Danish Research Service
for Plant and Soil Science

Plant diseases, pests and weeds in Denmark 1989

106th annual report
Compiled by
The Research Centre for Plant Protection

Lyngby 1990

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Contents

A. DANISH RESEARCH CENTRE FOR PLANT PROTECTION

Director: E. Henning Jensen

The Research Centre for Plant Protection is the central research institute of the Ministry of Agriculture in the field protection of agricultural and horticultural crops against diseases, pests and weeds.

The Research Centre for Plant Protection is one of the four centres under the Danish Research Service for Plant and Soil Science. The three others are: the Administrative Centre, the Research Centre for Agriculture and the Research Centre for Horticulture.

The research carried out at the Research Centre for Plant Protection is located at Lyngby and Flakkebjerg in the following departments:

Secretariat	Søren W. Bille
Botany Department	Arne Jensen
Virology Department	Arne Thomsen
Biotechnology Department	Morten Heide
Zoology Department	Jørgen Jakobsen
Pesticide Research Institute	E. Nøddegaard
Institute of Weed Control	K.E. Thonke
Department of Pesticide Analysis and Ecotoxicology	Arne Helweg
Plant Protection Advisory Department	A. From Nielsen

The aim of the Research Centre for Plant Protection is to improve the basis for preventing and controlling plant diseases, pests and weeds in agriculture:

- to develop and recommend effective preventive and control measures which are not damaging to the environment
- to implement the results gained from the research and experimental work carried out at the centre and to use results from other national or international research institutes in the advisory work
- to contribute to the creation of a background for national and international plant protection legislation

The research carried out on the application of pesticides plays an important part in the work of the centre. Of primary importance is an agreement with the Danish Agrochemical Association concerning efficiency testing of pesticides. The testing is not required by law, but includes almost all marketed products. A pesticide, which is found suitable for its purpose according to the official testing, is granted an approval. The costs involved are paid by the applicant.

Furthermore, the Research Centre for Plant Protection assists the National Agency of Environmental Protection in the evaluation of suitability of the individual products.

The Research Centre for Plant Protection also performs a number of different research and development tasks in other fields, for which it charges payment. As examples can be mentioned: Production of healthy plant material, testing of bacterial ringrot of potatoes, diagnosis of diseases in plant samples, etc.

For a number of years work has been done to develop biological control methods against pests in glasshouse crops. Several methods are operative.

In recent years, the Research Centre for Plant Protection has hosted a biotechnology project, which at the moment employs nine scientific officers. The project is a well-defined, educational project, and one of the aims is to develop rational methods of diagnosis.

In the coming years, the Research Centre for Plant Protection will be very much involved in the establishment of an information system on diseases, pests and weeds.

To support this work, there is a great need for an intensification of the current research in a number of biological fields.

This has lead to a series of decisions aiming at making our work more efficient by a simplification of the organisation and, in particular, a closer integration of our biological research with the testing of pesticides.

The Pesticide Research Institute will be abolished and the pesticide testing and research work will be transferred to the Botany and Zoology Departments headed by Arne Jensen and Jørgen Jakobsen respectively.

At the same time the Virology Department will be abolished as an independent department and the tasks transferred to the Botany Department. This department will change its name to Plant Pathology Department.

With regard to financing, the Research Centre for Plant Protection must adjust to the fact that an increasing part of the funds will be provided by short-term research grants and work carried out on a contract basis, concurrently with a decreasing government grant.

The 6th Danish Plant Protection Conference was held 28th February - 1st March, 1989 attracting about 670 participants.

B. SECRETARIAT

Head of secretariat: Søren W. Bille

The central administration of the Research Centre for Plant Protection lies in the Secretariat.

Furthermore, the Secretariat acts as a link between the individual departments and the other centres under the Danish Research Service for Plant and Soil Science.

In collaboration with the departments the Secretariat performs the following tasks, among others:

Administration of the financial circumstances
The annual plant protection conference
Management of common facilities, i.e. maintenance of buildings, official cars and cultivation of fields
Planning and execution of meetings and conferences
Production of written material

Of about 179 employees, approx. 105 are located at Lyngby, 4 at Skejby at the Plant Protection Advisory Department and the rest, about 60, at Flakkebjerg.

The distribution of the staff at the departments will appear from the following:

	SO	TS	Total
Administration and common functions	3	18	21
Pesticide Research Institute	8	19	27
Botany Department	9	10	19
Virology Department	6	10	16
Zoology Department	8	11	19
Advisory Service	5	2	7
Institute of Weed Control	20	38	58
Laboratory for Analysis of Pesticides	5	7	12
Total	64	115	179

SO: Scientific officers
TS: Technical-administrative staff

Financing and staff
Approximately 55 per cent of the activities of the Research Centre for Plant Protection are being financed by way of the government budget. The remaining part of the funds are being provided by way of research programmes financed publicly or privately as well as by different forms of economic activity. In 1989 the total expenses of the Research Centre for Plant Protection amounted to about 42 mio. Dkr.

C. ADVISORY WORK

Scientific staff:

Lyngby:
Ghita Cordsen Nielsen: Pests and diseases of agricultural crops
Lars A. Hobolth: Pests and diseases of horticultural crops
N.S. Murali
and Bo Secher: Computer aided advisory system for pest and disease control

Skejby:
A. From Nielsen: Head of Department. Pests and diseases of agricultural crops
Søren Holm: Pests and diseases of agricultural crops

Institute of Weed Control, Flakkebjerg:
O. Permin: Weed in agricultural crops
Georg Noyé: Weeds in horticultural crops
Marianne Baandrup: Computer aided advisory system for weed control

Advisory work concerning plant diseases and pests is carried out from the Research Centre for Plant Protection at Lyngby and from the Plant Protection Advisory Department at Skejby, Aarhus.

During 1989, 54 Plant Protection Bulletins were sent out dealing with 40 different subjects.

Weather conditions in 1988-89:

	Temperature °C		Precipitation	
	average	normal	average	normal
September 1988	13.1	13.1	91	72
October -88	8.5	8.8	73	70
November -88	3.7	5.0	37	60
December -88	3.9	2.3	61	55
January -89	4.8	0.0	20	55
February -89	4.4	-0.3	55	39
March -89	5.4	1.7	75	34
April -89	6.0	6.21	40	39
May -89	11.4	11.0	25	38
June -89	14.6	14.4	37	48
July -89	16.6	16.4	53	74
August -89	15.1	16.1	64	81

Survey of main diseases and pests in agricultural crops in 1989

Cereals

Eyespot (*Pseudocercosporella herpotrichoides*) was favoured by the mild autumn and winter. The dry weather in May, however, prevented the development somewhat, and the resulting damage therefore was far more moderate than expected.

Mildew (*Erysiphe graminis*) developed strongly during the mild winter, especially in winter barley, but also in rye and wheat. In winter barley the attack was reduced considerably during May and June, but this was not the case in rye and wheat.

In spring barley mildew occurred commonly in May, but the attacks remained weak.

Yellow rust of wheat (*Puccinia striiformis*) was widespread, and severe attacks occurred especially in the susceptible varieties Anja and Kraka, but also in the variety Sleipner.

Brown rust (*Puccinia recondita*) was rather widespread. In wheat only weak attacks were seen.

Speckled leaf spot (*Septoria tritici*) was common in spring, but neither speckled leaf spot nor glume blotch (*Septoria nodorum*) became of any importance.

Barley yellow dwarf occurred much more widespread than usually, but the attack were of no economic importance. Symptoms were seen in oats and spring barley, in particular, but also in wheat.

Aphids (*Rhopalosiphum padi* and *Sitobion avenae*) were widespread, and severe attacks occurred in several fields.

Shoot fly (*Opomyza florum*) becomes still more widespread. The attacks, however, were generally weak.

Leaf beetle (*Oulema melanopus*) was very common, and severe attacks occurred.

Grass

Mildew (*Erysiphe graminis*) was widespread with severe attacks.

Leatherjackets (*Tipula paludosa*) caused damage in several fields. Especially **Fever flies** (*Dilophus febrilis*) were much more common than usual, and damage occurred at several localities.

Maize

Common smut (*Ustilago maydis*) was seen in several fields, but the damage was generally of no importance.

Legumes

Because of the dry weather conditions during the summer and an early harvest diseases became of no importance in peas and beans. **Downy mildew** (*Peronospora vicia* f.sp. *pisi*) and **leaf and pod spots** (*Ascochyta pisi, Mycosphaerella pinodes* and *Phoma medicaginis* var. *pinodella*) occurred only with weak attacks. During August some fields with crops for canning were attacked by mildew (*Erysiphe pisi*)

Pea weevil (*Sitona lineatus*) occurred from April and became very widespread with severe attacks at several localities. During July and August heavy attacks occurred in fields with clover. **Pea aphid** (*Acyrthosiphon pisum*) were common, and severe attacks occurred in several pea fields.

Rape

Light leaf spot (*Cylindrosporium concentricum*) in winter rape was observed in several fields, and also *Phoma lingam* occurred more frequently than usual. The attacks, however, were weak and without importance. Neither **stem rot** (*Sclerotinia sclerotiorum*) nor **leaf and pod spot** (*Alternaria* spp.) were of any importance.

The blossom beetle (*Meligethes aeneus*). Immigration into the rape fields was considerable in late May, and serious attacks were seen all over the country. Also the **seed weevils** (*Ceutorrhynchus asimilis*) occurred commonly, but the attacks were weak. **Brassica pod midge** (*Dasyneura brassicae*) occurred early, but the resulting damage was without importance.

Slugs (*Agriolimax agrostis*) caused considerable damage in some fields with winter rape.

Beet

Peach-potato aphid (*Myzus persicae*) had excellent conditions of survival. The first aphids occurred early in the beet fields, and a warning to spray was sent out on 24th May. During June the aphids became very widespread. The first symptoms of Virus Yellows were observed in late June and during July symptoms were widespread.

Mildew (*Erysiphe betae*) occurred in some fields in August and developed somewhat in September.

Beet leaf miner (*Pegomyia hyoscyami*) was widespread in May and severe attacks occurred in several localities.

Also the **black bean aphid** (*Aphis fabae*) was widespread with severe attacks in June and July.

Potatoes

Late blight (*Phytophthora infestans*) was of no importance due to the dry weather conditions. Early blight (*Alternaria solani*), however, occurred commonly, but only with rather weak attacks.

Cutworms (*Agrotis segetum*) occurred only with weak attacks, even though the conditions for development were good.

