sweden. The characteristic symptom of clubroot is the presence of irregular swellings on the root system, often with associated wilting and stunting of plants.

A number of outbreaks of clubroot on oilseed rape has been observed in recent years, mainly in the southern and western areas of Sweden. The occurrence of the disease has usually been associated with short rotations of Brassica crops. Clubroot can also occur on Cruciferous weeds e.g. charlock (Sinapis arvensis L.), pennycress (Thlaspi arvense L.) and shepherds purse (Capsella bursa-pastoris (L.) Medic.) which could thus sustain and multiply inoculum in the soil in the absence of susceptible crops.

This paper gives details of the incidence of clubroot infection in soil samples of potential oilseed rape fields in Sweden.

2. Material and Methods

Origin of soil samples.
Soil samples were collected from two sources. The first source was 228 fields from randomly selected locations of official oilseed rape trials. The second source was 167 fields from oilseed growers wishing to test their fields prior to sowing.

Soil testing.

Svalöf AB operates a service in which soil from fields to be sown with oilseed rape (or other Brassicas) can be tested for presence of P. brassicae before sowing. A 6 litre soil sample (general sample of 50 soil cores taken to ploughing depth representatively over the field) is thoroughly mixed and divided into 6 new pots. These are then sown with 20 seeds of chinese cabbage (cv. Granat) and placed on a glasshouse bench at an air temperature of 25°C with 16h light/day. When plants are 2-3 cm tall they are thinned to 10 plants/pot. The soil in the pots is maintained at field capacity moisture throughout the test period. After 6 weeks the roots are assessed for clubroot severity. The test is regarded as positive if at least one plant shows any degree of infection. The result is presented as percentage infection i.e. calculated as number of plants showing clubs/total number of plant x 100.

3. Results

Table 1 shows the results for the years 1987-1989 of soiltests by Svalöf AB for presence of clubroot. Samples were taken from fields which were intended to be sown with oilseed rape. Clubroot was found in 17% of the soil samples originating from the official oilseed rape trial locations (Figure 1). The fungus was found in 16 of the 20 counties where samples were taken.

The frequency distribution of soil samples for degree of infection by the fungus is given in table 2.

The degree of infection ranged from zero to 100%. The 228 soil samples from the official trial locations had an average infection of 6%.

4. Discussion and Conclusion

The results indicate the widespread incidence of P. brassicae in field soils in Sweden.

It should be pointed out that, by using the very susceptible chinese cabbage as the testplant, the detection of very low levels of infection in the soil is possible. This gives a picture of a higher infection rate than would be the case if oilseed rape was used as testplants or than would occur under field conditions growing oilseed rape.

For the purpose of diagnosis of the field soils it is felt however that a very susceptible testplant should be used. The infection rate could be used by the farmer to plan his crop rotation.

With regard to the frequency of occurrence, the 228 samples from the official oilseed rape trial locations are likely to best represent the conditions in the oilseed rape growing regions of the country.

Table 1. Results of soil tests for presence of clubroot. Samples were collected in fields to be used for oilseed rape cropping, Sweden, 1987-1989.

County of	Soil samples from official trial locations: No.of tests	Soil samples from official trial locations: No.of positive	Soil samples mainly from oil seed growers: No.of tests	Soil samples mainly from oil seed growers: No.of positive	Total no.of samples	No.of samples with clubroot	Hectareage of oilseed rape 1989
B Stockholm	9	1	5	3	14	4	7890
C Uppsala	13	1	2	0	15	1	11379
D Södermanland	15	2	1	0	16	2	10556
E Östergötland	23	7	5	1	28	8	20763
F Jönköping	-	-	2	1	2	1	886
G Kronoberg	2	0	-	-	2	0	807
H Kalmar	4	0	-	-	4	0	5125
I Gotland	3	1	1	0	4	1	8462
K Blekinge	-	-	1	0	1	0	1958
L Kristianstad	30	6	11	7	41	13	12788
M Malmöhus	80	12	45	24	125	36	41416
N Halland	4	2	43	32	47	34	4012
O Göteborg & Bohus	2	0	6	5	8	5	1261
P Älvsborg	6	1	13	11	19	12	5668
R Skaraborg	12	3	6	4	18	7	17115
S Värmland	5	0	5	3	10	3	3198
T Örebro	5	1	15	3	20	4	5280
U Västmanland	8	0	7	3	15	3	7975
W Kopparberg	4	1	-	-	4	1	1962
X Gävleborg	2	0	-	-	2	0	956
B-X	228	38 (17%)	167	97 (58%)	395	135	169457

Table 2. Frequency distribution of soil samples for degree of infection by Plasmodiophora brassicae, Sweden, 1987-1989.

	Degree of infection, %											
0	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total no.	$\bar{x}$
Soil samples from official trial locations County B-X												
190	12	7	3	2	2	0	4	4	3	3	228	6%
Soil samples mainly from oilseed growers County B-X												
70	38	18	9	7	1	5	1	3	5	10	167	17%
Total no. of samples County B-X												
260	50	25	12	9	3	5	5	7	8	13	395	11%

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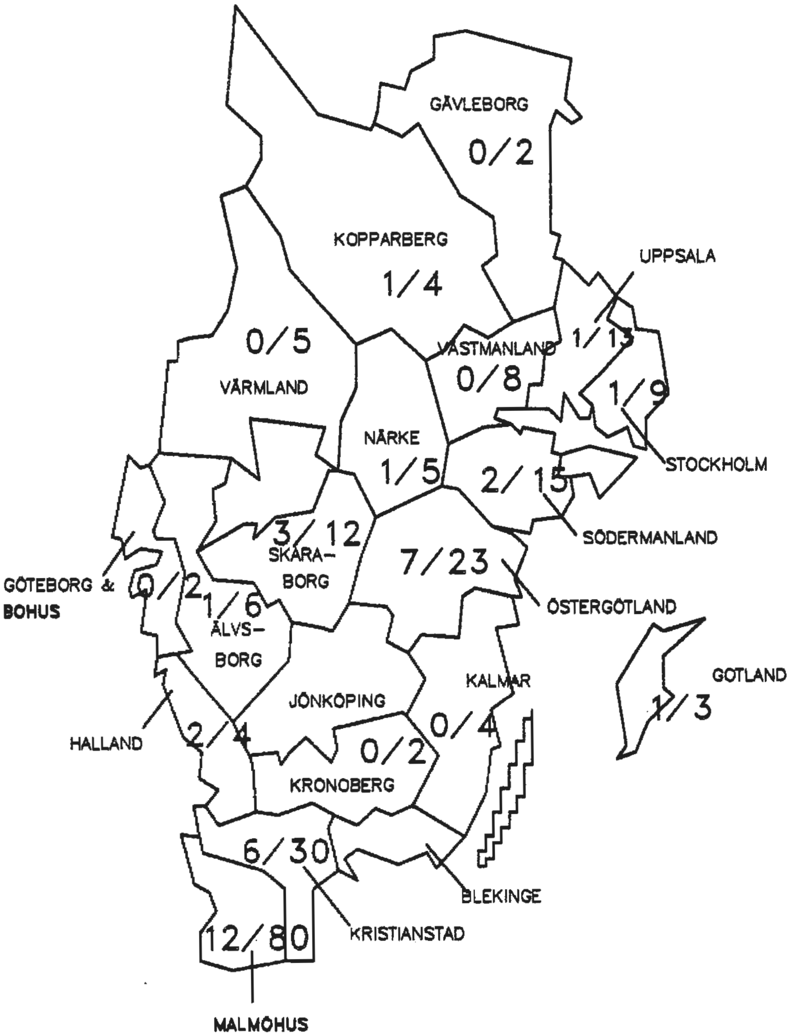

Fig. 1. Presence of clubroot in soil samples from official oilseed rape trial locations 1987 – 1989, Sweden.

No. infected soil samples/Total no. soil samples

THE SPECTRUM AND SEVERITY OF FUNGAL DISEASES IN FIELD INFECTIONS OF WINTER OILSEED RAPE IN POLAND. A REVIEW OF THE 1980s

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Summary

A survey of the occurrence, spread and intensity of winter oilseed rape fungal diseases in Poland over the last decade points out the potential economic importance of such pathogens as *Phoma lingam*, *Sclerotinia sclerotiorum*, *Alternaria* spp. and *Botrytis cinerea*. The economic significance of *Peronospora parasitica* and *Erysiphae* spp. infection of winter oilseed rape has not been sufficiently proved so far, although high level of pathogen attacks are rather common. For the last three years an increasing infection with *Cylindrosporium concentricum* and, to a certain extent, with *Pseudocercosporella capsellae* has become evident. Some other fungi, such as *Verticillium* spp., *Rhizoctonia solani* and *Fusarium* spp., were repeatedly isolated locally, mostly from small areas. Only one case of infection with *Plasmodiophora brassicae* was identified.

1. Introduction

For the last 30 years the area under oilseed rape in Poland has increased continuously, recently attaining about 500.000 hectares, which represents a fivefold increase in comparison to the 1960s (Table 1., data from the Statistic Annual of 1988).

Table 1. Oilseed rape sowing areas ($\times 10^3$ ha), crop production ($\times 10^3$ T), yield (q per ha) in Poland 1960 - 1987 (Annual Statistics, 1988).

	1960	1970	1980	1985	1987
Sowing area	107	298	320	467	499
Crop production		557	637	1073	1186
Crop yield		18.3	19.5	23.0	23.8

The main production crops are cultivated in the north-western and south-western parts of Poland. The range of commercial cultivars grown in the last decade has continously changed. In the 1980s the most significant changes were firstly the introduction of the cultivar Jet Neuf, more resistant to *Phoma lingam/Leptosphaeria maculans*, which replaced the previously grown cultivars Quinta or Primor and then a steadily increasing proportion of low-erucic and low-glucosinolate ("double low") cultivars, such as Jantar, Ceres, Liporta and Bolko. A dramatic change in this direction took place in 1989 when almost exclusively double-low cultivars with the domination of Bolko (about 70% of the area) were grown as production oilseed rape crops. An exception was one traditional cultivar Skrzeszowicki, the cultivation of which has been preserved in the north-eastern area of Poland (Suwałki region).

Detailed studies on the occurrence of fungal diseases of oilseed rape were started in the beginning of the 1980s and are under way now. Our attention has been focused first of all on the economic importance of some of the diseases which have already become evident, or may be predicted, as an increasing problem in the near future.

2. Material and methods

Three to four observations of plants on production fields or trial crops have been conducted during each vegetation season beginning in autumn. The degree of infection was determined by the percentage of diseased plants, in at least 100 randomly chosen plants, assessed on a 6-degree scale (Frencel *et al*. 1985a, 1985b).

3. Results and Discussion

The first findings and results of the studies, as well as their continuation, made it possible to establish the range of main pathogens causing fungal diseases and to identify the most frequent, most widespread and potentially harmful. As a consequence, further studies have dealt particularly with the pathogens *Phoma lingam*, *Sclerotinia sclerotiorum*, *Alternaria* spp. and *Botrytis cinerea*, as well as research problems of the diseases caused by them.

Phoma lingam is quite common on rape in Poland in all regions were it is cultivated, although greater severity is usually noted in the regions of intensive culture (Frencel *et al*., 1985a). Symptoms are most frequently seen on the stem. The disease symptoms are first visible in spring, gradually becoming more severe along the stem during vegetative growth. It should be noted that clearly visible infection in the form of spots on rosette leaves in the autumn were usually not observed, unlike the experience in West European countries (observations of one of the present authors). Differences in the degree of the susceptibility or resistance to fungal diseases in some commercial cultivars and breeding lines were detected and some of these were statistically significant.

The relative harmfulness of stem rot (*Sclerotinia sclerotiorum*), dark leaf and pod spot (*Alternaria* spp.) and grey mould (*Botrytis cinerea*) varied in different years depending on local conditions and weather. An epidemic infection by *Sclerotinia sclerotiorum* was observed in a field where oilseed rape (cultivar Jet Neuf) was sown immediately after previous pulse crops (peas in a mixture). A smaller or larger intensity of dark leaf and pod spot was usually encountered during the later period of vegetation; locally, rape crops sometimes had 50% or more plants infected In spring a relatively severe infection of grey molud, infecting over 20-50% of plants in crops, often occurred and there are signs of such infection levels also in 1990.

The occurrence of downy mildew (*Peronospora parasitica*) in spring is rather common. The leaf infection level and the percentage of diseased plants differs from year to year, depending on the weather conditions. The harmfulness of the disease has not been clearly proved so far.

Infection with powdery mildew (*Erysiphae* spp.) is usually seen on maturing plants; the percentage of diseased plants was sometimes as high as 50 to 75.

Since 1987 there has been an increasingly frequent occurrence of *Cylindrosporium concentricum*. This disease began to appear first in the north-western region of Poland and seems to have spread towards the north east. The frequency of the disease incidents and the infection intensity seems to have increased from year to year. The disease severity, however, is much greater in the localities of its primary occurrence, than in the north-central part of Poland (Żuławy, Gdańsk and Elblag regions), uwhere only single incidents of the disease, causing a small degree of the infection, were observed.

White leaf spot and grey stem (*Pseudocercosporella capsellae*) was found firstly in 1987 and disease incidents were observed also in the last growing season. In both mentioned years the mean level of fungal disease infections of *Brassica napus* was rather high.

Verticillium stem disease (*Verticillium* spp.) has not been widespread in Polish oilseed rape crops so far, although this pathogen was sporadically isolated from single plants. It was notable that infection of rape roots by *Plasmodiophora brassicae* was identified only in a single case on a crop in south-western Poland. In addition to this, species of *Fusarium* and *Rhizoctonia* were also isolated from the roots.

In summary it should be mentioned that production crops of oilseed rape in Poland have not been covered so far by a detailed registration of diseases with regard to chemical protection. It is known, however, that some farmers follow the recommendations of the Institute of Plant Protection in this respect and sometimes apply one spray of the fungicides Ronilan (vinclosolin), Sportak (prochloraz) or Sumilex (procymidione) at the final stage of flowering.

4 Conclusions

On the basis of the survey and review of the occurrence of fungal diseases of oilseed rape in Poland it seems evident that there are the same trends in their spread as in other countries of continental Europe. It may be suggested that there is a clear relation between disease severity and intensity of crop cultivation - the size of area under oilseed rape and the frequency of rape rotation.

It is difficult to say whether current views on the phytopathology of oilseed rape concerning the relative economic importance of problems arising from plant diseases will change in future under the influence of large scale production of double-low cultivars. It seems certain, however, that breeding programmes aimed at increasing plant resistance are not only justified, but also are highly promising.

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SPREAD OF RINGSPOT (MYCOSPHAERELLA BRASSICICOLA [DUBY] LINDAU) BETWEEN OILSEED RAPE AND OTHER BRASSICA CROPS IN SCHLESWIG-HOLSTEIN (GERMANY)

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Summary

Since 1985 ringspot, caused by Mycosphaerella brassicicola, has occured regularely on oilseed rape and cole crops in Schleswig-Holstein and has led to severe losses in yield of cabbage. It became evident that oilseed rape, which has been introduced into the cabbage growing area since about 1980, is very important for the epidemiology of the fungus in this region. Cabbage is grown from May to October and bridges the gap in the growing season of oilseed rape (late August to July of the following year), so the pathogen is able to build up a high inoculum potential on host crops all the year round. Its epidemic is polycyclic and needs four to five infection periods (two to four days continuous leaf wetness at 5 to 20 ^{o}C, optimum between 15 and 20 ^{o}C). By prolongating the period over which the fungus can infect oilseed rape supports the development of epidemics, because M. brassicicola has more opportunities to infect, if the wheather is favourable.

1. Introduction

Mycosphaerella brassicicola, the cause of ringspot of crucifers was first observed on oilseed rape in Schleswig-Holstein in 1985 (Crüger, 1986). Schleswig-Holstein is the northmost region of the Federal Republic of Germany. It is situated between the North Sea and the Baltic Sea. A part of the west coast is a traditional cabbage growing area (3000 hectares) which was well separated from oilseed rape growing areas before 1980. Since the introduction of the 00-cultivars of oilseed rape this crop has been grown increasingly in the cabbage growing area and often in neighbourhood of cabbage fields. In 1985 a severe epidemic of the disease occured on cabbage and other cole crops (Rudnick, 1986), followed by a second in 1987.

Vanterpool first described ringspot of oilseed rape in 1960 though it has been well known as a disease of cole crops since the beginning of the last century (Chevallier, 1826). Hosts are chiefly Brassica species; only a few records exist from other genera (Dingley, 1969; Zornbach, 1990). The disease is spread worldwide over coastal regions, where long periods of high humidity and temperatures below 20 ^{O}C are prevalent and cruciferous crops are grown all the year round (Anon., 1981).

In this study field experiments investigated whether the neighbouring cultivation of oilseed rape and cabbage in Schleswig-Holstein had an influence on the epidemiology of M. brassicicola.

2. The Symptoms

All green parts of oilseed rape were capable of being infected, but leaves and pods were mainly affected. Typical ringspots on the leaves were round to oval, brown to greyisch brown and had a diameter of one to three centimetres. Alternating low and high densities of fruiting bodies (spermogonia and pseudothecia) caused light and dark zones on the spot, hence the name of the disease. These symptoms occured from mid of October to the beginning of June and were often associated with yellowing of the leaves and early leaf fall. During winter irregular, dark brown to black spots with a diameter of three to five millimetres were often found. They were numerous after periods when the leaves were wet and the temperatures remained above 5 ^{O}C for more than a week.

Similar symptoms were found on the pods, while they remained green, but when pods matured (EC 80) the colour of the spots turned to grey and fruiting bodies developed on them like on the leafspots.

3. Materials and Methods

A field experiment to determine the influence of oilseed rape on disease incidence in white cabbage was carried out at Braunschweig. Four plots, each with five cultivars of oilseed rape ('Doral', 'Jet Neuf', 'Ceres', 'Liporta', 'Lirabon') were sown in alternating rows in a field with an area of 1000 m^2 in late August 1987. Plots A, B and D (Fig. 1) were inoculated when the seedlings had two to three leaves (EC 15/EC 17); C was not inoculated. Plot a was inoculated with infected leaf material from white cabbage (30 g/m^2 dried and pulverized leaves), plot B with the same amount of infected oilseed rape pods and D with mycelium of M. brassicicola (one 30 day-old PDA culture without fruiting bodies per m^2), which was dug into the upper layer of the soil between the seedlings. The oilseed rape was assessed on 11 November by estimating the percentage leaf area infected.

On 23 May of the following year the space between the four oilseed rape plots was planted with three highly susceptible cultivars of white cabbage ('Lennox', 'Octoking', 'Tam Tam') in alternate rows. The incidence of infected plants was recorded until the end of July.

4. Results

Twenty days after inoculation all cultivars of oilseed rape showed the first symptoms as small light brown circular spots. The results of assessments on 11 November are shown in Table 1. Data from plot D are omitted because poor soil conditions in this area led to reduced growth of the oilseed rape. The disease severity in cultivar Doral was significantly lower than in the cultivars Jet Neuf, Liporta and Lirabon.

Tab. 1 Percent leaf area of oilseed rape infected on 11 November 1988 after inoculation with Mycosphaerella brassicicola on cabbage leaves (A), on oilseed rape pods (B) and not inoculated (C)

	Oilseed rape plots		
Cultivar	**A**	**B**	**C**
Doral (0) [1]	15 b	1 a	0.1 a
Jet Neuf (0)	25 a	2 a	0.02 a
Ceres (00)	19 ab	2 a	0.1 a
Liporta (00)	22 a	1 a	0.1 a
Lirabon (00)	22 a	2 a	0.1 a

P = 0.05, Ryan-Einot-Gabriel-Welsh Multiple F-Test
Means with the same letter within the columns are not significantly different.
1) 0 = cultivar with low erucid acid; 00 = cultivar with low erucid acid and a poor content of glucosinolates ('dubble low')

The first Symptoms on white cabbage were visible on 16 June 1988 near plot A. The situation on 19 July is shown in Fig. 1. All infected plants were recorded near and to the southeast of the oilseed rape plots A, B, and C. Seventy-five infected cabbage plants were recorded near plot A, twenty near B and thirteen near C.

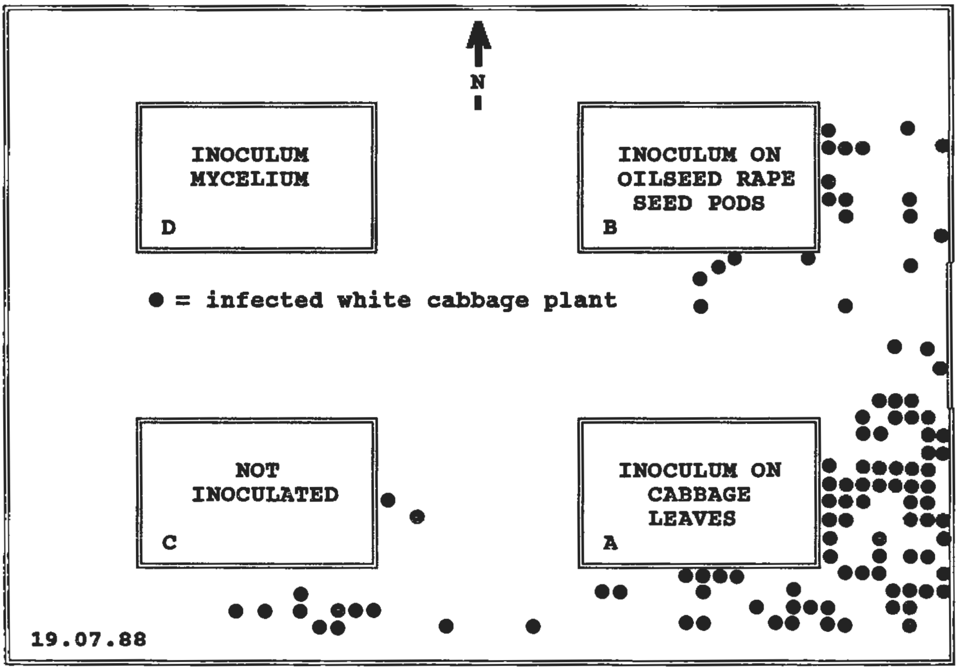

Fig. 1 Location of cabbage plants infected with Mycosphaerella brassicicola on 19 July 1988 near inoculated oilseed rape plots A, B, C and D

5. Discussion

The outbreak of ringspot in 1985 was thought to be due to the humid weather conditions in that year and to the frequency of neighbouring fields of oilseed rape and cabbage in the cabbage growing areas of Schleswig-Holstein. The experiment showed the close relationship between the incidence of ringspot in oilseed rape and in cabbage. Infected cabbage fields provide the inoculum for oilseed rape sown in late summer and similarly infected oilseed rape is the source of infection for cabbage in the following year.

All the cultivars of oilseed rape tested were susceptible to the disease; 'Doral' showed a slightly lower disease severity than other cultivars, but the difference was not sufficient to be interesting for breeding. The infected pods used as inoculum for plot B seemed to have a much lower inoculum potential than the cabbage inoculum since disease severity was much less in plot B. The few ringspots found in plot C were possibly due to ascospores blown towards this plot from the inoculated areas. The prevailing wind north westerly during the infection period obviously accounts for the infection mainly found to south east of the plots (Fig. 1).

Yield losses of oilseed rape caused by the disease in this experiment were not recorded, but losses up to 15 % are known from a few other experiments (Krostitz, 1988).

The increase in inoculum potential in the western area of Schleswig-Holstein is obviously not the only reason for the epidemic of ringspot in 1985 and 1987; such epidemics develop polycyclicly (Frinking & Geerds, 1987; Zornbach, 1990). They need four to five infection periods during one growing season (two to four days leaf wetness, temperatures between 5 to 20 ^{o}C; the optimum temperature is between 15 and 20 ^{o}C) until the inoculum potential is sufficient to lead to an epidemic. If only cabbage is grown, the fungus can infect in the period May to November, but if cabbage and oilseed rape are cultivated together in one area hosts are available all the year round. Thus, it is able to utilise every period of favourable weather conditions for infections.

6. Conclusion

Ringspot of Brassica crops is only one example of problems which may arise if oilseed rape and cole crops are grown together in the same region. The overlapping growing seasons of cabbage (May to November) and oilseed rape (August to July) in Schleswig-Holstein support the accumulation of pathogens and pests in the growing area. Humpherson-Jones (1984) and Wheatley & Finch (1984) mentioned other pathogens, like Alternaria brassicae and Phoma lingam, and pests, such as Delia radicum, Brevicoryne brassicae and Meligethes spp., which became more evident in cruciferous vegetables in England and Wales when oilseed rape was grown nearby. The aim of the growers, to avoid epidemics like those descibed in Schleswig-Holstein, should be to separate vegetable and oilseed rape growing areas.

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OCCURRENCE OF FERTILE APOTHECIA AND THE EPIDEMIOLOGY OF *PYRENOPEZIZA BRASSICAE* SUTTON & RAWLINSON (ANAMORPH: *CYLINDROSPORIUM CONCENTRICUM* GREV.) IN THE GERMAN DEMOCRATIC REPUBLIC

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Summary

Infection by *Pyrenopeziza brassicae* Sutton & Rawlinson begins in autumn and can cause severe damage in mild winters, but symptoms are not usually seen until spring on leaves and later on stems. Fertile ascocarps were found in the mild winter of 1988 on oilseed rape stubble and on debris on soil and later in summer on dead leaf petioles near or on the soil surface. It is probable that the development of fertile ascocarps is necessary for survival and spread of the fungus.

1. Introduction

The Edinburgh botanist Robert Kaye Greville (1794-1866), who trained in medicine (Hawksworth, Sutton & Ainsworth, 1983), first described the type species *Cylindrosporium concentricum*, in the new genus *Cylindrosporium* parasitic on cabbage, in the Scottish Cryptogamic Flora of 1823.

First records of the teleomorph, reviewed by Rawlinson, Sutton & Muthyalu (1978), described sclerotia-like structures which were primordia of ascocarps. Staunton & Kavanagh (1966) claimed the first record of naturally occurring fertile apothecia on Brussels sprouts in Ireland, but did not formally describe the teleomorph. Rawlinson, Sutton & Muthyalu (1978) provided the first formal description from apothecia formed in culture and validated the teleomorph as *Pyrenopeziza brassicae* Sutton & Rawlinson sp.nov. and later Ilott, Ingram & Rawlinson (1984) demonstrated that the fungus was heterothallic with two mating types.

Lacey, Rawlinson & McCartney (1987) made the first discovery of fertile apothecia under natural conditions in England on fallen, decaying leaf debris of oilseed rape; apothecia were found on leaf debris from April to August and on stubble in September and October.

2. Results and Discussion

We now report the first record in the German Democratic Republic (GDR) of the sexual stage of *P.brassicae*. Fertile apothecia were found on oilseed rape stubble and debris in January and February of the mild winter 1988, and later in July on dead leaf petioles on or near the soil surface. The apothecia had a diameter of *c*.0.3mm, similar in size to the larger apothecia recorded by Lacey *et al*.(1987), but still extremely small objects to detect by the unaided eye. The difficulty of detection was increased by the drying and shrinkage under natural conditions of both debris and apothecia. This difficulty makes it possible that apothecia occur in most months of the year, but have been overlooked.

Light leaf spot was regarded as an unimportant disease of vegetable brassicas prior to 1974. Since then it has occurred regularly on winter oilseed rape crops in England and Scotland, often with severe attacks following mild winters, and also in France since 1983 (Rawlinson, 1988). During this latter period, symptoms of the disease were seen in Mecklenberg in the northern part of the GDR, but the symptoms were misinterpreted until 1977 when Amelung & Daebeler (1989) demonstrated their causal link with *C. concentricum*. Now the disease occurs regularly and is distributed widely in both East and West Germany with severity varying with location. Normally, symptoms of the disease are rarely seen in autumn, but become apparent in spring after mild winter weather and damage can be severe when followed by frost (Table 1) or when plants are stressed by herbicides. Wet weather increases the incidence and severity of disease which begins on lower leaves where symptoms are usually most severe (Tables 2 and 3). Conidia are splashed by rain and dispersed in wind-borne droplets from infected plants. Under the weather conditions prevailing in the GDR the disease is seldom recorded on pods. Cultivars differ in their susceptibility to the disease (Table 2).

Table 1. Disease on oilseed rape caused by *Cylindrosporium concentricum* in relation to frost damage, at Bandelstorf, 1988.

Cultivar	12 February 1988		24 March 1988
	% plants diseased	%leaf area damaged	% frost damage
BNW 163	70.0	5.6	25.7
Ceres	92.0	18.0	40.0
Cobra	100.0	20.0	46.7

Over the past decade light leaf spot has spread widely and, with the discovery of its sexual stage, it now seems possible that spread by wind-born ascospores could be the main method of initiating epidemics in autumn (McCartney & Lacey, 1990), similar in this respect to *Leptosphaeria maculans* (Desm.) Ces. & de Not. Other methods of transmission are possible because conidia can survive for at least 10 months on dried debris and for up to two months on seed (Maddock & Ingram, 1981), although the latter route is not likely to be significant since seed is often held for a year in storage before sowing. Infected volunteer rape plants on roadsides are also a likely means of allowing the fungus to perennate and spread.

Table 2. Incidence and distribution of *Cylindrosporium concentricum*-infected leaves on oilseed rape plants of cv.BNW 163(I), Ceres (II) and Cobra (III) at Bandelstorf 1988. (Assessed on 3 June 1988 at end of flowering, GS 69, n= 60 plants for I, 15 each for II and III)

Leaf position*	% leaves infected**			Mean % leaf area infected					
				per leaf			per diseased leaf		
	I	II	III	I	II	III	I	II	III
1	23.3	40.0	85.7	0.8	2.7	12.9	3.3	6.7	15.0
2	18.3	40.0	85.7	0.7	2.8	12.9	4.0	7.0	15.1
3	21.7	30.0	78.6	0.6	1.7	11.1	2.9	5.0	14.1
4	5.0	13.3	78.6	0.1	0.4	10.5	2.3	3.0	13.4
5	8.5	26.7	50.0	0.2	0.8	5.7	2.6	3.0	11.4
6	3.7	20.0	57.1	0.1	0.7	2.7	1.0	3.7	4.8
7	4.5	15.4	35.7	0.1	0.9	2.2	2.0	1.0	6.2
8	0	11.1	25.0	0	0.9	0.9	0	1.0	3.7
9	0	14.3	0	0	0.1	0	0	1.0	0
10	0	----	0	0	---	0	0	---	0
11	0	----	----	0	---	----	0	---	----
12	0	----	----	0	---	----	0	---	----
Mean	7.1	23.4	49.6	0.2	1.1	5.9	1.6	3.5	8.4

* 1 to 12 = lowest to topmost leaf
** An earlier assessment on 12 February 1988 gave mean values of 5.6, 18.0 and 20.0% leaves infected for I, II and III respectively.

Table 3. Incidence and distribution of *Cylindrosporium concentricum*-infected leaves on plants of cv.Ceres at Biestow, 7 April 1990. (assessed at bud stage, GS 57, n = 10)

Leaf position*	Total No. healthy leaves	% infected leaves**	Mean % leaf area infected	
			per leaf	per infected leaf
1	10	70.0	20.5	29.3
2	10	90.0	20.8	23.1
3	10	70.0	17.6	25.1
4	10	80.0	8.7	10.2
5	10	60.0	6.7	11.2
6	10	40.0	4.1	10.3
7	10	30.0	2.2	7.3
8	10	20.0	1.5	7.5
9	10	40.0	1.2	3.0
10	10	20.0	1.1	5.5
11	9	11.1	0.1	1.0
12	9	22.2	0.2	2.0
13	8	12.5	1.3	3.0
14	4	0	0	0
15	3	0	0	0
16	2	0	0	0
Mean	8.4	35.4	5.4	9.3

* 1 to 16 = lowest to topmost leaf.
** An earlier assessment on 16 March 1990 indicated that < 1% of leaves were infected.

Another potential source of inoculum aiding the spread of disease is infected weeds. Rudnick & Ahlers (1989) extended the work of Maddock & Ingram (1981) on weed species and report *C.concentricum* infection on *Anthemis arvensis* L., *Capsella bursa-pastoris* (L.) Med., *Galeopsis tetrahit* L., *Circium arvense* (L.) Scop. and species of *Anchusa* These records would be most significant, if substantiated, because they constitute the first report of infection on species other than *Brassicae*. The fungus is normally regarded as a specialised pathogen of *Brassicae*. Maddock & Ingram (1981) were not even able to infect the closely related crucifer *C.bursa-pastoris*. These records on species of the *Boraginaceae*, *Compositae* and *Labiatae* need to be authenticated and confirmed because of their possible impact on the epidemiology, spread and control of the disease.

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INFLUENCE OF WEEDS ON THE INFECTION OF WINTER OILSEED RAPE (*BRASSICA NAPUS* L. VAR. *OLEIFERA* METZGER) WITH FUNGAL PATHOGENS

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Summary

Weeds attacked by *Botrytis cinerea*, *Sclerotinia sclerotiorum* and *Verticillium dahliae* were found in 18 rape fields in 1988. Five of the 30 occurring weed species were infected by *Sclerotinia sclerotiorum*. The rape was more heavily attacked and contained larger sclerotia of the fungus than the weeds.

Rape, barley and eight weed species were infected with *Sclerotinia sclerotiorum* in the greenhouse. *Myosotis arvensis*, *Lamium purpureum*, *Galium aparine*, *Matricaria inodora* and *Capsella bursa-pastoris* were more susceptible than the rape.

The same plant species were infected with *Verticillium dahliae* in the greenhouse. The rape plants, but no weeds were killed by the fungus. *Verticillium dahliae* could be reisolated from all species.

The attack of the rape by fungi and pests was assessed in a field with different drilling dates, different rape densities and different densities of volunteer barley. Late drilling decreased the damage due to fungi, insects and frost and increased yield. An increasing rape density decreased insect and frost damage, but did not affect rape pathogens. An increasing density of volunteer barley resulted in a decrease in the damage due to pathogens and pests and a decrease in yield.

1. Introduction

Weeds can be hosts of rape pathogenic fungi (Saur & Löcher, 1984; Skadow, 1969); and weeds can influence the microclimate in the field, thereby favouring pathogens (Saur & Löcher, 1984). This raises the question whether weeds have an influence on the infection of rape with pathogenic fungi. Such an effect might be important with regard to economic thresholds in weed control in rape (Heitefuß, 1986).

The important rape pathogens in Germany and their host ranges are:

Species	host plants
Sclerotinia sclerotiorum (Lib.) de Bary	very broad host range
Phoma lingam (Tode ex Fr.) Desm.	Brassicaceae
Verticillium dahliae Kleb.	very broad host range
Alternaria brassicae (Berk.) Sacc.	Brassicaceae
Alternaria brassicicola (Schw.) Wiltsh.	Brassicaceae
Cylindrosporium concentricum Grev.	Brassica
Botrytis cinerea Pers. ex Pers.	very broad host range

The present work concentrated on *Sclerotinia sclerotiorum* and *Verticillium dahliae*, two economically important fungi able to infect many weed species.

2. Infection of rape and weeds by *Sclerotinia sclerotiorum* in the field

The investigations were carried out in 18 rape fields in Germany in 1988, when spring weather was too dry to allow a heavy attack by *S. sclerotiorum*. Symptoms of a *Botrytis cinerea*-attack could be found on *Galium aparine* L., *Lamium purpureum* L. and *Myosotis arvensis* (L.) Hill. in a field where 10% of the rape plants were damaged by the fungus.

In a field where the rape was strongly infected by *V. dahliae*, disease symptoms and microsclerotia of the fungus could be found on *Matricaria chamomilla* L. as well.

In 8 fields where the rape was attacked by *S. sclerotiorum*, the following weeds were also attacked: *Anthriscus sylvestris* (L.) Hoffm., *Capsella bursa-pastoris* (L.) Med., *Cirsium arvense* (L.) Scop. and *Galium aparine*. Sclerotia could be found in the stems of *C. bursa-pastoris* and *C. arvense*.

In one of these fields *Stellaria media* (L.) Vill. and *Viola arvensis* Murray were the most frequent weeds. Neither species was attacked by the fungus, but sclerotia were found in dead stems of *Matricaria chamomilla*.

In another field, sclerotia of *S. sclerotiorum* were present in stems of *C. bursa-pastoris* and *Matricaria inodora* L.. The sclerotia were smaller in the weeds than in the rape, their mean weight being 8 mg in *C. bursa-pastoris*, 41 mg in *M. inodora* and 57 mg in the rape. The reason for this difference in size is obvious: sclerotia are formed in the stems, and the rape has a larger stem diameter than the weeds. Small sclerotia form fewer apothecia (Krüger, 1975), have a lower content of reserve substances and are more easily destroyed by soil organisms than large sclerotia (Hoes & Huang, 1975).

These results indicate that the attack of weeds by *S. sclerotiorum* may not be a very important source of infection for the rape, and that infected weeds are unlikely to significantly increase the number of sclerotia in the soil. Before drawing final conclusions, however further investigations are necessary which should be carried out in years when the weather is more favourable to the fungus than in 1988.

3. Artificial inoculation of rape and weeds with *Sclerotinia sclerotiorum* and *Verticillium dahliae* in the greenhouse

These experiments were carried out to reveal whether rape and weed species differ in their susceptibility to the fungi. The following species were infected: *Brassica napus* L. var. *oleifera* Metzger, 00-variety Lirabon (winter oilseed rape); *C. bursa-pastoris*; *G. aparine*; *Hordeum vulgare* L., variety Ermo (winter barley); *L. purpureum*, *M. inodora*, *M. arvensis* , *Poa annua* L., *S. media* and *V. arvensis*. Barley was included because volunteer barley frequently occurs in rape in Germany.

Twenty plants of each species were infected at the age of four weeks with mycelium of a rape-isolate of *Sclerotinia sclerotiorum*.They were then kept in the greenhouse under conditions favouring the fungus.

The rape was less susceptible than *M. arvensis*, *L. purpureum*, *G. aparine*, *M. inodora* and *C. bursa-pastoris*. Barley and *S. media* were slightly, *P. annua* and *V. arvensis* were not susceptible.

Twenty to twenty-eight plants of each species were infected at the age of 5 to 14 days with a rape-isolate of *V. dahliae* and kept in the greenhouse at 18°C. Disease symptoms occurred only on the rape and *L. purpureum*. All rape plants, but no weeds were killed by the fungus. Even *L. purpureum* could flower and set seeds.

V. dahliae could be reisolated from all species. The isolation frequency was much higher from the rape than from the weeds. Latent infections of weeds by this fungus in the greenhouse and in the field have also been found by other authors (Skadow, 1969; Vargas-Machuca et al., 1987).

The formation of microsclerotia on weeds in the field can lead to a rise of the propagule number in the soil, but this is certainly negligible compared to the inoculum stemming from infected rape plants. However, the carry-over of the fungus on weeds must be further investigated.

