Danish Research Service
for Plant and Soil Sience

Plant diseases, pests and weeds in Denmark 1988

105th annual report
Compiled by
The Research Centre for Plant Protection

Lyngby 1989
ISSN 0107-6167

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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
Zoology Department	Jørgen Jakobsen
Virology Department	Arne Thomsen
Biotechnology Department	Morten Heide
Pesticide Research Institute	E. Nøddegaard
Institute of Weed Control	K.E. Thonke
Laboratory for Pesticide Analysis	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 testing of efficiency 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 an increase is greatly needed of the current research in a number of biological fields.

With regard to financing, the Research Centre for Plant Protection must adjust itself 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 5th Danish Plant Protection Conference was held 1st and 2nd March, 1988 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:

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

Of about 170 employees, approx. 106 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	2	26	28
Pesticide Research Institute	9	14	23
Botany Department	9	8	17
Virology Department	6	8	14
Zoology Department	8	9	17
Advisory Service	6	2	8
Institute of Weed Control	14	30	44
Laboratory for Pesticide Analysis	5	11	16
Total	59	108	167

SO: Scientific officers
TS: Technical-administrative staff

Financing and staff
50-60 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 1988 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 plants
Lars A. Hobolth: Pests and diseases of horticultural plants
N.S. Murali: Computer aided advisory system for pest and disease control

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

Institute of Weed Control, Flakkebjerg:
O. Permin: Weed in agricultural plants
Georg Noyé: Weeds in horticultural plants
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 1988, 52 Plant Protection Bulletins were sent out dealing with 30 different subjects.

Weather conditions in 1987-88 :

	Temperatures °C		Precipitation	
	average	normal	average	normal
September 1987	11,9	13,1	100	72
October - 87	9,4	8,7	86	70
November - 87	5,6	4,9	79	60
December - 87	3,0	2,2	52	55
January 1988	3,5	-0,1	117	55
February - 88	2,3	-0,4	88	39
March - 88	2,0	1,7	78	34
April - 88	5,4	6,2	21	39
May - 88	11,9	11,0	37	38
June - 88	15,9	14,5	39	48
July - 88	15,9	16,6	124	74
August - 88	15,1	16,3	70	81

Survey of main diseases and pests in agricultural crops in 1988.

Cereals

Eyespot (*Pseudocercosporella herpotrichoides*) was favoured by the mild winter, but because of the dry weather conditions in April-May the disease became only of minor importance.

Mildew (*Erysiphe graminis*) in winter- and spring barley occurred commonly, but the attacks developed only weakly during the growing season. In wheat the mildew spread somewhat in June, but also in this crop the attacks became rather weak.

Yellow rust of wheat (*Puccinia striiformis*), however, occurred with strong and widespread attacks throughout the growing season in the susceptible varieties (Anja and Kraka). Also brown rust of barley (*Puccinia hordei*) occurred commonly and increased strongly through July.

Speckled leaf spot (*Septoria tritici*) was rather widespread, but the attacks were rather weak, whereas especially **glume blotch** (*Septoria nodorum*) developed through August. Serious attacks occurred, however, only to a limited degree.

Slugs (*Agriolimax agrestis*) made rather severe damages in several fields on heavy soil. **Aphids** (*Rhopalosiphum padi* and *Sitobion avenae*) were common in both winter wheat and spring barley. The degree of the attacks, however, varied very much between the fields. In winter wheat the **shoot fly** (*Opomyza florum*) occurred in several fields, whereas the common **frit fly** (*Oscinella frit*) was of minor importance.

Rape

Club rot (*Plasmodiophora brassicae*) becomes still more widespread, and also in 1988 several severe attacks were reported.

Stem rot (*Sclerotinia sclerotiorum*) occurred rather widespread in a number of rape fields, but the attacks were only of importance in few fields. **Leaf and pod spots** (*Alternaria* spp.) was especially widespread in spring rape, but the attacks were generally weak.