Aphids (*Myzus persicae, Aulacorthum solani* a.o.) occurred early and became widespread in the potato fields. This has resulted in rather heavy spread of stylet-borne virus diseases.

Survey of diseases and pests in horticultural crops in 1989

In 1989, the horticultural advisory department received 762 samples. The distribution according to crops and according to group of pathogen will appear from the following table, in per cent:

	Physiological	Mycological	Bacteriological	Virological	Zoological	Unexplained	Total
Grass		0.3			0.1		0.4
Cruciferous crops	0.4	1.4	0.9		0.3		3.0
Potatoes						0.4	0.4
Fruit bushes and trees	1.1	2.2	0.4	1.2	1.2		6.0
Vegetables	1.1	9.2	1.4	0.8	5.1	0.1	17.7
Ornamentals	8.8	38.7	5.5	4.7	12.5		70.2
Without host plant		0.1			0.7		0.8
Total	11.3	52.0	8.3	6.74	20.2	0.1	98.6
Diverse							1.4

Computer aided advisory system for pest and disease control (N.S. Murali and Bo Secher)

A PC-based farm advisory information system is being developed. The system contains general information on pests, diseases and chemicals, as well as recommendation programs for control of diseases and pests in winter wheat and spring barley. The system will be tested in field trials and farmers fields in 1990.

A pest monitoring and advisory is also undertaken under the information system program. The farmers taking part in the program send in their field observations, and in return receive pest control recommendations. Observations are also used to monitor the development of pests and diseases in the country. The system covers a wide range of crops, diseases and pests. In 1989, ca. 650 growers took part in the program. Recommendation models are made in collaboration with the departments of Pathology and Zoology.

Weed control (Ole Permin)

The advisory service is primarily a link between research and the advisors employed by the farmers' union. Participation in meetings and field excursions all over the country provides the opportunity for an exchange of ideas and problems which is necessary in the planning of the research work in the future.

The work done enable organisations to bring out new knowledge gained from research to the user at the actual point of time. Organisation of courses training advisors in weed control handling on a higher level. Compilation of new results from research in cooperation with the Danish Agricultural Advisory Centre working out strategies for weed control in different crops.

Advisory computer system for weed control (Marianne Baandrup)

An advisory computer system for weed control is being developed, which can help the farmer in the decision-making process concerning herbicide management.

The advisory system has two primary aims: it can give information on crops, weed species, herbicides and spray application, and advice on which herbicide and what dose to apply for a current weed problem in the field.

This advisory part of the system is based on a number of observations carried out by the farmer in the field: the crop condition and expected yield, the weed species present, the number of weed plants per m^2 and their growth stage (number of leaves). Based on these observations the advisory system judges the need for control, and if judged positively, recommends the herbicide which will be most sufficient to the current problem, and finally the system calculates a dose, which is often reduced.

The size of the dose reduction depends on the weed species, their growth stage and in the future also on the climatic factors present at the time of spraying.

The advisory system has been developed for weed control in spring barley and in winter wheat. A recommendation of the time of spraying (autumn/spring) is included in the advisory model for winter wheat.

It will become more and more widespread that farmers will use computers in the agricultural management, and this advisory system can together with other programmes on plant protection become a very useful tool for the farmer in the decision-making process.

D. BOTANY DEPARTMENT

Head of Department: Arne Jensen

Scientific staff:

Karen Bech: Bacteria in meristem cultures
Lone Buchwaldt: Sclerotinia stem rot in oil seed rape (part time)
Lars Bødker: Root pathogenic fungi in peas
Ib G. Dinesen: Bacterial diseases
Mogens S. Hovmøller: Virulence analysis of mildew of barley and wheat
Bent Løschenkohl: Fungal diseases in horticulture. Testing of resistance to potato wart
Hellfried Schulz: Root and foot rot of cereals, diseases of peas
Sten Stetter: Threshold values for leaf diseases of cereals
Kirsten Thinggaard: Root diseases in glasshouse crops. Red core in strawberry
Boldt Welling: Leaf diseases of cereals and grasses

General report (Arne Jensen)

The main tasks of the department are investigations, surveys, experimental work and testing for diseases in agricultural and horticultural crops. In 1989 increased efforts have been put on the development of decision models for the control of leaf diseases in barley and winter wheat. The virulence gene survey for leaf diseases in barley and wheat is continued; besides mildew and barley net blotch, preliminary work is started on yellow rust. As part of a project on a registration network for diseases, observations have been made for cereal diseases, pea leaf diseases and Sclerotinia stem rot in rape. A new research project is started on root pathogenic fungi of peas.

On the horticultural side especially diseases in glasshouse crops are of great concern. In growth systems with recirculating water, investigations are continued concerning methods on control of root pathogenic fungi. Investigations on computerized climatic control systems may help to a better prevention of fungus diseases. The importance of healthy motherplants calls for a continued research and testing of all kinds of vegetatively propagated planting material. A research project is aimed at finding better ways of detecting bacteria in meristem cultures.

Besides the research some time is spent on different testing work like for potato ring rot, potato wart and efficiency of disinfectants, all done on contract basis.

As part of the MSc thesis work 3 agricultural students have been working as the department with club root (*Plasmodiophora brassicae*) detection methods, with resistance to *Septoria nodorum* and *S. tritici* in wheat and with spread of virulence genes in barley powdery mildew (*Erysiphe graminis*).

Bacterial ring rot of potatoes (*Clavibacter michiganensis* subsp. *sepedonicus*) (Ib G. Dinesen)

In 1989, as in the previous year, a great part of the bacterial work carried out concerned ring rot, especially testing for the disease. This testing was performed not only on material from the meristematic cultures but also from potatoes for seed and consumption. In the beginning of the year it was mainly tubers for export. The total amount was about 700 samples tested.

At the end of the year an EEC-project was secured. The title of the project was: "Development of DNA technique and protein electrophoresis for rapid and reliable detection and identification of quarantine bacteria, in particular the potato ring rot organism, *Clavibacter michiganensis* subsp. *sepedonicus*". It is a co-work between twelve laboratories in the EEC.

Healthy nuclear stock plants (Ib G. Dinesen)

Bacterial tests were carried out in connection with the renewal of the nuclear stock plants at the institute of glasshouse crops and also tests of nuclear stocks for private companies.

Effect of disinfectants (Ib G. Dinesen and Bent Løschenkohl)

The newly developed methods of testing disinfectants against fungi and bacteria were used. Four disinfectants were tested and three of them obtained the official approval.

Diseases in *Hedera helix* (Bent Løschenkohl and Ib G. Dinesen)

Preliminary investigations on fungal and bacterial pathogens in *Hedera helix* were carried out in 15 nurseries. *Fusarium* sp., *Verticillium* sp., *Phytophthora* sp., *Rhizoctonia solani* and *Xanthomonas campestris* pv. *hederae* were the main pathogens.

Outbreak of the diseases were dependent of the climatic conditions in the greenhouse.

Detection of plant pathogenic bacteria in micropropagated plants (Karen Bech)

In *Kalanchoë blossfeldiana* infected with *Erwinia chrysanthemi* the risk of transmission of the bacteria with the meristems for in vitro culturing was assessed.

The results were compared to the size and location of the meristems on the plant.

The indirect immunofluorescens method and plating on agar was used for testing.
50 per cent of the excised meristems from bacteria-free motherplants, cultivar 'Pollux' were established in vitro compared to 13 per cent from infected motherplants.
Meristems from basis of infected motherplants dropped-out early because of bacteria.
Meristem plants were tested six months after transfer to glasshouse conditions. All plants were free of *E. chrysanthemi*.

Take-all (*Gaeumannomyces graminis*) (H. Schulz)

Light attacks were found in nearly all wheat fields examined. Moderate to severe attacks were found in about 20 per cent of the examined fields. In spring barley only very light attacks were found.

Eyespot (*Pseudocercosporella herpotrichoides*) (H. Schulz)

The mild winter 88/89 increased the attack of eyespot - and in spring time it was necessary with chemical treatment in about 70 per cent of the examined fields.

The dry weather conditions in May-June inhibited the development of the disease, but less than expected. The summer estimates still showed moderate attacks and in some cases even severe attacks in wheat.

Naturally infested straw collected from 22 different wheat fields placed under natural conditions in the field from October until April did not form *Tapesia yallundae* (Wallwork and Spooner) the teleomorph of *Pseudocercosporella herpotrichoides* (Fron) Deighton.

Sharp eyespot (*Rhizoctonia cerealis*) was found in many wheat and rye fields but the attacks were on a very low level.

Threshold values for leaf diseases on cereals (Sten Stetter)

Epidan is a computer programme aimed at determining threshold values for chemical control of leaf diseases on spring barley and winter wheat.

In 1989 Epidan was used in 70 plot experiments - 36 in wheat and 34 in spring barley. The spring barley programme was used for the last time after 8 years. It was reliable, when advising not to spray, fairly reliable when advising to spray, but not reliable at all when recommending dosages. It was evident too, that the program was far too laborious for practical use.

The experience from the spring barley programme was used to make a flow diagram for practical use in barley fields. This was tested in plot experiments in 1989 and proved to be superior to Epidan, the economical outcome was higher, the total use of fungicides and labour was lower, and agricultural advisers, who tested the diagram, recommend it for future use instead of computer programmes.

A winter wheat programme for practical use is not ready yet. A winter barley programme for experimental use will be prepared in 1990.

Identification of race specific powdery mildew resistance in wheat cultivars (Mogens S. Hovmøller)

Race specific powdery mildew resistance in 23 winter wheat cultivars, eight spring wheat cultivars, and 14 lines/cultivars possessing known powdery mildew resistance genes, has

been studied by analyzing host/pathogen interactions. The cultivars were tested as intact seedlings, and as detached primary leaf segments on water agar; both methods revealed reproducible and concordant results. The 45 cultivars/lines were divided into 24 resistance spectra according to the patterns of reaction to the powdery mildew isolates used. Of the 31 cultivars investigated, eight did not possess any of the resistance genes detected, and the remaining 23 were divided in 16 resistance spectra. The race specific resistance of nine cultivars was conferred by the single resistance genes Pm2, Pm4b, Pm5/Ml-i or Pm6, while the race specific resistance of 14 cultivars was conferred by 2, 3, 4 or 5 genes in combination.