4. Attack of the rape by fungi and pests in a field with different drilling dates, different rape densities and different densities of volunteer barley

The experiment was arranged in a field of winter oilseed rape (00-variety Lirabon) as a split plot with six replicates and a plot size of 18 m^2. The drilling dates were 15.8., 25.8. and 4.9.1987; the rape densities 30, 45 and 60 plants/m^2 and the volunteer barley densities 0, 50 and 150 plants/m^2.

At EC 75 (lower main stem pods normal size) to EC 83 (all pods and seeds fully developed) of the rape the following parameters were assessed:

- Attack by *Botrytis cinerea*, *Cylindrosporium concentricum*, *Phoma lingam* and *Sclerotinia sclerotiorum*
- Lesions and distorsions of the stems due to a late frost and *Ceutorrhynchus napi* Gyllh..

At EC 92 (straw dry), the symptoms caused by *P. lingam*, *S. sclerotiorum*, *C. napi*, *Ceutorrhynchus quadridens* Panz. and *Psylliodes chrysocephala* L. were recorded on the stubble after harvest. *Verticillium dahliae* did not occur in the field.

The damage due to *B. cinerea, P. lingam* at the first assessment and to *S. sclerotiorum* was too low to be interpreted. For the other parameters, disease indices were calculated on the basis of disease incidence and severity. These indices were subjected to an analysis of variance.
From the early to the late drilling date, the damage due to *C. concentricum, P. lingam,* the insects and frost decreased whereas yield increased by about 10 %.
Increasing rape density led to a decrease in the damage due to the insects and frost. *C. concentricum* and *P. lingam* were not significantly influenced by rape density. Yield was highest at the medium rape density.
With increasing density of volunteer barley the damage caused by the pathogens and pests decreased and yield was reduced by about 20 %. The competition between the plants therefore had a stronger impact on yield than the diseases and pests. High densities of volunteer barley thus improved the health of the rape, but reduced yield at the same time.

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SESSION 2

Disease Resistance

RESISTANCE TO *ALTERNARIA BRASSICAE* IN CRUCIFERS

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Summary
The blackspot disease of rapeseed, caused by *Alternaria brassicae*, is economically important in many parts of the world. All commercial cultivars of rapeseed are susceptible to this pathogen. However, cultivars of *Brassica napus* ssp. *oleifera* are less susceptible than those of *B. campestris* ssp. *oleifera*. A number of oleiferous, vegetable and wild crucifers were studied for their reactions to *A. brassicae*. The mechanism of susceptibility/resistance was also studied in some cases. High degrees of resistance were found in *Camelina sativa* (false flax), *Capsella bursa-pastoris* (shepherd's purse) and an accession of *Eruca sativa* (taramira). An accession of *B. campestris* ssp. *rapifera* (turnip) showed intermediate resistance. The host-parasite interaction studies indicated, that resistance to *A. brassicae* in crucifers, is based on the presence of a well developed fluffy layer of epicuticular wax, pathogen becoming subcuticular after penetration, calcium sequestration, sensitivity to the host-specific toxin destruxin B, qualitative and quantitative elicitation of phytoalexins and hypersensitive reaction. It is concluded that the resistance is layered and multicomponent. It should be possible to transfer this resistance to rapeseed, using conventional breeding and biotechnological techniques.

1. Introduction

Alternaria brassicae (Berk). Sacc. is world-wide in distribution and is known to cause the blackspot (leaf, stem or silique spots) disease on various crucifers (Ellis, 1971; Kolte, 1985; Tewari, 1985). Leaf lesions reduce the photosynthetic area and cause accelerated senescence. The pathogen synthesizes abscisic acid (Dahiya *et al.*, 1988) which may be partly responsible for the latter effect. In rapeseed, the siliques themselves produce the assimilates necessary for their own increase in size and weight (Allen *et al.*, 1971). Therefore, silique infections are a major cause of yield loss in the blackspot disease syndrome. Often the pathogen goes through the silique wall and infects the developing seeds directly (Conn *et al.*, 1990). The disease is economically important in many parts of the world. The weather was rainy in the summer of 1989 in Alberta during the silique maturation period (approximately middle of August) of rapeseed. This stimulated *A. brassicae* resulting in extensive blackspot development (Conn and Tewari, 1990). In this cropping year in Alberta the actual yield of rapeseed was 21.3 bushels/acre compared to the expected yield of 25.7 bushels/acre (Mr. P. Thomas, personal communication). It is believed that the reduced yield was due to atleast four different factors i.e. Alternaria blackspot, Sclerotinia stem rot, root maggots and sulphur deficiency. A modest estimate would be that about one-third of the yield reduction was caused by A. brassicae. This translates into a monetary loss of $23,750,000 considering a $6/bushel price of rapeseed and a total area of 2,700,000 acres of rapeseed in Alberta. Yield losses caused by A. brassicae in parts of India are higher.

The author and his associates have been studying the sources of resistance and the mechanism thereof in rapeseed to A. brassicae for the last number of years. This article summarizes the information gathered so far in this ongoing project.

2. Epicuticular Wax on the Host Surface

Many cultivars of rapeseed have a bloom or bluish coloration on their aerial surfaces. This is due to the presence of a crystalline layer of wax which causes selective reflectance of light of certain wavelengths. Cultivars of Brassica napus L. ssp. oleifera have appreciably more epicuticular wax and are less susceptible to A. brassicae than those of B. campestris L. ssp. oleifera (Tewari and Skoropad, 1976; Skoropad and Tewari, 1977; Conn and Tewari, 1989 a, b). The higher quantity of wax in B. napus ssp. oleifera confers lesser susceptibility through a disease escape mechanism. The waxy plant surfaces of B. napus ssp. oleifera are hydrophobic and retain less water-borne inoculum compared to those of B. campestris ssp. oleifera (Tewari and Skoropad, 1976, Conn, 1986). The epicuticular wax forms a fluffy layer enclosing air pockets and perhaps impedes diffusion of foliar exudates to the leaf surface (Conn et al., 1984). This is perhaps the cause of reduced rate of germination and lesser number of germ tubes produced by A. brassicae conidia on B. napus ssp. oleifera leaves compared to those of B. campestris ssp. oleifera (Conn and Tewari, 1989 a). These effects of wax are only physical in nature as isolated and recrystallized wax has no anti-fungal properties (Conn and Tewari, 1989a).

The ultrastructure of wax has been studied in a number of different cultivars of rapeseed (Wortmann, 1965; Whitecross and Armstrong, 1972; Armstrong and Whitecross, 1976; Tewari and Skoropad, 1976; Holloway et al., 1977) including four canola-type cultivars (Conn and Tewari, 1989 b). The wax is organized in three layers. The lower most layer is amorphous and continuous on which are situated flat plate-like crystals and erect filamentous, rod-like (singly or in blocks) and tube-like crystals. The erect crystals impart the fluffy characteristic to rapeseed wax. Baker and Hunt (1986) have shown that part of wax on the leaves of Brassica spp. is subject to erosion by simulated rain.

The chemistry of wax has been studied in B. napus, B. campestris and a few vegetable crucifers (Baker and Holloway, 1975; Holloway and Brown, 1977; Holloway et al., 1977; Flore and Bukovac, 1978, Conn et al., 1984; Conn, 1986). There are nine major constituents of rapeseed wax including alkanes, esters, ketones, aldehydes, secondary alcohols, ketols, primary alcohols, triterpenols and fatty acids. Wax in the cv. Altex of B. napus has four principal constituents including C_{29} alkane, C_{29} ketone, C_{29} secondary alcohol and C_{40-48} esters (Conn, 1986).

3. Subcuticular Growth of the Pathogen after Penetration

Alternaria brassicae becomes subcuticular following direct penetration of the leaves of rapeseed (Tewari, 1986). The subcuticular phases in the cultivars of B. napus ssp. oleifera and B. campestris ssp. oleifera so far studied are short lived and the deeper cell layers are invaded soon after. Subcuticular growth of the pathogen indicates a degree of resistance to invasion in the deeper cell layers and is also common in the scald of barley caused by Rhynchosporium secalis (Oud.) Davis (Jones and Ayres, 1972) and in a number of diseases of fruits (Verhoeff, 1974; Daykin and Millholland, 1984) In the scald of barley, the subcuticular mycelium is thought to cause permeability changes in the underlying cells making more nutrients available to the pathogen (Jones and Ayers, 1972). A similar role is envisaged for the subcuticular hyphae of A. brassicae in rapeseed as well. Search should be made of crucifers in which the subcuticular phase is of prolonged duration.

4. Calcium Sequestration by the Pathogen

A large proportion of calcium in plant tissues is bound to pectins in the cell wall (Demarty et al., 1984). There is considerable evidence that calcium confers resistance to many plant pathogens. The plant pathogens, however, strive to overcome this resistance factor by synthesizing various organic acids, such as oxalic acid, which sequester calcium (Punja and Jenkins, 1984; Havir and Anagnostakis, 1985; Rao and Tewari, 1987). Alternaria brassicae also sequesters calcium during the process of pathogenesis on rapeseed (Tewari, J.P. and Awasthi, R.P., unpublished data). This calcium sequestration can be observed on the leaf surface by scanning electron microscopy in conjunction with energy-dispersive x-ray microanalysis. The anion(s) involved in this sequestration has so far not been characterized. Calcium sequestration by A. brassicae on rapeseed raises some interesting possibilities in disease control. These control measures may include selection for higher calcium-containing lines, application of calcium-containing fertilizers to increase the content of this cation in plant tissues and foliar application of calcium-containing compounds to sequester the anion (organic acid) secreted at the site of infection. The last two possibilities have already proven useful in controlling some other plant diseases (Punja et al., 1986; Rao and Tewari, 1988).

5. Sensitivity to the Host-specific Toxin, destruxin B

Alternaria brassicae has recently been shown to produce the phytotoxin, destruxin B, which is a cyclodepsipeptide, molecular formula $C_{30} H_{51} N_5 O_7$, molecular weight 593 (Ayer and Pena-Rodriguez, 1987; Ayer et al., 1987; Bains and Tewari, 1987). Similar levels of symptoms are caused both by A. brassicae and destruxin B on the hosts of this pathogen. The toxin is able to distinguish differences in susceptibility to A. brassicae even among the cultivars of B. campestris. The non-host plants of A. brassicae are not affected by this toxin. All these facts indicated that destruxin B is a host-specific toxin (Bains and Tewari, 1987). Some other important traits of this system are that this toxin is produced by the germinating spores of A. brassicae and also in the blackspot leaf tissue of rapeseed (Ayer, W.A. and Tewari, J.P., unpublished data). All this information supports the role of destruxin B as a primary determinant of the blackspot disease.

Destruxin B has insecticidal properties as well and is also produced by the entomogenous fungus Metarhizium anisopliae (Metschn.) Sorokin (Gupta et al., 1989 a, b). Thus, this unique toxin is active both against plants and insects.

6. Phytoalexin-elicitation and hypersensitive reaction

The crucifer-phytoalexins are a unique group of compounds and contain sulphur in their molecules. Seven such phytoalexins have so far been fully characterized (Takasugi et al., 1986, 1987, 1988; Devys et al., 1988). Alternaria brassicae is reported to elicit phytoalexins in some crucifers (Tewari et al., 1987, 1988; Conn at al., 1988; Devys at al., 1988). Brassica napus ssp. oleifera and B. campestris ssp. oleifera are both susceptible to A. brassicae and elicit small quantities of a phytoalexin with Rf value similar to that of cyclobrassinin. An accession of B. campestris ssp. rapifera (turnip) is moderately resistant to A. brassicae and elicits relatively large quantity of the above phytoalexin. Camelina sativa (L.) Crantz produces two completely different phytoalexins, one of them being in relatively large quantity. Both these phytoalexins are new compounds and their molecular structures are being currently investigated (Conn, K.L., Tewari, J.P. and Ayer, W.A., unpublished data). Capsella bursa-pastoris (L.) Medik is also highly resistant to A. brassicae and elicits two phytoalexins, one of which is produced in relatively large quantity and has the same Rf value as the minor phytoalexin in C. sativa. The other phytoalexin is produced in relatively small quantity and is similar to cyclobrassinin in Rf value. Therefore, differences in the susceptibility of these plants to A. brassicae may atleast in part be due to qualitative/quantitative elicitation of plytoalexins (Conn et al., 1988). Alternaria brassicae is also known to elicit the phytoalexin, brassilexin, in B. juncea L. (Devys et al., 1988) This pathogen induces hypersensitive reaction in an accession of Eruca sativa Mill (Conn and Tewari, 1986), but any phytoalexin-elicitaton associated with this response has not been studied.

7. Concluding Remarks

A number of mostly sequential factors appear to control resistance to A. brassicae in rapeseed. Therefore, this system is similar to many others where the mechanisms for resistance are known to be layered and multicomponent, (Gottstein and Kuc, 1989). One of these factors confers disease escape capability on the host while the others appear to be of true resistance type. Some factors are dynamically elicited at the time of infection while others are pre-formed. The genetics of this host-parasite interaction should be studied. There is some evidence that strain variation exists in A. brassicae (Tewari, J.P. and Awasthi, R.P., unpublished data) but it is not known at this time if discrete races exist in this pathogen. Resistance to A. brassicae is located in crucifers both closely and distantly related to rapeseed and should be transferable to rapeseed by biotechnological techniques and routine breeding.

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METHODS FOR TESTING THE SUSCEPTIBILITY OF OILSEED RAPE TO *ALTERNARIA BRASSICAE* AND *A. BRASSICICOLA*

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Summary
Alternaria brassicae is the main cause of the black spot disease which attacks stem, leaves and pods of oilseed rape; *Alternaria brassicicola* also occurs but is much less common. *A. brassicae* usually causes concentric (ring) spots which are less pronounced if caused by the other fungus. As *in vitro* sporulation of *A. brassicae* is usually sparse, a method was developed to obtain a sufficiently large number of conidia for the inoculation of a large number of rape plants. The susceptibility of oilseed rape to *A. brassicae* and *A. brassicicola* was tested in the laboratory using seedlings, leaf discs and detached pods. We have yet to compare the laboratory data with susceptibility data obtained in the field under natural conditions.

1. Introduction

Different species of *Alternaria* infect seedlings, leaves, pods and stems of oilseed rape and usually cause black, sunken spots. Tewari (1985) conducted intense histological studies of individual phases of the pathogenesis of *A. brassicae* and Singh (1980) studied the cultivation of *A. brassicae* on artificial media. Due to the low spore production on artificial media (Köhle and Hoffmann, 1988) it has been impossible to carry out large-scale spore inoculation using *A. brassicae* so we investigated methods to overcome this problem.

2. Material and Methods

Fungus cultures

A. brassicae was isolated on the usual media (e.g. yeast-glucose-antibiotics medium) from infected stems and pods of plants from Southern Germany after sterilisation of the surface with 0.5 % NaOCl followed by 70% ethanol. Monospore lines of the pathogen were obtained from the isolates after transfer of individual spores with a glass needle.

Sporulation

The factors light, temperature and contact stimulus (filter paper) were investigated in order to optimize sporulation intensity of *A. brassicae*. The medium PDA (ph 5.5) was used throughout. The plates were inoculated with the monospore lines of *A. brassicae*. Radial growth was measured on every third day over a period of three weeks. In order to determine the sporulation intensity the plates were flooded with 4 ml of water after 21 days and the suspension thus obtained was counted in a Fuchs - Rosenthal chamber. Data were subjected to variance analytical calculus and checked for significant differences. The spore suspensions obtained under the best possible conditions were used for artificial inoculation.

Seedling test

Seedlings of different rape cultivars were raised in plant propagators. When the cotyledons had developed (EC 13) they were sprayed with a spore suspension of *A. brassicae* (4000-6000 spores/ml) using a Sata-colour spray container (1mm nozzle, 1 bar). After inoculation the trays were covered with transparent domes and kept at 25°C/15°C and 8000 Lux/darkness (12h/12h). Air humidity within the propagators reached 99% relative humidity.

Detached leaf test

The first true leaves (EC 15) of young plants raised in propagators were punched in order to obtain leaf discs with a diameter of about 10 mm; discs with main leaf veins were rejected. The leaf pieces were then put on cooling BCM-agar (100 ppm benzimidazole/litre) and sprayed with spores of *A. brassicae* and *A. brassicicola* in the way described above.

Pod test

Following a slightly modified Gieffers-method (Gieffers *et al.*, 1988) we used fully mature, but still green pods from the field and put them into "Gerda" - dishes. Inoculation with spores of *A. brassicae* was carried out after filling the dishes with sterile water up to a height of 0.5 cm. Control pods of the same origin were treated in the same way (25°C, closed top) but not inoculated.

Evaluation

The inoculation tests on seedlings, leaf-discs and pods were evaluated after three to four days with special regard to differences in symptom development.

A. brassicicola produced mainly small, pinhead-sized necrotic spots which only very rarely spread. The number of spots per unit of surface was counted under a stereo magnifier using an inoculating loop as an estimation frame.

The symptoms caused by *A. brassicae* were much more severe consisting of large, concentric necrotic areas which in some cases were covered by the whitish mycelium of the fungus. The disease was evaluated using a scale (1=healthy, 9=completely necrotic) based on the relative extension of diseased tissues (Daebeler & Amelung, 1988).

3. Results

Growth and sporulation

NUV-radiation reduced the radial growth of the mycelium by 10%, but the intensity of sporulation was increased by a factor of 3. The contact stimulus caused a slight inhibition of mycelial growth but also a considerable rise in the rate of sporulation. The lower of the two temperatures tested appeared to be slightly more favourable for sporulation and growth, though the differences were not statistically significant (Table 1).

Table 1: Sporulation and mycelial growth of *A. brassicae* on potato dextrose agar (PDA) in different environmental conditions

Factor	Growth		Spores/dish	
Level	mm	%	no	%
Temperature				
22°C	46 A	121	30800 A	111
25°C	38 B	100	27800 A	100
NUV - Illumination				
12h	40 B	100	42340 A	262
absent	44 A	110	16300 B	100
Contact stimulus				
present	41 B	100	38000 A	190
absent	43 A	105	20600 B	100

A,B: Significance (Duncan 1%)

Artificial infection

Inoculations with both species of fungi gave visible symptoms after two to four days. The leaves and pods responded to inoculation with spores of *A. brassicicola* with pinhead - sized necroses (hypersensitivity reaction) or, in few cases where the infection could spread inside the organ, with larger spots which rarely showed sharply defined edges. With spores of *A. brassicae* the development of the disease was much more rapid and severe. Only artifical inoculations with spores of *A. brassicae* caused the large, concentric necroses of the leaves and pods which are typical of natural infections.

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RESISTANCE TO DOWNY MILDEW IN *BRASSICA NAPUS* SSP. *OLEIFERA*

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Summary

Data are given on the expression of resistance to three isolates of *Peronospora parasitica* at different seedling growth stages in a range of single - and double - low cultivars of winter oilseed rape. There was no significant difference in resistance between the two cultivar types, none of which had a known major gene for resistance to downy mildew. Screening for resistance among a much wider range of germplasm, including both winter and spring types of *Brassica napus* ssp. *oleifera*, has identified five new sources with major gene(s) for resistance to downy mildew at the cotyledon stage and revealed segregation for resistance among some populations. Attempts to establish dual cultures on callus tissue derived from cotyledons and hypocotyls were partially successful. These results are discussed in the context of the potentially underrated status of downy mildew as a disease of oilseed rape in Europe.

1. Introduction

Downy mildew (*Peronospora parasitica* (Pers.) Fr.) is the most frequently recorded disease of winter oilseed rape *Brassica napus* ssp. *oleifera* in the United Kingdom (Evans, *et al*., 1984; Gladders, 1987). Some cultivars are very susceptible at the seedling stage (Anon., 1987, 1988), but the disease is not thought to limit yield except, rarely, when seedlings are killed (Davies, 1986). Consequently, selection and breeding for resistance is not given a high priority at present. By contrast, elsewhere in northern Europe (Sadowski, 1989) and Asia (Kolte, 1985) severe infection can cause regular, significant yield loss. The status of downy mildew in much of Europe may change with the recent introduction and widespread cultivation of new cultivars with a low content of glucosinolates in seed. Some glucosinolate breakdown products are toxic to *P. parasitica* (Greenhalgh & Mitchell, 1976) and to other pathogens of oilseed rape (Mithen *et al*., 1987), so smaller amounts or changed types of glucosinolates in vegetative tissue may favour infection (Rawlinson, *et al*., 1989; Milford *et al*., 1989). Moreover, predictions of climate warming (Parry, Carter & Porter, 1989) and the possibility of milder, wetter winters in Europe would also be likely to favour downy mildew.

These considerations indicate a need for work on downy mildew to be given higher priority, to establish whether the new double-low cultivars (low glucosinolate, low erucic acid) are inherently more prone to infection than the single-low (low erucic acid) cultivars grown hitherto, and to seek sources of resistance for use by plant breeders. Lucas *et al*., (1988) identified the only reported major gene for resistance to downy mildew in the spring rape cultivar Cresor. This paper describes tests on seedlings of single - and double - low cultivars and on a wide range of winter and spring types, using a screening method requiring minimum facilities, which have identified new sources of resistance to downy mildew in *B. napus*.

An attempt to develop a method for the routine culture and preservation of *P. parasitica* on callus tissue is also described.

2. Materials and methods

2.1 Provenance and maintenance of *P. parasitica* isolates

Three isolates of *P. parasitica* were used in this study: R1 was a single spore isolate collected from winter oilseed rape cv. Cobra at Rothamsted Experimental Station; P033 [RO(10)] and P004 [RO(7)] were obtained from N.A. Moss, Institute of Horticultural Research, Wellesbourne, Warwick, UK. The latter two isolates were oospore progeny from isolate R3 collected by J.A. Lucas, Department of Botany, University of Nottingham, Nottingham, UK (Lucas *et al*., 1988). All three isolates were maintained on cv. Ariana.

The pathogen was maintained either; 1. on cotyledons, 2. on callus tissue cultures.

1. Cotyledons were obtained from 6-day old seedlings raised in EFF compost (Nursery Trade - Lea Valley Ltd., UK) in a modified plant propagator (35.5cm x 21.6cm x 18cm) sited in a glasshouse and supplied with continuous, filtered (spore-free) moist air at 18 $\pm$ 2°C through a central flue conducting air from beneath the propagator to exhaust at two adjustable ventilators on the cover, and the junction between the cover and the base (Jenkyn, Hirst & King, 1977), and given supplementary light to maintain a photoperiod of 16h day^{-1}. Cotyledons and a short length of hypocotyl were detached and transferred to folded filter paper (Whatman 12.5cm, 113v) supports in glass jars (8cm diameter, 7cm depth) containing 20ml sterile distilled water. Cotyledons were then inoculated in a sterile air flow with 5μl of conidial suspension on each half-cotyledon using a micropipette. Suspensions were prepared by tapping infected cotyledons to dislodge conidia into sterile distilled water; this minimised bacterial contamination. After inoculating the cotyledons, the glass jars were covered with clear plastic lids, sealed with parafilm and incubated in Saxcil growth cabinets at 16°C with light at 70$\mu EM^{-2}s^{-1}$, 16h day^{-1} for 7 days after which peak sporulation occurred. Using this method, the reculturing interval was normally 7 days, but this could be extended to 21 days at *c*.10°C.

2. Maintenance was attempted using dual cultures on callus tissue derived from cotyledons and hypocotyls initiated on UM - medium (Uchimaya & Murashige, 1974) following a method developed by Ingram (1980).

2.2 Germplasm screening and evaluation

Seedlings were grown in propagators, as described for culture maintenance, except that 5cm 'Jiffy-pots' x 2 for each line or cultivar were used as pots. The pots were placed on capillary matting to ensure uniform water supply. Each propagator contained up to 13 lines or cultivars arranged as two randomised blocks (propagators) with each line occurring only once in each propagator. Initially, 9-15 seedlings/line or cultivar were grown in each propagator, but were thinned to 6-10 six days after sowing to reduce growth variability. Sowing dates were staggered to produce seedlings at the required growth stage for inoculation at the same time. The average times required under these conditions to reach fully expanded cotyledons, first and second true leaves were 7, 16 and 22 days respectively.

Seedlings were inoculated by spraying to run-off with a suspension of conidia (c.2.5 x 10^5 conidia ml^{-1}), challenging each line or cultivar with 3 separate isolates of *P. parasitica* (R1,P033, P004). Seedlings at the first and second true leaf stage were then transferred with their original trays to a larger plant propagator (57cm x 29cm x 23.5cm). This was not necessary for seedlings at the cotyledon stage. The propagators were sealed after inoculation, the ventilators adjusted to allow the relative humidity to rise to c.100%, then incubated in growth cabinets under the conditions described for culture maintenance. Infection phenotypes (IP) were observed 7 or 9 days after inoculation (on cotyledons and leaves respectively) using a 0-9 scale slightly modified from Williams (1985).

0 = No symptoms or signs of *P. parasitica*.

1 = Very minute to larger scattered necrotic flecks under the inoculum drop, none to small amounts of necrosis on the lower cotyledon surface, no sporulation.

3 = Very sparse sporulation, 1 to few conidiophores on the upper or lower surfaces, necrotic flecking often present, tissue necrosis present.

5 = Sparse scattered sporulation on either or both cotyledon surfaces, tissue necrosis.

7 = Abundant to heavy sporulation mainly on lower surfaces, light to scattered sporulation on upper surfaces, tissue necrosis and chlorosis may be present.

9 = Heavy sporulation, leaf or cotyledon collapsed.

A disease index (DI) was calculated from the following formula:

$$DI = \frac{\sum_{i=0}^{9}(i \times j)}{n}$$

where n = total plants, i = IP class and j = number of plants/class.

Additionally, all IP scores on the 0-9 scale (where 9 represented 100% susceptibility) were transformed to logits, to give similar variance for all cultivars, before being subject to analysis of variance. These fitted scores and the disease indices are given in Fig.1 together with Least Significant Differences derived from the analysis of logits. Kendall's coefficient of concordance over growth stage was also calculated for all three isolates to assess the consistency of the score over the three growth stages. Host material was classified into three selection categories: susceptible (IP = 7 to 9), partial resistance (IP = 3 to 5) and resistant (IP = 0 to 1).

3. Results and Discussion

3.1 Comparison of cultivar types and tissues

Fig. 1 shows the expression of resistance to three isolates of *P. parasitica* in 12 cultivars at three growth stages; cv. Cresor was included in each test, for comparison, as an example of a resistant host with a known major gene for resistance. Five of the other cultivars were single-low and 6 were new double-low cultivars; none of these had a known major gene for resistance.

Comparisons of response to infection among the single- and double-low cultivars showed no significant difference between the two cultivar types. These tests, done on cotyledons and young leaves, should fairly reflect large differences in amounts of glucosinolates in the tissues of the two cultivar types because concentrations in seedling tissues are highly correlated with those in the seed (Glen, Jones & Fieldsend, 1989), unlike the concentrations in older vegetative tissue (Milford *et al.*, 1989). The absence of a clear distinction between the two cultivar types indicates that total glucosinolate concentration is unlikely to be related to the level of resistance to downy mildew. This observation is compatible with other work with naturally infected field crops (Rawlinson *et al.*, 1989), which indicates that double-low cultivars are not consistently more or less susceptible than a single-low cultivar to downy mildew and a range of other pathogens.

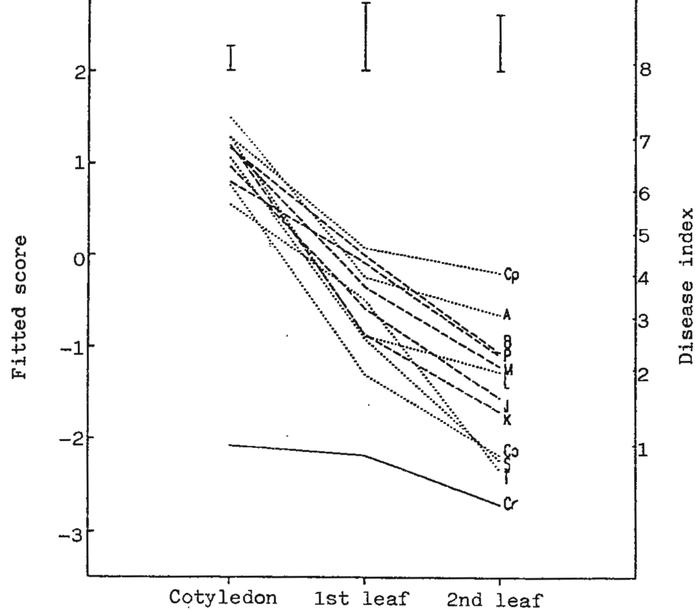
The conclusion of Greenhalgh & Mitchell (1976) that resistance to downy mildew in cabbage (*B. oleracea*) may be related to concentration of the glucosinolate hydrolysis product, allyl isothiocyanate, may be explained by the much greater concentration of its precursor, sinigrin, in cabbage tissues than in winter oilseed rape. Moreover, changes in the principal types of glucosinolates occur during the germination of oilseed rape seed (Glen, Jones & Fieldsend, 1989) and later during vegetative growth (Milford *et al.*, 1989), so it remains possible that resistance could be related to certain individual glucosinolates or their hydrolysis products.

In our tests Ariana and Capricorn were consistently among the most susceptible cultivars; either may be used as a susceptible control against which others may be compared. Cresor was fully resistant, confirming the work of Lucas *et al.*, (1988) which reported that the resistance in Cresor was controlled by a single dominant allele. However, the virulence of isolate P033 on Cresor (J. A. Lucas, personal communication) was not substantiated in our tests.

Cotyledons of all cultivars, except Cresor, were markedly less resistant than first or second true leaves. This was related to the absence of surface wax rodlets (revealed by scanning electron microscopy of fresh tissue), which resulted in increased wettability and spore retention on cotyledons, and to the greater efficiency of the necrotic reaction to infection on leaves. However, the relative differences in resistance between cultivars remained largely unchanged, regardless of which tissue was inoculated. The differences in the level of resistance expressed in cultivars to each of the three isolates is likely to be attributable mainly to the effect on host tissue and development of fluctuations in ambient temperature and light intensity, since each isolate was tested at a different time of year. The three experiments using isolates P004, P033 and RI were done in July, September and October 1989 respectively.

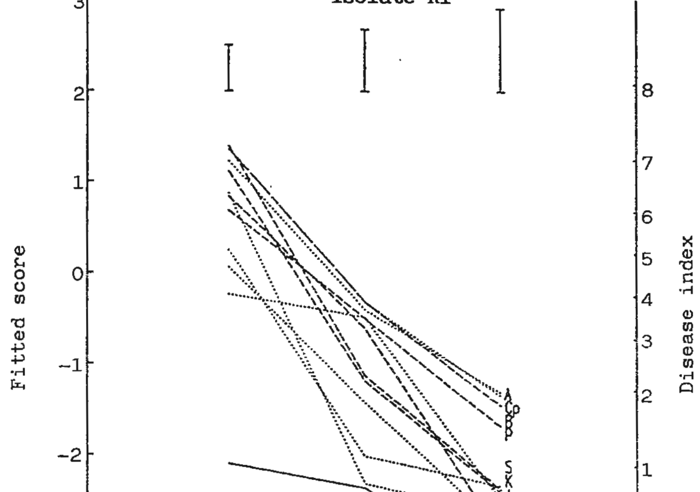
3.2 New sources of resistance identified

In parallel with the tests of resistance of single- and double-low cultivars to downy mildew other work screened a much wider range of oilseed rape germplasm collected from sources in the UK, Canada, China, France,

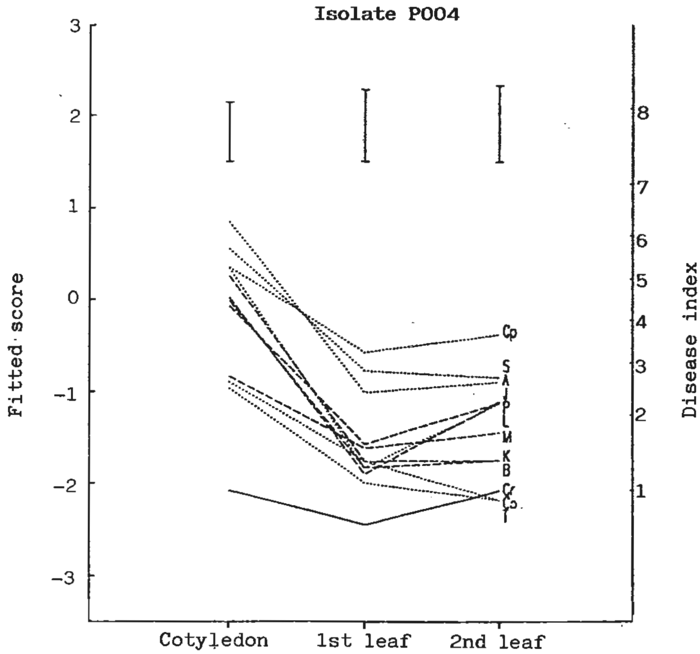


Fitted score
Disease index
Cotyledon
1st leaf
2nd leaf
Cp
A
B
P
M
L
J
K
Co
S
T
Cr

Isolate R1



Fitted score
Disease index
A
Cp
B
S
K



Key

Cr = Cresor	A = Ariana
B = Bienvenu	Cp = Capricorn
J = Jet Neuf	Co = Cobra
K = Korina	L = Lecor
M = Mikado	S = Score
P = Primor	T = Tapidor

—— single low varieties

... double low varieties

Bars indicate LSD at P=0.05 (n=12)

Germany and the USA. Five new sources of resistance among this material have now been identified indicating a major gene, or genes, for resistance expressed at the cotyledon stage to isolates P004, P033 and RI. These sources, carrying resistance equivalent to that in Cresor, included double-low winter rape and single-low spring rape types, all of them were *B.napus* ssp. *oleifera*. The identity of these sources will be published elsewhere.

Our early work on screening for resistance to downy mildew indicated that, for speed and simplicity, initial screening could be done on cotyledons since this gave a good reflection of the resistance expressed in other seedling tissues (e.g. Fig.1). However, it is possible that resistance expressed at much later growth stages may be determined by a gene, or genes, different from those effective at the seedling stage, as noted by Hoser-Krauze, Lakowska-Ryk & Antosik (1987) for downy mildew of broccoli. Moreover, a gene, or genes, not fully expressed at the seedling stage may be expressed in a different fashion at later stages. The adult plant resistance of the new sources identified in this study has yet to be confirmed. Under UK climatic conditions resistance to downy mildew at the seedling stage is thought to be more important than that at later stages (Davies, 1986) but durable resistance throughout the growth of the plant would, if confirmed, make the new sources of value to plant breeders in northern Europe and Asia where the disease is also important on mature plants.

When the germplasm collection was screened for resistance it was noted that some cultivars showed distinct variation in the level of resistance to downy mildew. Further work continues on this material to breed truly homozygous lines from the populations to further widen the base of available sources of resistance. Future work will also determine the host-pathogen specificity, if any, of the gene, or genes, for resistance in both the new sources and the resistant members of segregating populations.

3.3 Dual cultures on callus tissue

Attempts to establish dual cultures on callus tissue derived from both cotyledons and hypocotyls were partially successful; some calluses were completely susceptible, others were only partially susceptible or resistant. For success it was important to avoid bacterial contamination when inoculating calluses with conidia of *P. parasitica*. A method has now been devised that ensures most calluses remain free of contamination, marking a substantial improvement on the high rate of contamination experienced in previous work of this type (Ingram, 1980). To ensure that bacterial contamination is minimised the excess surface water should be removed from infected cotyledons that are to be used to provide inoculum and the cut hypocotyl ends should not touch the culture medium on which cotyledons are placed during incubation and inoculation. Further work is now needed to define the conditions and tissue types which will allow regular initiation and maintenance of dual cultures so that these may become a viable, easily available, alternative source of inoculum for studies on host resistance to downy mildew.

4. Acknowledgements

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Preliminary results of research on *Peronospora parasitica* (Pers. ex Fr.) Fr. in winter oilseed rape with special regard to the susceptibility of double-low cultivars

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Summary

In various regions of Germany an unparallelled infection of oilseed rape by downy mildew was noted between 1987 and 1988, both in autumn and spring, with more serious infections in spring. This was due to the very mild and humid winters. First studies of nine double-low cultivars in laboratory, greenhouse, and field indicated that winter oilseed rape shows different degrees of susceptibility to **Peronospora parasitica**. First and second leaf stage, rather than cotyledons proved to be more appropriate for susceptibility tests of cultivars to downy mildew. First results show that there is a positive correlation between greenhouse and field in view of susceptibility of leaves of the cultivars to downy mildew. The cultivars Diadem and Libraska turned out to be highly susceptible, whereas Cobra and Liporta were less susceptible to **P. parasitica**. Fungus sporulation varied considerably according to the susceptibility of the cultivar.

1. Introduction

As compared to other fungal infections of oilseed rape, downy mildew infection caused by the pathogen **Peronospora parasitica** has been studied very little, although the disease is very widespread in countries like France, Poland and Britain (Hardwick et al. 1989). This may be partially due to the fact, that in practice leaf symptoms of **P. parasitica** may easily be mistaken for those caused by **Phoma lingam** and are very often attributed to the latter. Pod symptoms may be mistaken for those caused by **Cylindrosporium concentricum** or **Alternaria**. In the Federal Republic of Germany, our exploratory field observations during the last three consecutive mild winters showed that oilseed rape may be heavily infected by **P. parasitica** even during germination of rape but particularly during the flowering stage up to maturation, depending on site and cultivar. Field trials conducted by Sadowski (1987) on the control of downy mildew using fungicides showed that considerable yield losses may be caused by this fungus. Depending on the type of active ingredients yield losses could be reduced by 10 to 25 % in certain cases.

The purpose of the present exploratory study was to determine the reponse of new double-low cultivars to downy mildew. This was particularly important because there were no relevant data available in the Federal Republic of Germany. A further objective of the study was to determine whether there are different degrees of susceptibility even in the juvenile stages of development of double-low oilseed rape cultivars and whether there is a correlation between these test results and the degrees of susceptibility of mature plants in the field.

2. Materials and Methods

For laboratory and greenhouse tests leaves of the cultivar Lirajet with sporulating **P. parasitica** were collected from the field. Conidiospores of the fungus were carefully removed using a paintbrush and tap water to which 0.01% of Tween 20 had been added. These conidiospores were then multiplied on the cultivar Diadem in the cotyledon stage.

For susceptibility tests to downy mildew, nine double-low cultivars were available. Their susceptibility to **P. parasitica** had been evaluated in field trials in 1989. The test plants were kept for approx. 3 to 4 weeks in a greenhouse with an additional light source (approx. 10.000 lux) at a temperature of 15 to 20° C by day and of 10°C by night. At the end of this period, the plants were at 2nd to 4th leaf stage.