The blossom beetle (*Meligethes aeneus*) was very widespread because of the warm and dry conditions and also the **seed weevils** (*Ceutorrhynchus assimilis*) and the **pod midge** (*Dasyneura brassicae*) occurred commonly, but generally the attacks were weak.

On heavy soils a large amount of **slugs** (*Agriolimax agrestis*) occurred and made considerable damage at several localities in winter oil seed rape.

<u>**Peas**</u>

Downy mildew (*Peronospora vicia* f. sp. *pisi*) was common in most fields, but the attacks were weak. Also attacks of **leaf and pod spots** (*Ascochyta pisi, Mycosphaerella pinodes* and *Phoma medicaginis* var. *pinodella*), which developed during July became of limited importance because of an early harvest.

The pea weevil (*Sitona lineatus*) was common. Heavy attacks occurred in 20 per cent of the areas. Also the **pea aphid** (*Acyrthosiphon pisum*) was widespread, but the attacks were weak.

<u>**Potatoes**</u>

Late blight (*Phytophthora infestans*) was widespread and with strong attacks.

<u>**Beet**</u>

Peach aphid (*Myzus persicae*) occurred early and was widespread in most sugar beet fields. The first visible attack of Virus Yellows was observed as early as in late June. The disease developed strongly during July and August.

The black bean aphid (*Aphis fabae*) was common and occurred with rather heavy attacks in several fields.

Survey of diseases and pests in horticultural crops in 1988

In 1988, the horticultural advisory department received 881 samples. The distribution according to crops and according to group of pathogen will appear from the following table as percentage:

	Physiological	Mycological	Bacteriological	Virological	Zoological	Unexplained	Total
Grass		0.2					0.2
Cruciferous crops	0.1	0.5	0.1	0.1	0.6		1.4
Potatoes	0.2	0.5	0.1	0.1	0.1		1.0
Fruit bushes and trees	1.0	1.4	0.3	1.4	1.6		5.7
Vegetables	1.8	13.6	1.1	1.9	3.9		22.4
Ornamentals	8.0	34.0	4.8	6.0	13.4	0.2	66.6
Without host plant		0.2			0.9		1.1
Diverse							1.6
Total	11.3	50.4	6.5	9.5	20.4	0.2	100

The following enquiries about unusual attacks were received:

Chinese cabbage (*Brassica pekinensis*). Attacks of *Phytophtora porri*. The disease starts typically with a browning of the cut of the stalk and gradually spreads, as the attack develops, up into the inner leaves. In many cases no damage is registered on the exterior leaves of the head.

Leek (*Allium porrum*). Attacks of rust (*Puccinia porri*). Apparently attacks were concentrated on the island of Funen. The department received no reports of attacks from other parts of the country. Generally, the exterior leaves were attacked, whereas attacks of the youngest leves were rarely seen.

Carrots (*Daucus carota*), **root parsley and parsley** (*Petroselinum crispum* spp. *crispum* **and** *P.c.* spp. *tuberosum*). Attacks of powdery mildew (*Erysiphe umbelliferarum* (syn. *Erysiphe heraclei*)). The attack affected the growers of the two species of parsley most, as both species are brought to the market either as green leaves or with the green top on the root.

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

An information database containing information on diseases and pests as well as on their prevention and control is being developed. It is expected to be partly operative in 1990. The data base is divided into two parts, a library part containing information on pesticides and a recommendation part giving advice on the need for control in the individual field. The advice will be given on the basis of grower information on the crop condition and the level of attack.

Metalaxyl resistance and late blight (*Phytophthora infestans*) (Søren Holm)

In 1987 and 1988 150 potato fields were monitored and late blight with very reduced sensitivity to matalaxyl was found in 58 per cent and 52 per cent, respectively, of the fields examined.