Virulence analysis of barley and wheat powdery mildew (*Erysiphe graminis* f.sp. *hordei* and *Erysiphe graminis* f.sp. *tritici*) (Mogens Hovmøller)

A virulence survey was carried out at 10 localities during 1989. Virulence frequencies were estimated based on coloury countings on seedlings in mobile nurseries, exposed at a distance of at least 200 m from barley and wheat fields.

Barley powdery mildew: Virulence against Mla13 (Va13) were found in frequencies below 10 per cent, while resistance Va1 and Va3 were found in frequencies from 10 to 25. This was an increase compared to previous years. The virulences Va7 and Va12, which matches the most widely used resistance genes in spring barley in Denmark, were found in frequencies from 50 to 70 per cent.

Wheat powdery mildew: Virulence against the resistance genes Pm2 and Pm6, V(Pm2) and V(Pm6), increased in frequency during 1989, and was found in frequencies between 50 and 100 per cent. Virulence against Pm4b was unchanged and found in a frequency about 25 per cent.

Variety mixtures of winter wheat (Boldt Welling and Carl Chr. Olsen)

Experiments with variety mixtures in winter wheat have been carried out at Roskilde and Rønhave Experiment Station in the years 1987-89.

At Roskilde, 1987, mildew and *Septoria* spp. were prevalent while yellow rust occurred on both locations in 1989 with a high level of attack. Both three and four component mixtures reduce the level of mildew, yellow rust, but not *Septoria* spp. The mixtures equalize the variation for both diseases compared with single varieties.
Yield increase when using mixtures varied from 0,9 hkg/ha (ns) at Roskilde to 3,1 hkg/ha at Rønhave. A comparison of yield between 3 comp. mixtures (average) and the four comp. mixtures showed no significant difference.

Fungicide application gave in the single varieties Kraka and Sleipner big yield increases and small or negative yield increase in the resistant varieties Citadel and Kosack.
These differences are reduced when spraying the mixtures. There is no difference between single spraying at stage 7-8 and 10.1, spraying twice doubled the yield increase at Rønhave but not at Roskilde.

Resistance in barley varieties to net blotch (Boldt Welling and Klaus Olsen)

The aim of these experiments was to evaluate the interaction of fungus population (*Drechslera teres*), barley varieties and localities.

42 barley varieties were sown at 6 localities in 1989. The collection consisted of differential - and commercial varieties - at all given big variation in resistance against *D. teres*. At all 6 localities the varieties were inoculated with 3 different populations of different origins.

Unfortunately the climatic conditions were very dry giving low disease level except at two localities where artificial watering was supplied.

The resistance of the commercial varieties was very different. This depended on interaction between variety, population and locality.

Symptoms of *D. teres* was normally observed as spot type and rather seldom as net type.

Parallel experiments were carried out in the greenhouse on 14 test varieties (seedlings) where 30 different isolates of *D. teres* originating from different localities were tested. The results from these experiments are not reproducible under these conditions.

Stem rot (*Sclerotinia sclerotiorum*) in oilseed rape (Lone Buchwaldt)

A forecasting system is now in use in Denmark and is based on the registration of carpogenic germination of sclerotia placed in depots in fields of oilseed rape all over the country. In this way, the risk of attack by stem rot can be assessed on a regional basis.

In 1989, the percentage germination varied from 0-28% in depots of both winter and spring rape at the time of full flowering. In the weekly bulletins chemical control was not recommended, and no attacks of stem rot above the threshold value were observed in any part of the country.

Pea diseases (H. Schulz)

Ascochyta spp. Foliar diseases occurred mainly with very weak attacks and with no influence on yields.

Mycosphaerella pinodes was the most common fungus isolated from leaf spots and pods. Only at one location *Ascochyta pisi* was found on pods.

Grey mould (*Botrytis cinerea*) occurred only on a very low level and had no influence on the crop.

Downy mildew (*Peronospora viceae* f.sp. *pisi*) was less widespread than in 1988 and only in few fields moderate attacks were registered.

Powdery mildew (*Erysiphe pisi*) occurred widespread in vining peas in August.

Root diseases of pea (Lars Bødker)

In 1989, a three year disease survey was started with the purpose of investigating the prevalence and importance of root diseases of pea in Denmark and adjusting a prediction soil test system to Danish conditions.

Out of 443 fields visually assessed for dark-coloration 101 fields with symptoms of root diseases were investigated for the composition of pea pathogens. Out of 2098 fungal isolates identified the disease survey yielded on average 39 per cent *Fusarium solani*, 8 per cent *Fusarium oxysporum*, 28 per cent *Fusarium* spp. which mainly consisted of *Fusarium redolens*, 5 per cent *Phoma medicaginis* var. *pinodella*, 1 per cent *Mycosphaerella pinodes*, 1 per cent *Pythium* spp. and 1 per cent *Rhizoctonia* spp. The average frequencies in per cent of fields with the fungal species present were 95: 55: 95: 31: 4: 3: 5 respectively.

There was no evidence of *Aphanomyces euteiches* in the fields but a glasshouse test of a few soil samples showed that the fungus is, however, present in Danish fields.

Chalara elegans, better known as *Thielaviopsis basicola*, was detected in 8 per cent of fields with vining peas showing symptoms of root diseases.

For combining peas there was a significant correlation between the disease index for soil samples tested in the glasshouse and disease index in the fields.

Potato wart (*Synchytrium endobioticum*) (Bent Løschenkohl)

The Danish Potato Breeding Station at Vandel sent 358 tuber samples, and the Swedish Breeding Station Svalöf AB sent 328 tuber samples to be examined for wart resistance.

Root rot and dieback (*Phytophthora fragariae* var. *rubi*) in raspberry (Kirsten Thinggaard)

The fungus *Phytophthora fragariae* var. *rubi* (*P. megasperma*) was isolated from roots of raspberry. It was the first time this serious root pathogen was observed in Denmark.

Phytophthora and *Pythium* in greenhouse crops (Kirsten Thinggaard)

Root diseases caused by *Phytophthora* and *Pythium* gave many problems especially in nurseries recirculating the nutrient culture solution e.g. in tomato, dill, parsley, lettuce and many pot plants. An experiment in tomatoes grown in rockwool where the recirculating nutrient solutions were treated with surfactants there was no influence of the yields. In addition the root systems were in a better condition.

Development of thermal control strategies to substitute for pesticide plant disease control in protected cultivation (Bent Løschenkohl)

Data recording equipment and detection methods for spore germination are tested in commercial greenhouses. The aim is to develop control strategies that recognizes conditions under which fungi spores can germinate, and take proper action with heating/ventilation to avoid the dangerous conditions.

E. VIROLOGY DEPARTMENT

Head of Department: Arne Thomsen (acting)

Scientific staff:

Jens Begtrup: Electron microscopy
Bernhard Borkhardt: Biochemical diagnosis methods
Bent Engsbro: Viruses of agricultural plants: production of healthy nuclear stocks of potatoes
Morten Heide: Serological diagnosis methods
Niels Paludan: Viruses of vegetables and ornamental plants (herbaceous): production of healthy nuclear stocks

General report (Arne Thomsen)

In the diagnostic fields, great importance is attached to electron microscopy, and numerous analyses, in particular by means of the ISEM technique, have been carried out.

Investigations of virus diseases in agricultural plants have been continued with regard to potatoes, cereals and sugar beet. Several investigations concerning *Rhizomania* in sugar beet have been carried out, but so far the disease has not been found in Denmark. In connection with this investigation, other viruses were found, such as TNV and a Swedish soil-borne beet isolate, 86.109. It was found in 60 per cent of the soil samples examined.

During the year the department was engaged in the establishment of virus-free nuclear stocks of various horticultural plants.

The work on virus diseases of nursery plants was continued especially with regard to *Quercus, Populus*, *Sambucus*, *Ribes* and *Prunus*. In the field of ornamental plants the efforts were concentrated on virus problems in *Begonia*, *Dipladenia*, *Kalanchoë* and *Pelargonium*.

Virus diseases of agricultural plants (Bent Engsbro)

Potato Mop-Top

Resistance trials on infected soil continued, now comprising 40 potato varieties. 19 varieties showed resistance, 13 were very tolerant (up to 2 per cent tubers affected), 4 were susceptible (2-10 per cent tubers affected) and 4 were very susceptible (more than 10 per cent tubers affected).

No attacks have been observed, however, in other fields where 'Primula', another very susceptible variety, has been grown for decades. Contrary attacks occur in many fields in the area where the very susceptible variety,is 'Saturna' is grown.

Virus diseases of woody plants (Arne Thomsen)

Poplar mosaic virus

Poplar mosaic virus, tobacco necrosis virus and an unknown virus were isolated by a direct inoculation method (Th. M. Berg method). In infected plants virus symptoms were observed in several cases, but symptomless *Populus* plants were also found infected.

Virus diseases of vegetables (Niels Paludan)

Disinfection trials

Experiments concerning the effect of different disinfectants on viruses have been continued. They comprise suspension and contamination tests.

The disinfectants were: Brown soap 10%, Trisodium phosphate 10% in combination with the detergent 'Lissapol' 1%, Korsolin 5% (aldehyde), Venno Terra Spray 100% (organic acids), Venno Terra Man 10% (organic acid and ethanol) and water as control.

The effect of the investigated disinfectants was depending on the virus species, the concentration used and the duration of treatment, respectively.

Inactivation of the rod shaped tobacco mosaic virus, tomato strain (TomMV) was more difficult than the corresponding stable spherical viruses Pelargonium flower break and Pelargonium line pattern.

Higher concentration of the disinfectant and a prolonged period of treatment have both increased the TomMV inactivation.

In the suspension tests, inactivation of TomMV was achieved only with the disinfectants based on organic acids.

In the knife contamination tests, transmission of TomMV was reduced or totally stopped by all the disinfectants used after 5 to 10 minutes of treatment, but not by only dipping or after treatment for 1 minute.

The solution of the disinfectant has to be renewed regularly due to a accumulation of virus infectious matter in the liquid during the disinfection work.

Virus diseases of ornamental plants (Niels Paludan)

Kalanchoë blossfeldiana

Symptomless and virus-free meristem plants of the cultivar 'Attraktion' with chlorotic mosaic have been established as well from untreated (29 per cent) as heat treated plants (45 per cent).

Different mosaic types as chlorotic mosaic and dark green raised areas have both been transferred by sap and *Myzus persicae* (15 minutes of feeding) to healthy plants causing identical symptoms.

The following viruses have been shown in these mosaic types: Tomato bushy stunt, tobacco mosaic, carnation mottle, carla- and potylike particles.