First, some laboratory tests were conducted to compare susceptibility at cotyledon and at 2nd leaf stage using a detached-leaf-test. For this test, cotyledones and true leaves were detached from the plant and placed up side down on BCM agar (200mg benzimidazole in 1l aqua dest.). Subsequently they were inoculated using the same methods as for the greenhouse tests. Infected cotyledones of the cultivar Diadem with heavy sporulation were stirred carefully in tap water, using a magnetic stirrer to remove the conidiospores from the leaves without damaging them. Spore concentrations were counted in a Fuchs-Rosenthal chamber. In detached leaf tests a spore concentration of 10.000 conidiospores/ml was applicated using a SATA paint spray gun operating on compressed air (2 bar). 50 cotyledons and 50 leaves per cultivar were inoculated. For inoculation of whole plants in plastic trays (70 compartments) 10 ml suspension of 30.000 conidiospores/ml were used. The plants were then kept at 100 % relative humidity and moderate light at a temperature of 15 to 17°C by day and of 5 to 10° C by night.

The plants were classified for susceptibility 10 days after inoculation, when the cultivar Diadem, which proved to be highly susceptible, developed marked leaf symptoms. The infection was classified at 2nd to 3rd leaf stage on the basis of percentage of diseased leaf area. 60 plants were classified per cultivar with two replications. In addition, the sporulation rate was visually determined. The natural infection of double-low oilseed rape cultivars with downy mildew was studied in 1989 at two sites in Westphalia (Soest and Unna) during official tests of cultivars, which had been cultivated by the Westphalian Chamber of Agriculture in 4 consecutive seasons. The mean percentage of diseased area of all leaves of 9 double-low cultivars was determined, using the central part of the plant, at the beginning of the flowering stage and at maturation of pods.

3. Results

The comparison of susceptibility of oilseed rape cultivars to **P. parasitica** at cotyledon and 1st and 2nd leaf stage, using a detached-leaf test, showed that the cotyledons of nearly all plants under investigation were seriously infected, and that the variation in degree of susceptibility to downy mildew was only minor. Clearly visible chloroses could be observed, although there was none of the typical sharp sized flecks on leaves; the leaves turned yellow and had a high moisture content. The cultivars varied considerably as to their sporulation rate (Table 1). The degree of infection on the leaves differed considerably from cultivar to cultivar. Typical leaf symptoms could be observed on true leaves, but in the detached-leaf-test (Table1) no sporulation on those leaves could be detected.

Table 1 **Sporulation and degree of infection by *Peronospora parasitica* on cotyledons and on true leaves of nine double-low cultivars in a detached-leaf-test**

cultivar	*sporulation rate on cotyledons*	*severity (mean % area) on the first true leaf (*)*
Cobra	very low	85.7
Liporta	very low	50.0
Liborius	low	46.7
Lirabon	very low	29.4
Ceres	high	35.0
Libravo	high	52.9
Arabella	low	21.4
Libraska	high	87.5
Diadem	high	87.5

*no sporulation visible

During exploratory greenhouse tests with oilseed rape plants, there were strong indications for differences between cultivars as to their susceptibility to downy mildew (Table 2 and 3)

Table 2 Response of nine double-low winter rape cultivars to downy mildew *(P. parasitica)* in the greenhouse in 1990

cultivar	*% d i s e a s e d l e a f a r e a* experiment 1*	experiment 2*	mean	rank
Cobra	1.8	1.8	1.8a	1
Liporta	1.8	2.0	1.9a	2
Liborius	2.4	2.3	2.3a	3
Lirabon	2.8	3.6	3.2ab	4
Ceres	5.1	3.0	4.0 bc	5
Libravo	5.6	5.2	5.4 cd	6
Arabella	8.6	4.2	6.4 d	7
Libraska	16.6	5.5	11.1 e	8
Diadem	15.5	8.4	12.0 e	9
mean	*6.6*	*4.0*	*5.3*	
LSD (1 %)			*1.8*	

* 60 Plants of each cultivar

Table 3 ***P. parasitica* on nine double-low cultivars: Frequency of leaves in classes of attack (% area)** (mean of two greenhouse experiments)

classes / *cultivars*	*frequencies of leaves (mean % area)* 1	*3*	*6*	*10*	*15*	*20*	*30*	*40*	*50*
Cobra	91	17	8	4					
Liporta	83	27	6	4					
Liborius	68	35	12	5					
Lirabon	52	42	14	10	1	1			
Ceres	46	32	26	9	5	2			
Libravo	39	29	20	19	10	2	1		
Arabella	31	25	23	22	12	6	1		
Libraska	9	26	20	24	16	12	9	3	1
Diadem	12	17	19	26	17	14	12	2	1

The cultivars Cobra and Liporta proved to be the least susceptible of the investigated double-low cultivars. Both cultivars showed very little cotyledons' decay after infection. The cultivars Diadem and Libraska proved to be most susceptible to infection with **P. parasitica**. The cotyledons of both cultivars died completely after infection. Good sporulation on dead cotyledons could be observed in the case of the cultivar Diadem, with slightly lower sporulation for Libraska. In the case of both cultivars, the cotyledons had died off completely.
Dead cotyledons of Diadem showed heavy sporulation, those of Libraska little less. In the case of the cultivar Libravo

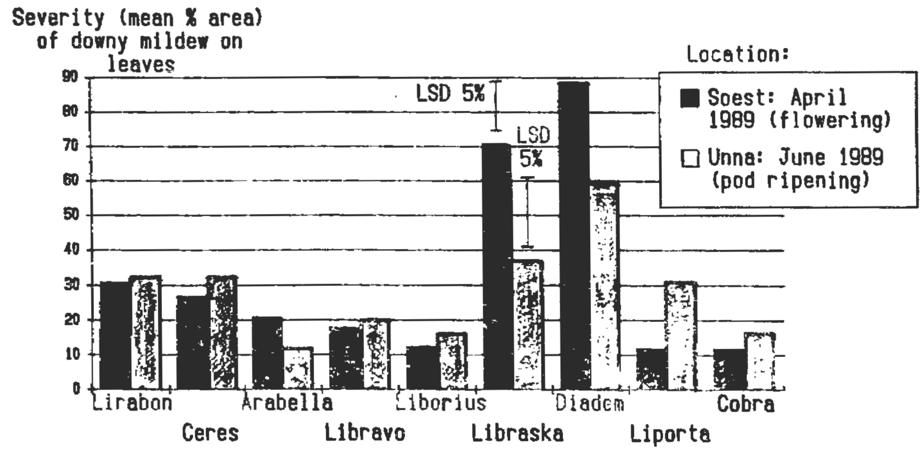
cotyledons had died as well, but very little sporulation could be noted. Although the cultivar Arabella may be considered to be susceptible, cotyledons did not die off after fungus infection. Very few conidiospores developed on cotyledons, whereas sporulation on true leaves was very high depending on the cultivar. (Table 4)

Table 4 **Sporulation of *P. parasitica* on cotyledons and true leaves of nine double-low winter rape cultivars in the greenhouse** (10 days after inoculation)

cultivar	*Sporulation rate on* *true leaves*	*cotyledons*	*cotyledons killed*
Cobra	high	low	no
Liporta	low	low	no
Liborius	high	low	no
Lirabon	high	low	no
Ceres	low	low	no
Libravo	high	low	yes
Arabella	very high	low	no
Libraska	high	high	yes
Diadem	very high	very high	yes

In field trials, the nine cultivars tested showed varying degrees of infection by downy mildew at the beginning of flowering and at maturation. The differences between cultivars were rather similar on both sites with varying degrees of infection (Fig. 1).

Fig. 1 RESPONSE OF DOUBLE-LOW WINTER RAPE CULTIVARS TO DOWNY MILDEW (PERONOSPORA PARASITICA) IN TWO FIELD TRIALS IN 1989



This was true both for leaf infection at flowering stage and at pod maturation in the field. A certain correlation exists between downy mildew infection in the greenhouse during the youth stages of the plant and, in the field during maturation for different cultivars (Table 5).

Table 5 **Response of double-low winter rape cultivars to *P. parasitica* in the greenhouse and in the field in 1989**

cultivar	*disease severity on leaves (mean % area)*		
	greenhouse	*field*	
		Soest	*Unna*
Diadem	12,0	89	58
Libraska	11,1	71	38
Lirabon	3,2	31	33
Ceres	4,0	26	33
Liporta	1,9	13	29
Libravo	5,4	18	21
Arabella	6,4	21	13
Liborius	2,3	13	17
Cobra	1,8	12	17
LSD (5 %)	*1,3*	*15*	*20*

4. Discussion

Susceptibility of oilseed rape to **P. parasitica** as well as the propagation of the disease is, among other factors, marked by the sporulation rate of the pathogen on the leaves.The cotyledons of rapeseed are obviously very susceptible. After infection the colour of the cotyledons of all cultivars tends to fade. Chlorophyll is disassimilated and finally the complete leaf surface fades together. The spots an the leaf surface which are typical for the infection of true leaves cannot be found on cotyledons. Sporulation increases with the age of the plant. Sporulation differs according to the cultivar. After first greenhouse and field tests, less susceptible cultivars seem to vary with regard to sporulation. The same holds of course true for susceptible cultivars.

True leaves are more resistant than cotyledons. Whereas the latter were seriously infected with 10 000 spores/ml, true leaves showed only moderate infection at 30.000 spores/ml.
On inspection true leaves showed differences in the pathogen's tendency to sporulate. Therefore few disease symptoms but high sporulation could be observed with the cultivar Cobra. The cultivar Liporta which is also less susceptible showed, however, little sporulation. The cultivar Ceres showed very little sporulation despite its high susceptibility. The susceptible cultivar Arabella sporulated quite well on cotyledons. Infected cotyledons would not have died even ten days after inoculation.

The relative frequency of occurence indicates that Cobra, Liporta and Liborius show little variation, whereas susceptible cultivars show very high variation. The first test results indicate a correlation between susceptibility at youth stages and at mature stages of development. Further investigation is required to gather more accurate and reliable data, especially as regards susceptibility during various stages of development, inoculation methods, virulence and resistance mechanism, as well as sporulation, early diagnosis and early selection.

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FIRST RESULTS OF RESEARCH ON ARTIFICAL INFECTION OF RAPE SEEDLINGS WITH *CYLINDROSPORIUM CONCENTRICUM* GREV. (TELEOMORPH: *PYRENOPEZIZA BRASSICAE* SUTTON & RAWLINSON) AND REACTIONS OF DOUBLE LOW CULTIVARS

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Summary
In spring 1988 severe attacks of light leaf spot on oilseed rape occured in Westfalia for the first time. The pathogen was isolated from diseased plants. Seedlings inoculated with conidia grown on artificial media showed typical symptoms of the disease on their cotyledons and hypocotyls. Cultivar reactions observed in the field correlated well with those on inoculated seedlings grown in a controlled environment for the cvs. Liberator, Lirabon and Ceres. Slight deviations between the two assessment scores were found for Liradonna, Cobra and Diadem.

1.Introduction

The cabbage plant disease caused by *Cylindrosporium concentricum* Grev. (teleomorph: *Pyrenopeziza brassicae* Sutton & Rawlinson) has been known for more than 100 years (Berkeley, 1851; Hickmann, 1955). Due to the colour of the acervuli, the fungus was described as "white rust of cabbages" and classified under the genus *Gloeosporium*. The sexual stage was not discovered until fairly recently and assigned to the ascomycetes (Staunton & Kavanagh, 1966; Rawlinson *et al.*, 1978). In 1988 the oilseed rape crops in the Federal Republic of Germany showed an increased incidence of the fungus for the first time.

2. Material and Methods

Field assessments

In April 1988 various cultivars of oilseed rape were assessed for their susceptibility to the pathogen at a time when the leaves were much infected. For the assessment of severity of attack in the field a scale ranging from "1 = leaves without symptoms of the disease" to "9 = more than 50% of the younger leaves' surface with symptoms of the disease" was adopted. Symptoms on the stems of the rape plants were less severe because the subsequent warm, dry weather allowed the plants to "grow away" from the fungus.

Inoculation and Incubation

The pathogen was isolated from infected rape plant leaves and cultured on PDA. After ten weeks a suspension of conidia ($1x10^6$/ml) was prepared from the plates and applied to the seedlings of different cultivars. Incubation was carried out in a controlled climate chamber over six days in a 16/8 hour cycle of light(6000 lux) and darkness and at 18°C/12°C respectively. The relative humidity was kept at 100% for the first six days and reduced after that. Symptoms were assessed 12-14 days after inoculation.

Five categories were employed for the disease assessment on inoculated seedlings (Table 1). Almost all plants in category "7" died after another two weeks after the scoring; only a few of the of the plants in category "5" actually survived.

3. Results and Discussion

Field assesments

The results of an assessment made after natural infection at growth stage EC 39 are given in Table 2. The mean value of scores from all cultivars showed that about 30% of the total leaf surface had symptoms of the pathogen (Acervuli, "elephant skin" or "salty coating").

Pathogenesis on inoculated seedlings

The inoculated seedlings showed the following symptoms:

- in some cases extension growth and thickness growth were very much reduced;
- unilateral, longitudinal whitish discolourations of the epidermis of hypocotyl and petioles; subsequent transversal bursting of the epidermis in the way which is typical of symptoms on fully grown plants;
- loss of turgor of the epidermis cells of the hypocotyl which also showed brownish discolourations to a greater or lesser extent (unilateral or stem -girdling);
- necrosis of the cotyledons starting at the petiole and spreading over the whole lamina. The first true leaves were very rarely affected;
- no acervuli were found;

Table 1. *Cylindrosporium concentricum* on oilseed rape: assessment of seedlings two weeks after inoculation

1 =	healthy
3 =	slight unilateral browning of the root collar
5 =	strong stem-girdling browning of the root collar; slight necrosis of the cotyledons
7 =	deep scars on the root collar; cotyledons nearly totally necrotic; plantlets severely stunted
9 =	plantlets completely necrotic

Both in the field and in the controlled climate chamber the assessments showed the great variability between cultivars with regard to their susceptibility to the pathogen. Due to the small number of data pairs a correlation parameter was not calculated even though there was some evidence of a correlation between both series of data. Further experiments with a wider range of cultivars are required in order to quantify this correlation. The strong deviation between the two scorings of cv. Doublol - almost all plants died in the climatic chamber whereas field susceptibility was very low - is most probably due to other fungal pathogen contamination (*Alternaria sp.*) of the seeds used in the climate chamber.

Very early and fast testing of oilseed rape resistance to *C. concentricum* now appears to be a viable possibility.

Table 2. *Cylindrosporium concentricum*: Cultivar reactions to natural infection in the field and to artificial inoculation in a controlled environment chamber, (1 = healthy; 9 = plantlet completely necrotic / more than 50% of leaf surface with symptoms)

Cultivar	**Disease Index**	
	Climate chamber	*Field trial*
Liberator	2.2	3
Lirabon	4.6	5
Ceres	7.4	7
Doublol	(10.0)*	2
Liradonna	4.9	5
Diadém	4.2	4
Cobra	6.8	6
Mean	5.2	4.6

*) The seeds were contaminated with *Alternaria sp.*

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SESSION 3

Host Resistance to Infection

CHITINASE AND PHYTOALEXIN ACCUMULATION IN *BRASSICA NAPUS* AND *BRASSICA JUNCEA* IN RESPONSE TO *LEPTOSPHAERIA MACULANS*

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Summary
Investigations on a model, consisting of a susceptible and a partly resistant *Brassica napus*, as well as a resistant *Brassica juncea* were carried out, to determine which factors are responsible for the resistance against different pathotypes of *Leptosphaeria maculans*. Besides glucosinolates, the induction of chitinases and phytoalexins was investigated.
Inoculation of cotyledons with aggressive and non-aggressive isolates of *Leptosphaeria maculans* resulted in a significant increase in chitinase activity with non-aggressive isolates on the resistant cultivars, while aggressive isolates suppressed this induction.
In cotyledons traces of the phytoalexins cyclobrassinin and methoxybrassinin were detected, but no correlation between chitinase induction and phytoalexin accumulation was observed.

1. Introduction

Leptosphaeria maculans (Desm.) Ces. et de Not., the teleomorph of *Phoma lingam* Tode (Desm.) causes blackleg and stemcanker on oilseed rape and represents an economic threat to this crop. Infection takes place on the cotyledons and true leaves in autumn. The fungus then grows from the leaf lesion into the stem (HAMMOND et al. 1985) where it can cause severe tissue damage often leading to plant death. Resistance of oilseed rape to *L. maculans* in the developmental stages 13 - 23 could therefore help to prevent severe crop losses.
At least two pathotyps of *L. maculans* are known, which are divided in aggressive/non-aggressive (HAMMOND & LEWIS 1987, ROUXEL et al. 1988, KOCH et al. 1989), or virulent/avirulent (HUMPHERSON-JONES 1983). A distinct difference between these pathotypes is the production of a group of toxins, the sirodesmins (KOCH et al. 1989). ROUXEL et al. (1988) proved, that these toxins inhibit the RNA-synthesis in embryogenic tissue culture of *Brassica napus*.

Little is known about the factors controlling resistance or susceptibility in *Brassica napus* and *Brassica juncea*. *B. juncea* is resistant against *L.maculans* and several interspecific crosses between *B.napus* and *B.juncea* expressed a higher degree of

resistance than the susceptible parents (ROY 1984, SACRISTAN & GERDEMANN 1985, 1986).
PETERKA & SCHLÖSSER (1988, 1989) demonstrated the influence of the volatile breakdown products of alkenyl-glucosinolates on mycelial growth of *L.maculans* and indicated the potential importance of these compounds as preformed chemical barriers against fungal attack.
TAKASUGI et al. (1986) isolated three novel phytoalexins from *Brassica campestris* and DAHIYA & RIMMER (1988a, b) found two of them, cyclobrassinin and methoxybrassinin, in both, *B.napus* and *B.juncea*.
In 1979 WILLIAMS and DELWICHE described a seedling inoculation assay for testing breeding lines for resistance to *L. maculans*. Several investigations in the last years revealed a strong correlation between resistance in the cotyledoneous stage and resistance in the field (HELMS & CRUIKSHANK 1979, CARGEEG & THURLING 1979, MITHEN & LEWIS 1988, SJÖDIN & GLIMELIUS (1988)
In our model system, consisting of the susceptible cv.Linetta, the partly resistant cv.Jet neuf, both *B.napus*, and the resistant *B.juncea* cv.Newton, the induction of chitinases and phytoalexins in response to an aggressive and a non-aggressive isolate of *L.maculans* was investigated.

2.Materials and Methods

Seedling Inoculation Assay

The isolates Pl 7 and Pl 9 of *L. maculans* were cultivated on a rapeseed agar containing 50g/l stem material homogenized in a Waring Blendor and 2% agar. For pycnidia production, the isolates were transferred to potato sucrose agar and incubated under 12h/12h near UV-light (Phillips TL D 36W/08) at 20°C.
Conidia suspensions were prepared by flooding a petridish with 5ml sterile distilled water and scraping the surface of the agar with a glass rod. The suspension was filtered through a double layer of muslin and the spore concentration adjusted to 10^6 conidia/ml using a Fuchs-Rosenthal counting chamber.
Seeds of *B.napus* cv.Jet neuf, cv.Linetta and *B.juncea* cv.Newton were sown in TKS2, 50 seeds per tray (60cm x 40cm). Seven to eight days after sowing each cotyledoneous leaf was wounded at an intercostal area with a pinprick and inoculated with 10µl of the conidia suspension.
The plants were kept under a plastic cover for three days to maintain a high humidity. Fourteen days after inoculation the resulting lesions were measured and the area calculated according to the formula of an ellipsis.

Chitinase-Activity

Activity was measured according to ABELES et al.1970, using tritiated chitin. In triplicate ten cotyledons were blended with an Ultra-Turrax in 100mM sodium-acetate buffer, pH5 at 20000rpm and centrifuged at 10°C and 10000g, for 30 minutes. The supernatant was used for the determination of protein (BRADFORD

1976) and chitinase activity. The reaction mixture consisted of 50µl leaf extract, 3mg ^{3}H-Chitin (1,2x10^{6}dpm/mg), 100mM sodium-acetate buffer pH5, in a total volume of 250µl. The reaction was stopped with 300µl 1M TCA. After centrifugation for 10 min at 6000g, an aliquot of the supernatant was counted in a scintillation counter (Packard TriCarb 2000CA) using Omniszint (Merck).

Phytoalexins

They were detected and quantified according to DAHIYA & RIMMER (1988b), using a Gynkotek HPLC and a Lichrospher 100 RP18 5µm column (250mmx4mm), with the LC-UV detector set to 267nm. The mobile phase consisted of acetonitrile/water 70%/30% (v/v), the flow-rate was 1,5ml/min at 30°C.
Pure phytoalexins, used as external standards, were kindly supplied by Prof. M. Takasugi (Hokkaido University, Sapporo, Japan).
For extraction 2g of cotyledons were macerated in 20ml 70% aqueous Methanol (v/v). After centrifugation the extracts were dried *in vacuo*, the residues redissolved in 1ml of 70% aqueous acetonitrile (v/v) and an aliquot injected into the HPLC.

3. Results

In the seedling inoculation assay the varieties "Linetta", "Jet neuf" and "Newton" revealed a different susceptibility to aggressive and non-aggressive isolates of *Leptosphaeria maculans*.

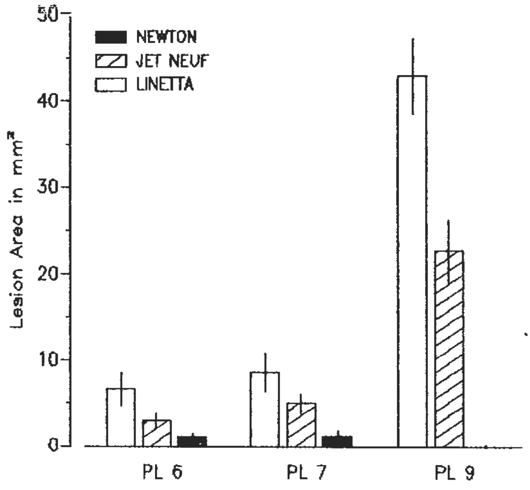

Fig.1: Lesion area in mm² 14 days after inoculation of cotyledons of cv.Newton, cv.Jet neuf and cv.Linetta with conidia of the aggressive isolate Pl 9 and the non-aggressive isolates Pl 6 and Pl 7 of *L.maculans* (n=40)

After 14 days the lesion area was significantly different between the three varieties, and within the varieties between the different isolates (Figure 1.). The aggressive isolate Pl 9 caused light, grayish lesions on "Linetta" and "Jet neuf", while the inoculation with the non-aggressive Isolate Pl 7 resulted in smaller brown, necrotic leaf spots.
Inoculation of the cotyledons of "Newton" with the non-aggressive Isolate resulted in a browning of the pinprick area, which did not develop after inoculation with Pl 9.

Microscopical investigations, using the staining technique of BRUZZESE & HASAN (1983), of the tissue and the petiols of cotyledons of "Linetta" and "Newton" 14 days after inoculation showed, that no hyphae were detectable in cotyledons of "Newton" (Table 1).

Tab.1: Percentage of cotyledons in which hyphae of aggressive (+) and non-aggressive (-) isolates were microscopically detectable at the inoculation site (I) and the petiole (P); (n=16)

	Linetta		Newton	
	I	P	I	P
	[%]		[%]	
Pl 6 -	100	43	0	0
Pl 7 -	100	0	0	0
Pl 9 +	100	88	0	0
Pl335 +	100	100	0	0

In the tissue of "Linetta" hyphae of both isolates were detectable in the lesions. In 88% respectivly all of the petiols of leaves inoculated with aggressive isolates hyphae were detectable, while only 43% respectively no hyphae of the non-aggressive isolates were observed in the petiols of "Linetta". These findings correspond with the formation of crown canker on these cultivars (data not shown), and demonstrate a significant difference in lesion area and the ability of the different pathotypes to grow into the petiols, even on the susceptible cultivar.

The induction of pathogenesis related (PR) proteins and phytoalexins depends on mRNA- and protein-synthesis in response to fungal attack. Protein synthesis is suppressible by cycloheximide. Hence a cycloheximid-resistant non-aggressive isolate Pl A6 was established by mass selection and cotyledons of the three cultivars were inoculated, adding 5µg/ml cycloheximide or 50 µg/ml of a mixture of sirodesmins to the conidia suspension. After 14 days the lesion area was determined.

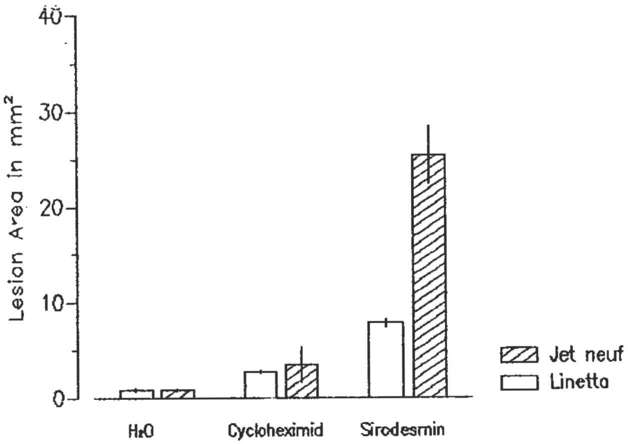

Fig.2: Lesion area in mm^2 14 days after inoculation of cv.Linetta and cv.Jet neuf with conidia of Pl A6 ± 5µg/ml cycloheximid or 50µg/ml sirodesmins to the conidia suspension (n=150)

There were significant differences between the lesion areas on cotyledons of Linetta and Jet neuf in both treatments as compared with the control (Fig.2). No lesions appeared in any treatment on the leaves of Newton. This indicates, that a suppresion of protein synthesis in the leaves has an influence on lesion formation and fungal growth in the cotyledons of Linetta and Jet neuf.

Chitanase-activity

Chitinases belong to the group of PR proteins and their induction is suppressible by cycloheximide (BOLLER et al. 1983). Therefore the induction of chitinases was measured during eight days, starting with the day of inoculation on the three cultivars with an aggressive and a non-aggressive isolate of *L.maculans*. In response to the non-aggressive isolate Pl 7 the chitinase activities in the partly resistant cv.Jet neuf and the resistant cv.Newton increased 3- 4-fold within 72h to 96h (Fig.3). Within six days the activity in Jet neuf increased up to eight times the level of the control. In Newton the activity stays on the level it reaches within 96h. The susceptible cv.Linetta reacts to the fungal attack after eight days with a 2-fold increase in activity.

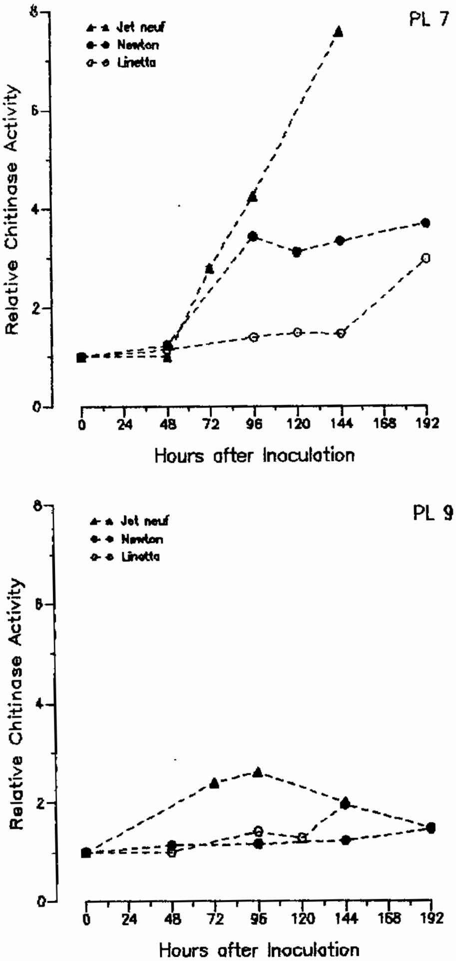

Fig.3: Chitinase activity in cotyledons of cv.Linetta, cv.Jet neuf and cv.Newton in response to inoculation with the non-aggressive isolate Pl 7 and the aggressive isolate Pl 9 relative to the control (mean of four replicates)

The reaction of all cultivars to the aggressive isolate Pl 9 was entirely different. There was no reaction observable witth Linetta and Newton. The partly resistant Jet neuf reacted with a twofold increase in activity within 72h - 96h which decreases again to the level of the control after six days.
These results support the hypothesis, that aggressive isolates are able to suppress the induction of pathogenesis related proteins, which allows them to develop faster in the colonized tissue.

Phytoalexins

In 1988 DAHIYA and RIMMER described two phytoalexins, cyclobrassinin and methoxybrassinin in *B.napus* and *B.juncea*, elicited by inoculation with *L.maculans*.

In a time course study over 15 days the amounts of these phytoalexins were monitored in the cotyledons of the three cultivars of our investigation. For inoculation the leaves were wounded with carborundum and sprayed with a conidia suspension of the non-aggressive isolate Pl 7 and an elicitor prepared from *L.maculans* cell walls. In parallel, the severity of sypmptoms was asessed.

Tab.3: Phytoalexin content in µg/g FW in cotyledons of cv.Linetta, cv.Jet neuf and cv.Newton monitored over 15 days after wounding with carborundum (Carb.) and spraying with elicitor and conidia suspension of Pl 7 respectivly (mean of 3 replicates)

cv / days	Symptom	Control	Carb.	Elicitor	PL 7
			[µg/g FW]		
Linetta					
3		nd	nd	nd	nd
6	♦	nd	nd	nd	nd
9	♦♦	nd	nd	nd	nd
12	♦♦♦	nd	nd	nd	nd
15	♦♦♦♦	nd	nd	nd	nd
Jet neuf					
3		nd	1,23 CB	nd	nd
6		0,3 CB	nd	nd	0,11 CB
12	♦	0,44 CB	nd	nd	nd
15	♦♦	nd	nd	0,54 CB	nd
Newton					
3		nd	nd	nd	0.52 CB
6		nd	nd	nd	nd
9		nd	nd	nd	nd
12		nd	nd	nd	nd
15		nd	nd	nd	nd

CB - cyclobrassinin, MB - methoxybrassinin; ♦ - symptoms

nd - not detectable

Cyclobrassinin was detectable in the cotyledons of cv.Jet neuf and cv.Newton. The phytoalexin methoxybrassinin was found in none of the samples. In cv.Linetta neither of the phytoalexins was found in any of the samples. No correlation between phytoalexin content and symptom severity was detecable taking the symptom severity into account.

To ascertain that the method used for detecting the phytoalexins is appropriate, 50µg/g FW each of pure brassinin, cyclobrassinin and methoxybrassinin were added to cotyledons of cv.Linetta before the extraction procedure. The recovery rates for the three compounds are shown in table 3.

Tab.3: Recovery rates of three phytoalexins, added to the cotyledons of cv.Linetta before the extraction procedure, detected by HPLC (mean of 3 replicates)

Phytoalexin	added	found	Recovery rate
	[µg/g FG]		[%]
Brassinin	50	49,05	98,1
Methoxybrassinin	50	46,65	93,3
Cyclobrassinin	50	46,45	92,9

4. Discussion

An induction of chitinases in response to fungal attack has been reported in several dicotyledoneous plants (BOLLER et al. 1983). Our report deals with the induction of chitinases in cruciferous plants.
In response to the non-aggressive isolate Pl 7, which causes restricted brown, necrotic leaf spots on cotyledons of cv.Jet neuf, the chitinase activity increases eightfold compared to the control. After inoculation with a sirodesmine producing pathogenic isolate, which causes light, grayish leaf spots on this cultivar, the increase in activity is twofold after 96h and decreases again to the level of control. Taking the findings of ROUXEL et al. (1988) and the results from our inoculation essays with sirodesmines and cycloheximide into account, it seems, that aggressive isolates are able to suppress the induction of chitinases and probably other pathogenesis related proteins. This is supported by results of HAMMOND & LEWIS (1987), who found a formation of a secondary cambium, callose deposition and lignification in response to a non-aggressive isolate in cv.Jet neuf, while these reactions were not observed after inoculation with an aggressive isolate.
A threefold increase in chitinase activity was detected in the resistant cv.Newton after inoculation with Pl 7 within 96h and the

activity remained on this level for another four days, while no induction was observed after inoculation with Pl 9. By adding cycloheximide or sirodesmins to the conidia suspension no lesion formation was noticed, indicating that a suppression of protein synthesis has no influence on fungal development on cotyledons of cv.Newton. This could be explained by preformed chemical barriers, like glucosinolates. Newton contains about 240 times the amount of alkylglucosinolates that are necessary to inhibit fungal growth *in vitro* (PETERKA & SCHLÖSSER 1989). The increase in chitinase activity in response to Pl 7 seems to be a more general response of the plants.
An induction of chitinases in Linetta was observed after eight days in response to Pl 7 and again no induction was detected in response to Pl 9. As the first symptoms are visible after six days, it means that at the time of response of the plant, the fungus is allready well established in the tissue. But still this reaction, possibly together with lignification and other defense reactions, leeds to a restriction of the lesion area as compared with aggressive isolates (Figure 1.).

Another protein synthesis dependend defense reaction is phytoalexin synthesis (SEQUEIRA 1983). Hence, the phytoalexin concentration in the cotyledons of the three cultivars was monitored after spraying the plants with conidia of a non-aggressive isolate and an elicitor. No correlation was found between fungal development on the leaves or elicitor treatment and phytoalexin accumulation. The concentrations found by DAHIYA & RIMMER (1988) in their investigations were fifty times higher as in the cotyledons in this study. Possibly phytoalexin synthesis occurs in true leaves and in the plants at later growth stages, but in the model investigated here the phytoalexins cyclobrassinin and methoxybrassinin do not seem to play an important role in resistance to *L.maculans*.
In 1989 ROUXEL et al. reported a new phytoalexin in *B.napus* and *B.juncea* which was not determined in our investigation. So the question whether phytoalexins are a factor of resistance in the host-pathogen system *L.maculans-Brassica* spp. requires further studies.

The results presented here indicate, that aggressive isolates of *L.maculans* are able to develop faster in leaves of *B.napus* and, by producing a group of toxins, are able to suppress the induction of chitinases and probably other defense reactions of the host-plants.

Acknowledgement

We wish to thank Prof. M. Takasugi (Hokkaido University, Sapporo, Japan) for supplying pure phytoalexins and Prof. H. H. Hoppe (Gesamthochschule Kassel, FB Landwirtschaft, Witzenhausen, FRG) for supplying sirodesmins. This investigation was supported by the Gemeinschaft zur Förderung der privaten deutschen landwirtschaftlichen Pflanzenzüchtung e.V.(GFP).

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STUDIES OF IN VITRO TOXIC EFFECT OF *PHOMA LINGAM* (Tode ex Fr.) Desm. CULTURE FILTRATE ON WINTER OILSEED RAPE (*BRASSICA NAPUS* L.) HAPLOID EMBRYOS

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Summary

A method was developed for *in vitro* screening of *Brassica napus* haploid embryos on *Phoma lingam* (Tode ex Fr.) Desm. culture filtrate selective medium. The haploid embryos were obtained from anthers on modified Gamborg B-5 medium supplemen-ted with 0.1 mg/l 2,4-D and 0,1 mg/l NAA.[1] The efficiency of embryogenesis was relatively high (143,9 %) but highly dependant on the cultivar. Haploid embryos from globular to late torpedo stage were subcultured on media with various concentrations of *Phoma lingam* culture filtrate (from 1 to 50 %). The embryos which survived from 6 to 8 weeks on a selective medium with the highest concentration of culture filtrate were derived from the Polish double low cultivar Bolko. They were regenerated into plants, vernalized and treated with colchicine to obtain double haploid plants. The seedlings from C-2 generation were examined for resistance in a greenhouse test. The majority of the lines obtained showed either delayed symptom development or a hypersensitive reaction.

1. Introduction

Phoma lingam (the asexual form of *Leptosphaeria maculans*) is one of the most severe fungal pathogens of oilseed winter rape in Poland (Frencel *et al.*, 1987) and other countries (Brunin, 1970; McGee, 1977; McGee & Emmett, 1977; McGee & Petrie, 1978; Williams & Delwiche 1979; Helms & Cruickshank, 1979; Renard & Brun, 1979; Lorelle *et al.* 1980; Krüger, 1983; Gabrielson, 1983; Seidel *et al.* 1984; Krüger & Wittern 1985; Hammond & Lewis, 1986). The rape cultivars differ in their resistance to *Phoma lingam* from more resistant like Jet Neuf (Cargeeg & Thurling, 1980; Sacristan, 1982) to the susceptible

[1]ABBREVIATIONS:
NAA - α-naphthaleneacetic acid,
2,4-D - dichloro-phenoxyacetic acid,
V8 - juice agar medium

ones like Quinta, Primor, Westar e.t.c. (Newman, 1984; Wittern *et al.*, 1985; Spanier, 1989).

There are three modern approaches to obtain more resistant plant material:

- making interspecific crosses with other Brassicaceae resistant to the fungus e.g. *Brassica juncea* or *Brassica carinata* (Gerdemann & Sacristan, 1986; Sacristan & Gerdemann, 1986),
- transferring the pathogen resistance by protoplast fusion e.g. from *Brassica nigra* (Sacristan *et al.*, 1989),
- screening *in vitro* of either calli, protoplasts, cells or embryos on selective media containing crude fungus culture filtrate or the pure toxin - sirodesmin PL (Sacristan 1981, 1982, 1985a,b, 1986; Spanier 1987; Sjödin *et al.*, 1987; Newsholme *et al.* 1988; Sjödin *et al.*, 1988; Spanier & Röbbelen, 1989).

All the methods mentioned above are impossible to carry out without using tissue culture techniques. The results obtained so far are both encouraging and discouraging (Newsholme *et al.*, 1988).

The aim of experiments reported here was to develop a method for mass screening of plant material seeking forms resistant to *Phoma lingam* infection, and to investigate the possibility of generating resistant winter oilseed rape lines. The approach chosen for this purpose was the utilization of haploid embryos culture on media containing fungus filtrate followed by plantlet regeneration and colchicine treatment. From the double haploid plants 55 lines were derived using self-pollination of isolated inflorescences.

2. Materials and methods

Phoma lingam cultures

The highly aggressive *Phoma lingam* isolate (P IV) (Frencel *et al.*, 1987) was grown for 4 weeks on shaken Czapek - Dox liquid medium supplemented with yeast (2g/l). The culture was filtered through muslin, filter paper, and finally through Sartorius 0.22 μm pore size filter. Haploid embryos were placed on Gamborg B-5 medium (Gamborg *et al.*, 1968) supplemented with different concentrations (0%, 1%, 5%, 20% and 50%) of the filtrate to determine the selective conditions (Starzycki *et al.*, 1987; Jędryczka & Starzycki, 1987). The highest concentration was used for the plant material selection.

The same isolate was used in the greenhouse test. Mycelium and pycnidia were scraped from V8 medium after 3 weeks of subculturing at 20°C, suspended in sterile distilled water and filtered. The suspension was adjusted to 1.5×10^7 pycnospores per 1 ml of water.