Yield trials with 2 x Ridomil MZ treatment incorporated in a spraying programme confirmed that Ridomil MZ was no more effective for control of late blight than the traditional contact compounds (maneb and mancozeb) where reduced sensitivity to metalaxyl occurred.

Monitoring of frit flies (*Oscinella frit*) (Søren Holm)

For a number of years, the imago activity has been monitored at about 30 localities. The investigations show that in many cases and in many years the activity is so low that routine treatment with insecticides cannot be recommended. The temperature sum (basis 7°C) seems to be an important supplement in a prediction of when attacks can be expected. Blue tray traps give a reasonable estimate of the density of adult frit flies (imagos).

Weed control

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 enables 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.

Computer aided advisory system for weed control (Marianne Baandrup)

An advisory computer system of 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 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 dosage, which is often reduced.

The size of the dosage 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 Jørgensen Bech: Diseases of sour cherry. Bacteria in meristem cultures
Ib. G. Dinesen: Bacterial diseases
Lilian Kloster: *Polymyxa graminis* and *P. betae* as vectors for barley yellow mosaic and *Rhizomania* (co-work with Virology Department)
Bent Løschenkohl: Fungus diseases in horticulture. Testing of resistance to potato wart. Testing of disinfection compounds
Hellfried Schulz: Root and foot rot of cereals, survey and diagnosis of fungal diseases in peas
Sten Stetter: Threshold values for leaf diseases of cereals
Kirsten Thinggaard: Root diseases in greenhouse crops expecially *Pythium* and *Phytophthora*
Boldt Welling: Leaf diseases of cereals and grasses

General report (Arne Jensen)

In the course of 1988 the main objectives of the department have been a continued development of decision models for the control of leaf diseases in barley and winter wheat, a virulence gene survey for mildew in wheat and barley and net blotch in barley and diseases in peas. On the horticultural side especially diseases in glasshouse crops are of great concern including root pathogens in growth systems with recirculating water. The work on important diseases in sour cherry has come to a conclusion and a new research project is started on methods for detecting bacteria in meristem cultures.

A considerable part of the work at the department is financed by research grants, which are given for a limited number of years. Furthermore, much work is done on a contract basis especially testing of potato breeding material. As a part of development aid to China a number of students have been trained in improved cultivation of fruit tree crops and potatoes.

As part of the studies at the Agricultural University two students have worked with barley mildew and *Septoria nodorum* and *S. tritici* at the department. Two other students have worked with biological control of *Phytophthora parasitica* and *Pseudomonas syringae* pv. *pisi*.

<u>**Bacterial diseases**</u> (Ib G. Dinesen)

Bacterial ringrot of potatoes (*Clavibacter michiganensis* sbsp. *sepedonicus*)

In 1988, a great part of the bacterial work carried out concerned ringrot. Not only all the potato material from the meristematic cultures, but also potatoes for seed and consumption were tested.

Healthy nuclear stock plants

Bacterial tests were carried out in connection with the renewal of the nuclear stock plants at the Institute of Glasshouse Crops and the horticultural cultures grown in vitro at the Virology Department.

Effect of disinfectants (co-work with Bent Løschenkohl)

Methods of testing disinfectants against fungi and bacteria have been developed. The aim is to make it possible for disinfectants to obtain official approval.

<u>**Take-all and eyespot in cereals**</u> (H. Schulz)

Take-all (*Gaeumannomyces graminis*). Light to moderate attacks were found in several wheat fields. Only in wheat after wheat stronger attacks occurred. In spring barley mostly weak attacks were found, but severe attacks occurred at some localities.

Eye spot (*Pseudocercosporella herpotrichoides*). It was estimated that chemical treatment in spring was necessary in about 54 per cent of the wheat fields. The dry weather conditions in April-May inhibited the development of the disease. The summer estimates showed mainly weaker attacks than in 1987.

Sharp eyespot (*Rhizoctonia cerealis*) was found in many wheat and rye fields but mostly with weak attacks.