Tomato bushy stunt virus causes spoonlike chlorotic leaves in a short period after infection.

Pelargonium

Infection trials with pelargonium line pattern virus was carried out using sap inoculation to healthy plants of 'Springtime Irene'. All five plants developed vein chlorosis, vein clearing after one month and conspicuous vein bands and flower break.

COST-87 action programme concerning pathogen elimination and micropropagation:

Elimination of viruses

Pelargonium x hortorum 'Penny Irene' infected with both pelargonium flower break virus (PFBV) and tomato ringspot virus (TomRV) show leaf and flower symptoms which markedly reduce the economic value of the plants.

Apical explants (0.25 - 0.5 mm tall) were excised from virus infected mother plants and cultured: PFBV and TomRV were identified in leaves both from plants *in vitro* and potted stock plants *ex vitro*.

Previous heat treatment of infected mother plants at 34°C for two months eliminated the PFBV infection in all plants (cf 75% for non-heat treated plants) and TomRV in 92% of the plants (cf 24% for non-heat treated plants).

There was a loss of PFBV infection in shoot cultures during progressive subcultures.

Both viruses were routinely identified by immunosorbent electron microscopy (ISEM): additional bioassay by sap inoculation onto *Chenopodium quinoa* was also used and proved to be more sensitive concerning TomRV.

Propagation *in vitro*

Adventitious shoot production *in vitro* was obtained from *Pelargonium x hortorum* 'Alex' and 'Penny Irene' and from *P. peltatum* 'Ville de Paris'. Wide variation was found with all cultivars in relation to callus growth, shoot formation and the rate of plant multiplication.

The number of established explants which developed shoots was correlated both to the size of the primary explant used and to the health state of the mother plant. In this way both bigger explants and explants from virus-free plants clearly gave the highest number.

The rooting of shoots and the survival of plants were generally successful, but there was variation between cultivars and subculture steps, indicating differences in the quality of the plant material used.

Somaclonal variation occurred in 'Penny Irene' and 'Ville de Paris' ranging from 10-30 per cent, while no variation was observed in 'Alex'. The incidence of variation increased with successive subculturing, appearing as plant dwarfing, light green, white variegated and deformed leaves and as distorted flowers. A temporary form of dwarfing was also recorded.

Axillary shoot production from stem nodes *in vitro* was only obtained from 'Penny Irene', and only after 8 months in culture. Nodal segments showed better survival from virus-free plants than virus-infected plants. Somaclonal variation was not found in these plants.

<u>New virus attacks 1989</u> (Niels Paludan and Arne Thomsen)

Armeria juniperifolia	beet yellow closterovirus
Beta vulgaris	tobacco necrosis tobanecrovirus
Cissus rhombifolia	carnation mottle carmovirus
Dianthus 'Napoleon III'	carnation latent carlavirus
Kalanchoë blossfeldiana	carnation mottle carmovirus
Miscanthus sinensis	miscanthus streak geminivirus
Pelargonium peltatum	tobacco mosaic tobamovirus
Pisum sativum	bean yellow mosaic potyvirus
	tobacco mosaic tobamovirus
Populus canadiensis	tobacco mosaic tobamovirus
	tobacco necrosis tobanecrovirus
Prunus stock 'Colt'	tomato bushy stunt tombusvirus
	tobacco mosaic tobamovirus
Prunus trilobo	prunus ringspot ilarvirus
Rosa sp.	prunus ringspot ilarvirus

F. BIOTECHNOLOGY PROJECT

Head of project: Morten Heide

Scientific staff:

Merete Albrechtsen: Serological methods and electron microscopy
Bernhard Borkhardt: Molecular biology techniques
Lone Buchwaldt: Fungus diseases in rape seed
Morten Heide: Serological methods and electron microscopy
Karen Husted: Biochemical techniques for fungus diagnosis
Elisabeth Johansen: Molecular biology techniques
Søren V.S. Nielsen: Cell and tissue culture techniques
Gert Poulsen: Cell and tissue culture techniques

The biotechnology project has been set up in order to develop and implement biotechnological methods of relevance for Danish agriculture and horticulture. The project refers to the entire Danish Research Service for Plant and Soil Science, but is geographically situated at the Research Centre for Plant Protection, with close links to the Virology Department.

Work of direct relevance for plant protection:
Serological techniques (including ELISA and ISEM) for diagnosis of plant pathogens are continuously being developed and improved. Furthermore, DNA probes are produced for diagnosis in cases where serological methods are inappropriate. Non-radioactive detection systems for DNA probes are being developed. Special emphasis has been placed on diagnosis of viruses and viroids in potatoes, diagnosis of beet necrotic yellow vein virus (the causal agent of *Rhizomania*) in sugar beet, and on methods for distinguishing between the barley leaf pathogens *Pyrenophora teres* and *P. graminea*.

Research on the seed-borne pea viruses pea early-browning virus and pea-seed-borne mosaic virus is carried out with the aim of developing new sources of virus resistance in pea. The coat protein genes of both viruses have been cloned and are now being used in transformation experiments on tobacco and pea plants. (In other systems, transgenic plants producing virus coat protein have been found to be resistant to the homologous virus). Other virus genes are studied with the purpose of designing new virus resistance mechanisms.

The toxin produced by *Alternaria brassicae*, Destruxin B, has been isolated and characterized, and a large-scale purification method has been developed. The toxin was found to be non-host specific. The purified toxin is being used for *in vitro* selection of rape seed protoplasts - the object being to obtain toxin tolerant plants by regeneration from toxin resistant protoplasts.

In addition, the biotechnology group carries out research on more basic aspects of cell and tissue culture techniques (regeneration and transformation).

G. ZOOLOGY DEPARTMENT

Head of department: Jørgen Jakobsen

Scientific staff:

Henrik Brødsgaard: Biological control of pests in glasshouses
Annie Enkegaard: Biological and integrated control of the cotton whitefly (*Bemisia tabaci*)
Lars Monrad Hansen: Pests on cereals, beet, potatoes. Warning systems
N.S. Murali, Bo Secher: Computer aided advisory system for pest and disease control
Alex Percy-Smith: Pests on field vegetables and fruit.
Hans Peter Ravn: Insect pests in field peas an codling moths in apple orchards
Werner Riedel: Beneficial arthropods in cereal crops
Lise Samsøe-Petersen: Methods for testing side effects on beneficial arthropods

General report (Jørgen Jakobsen)

The main activities of the department are (1) to support the development of IPM in agricultural crops, (2) to develop biological control methods for thrips and whiteflies in glasshouse crops, (3) to develop new methods for determining the effect of pesticides on beneficials used for biological control as well as on beneficials, which are naturally occurring in the cultivated land and (4) to develop an information system on plant protection which is to be used as an advisory system for farmers. The database will contain information about crops/cultivars, soil treatment, weather conditions, pesticides, beneficials and recommendations for optimal prevention and control of pests and diseases.

For a number of years the department has been working with a special advisory system on aphid control in cereals based on a simple computer programme. By means of this system we have collected information on the aphid development in 2-300 fields grown with barley and winter wheat respectively. The occurrence of aphids in cereals was moderate in 1989.

Also aphid occurrence in potatoes and beet was registered during the summer months (June-July). The observations were made by growers and advisers. 15 potato fields were monitored and about 200 beet fields. Due to exceptionally high winter temperatures many peach-potato aphids survived during winter. Most growers were able to prevent severe attacks of virus yellows by means of an efficient warning system.

A grant from the Scandinavian Contact Agency for Agricultural Research increased the resources allocated to biological control methods for pests in glasshouse crops, and Annie Enkegaard could begin her studies of *Bemisia tabaci* and the possibilities of controlling this species by means of the parasitoid *Encarsia formosa*. Annie Enkegaard will combine this project with her PhD-studies.

A workshop was held in September under the auspices of the IOBC concerning biological control of pests on glasshouse ornamentals. The workshop was organized by Henrik Brødsgaard and Annie Enkegaard. The number of participants was 24.

The work with the computer based advisory programmes also received a grant from a fund made up of money from a special tax levied on pesticides. This made it possible to employ Bo Secher for this project from July 1989. Bo Secher will also combine this work with his PhD-studies.

Semi-field experiments with aphid infestations of cereals (Jørgen Jakobsen)

A new set-up for semi-field experiments has been established. These facilities make container experiments possible in which the containers are isolated in cages so that infestations can be established at a constant level and at definite developmental stages.

In 1989, experiments with "late" aphid infestations were carried out.

Pests in cereals (Lars Monrad Hansen)

One of the most important pests in spring barley and winter wheat is aphids. Therefore a computer based registration and warning system has been developed for these pests. The programme for spring barley also includes mildew and net blotch. Approximately 200 growers participated in the system.

Field trials were conducted with a view to adjusting the economic injury thresholds included in the programmes.

Pests in beet (Lars Monrad Hansen)

Peach-potato aphid is the most important pest in beet due to its capacity to transmit virus yellows. Therefore a computer based registration and warning system has been developed for peach-potato and black bean aphid. Approximately 125 growers participated.

Furthermore, emigration traps have been used to determine when the aphids emigrate from the clamps. Wind traps have also been placed in lighthouses facing south to observe possible invasions of peach-potato aphids from areas south of Denmark. Resistance tests have been conducted on peach-potato aphids. The result was similar to that of the last many years - 80 per cent were sensitive and mildly resistant.

Aphids in potatoes (Lars Monrad Hansen)

Different aphid species transmit virus to potatoes. By means of yellow tray traps placed at 15 localities all over the country the development is monitored. The results are used for determining the optimum time for haulm desiccation.

Slugs (Lars Monrad Hansen)

Slugs - primarily *Deroceras agreste* is a pest in autumn sown crops. A method to assess slug density is being developed by means of so-called slug traps placed in a number of fields. The investigations also aim at determining an economic injury threshold.

Investigations on insect pests in field peas (Hans Peter Ravn)

The area grown with field peas is of considerable dimensions. The use of insecticides on this area is rather intensive. Still our knowledge of the importance of insect pests is limited. Due to this, investigations have been commenced to clarify the impact of the most common insect pests. It is also the aim to develop simple and safe evaluation methods for practical use by the farmers.

In field studies the spring migration and colonisation pattern of the pea and bean weevil (*Sitona lineatus*) and the pea aphid (*Acyrthosiphon pisum*) into the pea fields have been investigated.