Androgenesis

The anthers were taken from young inflorescences of rape grown under field conditions. After sterilization with Parthlenone solution containing Tween 80 for 15 min the flowers were shaken 3 times for 5 min in sterile water. The anthers were cultured on Gamborg B-5 medium (10% sucrose, 0.1 mg/l NAA, 0.1 mg/l 2,4-D, 100 mg/l m-inositol, 100 mg/l L-serine, 800 mg/l L-glutamine). They were incubated at 35°C in darkness for 3 days and then transferred onto fresh medium and incubated at 25°C. The primary embryos obtained were placed on Gamborg B-5 medium (2% sucrose, 25 mg/l m-inositol, 25 mg/l L-serine, 100 mg/l L-glutamine).

Selective media

The sterile culture filtrate with pH adjusted to 5.8 was merged into cool Gamborg B-5 medium (3% sucrose, 25 mg/l m-inositol, 25 mg/l L-serine, 25 mg/l L-glutamine) with the same pH in following proportions:

I - control - no filtrate in medium
II - 1 % of filtrate in the final medium
III- 5 % of filtrate in the final medium
IV - 20 % of filtrate in the final medium
V - 50 % of filtrate in the final medium

In vitro testing

The primary haploid embryos of *B. napus* in globular, heart and torpedo stages (1337 in total) were transferred onto all variants of selective media. The majority of them came from the cultivar Jet Neuf and were placed on variants IV and V. The embryos were grown on the selective media for 2×4 weeks and thereafter the surviving ones were transferred onto Gamborg B-5 medium without the filtrate.

Regeneration and propagation of plants

The surviving embryos were cultured on Gamborg B-5 medium until they were seedlings, 3 to 5 cm long, and transferred into beakers with water and kept for 10 days under plastic covers. Thereafter the plants were placed in sterile soil mixed with perlite. They were vernalized in the rosette stage for 8 weeks at 4°C. The vernalized plants were treated with colchicine (0.05% solution) for 12 hours and thoroughly washed. The plants were grown under greenhouse conditions. The inflorescences were isolated and seeds of the C-1 generation were harvested and sown in the field in autumn 1988. The C-2 seeds were collected, after inflorescence isolation, from each plant separately.

Greenhouse testing

The progenies of 51 lines resistant *in vitro* to the highest concentration of culture filtrate were tested in greenhouse conditions together with 11 *Brassica napus* cultivars and 5 lines of *Brassica nigra*. The test was based on the method described by Williams (1985) as modified by Sjödin & Glimelius (1988). Each line was represented by 20-40 plants, depending on its fertility. Cotyledons of all 2-week-old seedlings were punctured twice in the middle of each half and every wound was covered with a 10 μl droplet of pycnospore suspension adjusted to 1.5×10^7 (control was sterile water).

Symptoms were thoroughly scored for each lesion 12 days after inoculation according to the following scale:

0 - no visible symptoms
1 - the edge of lesion slightly brown
2 - brown edge around lesion
3 - dark-brown edge plus some brown staining around lesion

4 - necrosis up to 1 mm radius
5 - the lesion surrounded by 2 mm necrosis, visible pycnospores
6 - necrosis 5-6 mm diameter, the cotyledon starts becoming yellow
7 - large parts of cotyledons yellow, deep necrosis with pycnospores
8 - cotyledon entirely yellow but attached to the seedling
9 - fallen necrotic cotyledon

The mean value for each line and cultivar was calculated from 60-120 individual observations.

3. Results

Androgenesis

The total efficiency of androgenesis was relatively high, 143.9 %, but the mean value was misleading because the number of primary haploid embryos obtained differed greatly - depending on the cultivar (Table 1).

Table 1. Number of anthers cultured on modified Gamborg B-5 medium and primary haploid embryos obtained

No	Cultivar - donor of anthers	Number of anthers		% of embryo-genic anthers	Number of primary embryos obtained
		cultured	embryo-genic		
1	Skrzeszowicki	74	0	0	0
2	Bolko	48	12	25	145
3	Jet Neuf	66	15	23	*ca* 1200
4	Jantar	42	5	12	36
5	Mikado	49	0	0	0
6	Rafal	66	6	9	52
7	Cobra	78	1	1	5
8	Ceres	64	0	0	0
9	Primor	82	0	0	0
10	Jupiter	84	1	1	1
11	Bienvenu	80	1	1	1
12	Marinus	79	0	0	0
13	Lirama	98	0	0	0
14	Librador	93	1	1	3
	Total	1003	42	73	1443
	Mean	72	3	5	103

In vitro testing

The embryos subcultured on media with low concentrations of culture filtrate of *Phoma lingam* (1% , 5%) did not visibly differ from the controls. They were green, without stains and successively developed normal stages toward the seedling. The 20% concentration restricted growth and development of embryos, mainly in the globular and heart stages; the majority of embryos were stained. A seriously toxic effect was observed at the highest concentration (50 %); nearly all of the embryos turned brown, stopped growing and died. Only 20 embryos out of 1337 tested remained green and developed normally; 18 of these embryos came from the Polish double low cultivar Bolko and 2 from Jet Neuf. The mean efficiency of surviving embryos was 1.5% and varied from 12.4% for Bolko, 0.18% for Jet Neuf to 0% for Jantar and Rafal.

Table 2. Mean value of infection level for lines derived from Bolko (A) and cultivars of winter oilseed rape and *Brassica nigra* tested by inoculation of cotyledons

No	Line or cultivar	Mean infection severity**
1	Rafal	8.48
2	A-3	7.68
3	Ceres	7.34
4	Bolko	7.33
5	Liracus	7.28
6	Jantar	7.27
7	A-4	7.24
8	MAH 386	7.02
9	Primor	6.79
10	Licantara	6.52
11	A-6	6.42
12	A-7	6.39
13	A-2	5.98
14	A-1	5.96
15	A-13	5.91
16	A-8	5.45
17	Marinus	5.42
18	Primus *	5.32
19	A-11	5.22
20	A-9	5.18
21	Sizaja*	4.96
22	A-16	4.90
23	A-65	4.86
24	A-50	4.70
25	A-12	4.58
26	A-47	4.53
27	A-10	4.27
28	BOH 1187	4.16
29	A-48	4.15
30	A-46	4.14
31	A-60	3.95
32	Jupiter	3.84
33	A-14	3.79
34	A-51	3.60

No	Line or cultivar	Mean infection severity**
35	A-28	3.40
36	A-15	3.29
37	A-17	3.07
38	Bulharska*	3.06
39	A-63	3.00
40	A-24	2.73
41	Rumuńska*	2.52
42	A-25	2.03
43	A-44	1.95
44	A-43	1.87
45	A-45	1.80
46	A-26	1.75
47	Krasnodarska*	1.75
48	A-18	1.68
49	A-67	1.66
50	A-42	1.35
51	A-20	1.35
52	A-19	1.28
53	A-68	1.17
54	A-35	1.00
55	A-37	0.92
56	A-36	0.88
57	A-39	0.86
58	A-71	0.82
59	A-34	0.77
60	A-41	0.75
61	A-40	0.60
62	A-29	0.58
63	A-38	0.56
64	A-32	0.58
65	A-72	0.32
66	A-33	0.30
67	A-30	0.23

* *Brasica nigra* cultivars

** Scale from 0 (resistant) to 9 (totally susceptible)

Regeneration and propagation of plants

All embryos resistant to the highest concentration of culture filtrate were successfully regenerated into plants. Plants obtained from the two surviving Jet Neuf embryos remained infertile. Eighty-four seeds obtained from the C-1 generation before autumn 1988 were sown in the field. Not all of them germinated and the plants obtained differed in vigour and fertility. Progeny (C-2) seeds were collected from the 55 best plants.

Greenhouse test

The first symptoms could be seen a few days after cotyledons inoculation and differences among lines and cultivars were clearly seen after one week. The mean scores obtained for all the lines and cultivars on the 12th day after inoculation are shown in Table 2.

Further observations revealed that the disease symptoms developed steadily on nearly all plants and after 3 weeks plants of only a few lines still possessed cotyledons. The 10 lines showing typical hypersensitive reactions seem to be the most promising plant material for breeding purposes.

4. Discussion

Obtaining resistance to biotic factors seems to be one of the most complicated problems in biological science A plant searches mainly for genetically resistant lines with high inheritance of resistance traits, but it is well known that there are many other characteristics which also make plants/ cultivars resistant. These are: climate and soil conditions, the appropriate agronomy, the aggressiveness and number of fungal propagules (in soil, air and seed material), ability of defence with phytoalexins etc. The role of secondary metabolites must also be taken into consideration.

This tendency of touching the problem from all sides can also be seen with *Brassica napus* and its fungal enemy - *Phoma lingam*. There are publications on phytoalexin accumulation in rape tissues inoculated with *Leptosphaeria maculans* (Dahiya & Rimmer,1988; Rouxel *et al.*, 1988) and the antifungal activity of glucosinolates (Mithen *et al.*, 1986 and 1987; Peterka & Schlösser, 1990 in press). However, breeding for resistance has profited from knowledge and use of the toxic effects of fungal culture filtrates (Sacristan, 1982) or sirodesmin PL, its phytotoxin (Sjödin *et al.*, 1987), in tissue culture conditions.

The results obtained in our laboratory seem to be very promising. The method we have developed advantages from haploid and double haploid plant material, exploits both the slightly mutagenic action of 2,4-D contained in media and the effects coming from gametoclonal variation.

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RESISTANCE TESTING IN OILSEED RAPE

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Summary

The increase of oilseed rape over the past decade has stimulated both an increase and an interst in its diseases. A disease survey in 1987 revealed that Phoma lingam was the most important fungus on oilseed rape in Germany. Resistance tests have to be developed for some diseases of oilseed rape. Unfortunately, the methods used have to be different for different pathogens. There are fungi which have a wide host range such as Sclerotinia sclerotiorum (Lib.) de Bary, Botrytis cineria Pers. ex Pers. and Verticillium dahliae Kleb. On the other hand fungi such as Phoma lingam (Tode ex Fr.) Desm. and Cylindrosporium concentricum Grev., to mention only the most important ones, affect few other species.
In resistance breeding the chances of success are very slight within the first group of fungi from a genetical point of view, although it may be possible to develop cultivars which escape infection. Success is more likely with the second group of fungi as has been demonstrated by the breeders. As resistance is probably governed by several genes, the aim should be to develop cultivars which have "horizontal resistance", which of course can be influenced by the infection pressure presented each season. This resistance must be effective against all the strains or races of the fungus.- This paper discusses now the methods used in resistance breeding ralate to the epidemiology of the fungi infecting oilseed rape.

I. Introduction

Breeding for disease resistance is a major aim in "Integrated Plant Protection" to avoid or reduce the use of plant protection chemicals. Unfortunately, there is quite a difference in the success achieved with different diseases due to the biology and epidemiology of the pathogens. An important factor is the influence of climate on the occurrence of several diseases. Furthermore, farmers should be encouraged much more a) to make observations on disease occurrence and b) to leave about 20- 30 m areas of crop unsprayed to check on the effect of treatments. Only be these means is it possible to get an impression of the real disease occurrence and the effectiviness of control measures.

From the point of view of practical research and for comparing the results of different workers within the IOBC it should be our aim to use scales of disease assessment which are similar. In the IOBC-Bulletin of 1990 (in press) I compiled the scales used forseveral diseases. Generally the trend was for scales to have several categories and it may be that 1- 9 will be the optimum. In this respect I only want to mention the statistical/mathematical implications involved when scales are used. All of us know the problems, but we do not have better proposals. Few diseases, however, can be estimated as % plant part infected, e.g. with root rot or leaf diseases. In this respect I would prefer the estimation to be on a percentage area basis.

2. Sclerotinia sclerotiorum

Now to the diseases themselves and the opportunities presented for successfully testing for resistance. Sclerotinia sclerotiorum (Lib.) de Bary, a fungus with a wide host range, can not yet be controlled by breeding. A certain degree of disease reduction was obtained repeatedly when certain cultivars escaped infection when flowering set in late (Fig. 1) in late flowering cultivars. Inoculations with the fungus into the stems revealed no differences,-double low cultivars behaved in a similar manner to single low cultivars. Unfortunately, the number of observations was only 5-6 or even less, due to slight infections in recent seasons when these cultivars were tested (Table 1).

Table 1. Susceptibility of oilseed rape cultivars to Sclerotinia sclerotiorum

Cultivars	Number of experiments in which the cultivars were classified according to a sclae 1- 9*					Number of experi-ments	Mean score*
	1	3	5	7	9		
Arabella			4	1		5	5.4
Ceres			4	1		5	5.4
Cobra			5	1	1	7	5.6
Liborius	2		3	1		6	4.0
Libraska	2		4	1		7	4.1
Libravo	1	1	5			7	4.1
Licantara			2			2	5.0
Lictor		1	5			6	4.7
Libritta	1	1	5			7	4.1
Liporta		1	4			5	4.7
Liquanta	1		5			6	4.3
Lirabon			2			2	5.0
Liradonna		1	4			5	4.7
Lirakus	1		4			5	4.2
Panter			6			6	5.0
Rubin	2	4	8	2	1	17	4.5
Santana			2			2	5.0

* 1= healthy, 9= severly attacked

Testing for resistance should be carried out under natural conditions in soil inoculated with sclerotia in autumn. This amendment with the fruiting bodies does not always lead to infection if the climatic conditions are unfavourable- e.g. heavy rains during flowering causing the spores to be washed onto the soil or a drought period before and during flowering. In the latter case the apothecia are not able to emerge through the soil surface or if they succeeded in this, they dry up afterwards. Spraying spores onto plants under both these weather conditions is not very helpfull because the spores are either washed off or they dry up.

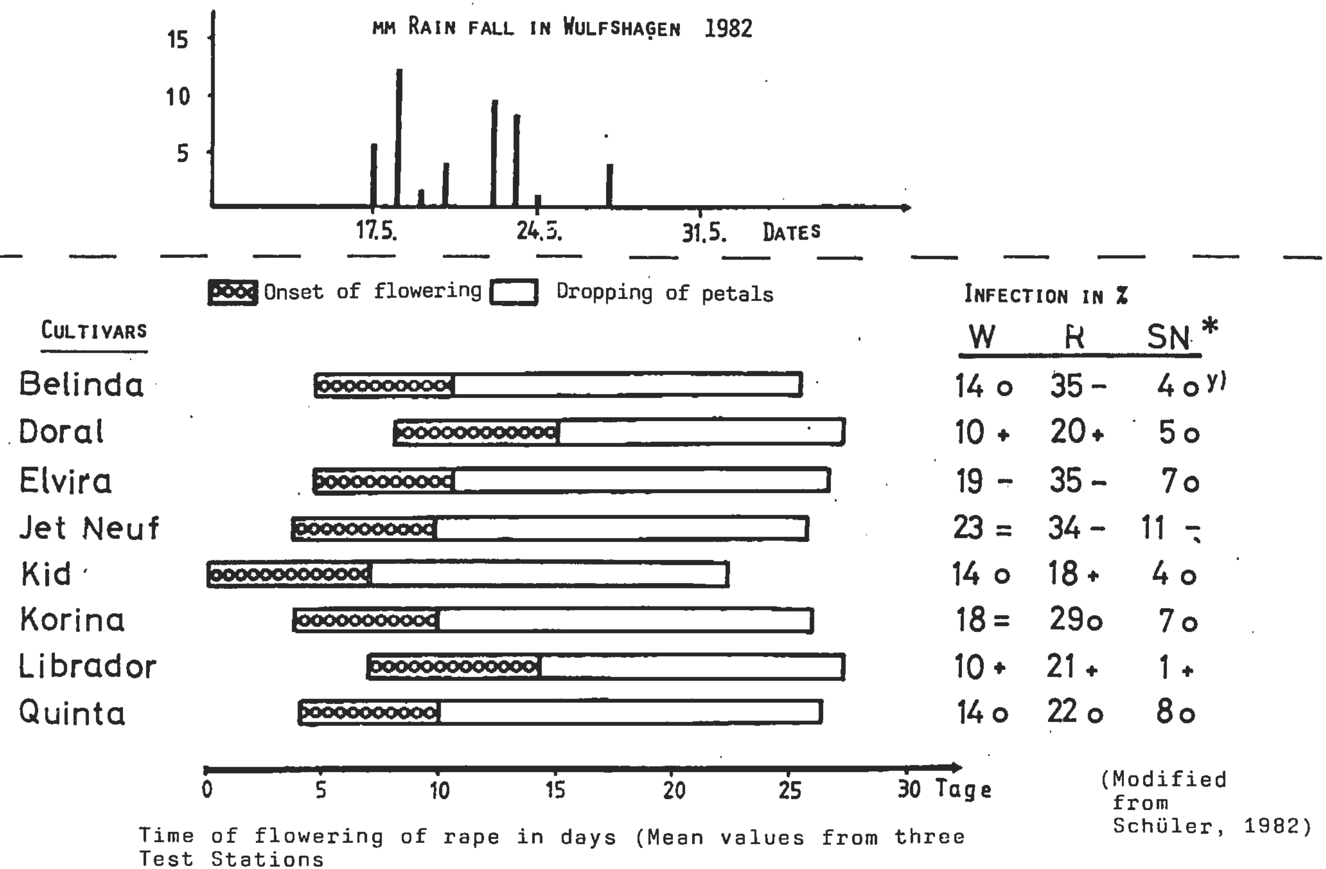

Fig. 1. Infection rate of oilseed rape cultivars with Sclerotinia sclerotiorum dependent on petal fall at three Test Stations

y) ++ resistant, + moderate resistant, o moderate susceptible, = very suceptible (1- 9)

*) W= Wulfshagen, R= Rosenhof, SN= Söhnke Nissen-Koog

3. Verticillium dahliae

Similar probelms are present with Verticillium dahliae Kleb The fungus has a wide host spectrum (Wooliams, 1966). The epidemiology is quite different from that of S. sclerotiorum. The fungus attacks the plants from the soil and grows within the vascular bundles causing a wilt symptom in many plant species. Resistance tests have to be carried out in inoculated soil. There is an indication that greenhouse tests may be used as well, but discrepancies between the results with this test and those under field conditions have to be expected (Fig. 2) since results also vary from field to field and season to season. Details about these methods will be published in the near future (Krüger, in press).

There is, however, a drawback to greenhouse tests, especially if winter oilseed rape cultivars are used. Generally the plants grow well when sown in pots at the end of August and left in the open for vernalization up to the end of Dezember; afterwards the plants are transferred to temperatures of at least 20°C. If, however, the temperature is high after sowing, es experienced in 1989/1990, many plants were infected at a young stage. This corresponds with the temperature requirements of the fungus, which grows best between 15 and 25°C (Krüger, in press). These temperatures are generally not common in September/October at 5- 10 cm soil depth. Work now in progress or planned will compare the reactions of young plants grown in the greenhouse at high and at cool teperatures with developing under field conditions. Emphasis should be paid to the possibility that V.dahliae may attack either very young plants or only those which reach the ripening stage. It has to be investigated whether a chemical analysis of young plants is possible to prove infection. Even if success in this is achieved the question remains whether the fungus is active and developing or dormant inside the plant. The inoculation of the soil should be carried out on fields with no previous history of oilseed rape and with infested oat kernels incorporated as inoculum rather than with infected stems, because the latter are in most cases also infected with Phoma lingam (Tode ex Fr.) Desm. The presence of P.lingam interferes to a certain degree with the symptom development of V. dahliae

4. Cylindrosporium concentricum

Another disease, up to now occurring sporadically and probably only in warm autumns and winters in Germany, is caused by Cylindrosporium concentricum Grev. It has its main infection areas in in certain districts in England. There are differences in resistance between Brassica species and between cultivars of oilseed rape (Maddock, Ingram and Gilligan, 1981). On one occasion in Germany in 1988 scoring of a "Wertprüfung" revealed that the reference cultivars were generally less infected than certain other entries. The variation between the cultivars was quite obvious as shown by the minimum and maximum scorings of the Bundessortenamt (Table 2). Depending on the Test Stations, the best differences were obtained under high infection pressure (Stations C and F) Of the registered cultivars "Arabella" and "Ceres" had a higher disease rating than "Lirabon" and "Libravo" at several Test Stations observed by Ahlers (1990).

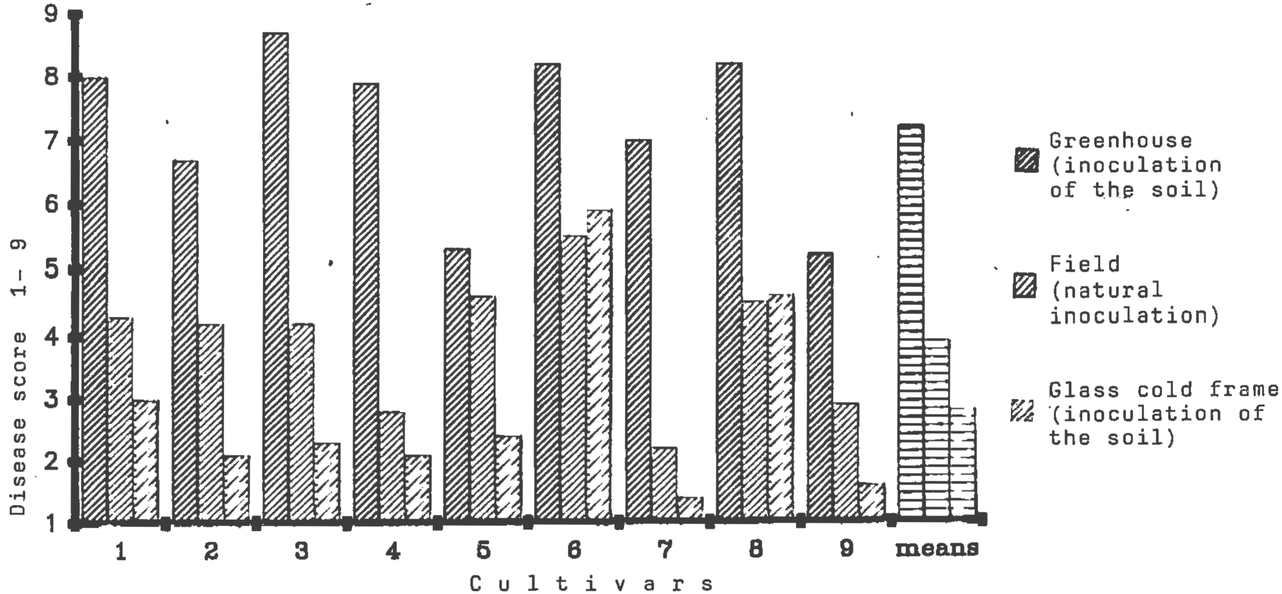

Fig. 2. Susceptibility of oilseed rape to <u>Verticillium dahliae</u> - Comparison of three methods (greenhouse, field and glass cold frame)

Table 2. Susceptibility of oilseed rape cultivars to *Cylindrosporium concentricum* (scale 1- 9) at various Test Stations (A- F), 1989.

Cultivars 1- 34	Test Stations A	B	C	D	E	F	Mean
Mean	3.9	2.6	3.7	2.5	1.7	3.6	3.0
Maximum	5.0	5.0	7.0	3.5	3.0	7.0	4.6
Minimum	3.0	1.8	2.0	1.3	1.0	2.0	2.5
Difference	2.0	3.2	5.0	2.2	2.0	5.0	2.5

5. *Phoma lingam*

The most impotant disease is caused by *P. lingam*. Methods to test cultivars were compared and published by Wittern (1984). It is possible to discuss whether a special field should be used for disease determination or whether some fields naturally infested with *P. lingam* should be used. The decision will depend on the manpower available. I personally prefer screening at several places to obtain more results, because the diseases discussed have in all probability several genes which govern the severity on the respective fields. The more results available the better the possibility to determine the fluctuation of the disease on the cultivars. There are some with a high degree of fluctuation, others behave in a similar fashion (Table 3).

The assessment for *P. lingam* has to be carried out on plants removed from the field at growth stage (EC) 83-85 and not later. Depending on the soil type the plants must be washed to score the symptoms on the root collar and the stem. Usually it is sufficient to cut the stalks at about 30 cm height. At least 25- 30 plants must be used per replication. Breeders have been able to succeed in developing cultivars which have a "field" or "horizontal" resistance for all parts of Germany, irresspective of races or strains of the pathogen.

By changing the breeding aims, however, it always happens that some degree of resistance is lost. The best example is *P. lingam*, resistance was present in single-low cultivars at a tolerable level, but decreased within double-lows. Now, after the goal of double-lows has been reached, emphasis is placed again on diseases and the success is visible with cultivars having a similar degree of restistance to those in former single-low cultivars.

I hope and wish that the breeders may be able to help by reducing at least some diseases to a level where fungicide treatment is not neccessary; by this means the farmer and our environment will be helped.

Table 3. General suceptibility of double-low oilseed rape cultivars to Phoma lingam over several seasons and various Test Stations

Cultivars	Number of experiments in which the cultivars were classified according to 1- 9 scale					Number of experiments	Mean score
	1	3	5	7	9		
Arabella		1	13	3	2	19	5.6
Ceres		1	15	3		19	5.2
Cobra		2	5	3	4	14	5.6
Diadem	4	5	4			13	3.0
Elena		2	7	3	2	14	5.7
Liborius			7	6		13	5.9
Libraska	3	5	5			13	3.3
Libravo		4	10			14	4.4
Libritta	3	3	6	2		14	3.9
Lictor	1	2	7	4	4	18	5.9
Lindora	1	6	5		2	14	4.4
Liporta	2	6	4			12	3.3
Liquanta	1	5	8			14	4.0
Lirabon	3	5	10	1	1	20	4.2
Liradonna	1	4	8			13	4.1
Lirajet	5	3	3			11	2.6
Lirakus		4	6	1	1	12	4.8
Panter	1	3	6	3		13	4.7
Rubin	4	8	21	4		37	4.4
Santana		1	9	2	1	13	5.5

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VARIETY BREEDING FOR DISEASE RESISTANCE IN DOUBLE-LOW WINTER OILSEED RAPE IN GERMANY- SITUATION AND RESULTS

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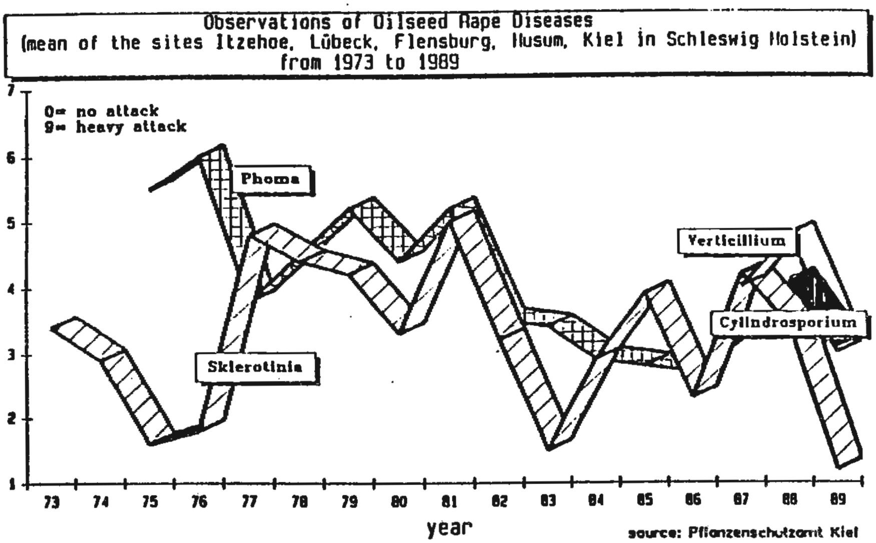
The increasing area of oilseed rape in West-Germany, up to 550.000 ha in 1990 has led to greater problems with disease and a higher infection potential.

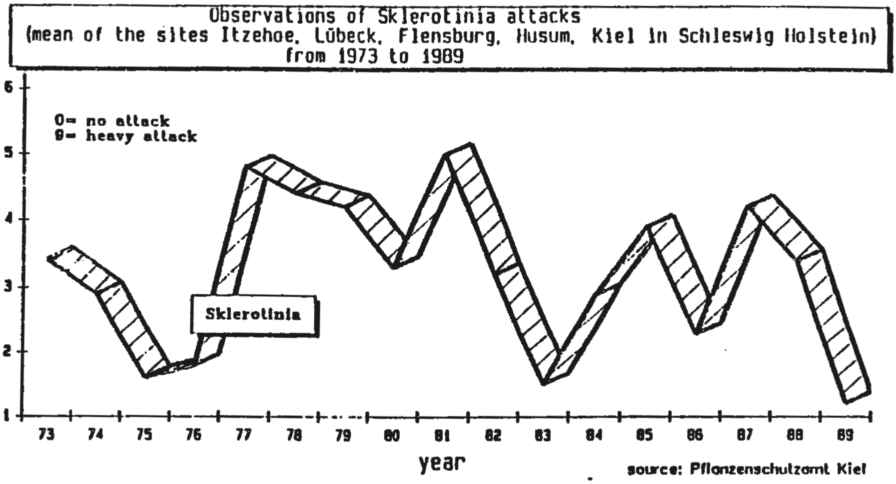
Traditionally, winter oilseed rape has been grown extensively in the northern part of Germany in the state of Schleswig-Holstein. Therefore, the highest infection potential is reached in this area. Figure 1 summarises reports from the Amt für Pflanzenschutz in Kiel showing the occurance of rapeseed diseases since 1973 in the four main growing areas: It is important to know that in 1974 Western-Germany totally changed to growing single-low varieties and between 1985 and 1987 gradually changed to double-low varieties.

Fig. 1



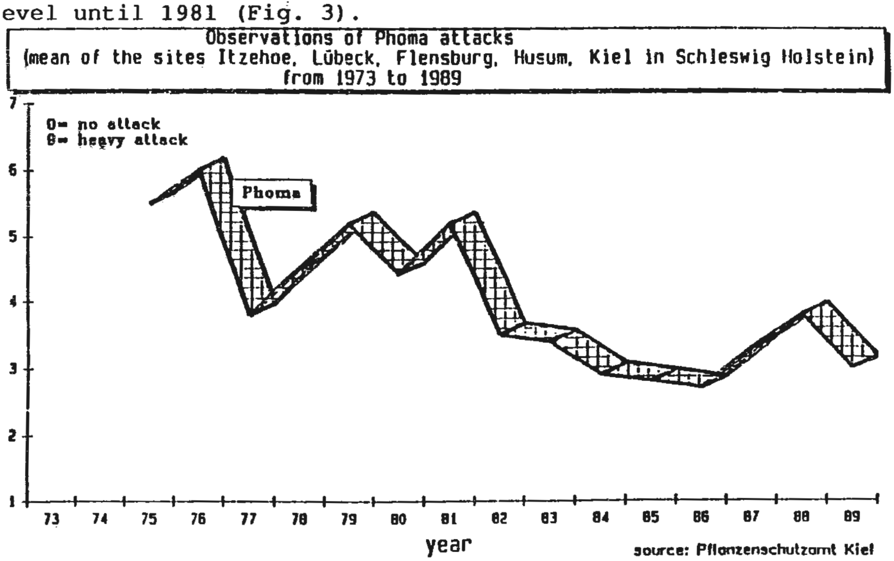
Over the period in question the four diseases Phoma, Sclerotinia and - especially during the last years - Verticillium and Cylindrosporium were observed. The intensity of attack with Phoma and Sclerotinia is of great interest. Sclerotinia was observed at all times while Phoma started in 1974 and Verticillium and Cylindrosporium in 1987 and 1988 respectively.

Fig. 2



Attacks by Sclerotinia varied over the years (Fig. 2). Depending on infection conditions of the year in question there were years with severe attack and some with slight attack. It is very difficult to prove a relationship to rape varieties, but more easy to note dependency of disease on crop rotation.

The situation with Phoma was quite different. In 1974 Germany totally changed to growing single-low varieties. The first single-low varieties showed greater Phoma susceptibility. Therefore, in 1975 there was a severe Phoma attack which remained at a high level until 1981 (Fig. 3).



In 1981 the single-low variety Jet Neuf, with a high level of Phoma resitance was registered and was the dominant variety in the following years. Since that time until 1986 Phoma attacks on rapeseed population declined.

Since 1985 W-Germany gradually changed to growing double-low varieties. The first varieties also showed a high susceptibility to Phoma and therefore the infection potential grew again, altough the slight attack in 1989 can be explained by dry weather which was not conducive to infection. The example of Phoma and Jet Neuf shows that cultivation of resistant varieties leads to a reduction of infection potential.

The same diseases are found in the southern Germandistricts.Only Sclerotinia varies from site to site. The disease Alternaria is of greater importance. Verticillium only appears in fields which have had a high proportion of oilseed rape in the crop rotation.

Since 1971 breeders have been developing double-low winter rape. To reach this aim the double-low quality of spring rape had to be transmitted to winter rape. DSV breeders have worked with the backcrossing method (Table 1).

Table 1.

DSV backcrossing breeding scheme for development of double-low oilseed rape varieties

year of crossing	O			●	listing year	variety	portion of winter rape in %
1972	spring rape Erglu Oro x Bronowsky)		X	winter rape (Lenora,Liragold, Rapol, Markus Jet Neuf)			60
	◒						
O ◒ ●		F1					
		F2		winter generation			
1974		F3	X	winter rape			75
							87,5
1976		F3					
							93,8
1978		F3					
							97
1980		F3					
1982		F3					98,8

Every backcrossing step increased the portion of winter rape character in the new varieties. This had a positive effect on the yield level, which can be seen in the results for the varieties listed in 1989 (Table 2).

Table 2.

Oil content, oil and seed yield of the varieties listed in December 1989 (mean of vcu tests 1987 - 89)

	breeder	seed yield rel.	oil content in %	oil yield rel.
o-standard varieties				
Lirakotta	DSV	105,0	39,9	104,0
Belinda	SEM.	100,0	40,1	101,0
Jet Neuf	NPZ	95,0	39,1	94,0
oo-standard varieties				
Lirabon *	DSV	102,0	41,5	105,0
Ceres *	NPZ	103,0	41,6	107,0
Lirajet	DSV	108,0	41,7	111,0
Liberator	DSV	109,0	41,9	113,0
Lirektor	DSV	104,0	41,1	106,0
Doublol	DSV	102,0	41,5	104,0
Falcon	NPZ	105,0	41,5	108,0
Collo	Eger	99,0	42,2	103,0
average yield in 100 kg/ha		39,6	39,7	15,8
no. of results		30,0	30,0	30,0

* = standard varieties since 1988, tested for only 2 years.
source: vcu results 1987 - 89

Winter oilseed rape varieties listed in 1989 exceeded for the first time the best single-low standard variety Lirakotta in yield, oil content and oil yield (by the mean of 3 years). In the beginning the breeding aims of quality, yield and frost resistance were of interest. But the first double-low varieties had lower disease resistance than the good single-low varieties. In our breeding program we therefore systematically carried out crossings and selections for disease resistance. Selection was made on locations where the natural infection potential was increased by spreading collected infected material. At harvest time healthy single-plants were selected and maintained. However, the German National List only describes the characters of Phoma and Sclerotinia susceptibility (Table 3).

Table 3.

Resistance to Phoma and Sclerotinia of selected double-low winter oilseed rape varieties				
variety	breeder	year	resistance to Phoma	resistance to Sclerotinia
Lirabon	DSV	1985	5	5
Ceres	NPZ	1986	5	4
Arabella	Semundo	1986	5	5
Libravo	DSV	1987	6	6
Cobra	NPZ	1987	4	4
Liborius	DSV	1988	5	5
Diadem	NPZ	1988	8	6
Libraska	DSV	1988	8	6
Lictor	DSV	1988	5	5

source: National List 1989 (BSA) 9 = very resistant

For Sclerotinia the scores of all varieties are very close to each other (between 4 and 6). Scores for susceptibility to Phoma range from 2 (low) to 6 (medium) and show the differences between the varieties. The National List s testing system allows only an orthogonal comparison of varieties listed in the same year. Table 4 shows the values for Sclerotinia.

Table 4.

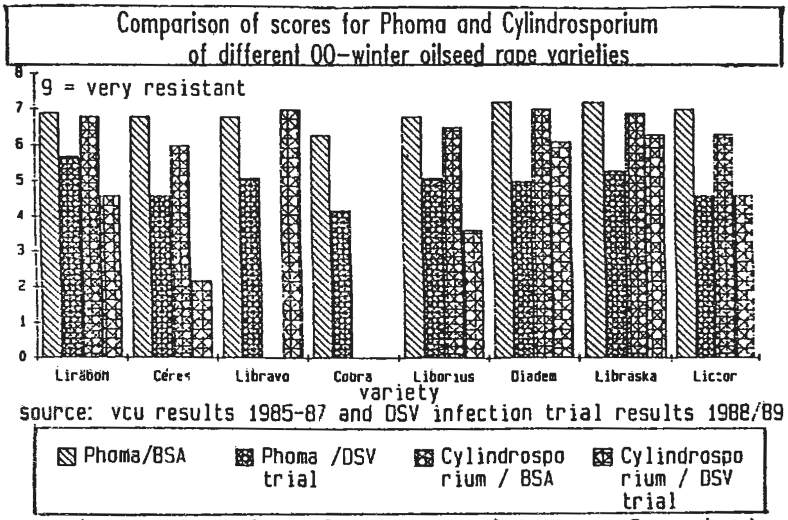
Classification, scores and percentage of attacked plants with Sclerotinia of the 1987/88 listed double-low winter oilseed rape varieties(mean of 3-year vcu tests)				
	variety	classification	score	% of attacked plants
	Libravo	6	7,4	22,9
	Cobra	4	7,0	35,3
	Liborius	5	7,1	23,7
	Lictor	5	---	30,2
	Libraska	6	7,7	18,9
	Diadem	6	7,6	20,2
number	1985 - 87		9	7
of results	1986 - 88		10	7

source: vcu results 1985 - 87 and 1986 - 88 9 = very resistant

Varieties classified "4" have lower scores and a higher (about 10%) percentage of attacked plants than the varieties classified "6". The intensity of attacks can be quite different between the years. The available level of resistance is not sufficient in years with heavy attack. We tried to select for Sclerotinia resistance by artificial infection but the results were not satisfactory. In 1987-1989 3.852 plants were infected. Progenies of the plants selected as resistant did not have better resistance. These results show that resistance selection against Sclerotinia was not successful.

The situation with Phoma and Cylindrosporium is quite different. VCU results show a close score classification resulting from the fact that a mean was taken over a large number of sites. Observing the varieties in special tests shows better differences in disease resistance (Fig.4).

Fig. 4.



These results show that the resistance of varieties is expressed more clearly when observations are carried out in special trials. This was especially true for the varieties listed in December 1989, such as LIRAJET and LIBERATOR, which show a better resistance against all important diseases (Table 5).

Table 5.