Epidan, threshold values for leaf diseases in cereals (Sten Stetter)

Epidan is a computer programme aimed at determining threshold values for chemical control of leaf diseases on cereals.

In 1988, Epidan programmes for spring barley and winter wheat were developed as PC versions, which could be used by the agricultural advisers, who took part in the experiments.

Future work includes adjustment of the programmes so as to make it work with fewer countings of attacked plants, better utilization of the varietal differences and not least the most adequate reduced dosages.

Variety mixtures in winter wheat (Boldt Welling, Mogens S. Houmøller and Carl Chr. Olsen)

Experiments with variety mixtures of winter wheat were started in the autumn of 1986 at the localities Rønhave and Roskilde. Four varieties are being used as components in all possible combinations in the mixture. Fungicide treatments are a second parameter in the experiment. Preliminary results indicate a reduction of the diseases mildew and glume blotch, but not a significant yield increase due to a variety mixture.

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

The main objective of the Danish National Powdery Mildew Virulence Survey is to improve forecasting of powdery mildew attacks in barley and wheat fields. Virulence frequencies are estimated from colony countings on seedlings in mobile nurseries, exposed, at a distance of at least 200 m, to barley or wheat fields.

Barley powdery mildew. In 1988, there were found minor changes compared to the two previous years, and the following resistance genes were still effective under Danish conditions (1) Ml-al, (2) Ml-a3, (3) Ml-a13, and (4) M10. In addition, the resistance gene combinations in the varieties Hulda (Ml-a7, Ml-k),?, Benedicte (Ml-a9,?), and Toga (Ml-a9, Ml-(Ab)) were effective. Ml-a12- and Ml-a7 virulence (Va12 and Va7) were found in frequencies between 40 and 50, whereas Va9 decreased in frequency from 10 to 20 in 1988. The frequency of V (La) was between 30 and 60, and Vg and Va6 had frequencies between 50 and 80. The most common virulence was V(ra), which was found in frequencies close to 100.

Wheat powdery mildew. A significant increase in V(Pm6) was seen in 1988 and it is now found in frequencies from 10 to 40. Similarly, the frequency of V(Pm4b) increased to 27 on an average. V(Pm2) occurred at frequencies between 40 and 60 as in the previous two years. The most frequent virulences were V(Pm8) and V(Pm5/Ml-i) occurring at frequencies close to 100.

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

Attacks of net blotch (*Drechslera teres*) were assessed in 42 spring barley varieties at seven localities in 1988. The experiments revealed big differences in resistance efficiency against *D. teres*, depending on the population origin of the fungus. This was clearly demonstrated at two localities where the inoculum was infected straw of barley of three different origins.

The CI varieties showed fairly small differences in resistance against the Danish population of *Drechslera teres*. On the other hand, considerable differences were found between the levels of attack in Danish commercial varieties.

Symptoms of *P. teres* was normally of the spot types.

Experiments with artificial inoculation of 14 differential varieties were initated under greenhouse conditions. Preliminary results show large differences between varieties and population origin.

Pea diseases (H. Schulz)

Bacterial Blight (*Pseudomonas syringae* pv. *pisi*) was only found at one locality in 1988.

Downy mildew (*Peronospora viciae* f.sp. *pisi*) was found with weak to moderate attacks.

Foliar diseases caused by *Ascochyta* spp. occurred mainly at the end of the growing season - and had no real influence on yields. *Mycosphaerella pinodes* was the most common fungus isolated from leaf spots, pods and seeds harvested in 1988. Attacks of **Powdery mildew** (*Erysiphe pisi*) were widespread in vining peas in August.

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

In the last few years forecasts of attacks of stem rot in winter and spring rape have been based on germination of apothecia in depots with burried sclerotia at different localities.

In 1988, there were observations from 60 localities in winter rape and 100 in spring rape.