Semi-field facilities have been established for controlled outdoor pot experiments of the impact of insect pests on pea plant growth and yield. In 1989, preliminary experiments with pea aphids were carried out.

Under laboratory conditions experiments with survival and egglaying of summer and autumn collected *Sitona lineatus* have been carried out at different temperature and daylength conditions.

Development of a computer based registration and advisory system for pests and diseases in field peas (Hans Peter Ravn and N.S. Murali)

In 1989, the system included three insect pests: the pea and bean weevil, the pea aphid and the pea moth (*Cydia nigricana*). Also four fungal diseases are included in the system.

The system is based on the farmer evaluating pest density and diseases in his field at least twice a week. The evaluations follow uniform guidelines and the result is sent by mail to the Research Centre for Plant Protection. On the day of receipt the evaluation data are run through a computer programme containing thresholds, calculations, etc. The same day, an advisory statement is sent to the farmer together with an outline of the pea pest and disease situation in his region and on a national scale.

92 farmer wanted to join this system in 1989. Pheromone traps were used for monitoring the pea moth and a white plastic tray traps for monitoring the pea aphids.

Influence of polyphagous predators on pea aphid populations (Mette Kjøbek Petersen & Hans Peter Ravn)

In three pea fields fluctuations of the carabid beetle fauna and the population of pea aphids have been measured by means of pit fall traps and white plastic tray traps respectively.

In laboratory experiments the consumption rate of *Bembidion lampros*, *Agonum dorsale* and *Pterostichus melanarius* on pea aphids were tested.

By dessications of the three species the gut contents was examined for chitin remains of pea aphids.

These experiments were carried out as a graduation project from the Agricultural University.

Testing *Bacterium thuringiensis* against pea and bean weevil and pollen beetle (Hans Peter Ravn)

A particular strain of *Bacterium thuringiensis* was tested under laboratory conditions and in rather high doses on adult pea and bean weevils and pollen beetles (*Meligethes aeneus*). The results showed no effect.

Monitoring Carrot Fly (*Psila rosae*) with yellow sticky traps (Alex Percy-Smith)

The first generation carrot fly was monitored using yellow sticky traps at 16 localities. The flight period started quite early and treatment was advised in several cases.

Flight activity was monitored at a total of about 160 localities. An attempt to decentralise the monitoring system was made and several processing companies administered their own monitoring and warning system. In addition, several advisors serviced traps themselves and interpretation of results was discussed with the Research Centre.

As in previous years, advisors were given weekly evaluations of the situation in their region and growers given individual recommendations each time their traps were serviced. In the drained area of N.W. Zealand (Lammefjorden) there was a general need for treatment, whereas the growers who are more scattered throughout the country had very varying treatment requirements.

Monitoring turnip moth (*Agrotis segetum*) by means of sex traps and forecasting cutworm attacks (Alex Percy-Smith)

The turnip moth was monitored at 40 localities in Denmark and 18 localities in Skåne, Southern Sweden. The overwintered population was a little higher than the previous year, but still quite low. Catch in pheromone traps was correspondingly slightly larger

than in 1988, but as a result of warm, dry weather, conditions for larval development were extremely good. Survival was high, so that treatment was recommended in most situations where carrots, beetroot and leeks were grown.

Reports of damage have been received where irrigation or chemical treatment have not been carried out.

Monitoring codling moth (*Cydia pomonella*) by means of sex traps (Alex Percy-Smith and Hans Peter Ravn)

Delta traps were used at 48 localities for monitoring codling moth in apple orchards. The main flight period was from the middle of June to the middle of July and there was evidence of a limited second generation in the latter part of August. The number of treatments for codling moth was low, although many growers treated for other pests, especially aphids.

Information Data Base on Pests and Diseases (N.S. Murali and Bo. J.M. Secher)

The project was started in 1987. The aim was to develop an information system comprising relevant information for farmers and agricultural advisers. The system consists of the following main parts:

* Recommendation models giving the economically best control of diseases and pests on a field basis
* Information on diseases and pests
* Information on plant protection means
* Information on crops/diseases and pests
* Information on beneficial animals/diseases, pests and plant protection means
* Farmer's field observations

In 1990, the information data base will be tested in winter wheat and spring barley. In the coming years other crops will be incorporated.

A field registration system (previously called "Avlerregistrering") is part of the information data base. Farmers participating in this system receive recommendations on plant protection from the recommendation programmes of the data base. The communication takes place by post or telefax. The user sends his field observations to the Research Centre for Plant Protection, and he receives from the Centre a recommendation and information about the next observation date. The observations during the season form the basis of a nationwide monitoring of the disease and pest development.

The following programmes are included in the system:

Crop	Initial year	Diseases and pests	Number of participants 1989
Spring barley	1983	aphids mildew net blotch	190
Winter wheat	1986	aphids	90
Beet	1987	peach-potato aphid black bean aphid	130
Field pea	1988	pea aphid pea and bean weevil pea moth (*) mildew (*) grey mould (*) leaf, stem and pod spot (*) fusarium wilt (*)	92
Apple	1987	codling moth	48
Vegetables	1984	carrot fly carrot fly	85 40

(*) no recommendations were given.

Cotton whitefly ***Bemisia tabaci*** (Annie Enkegaard)

Since 1987 cotton whiteflies have frequently been introduced into Denmark with imported plant material, primarily Poinsettia.

The cotton whitefly is categorized as a zero-tolerance pest on propagation material, and this together with an intensified control by the Plant Health Authorities and the efficiency of cyanide gas for control of the pest, whitefly problems in Danish glasshouses were dealt with relatively easily in 1989.

There is, however, a need for more substantial and coherent programmes for control of the cotton whitefly to oppose the constant importation (quarantine programmes) and the possibility of a more permanent presence of the pest in Denmark.
Such integrated control programmes are intended brought about in a cooperation between the Zoology Department, the Growers' Association and the Plant Health Authorities. The programmes should be based on the combined use of chemicals, microbial agents, natural arthropod enemies and cultural/physical means.

Investigations contributing to this final goal have been undertaken under this project.

The investigations include basic experiments on the biology of the cotton whitefly. The objective is to establish a basis for choosing the proper natural enemy for biological control. Furthermore, a general model for prediction of population growth and outcome of control under the conditions prevailing in Danish glasshouses is intended developed.

Experiments with yellow sticky tape are presently being made for evaluation of the suitability of the tape to catch sufficiently large numbers of adult whiteflies to reduce the population level.

Finally, on request of the Plant Health Authorities, methods for distinguishing between live and dead immature individuals of the cotton whitefly has been looked into. A method based on staining of leaves with immature stages seems promising. A confirmation of the reliability of the method is under way.

Thrips in glasshouses (Henrik F. Brødsgaard)

Biological investigations of (*Frankliniella occidentalis*) were carried out in the laboratory. These included lifetable studies at 25°C and different photoperiods on bean leaf discs and studies on cold tolerance. Furthermore, the thrips' ability to tolerate water coverage was studied.

The work on the use of sticky traps for monitoring *F. occidentalis* and *Thrips tabaci* was continued.

A bioassay to test insecticide residue exposure on different populations of *F. occidentalis* was developed.

Development of standard methods for determining the effect of pesticides on beneficials (Lise Samsøe-Petersen)

Rearing of the Carabid beetle *Bembidion lampros* was continued during 1989, but the development of a test to investigate effects of pesticides on adults ceased. This was due to reallocation of resources to another project and problems with the fertility of *B. lampros*.

A laboratory test for adult females of the Staphylinid beetle *Aleochara bilineata* has been developed earlier in co-operation with the IOBC Working Group "Pesticides and Beneficial organisms (Lise Samsøe-Petersen, 1987). Work on this species was resumed during 1989 in two ways.

The laboratory test was used to perform tests for the chemical industry on a contract basis, and development of other tests was initiated.

To achieve a more comprehensive picture of the effect of pesticides under field conditions it should be possible to conduct additional tests after the initial laboratory test.

Preliminary experiments with a test for *A. bilineata* under semi-field conditions were performed in 1989, and these will be continued together with laboratory experiments with pupae.

Manipulation of polyphagous predators in cereals (Werner Riedel)

In 1988, a Nordic project started with the aim of finding methods to enhance the population of naturally occurring enemies of cereal aphids. The Danish part of the project is to create good overwintering sites for beetles and spiders. As indicator organisms two ground beetles *Bembidion lampros* and *Agonum dorsale* as well as some beetles within the genus *Tachyporus* were chosen, because they are very common in Danish agricultural land. These beetles are overwintering as adults in field edges and hedges. Therefore a simple grass and herb ridge was created in a winter wheat field in spring 1988.

Results from the winter 1988/89 confirmed that the grass ridge was a good overwintering site for at least *Bembidion lampros*

H. PESTICIDE RESEARCH INSTITUTE

Head of institute: E. Nøddegaard

Scientific staff:

Bent Bromand: Insecticides for agricultural purposes
Hanne Lipczak Jakobsen: Fungicides in oilseed rape, peas, potatoes and outdoor grown vegetables
Lise Nistrup Jørgensen: Fungicides in cereals
Bent J. Nielsen: Fungicides in cereals
Steen Lykke Nielsen: Fungicides and insecticides for fruit growing
A. Nøhr Rasmussen: Fungicides, insecticides and growth regulators for soft fruit, nursery and glasshouse crops
Jørgen Simonsen: Fungicides and insecticides for agricultural purposes

General report (E. Nøddegaard)

Approval of pesticides and plant growth regulators

According to a voluntary agreement with the Danish Agrochemical Association and the Ministry of Agriculture (The Danish Research Service for Plant and Soil Science), the Pesticide Research Institute carries out the tests and investigations necessary to form the basis for approval of pesticides and growth regulators. The latest agreement is from 1988.

The firms pay for the testing according to fixed rules and rates.

In 1984, a registered mark was introduced for use on approved pesticides and plant growth regulators. The firms may place this mark on the labels of approved pesticides close to the approval statement, and it can be used for advertizing, provided it is accompanied by the approval statement. Besides, the mark is used by the Research Centre in publications where approved pesticides are mentioned.

Approved pesticides are included in the list of "Plant Protection Products Approved for Control of Plant Diseases, Pests and Weeds, for Desiccation of Seed Crops and Potatoes and for Growth Regulation". This list is revised annually in January.

Evaluation of efficacy of pesticides and plant growth regulators

According to the provisions of Statutory Order from the Ministry of the Environment No. 791 of Dec. 1987, section 42, subsection 2, on chemical products, the Pesticide Research Institute shall be consulted as to the efficacy of pesticides and growth regulators before the registration by the Environmental Protection Agency takes place.