Resistance to different disease of the winter oilseed rape varieties listed in December 1989 (mean of 1987 - 89)

	breeder	Phoma	Alternaria	Sclerotinia	Botrytis	Cylindro-sporium	Verti-cillium
o-standards							
Lirakotta	DSV	7,0	6,2	6,6	5,7	6,4	6,1
Belinda	SEM	6,6	6,3	6,4	6,6	5,7	5,8
Jet Neuf	NPZ	7,2	5,9	6,3	5,5	5,4	6,6
oo-standards							
Lirabon *	DSV	6,6	6,6		5,6	7,1	5,5
Ceres *	NPZ	6,5	6,0		5,0	6,3	5,8
Lirajet	DSV	7,2	6,7	7,0	6,6	6,0	6,6
Liberator	DSV	7,0	6,5	7,2	6,9	7,4	7,1
Lirektor	DSV	6,8	6,6	6,9	6,0	7,2	6,7
Doublol	DSV	6,8	6,3	7,1	6,4	7,3	6,5
Falcon	NPZ	6,8	5,8	6,2	5,5	5,9	5,6
Collo	Eger	6,8	6,4	6,9	6,2	6,7	6,6
no.of results		25,0	5,0	8,0	3,0	10,0	4,0

* = standard varieties since 1988, tested for only 2 years 9 = very resistant

source: gathered results 1989

The results of our tests with infection show that there is horizontal resistance to *Phoma* and *Cylindrosporium*. Each variety has susceptible and resistant plants in the population but resistant varieties have less infected plants; Table 6 illustrates this for *Phoma*.

Table 6.

Results from Phoma infection trial of a resistant, a medium susceptible and a susceptible variety

variety	$\bar{X}$ mean	number of plants per score class 1	3	5	7	9
Lirajet	6,3	2	8	13	4	17
Lirabon	5,0	4	16	8	6	10
Cobra	3,5	12	14	5	6	3

9 = very resistant   source: DSV Phoma infection trial

The same resistance behaviour can also be shown for Cylindrosporium.

In summary our results have shown that only weak resistance against *Sclerotinia* can be found, but good resistance against *Phoma* and *Cylindrosporium* can be obtained. It is possible to select for good disease resistance against other diseases such as *Verticillium*, *Botrytis* and *Alternaria*.

SESSION 4

Biology and Control of Pests

OVIPOSITION MARKER IN THE CABBAGE SEED WEEVIVL, *CEUTORHYNCHUS ASSIMILIS*, REMARKS ON A FILM: "DANCE FOR THE NEW GENERATION"

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Summary. A film "Dance for the generation shows in some detail ovipositional behavior in the cabbage seed weevil, *Ceutorhynchus assimilis*, and compares it with the related behavior found in different insects also . "dance" on their host object while depositing ovipositional markers. Research on persistency, pheromonal status, behavior of the females on plants in semi-natural conditions as well as preliminary comparison with ovipositional behavior of other *Ceutorhynchus* spp. is reported.

1. Introduction

"Dance for the new Generation or covergency in reproductive behavior of three different insect species" (Kozlowski, 1987) is a film that depicts ovipositional habits in females of the cabbage seed weevil, *Ceutorhynchus assimilis* (Coleoptera: Curculionidae), the cherry fruit fly, *Rhagoletis cerrasi* (Diptera: Tephritidae) and a Scelinid wasp, *Trissolcus* sp. (Hymenoptera: Scelionidae). Females of all these insects perform a specific movement ("a dance") after deposition of each single egg into their hosts (respectively: a winter rape seedpod a cherry fruit and an egg of a Pentatomid bug). During this "dance", they propagate a chemical substance on the host surface that deters the same or other females from deposition of another egg into the same host. It is suggested that such strict similarities in behaviors of taxonomically unrelated species could evolve as a consequence of the same selection pressures, related to increased fitness by a proper partitioning of resources for the progeny and by effectiveness in fast recognition of "free" and already "occupied" objects. (see also: Prokopy, 1981; Prokopy and Roitberg, 1984).

For the cabbage seed weevil, a separate study demonstrated the chemical character of a factor related to a "female dance". (Fig.1.) and close proximity (contact and/or olfactory) perception, for which inspection of a pod by a female is required (Kozlowski et al., 1983). Here, I report selected results of a subsequent study on the ovipositional marker that have not been published, and those of Kozlowski and Dmoch(1985) as well as Kozlowski and Dmoch (1990), that appeared in polish.

2. Persistency and pheromonal status of the marker

Contact or close proximity perception of the marker made important the question on its persistency, for both biological and practical (prospects in chemical identification and field application) aspects. To check whether the marker was persistent, we submitted pods that had been marked and kept for different periods of time, to females of uniformized oviposition drive We compared acceptance levels of such pods, counting the number of inspections before acceptance (=oviposition) took place. It was found that the "deterring power" of the marker apparently fell after about one hour following oviposition (Fig. 2.). The conclusion was that the oviposition deterrent was not very persistence, and that the marker was not a sole factor responsible for a high tendency ($p<.001$, $\chi 2$-test) to "one egg/one pod" distribution observed in the field. Results of this test hindered our motivation for chemical identification of the marking substance.

To answer the question on the origin of the marker, we considered both possible sources: the female body and the plant. Comparison of "deterring power" of pod freshly marked by a female or pods treated by the pod sap or the weevils' faces collected the walls of a glass container revealed that the two latter factors were less ($p<.01$, Mann-Whitney test) active than the original marker.

The classical definition of a pheromone describes its body origin and action on the other members of the species (Carlson and Luescher, 1959). The first condition has been fulfilled by the "deterrence" characteristic of the marker, the second, however, has not; at least in relation to the presumed behavior of the females in the field We speculated, that the prime function of the marker was rather "to organize" the female's behavior in a short term, e.i. to increase efficiency a of a visit to a single plant (where usally a number of pods proper for oviposition is available) then to protect her own progeny from the progeny of other females. Roitberg and Prokopy (1987) showed, that an analogous situation can exist with fruit flies.

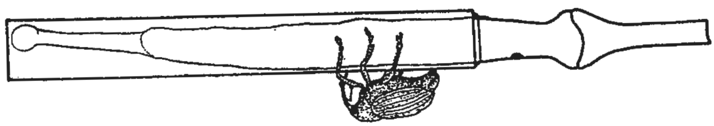

Fig. 1. A female cabbage seed weevil during post-oviposition propagation of the marker on a polyethylene tube attached to a winter rape pod. Such tube can be transferred with the chemical marker to another pod.

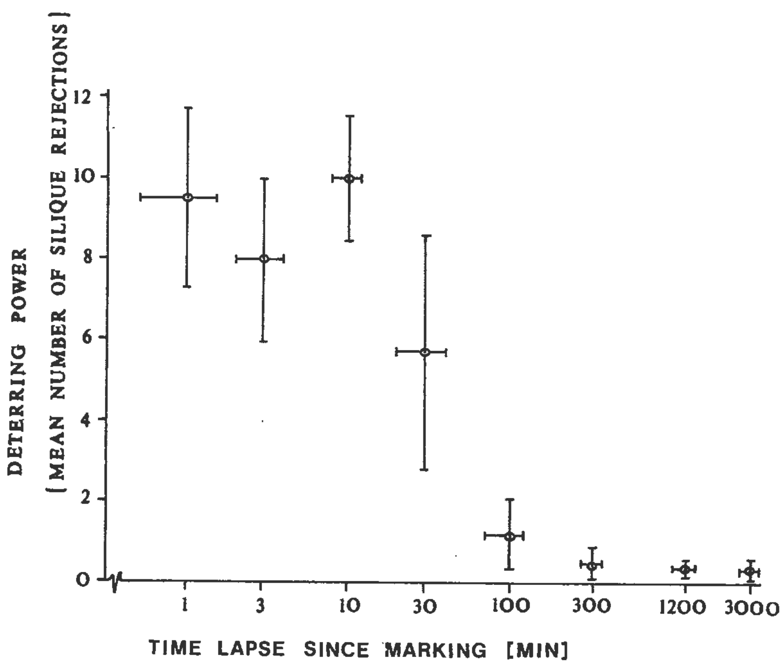

Fig. 2. The action of the oviposition marker at different times after deposition by a female on winter rape pods (siliques). Pods were kept at 25°C, in still air before submitting to females. Numbers of exploration were the measure of "deterring power" of the marker. N=10, vertical bars show standard errors.

3. Behavior of females in semi-natural conditions

The behavior of ovipositing females was observed in the laboratory on transferred from the field, winter rape plants that were surrounded by the other plants, . Females were observed for 8 hours continously or until they freely left the plant. No special algorithm in the movement between seedpods was observed, although, females seemed to prefer the upper part of a plant, with younger pods. Very high variability in quantitative determinants of the behavior among individual females was obtained. We did not find reasons for these differences, although possible factor were individually analyzed, like female age, time spent on a plant or plant variety. A striking characteristic, for which we could not find any ultimative explanation, was their behavior after initial deposition of 3-5 eggs. Such females usually did not cease their activity, but instead they made a high number of fast inspections to various classes of pods without any visible tendency to oviposit. This was in opposition to the optimal foraging concept and required an ethological (high motorical, low ovipositional motivation), rather then functional explanation. It also obscured our original concept of the short and effective visits to single plants.

4. Ovipositional habits in *Ceutorhynchus* spp. developing in Cruciferous plants.

In addition to the observations made on *C. assimilis*, we also observed ovipositions in *C. napi*, which arranges singly deposited eggs inside shooting stems, in groups, of *C. quadridens* and *C. sulcicolis* which deposit groups of eggs into leaf veins and/or stems and *C. floralis* which distributes eggs singly in pods. Preliminary comparisons suggest that complexity of ovipositional habits in different species can be related to the specifity of the parasitotion of the different plant organs. An evolutionary pathway from deposition of grouped eggs (*sulcicolis, quadridens*) through single eggs in uneven congregations (*napi*) to single eggs partitioning (*assimilis, floralis*) can be proposed. Only species ovipositing in pods were found to perform special post ovipositional activities related to marker deposition (see *C. floralis* on the film). It is possible that information of "fixed moving patterns" characteristic for oviposition females can contribute to a better understanding of the taxonomy and phylogeny of the *Ceutorhynchus* spp. group.

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Some Investigations with Heterodera schachtii Schmidt on Different Varieties of Rape

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Summary

In pot experiments the beet cyst nematode Heterodera schachtii reproduced significantly better on rape varieties with double low quality (low in erucic acid and glucosinolates) than in single low quality (low in erucic acid only) or conventionally varieties without reduced contents.But there was a tendency for greater tolerance to the damage caused by the nematodes in the double low varieties compared with the single low types. There was no relationships between the larval hatching intensity of H. schachtii under the influence of young rape roots of different varieties and the reproduction rate of the nematode.

1. Introduction

Nearly 150000 ha oilseed rape are cultivated in the German Democratic Republic. Most of the fields are in the northern region. At present there is a change in the varieties, which are cultivated. Farms cultivate a greater proportion of the area with varieties that have a low content of erucic acid only (single low) or a low content of both erucic acid and glucosinolates (double low) instead of the conventional varieties with high contents of erucic acid and glucosinolates.

It has been known for many years that the beet cyst nematode (Heterodera schachtii) can develope very well on the roots of rape (Kühn, 1881; Goffart, 1943). But now there is the question of the influence of the changed contents of the new varieties on the host-parasite relationship. Experiments were therefore carried out to investigate and quantify the behaviour of nematodes on a range of varieties differing in erucic acid and glucosinolate content.

2. Materials and Methods

The cysts of H. schachtii used in experiments came from a plot of 'Sollux' rape (in monoculture since 1979 at our research station in Rostock).

Experiments on hatching of larvae were made in staining blocks which were filled with distilled water. Each staining block contained 10 cysts of H. schachtii and three young rape roots. The experiments were replicated ten times including checks which were staining blocks without young rape roots. All staining blocks were kept at 22 °C. The hatched larvae were counted every week.

Experiments on the development of nematode populations were made in 'Mitscherlich'-pots containing 6000 cm^3 of soil. Two different nematode density levels were tested:

a) infested soil from the rape monoculture plot with c. 1784 eggs and larvae/100 cm^3 of soil

b) with half the original density (c. 982 eggs and larvae/100 cm^3 of soil), which was prepared by mixing the infested soil with an equal quantity of disinfested soil.

Four varieties of rape were sown on 20th of August 1988. The pots were put under outdoor conditions. The population density in soil was measured by the centrifugation method (Decker, 1969) at the end of June 1989 after the development of the first generation of the nematode.

3. Results

The results of the hatching experiments with the beet cyst nematode showed that the single-low variety 'Malux' stimulated a distinctly higher hatch of the larvae than the conventional variety 'Sollux' or the double low varieties 'Rubin' and 'BNW 1.63' (Fig. 1). All germinated roots stimulated the hatching process more than the distilled water-check.

The results of the population dynamic experiments are given in Table 1 and Fig. 2. Both double low varieties reproduced significantly more nematodes than the varieties 'Sollux' and 'Malux'. It was not possible to measure the yields of the plants because of damage by hail so no measure could be made of whether the higher nematode densities were connected with greater yield losses.

However, another experiment made some years ago with different varieties of rape showed that the variety 'Sollux' and the double low variety 'Start' suffered similar yield losses (17,4 and 18,7 % respectively) after nematode infestations of 600 and 950 eggs and larvae respectively/100 cm^3 of soil whilst the single low variety 'BNW 24' had a much greater yield loss (55,5 %). It was remarkable that the mean number of pods/plant was 35 % lower and the 1000 seed weight was 15 % lower than in the noninfested checks. These differences between the infested and noninfested series were not so strongly marked in the other varieties. The number of pods was even slightly higher in the double low variety in the infested soil, but the 1000 seed weight was reduced by 8,9 %. The number of pods/plant was reduced by 7,6 % in the variety 'Sollux' and the 1000 seed weight was also decreased by 3,4 %.

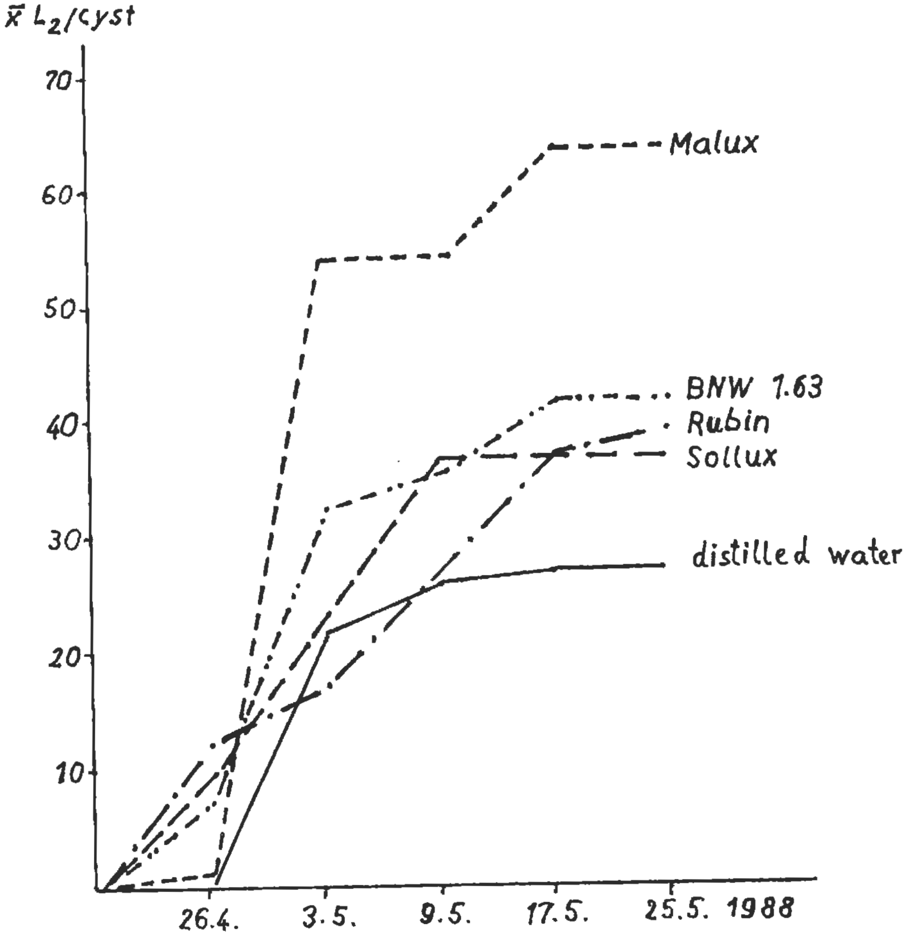

Fig. 1 Cumulative hatch curves of larvae of <u>Heterodera schachtii</u> on young roots of different varieties of rape (1988)
Malux = single-low; BNW 1.63 and Rubin=double-low; Sollux = high erucic acid and high glucosinolate content

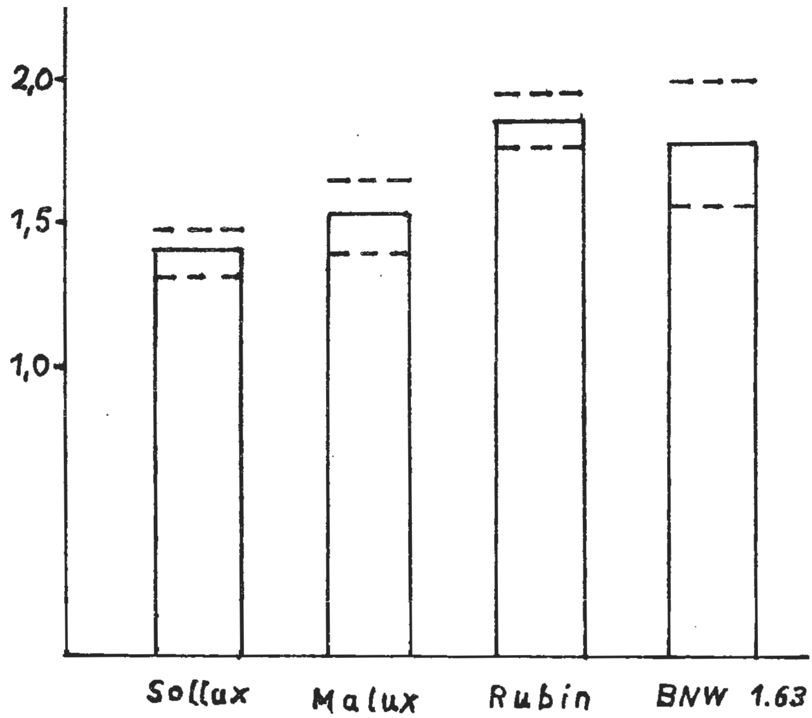

Fig. 2 Rates of reproduction of <u>Heterodera schachtii</u> on different varieties of rape (after development of the first generation 1989)
Sollux = high erucic acid and glucosinolate content
Malux = single-low; Rubin and BNW 1.63 = double-low

Table 1 Development of the population of *Heterodera schachtii* on different varieties of rape (P_f in June 1989)

variety	P_i = 892 E+L/100 cm^3	P_i = 1784 E+L/100 cm^3 (August 1988)
	$\bar{x}$	$\bar{x}$
Sollux	1320 a	2356 a
Malux	1480 a	2497 a
Rubin	1740 b	3162 b
BNW 1.63	1780 b	2813 b

P_i = initial population of eggs (E) plus larvae (L) in soil, P_f = final population. Values followed by, a, are significantly different from those followed by, b

4. Discussion and Conclusion

The higher hatching rate of the larvae of *H. schachtii* under the influence of the roots of the erucic acid free variety 'Malux' was also observed in other experiments. This was not dependent,in our opinion, on the quantity of the erucic acid but on a specific property of the variety. It is remarkable that this higher hatching rate of the larvae was not correlated with a higher reproduction rate; the final population density was not different to that under the variety 'Sollux'. However, in the double-low varieties, in which the larval hatching was similar to 'Sollux' and clearly lower than in 'Malux', the final population densities an the reproduction rate were significant higher. Therefore it is possible that the lower content of glucosinolates influenced the host-parasite interrelationships in the direction of a higher reproduction of the nematodes.

With regard to yields, the double-low varieties were more tolerant of nematode attack than the single-low varieties. Evans (1988) reached the same conclusion in his investigations with *H. cruciferae* Franklin on single-and double-low varieties of rape. In his experiments yields increased much more in single-low than in double-low varieties (179 % : 19 %) after a chemical treatment of infested plots. This is an indication of greater damage by the nematode in single-low than in the double-low varieties; our results from experiments with *H. schachtii* show the same tendency.

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REDUCTION OF THE FOLLOWING GENERATION OF POLLEN BEETLE BY PREVIOUS INSECTICIDE TREATMENT

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Summary

The effect of different timings of insecticide treatments on the abundance of mature pollen beetles (Meligethus aeneus L.), mature larvae and juvenile (hatched) beetles was tested in experimental plots of oilseed winter rape (cv. Jet Neuf and Ceres). This 3-year experiment indicates that an insecticide application during the bud stages of rape plants not only reduces the mature pollen beetles but also the larvae and juvenile pollen beetles of the following generation. Treatments applied only at "green buds separated" stage and double treatments at this stage plus the "small green buds close together" stage caused a greater reduction than later applications. In comparisions of untreated plots with insecticide treated plots the number of juvenile pollen beetles was decreased by up to 94 %. The possible influence on the abundance dynamics is discussed.

1. Introduction

Several abiotic and biotic factors have an influence on the dynamics of pollen beetle populations (Meligethes aeneus L.). The effect of insecticide application and of different timings of insectide treatments in relation to the inter-cyclic abundance dynamics of pollen beetle is relativly unknown. Therefore we tested the effect of differently timed insecticide applications, at different growing stages of oilseed winter rape, on the abundance of this pest.

2. Materials and Methods

Winter oilseed rape (1986: cv. Jet Neuf; 1987 and 1988: cv. Ceres) were autumn sown in the field at the Experimental Station Rostock-Biestow. The experimental plots (25 m²) were treated with the following insecticides at different growth stages:

1) Control (untreated)

2) Decis EC 2.5 at DC 54 (small green buds close together)

3) Decis EC 2.5 at DC 56 (green buds separated)

4) Decis EC 2.5 at DC 58 (yellow buds)

5) Melipax EC 60 at DC 64 (main flowering)

The number of mature pollen beetles (the previous year's population) was counted during their main activity on 5 x 25 plants from each plot to obtain the number of mature beetles/plant. Moreover, the plants in 5 x 1 m^2 areas of each plot were counted so that the number of mature beetles/m^2 could be calculated from both values.

The mature larvae which fall down to the soil to pupate were collected in black dishes (454.4 cm^2) filled with a formol-solution (4 %) and counted. After the last fall of larvae conical frames covered with gauze (covering an area of 434 cm^2) were put on the soil surface. Glass vessels situated on the upper end of this cone collected the juvenile (hatched) pollen beetles.

3. Results

The effect of differently timed insecticide treatments on the number of mature larvae is given in Table 1. The results show that a treatment during the bud stages reduces the number of larvae more than a application during flowering. Treatments at DC 56 and double treatments at DC 54 and DC 56 give the greatest reduction followed by treatment at DC 58.

Similar results show the effects of different timings of insecticide treatments on the number of juvenile (hatched) pollen beetles (Table 2). The number of juvenile beetles compared with the number of mature pollen beetles (the previons year's generation) indicates the same effects (Table 3). In this case a double application, at DC 54 and DC 56, gave the highest reduction. Only 31 juvenile pollen beetles resulted a starting population of 100 mature beetles.

4. Discussion and conclusion

The 3-year plot experiments indicated that an insecticide application during the bud stage of rape plants reduces not only the mature pollen beetles from the previons year's population but also the larvae and juvenile (hatched) beetles of the following generation. In our experimental conditions an application of deltamethrin at the "green buds separated" stage (DC 56) and a double treatment at the "small green buds close together" stage (DC 54) and the "green buds separated" stage of rape plants (DC 54 + DC 56) gave greates reductions in the number of mature pollen beetles from the previous year's population, the mature larvae and the juvenile (hatched) beetles than later insecticide (deltamethrin, camphechlor) applications. In comparisions of untreated and insecticide treated plots the number of juvenile pollen beetles was reduced, by a correctly timed insecticide, by up to 94 %.

Plot experiments can not give an entirely correct interpretation of the intercyclic abundance dynamics of the whole pollen beetle population of a large area. But we believe that the methods used in our experiments permit a general interpretation and view of the effects of differently timed and widely used insecticide applications on the intercyclic abundance dynamics of pollen beetle. Moreover these results indicate the likely influence of an effective, widespread and correctly timed insecticide treatment on the intercyclic abundance dynamics of insects.

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TABLE 1.

INFLUENCE OF INSECTICIDE TREATMENTS AT DIFFERENT GROWTH STAGES OF OILSEED RAPE ON THE NUMBER OF LARVAE OF THE POLLEN BEETLE

	LARVAE/m^2 (untreated = 100)				
YEAR	UNTREATED	TREATMENT AT GROWTH STAGE [1]			
		DC 54	DC 56	DC 54 + 56	DC 64
1986	100 (7443)[2]	34,4	46,5[3]	17,8[3]	62,5
1987	100 (5118)	30,8	20,4	18,5	73,2
1988	100 (5075)	61,5	15,7	13,1	56,7

1) DC 54: small green buds close together
DC 56: green buds separated
DC 58: yellow buds
DC 64: main flowering

2) ( ) = number of larvae/m^2

3) 1986 at "yellow bud stage" (DC 58)

TABLE 2.

INFLUENCE OF INSECTICIDE TREATMENTS AT DIFFERENT GROWTH STAGES OF OILSEED RAPE ON THE ABUNDANCE OF THE NEXT GENERATION OF POLLEN BEETLES

JUVENILE (HATCHED) BEETLES/m^2 (untreated = 100)					
YEAR	UNTREATED	TREATMENT AT GROWTH STAGE			
		DC 54	DC 56	DC 54 + 56	DC 64
1986	100 (2415)+)	34,2	68,1++)	26,7	116,8
1987	100 (1802)	40,4	24,3	6,2	36,8
1988	100 (3935)	53,2	15,7	10,9	54,5

+) ( ) = number of juvenile beetles/m^2

++) 1986 at "yellow bud stage" (DC 58)

TABLE 3.

INFLUENCE OF INSECTICIDE TREATMENTS AT DIFFERENT GROWTH STAGES OF OILSEED RAPE ON THE REPRODUCTION OF POLLEN BEETLES

JUVENILE (HATCHED) BEETLES/m^2 IN PROPORTION TO MATURE BEETLES/m^2 (=100)					
YEAR	UNTREATED	TREATMENT AT GROWTH STAGE			
		DC 54	DC 56	DC 54 + 56	DC 64
1986	732	327	569+)	461+)	855
1987	375	157	96	31	138
1988	525	517	87	106	286

+) 1986 at "yellow bud stage" (DC 58)

SESSION 5

Status and Control of Weeds

WEED COMPETITION IN WINTER OILSEED RAPE IN THE UNITED KINGDOM

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Summary
The effects of competition from grass weeds, especially volunteer cereals, on winter oilseed rape have been studied for a number of years in the UK. Their adverse effects increase as sowing is delayed. Tentative threshold values are proposed for volunteer barley of 50-100 plants/m^2 for August sown crops and 10-20 plants/m^2 for early September sown ones. Timing the control of barley populations exceeding these values does not seem to be critical. Delaying herbicide treatments from September/October to December/January has not jeopardised yields, except when the crop is late sown and/or poorly established. Detailed data on the competitive effects of broad-leaved weeds, such as Stellaria media and Veronica persica, are much more limited but many experiments indicate that the majority of these weed species are much less competitive than the grass weeds.

1. Introduction

Over the last 10 years the area of winter oilseed rape in the United Kingdom has increased from approximately 50,000 ha to almost 400,000 ha. In recent years each crop has received, on average 1.6 herbicide treatments. Each herbicide treatment will cost from £14 - £64/ha including application, the commonest treatments costing in the region of £50/ha. So it is of considerable national concern that these herbicide treatments are applied wisely. When the profitability of the crop was high farmers were willing to apply herbicides prophylactically with the main emphasis is on ensuring that the correct herbicide was used for the weed flora present in each field. In recent years, as profits have declined there has been greater interest in managing weeds to minimise their effects on the crop. Cereal research programmes have taken the lead in developing threshold techniques for weed management. Guidelines on when to control weeds in winter cereals are now available in the UK (Wilson & Wright, 1990) and in W. Germany (Gerowitt, 1990). However, only limited information is available for oilseed rape.

Weeds can have a number of adverse effects on rape but their competitive effects are arguably the most important. Weeds in the crop compete for light, moisture and nutrients, thus inhibiting crop growth, reducing pod production and seed numbers/pod and consequently lowering seed yields/ha . The precise effects will depend on the species present, their density and the stage of crop growth when they exert their greatest effects. As well as affecting yields directly, weeds can impede harvesting operations and their seeds contaminate harvested rape seed. Weeds may also carry pests and diseases that will attack the rape and other adjacent crops.

Some information is available from research in the UK on the competitive effects of weeds in rape, but few data have been collected on the indirect effects outlined above.

2. Weed Competition

There are two basic approaches to the study of weed competition; the first is to establish a range of populations of an individual species (including zero) within an otherwise weed-free rape crop and to monitor their effects on the crop; the second is to monitor natural weed infestations within a considerable number of crops and to record the growth and yield of weedy and, herbicide treated, weed-free areas. Both approaches have been used in the UK. Up until 1987, research on the effects of weeds concentrated on annual grass weeds, especially volunteer cereals. These species are particularly competitive and are frequent weeds of rape crops. A recent survey has shown that volunteer cereals were present on 88% of rape fields and that Alopecurus myosuroides and Avena fatua were each present on 40% of fields (Whitehead & Wright, 1989). More recently, greater emphasis has been put on studies of the effects of broad-leaved weeds. These tend to be less competitive but, because of this, the need for control to prevent yield loss is in greater doubt.

2.1 Competition from volunteer cereals

Experiments over the past 8 years have investigated the effects of natural and 'artificially sown' populations of volunteer barley on the growth and yield of rape. Much of this work has been done at research stations of the Agricultural and Food Research Council (Weed Research Organization, Long Ashton Research Station) but an appreciable contribution has also been from the Agricultural and Development Advisory Service (ADAS) and Experimental Husbandry Farms of the Ministry of Agriculture, Fisheries and Food. Initial studies indicated that yield losses from substantial populations of barley growing in well-established rape were often small. However, where the rape was less vigorous as a result of, for example, late drilling or growing the crop in exposed conditions, competition from barley was much more severe (Lutman & Dixon, 1986; Orson, 1984). Most of the more recent detailed information is derived from experiments with a number of sown barley densities. Combined analyses of the data from many of these experiments indicated that drilling date was of considerable importance when assessing the likely competitive effects of barley. Regression analyses, based on a rectangular hyperbolic model described by Cousens (1985), with the experiments grouped into three classes (early-, mid- and late-sown), showed that competition was much lower in crops drilled in August than it was in those drilled in September (Lutman, 1989). A 5% loss of yield was caused by 65 barley plants m^{-2} in the August sown crops but the same yield loss was caused by only 10 plants m^{-2} in the September sown ones (Fig. 1).

Further analysis of these data together with the recent results reported by Ogilvy (1989) has revealed a clearer picture. The data set is now based on 26 experiments and 119 individual yield/weed density comparisons. It has been possible to plot rape yields against weed density for these 26 experiments using the rectangular hyperbolic model ($Y = A + B/(1 + DX)$). This model is based on three parameters;

A = the rape yield at very high weed density (in this case constrained to zero),

A + B = the yield of the weed-free crop,

BD = yield loss/weed plant at low weed density

The most interesting value to be derived from this analysis is I, where $I = (B \times D)/(A + B) \times 100$. I is an estimate of the % yield loss/weed plant at low weed densities. When $A = 0$ then $I = D \times 100$. When Log_{10} I was plotted against drilling date, a linear relationship was observed, with increasing I values as drilling was delayed (Fig. 2); $R^2 = 0.54$ (df = 18) ($p = <0.001$). Some values do not fit the analysis. Two are particularly aberrant (A,B in Fig. 2), as although they were sown in late August their competitive response to barley is similar to crops sown in mid September. This was because the emergence of both these crops was delayed by drought. In contrast, one other experiment (C) is clearly less affected by the barley than its drilling date would predict. In this experiment

Fig. 1. Effects of volunteer barley on the yield of oilseed rape sown 18–31 August (—·—), 1–10 September (——), 11–22 September (----).

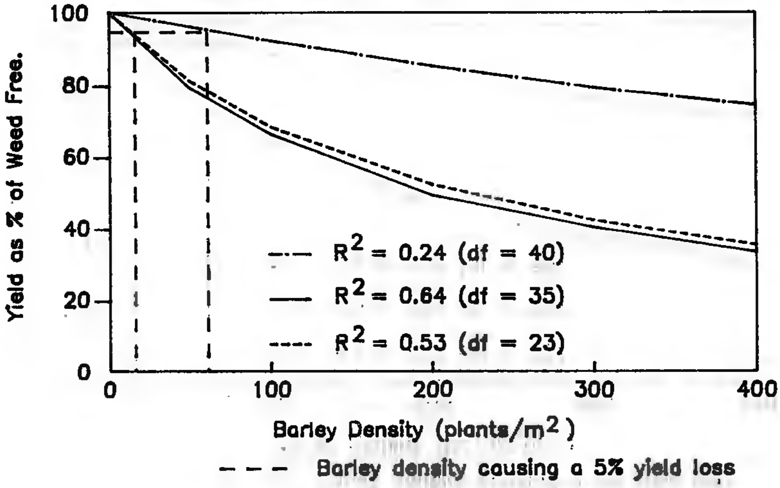
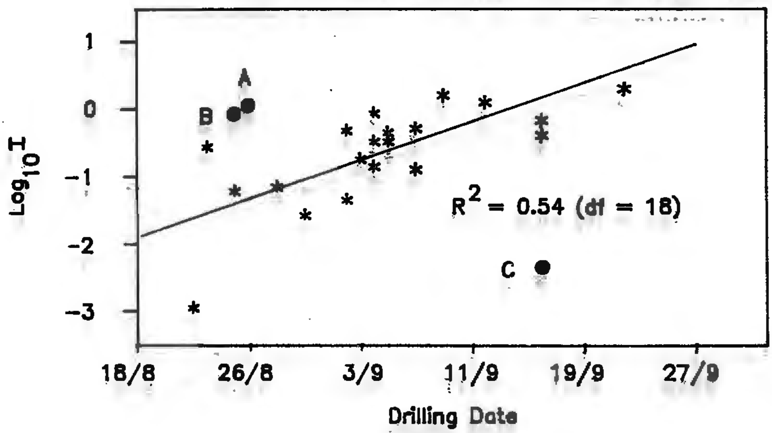


Fig. 2. Relationship between rape drilling date and yield loss / volunteer barley plant (I)



all the barley died during the winter as a result severe winter weather, thus removing its competitive effects. In three other experiments, where the rape was drilled at the end of August, there was little competition from the barley and no decline in yield with increasing weed density. Inclusion of these three values would have distorted the analysis and exaggerated the decline in competitiveness of the barley on early sown crops. Further analysis may be needed to resolve the difficulty of using this analysis to extrapolate to earlier and later drillings. Re-interpretation of the regression analysis presented in Fig. 2 shows the number of barley plants that will reduce rape yields by 5% (Fig. 3), a tentative economic threshold value (based on a conservative estimate of herbicide costs of ca £35/ha, a crop yield of 3.0 t/ha and a value of £250-300/t). Thus, 100 barley plants m^{-2} will reduce yields of a crop sown on 26 August by 5% and 10 barley plants will have the same effect on a crop sown on 9 September. This clearly shows the importance of early crop establishment in minimising weed competition.

In addition, there is evidence that later drilled crops and those that have suffered from weed competition during the autumn and winter will mature somewhat later than earlier sown and weed free crops. This may jeopardise yields.

Table 1 The influence of the date of herbicide application on the yields (t/ha) of winter oilseed rape.

Month of application	Lutman & Dixon 1985		Roebuck & Flint 1985		Ogilvy 1989	Lutman 1984
number of trials	3	1	4	1	5	1
September					3.38	
October	3.28	3.68	3.51	3.25	3.49	4.80
November	3.48	2.94	3.46			4.47
December				3.30	3.57	
January	3.38	3.04				
February						4.07
Untreated	2.21	0.79	2.14	0.83	2.34	1.38
Drilling date	22/8-7/9	7/9	25/8-19/9	5/9	2/9-5/9	3/9
Weed Species	Volunteer barley		Volunteer barley		Volunteer barley	*Alopecurus myosuroides*
Plants/m^2	115-227	344	112-383	676	52-658	650

2.2 Timing of control of grass weeds

If the grass weed population present in a rape crop is likely to affect yields, a decision must be taken as to the herbicide to use and the timing of the treatment. Most grass weed control treatments in UK are applied post-emergence during the autumn and early winter. Early treatments with non soil-persistent herbicides may fail to control later emerging plants and thus fields may require re-treatment. Conversely, it is believed that delayed treatment will jeopardise yields due to weed competition prior to control. Experiments on the timing of grass weed control have rarely confirmed this. In general, yields from grass weed

Fig. 3. Influence of drilling date on the number of volunteer barley plants to cause a 5% loss in rape yield.

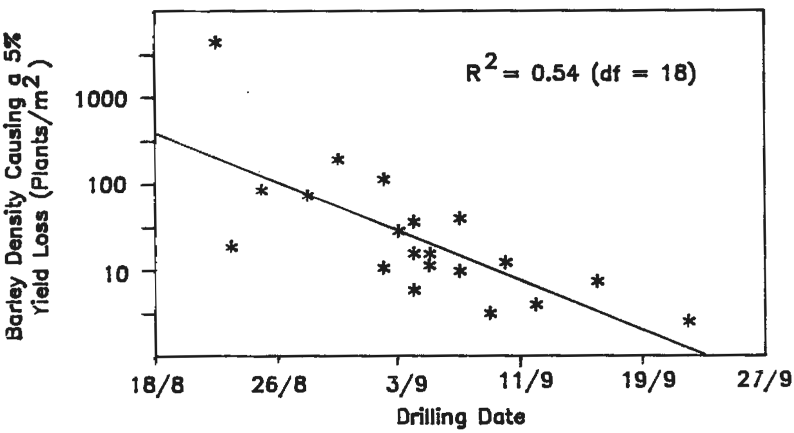
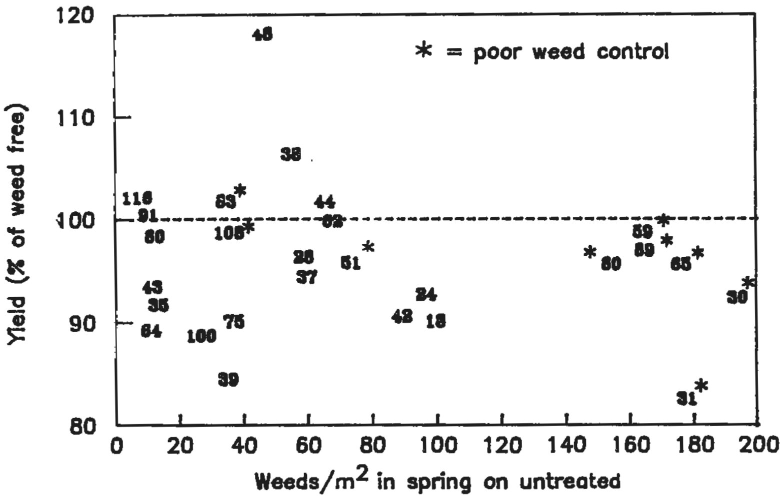


Fig. 4. Effect of mixed broad-leaved weed infestations on yields of oilseed rape. (numbers = rape plants/m^2).



infested crops have not been detectably different on plots treated in September/October to ones treated as late as January (Lutman, 1984; Lutman & Dixon, 1985; Ogilvy, 1989; Roebuck & Flint, 1985)(Table 1). Early weed control was an advantage in two of the fifteen relevant trials included in these four papers. In both these cases the weed density was high but there were sites with similar or higher densities where delayed weed control did not reduce yields. The risk to yield is believed to be somewhat greater with later-sown crops, as has been explained above but in these 15 trials, the latest sown one (19 September) was not particularly sensitive.