In vinter rape local precipitation led to attacks above the threshold in two smaller areas of Vejle-Kolding, as the sclerotial germination reached 30-40 per cent during flowering. Germination elsewhere was below 20 per cent which was in agreement with common but low levels of attack which did not need control.

In spring rape precipitation provoked germination in depots in several regions. Control measures were generally not taken because germination in the depots came suddenly during late flowering, but naturally occurring apothecia caused severe attacks in some cases.

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

The Danish Potato Breeding Station at Vandel sent 224 tuber samples, and the Swedish Breeding Station Svalöf AB sent 250 tuber samples to be examined for wart resistance.

Fungi in recirculating watering systems for pot plants (Bent Løschenkohl)

The investigations on higher fungi in recirculating systems for pot plants were finished. *Pestalotiopsis menezesiana* (Bres. & Torr.) caused cuttings wilt in propagation beds and was found in the recirculating water.

Diseases in *Catharantus roseus* (Bent Løschenkohl)

Preliminary investigations on fungal pathogens in *Catharantus roseus* were carried out in 9 nurseries. *Pythium* sp. *Rhizoctonia solani, Chalara elegans, and Botrytis cinerea* were main pathogens.

Downy mildew (*Bremia lactucae*) **in lettuce** (Kirsten Thinggaard)

Physiological races of *Bremia lactucae* were determined. Races were used in the screening of new varieties for suitable resistance for the Danish growers.

Red core (*Phytophthora fragariae*) **in strawberries** (Kirsten Thinggaard)

The disease red core was detected for the first time in Denmark. The fungus was identified in the microscope by the presence of oospores in the core of the root.

Attempts are being made to develop a serological method capable of detecting *P. fragariae* in strawberries.

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

Research was carried out on root pathogenic *Phytophtora* and *Pythium* in vegetables (cucumber and tomato) as well as in pot plants, especially in growing systems recirculating the nutrient solution.

A diagnosis method for *Phytophthora* and *Pythium* which can be used in practice, including a pathogenicity test, was developed.

Experiments with zoospore infections and treatment with surfectants showed that attacks could be reduced considerably, and this will be developed further for use in practice.

Diseases in sour cherry (Karen Bech)

Investigations on diseases in sour cherry were terminated in 1988.

In particular the following diseases causing tree decline and death in Danish orchards were investigated: Prunus necrotic ringspot virus, little cherry, bacterial canker *Pseudomonas syringae* pv. *morsprunorum* in the sour cherry variety 'Fanal', and *Monilinia laxa* in the cultivar 'Kelleriis 16'.

Perennation state, primary infection and control of cherry leaf spot disease *Blumeriella jaapii* were investigated.

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

Incidence of latent bacterial infections in plants especially near the meristems is investigated by means of plant anatomy and serological methods.

Diagnostic work (Bent Løschenkohl, Ib. G. Dinesen, a.o.)

During the year, the Botany Department received a number of plant samples for diagnosis of bacterial and fungal diseases. Most of the samples were horticultural plants.

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)

The diagnostic work of the department has been further developed and very sensitive diagnostic methods (ELISA and ISEM) for routine analysis of several viruses are carried out. Furthermore in many tests the dot-immuno-binding technique has been adopted.

The investigations of virus diseases in agricultural plants were continued especially with regard to potatoes, sugar beet and cereals.

Special investigations were carried out concerning Potato Mop-Top virus. So far this virus has only been a problem in the potato variety Saturna grown in special areas in Denmark.

Rhizomania, which is found in sugar beet in several European countries, has not been detected in Denmark.

The work on virus diseases of nursery plants was continued. Investigations concerning an apparently seed-borne virus in oak were initiated.

In ornamental plants, experiments were carried out with virus of *Agyranthemum, Begonia, Dipladenia* and *Kalanchoë*.

Also much work was carried out concerning the establishment of virus-free stocks of potatoes and various horticultural plants.