Re-evaluation of the efficacy of pesticides and plant growth regulators

According to the Statutory Order from the Ministry of the Environment No. 791 of December 1987, on Pesticides, the Pesticide Research Institute shall give an opinion on the importance and application of the pesticide in question, on possible alternative compounds and methods as well as the financial consequences of a limitation in the use of the pesticides and growth regulators.

Control of diseases in winter wheat 1989 (Lise Nistrup Jørgensen and Bent J. Nielsen)

As part of the new agreement between the Danish Agrochemical association and the Danish Research Service for Plant and Soil Science, all fungicides were tested in full, three-quarter and half rate in 1989. 48 trials were carried out testing various fungicides and combinations in winter wheat.

In spring severe attacks of eyespot (*Pseudocercosporella herpotrichoides*) were found in 70% of the tested fields (> 15% attacked plants). Split application, using 2 x 0.5 l Sportak 45 ec, applied in the autumn and in the spring (Zadoks 30-31) gave in 1989 as well as in 1988, an important improvement of the efficacy compared to traditional spring treatments using 1.0 l/ha. The increase in efficacy has not been reflected in grain yield increases.

Yellow rust (*Puccinia striiformis*) was widespread in 1989. The epidemic started already in February and March in the varieties Anja and Kraka, while the epidemic in Sleipner did not become severe until June. Two standard applications (Zadoks 31-32 & 45) in the growth season 1989 gave insufficient effect in varieties with early and severe yellow rust, independently of dosages used.

Very low dosages (0.15 or 0.25 l/ha of broad spectrum fungicides) gave in particular insufficient effect on yellow rust, especially when the first application took place on established attacks. In 1989 satisfactory control required 3 or 4 applications in order to protect plants for the whole season if very reduced dosages were applied.

The long term effect against yellow rust varied considerably between products. Folicur 250 ec (tebuconazol 375 g/ha) and Dorin (triadimenol 125 g/ha + tridemorph 375 g/ha) had best long term effect (4-5 weeks), while Corbel (fenpropimorph 750 g/ha) and Rival (prochloraz 225 g/ha) had the shortest long term effect. Tilt top (Propiconazol 125 g/ha + fenpropimorph 375 g/ha), DPX N 7876 (fluzilazol 160 g/ha + fenpropimorph 375 g/ha) and CX 021 (prochloraz 80 g/ha + cyproconazol 300 g/ha) had medium long term effect. Even half rate of Dorin and 0.5 l of Folicur gave better long term effect, than the standard, 1.0 l Tilt top.

Powdery mildew (*Erysiphe graminis*) incidence was low. By 1st June, a 5 per cent coverage of green parts was found, as an average. Attacks could not compete with the severe yellow rust infections.

Because of a dry and warm season *Septoria* spp. attacks did not develop to any significant level. In mid May, 2.5 per cent attack was found, average of 20 trials. Reduced dosages gave lower gross as well as net returns for several products. This was in particular the case when products showed a clear dose response to yellow rust control.

Seed treatment against seed-borne diseases of wheat (Bent J. Nielsen)

In Denmark, 97% of the wheat is sown in the autumn (434.000 ha, 1989). Normally the seeds are without diseases and only a little winter damage occurs, but in 1989 a rather high incidence of *Tilletia caries* was reported. Neo-Voronit and Panoctine 30 have until now been the most used seed dressings in Denmark, but their efficacy is only 70-86% against *Tilletia caries*, and with lower dose the efficacy drops very quickly. Poor quality of seed treatment can very quickly lead to severe epidemics of *Tilletia caries*, and it is therefore very important that only the recommended dose rate is used and that the seed dressing is evenly distributed on the kernels. The efficacy of the new seed dressings has been improved but it is still necessary to have a high quality of the seed treatment.

Seed treatment is a preventive cure which normally, in Denmark, does not give significant yield increases. But occasional infections of kernels with *Fusarium* and *Septoria nodorum* and the risk of winter damage together with the widespread but low incidence of *Tilletia caries* still make it necessary to recommend seed treatment of all winter wheat in Denmark.

Products approved for use in wheat in Denmark: Baytan bejdse IM (150 g), Derosal M bejdsemiddel (150 g), Neo-Voronit (250 ml), Panoctine 30 (200 ml) and Sibutol LS 280 (150 ml). Dithane M 45 (200 g) and DLG Maneb bejdse (200 g) have only been approved for spring wheat. Because of resistance in *Fusarium* to benzimidazoles no seed dressings with only benzimidazoles are approved in Denmark.

Fungicide resistance in powdery mildew. Present situation and status (Bent J.Nielsen)

Use of cereal fungicides in Denmark has increased up to 1984, reaching a maximum of 1.75 full dose sprays per ha, on average. Since then the use has declined and has now stabilised on 0.75 sprays per ha. (1.2 mio. ha of cereal treated). The fungicides used in cereals are DMI-compounds and morpholines, most often in mixtures. An important development now is to spray several times with reduced dosages.

Monitoring of fungicide resistance to DMI-fungicides in powdery mildews (*Erysiphe graminis*) in Denmark started in 1983. By using the test tube method a decline in sensitivity was shown in wheat powdery mildew from 1983 to 1985. In barley powdery mildew it was not possible to show any significant change in sensitivity from 1984 to 1986 but sensitivity of the isolates was 13-19 times lower than that of isolates collected around 1950-60.

Later investigations where single colony isolates were tested on leaf segments showed that the sensitivity of wheat powdery mildew to triadimenol (DMI fungicides) has been stable since 1986, but on a relatively high level.

In barley powdery mildew it was shown by the leaf segment test with triadimenol that since 1985 sensitivity has declined in Denmark. This development in barley powdery mildew has followed the same pattern as in other areas of Europe where barley is grown intensively.

The development of the resistance level in powdery mildew in Denmark has taken place despite the wide use of mixtures of DMI/morpholines. But the use of mixtures may have played an important part in restraining the development of the resistance level.

Control strategies for diseases in winter barley (Bent J. Nielsen and Lise Nistrup Jørgensen)

The growing season of winter barley is very long, around 300 days. In this period it is important that the crops are kept free of diseases. Especially in the active growing season from mid April to mid June. If there are severe attacks of powdery mildew (*Erysiphe graminis*) in the autumn, or early spring, however, spraying can be necessary. The treatment seldom gives a net return, but reduces the risk of early and severe epidemics in spring barley.

Until 1989 it was obligatory to spray winter barley twice with full dose. The treatment gave good control, but the net yield was often below 2 hkg per hectare. Trials have shown that a better timing of the sprayings and use of reduced dosages give optimum control and yield. Disease control is important between mid April and mid June. A first treatment around Zadoks 30-31 with 0.3-0.5 l broad spectrum fungicides (Rival, Tilt top, Tilt turbo) is often necessary followed by a second spray after about 30 days around Zadoks 37-45 with 0.3-0.5 l. The doses have to be adjusted to the disease pressure. If scald (*Rhynchosporium secalis*) and net blotch (*Drechslera teres*) are developing, a dose of 0.75-1.0 l is often necessary followed by 0.3-0.5 l after 3-4 weeks.

The trials have shown that good control can be obtained in winter barley with a total amount of 1.0-1.5 l fungicide divided into 2-3 sprayings. In most seasons 1.0 l is enough and if the season is long, the dose can, with advantage, be split into 3 x 0.3 l.

Control of fungal diseases on oilseed rape, peas, potatoes and outdoor grown vegetables (Hanne Lipczak Jakobsen)

In 1989, 73 field and glasshouse experiments were made.

Oilseed rape: Fungicides for spraying against stem rot (*Sclerotinia sclerotiorum*) were tested. Due to the lack of precipitation this season, no attacks appeared in the trials.

Late frost injury to winter oilseed rape caused severe attacks of grey mould (*Botrytis cinerea*) which were prevented by early fungicide spraying in 3 trials.

Peas: Several seed treatment products were tested against seed- and soilborne fungi using infected seed and infected soil. Attacks did not appear until early flowering because of no precipitation.

The main leaf fungi were leaf and pod spot (*Ascochyta* spp.) which appeared late in the season. Attacks caused no seed infection. 2 sprayings at full bloom and late bloom prevented attacks on leaves and pods.

Potatoes: Experiments were made with several sprayings against late blight (*Phytophtora infestans*). Attacks of late blight were weak and came late due to the lack of precipitation.

Seed treatment products with effect against black scurf (*Rhizoctonia solani*) were tested using several different strategies. ULV-spraying before storage gave good control of black scurf.

Cucumber: Downy mildew (*Pseudoperonospora cubensis*) has become a severe disease in late summer. Several products for spraying against this disease were tested using 2 or 3 sprayings in August.

Pests in agricultural crops and field vegetables (Bent Bromand)

The testing of pesticides is carried out according to: "Agreement between the Agrochemical Association and the Ministry of Agriculture (the Danish Research Service for Plant and Soil Science) concerning application, testing and approval of pesticides and plant growth regulators".

From 1989 onwards, all chemicals will be tested in 3 doses, normal = 1/1, 3/4 and 1/2 dose.

In 1989, 67 field trials were conducted. Trials with seed treatment were carried out against frit flies in oats, against soil pests and the pygmy beetle in sugar beet, against field thrips and flea-beetles (*Phyllotreta* spp.) in oilseed rape and against the pea and bean weevil in peas.

Trials were carried out with spraying against aphids and thrips in winter wheat, spring barley and winter rye. I oats, cut grass and grass for seed, sprayings were carried out against frit flies and in sugar beet fields the problems were caused by thrips and aphids. In oilseed rape, trials were conducted with sprayings against blossom beetles, the seed pod weevil and the brassica pod midge. In peas, the work carried out concerned pea and bean weevils, aphids and pea moths.

In field vegetables, granules and sprayings were applied against the carrot fly and observations were made on the effect on cutworms.

Besides the testing of pesticides, a warning system for first and second generation of the cabbage root fly has been developed and has been in operation for 5 years now.

Fruit growing (Steen Lykke Nielsen)

Chemicals were tested for control of *Gloeosporium*, apple scab, apple mildew, pear scab, brown rot on cherry, cherry leaf spot, tortrix moth, winter moth, fruit tree red spider mite, apple rust mite, codling moth, plum fruit moth, cherry blackfly, mealy plum aphid, pear sucker and *Phyllonorycter blancardella*. The chemicals were tested with the recommended dose and half the recommended dose. An electronic apple scab warning equipment was tested and compared to a traditional preventive spray scheme for control of apple scab. The incidence of leaf scab did not differ between the two treatments while there was found significantly more fruit scab when the warning equipment was used. The incidence of fruit scab was quite low, however. Use of the warning equipment saved 40% of the applications.