It is clear from these trials that the higher the grass weed density, the later the drilling and the later the weeds are controlled the greater is the risk of yield loss. However, the relationship between these three factors and yield is not always very high and it is clear that other factors are acting on the response of the crop to weed competition. The weather during the growing season appears to have a considerable influence. The severity of the winter will influence the growth of the rape and hence its ability to recover from earlier weed competition. For example, a cool dry autumn seems to increase the competitive effect of weeds but a severe winter in combination with a dense rape crop, can completely eliminate volunteer cereals, even where a herbicide has not been used. Subjective observations of the growth of rape and cereals suggest that rape's response to temperature change is greater than that of cereals. Thus, rape will grow faster than cereals under warm conditions and slower under cool conditions. This aspect requires further study.

2.3 Competition from broad-leaved weeds

The amount of information available on the competitive effects of broad-leaved weeds in the UK is rather limited. General data from herbicide evaluation experiments can provide useful 'survey' information but as the experiments are primarily concerned with studying herbicide performance the data is often difficult to interpret. Invariably, there has been a mixture of grass and broad-leaved weeds present on the trials, so it has not been possible to separate the effects of the broad-leaved weed component. The most frequent conclusion from these general trials was that low populations of grass and broad-leaved weeds were unlikely to affect yields (Davies, 1987; Lutman, 1984; Ward & Turner, 1985). Because of the intrinsic variability of rape trials it is more correct to state that the weeds had no 'detectable' effect on yields, as small effects would not be measurable. In some more recent work Davies, Walker & Whytock (1989) concluded from three 'weed population and yield' trials, with Stellaria media as the major weed, that although all treatments improved yields, the yield responses did not correspond to the levels of weed control. Similarly, Bowerman (1989), reporting ADAS results 1985-87, concluded that yields of rape were not reduced by moderate levels of broad-leaved weeds in well-established crops. Marked reductions in yield (over 20%) were recorded on only two of the 22 experiments, in both cases the populations of S. media and Veronica persica were high and at one site the crop was also sown late.

Few experiments had been done to investigate, in detail, the effects of broad-leaved weeds, until 1987. Because of the intrinsic variability of the rape crop and the difficulty of detecting the often small differences in yield, it has been difficult so far to reach valid conclusions. Recent experiments by ADAS have concentrated on studying the interaction between broad-leaved weed density, crop density and yield. Over the past two years they have done twelve experiments, with the rape sown at three densities in fields containing a range of broad-leaved weeds, dominated by S. media and V. persica, but few grass weeds except Poa annua. Some of the data have been published by Sansome (1989) but some are, as yet, unpublished. Herbicides were used to create, as far as possible, weed-free plots.

Overall analysis of these data indicates that, although there was a suggestion that weeds were having a small effect on yields, there was no relationship between yield reductions and weed density, nor an interaction with crop density (Fig. 4). It is possible that the sites with the highest weed density would have shown a greater loss of yield, if the performance of the herbicides had been higher on Capsella bursa-pastoris and/or Viola arvensis.

We have recently started a programme to investigate the competitive effects of individual broad-leaved weed species . Yields were not measured in the first experiment, started in autumn 1988, because of concerns about the reliability of yield estimates from small 1m^2 samples. Despite considerable variability, the dry weight data collected in the autumn, winter and spring indicated that the competitive ability of V. persica was appreciably less than Galium aparine and volunteer barley. The pattern of competition was also different for the three species. The barley was competitive from the early autumn through to the following June. In contrast, the less competitive V. persica had its greatest effect at the end of the winter, whilst the later growing G. aparine was most competitive in June. Further work is in progress both in the AFRC and in ADAS.

3. Other adverse effects of weeds

Although the competitive effects of weeds is of major concern, it is clear that weeds can also affect other aspects of rape production. There is little quantitative information on the precise indirect effects of weeds, so at present it is not possible to calculated the likely costs to the farmer. However, a number of practical problems arise. Vigorous weeds, such as G. aparine can hinder harvesting and seeds from weeds growing in rape can contaminate the harvested product. For example, seeds of G. aparine and of some crucifer weeds (e.g. Sinapis arvensis) are similar in size and shape to rape seed and their removal, where possible, incurs extra cleaning costs. The recent change to low glucosinolate cultivars of rape has added a further aspect to the risk of contamination, as the presence of high glucosinolate weed seeds in a low glucosinolate crop may cause its rejection. Weed plants, especially those in the Cruciferae, will harbour pests and diseases that can attack rape and other neighbouring arable crops. A few investigations have been carried out in W. Germany but no detailed studies have been done recently in the UK, although some anecdotal evidence is available (Lutman, 1989).

Deliberate decisions not to control weeds in the rape crop, because it is considered unlikely that the weeds will affect yield, can have repercussions in subsequent crops. If the seed return from low densities of weeds in the rape crop is high, then weed populations may be higher in subsequent crops, incurring extra herbicide costs. There is a lack of research data on the indirect effects of weeds in rape. Some information is being collected on the seed return from low populations of weeds in winter cereals, and the effects of crop density, but none is yet available from oilseed rape experiments in the UK. These aspects are of particular concern with species that are not easy to control in the rape and/or the following cereal crops (e.g. Papaver rhoeas, G. aparine, Bromus spp.).

4. Conclusions

Research on weed competition in winter rape in the UK has shown that the competitive effects of volunteer barley, and other annual grass weeds, are greatly affected by the time of drilling. Precise economic threshold values will depend on the value of the crop and the cost of the herbicide but for August sown crops would be in the region of 50-100 plants/m^2 and for later sown crops 10-20 plants/m^2. If grass weeds need to be controlled, timing does not seem to be very critical, except for late-sown or poorly established crops. Research data, not only from UK but also from France and W.Germany, all indicate that treatments applied from September to December or January will achieve yields that are not detectably different, although late treatments may delay maturity.

Information on broad-leaved weeds is much more limited and rather conflicting. Some experiments dominated by S. media have shown no detectable effect on yields from weed populations of approximately 250 plants/m^2 (Davies, 1987) whilst Bowerman (1989) concluded from his experiments that the threshold for this weed should be in the region of 40 plants/m^2. Our view is that threshold values for broad-leaved weeds will be considerably higher than those for cereals. In our experiment in 1988/89 autumn populations of 600 V. persica plants/m^2 had no effect on the growth of rape in June and so probably would not have affected yields. Current experiments indicate a similar level of competition for early sown crops. More research is needed to establish the competitive effects of a range of broad-leaved weeds, in order to provide farmers with better guidance on when to control these species.

There is even less information available in the UK on the indirect effects of weeds on harvesting efficiency and crop quality.

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A preliminary Decision Model for Economic Weed Control in Winter Oilseed Rape

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Summary

The factors weed species, weed density, crop competition and weed emergence delay are important parameters in estimating yield loss from weeds in winter rape. Field trials carried out since 1985 quantified the effect of the above parameters on rape yield. A functional empirical model was developed incorporating these factors to aid growers in making economic weed control decisions.
To validate the model a series of field trials are currently being carried out in several regions of the FR Germany.

1. Introduction

The considerable increase in hectarage of winter oilseed rape grown in the FR Germany has made this crop of high economic importance in arable farming. Plant production measures, including the application of herbicides, have become almost routine in oilseed rape and contribute to a high degree to the production costs. The tendency towards a decrease in price of the product and, moreover, the need to avoid any unnecessary contamination of the environment by pesticides underline the necessity to develop economic thresholds for important diseases, pests and weeds. Careful evaluations of numerous field trials with chemical weed control in rape have shown that a high percentage of herbicide applications was not economically justified, but resulted in considerable economical losses (Wahmhoff, 1990). Therefore, the development of economic thresholds for weeds in oilseed rape appears very promising. Moreover, with the introduction of suitable post emergence herbicides an important prerequisite was fulfilled to avoid prophylactic, preemergence weed control measures and thereby unnecessary costs for the farmer. Several workers have shown that the yield potential of the highly competitive oilseed rape can be realized even with a high weed infestation around 150 plants/m² controlled by a post emergence herbicide application.

Economic thresholds for weeds in cereals have been successfully used in practical farming. However, experiments to develop similar thresholds and weed/loss ratios for oilseed rape, by means of assessing weed density or ground coverage, have been unsuccessful. It soon became apparent that a larger number of parameters have to be taken into consideration in order to assess the yield losses caused by weed competition. The prevailing weed species, their density, their date of emergence relative to the crop, the competitiveness of the crop and its yield level are important factors to determine field specific, weed economic thresholds. These factors had to be quantified as components of a decision model for weed control in oilseed rape. As economic components, the actual prices of the products and the costs of herbicide applications were also taken into account.

2. Material and methods

The competitive effects of prevailing weed species in winter oilseed rape were investigated for several years in small plot experiments on farmers fields (Küst, 1989, Küst *et al.*, 1990). In each experiment only one weed species was included. Different weed densities in the small plots (2 m^2) were obtained by hand-weeding. At least 4-5 different densities were included in 10-20 replications in randomized blocks. The yield of rape was determined after manual harvest of 1 m^2 areas. In order to quantify the effects of weed emergence delay in relation to crop emergence several field experiments were carried out from 1987 - 1989 (Klostermyer, 1989). In two factorial trials the influence of *Matricaria inodora* and *Stellaria media* on dry weight of the crop plants was varied by establishing different densities and by sowing the weeds 0, 10 or 20 days after sowing the crop. Details of the experimental design are given elsewhere (Klostermyer, 1989).

3. Results

The species-specific relation between weed density and relative crop yield loss was evaluated by linear regression analysis. The regression coefficients obtained were included as competition factors in the preliminary model (Fig. 1). *Stellaria media* proved to be by far the most competitive species (competition index 0,3), followed by *Alopecurus myosuroides* (0,08) and *Matricaria inodora* (0,05). Of the species investigated the lowest competitive index was found for *Viola arvensis, Myosotis arvensis, Lamium* ssp. and *Capsella* bursa-pastoris (0,03). The effects of volunteer barley and drilling date on the yield of winter oilseed rape were studied over three years. The relation of crop cover to weed cover was the most suitable parameter to describe the yield loss caused by volunteer barley (Küst, 1989 und Küst *et al.*, 1990). If the drilling is delayed compared to the optimal date, the critical relation has to be increased. In the experiments the critical relationship was 3:1 (crop cover : weed cover) for the regional optimal sowing date, while it was raised to 6:1 for a 10

Fig.1 Model for assessment of weed-infestation and weed control according to economic thresholds in winter oilseed rape

sample number	A.myosuroides/ A.spica venti	Stellaria media	Matricaria ssp. Anthemis ssp.	Lamium ssp.	Viola arvensis	Myosotis arvensis	C. bursa pastoris	other	Galium aparine
	number of weeds								
1									
2									
⋮									⋮
30									
sum									
weed density /m²									
xcompetition index	0,08	0,3	0,05	0,03	0,03	0;03	0,03	0,03	
product									= sum = ____

crop competition	very good= 0,5 good = 1 middle = 1,2 bad = "2"	..... x [ ] = ____
relative time of weed emergence	simultaneous = 1 ≈ 10 days delay = 0,6 ≈ 20 days delay = 0,3	..... x [ ] = ____
expected yield	dt/ha : 100 = 0,	0, ... x [ ] = ____
expected selling price		..... x [ ] = loss/ha
application costs/ha		[ ] = costs/ha

Herbicide-application if - loss exceeds costs; more than 0.2 pl/m² Galium aparine day delay in drilling the oilseed rape. For *Galium aparine* a fixed threshold value of 0,2 plants/m² was used, since this species primarily leads to difficulties with combine harvesting and increase in grain moisture.

Multiplication of the competition index (Fig. 1) with the respective number of weeds found in the field and addition of the products leads to the estimated relative yield loss caused by the observed weed community and density. Since the competition factors were experimentally obtained at locations with well developed rape crop stands and weeds emerged simultaneously with the crop, the estimated yield loss applies only for these conditions. If this is not the case at a field, a correction is required. The competitive power of the crop is of great importance for the weed development. This applies especially to crop ground coverage, growth intensity, patchiness, and nutrient supply. Under a poorly developed and patchy crop the weeds can spread considerably and reach a high competitive value. On the other hand a good crop stand developed early will provide good shading and weed suppressing effects. These conditions are taken into account by including a corresponding correction factor.

The date of emergence of weeds relative to that of the rape crop is the next important correction factor in this model. The consequence of a delay in emergence is a decreasing dry weight production by the weeds (Table 1). When emerging together with the crop *S. media* and *M. inodora* produced 136,4 g/m² and 41,0 g/m² respectively under the conditions of the experiment. A weed emergence delay of 10 days reduced the dry weight production of both species by about 90 %. A total delay by 20 days reduced the dry weight again, but to a smaller extent. Table 2 shows that an increase in density of *M. inodora* leads to a decrease in rape dry weight production, in the variant with simultaneous emergence of weed and crop which was significant only at the highest weed density. The grain yield was also reduced significantly only under these conditions.

Table 1. Effect of weed emergence delay (ED) and weed density on dry weight production of weeds and rape crop

Species	ED days	Density /m²	Weed Dry Wgt g/m²	Weed Dry Wgt g/plant	Crop Dry Wgt. g/m²
S. media	0	59	136.4	2.30	238.6
	10	51	15.6	0.30	308.4
	20	13	3.4	0.04	314.4
M.inodora	0	190	41.0	0.20	286.8
	10	105	4.6	0.04	318.4
	20	72	3.4	0.04	335.6

In order to include this influence into the model, the correction factors 0,6 for 10 days delay and 0,3 for 20 days delay in weed emergence were used.

The estimated relative yield loss finally has to be multiplied by grain yield level/100 and the price of the product. Comparison of the cost of herbicide treatment with the estimated monetary yield loss provides information about the economic feasibility of chemical weed control.

Table 2. Effects of weed emergence delay (ED) and density of *Matricaria inodora* on dry weight production and grain yield of oilseed rape

ED Days	Weed Density /m2	Weed dry Wgt. April 1st g/m2	Crop Dry Wgt. Nov 6th (%)	Crop Dry Wgt. April 1st (%)	Grain Yield July 12th (%)
0	0	0	100	100	100
	97	12	84	92	86 *
	187	19	81	86	87 *
	288	31	74 *	71 *	81 *
10	0	0	100	100	100
	37	1	100	93	106
	68	1,5	102	100	104
	208	5	89	81 *	97
20	0	0	100	100	100
	37	1	85	98	108
	58	1	105	97	109
	113	2	104	98	103

* = significant compared with weed free control,GD = 5%

4. Discussion

The differential assessment and evaluation of a field specific weed infestation in relation to the stage of the crop is required in order to decide on appropriate and economic weed control by herbicides. The evaluation of yield losses was carried out in the model by means of regression coefficients for single weed species. The intraspecific competition between weeds of one species is not taken into account, since this competition starts only at higher weed densities well above the economic threshold and therefore is irrelevant for a control decision (KLOSTERMYER, 1989). Whether a simple addition of the competitive effect of different weed species in the model is sufficient or whether interspecific competition takes place at relevant densities will be assessed in further experiments.

Correction factors were included to adjust the model to individual field situation. This is required especially for the status of the rape crop stand. Other authors also emphasize the good weed suppressing ability attorded by good crop ground cover (Nölle, 1986, Lutman and Dixon, 1986 and Dingebauer and Krüger, 1988). In our experiments a precise correction factor for poor stands cannot, so far, be quantified, therefore we use a preliminary estimated factor.

The decision model will be evaluated in two further years of experiments. The competitive values for different weeds and the correction factors so far are derived from a limited number of field experiments, which certainly need supplementation by further data. Modifications and hopefully improvements should thereby be possible. In spite of certain limitation the model, however, represents a realistic approach to targeted weed control in winter oilseed rape by which the unnecessary application of herbicides in this crop can largely be avoided.

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SOME ASPECTS OF MECHANICAL AND CHEMICAL WEED CONTROL IN WINTER RAPE

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Summary:

Investigations into mechanical and chemical weed control in winter rape grown on soils derived from till were carried out on the basis of precise plot experiments, farm-scale experiments under commercial conditions, production analyses and older investigations in Mecklenburg-Western Pomerania. Efficient combination of mechanical and chemical weed control operations would be most advisable. Modern arable farming with its need for herbicidal treatment should not exclude established practices, such as mechanical intercultivation, but use them more often, praticularly for reasons of ecology.

1. Introduction

Winter rape is grown on an area of about 150,000 hectares in the German Democratic Republic. The cropping concentration is highest in Mecklenburg-Western Pomerania, an area where the highest yields are obtained. For example, average rapeseed yields were 3.15 t/ha for the years 1987 - 1989 in the county of Rostock. Rapeseed yields were particularly high in 1989: 3.62 t/ha, and on some 30-hectare fields even more than 5.0 t/ha.

Although site-specific yield development seems very promising at first sight, certain consequences of high cropping concentrations should not be neglected. It is well known that a close correlation exists between cropping concentration and the occurrence of pests and fungal diseases (DAEBELER et al., 1988; DAEBELER et al., 1989; MAKOWSKI et al., 1985; SCHULZ et al., 1988). On the other hand, intensive winter rape growing has inevitably led to great changes in the crop rotations. As a rule, in Mecklenburg-Western Pomerania rape is grown after two cereal crops which leaves little time for preventive weed control by tillage. Due to the inadequate power and availability of tillage machinery, the incidence of volunteer cereals and dicotyledonous weeds is often very high.

As has been known from older literature, a very close correlarions exist between the frequency of weeds and rapeseed yields (MÖLLER, 1974; REUTER, 1979). Decades ago, mechanical weed control was the most common approach, but now chemical treatment is used almost without exeption. The progress made in the development of herbicides and the general decline in the agricultural labour force have had a major impact on that process. The unfavourable position in the crop rotation in terms of soil physics along with the growing ecological consciousness and the greater potential of farm machinery have been the reasons for thinking about efficient combinations of mechanical and chemical weed control methods (GRUBER, 1984; MAKOWSKI et al., 1990).

2. Material and method

Plot experiments (single- and multifactor split-plot and block designs with four replications) were laid out on the Rostock-Biestow experimental field of the Institute of Plant Breeding Gülzow-Güstrow. The harvest area per plot was 10 m^2. The plot experiments included variants to answer the following questions:

- influence of row spacing on the rate of weed infestation,
- influence of the rate of weed infestation on rapeseed yield,
- influence of mechanical and chemical measures for weed control and yield variation.

Further weed control operations were tested in large-scale experiments (five hectares for each variant) under conditions of farming practice.
Variance analysis was applied to evaluate the plot experiments and farm-scale trials.
Experiments from previous years and production analyses were also included for further verification of the results.

3. Results

Growing rape after cereal crops may cause rapeseed yields to decline due to shed cereal grains coming through as volunteer plants in the subsequent rape crop (Table 1).

Table 1

Influence of volunteer cereals on rapeseed yields
(two test years, n = 4)

Volunteer cereals	Yield	
	t/ha	Relative
None	3.78	100
Winter barley	3.62 *	96
Winter rye	3.58 *	95
Winter wheat	3.67	97
Spring barley	3.74	99
LSD 5 %	0.15	

The decline of rapeseed yields depends not only on the cereal species involved, but to a much greater extent on the rate of volunteer cereals (Table 2).

Table 2

Influence of volunteer winter barley on rapeseed yields
(two test years, n = 5)

No. of shed grains/m^2	Yield	
	t/ha	Relative
0	3.82	100
20	3.66	96
40	3.60	95
60	3.57 *	94
80	3.48 *	92
LSD 5 %	0.24	

Wider row spacing leads to greater weed infestation (Table 3).

Table 3

Influence of row spacing on weed infestation in rape fields (three test years, n = 6)

Row spacing (cm)	Weed coverage (%)	
	Autumn	Spring
13.9	55	75
25.0	62	77
41.7	77	86

Dicotyledonous weeds strongly impair the yield of rapeseed (Table 4).

Table 4

Influence of weed infestation on rapeseed yields (three test years, n = 5)

Weed coverage (%)	Yield	
	t/ha	Relative
1 - 5	4.41	100
60 - 65	3.20	73
90 - 95	2.10	48
LSD 5 %	0.21	

In recent years, chemical weed control has had a beneficial effect on winter rape yields due to the progress made in the development of herbicides. This applies particularly to specific preparations against problematic weeds (cleavers, etc.) and to herbicides with a wide range of action.

Hoeing of winter rape leads to significant yield increase, as has been shown already in older studies (Table 5).

Table 5

Relative influence of mechanical intercultivation on rapeseed yields

Reference / Control Measure	ROGGOW (10) 1960 n=9 trials	HOFFMANN (5) 1967 n=115 trials	HOFFMANN (5) 1967 n=390 fields	GEORGE (3) 1979 n=194 fields
None	100	100	100	100
Harrowing A + S	-	-	-	82
Hoeing A	112	110	98	121
Hoeing S	117	115	111	107
Hoeing A + S	122	119	116	130

A = autumn, S = spring

The effect of mechanical intercultivation together with chemical weed control depends strongly on the kind of herbicide, on the preceding crop species and on the weather. Between 0 % and 10 % extra yield was obtained in experiments and production analyses.

4. Discussion and conclusions

As proved by the results obtained, significant correlations exist between weed infestation and winter rape yields. Therefore specific control has become inevitable. First, it is necessary to minimise grain losses in the preceding cereal crop then, through intensive tillage, to create better soil conditions in most situations except where there are low rates of weed infestation. In years when larger numbers of volunteer cereals can be expected, herbicides should be applied after winter barley and winter rye, since these two cereals will tiller heavily when the weather is favourable in autumn, and this may strongly impair the development of the rape crop in autumn. The threshold should be about 60 seeds per square metre. Another possibility for cutting down the rate of weed infestation is appropriate row spacing. In practice, wider

row spacing normally leads to greater weed competition for the crop plants. Rows more than 30 cm apart normally require hoeing. Narrow rows are not suitable for hoeing and may be conducive to the development of Phoma lingam. There are many points in favour of 22 cm to 24 cm row spacing. Progress in the field of farm machinery may enable hoeing even between such narrow rows. For the time being, in the German Democratic Republic narrow spacing is recommended only for slopes and stony soils where herbicides are the only means of weed control.
The direct elimination of weeds with mechanical hoes produces very different effects. With classical preceding crops, e. g. bastard fallow of clover and alfalfa, and after early potatoes and peas the effect of hoeing will be very small. Under the conditions prevailing in the GDR, hoeing of rape fields is particularly beneficial after two cereal crops. This effect has its origin not only in the destruction of weeds but also seems to be connected primarily with the improvement of soil physical properties. Wider row spacing and few stones in the soil are prerequisites for efficient hoeing. One should not neglect, however, amount of labour involved in mechanical intercultivation. This raises the question of replacing the hoe by the harrow. According to the results obtained, harrowing has an adverse effect on the yield formation process. This is due to the stimulation of fungal diseases (in particular Phoma) and lateral shoots. For example, all larger weeds and especially volunteer rape plants from previous cropping can only be destroved by hoeing. The latter may become important contaminants after the change to efficient double-low rape varieties. Parameters that are essential to seed quality (uniform ripeness, purity, etc.) are also strongly influenced by weed control.

The above results allow the conclusion that weed infestation should be controlled by a complex of measures. For economic and ecological reasons it would be advisable to look for an efficient combination of mechanical and chemical treatments.

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SESSION 6

Integrated Control, Crop Production and Protection

DISEASE RESISTANCE AND FUNGICIDE RESPONSE IN OILSEED RAPE CULTIVARS

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Summary
Both single and double low oilseed rape cultivars were subjected to various fungicide programmes, and were studied for the effects on resistant and susceptible cultivars. Largest yield responses were generally recorded in cultivars with low resistance to light leaf spot. However, some cultivars appeared sensitive to levels of inputs. Double low cultivars showed a wide range of disease resistance and fungicide response.

1. Introduction

Winter oilseed rape cultivars are routinely assessed by the National Institute of Agricultural Botany for their resistance to light leaf spot (*Pyrenopeziza brassicae*), stem canker (*Leptosphaeria maculans*) and downy mildew (*Peronospora parasitica*) using data from inoculated tests and natural infection. Resistance ratings are published annually for the NIAB Recommended List of cultivars (Knight and Furber, 1980).

The disease assessment methods described by Priestley *et al*. (1984) and Knight and Furber (1980) are based on the severity and incidence of disease symptoms observed in both field trials and artificially inoculated tests. Resistance ratings calculated from these levels of disease by the method of Doling (1965) do not necessarily reflect the effects of diseases on the yields of cultivars.

A series of replicated trials was established in which cultivars were treated with a comprehensive fungicide programme to determine their sensitivity and tolerance to disease and their performance compared with that of untreated plots.

In addition, the performance and levels of disease in cultivars in the English series of National List (NL) and Recommended List (RL) trials in 1988 and 1989 were examined in relation to the fungicide treatments they h had received.

2. Materials and Methods

Nine trials were conducted in the years 1983-1986, as described in Table 2, using the cultivars shown in Tables 1 and 3.

The trials were of the split block design with four replicates for each treatment. Plots were a minimum of 50 sq m and drilled with a mixture of farm and plot drills according to the trial site. Trials were grown according to normal local practice in respect of fertilizer and herbicide usage and harvested when most plots were mature. At Bridgets Experimental Husbandry Farm in 1985 and 1986, plots were harvested individually as they matured.

Table 1 NIAB Resistance ratings of cultivars used in the fungicide trials, 1983-1986

	Light leaf spot	Stem Canker	Downy Mildew
Bienvenu*	6	7	7
Darmor	4	7	8
Jet Neuf*	1	7	7
Mikado*	8	8	2
Rafal*	6	7	5
Karma	1	4	7
Korina*	5	4	7
Fiona*	6	4	7

1 = very susceptible 9 = very resistant
* single-low varieties

Yields and seed samples were taken from each plot. The samples were analysed for their moisture content and oil content. Any shedding and loss of seed at harvest due to pod shattering was also observed.

Disease incidence in plots was monitored throughout the growth of the crops and disease levels assessed at appropriate times using the methods of Knight and Furber (1980) and Priestley et al. (1984).

The performance of NL and RL trials at various locations in England was examined. In 1988, 7 trials not receiving fungicides and 8 trials principally receiving treatments for light leaf spot control were examined for yield (Table 9). In 1989, 7 trials not receiving fungicides and 11 trials mainly treated for light leaf spot control were examined for yield (Table 10). The trials were located at different sites in England and received different levels of fertilisers, insecticides and herbicides, the fungicide treated trials generally having higher levels of the other inputs.

Diseases were recorded on some of the trials, the predominant disease being light leaf spot, and resistance ratings were calculated from these data (Tables 9 and 10).

3. Results

The effects of the fungicide treatment on seed yields of the 1983-86 series of trials are shown in Table 3 and effects on oil yield are shown in Table 4.

The trial at High Mowthorpe in 1985 suffered from high seed losses at harvest due to shedding in untreated plots and therefore the yield results have not been included. The trial at Boxworth in 1986 was poorly established with very variable plant populations so data from this trial have not been included. Oil determination was not carried out on the Bladon trial in 1986.

The effects of the fungicide treatments on disease levels are shown in Tables 5,6,7. Light leaf spot was recorded in all 7 of the trials from which yield data have been assessed and infection levels were reduced by the fungicide treatments (mean 80% effective control of light leaf spot). Light leaf spot levels varied between cultivars, with cvs. Karma and Jet Neuf having the highest levels of infection and cvs. Mikado, Rafal and Bienvenu the lowest levels. There was a significant correlation between the levels of light leaf spot on untreated plots and the increase in yield due to fungicide ($r = 0.991$, $P < 0.01$) and between the reduction in light leaf spot due to fungicide treatment and the increase in yield in the fungicide treated plots ($r = 0.990$, $P < 0.01$).

Stem canker levels were high in cv. Karma in two trials (Table 7) and dark podspot (Alternaria brassicae) (Table 7) and downy mildew (Table 6) were most severe in cvs. Mikado and Rafal. Control of downy mildew was poor in some trials especially on cv. Mikado.

The 1988 NL and RL trials showed yield responses to fungicides and other inputs ranging from 0.11 to 1.14 tonnes/ha and the 1989 trials showed yield responses ranging from 0.24 to 0.65 tonnes/ha (Table 8).

4. Discussion

In the 1983-86 trials the fungicide treatments increased the mean yield of cultivars over all the trials and in most cultivars within each trial. Oil content was also increased in many instances so that fungicide treatments increased the mean oil yield by more than expected from the increase in seed yield on all cultivars.

There was a close correlation of both the level of light leaf spot and the reduction in level of light leaf spot by fungicide treatment with the seed yield response of varieties ($r = 0.991$ and $r = 0.990$, $P < 0.01$ respectively). Therefore, it appears that light leaf spot may be the main cause of reductions in yield in susceptible cultivars.

The increase in yield in light leaf spot resistant cultivars caused by fungicides may be due to several factors. Fungicides delay pod ripening allowing a longer period for seed development and thus either a higher seed weight, or more seeds to develop per pod. However, seed weights were only assessed in one trial so no conclusions can be drawn at present.

Light leaf spot is known to occur as a systemic cryptic infection in oilseed rape (McCartney et al., 1986) with little conspicuous sporulation on leaf and stem surfaces. These cryptic infections may affect the yield of cultivars in the absence of any apparent disease and thus explain the yield response of supposedly resistant varieties to fungicides.

Dark pod spot tended to develop more on the earliest maturing and shorter cultivars, though seasonal factors and time of harvest largely influenced the development of pod spot. Sweet et al. (1988) showed similar effects in cultivars with no clear pattern of resistance.

In the NIAB NL and RL trials there was some indication that the cultivars with low light leaf spot resistance were giving the greatest response to the higher levels of inputs and fungicide treatments. However, some varieties with high resistance, such as Score, gave high responses. Score and the genetically closely related Capricorn and Corvette have been noted by Rawlinson et al. (1989) to give high responses to fungicides so that these cultivars may be sensitive to low inputs and thus give a greater response.

Table 11 shows the ranking order of cultivars by yield in the trials in the two years. Cultivars such as Falcon, Lictor and Libravo maintain their position relative to other cultivars in both years and with differing levels of input and fungicide treatment. Other cultivars such as Cobra and Capricorn show large responses to fungicides and other inputs, and their performance is improved relatively.

It therefore appears that, in addition to the larger responses to disease control in susceptible cultivars, there are also differential responses by certain cultivars. These latter cultivars could be considered to be environmentally sensitive only showing their full genetic potential under high input systems.

The results demonstrate the benefits of growing cultivars with resistance to light leaf spot. The reduction in yield due to disease is usually less in these varieties and it is likely that they will require less fungicide input to achieve their yield potential.

The newer double-low cultivars with low levels of both glucosinolates and erucic acid in their seeds show as wide a range of responses to inputs as the earlier tested single-low (low erucic acid) cultivars. The results of these NIAB trials do not confirm the results of Rawlinson et al. (1989) which suggested that double-low cultivars gave higher responses to both fungicide and insecticide treatments than single-low cultivars. However, in NIAB NL and RL trials it was not possible to separate the effects on yield of fungicides from the influence of other inputs and insecticides were not tested.

Table 2 **Winter oilseed rape fungicide trials 1983-1986**

Harvest Year	No.of Trials	Location	Sowing Date	Swathing Date	Desiccation Date	Harvesting Date	Fungicide Treatments
1983	1	Caxton, Cambridgeshire	26/27.8.82	-	-	26.7.83	ABC
1984	2	Boxworth Experimental Husbandry Farm, Cambridgeshire	31.8.83	-	30.7.84	9.8.84	ABC
		Bridgets EHF, Hampshsire	31.8.83	-	-	2-7.8.84	ABCD
1985	3	Boxworth EHF	30.8.84	-	23.7.85	7.8.85	BC
		Bridgets EHF,	30.8.84	-	-	6-13.8.85*	ABCD
		High Mowthorpe EHF, Yorkshire	29.8.84	9.8.85	-	26-27.8.85	BCD
1986	3	Bladon, Oxford	05.9.85	-		5.8.86	ABCD
		Bridgets EHF	30.8.85	-		30.7-12.8.86*	ABCD
		Boxworth EHF	11.9.85	-	21.7.86	29.7.86	ABC

Fungicide Treatments were as follows:-

A) Autumn application (October/November); Fubol (=10% w/w metalaxyl + 48% w/w mancozeb) 1.5 kg/ha and Sportak (=38.1% w/w prochloraz + xylene) 1.25 litres/ha.

B) Spring application (late March/early April): Fubol 1.5 kg/ha and Sportak 1.25 litres/ha.

C) Mid flowering application: Sportak 1.25 litres/ha, Rovral (=25% w/v iprodione) 2 litres/ha, Ronilan (=50% w/w vinclozolin) 1 kg/ha.

D) Late flowering application: Rovral 2 litres/ha.

* Untreated plots were harvested from the earlier date as they matured and treated plots harvested at the later date.

Table 3   **Seed yield (t/ha) and yield response to fungicide treatment over 7 trials, 1983-1986**

	1983		1984				1985				1986						
Location	Caxton		Boxworth		Bridgets		Boxworth		Bridgets		Bladon		Bridgets		≠ FITCON mean		Yield response %
	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	
Variety																	
Bienvenu	3.29	3.89	4.17	4.81	4.19	4.08	4.17	4.48	3.37	3.61	3.56	4.55	3.62	3.95	3.77	4.20	+11
Darmor	2.96	3.31	3.65	4.60	3.31	3.40	3.62	4.07	-	-	3.05	3.82	3.43	3.87	3.24	3.76	+16
Fiona	-	-	-	-	-	-	3.93	3.80	3.58	3.83	-	-	-	-	-	-	-
Jet Neuf	3.18	3.46	3.71	4.17	2.65	3.22	3.44	3.55	2.15	3.27	3.26	4.58	2.99	3.61	3.05	3.69	+21
Karma	-	-	1.93	3.10	2.74	3.36	2.87	2.96	1.60	2.61	-	-	-	-	2.18	3.03	+39
Korina	-	-	-	-	-	-	-	-	-	-	3.63	4.46	3.18	3.94	-	-	-
Mikado	-	-	4.08	3.97	3.87	4.28	4.14	4.14	2.95	3.47	3.46	4.75	3.25	3.67	3.57	3.99	+12
Rafal	3.04	3.62	3.98	4.17	3.61	3.83	4.44	4.45	3.22	3.48	4.02	4.68	3.57	4.22	3.70	4.06	+10
Mean	2.93	3.36	3.61	4.16	3.38	3.65	3.80	3.92	2.81	3.38	3.50	4.50	3.37	3.91	3.25	3.79	+17
% U	100	115ns	100	115ns	100	108*	100	103ns	100	120**	100	129**	100	116*	100	117***	

*, **, *** = treated yields greater than untreated yields at P = 0.05, 0.01 and 0.001 respectively.
U = Untreated
T = Treated with fungicide programme shown in Table 2.
≠ = Fitted constants analysis after Silvey (1978) J. Natn. Inst. Agri. Botany. 14, 385

Table 4 Oil yield (t/ha) and yield (t/ha) response to fungicide treatment over 6 trials 1983-1986

	1983		1984				1985				1986				
Location	Caxton		Boxworth		Bridgets		Boxworth		Bridgets		Bridgets		FITCON mean		Yield Response
Treatment	U	T	U	T	U	T	U	T	U	T	U	T	U	T	%
Cultivar															
Bienvenu	1.40	1.65	1.69	2.04	2.01	1.96	1.77	1.89	1.47	1.58	1.59	1.75	1.65	1.81	+10
Darmor	1.23	1.38	1.38	1.89	1.46	1.53	1.46	1.61	-	-	1.43	1.65	1.34	1.58	+18
Fiona	-	-	-	-	-	-	1.58	1.54	1.47	1.60	-	-	-	-	-
Jet Neuf	1.35	1.42	1.41	1.65	1.18	1.43	1.32	1.38	0.87	1.36	1.22	1.54	1.22	1.46	+20
Karma	-	-	0.73	1.27	1.21	1.49	1.18	1.18	0.66	1.09	-	-	0.91	1.23	+35
Korina	-	-	-	-	-	-	-	-	-	-	1.30	1.68	-	-	-
Mikado	-	-	1.62	1.66	1.81	2.01	1.73	1.74	1.28	1.51	1.41	1.55	1.55	1.67	+8
Rafal	1.27	1.46	1.56	1.66	1.61	1.74	1.82	1.76	1.32	1.40	1.47	1.77	1.51	1.63	+8
Mean	1.23	1.40	1.40	1.70	1.53	1.67	1.55	1.58	1.17	1.43	1.41	1.67	1.36	1.56	+15
%U	100	114ns	100	121ns	100	109*	100	102ns	100	122***	100	118*	100	115**	

*,**,*** = treated yield greater than untreated yields at P = 0.05, 0.01 and 0.001 respectively.

Table 5 Light leaf spot infection in untreated (U) and fungicide treated (T) cultivars in seven trials 1983-1986

	1986						1985				1984		1983		1983-1986			
Location	Bladon		Bridgets		Boxworth		Bridgets		Boxworth		Bridgets		Caxton		Fitcon Mean		Control	Mean %
Treatment	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	(U-T)	Control
Cultivar																		
Bienvenu	5.3	0.0	0.0	0.0	1.2	0.7	0.4	0.0	0.0	0.0	1.4	0.1	4.7	1.2	1.9	0.3	1.6	84.2
Darmor	3.7	0.6	2.0	0.1	4.0	0.7	0.1	0.0	2.5	0.0	3.3	0.4	9.0	2.5	3.5	0.6	2.9	82.9
Jet Neuf	8.4	0.8	20.0	0.4	9.0	6.2	7.3	0.1	15.0	0.1	7.7	1.7	5.7	1.2	10.4	1.5	8.9	85.6
Korina	4.0	1.2	4.3	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	
Mikado	6.9	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.5	0.0	0.0	0.0	-	-	1.5	0.2	1.3	86.7
Rafal	9.4	3.0	0.3	0.0	0.5	0.7	0.1	0.0	0.1	0.1	0.4	0.1	3.3	1.5	2.0	0.8	1.2	60.0
Fiona	-	-	-	-	1.1	1.0	0.1	0.0	-	-	-	-	-	-	-	-	-	
Karma	-	-	-	-	14.6	11.2	13.3	1.9	6.5	0.0	56.7	6.7	-	-	23.9	5.1	18.8	78.7
Mean	6.3	0.9	4.4	0.1	4.4	2.9	3.0	0.3	4.1	0.0	11.6	1.5	5.7	1.6	7.2	1.4	5.8*	80.6
$\frac{U-T}{U}$ x100	85.7		97.7		34.1		90.0		100		87.1		71.9		80.6		?	

* Effect of treatment significant at P=0.05

Table 6 **Downy mildew infection in untreated (U) and fungicide treated (T) cultivars in seven trials, 1983-1986**

	1986				1985				1984				1983		1983-1986		
Location	Bladon		Bridgets		Boxworth		Bridgets		Boxworth		Bridgets		Caxton		Fitcon Mean		Mean Control
Treatment	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	%
Cultivar																	
Bienvenu	0.8	0.0	0.1	0.0	15.0	7.0	1.4	0.4	5.1	6.5	1.7	1.3	5.7	5.0	4.3	2.9	33
Darmor	0.0	0.0	1.5	0.0	12.3	10.0	0.1	0.0	4.5	15.0	5.0	5.0	4.0	3.3	3.9	4.8	-23
Jet Neuf	0.7	0.5	0.1	0.0	13.3	5.4	1.7	0.1	2.5	15.0	3.0	1.7	6.0	5.0	3.9	4.0	-3
Korina	1.5	0.0	0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Mikado	1.0	0.0	0.1	0.0	11.3	6.0	2.7	0.7	5.5	10.0	13.3	19.0	-	-	5.7	6.1	-7
Rafal	3.9	0.0	1.5	0.0	12.7	5.7	4.7	2.7	17.5	19.0	2.7	4.0	5.3	7.7	6.9	5.6	19
Fiona	-	-			12.0	6.0	0.7	0.0	-	-	-	-	-	-	-	-	-
Karma	-	-			11.0	8.3	0.1	0.0	1.5	2.5	5.3	5.3	-	-	2.6	2.0	23
Mean	1.3	0.1	0.6	0.0	12.5	6.9	1.6	0.5	5.8	10.8	4.8	6.0	5.3	5.3	4.6	4.2	
(U-T)/U x 100	?		?		?		?		?		?		?		9		

Table 7 **Dark pod spot and stem canker infection in untreated (U) and fungicide treated (T) cultivars in three trials, 1984-1986.**

Location	1986 Bridgets		1985 Bridgets		1984 Bridgets		1984-1986 Fitcon Mean		Mean Control
Treatment	U	T	U	T	U	T	U	T	%
Cultivar									
Bienvenu	14.0≠	0.1	4.3	1.0	12.3	0.7	10.2	0.6	94
Darmor	6.7	0.1	6.0	1.0	24.0	3.6	12.2	1.6	87
Jet Neuf	12.7	0.1	6.0	1.0	16.2	8.2	11.6	3.1	73
Korina	10.0	0.1	-	-	-	-	-	-	
Mikado	18.3	0.5	16.7	2.3	19.2	1.0	18.1	1.3	93
Rafal	18.3	0.5	13.3	1.7	10.1	3.5	13.9	1.9	86
Fiona	-	-	5.0	1.0	-	-	-	-	
Karma	3.0	1.0	3.3	0.4	15.7	2.5	9.9	0.7	93
Mean	13.3	0.2	7.8	1.2	16.3	3.3	12.7	1.5	

Location	Bridgets 1984		Boxworth 1984		Caxton 1983		Fitcon Mean		Mean Control
Treatment	U	T	U	T	U	T	U	T	%
Cultrivar									
Bienvenu	0.6*	0.2	1.5	1.6	0.9	0.4	1.0	0.7	30
Darmor	1.0	0.1	1.1	1.1	1.4	0.8	1.2	0.7	42
Jet Neuf	0.6	0.2	2.0	1.3	1.1	0.3	1.2	0.6	50
Korina	-	-	-	-	-	-	-	-	-
Mikado	0.4	0.2	1.1	0.8	-	-	0.7	0.4	43
Rafal	0.6	0.5	1.5	1.9	1.0	0.9	1.0	1.1	10
Fiona	-	-	-	-	-	-	-	-	
Karma	3.0	1.0	3.0	2.4	-	-	3.0	1.6	47
Mean	1.0	0.4	1.7	3.0	1.1	0.6	1.4	0.9	

*0-4 scale, 0 = no infection 4 = severely affected with stem canker.
≠ % infection with dark pod spot.

Table 8 Summary of yield response to fungicides and disease resistance ratings of cultivars in National List and Recommended List Oilseed Rape Trials 1987 to 1989.

Cultivar	Yield (t/ha) Low input no fungicide	High input + fungicides	response to inputs	Light leaf spot resistance rating
1987/88				
Capricorn	2.80	3.94	1.14	5
Lecor (Corvette)	3.03	2.65	0.62	4
Score	3.37	3.94	0.57	7
Samourai	3.54	3.92	0.48	6
Falcon	3.78	4.22	0.44	6
Libravo	3.57	3.98	0.41	7
Ariana	3.33	3.72	0.39	5
Cobra	3.67	4.04	0.37	4
Tapidor	3.35	3.68	0.33	6
Bienvenu*	3.73	4.05	0.32	6
Susana	3.51	3.83	0.32	6
Link	3.75	4.03	0.28	7
Lictor	3.76	4.00	0.24	6
Liborius	3.63	3.88	0.25	7
Doublol	3.76	3.92	0.16	7
Rafal*	3.72	3.83	0.11	6
1988/89				
Susana	3.54	4.19	0.65	5
Cobra	3.72	4.35	0.63	4
Capricorn	3.42	4.03	0.61	5
Falcon	3.82	4.38	0.56	6
Score	3.34	3.87	0.53	7
Samourai	3.67	4.18	0.51	6
Doublol	3.51	4.00	0.49	7
Ariana	3.57	4.03	0.46	5
Libravo	3.79	4.25	0.46	7
Lictor	3.82	4.28	0.46	6
Tapidor	3.75	4.15	0.40	6
Liborius	3.65	3.95	0.30	7
Link	3.87	4.11	0.24	7

Resistance rating 1 = very susceptible
9 = very resistance
* Single-low cultivars

Table 9 Ranking order of varieties by yield in the NIAB NL/RL trials

	87/88 Low input No Fungicides	87/88 High input +Fungicides	88/89 Low input No Fungicides	88/89 High input +Fungicides
Highest Yield	FALCON	FALCON	LINK	FALCON
	LICTOR	BIENVENU*	FALCON	COBRA
	DOUBLOL	COBRA	LICTOR	LICTOR
	LINK	LINK	LIBRAVO	LIBRAVO
	BIENVENU*	LICTOR	TAPIDOR	SUSANA
	RAFAL*	LIBRAVO	COBRA	SAMOURAI
	COBRA	CAPRICORN	SAMOURAI	TAPIDOR
	LIBORIUS	SCORE	LIBORIUS	LINK
	LIBRAVO	DOUBLOL	ARIANA	ARIANA
	SAMOURAI	SAMOURAI	SUSANA	CAPRICORN
	SUSANA	LIBORIUS	DOUBLOL	DOUBLOL
	SCORE	RAFAL*	CAPRICORN	LIBORIUS
	TAPIDOR	SUSANA	SCORE	SCORE
	ARIANA	ARIANA		
	LECOR (Corvette)	TAPIDOR		
Lowest Yield	CAPRICORN	LECOR (Corvette)		

* = single low varieties

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High or Low Input Production with Winter Rape Experience and Environment Aspects

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Summary
Winter rape has been grown for many years in Schleswig-Holstein. This has allowed the accumulation of long-term experimental results concerning the economic and environmental aspects of nitrogen utilization and variety-specific reaction to fungicides, nitrogen and growth-regulators. Theses are discussed in the context of the need to reach a better balance between inputs, agricultural productivity and environmental safety.

1. Nitrogen utilization

The following results come from our experimental station at Wulfshagen where all rape experiments are grown in a normal farming system of crop rotation. In consequence the N-dynamics of the soil reflect real, practical conditions typical of Schleswig-Holstein.

Reliable information concerning rape yields and N-fertilization is available from 1972 onwards. Average yields of rapeseed over two eight year periods are given in Table 1.

Table 1: **N-fertilization and N-utilization in relation to yield of winter rape at the experimental station at Wulfshagen 1972 - 1988**

Years	N-fertilization kg/ha	Yield dt/ha	% N-utilization by the seed
1972 - 80	189	33,2	65
1981 - 88	207	41,4	74

In the period 1981 - 88 a relative small increase in the amount of N-fertilizer (18 kg/ha) gave much better N-utilization and a mean yield increase of 8,2 dt/ha as seen in the comparison of these two 8-years periods.

Rape in Schleswig-Holstein crop rotations is followed by winter wheat, the latter often having a negative direct N-balance;

consequently winter wheat makes use of the N-surplus from the preceding rape. The relationship between N-utilization and yield becomes even more evident when the rape yields for the years 1972 - 88 are grouped as in Table 2.

Table 2: **N-fertilization and N-utilization at different yield levels 1972 - 89 (experimental station Wulfshagen**

Years	Yield dt/ha	N-fertilization kg/ha	% N-utilization by the seed	Surplus N kg/ha
1972-88	> 30	203	50	100
	30-35	190	64	71
	35-40	203	70	62
	> 40	192	89	22
1989:	53	170	115	-

Rape yielding more than 40 dt/ha had a N-utilization of about 90%. At this level of efficiency nitrogen applied to rape can not be considered as environmentally harmful.

There were special circumstances in 1989 where, after using only 170 kg/ha of fertilizer N, the crop removed in complex 196 kg N at 53 dt/ha of seed yield. The N-utilization impressivly reached more than 100 %. 1989 was an exceptional year with "English" winter and spring conditions. It is possible however to handle the N-fertilization of rape much more precisely than has been done up to now.

2. <u>Specific variety reaction to fungicides, nitrogen and growth - regulators</u>

With our recent work we address two important questions: Do "high" or "low" input varieties exist? What is the optimum level of input for rape? Our preliminary experiences from the last two years are shown for 4 varieties in Table 3 where the yield differences obtained using three input variations are compared and in each case the variety-specific economic optimum is given.

Table 3: **Differences in yield obtained under contrasting input systems compared to the normally used input system in variety tests in Schleswig-Holstein, 1988 - 89**

Input level:		Cost (DM/ha)
I	Normal system, 1 fungicide application	± 0
0	Without fungicide	- 100
II	Like I, plus fungicides in spring and autumn, growth regulator, plus 2 x 20 kg N/ha	+ 250

Table 4: **Yield differences in dt/ha compared to system I**

	Input level						
	0			II			I
	1988	1989	Mean	1988	1989	Mean	1988
Ceres	-3.7	+0.1	-1.8	***+4.2***	***+6.7***	***+5.5***	
Lirabon	-7.3	**-0.2**	-3.8	*+2.2*	*+1.8*	*+2.0*	**x**
Libravo	-3.4	***+0.8***	-1.3	-1.5	*+2.5*	*+0.5*	**x**
Arabella	-0.6	**-0.2**	-3.1	*+1.9*	*+1.7*	*+1.8*	**x**
Mean	-5.1	**+0.1**	-2.5	+1.7	**+3.2**	+2.5	x

bold = optimal yield at a rape price of 100 DM/dt
italics = maximum yield

The specific reactions to N-fertilization, fungicides and growth regulators show great differences between varieties and between years. In both years only Ceres reached the economic optimum with the highest input system. Maximum yield and economic optimum with Ceres were identical.

The other three varieties Lirabon, Libravo and Arabella reacted differently. In 1988 they reached the economic optimum with the production system I, even without fungicide application in 1989. The production system I is common in todays practical agriculture. Maximum and optimal yield for Lirabon, Libravo and Arabella were not congruent.

3. Conclusions

Yield stability and yield increase are the main possibilities to achieve better N-utilization with rape, thus preventing ecologically harmful N surplus.

The optimum input system varies between years and varieties. It is a challenge for people who work in plant protection and plant production to establish the reasons for this and to make useful and reliable recommendations for practical agriculture.

The economic optimum for growing rape often lies below the maximum yield. The problem is that this only becomes evident after harvesting.

The yield risk arising from a reduction in inputs is not yet sufficiently well quantified.

The positive and negative economic and environmental aspects of using a fungicide on the 100 000 ha of rape in Schleswig-Holstein are illustrated in Table 5.

Table 5: **Economic and ecologic importance of a fungicide application to 100 000 ha of rape**

Efficiency of fungicide	Consequences
Fungicide is without effect:	
Input: 100 000l - 150 000l of fungicide costing	superfluous, also potentially environmentally harmful input
Loss: 10 Million DM	
Fungicide is effective (+3.5 dt/ha):	
Benefit: 25 Million DM	additional profit for agriculture
and	
1,3 Million kg N	better N-utilization from 2927 t of urea or 48148 dt ammoniumnitrate

EFFECTS OF FUNGICIDES ON THE HEALTH AND YIELD OF OILSEED RAPE

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Summary

Field observations with rape during 1984 - 1988 tested the effect of 17 fungicides applied at different times on disease and yield. The major diseases encountered in the surveys were downy mildew (Peronospora parasitica), stem rot (Sclerotinia sclerotiorum), dark pod spot (Alternaria spp.), grey mould (Botrytis cinerea), **canker (Leptosphaeria maculans), and recently light leaf spot (Pyrenopeziza brassicae).**
The application of metalaxyl decreased the incidence and severity of downy mildew and increased yield by up to 14 %. Iprodione, viclozolin, prochloraz or fenetrazol + terbutazol were partly effective on other diseases and increased yield by up to 21 %. These chemicals did not control P. parasitica.

Introduction

Recently in Poland, a greater incidence of deseases has been observed on winter rape. The main reasons for the seriousness of diseases are the increase in the area sown and the change of cultivars from high erudic acic to so called double-low cultivars (low in both erucic acid and glucolinolates). The occurrence of diseases on winter rape also depends on climatic conditions and often diseases have been so severe that even with good cultivation techniques and appropriate husbandry chemical control has been necessary.

The most common diseases on winter rape in Polish climatic conditions are downy mildew (Peronospora parasitica (Pers. ex Fr.) Fr.), stem rot (Sclerotinia sclerotiorum (Lib.) de Bary), dark pod spot (Alternaria spp.),canker (Leptosphaeria maculans (Desm.) Ces. and de Not.) grey mould (Botrytis cinerea Fr.) and recently light leaf spot or scorch (Pyrenopeziza brassicae Sutton and Rawlinson), (Sadowski,1989a).Similar pathogens occur in other countries (Rawlinson and Muthyalu, 1979; Rawlinson et al., 1984; Tewari et al., 1987; Evans and Gladders 1985). Experiments on the influence of agriculture cultivations and chemical control were performed by the Department of Plant Pathology, Technical-Agricultural University at Bydgoszcz from 1983; The results of some of the chemical control investigations are included in this paper.

2. Materials and Methods

The effect of seventeen fungicides on diseases and yield of seed were tested from 1984 - 1988. There were eleven experiments conducted at different sites near Bydgoszcz, Poland. In the first year of the experiments, fungicides were chosen mainly to control <u>Peronospora parasitica</u>. After the first year, it became clear that other pathogens also needed to be controlled, so more fungicides were applied. An estimate of the effectiveness of the fungicides was made about 14 days after the plants were sprayed.

For Alternaria, Botrytis and Leptosphaeria the percentage of infected leaves, stems and pods was recorded. For Pyrenopeziza the percentage of infected leaves, and for Sclerotinia the percentage of infected plants were recorded. The percentage of Peronospora - infected leaves and the severity of their infection was recorded on a scale 0-5 (Sadowski, 1989). Most of the results concerning P. parasitica have been published together with comments on the epidemiology of the pathogen (Sadowski, 1989), so only some of findings are reported in this paper.

Each year, experiments were conducted on randomized plots, each 16 sq m., replicated 4 times and sown with cv. Jet Neuf. After Bliss or Freeman-Tukay´a transformation, the results were analysed statistically using Duncan´s Multiple Range Test.

3. Results

The incidence and severity of diseases of winter rape differed during the years of the investigation. More symptoms of diseases were observed in 1984, 1985 and 1987 when rainfall levels and humidity were higher. The major pathogens which occurred were P. parasitica, S. sclerotiorum, Alternaria spp., L. maculans, B. cinerea and in 1987 P. brassicae.

The fungicides used for the control of winter rape deases are given in Table 1.

Table 1. List of fungicides for the control of winter rape diseases investigated in 1983 - 1987

Fungicide	Active ingredient	%	Dose
Bayleton	triadimefon	5	1,5 kg/ha
Cynkomiedzian	zineb + copper oxychloride	32 + 28	4,0 kg/ha
Cynkotox	zineb	65	2,5 kg/ha
Dithane M-45	Mankozeb	80	2,0 kg/ha
Euparen	dichlofluanid	50	1,5 kg/ha
Folicur Plus	fenetrazol + terbutazol	?	3,0 dm^3/ha
IPO 2584 A	?	?	1,0 and 2,0kg/ha
IPO 2584 C	?	?	2,0 and 3,0kg/ha
Ridomil MZ 58 WP	metalaxyl + copper oxychloride	10 + 48	2,0 kg/ha
Ridomil Plus 45 WP	metalaxyl + copper oxychloride	5 + 40	4,0 kg/ha
Ronilan	vinclozolin	50	1,5 kg/ha
Rovral	iprodione	50	1,5 kg/ha
Sandofan MB	oxadixil + mancozeb	8 + 56	2,0 kg/ha

Sandofan G	oxadicil + copper oxychloride	10 + 40	2,0 kg/ha
Sportak	prochloraz	45	1,5 dm^3/ha
Sumilex	procymidone	50	1,5 kg/ha
Tilt 250 EC	propiconazole	25	0,5 dm^3/ha

In 1984, when Ridomil, Dithane M-45 and Cynkomiedzian were used, Peronospora parasitica was nearly completely controlled by Ridomil applied twice. The effect of Dithane M-45, Cynkomiedzian was poor. However, the yield of seeds from plants treated with Dithane M-45, Cynkomiedzian was not much lower than the yield from plants sprayed with Ridomil. The differences were not statistically significant, but a tendency to increase the yield was noticed when Ridomil (27,6 dt/ha) or Dithane were used. The increase in yield obtained as the result of spraying with Dithane, which had little influence on downy mildew, indicated the possibility of further control in the following years against other diseases.

The fungicides and their effects in 1985, a year in which the incidences of the pathogens was high, are presented in Tables 2 and 3. The best control of B. cinerea, S. sclerotiorum and Alternaria spp. was obtained when Ronilan or Rovral were used. For P. parasitica, Ridomil was most effective, but for L. maculans the results were not clear; some evidence of control was obtained but this was not very marked. Ridomil was not effective in controlling diseases other than downy mildew, but even so yield of seeds was increased.

The incidence of disease in 1986 was not great (Table 4,5). The most common pathogen in this year was Alternaria spp. The best results were obtained when fungicides were used twice; only prochloraz (Sportak) also gave positive results when applied once. Other diseases were infrequent , but despite this a high yield of seeds was obtained when plants were sprayed twice with iprodione or once with prochloraz followed by propiconazole.

1987, like 1985, was a year in which many symptoms of fungal diseases were recorded (Table 6). P. parasitica was controlled, as previously, with the best results coming from metalaxyl or oxadixil, Alternaria spp. were controlled by all fungicides, but the best results were obtained when Rovral, Ronilan, Folicur or Sportak were used. The same fungicides gave good results against S. sclerotiorum. These defferences were calculated statistically. B. cinerea was not decreased by Ridomil and Sandofan, but the other fungicides used gave good control. The occurence of L. maculans was satisfactorily decreased only when plants were sprayed twice with Ronilan, Rovral, Folicur or Sportak. In this year, severe occurrence of P. brassicae was observed for the first time; up to this time the fungus had been little known in Poland. The application of all fungicides , except Sandofan and Ridomil, limited this pathogen, and the fungicides were more effective when they were applied twice. All the fungicides investigated, except Sandofan and Sumilex, significantly increased the yield of seed and they were more effective in this respect when plants were treated twice.

Table 2. Effect of fungicides on diseases of winter rape, Mochełek 1985

Fungicide	% of infected								
	leaves	stems	pods	leaves	stems	pods	leaves	stems	pods
	Alternaria spp.			B. cinerea			L. maculans		
Rovral	5 a[x]	10 a	5 a	4 a	3 a	4 a	9 a	6 a	7 a
Ronilan	6 a	12 a	7 ab	3 a	4 a	4 a	8 a	7 a	8 ab
Dithane M-45	10 ab	18 ab	18 ab	10 ab	9 b	9 b	10 a	9 ab	10 abc
Cynkotox	10 ab	26 bc	17 bc	9 b	10 b	10 b	11 ab	9 ab	12 abc
Ridomil MZ 58	12 b	29 c	23 c	9 b	9 b	10 b	12 ab	8 ab	11 abc
Ridomil Plus	15 b	28 c	21 c	10 b	9 b	12 b	11 ab	9 ab	12 abc
Check	21 c	38 d	28 c	15 c	13 b	18 c	17 b	12 b	16 c

[x]Values in the same column followed by different letters are significantly different.
Spray applied on May 9 and repeated on May 30.

Table 3. Effect of fungicides on occurence of *P. parasitica*, *S. sclerotiorum*, yield, content of oil and weight of 1000 seeds of winter rape, Mochełek 1985.

Fungicide	S. sclerotiorum	P. parasitica		Yield	% of oil	Weight of 1000 seeds
	% of infected plants	% of infected leaves	degree of infection	dt/ha		g
Rovral	5 ab[x]	42 bc	0,7 b	33,9 a	45,6	5,41
Ronilan	2 a	39 bc	0,7 b	34,6 a	45,8	5,41
Dithane M-45	6 b	41 bc	0,8 b	31,4 bc	44,4	5,39
Cynkotox	8 b	50 bc	0,9 bc	30,7 c	44,0	5,36
Ridomil MZ 58	7 b	12 a	0,2 a	36,0 a	45,3	5,54
Ridomil Plus	8 b	14 a	0,2 a	35,5 a	45,2	5,52
Check	13 c	61 c	1,1 c	30,7 c	44,3	5,38

[x]Values in the same column followed by different letters are significantly different.
Spray was applied on May 9 and repeated on May 30.

Table 4. Effect of fungicides on diseases of winter rape, Mochełek 1986

Fungicide	Date of spray	% of infected								
		leaves	stems	pods	leaves	stems	pods	leaves	stems	pods
		Alternaria spp.			B. cinerea			L. maculans		
Rovral	May 6, 22	3 a	7 a	8 a	4 a	4 a	3	4 ab	4 a	4
Sportak/Tilt	"	5 ab	8 a	10 ab	5 ab	6 ab	6	3 a	6 ab	6
Ronilan	"	6 abc	10 ab	10 ab	3 a	4 a	4	3 a	3 a	4
Sportak	"	6 abc	8 a	11 ab	6 abc	5 ab	5	3 a	3 a	5
Cynkomiedzian	"	7 abc	8 a	10 ab	7 abc	5 ab	5	4 ab	6 ab	5
Dithane M-45	"	6 abc	8 a	10 ab	5 ab	4 a	3	4 ab	7 ab	5
Euparen/Bayleton	"	5 ab	10 ab	10 ab	4 ab	5 ab	5	4 ab	6 ab	5
Sportak	May 6	5 ab	10 ab	12 ab	7 abc	6 ab	7	5 ab	6 ab	5
Tilt	"	7 abc	14 ab	15 ab	8 bc	8 b	7	6 ab	7 ab	7
Ronilan	"	8 bc	13 ab	15 ab	5 a	5 ab	6	4 ab	4 a	4
Dithane M-45	"	8 bc	12 ab	11 ab	6 ab	6 ab	7	5 ab	6 ab	5
Rovral	"	8 bc	13 ab	14 ab	5 a	4 a	6	4 ab	5 ab	5
Ridomil Plus	May 6, 22	10c	12 ab	13 ab	8 bc	7 ab	7	6 ab	7 ab	6
Cynkomiedzian	May 6	10 c	17 b	18 b	7 abc	6 ab	8	5 ab	6 ab	5
Check	-	10 c	18 b	19 b	10 c	9 b	7	7 b	9 b	8

Values in the same column followed by different letters are significantly different.

Table 5. Effect of fungicides on occurrence of *P. parasitica*, *S.sclerotiorum*, yield, content of oil and weight of 1000 seeds of winter rape, Mochełek 1986

Fungicide	Date of spray	S.Sclerotiorum	P. parasitica		Yield dt/ha	% of oil	Weight of 1000 seeds g
		% of infected plants	% of infected leaves	degree of infection			
Rovral	May 6, 22	6 a[x]	7 abc	0,1 b	52,3 a	45,1	5,59
Sportak/Tilt	"	5 a	9 bc	0,1 b	49,6 ab	45,9	5,31
Ronilan	"	3 a	9 bc	0,1 b	49,2 bc	45,3	5,41
Sportak	"	5 a	9 bc	0,1 b	49,0 bc	45,2	5,46
Cynkomiedzian	"	6 a	9 bc	0,1 b	47,9 bcd	45,9	5,42
Dithane M-45	"	6 a	2 a	0,1 b	47,8 bcd	45,1	5,21
Euparen/ Bayleton	"	2 a	3 a	śl. a[x]	47,4 bcd	44,9	5,38
Sportak	May 6	5 a	8 bc	0,1 b	47,4 bcd	45,9	5,20
Tilt	"	4 a	6 ab	0,1 b	46,6 cd	44,7	5,12
Ronilan	"	4 a	11 c	0,1 b	46,1 d	45,4	5,22
Dithane M-45	"	5 a	7 b	0,1 b	46,3 d	45,8	5,35
Rovral	"	6 a	4 ab	śl. a	46,0 d	44,1	5,18
Ridomil Plus	May 6, 22	6 a	2 a	śl. a	45,8 de	44,9	5,37
Cynkomiedzian	May 6	6 a	5 ab	0,1 a	45,4 de	45,1	5,08
Untreated	-	10 b	16 cd	0,2 c	45,1 e	45,0	5,01

[x] Values in the same column followed by different letters are significantly different.

[xx] śl. - indicates trace of infection.

Table 6. Effect of fungicides on diseases of winter rape, Bożejewice 1987

Fungicide	Date of treatment	% of infected leaves			% of infected plants		
		P. parasitica	B. cinerea	C. concentricum	Alternaria spp.	L. maculans	S. sclerotiorum
Rovral	May 15, 29	35,2	21,4	8,3	8,5	3,3	3,5
Ronilan/Rovral	"	38,2	18,2	6,5	12,3	5,0	3,5
Folicur Plus	"	36,3	17,5	7,4	17,5	4,5	3,5
Sportak	"	37,3	15,3	8,7	13,1	4,5	3,3
Ronilan	"	35,2	13,8	9,5	18,2	4,0	3,6
Rovral	May 15	40,0	25,5	13,4	20,5	7,3	7,0
Folicur Plus	May 29	45,5	23,3	15,8	18,5	5,3	7,5
Ridomil/Ronilan	May 15, 29	23,9	12,9	12,3	21,3	6,8	6,0
Folicur Plus	May 15	39,8	25,2	16,2	41,3	7,6	7,5
Sumilex	"	40,2	22,2	17,3	40,1	7,3	8,2
Sportak	"	38,5	22,9	15,4	42,7	7,4	7,2
Ronilan	"	39,0	20,1	13,2	45,5	7,6	6,5
Ridomil Plus	May 7, 21	8,5	34,2	19,9	68,5	9,3	11,1
Sandofan MB	May 15	19,5	33,5	21,2	70,5	7,7	10,5
Sandofan G	"	17,3	31,3	23,1	73,0	8,0	10,8
Ridomil Plus	May 12	18,2	33,8	25,4	78,0	12,5	14,0
Untreated	–	55,8	35,5	28,4	85,5	11,5	13,3

———— indicate values significantly different from plants untreated (after log transformation of % values)

Table 7. Effect of fungicides on seed yield of winter rape.

Fungicide	Date of spray	Yield of seed	
		dt/ha	% of untreated
Rovral	May 15,29	35,6	120,7
Folicur Plus	"	35,1	119,0
Ridomil, Ronilan	"	35,1	119,0
Folicur Plus	May 15	34,7	117,6
Sportak	May 15,29	34,2	115,9
Ronilan, Rovral	"	34,2	115,9
Ronilan	"	34,1	115,6
Rovral	May 15	34,0	115,2
Sportak	"	33,9	114,9
Ronilan	"	33,8	114,6
Ridomil Plus	May 7,21	33,7	114,2
Ridomil Plus	May 12	33,4	113,3
Folicur Plus	May 29	33,2	112,5
Sandofan MB	May 15	33,0	111,9
Sandofan G	"	30,4	103,1
Sumilex	"	30,0	101,7
Untreated	–	29,5	100,0
LSD		3,01	–

In 1988, only Ronilan, Rovral, Folicur Plus and Sportak were applied once at the begining of flowering. All gave similar results to those obtained in 1987. The most common pathogens were Alternaria spp. and S. sclerotiorum.

4. Discussion and conclusion

Diseases of winter rape have become a problem in Poland. In some years it is necessary to use chemicals to control these diseases.There are some problems when choosing which disease ought to be controlled. These results show that fungicides for the control of P. parasitica which give specific control of Oomycete fungi are needed and different fungicides are required for other diseases. These other diseases can be slightly lessened by a chemical such as metalaxyl, but the sum of these pathogens (Botrytis, Sclerotinia, Alternaria Leptosphaeria, Pyrenopeziza) is more dangerous than P. parasitica alone, even if their occurrences is not very severe.If P. parasitica infection is very severe it may be necessary to control this disease separately from other diseases.

These results can be compared with other authors who agree that diseases on winter rape are increasing and are becoming a problem, or have already become a problem, in the cultivation of winter rape (Rawlinson and Muthyalu 1979; Dueck et al., 1983; Rawlinson et al., 1984; Ogilry, 1984 , Evans and Gladders 1985; Tewari et al., 1987; Evans et al., 1988).

The great severity, in some years, of fungal pathogens on winter rape indicates a necessity for further study of their epidemiology under Polish climatic conditions.

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SOME PROBLEMS OF CHEMICAL CONTROL OF BLACKLEG (PHOMA LINGAM) IN WINTER OILSEED RAPE

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Summary

Ten years' field trials with fungicides (benzimidazole, triazole) showed many cases of effective control of blackleg in winter oilseed rape. However, the success and economic benefits of fungicide spraying programs can not be guaranteed by existing criteria for determinating application dates. Under the conditions of disease progress in Mecklenbourg combined autumn+spring applications give most effective control. It seems to be possible to choose an application date in autumn according to ascospore release. The application in spring had to conform to the disease progress during winter and in early spring as well as to the occurrence of damage by pests (Psylliodes chrysocephala L., Ceutorhynchus napi Gyll., C. quadridens Panz.).
In future crop rotations the planting of resistant cultivars will remain the best measure for blackleg control.

1. Introduction

In the north of the G.D.R. blackleg disease caused by Phoma lingam (Tode ex Fr.) Desm. (teleomorph; Leptosphaeria maculans (Desm.) Ces et de Not.) became of great economic importance due to the enlargement and intensification of oilseed rape. The disease was observed in oilseed rape crops in the district for the first time in 1974 with incidence below 1 %. Up to 1989 there has been increasing disease incidence and severity with yearly variations (attacked stem surface in 1984 6 %, in 1989 35,4 %; mean score on the disease severity scale * in 1984 1,7, in 1989 4,6). At present blackleg disease causes approximately 12 % (range 3 to 21 %) yield loss per year in Mecklenbourg.
Control is based on prophylactic measures within crop rotations as well as on the planting of resistant cultivars. The application of fungicides is used as an additional control measure. Unfortunatly, chemical control has failed worldwide up to now because of difficulties in determining application criteria and the short effective persistence of the available fungicides. For timing applications in autumn Schramm and Hoffmann (1988) proposed that the decision should be based on thresholds according to the latent disease incidence and disease progress.

*/ 1 = plant without symptoms
9 = plant completly dead

2. Material and Methods

The basis of successful chemical control is a detailed knowledge of the biology and pathogenesis of the fungus. Fungicide application date was determined by the release of ascospores in autumn, recorded with simple spore traps. In addition, latent disease incidence was established by incubation of whole plants as well as crown samples under favourable conditions for development of symptoms (20 to 24° C. 85 % relative humidity, UV-light). Artificial inoculation experiments with pycnospores of *Phoma lingam* were carried out at different growth stages of the plants in spring and summer to examine the secondary dissemination of the pathogen. Since 1979, in 122 field trials, fungicide spraying programs with benzimidazole (bercema Bitosen N, Chinoin Fundazol WP 50) and triazole fungicides (Sportak 45 EC, Folicur 250 EC) were tested for the limitation of primary infections in autumn and the secondary dissemination of the pathogen in spring. The success of chemical control was assessed by the reduction of attacked stem surface, the yield reaction in comparision to untreated control and the calculation of rates of economic benefit (threshold = 0,1 t yield increase per hectare, taking in to account the number of applications and current costs for preparations and applications at present prices in the G.D.R.).

3. Results

Under the climatic conditions in the north of the G.D.R. peak ascospore release was detected at the earliest in the "5-leaf stage" of the plants. Dryness in the late summer delayed ascospore release. Mild conditions during the winter increased the potential for infection. The latent disease incidence increased with the quantity of ascospores released. Examinations in 1987/88 and 1988/89 showed a latent disease incidence on crowns of an average of 41 % if the plants had developed 9 true leaves (DC 29). Both methods of incubation (for whole plants and crown samples) allowed an equivalent quantification of latent infections. However, uncertainties remain in the prognosis of the final disease incidence and the determination of need for fungicide applications. Two years' field experiments with artificial inoculations at the growth stages "small green buds close together" (DC 54), "main flowering" (DC 64), "end of flowering" (DC 69) and "end of pod development" (DC 78) caused losses in total seed weight of 12,8 %, 7,5 %, 15,2 % and 11,0 % respectively as well as losses in thousand seed weight of 8,3 %, 1,0 %, 6,9 % and 7,0 % respectively.

The 7 years' field trials with benzimidazole fungicides (Table 1) demonstrated that combined autumn+spring applications were most effective, while repeated applications showed additional advantages. Single applications in autumn or spring controlled the disease less effectively. In most experiments

Table 1 Control of blackleg (*Phoma lingam*) and yield reaction in oilseed rape by benzimidazole fungicides, Rostock 1979 - 1985 $\bar{x}$ 98 trials (yield analysis in 70 trials)

Application data (DC)	Phoma lingam mean score on disease severity scale 1...9*/	reduction of attacked stem surface %	Yield %	Trials with lucrative result %
Untreated control	4,5	0	100	–
DC 25	4,2	20,7	96	40
DC 25, 27	3,7	39,6	94	20
DC 45	4,4	21,7	100	36
DC 45, 51	2,9	49,0	102	33
DC 25 + DC 45	3,6	43,9	97	50
DC 25 + DC 45, 51	2,4	65,9	103	0
DC 25, 27 + DC 45	3,5	43,5	103	27
DC 25, 27 + DC 45, 51	2,1	62,7	102	0

*/ 1 = plants without symptoms   9 = plants completly dead

only the combined repeated autumn+spring applications resulted in yield stability. However, the economic benefit of fungicide spraying programs was unsatisfactory (maximum rate: 50 % after combined autumn+spring application at DC 25 and DC 45).

Table 2. Control of blackleg (*Phoma lingam*) and yield reaction in oilseed rape by triazole fungicides, Rostock 1986 - 1989 ($\bar{x}$ 24 trials)

Application data (DC)	*Phoma lingam* mean score on disease severity scale 1...9	reduction of attacked stem surface %	Yield %	Trials with lucrative result %
Untreated control	4,3	0	100	–
DC 25	3,2	46,2	115	100
DC 27, 29	2,7	54,5	113	100
DC 25, 27, 29	3,3	40,6	114	100
DC 45	4,9	+ 1,3	100	0
DC 45, 51	3,8	40,9	101	33
DC 45, 51, 55	5,5	+14,3	102	0
DC 25 + DC 45	2,0	75,4	110	100
DC 25, 27 + DC 45	2,8	71,4	106	50
DC 25, 27 + DC 45, 51	1,7	84,0	107	50

Field trials with triazole fungicides applied at peak times of ascospore release in autumn from 1986 to 1989 (Table 2) showed that repeated applications in autumn led to an acceptable control efficiency and the highest yield stability. Again the combined autumn+spring applications resulted in the best control of blackleg and partially successful control of *Cylindrosporium concentricum* Grev. also occurred ($\bar{x}$ reduction to about 57 % of attacked stems in comparision to untreated control). Applications in spring, except where sprays were applied twice, gave less effective control. Only the repeated applications in autumn as well as the combined autumn+spring applications (DC 25 + DC 45) were economically beneficial.

4. Discussion and Conclusion

The control of blackleg (*Phoma lingam*) in winter oilseed rape with fungicides is problematic. The main difficulty is to determine the application date. The long teme potential for infections by ascospores in autumn and by pycnospores up to the ripening stage aggravates the timing of fungicides.

Ten years of fungicide spraying programs in field trials in Rostock have been aimed at limitating primary infections in autumn and the secondary dissemination of the pathogen in the early spring. This work has shown that seems to be possible to determine the application in autumn according to the release of ascospores. Long experience was necessary to obtain these results and, despite the economic benefits of repeated applications in recent years (Table 2), it is still only possible to give orientations.

The timing of fungicide application based on the method described by Schramm and Hoffmann (1988), according to the latent disease incidence, seems to be not practicable under the specific conditions of Mecklenbourg. Thresholds did not apply during the examinations in 1987/88 and 1988/89. In addition, there was significantly lower disease incidence at the "9 leaf stage" (DC 29) than at the "end of ripening" (DC 89). One reason for these differences is variation in the disease progress beginning in the early spring. Moreover, the secondary dissemination of the pathogen in spring through infection points made by pests (*Psylliodes chrysocephala* L., *Ceutorhynchus napi* Gyll., *C. quadridens* Panz.) or frost- and growth cracks on the stem have notable influences on yield building processes. Even an attack in the flowering period and at the beginning of natural maturity can result in significant yield losses.
An acceptable efficiency against disease incidence in autumn and spring can be given by combined autumn+spring applications. The application dates must conform to local disease progress (in Mecklenbourg DC 25 and DC 45). Until now it has been difficult to recommend thresholds or directions for timing of fungicide spraying programs; even now the success of control and the economic benefits of application cannot be guaranteed, although positive additional effects could come from the control of *Cylindrosporium concentricum* Grev.