I. INSTITUTE OF WEED CONTROL

Forsøgsvej 1, Flakkebjerg, DK-4200 Slagelse

Head of institute: K. E. Thonke

Scientific staff:

Peter Kryger Jensen and Svend Christensen: Applied research on chemical weed control in agriculture including work on competition and thresholds

Peder Elbæk Jensen and Per Rydahl Nielsen: Testing and approval of herbicides and growth regulators in agriculture

Georg Noyé and Anette Binder: Weed control and approval of herbicides in horticultural crops

Thomas Rubow and Ole Hansen: Weed control and approval of herbicides in forestry and windbreaks

Per Kudsk, Jens Kristensen, Solveig Kopp Mathiasen and Hanne Juul Pedersen: Research on factors affecting the efficiency of herbicides

Bo Melander, C. Holm-Nielsen and Ilse A. Rasmussen: Distribution of weeds, seed production and weed seed bank

Jesper Rasmussen, Jakob Vester, Anders Nemming and Birgitte Tønnes Pedersen: Weed control by means of non-chemical methods

Ole Permin and Ebbe Nordbo: Research on spray technique and drift

Ole Permin and Marianne Baandrup: Advisory service (see p. 4)

The staff consists of 22 scientists and 31 assistants.

The institute was founded in 1946. In 1972 the institute moved from Lyngby to Flakkebjerg.

The institute holds a total farmland of 83,6 ha acres, annually 1/3 of this area is used for weed control experiments.

From the institute a substantial number of trials are placed on agricultural and horticultural land and forests all around Denmark.

The buildings of the institute are equipped with offices, laboratories, climate chambers, green houses, aviary for pot trials, library, work shops, garages and barn. In 1989 an extension of 16 offices and a barn of 400 m^2 was finished.

Applied research on chemical weed control in agriculture including competition and threshold (Peter Kryger Jensen)

Split applications of herbicides

Split applications of herbicide mixtures in peas were compared with single applications. In the split applications, the dosage each time was 50% of the dosage with single application. Both the tolerance of the crop and effect on weeds have been investigated.

With the same total dosage of the herbicide mixtures, the weed control was enhanced with split applications, compared to a single application. Also there was a tendency that the split application was more lenient towards the crop than a single application. The optimum time interval between the 2 applications was between 7-12 days, with a decreasing weed control when this interval was exceeded. The principle with split application has also been investigated with control of *Avena fatua* with Barnon Plus, control of grassweeds with isoproturon and control of *Elymus repens* with glyphosat.

Varieties in competitive ability in spring barley (Svend Christensen)

This project is supported by the Danish Agricultural and Veterinary Research Council and is part of the efforts to reduce the use of herbicides. The main aim of the project is to evaluate the competitive ability of spring barley varieties and to investigate the interaction between competitive ability and herbicide doses. Morphological (plant height, leaf area, etc.) and physiological (canopy light interception) characters of the varieties are measured and compared to the amount of weed dry matter. Preliminary trials show that the competitive ability of the varieties can be correlated to the light interception of the canopy.

Testing and approval of herbicides and growth regulators in agriculture (Peder Elbæk Jensen and Per Rydahl)

Testing of herbicides, desiccants and growth regulators in agriculture

In 1989, the tests were performed according to a new agreement between the Danish Agrochemical Association and the Ministry of Agriculture (the Danish Research Service for Plant and Soil Science). This agreement means that the tests must be performed in various dosages. Tests with yield assessment and evaluations of other crop and weed statements are performed in 2/1 and 1/1 dosage. Tests for determination of the effects of the herbicides on weed species were performed in 1/4, 1/2 and 1/1 of the dosage recommended by the importer. We think that this new agreement gives a much better and wider foundation for approval and furthermore a basis for much more detailed instructions for practice in the years ahead.

In 1989, the Institute of Weed Control was requested to carry out tests in anticipation of 162 approvals. Some herbicides were notified to various purposes for which reason the number of herbicides and/or combinations of herbicides were 86.

Table 1 shows the number of requests for approvals in various crops, and as the result of the testing of this year, the assigned approvals on these crops, too. Obviously, the requests for approval were concentrated to the crops, that are grown in the largest area.

Table 1. Requested approvals and given approvals in 1989

culture	requests	approvals
beet	26	7
horse bean	3	0
potato	4	0
maize	2	0
rape	21	10
pea	22	3
spring cereals	24	17
winter cereals	52	26
seedgrass	6	6
uncultivated	2	2
Total	162	71

Of the approved herbicides, only a few are marketed yet, therefore only 8 out of the 71 given approvals can be utilized in practice.

<u>Weed control and approval of herbicides in horticultural crops</u> (Georg Noyé and Anette Binder)

Newly approved herbicides for use in horticultural crops

In the growing season 28 herbicides were applied for testing. The distribution on crops was 1 in onions, 3 in carrots, 7 in green peas, 2 in sweet corn, 5 in cabbage, 6 in strawberries, 3 in black currant and 8 in different nursery crops.

The 12 chemicals listed below obtained approval for use or extended approval for use by the Danish Research Service for Plant and Soil Science.

1. Dimefuron WP (dimefuron 500 g/kg) has been given approval for the control of some dicotyledon weeds in white and red cabbage.

2. Dual 720 (metolachlor 720 g/l) has been given approval for the control of some dicotyledon weeds in white and red cabbage and kale.
3. Focus (cycloxydem 200 g/l) has been given approval for the control of couch grass in peas and black currant.

4. Flexidor (isoxaben 500 g/l) has been given approval for the control of some dicotyledon weeds in a few species of nursery crops.

5. Karmex DW (diuron 800 g/kg) has been given approval for the control of various weeds in some species of nursery crops, apple orchards and black currant.

6. Karmex DF (diuron 800 g/kg) is a new formulation, watersoluble, minigranulate, which has been given the same approval as Karmex DW.

7. Kerb 50 F (propyzamid 500 g/l) is a new fluent formulation, which has been given the same approval in nursery crops and fruit orchards as Kerb 50.

8. Stomp + Basagran 480 (pendimethalin 330 g/l + bentazon 480 g/l) has been given approval for use in peas.

9. Stomp SC + Basagran 480 (pendimethalin 400 g/l + bentazon 480 g/l) has also been given approval for use in peas. Stomp SC is a new formulation of Stomp, where the amount of the active component is larger.

10. Stomp SC (pendimethalin 400 g/l) has been given approval for use in onions, leek, chives, tulip and some species of nursery crops for the control of some mono- and dicotyledon weeds.

11. Topogard (terbuthylazin 150 g/l + terbutryn 350 g/l) has had its approval extended to include green peas.

12. Treflan Plus (trifluralin 240 g/l + napropamid 190 g/l) has had its approval extended to include cabbage.

Investigations on new strategies for weed control in new varities of strawberries and black currant are continued.

Wind control and approval of herbicides in forestry and windbreaks (Thomas Rubow and Ole Hansen)

Forestry, windbreaks and marginal land

Due to the surplus production of some agricultural products inside the EEC and for environmental reasons certain kinds of landscapes are left out of intensive farming. Consequently, the agricultural production on large-scale agricultural acreages will be cancelled. A part of this margin farmland will be planted with forest. On the basis of this a research project was started 1987 at the Institute of Weed Control called "Utilization of pesticides at the establishment of forest on marginal farmland".
The object of the project is to develop an EDP-based information system. The system is based on an information data base, which can give information on the preparing weed control at the establishment of the plantation as well as on the use of pesticides and

mechanical control of weeds in existing plantations. The basis for such an information data base is the content of data comprising results from trials on weed and pest control in forests, windbreaks and first generation of plantations on previous farmland.

In order to procure supplementary results for the data base, trials in plantations of relevant wood species established on former farmland have been started. The objective of the trials is to test the effect of various soil applied herbicides on weeds and the tolerance of the woody plants in relation to soil cultivation/non-soil cultivation on dry and sandy soils. The experience gained from these new trials will, together with the existing knowledge, form the basis of the input to the system.

The data base is designed to be used by forestry educated "advisors" and at the beginning it will cover 3 tree species: Norway spruce, sitka spruce and oak, as these species are supposed to be represented in the future afforestation

Research on factors affecting the efficiency of herbicides (Per Kudsk, Solveig Kopp Mathiassen, Jens Kristensen and Hanne Juul-Pedersen)

Interactions between herbicides

The influence of different formulations of MCPA on the activity of imazamethabenz-methyl on wild oat (*Avena fatua* L) was examined in pot trials. Whereas the dimethylamine salt of MCPA significantly reduced the effect of imazamethabenz-methyl, no reduction was observed when imazamethabenz-methyl was tank mixed with a butoxyethyl ester of MCPA. Volume rate and addition of a mineral oil or a surfactant did not reduce the antagonistic effect of the dimethylamine salt of MCPA on imazamethabenz-methyl.

The joint action of phenmedipham and desmedipham was studied on three plant species. The effect of fixed-ration mixtures of the two herbicides was found to follow the Additive Dose Model.

Rainfastness of herbicides

The rainfastness of glufosinate-ammonium was studied on *Sinapis alba* and barley using a rain simulator. On both plant species a time interval of more than 8 hours between herbicide application and the onset of rain was required to obtain maximum effect. Addition of ammonium sulphate, an anionic surfactant and a weakly cationic surfactant increased the activity and rainfastness of glufosinate-ammonium.

The effect and rainfastness of an EC and EW formulation of fluazifop-butyl was compared using barley as test plant. No difference neither in activity nor in rainfastness was observed.

Influence of environmental factors on the effect of herbicides

The influence of water stress on the effect of different herbicides was examined in controlled environment cabinets.

It has been shown that the efficacy of bentazon and phenmedipham was reduced when the test plants were subjected to water stress with a water potential of less than -8 bar.

In other experiments the influence of moderate water stress on the efficacy of bentazon, phenmedipham, ioxynil + bromoxynil, chlorsulfuron, glyphosate and dichlorprop + MCPA was examined.

The results show that the efficacy of bentazon and phenmedipham was considerably reduced by water stress. The efficacy of ioxynil + bromoxynil, chlorsulfuron and glyphosate was also reduced when the test plants were water stressed, but to a smaller degree than with bentazon and phenmedipham. Finally it was shown that the effect of dichlorprop + MCPA was slightly improved when the herbicide was applied to water stressed plants.

Influence of a synthetic latex (Bond) on the rainfastness and redistribution of mancozeb on potatoes (In cooperation with E. Kirknel, Laboratory for Ecotoxicology and Pesticide Analysis)

Addition of the synthetic latex Bond to both flowable and wettable powder formulation of mancozeb was found to increase the rainfastness of the fungicide. Furthermore, the rain caused less redistribution of the fungicide on the leaves when Bond was added to the spray solution resulting in a more even distribution of mancozeb on the leaves after rain.

Distribution and weeds, seed production and seed bank (Bo Melander)

Biology and control of weeds in crop rotations predominated by winter cereals and winter rape

In order to reduce the leaching of nitrogen from the fields to the surrounding environment the Danish goverment has ordered the farmers to grow more crops in the late summer and in the autumn. Consequently, the area with wintering crops has risen considerably in recent years.

More wintering crops will change the composition of weed species on the fields. In order to investigate the changes as well as other aspects concerning weed problems in wintering crops a 5-year research project was started in 1988. The project will mainly be directed towards problems with grass weeds as Couch (*Elymus repens*), Silky Bentgrass (*Apera spric - venti*), Black Grass (*Alopecurus myosuroides*) and Annual Meadow Grass (*Poa annua*).

Weed biology (C. Holm-Nielsen)

Investigations are still going on to determinate both quantification, identification as well as sliding movement of the weed seed from the seed bank.

To facilitate the seed identification a Danish seed identification guide is in preparation.

Weed seed production in relation to different methods and intensities of weed control (Ilse Rasmussen)

A project supported by the Danish Agricultural and Veterinary Research Council was started in 1989. The aim of the project is to establish the fate of weed seed production as a result of reduced herbicide usage and/or mechanical weed control. Methods to determine weed seed production are investigated. Literature studies lead to planning of experiments in the coming years.

Weed control by means of non-chemical methods (Jesper Rasmussen)

Mechanical weed control in agricultural crops

The aim of the work is to develop and evaluate methods for mechanical weed control of annual weeds. Weed harrowing and hoeing have been the main subjects of the research.

It has been shown that both methods can be improved by research. With respect to weed harrowing, selectivity between crop and weeds has been proved to be a very important parameter to achieve satisfying results. The most important factors determining the selectivity have been identified. As opposed to weed harrowing the disturbance of the crop is very small when hoed, but there are drawbacks to this method too. Hoeing is rather costly, and it is not fully efficient in all cases. Improvements of the implements seem possible and will be tested in 1990.

Non-chemical weed control (Jakob Vester)

A row brush hoe has been compared with an ordinary row crop hoe in sugar beet. The experiments which combined thermal and mechanical treatments in maize were continued. In vegetables the investigations have dealt with flame treatment before germination and weed harrowing after emergence. Flame treatment for desiccation of potato leaves has been compared with Diquat treatment and mechanical cutting. Different types and treatments of straw for mulching are investigated.

Development of steering systems and tools for row cultivation in cereals (Birgitte Tønnes Pedersen)

A project concerning row cultivation and steering systems for hoes, started in 1989. The project is supported by the Ministry of Environment and is made in cooperation with

the Institute of Agricultural Engineering at The Royal Veterinary and Agricultural University.
The aim of the project is to improve the efficiency of the hoe, and hereby make a better economy of inter row cultivation. By an automatic guidance system the hoe will work more precisely, and a single man can do the job.

There are different possibilities: Simple mechanical solutions, systems with mechanical sensors and steering wheels or frame, or advanced systems based on vision sensors. All possibilities have been considered and will be examined. Cereals are the test crop.

Weed control in organic farming (Anders Nemming)

18 organic farms in Denmark are studied intensively in a cooperation of different research institutes.

Together with The National Institute of Agricultural Engineering, the Institute of Weed Control is following the existing weed situation, the actual aims of weed control and the obtained weed controlling effect.

From 1990 we start to introduce new strategies, machinery and intensive advisory activity on some of the farms.

J. DEPARTMENT OF PESTICIDE ANALYSIS AND ECOTOXICOLOGY

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Scientific staff:

Susanne Elmholt: The effect of pesticides on the microflora
Gitte Felding: Determination of leaching of pesticides
Arne Helweg: Degradation of pesticides, etc. in soil
Erik Kirknel: Fungicides and insecticides in plants
Peder Odgaard: Herbicides in plants

The laboratory supports the experimental work at different departments at the research centre with chemical analysis of pesticides. Furthermore, the department is using increasing resources on terrestrial environmental research. The main objective is determination of the fate of pesticides in the terrestrial environment and the environmental consequences of the use of pesticides. The experiments are carried out by means of advanced chemical and biological methods and the main tasks are the following:

1. Carry out residue analysis of pesticides in crops and soils in cooperation with the experimental work at the centre.

2. Determine degradation, adsorption and transport of pesticides in soil.

3. Analyse infiltrated water to determine the risk of leaching of pesticides out of the root zone.

4. Determine the influence of pesticide treatment on soil microorganisms.

5. Participate in determination of pesticide transport and deposition during spraying and determine exposure of spraying personnel to pesticides.

The laboratory is equipped with analytical instruments: gaschromatographs with EC, NP, HW and FPD-detectors and gaschromatograph with masspectrometer. To determine drift of pesticides fluorescent compounds are used, these are determined by fluorometry, and to determine adsorption and degradation ^{14}C-labelled compounds are used, determined by scintillation counter.

The staff consists of 5 scientists, 6 laboratory assistants and 2 to 4 MSc-students.

<u>The appearance of pesticides in groundwater and drain water</u> (Gitte Felding)

The drain water samples collected under cereal fields, where phenoxy acids have been applied during the last 12 years, are to be analysed for residues of phenoxy acids and phenols, that may appear during the decomposition of phenoxy acids. The following

phenoxy acids have been used: dichlorprop (2-(2,4-dichlorophenoxy) propionic acid), 2,4-D((2,4-dichlorophenoxy)acetic acid) and MCPA ((4-chloro-2-methylphenoxy)acetic acid) and Dicamba (3,6-dichloro-2-methoxy benzoic acid).

Methods of analysis have been worked out and quantitative GC/MS programmes have been run in order to detect the phenols that might be degradation products of the above mentioned phenoxy acids and the following phenols: 2-chlorophenol, 2,4-dimethylphenol, 2,4,6-trichlorophenol, pentachlorophenol and phenol.

At 5 selected localities stainless steeltubes have been set up. The tubes (3 at each locality), have been placed in the soil for collection of water, leaving the root zone, samples are taken during the winter.

Degradation and adsorption of pesticides in surface and in subsurface soils (Arne Helweg)

The influence of soil temperatures and soil water content on pesticide degradation is determined by use of ^{14}C-labelled pesticides. Also the influence of incubation time and the influence of drying and freezing of soil on the capacity for degradation is determined. In the experiments atrazine, TCA and MCPA have been used as model compounds.

Degradation of ^{14}C-labelled MCPA, parathion, dichlorprop, 2,4-dichlorophenole and TCA has been determined in soil cores sampled in the unsaturated zone at 1 meter's depth. In most cases degradation appears, also in these subsurface soils but normally the degradation rate is very low and rarely exceeds 1/10 of the degradation rate in surface soils. In future experiments the capacity of different subsurface soils to carry out the degradation will be determined.

6 lysimeters consisting of monoliths of 0,5 m^2 x 1 m are installed according to the principle developed by Prof. Fritz Führ. The lysimeters will be used to determine degradation and transport of ^{14}C-labelled pesticides under more natural conditions than in the laboratory.

Analyses for herbicides and plant growth regulators etc. (Peder Odgaard)

Chemical analyses of samples of nutrient solutions from experiments with growth regulating agents are continued. The new active substances paclobutrazol and uniconazole have been subjected to these experiments, which are carried out with plants in flood systems at the Institute of Glasshouse Crops, Årslev.

Residual concentrations of paclobutrazol and uniconazole in the solutions were fairly equal to those of ancymidol. It is expected that the persistence in the pot soil/water system is not very different either.

Wind drift by the use of different sprayers is investigated at the Institute of Weed Control, in 1989 with 4 experiments. Like previous years, analyses of deposited fluorescing tracer were carried out in the laboratory.

Herbicide analyses have been ordered in a number of instances with potential or actual injury to culture plants, frequently caused by improper use of herbicides. One of the cases should be mentioned because of its more general interest:

Weed control on the footpaths in a city suburb was carried out on a contract basis. Shortly after the treatment (with simazine, diuron and linuron), and before any rainfall, the paths were swept by machine. The material had a great concentration of the herbicides, a satisfactory weed effect from the remaining part on the paths still appeared.

Insecticides, fungicides and growth regulators on plants (Erik Kirknel)

Effect of ethephon on rats and residue of ethephon in rat tissue

National Institute of Animal Science are feeding rats with ethephon and measuring different biological parameters such as biological value of ethephon sprayed barley. The Laboratory has analysed heart, testicles and muscles for ethephon. No ethephon was found.

Deposition of pesticides on spraying personal

In cooperation with the Danish Agricultural Engineering Institute it was investigated how the spraying personnel is contaminated in a normal agricultural spraying situation. 90% of the contamination took place at mixing and loading. Only 10% when spraying. Recommendations for spraying personal regarding protective means have been worked out.

The influence of formulation and additives on rainfastness of dithiocarbamates

In semi-field experiments it was determined that formulation and additives to a very high degree influenced the rainfastness of dithiocarbamates. The experiments were made in pea and potatoes.

The effect of fungicides on the fungal flora and on the decomposition of straw in the soil (Susanne Elmholt)

The purpose of this project is to elucidate possible side-effects of fungicides on non-target soil fungi, especially with regard to straw decomposition and straw decomposing fungi. Emphasis is being placed on minor pathogens, like *Fusarium* spp. In 1988 a field experiment was performed in winter wheat, using the EBI fungicides Calixin (tridemorph) and Sportak 45EC (prochloraz) in the recommended and 5 x the recommended dosage. The decomposition of leaves as well as stems is currently being investigated in a litter-bag field trial. Pure culture studies of fungicide effects on different

species of Fusarium spp. have been performed to support the results of the field trials, using a microtiter method.

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ISSN 0107-6167