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TARGETS FOR THE CONTROL OF GROWTH AND CROPPING IN OILSEED RAPE

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Summary
The potential yield of oilseed rape (6 - 7 t/ha), calculated from hand-harvested samples, is greatly in excess of the average yields of 3 - 4 t/ha recovered by the combine. Experiments with growth retardants and with the ethylene generating chemical ethephon indicate that (a), changes in yield components are unlikely to lead to changes in potential yield because of compensatory growth (b), improved yields recovered by the combine are associated with a canopy structure which is more stable and less likely to lodge and (c), improvements in recovered yield in the absence of lodging appear to be associated with shorter racemes which ripen more evenly because they allow more light to penetrate the canopy.

1. Introduction

The potential yield of oilseed rape, calculated by Daniels *et al.*, (1982), is over 7 t/ha, yet the yields recovered by the combine are only 3 - 4 t/ha. Yields from hand-harvested plots occasionally reach the calculated potential, indicating that much is lost during harvest. Improved recovery would increase efficiency irrespective of whatever level of crop husbandry inputs are chosen by the farmer and would ensure production efficiency nearly comparable with levels in other combine crops such as wheat and barley. The identification of characters associated with high levels of seed recovery will also help in selecting new cultivars many of which are introduced with only improved grain quality or disease resistance.

The importance of husbandry inputs in relation to productivity in oilseed rape is well understood and, as in other broad-acre crops, relates to the duration and amount of light intercepted. The number of pods which set is determined by the length of the growth period up to flowering, although potential seed yields do not vary greatly because of compensation in the numbers of pods and seeds which survive to maturity (Scarisbrick *et al.*, 1982). It seems unlikely that manipulation of pod numbers will result in yield benefit. However, a protracted flowering period results in pods of widely differing stages of development throughout the grain-filling period. Late-formed flowers produce pods of low yield potential which are still immature when the earlier-formed, higher-yielding pods are already mature and ready for harvest. The development of distal pods on the racemes can be prevented by carefully timed applications of the ethylene releasing chemical, ethephon, and this is associated with compensatory growth in the remaining pods (Child *et al.*, 1987a). However, ethephon also retards branch growth, reducing canopy density and improving light penetration, and may be responsible for the compensatory growth which results in similar seed yields in treated and untreated crops.

The differences in morphology of oilseed rape cultivars have more effect than the number of yield components on seed growth and on recovery. Plant structure derives from the primitive species which evolved as a result of successful competition and survival in mixed populations of varying density. The long branches are liable to form dense layers during pod growth, reducing the efficiency of light harvesting by the pods and causing uneven ripening and lower yields. Even greater reduction in yield is caused by lodging. Although it is not possible to improve crop stability by changes in the normal range of husbandry inputs, such as planting density or fertiliser rates, improved lodging resistance is possible with the use of plant growth regulators (pgrs). However, the chemicals used with cereals and the timing of their application are not appropriate in oilseed rape. For example, when application is made during early re-growth in the spring, the quaternary-ammonium retardants have only a temporary effect on stem extension which is followed by extra compensatory growth. Formulations containing ethephon, applied during extension, have a very potent and long-lasting retardant effect on the growth of the stem but can also cause pod failure (Child, 1984). These pgrs have inconsistent effects on yield (Bowerman, 1984).

Other growth retardants such as daminozide (dimethyl amino-succinamic acid) and the pyrimidine retardant fluprimidol, appear to have more consistent effects on growth but the consequences for yield are unclear because their effects appear to be associated with increased disease (Child *et al.*, 1988). More consistent effects on lodging and yield have been reported following treatment with the experimental triazole retardants, triapenthenol and BAS111..W, during stem extension (Hack *et al.*, 1985, Child *et al.*, 1985 and Luib *et al.*, 1987). These powerful retardants are effective throughout crop growth and, in the absence of lodging, have improved yield through changes in architecture of the canopy which alter light profiles (Child *et al.*, 1987b). The fungicidal properties of the triazole chemicals also reduce disease incidence.

This paper describes experiments with growth retardants and ethylene regulators and aims to identify the relationship between canopy structure and the components and level of yield.

2. Materials and Methods

Experiments with pot-grown plants

Winter oilseed rape cultivars Jet Neuf or Ariana were sown, in 15 cm pots containing John Innes No. 2 compost during the first week of September over the period 1984 - 1988, into pots and thinned to one plant per pot. The pots were buried to their rims in beds of gravel and drip irrigated with water containing supplementary nitrogen. Pots were arranged in rows of eight to give 35 - 40 plants m^2, which is approximately half the field density.

Growth regulators were applied to blocks of four or five rows *in situ*. The formulations contained wetting agents and plants were sprayed to run off with concentrations of 2.8 g/litre for triapenthenol (UK244) or 1.8 g/litre for BAS111..W or 960 µg/ml ethephon ('Cerone'). These applications delivered approximately twice the volume of spray per unit area than were used in the field experiments.

Experiments in crops

Agronomic details: Seeds of Jet Neuf or Ariana were sown in the field during the same period as the experiments with pot-grown plants at rates of between 7.00 - 8.00 kg/ha depending on seed size (row spacing 114 mm). Top dressings of nitrochalk equivalent to totals of 220 kg N/ha were applied as split treatments in the last weeks of March and April. The fungicide prochloraz was applied to specified plots during stem extension when disease assessments indicated rapid new infection of the lower leaves with light leaf spot (*Pyrenopeziza brassicae*). Crops were desiccated with glyphosate during the second week of July, when the seeds in approximately one third of the pods were light brown, and harvested 10 days later with a Claas Compact plot harvester (2.15 m wide cut) when moisture contents were 20 - 25%. Seed yields were calculated as t/ha equivalent at 8% moisture.

Experimental treatments: Plots (12 x 4 m) were sprayed at 250 l/ha with UK244 (containing 490 g a.i. triapenthenol or BAS111..W at 450 g a.i./ha or 'Cerone' at 0.5, 1.0 or 2.01 l/ha (equivalent to 240, 480 and 960 g a.i. ethephon/ha). The retardants were applied either at early regrowth during March when the crop was approximately 20 cm high and 2 - 4 new leaves had emerged, or at late stem extension during April when the crop was 70 - 100 cm high, all the leaves had unfolded and the branches were starting to extend. The experimental pyrimidine retardant (with no known fungicidal properties) was applied at 100 g a.i. in some experiments. Treatments were randomized in each of six replicate blocks.

3. Results

3.1 Relationship between pod numbers, synchrony of development and yield.

When ethephon was applied to pot-grown plants of Jet Neuf, at 70% flowering, unopened and open flowers failed to develop but the growth of developing pods appeared to be unaffected. Although the number of pods was significantly reduced by ethephon, the reduction in pod and seed weight was small and non-significant (Table 1). In plants in which flowers at the ends of the racemes were removed by hand at 70% flowering, the weight of seeds was significantly increased, indicating the scope for compensation in growth by fewer pods.

Table 1. **Comparison of ethephon-induced flower abscission and removal by hand at 70% flowering on pod set and seed yield in the winter oilseed rape cv. Jet Neuf**

	Unsprayed (control)	Ethephon	Hand-thin	Ethephon + hand-thin	SED (24 df)
No. of pods/ plant	309	208***	169***	181***	22.1
Total weight (g) pods/plant	46.1	39.5	45.6	39.1	5.00
Total seed weight (g)/ plant	18.9	17.8	23.2	19.3	3.49
Wt (g) seeds/ 100 pods	6.6	8.8	13.2***	10.6*	1.45

*,*** indicates significant difference from control at 5 or 0.1% probability level.

The rate of senescence of leaves was increased by ethephon. In the field, there was a trend towards increased yield with increasing ethephon rate of application (Table 2), but none of the differences were large enough to be statistically significant. Raceme growth was reduced by all treatments and this resulted in a more open canopy.

Table 2. **Yield of winter oilseed rape cv. Jet Neuf sprayed with ethephon ('Cerone') at 70% flowering.**

Rate of application (l/ha)	0	0.5	1.0	2.0	SED (23df)
Yield (t/ha at 8% moisture)	3.13	3.16	3.32	3.35	0.145

Coefficient of variation (%) : 9.0

3.2 Crop Structure and Yield

The growth retardants triapenthenol and BAS111..W, applied at early regrowth in the spring to the winter oilseed rape cultivars Jet Neuf and Ariana, greatly reduced final crop height of both cultivars although later the effectiveness diminished and some compensatory growth occurred in the racemes. This increased the number and length of branches, and extended the flowering period. The number of late-formed pods developing at the ends of branches also increased, though they were smaller in size than those formed earlier and situated lower in the canopy.

Applications of growth retardants, at a time closer to the end of stem extension (early branch extension), shortened the branches resulting in a shallower and more open pod-bearing portion of the canopy. Although pod numbers in cv. Ariana treated with BAS111..W were unchanged when the retardants were applied at this later growth stage, the proportion of pods produced in the lower canopy was greater. The proportion of large seeds also increased in lower sections of the canopy. This redistribution suggests that the improved light penetration into the more open canopy increased assimilate production by pods and this increased their individual yield.

Differences at maturity in the light profiles of untreated crops and those treated at early stem extension were correlated with differences in the heights of the two canopies of cv. Ariana in 1989. However, the total amount of light reaching the base of the canopy was similar in both treatments throughout crop development. Light absorption in different positions in the canopy varied with stage of development. During stem extension and flowering, the light profiles were similar throughout the canopy in treated and untreated crops. During pod filling, there was greater absorption by the pods in treated canopies.

Treatment with growth retardant at late stem extension, just before flowering, reduced branch lengths and petal size sufficiently to allow greater light penetration to the leaves thus increasing the proportion of light they absorbed. During pod filling, the patterns of light interception were similar in crops receiving early or late applications of retardant.

3.3 Effects on crop growth and yield in cv. Ariana

Throughout canopy development, the height of the treated crop and its surface area remained less than in control plants. Up to the end of flowering, all components were reduced in area, although subsequent effects on pods were small and, at harvest, they were similar to the control. In oilseed rape, the entire surface area (leaves, stem, branches and pods) is green and therefore all components contribute to assimilate production at different stages of development. Therefore, reduced surface area may affect assimilate production adversely. Table 3 compares the effects of time of treatment with BAS111..W in cv. Ariana on seed production in 1987 and 1988. In both seasons there was a significant reduction in total shoot weight as a result of treatment at early stem extension, but there was no reduction with later treatment. The reductions in total shoot dry weight was also accompanied by reductions in the seed yields gathered by hand just before maturity and seed shedding.

The large differences between potential and recovered yield in untreated crops in 1987 and 1988 indicate seed losses of 38% and 54% respectively. These figures for loss during combining do not indicate poor technique with the harvesting procedure, but they do demonstrate the inefficiency of this traditional approach to harvesting, since yields greater than 4 t/ha are exceptional. The significant increases in each year due to treatment with BAS111..W indicate the importance of canopy structure in yield recovery during combining.

Table 3. **The effect of time of treatment of oilseed rape cv. Ariana with BAS111..W on dry weight production, potential (hand-harvested) and recovered (combine) yield (t/ha at 8% moisture).**

		Unsprayed	Sprayed		SED	df
			Early regrowth	Late stem extension		
	1987	6.35	4.95*	5.44	0.585	15
Potential yield	1988	6.12	5.13*	6.35	0.441	40
Recovered yield	1987	3.91	4.41**	4.31**	0.139	35
	1988	2.83	3.18**	3.37***	0.094	40
Total dry weight	1987	2066	1659*	1957	154.3	15
(g/m^2)	1988	1349	1161*	1446	79.7	40

*,**,*** = significant difference from unsprayed at 5, 1 or 0.1% probability level.

3.4 Canopy Structure and Disease

Applying pgrs to alter crop structure also influences disease incidence. For example, light leaf spot (*Pyrenopeziza brassicae*) is reduced following treatment with triapenthenol or BAS111..W but is unaffected by daminozide. The differences between treatments may be due partly to changes in density of the foliage and partly to the fungicidal properties of the triazole pgrs. The significance of the fungicidal properties of these chemicals has been demonstrated in trials with Jet Neuf and Ariana in 1987 and 1988. In these experiments a non-triazole retardant, flurprimidol, was used for comparison with triapenthenol.

The alteration of canopy structure caused by growth retardant treatment significantly changed the incidence and severity of disease on leaves and pods. The increased branch growth and denser canopy which followed the early application of flurprimidol, may have created a more favourable microclimate for disease infection. The same structural effects were obtained with triapenthenol, which is also fungicidal and probably restricted disease levels. The shortened branches which resulted from the late treatment with flurprimidol, providing a more open canopy, did not greatly alter disease severity compared with that on the unsprayed area (Tables 4,5). In 1987, recovered yields were increased when triapenthenol but not when flurprimidol was applied early or late. Flurprimidol was effective only in combination with the fungicide prochloraz. In 1988, yields were increased by triapethenol or flurprimidol treatment only if applied early to crops that did not lodge.

Table 4. ***Alternaria* spp. and yield in oilseed rape cv. Jet Neuf, treated with growth retardants and prochloraz (p'rz) in 1987.**

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

Table 5. **Light leaf spot (*Pyrenopeziza brassicae*) and yield of oilseed rape, cv. Ariana treated with growth retardants and prochloraz (p'rz) in 1988.**

Treatment	Area diseased (%) leaves (DA)		pods (DI)		Yield (t/ha)	
	nil	+ p'rz	nil	+ p'rz	nil	+ p'rz
unsprayed	5.61	5.84	7.17	2.91*	2.55	2.89
triapenthenol-early	3.70*	-	3.02*	-	3.11**	-
triapenthenol-late	4.78*	-	3.11*	-	2.58	-
flurprimidol-early	6.52*	6.83**	6.74	1.99**	3.00*	3.21 **
flurprimidol-late	6.95*	4.75*	8.92	3.67*	2.45	2.92
SED (36 d.f.)		0.375		1.446		0.205

DA (%); diseased leaf area. DI; pod disease index (12)

*,**; significant difference from unsprayed at 5 or 1% probability level

4. Discussion

Improved synchrony of pod development in oilseed rape is possible with carefully timed pgr treatments towards the end of the flowering period. Potential for compensatory growth and increased seed yields exists, as was demonstrated in the experiment with pot-grown Jet Neuf, where late-flowering and pod development were prevented by removal of the end of the racemes. This treatment resulted in increased seed yield per pod but, although ethephon increased this component, it was not a significant effect. The increased rate of senescence of leaves on the main stem may have partly caused this short fall in compensation in pot-grown plants. At the same stage in the field, this is less likely to be limiting because of the dense canopy which is in itself limiting. Seed growth depends on photosynthates from stems, branches and pods (Brar and Thies, 1977). The effect of the highest rate of ethephon (2.0 1 Cerone ha) was most marked on branch extension, and there may have been better light penetration into the crop, allowing pods at the base of the canopy to intercept more light. In the field experiment there was a trend towards increase in yield with rising concentration of ethephon.

Although combine yields were increased in our experiments, the changes in canopy structure caused by treatment with growth retardants did not significantly change the potential yield calculated from hand-harvested samples. This result is consistent with previous work which has illustrated the compensatory capacity of the crop in response to other agronomic variables. For example, increasing the density from 30 to 200 plants per m^2 had little effect on seed yield (Helps, 1971). The numbers of branches, flowers and pods per m^2 increase with crop density but does not change seed yield per unit area of crop significantly. Similarly changes in crop structure induced by growth retardants alter pod distribution but not total seed yield. However, we have found significant changes in seed size, associated with deeper light penetration into the canopy and probable increased photoassimilation by leaves during flowering and by the pods during seed development. Although we have found that the two triazoles, in common with other retardants, reduce the rate of photosynthesis of individual leaves for up to 14 days after treatment (Butler *et al.*, 1989), total biomass is not affected. Claims that whole plant photosynthesis is increased by triapenthenol application (Lürssen and Reiser, 1985) appear to contradict this. However, smaller leaves at the top of the canopy cause less shading (as we have described) and this will tend to increase the contribution of lower leaves to dry matter production of the whole plant.

It is concluded that the retardants affect canopy structure and this leads to improved seed recovery during combining, and changes in yield components are not related to the yield improvements that we have consistently obtained. The fungicidal properties of triapenthenol and BAS111..W also reduce disease and thus increase both potential and recovered yield.

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USE OF PLANT GROWTH REGULATORS IN RAPE AND PEST MANAGEMENT

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Summary

There are effective application possibilities for growth regulators in winter rape. Of special importance are the prevention of overgrowing in autumn, the increase of winter hardiness and a better prophylaxis towards disease attacks (among others Phoma). Especially triazol combinations (among others triapenthenol) and Chlormequat have proved successful. Spring application of the preparates Baronet and Cultar improve the stability by 2-4 bonitur grades. Through the application in autumn (DC 25-28) the stability can be increased probably in the crop year, too. The improvement of stability leads to higher yields and important technological advantages during the harvest. The crops treated with triazol preparates showed a lower attack by Phoma, root neck and stalk rot as well as rape black rot.

1. Introduction

Plant growth regulators (PGR) gain more and more in significance for the increase of crop resistance and the protection and yield increase. They must be used effectively where arable and plant cultivating measures or variety selection don't succeed in overcoming difficulties in cultivation methods. Global preventive applications must be neglected; analogous to the application of PGR to cereals plot related specific standard values of treatment must be the prerequisite for a carefully directed ecologically-economically oriented application (Hoffmann, 1988). Although various possibilities of applying PGR in rape cultivation had been in the offing they were hardly taken into consideration in the last years (Hoffmann, 1987). In our time this situation has changed fundamentally and a big innovation growth is to be expected. This may be due to the worldwide strong expansion of rape cultivation (FRG 570.000 ha; GDR 175.000 ha) and to the presence of varieties with higher durable characteristics. Increasing importance is attached to rape because of its high first crop value for the crop optimated plot control, too. Investigating this development various pesticide producers have developed growth regulators for the increase in rape performance. Some of the applicabilities (depicted in Table 1) are in intensive preparation on a worldwide scale. Undoubtedly not all of them will come to a practical relevance. But for others there are good prerequisites of being used if the principle of effect can be secured through comprehensive toxicological and ecological clearance. As growth regulator effects depend to a high degree on the immediate physiological state of the plants, it is very expensive to lead the basic results to a sure practical relevance. A classic example for this is the displacement of the flowering phase by 4-7 days by means of the PGR Pydanon to diminish rape blossom beetle (Meligethes aeneus) attack (Schuette, 1979). But nontolerable yield losses were connected with the developmental delay.

To avoid throwbacks with the introduction of PGR their special characteristics must be taken into consideration. To these belong, among others, the close dependence of effect on weather, plant variety, organ, the developmental stage and the developing process after treatment.

At present there are advantageous real starting points for future application (Table 2) concerning the offer of active agents : stability, winter hardiness (triazole, cyclohexantrion); stabilization of fruit-setting ovules (Phyl-Set, Limbolid, Nevirol, brassinosteroide, gibberelline); support of emergence (Ju-Knol, gibberelline); flowering concentration (gibberelline; ethephon); antistress-effect (brassinosteroide, ethanolamin); senikation (dimethipin); pod shutter (auxine, di-1p-menthene).

2. Results

2.1. Improvement of winter hardiness

Mild early winters lead to overgrowing of rape (stretching of the shoot axis over 2 cm). "Overgrown" plants which are rich in biomass, are damaged far more heavily through frost than shoots being in the resistant rest phase. Should the trend towards a general warming continue more "overgrown" stands could be expected. Furthermore the high nitrogen offer caused by emissions (in Central Europe 50 - 60 kg/ha) must be taken into consideration as it also stimulates the vegetative growth in autumn.

Even though partly damaged rape plants regenerate well these stands show yield losses through a delayed onset of stretching and mass growth. To prevent overgrowing chlorcholinchlorid (CCC) has been admitted by the governments in various countries (Fabry and Vasak, 1984, Hoffmann, 1985). In critical control years 6 l CCC/ha must be applied (Table 3). At present it is difficult to work out objective criteria for a necessary treatment as the application of CCC must be carried out about 1-2 weeks before shoot axis stretching begins and the further autumnal vegetation course cannot to be prognosticated. Even histological evidences for the begin of the prefloral phase have not led to any sure diagnosis yet. There are, however, prerequisites to achieve a purposeful use by more exact microphenologically aided treatment standard values with the aid of the stand diagnosis device after Verreet/Hoffmann (Hoffmann et.al., 1988). When the rape plants are already in the prefloral stage (therefore application restriction in the GDR on September 30) CCC can even cause a stimulation of growth. Better effects than by CCC can be achieved, among others, by PGR on triazol basis (Child, 1984, Lembcke et. al. 1989, Paul, 1987, Paul and Guenzelmann, 1989). In addition to the growth suppression wished these preparates lead to a significant growth of the root neck diameter and root mass (Fig. 1, 2).

The autumnal application of PGR induces a better prophylaxis, among others, towards Phoma light by decreasing partial shoot injuries. Mechanical injuries (hoeing) and damages, caused by herbicides and pests, rape flea beetle (Psylliodes chrysocephala), cabbage seed weevil (Ceutorhynchus assimiles) and others spot entries for Phoma (Steinbach et. al., 1989). Frost damages on the shoot lead to an essential increase in attack intensity. Furthermore we must consider that leaf losses and shoot damages result in later and more irregular shooting. This leads to yield decreasing developmental delays, a prolonged flowering phase and an irregular maturity (siccation measures are necessary). It is thought that overgrowing can be prevented by exact adherence to the agrotechnical optimal parameters. However, it could be proved that shoot stretching is also possible in a plant stand of 25 plants/sqm in autumn with favourable growth conditions.

For many years they have tried to apply PGR through seed dressing (Sleiman, 1988), or as granulated material by the date of sowing, as seed dresses have already been used for the addition of pesticides. The results achieved are contradictory and dependent on the encrusted pesticides.

2.2. Improvement of stability

A dominating cause for the instability of rape yields is the insufficient stability. Lodging leads to high yield and quality losses. The technological difficulties due to lodging might still exceed necessary additional expenditures in cereal lodgings (Hoffmann, 1980). The application of a PGR in rape is mainly aimed at guaranteeing the yield and making easier the harvest by preventing early and strong lodging. Since 1982 substances for the improvement of stability and shoot retardation on guiding-lines have been tested in the GDR. Especially triazol combinations (Table 4) have proved successful. Stability is improved by 3-5 bonitur grades (reduction of the plant length by 20-25 %). Through different ethene-releasing preparates (late application DC 60-62) temporarily-limited growth suppressions are also possible (e.g. cerone, terpal, camposan), these preparates, however, can lead to yield decreases (Hoffmann, 1985, Ogilov, 1985, Hornig, 1986).

Besides retardation, the stronger stalk diameter, an anatomically-histologically caused improvement of the shoot stability contributes to an increase in stability, as well. Standing plants assimilate longer, have no double growth and make a single-phase harvest possible. Through lodging prevention yield increases are possible on the average of 3-6dt/ha (top values up 10 dt) (Lembrich, 1988, Anonym, 1989, Lembcke et. al. 1989). A stubble height of 40 cm allows an economical use of combine harvesters. Harvested crops from lodging crops are of lower quality and are contaminated with mycotoxines.

According to the date of application triapenthenol changes the plant habit through the modification of the apical dominance and the promotion of the side shoot growth ("candelaber"-type) as well as stronger pod setting. (There are significant performance reserves for cropping -leaf-/fruit organs - more than the 4-5 fold of the area in the possibility of a planned influence of shoot morphology.) An application amount of 0,4-0,5 kg/ha baronet has proved sufficient. Too strongly shortened plants wished prevent the slight inclination of the pod bundle wished as a prophylaxis against "pod shutting" (1989 in exposed positions losses of about 4 dt/ha).

Increase of resistance properties by means of PGR through the application of triazol growth regulators certain fungal pathogens could be inhibited in their development in autumn as well as in spring application. Thus triapenthenol led to a reduction of the damage extent of Phoma lingam and other diseases (Table 6, Fig. 3). This is due to the stronger shoot axis diameters, the constitution of the tissue and the periderm, the better aeration of upright crops but to fungicidal secondary effects of the preparates as well (Gebert, 1988, Hoffmann et. al., 1989).

One has to bear in mind that especially triapenthenol and paclobutrazol dispose of an active fungicidal component (Luerssen, 1988). This fungicidal side effect have been described for triapenthenol when the application coincides with the infection (Hack et. al., 1985). However, the improved induced resistance properties caused by PGR might be of the same great importance. This also confirms the fact that the spreading, among others, of Phoma in spring was inhibited considerably in the crops when Baronet was applied in autumn in order to improve the ability of overgrowing.

In this case no exclusively prophylactic fungicidal effect but an indirect effect is present. These small attacks discovered are an efficient secondary effect towards rape diseases which are difficult to combat and show the positive effects which can be used in the integration of PGR in the production process of rape. PGR can influence the direct system of agro-ecosystems and diminish biotic and abiotic harmful factors by induced resistance which are not possible to combat with methods of traditional plant protection.

Moreover, working mechanisms caused by PGR can be important as elicitors and sensitizers. The admission of a toxicologically harmless retardant for shoot shortening is necessary. Lodging prevention does not only lead to yield increaes, decreases the expenditure of energy during the harvest, but also diminishes the application of pesticides and siccantien.

To avoid routine treatments guidelines are necessary (Hoffmann and Schaedlich, 1987) which introduce the application plot specifically according to date and the differentiated amount of preparates on the basis of an adequate plot diagnosis. After a bonitur in the onset of winter, date of germination, developmental stage, surface biomass, number of plants/sqm, a registration of the state at the begin of vegetation (among others plot density, vital leaf and stalk mass) and with regard to the time "begin of growth" concrete prognoses can be made on the lodging endangerment of the single plots.

Compared to cereals rape (Table 7) is an especially labour-intensive test-object (among others flexible shifting course of flowering and seed ripeness through shoot positions, insertion depending shoot growth). A high compensation capability derives from this biological interplay and so does a strong reactivity towards environmental influences.

In conclusion should be stressed that further PGR for rape have been admitted so far apart from chlormequat for the improvement of winter hardiness and Baronet and Parlay C (France, Belgium) for stability improvement as well as ethephon (FRG) for shoot shortening in guiding-lines. Further preparates are being tested by the state and admissions can be expected for selected areas (Table 1). Prerequisites for performance promoting applications of PGR also occur in rape after the optimal use of arable and crop cultivation conditions and the effective use of intensification factors of normatively cultivated crops.

Breeding and application of PGR compete frequently about the solution of equal aims. But modern plant breeding, too, can only solve their tasks partly over longer periods. That's why PGR belong to the necessary instrumentarium of integrated plant cultivation in future, too, and there are sufficient fields of application, which remain the primacy of the PGR application. To this belongs, among others, the overgrowing of crops in autumn. If determined prognoses concerning the warming of the climate prove true, these problems will gain steadily increasing importance not only for rape.

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Table 1 Possibilities of applications of plant growth regulators in winter rape

Emergence DC 0-19	leaf/rosette shoot performing autumn/spring DC 20-34	shoot elongation DC 35-46	bud development DC 52-59	anthesis development DC 62-66	pod development DC 72-79	ripeness DC 80-89
acceleration of emergence winter hardiness (seed treatment)	growth inhibition ("over-growing") stimulation endogen frosthardiness resistance behavior (pests/ diseases	lodging resistance resistance behavior (pests/ diseases) stimulation antistress preparations (droughtness)	lodging resistance ovule stabilisation shoot morphology resistance behavior (pests/ diseases) stimulation anthesis concentration antistress preparations (droughtness)	ovule stabilisation anthesis concentration antistress compounds (droughtness) growth stimulation heterosis breeding growth ("guiding line" for plant protection combine)	pod stabilisation seed filling stimulation	homogenous ripeness (senication) pod shutting

Table 2 Review of preparates. Plant growth regulators were used for the treatment in winter rape (Institute of Plant Protection)

Preparates	Common name	Producer
bercema-CCC	Chlormequat	VEB Berlin Chemie (GDR)
CKB 1291	Ethephon and synergist	VEB CK Bitterfeld (GDR)
Cekamin	Ethanolamin	VEB CK Bitterfeld (GDR)
Elbanil-Spritz-pulver	Chlorpropham	Fahlberg List Magdeburg (GDR)
MLU 2081	Dichlorisobutric-acid	MLU Halle (GDR)
Baronet	Triapenthenol	Bayer AG (FRG)
Folicur	Flutriazol	Bayer AG (FRG)
Alar 85	Daminozid	Uniroyal Chemical (USA)
Cultar	Paclobutrazol	ICI (GB)
EL 500	Flurprimidol	Elanco (USA)
Pix	Mepiquatchlorid	BASF (FRG)
Terpal	Ethephon + Mepiquat	BASF (FRG)
BAS 11104 W	Tetcylasis	BASF (FRG)
S-3307 D	Uniconazol	Sumitomo (Japan)
A 7725 A	Chlorhexantrion	Ciba Geigy (Swiss)
Nevirol	N-Phenyl-phthal-aminacid	Novik (Hungaria)
Spodnam	Di-1p-menthene	FNC (USA)
Harvade	Dimethipin	Uniroyal Chemical (USA)
Parlay C	Paclobutrazol + Chlormequat	ICI (GB)

Table 3 Influence of chlormequat (CCC) on the shoot axis length of winter rape (production experiments 5 ha)

Location	Variety	Date of Treatment	Control	Shoot axis length (cm) and shortening (%) with 6 l/ha	
Dobbertin	Marinus	14 Sept.,83	2,8	1,8	35,7
Gnevsdorf	Marinus	19 Sept.,84	4,1	2,8 +	31,7

+ = Significance at = 5 % t-test

Table 4 Spring treatment with plant growth regulators to improve stability
Application: 22 April,1986; plot tests; location: Benzin -
Stability: 1 = strong lodging; 9 = no lodging

	Crop	height cm		Stability	from 9-1		Harvest yield/ 22 July,1986
Variant	5 May, 1986	20 May, 1986	5 June, 1986	16 June, 1986	24 June, 1986	3 July 1986	dt/ha
Control 0,75 l/ha	74	155	171	7,00	6,50	4,50	31,18
Paclobutrazol 0,75 l/ha	49	130	146	9,00	7,50	6,50	34,30
Alar 1,0 kg/ha	71	149	157	7,00	6,25	4,50	35,75
Triapenthenol 0,75 kg/ha	46	127	141	9,00	8,25	7,00	40,75

Table 5 Results of production experiments (5 ha) for the improvement of stability through plant growth regulators; test place: Veelboeken; variety "Liglandor". Application: 27 April, 1986 (DC 53). Stability: 1 = strong lodging; 9 = no lodging.

Stage of assesment	Control	Triapenthenol 0,75 kg/ha	Paclobutrazol 0,75 l/ha
begin of flowering	15 May,86	17 May,86	17 May,86
end of flowering	2 June,86 (second flowering)	7 June,86	7 June,86
duration of flowering	18 days	21 days	21 days
growth height/cm	163 cm	129 cm	128 cm
stability at harvest time	1	9	9
stubble height	10 cm	40 cm	40 cm
yield dt/ha	29.23	36.56	

Table 6 Influence of growth regulators on stability and the attack by <u>Phoma lingam</u> on winter rape (variety "Belinda"; test place Luebz; treatment: 22 April, 1986; 9-stage-scale; stage 9 = no lodging, no attack resp.)

Treatment	Lodging development 13 July,1986	Phoma-attack 24 June,1986	
control	4,5	4,0	4,0
Alar 1,0 kg/ha	4,5	6,3	6,3
Paclobutrazol 0,7 l/ha	6,5	7,0	6,3
Triapenthenol 0,7 kg/ha	7,0	8,5	8,0

Table 7 Required random samples for the determination of single plant features and yield elements in winter rape (after Boelcke, 1984)

Features	Random samples	Features	Random samples
length of main shoot	5	single seed weight	20
number of ramification	70	seed number/pod	30
pods on main shoot	20	yield/pod	30
total pod number	140	yield of single plant	200

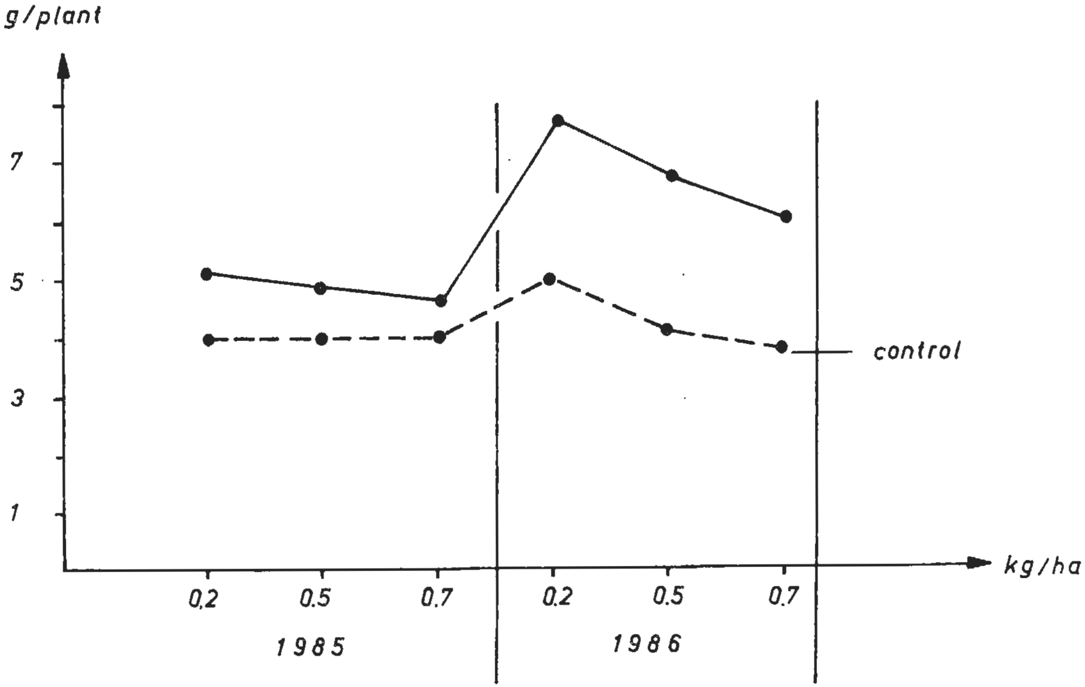

Fig.1 *Influence of Baronet (Triapenthenol) on the root-mass in winterrape. Date of bonitur : 1.12. ; variety : Belinda*

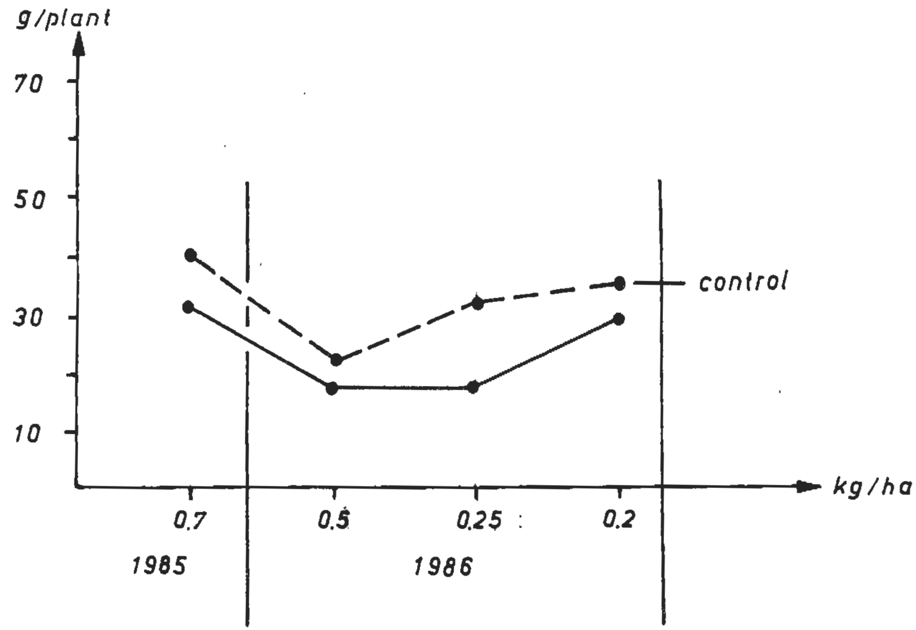

Fig. 2 Influence of Baronet (Triapenthenol) on the epigeous biomass in winterrape.
Date of bonitur : 1.12. ; variety : Belinda

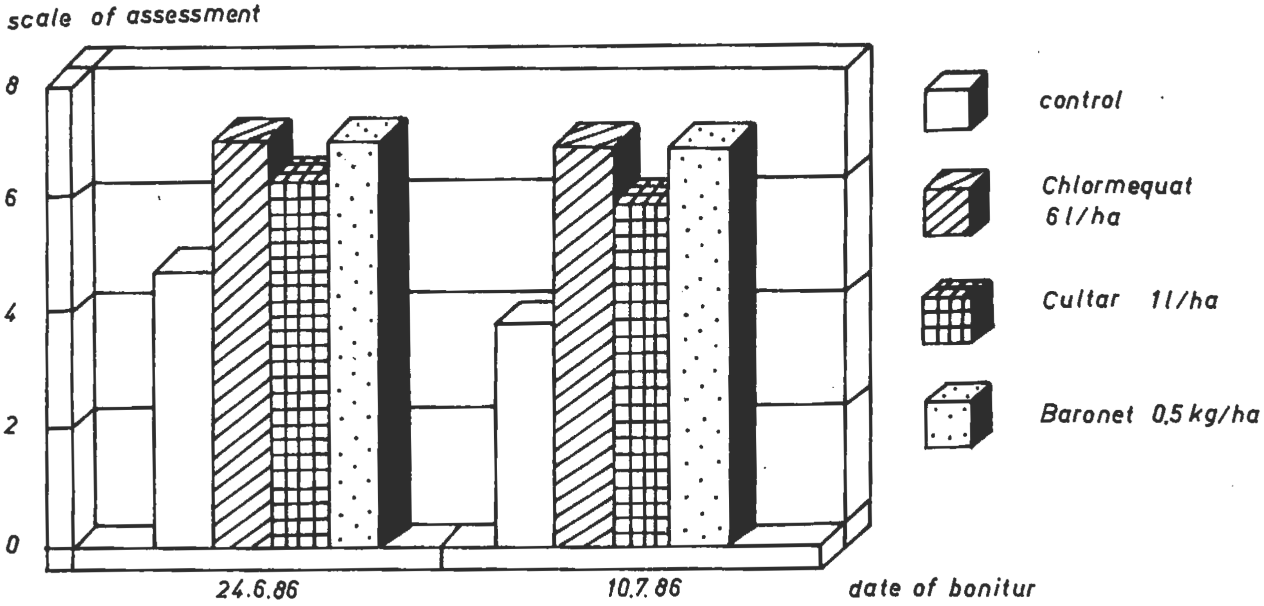

Fig. 3 Influence of plant growth regulator on the infestation (stalk attack) by _Phoma lingam_.
Date of application: 26 September, 1986;
variety: Belinda; disease scale: 9 = no infection; 1 = strong infection