During the year 1988 members of the scientific staff of the Virology Department gave lectures on virology concerning production of virus-free potatoes and virus-free fruit trees to Chinese students in China and Denmark.

During the year the staff of the department undertook 16 journeys abroad and the department received visitors from 24 countries.

<u>Virus diseases of agricultural plants</u> (Bent Engsbro)

Barley yellow mosaic (assisted by Lilian Kloster)

A survey in winter barley fields and investigations of soil samples from spots in these fields especially from the south part of the country and soil samples randomly taken have not shown any attack of barley yellow mosaic.

The barley variety Igri was used as bait plant in these investigations.

Polymyxa graminis was present in soil samples.

Cocksfoot mottle

In trials carried out at 5 localities with infections of cocksfoot mottle virus the same order of attack among cocksfoot varieties was found as in trials with mechanical inoculation carried out in glasshouse.

Potato Mop-Top

In trials carried out 1986-88 2 potato varieties Primula and Saturna proved to be very susceptible; 1 variety Sieglinde susceptible and 12 varieties were tolerant or resistant to Potato Mop-Top virus.

Soil samples were randomly taken from 192 sugar beet fields using beet as bait plant. *Polymyxa betae* was found in most samples, but the virus causing *Rhizomani*a was not found in any of the samples (assisted by Lilian Kloster)

In 18 per cent of the soil samples other still unknown viruses were shown.

A survey through Zealand and Funen where 16 soil samples were collected from spots in beet fields with low chlorotic-yellowing, very branched sugar beet showed no attack from *Rhizomania*.

On 2 occasions another unknown virus was found.
In field trials it seems that *Polymyxa betae* needs temperatures around 15°C to be active.

<u>**Virus diseases in woody plants**</u> (Arne Thomsen)

Tomato bushy stunt virus

Attacks of Tomato bushy stunt virus were found to be present in some 10-year-old trees of *Quercus robur* and *Q. petraea* as well as in many young seed plants of *Quercus*.

<u>**Virus diseases in fruit trees**</u> (Arne Thomsen)

Vein yellows of pear

Vein yellow was found in seven lots of the pear variety Clara Frijs. The source of infection was found to be not virus tested Quince A used as root stock in one nursery.

<u>**Virus in ornamental plants**</u> **(Niels Paludan)**

Agyranthemum frutescens

Virus-free plants were produced by meristem culture from selected clones infected with Chrysanthemum virus B. The plant material was also found free from *Agrobacterium tumefaciens* and *Erwinia chrysanthemi*.

Begonia elatior

Selected clones of 5 'Nixe'-group cultivars were observed for leaf curl symptoms during 20 months. Symptoms were recorded in all cultivars after a latent period of 8 to 15 months. From the first appearance the plants developed symptoms regularly and more strongly.

Meristem plants of these cultivars were observed for leaf curl symptoms. The observation comprised 82 plants and 24 per cent did not develop any symptoms during a period of 15 months.

In order to detect carnation mottle virus in *Begonia* a DNA-probe was produced. Reactions were achieved, but so far only with the virus from carnations and indicator plants.

Kalanchoë blossfeldiana

Infection trials with 2 strains of tomato bushy stunt virus (TBSV) have caused the development of both chlorotic 5-7 mm spots in older leaves (4 of 5 cultivars) and mosaic in young leaves in 3 of 9 cultivars. There was a difference between both the effect of the virus strains and the sensitivity of the cultivars.

A survey of viruses in *Kalanchoë* crops from 13 nurseries showed the occurrence of virus-like symptoms in almost all cultivars, mainly as mosaic, yellow spots, leaf curl and mottle. The mosaic symptoms were found most common in 8 of 18 cultivars.

TBSV was the only diagnosed virus found in 'Kristina' and in 1 of 10 water samples, respectively. There was no connection between the mosaic and the shown virus infection.

Dipladenia sanderi

All selected clones show mosaic symptoms. A poty-like virus is present, sometimes in combination with tobacco mosaic virus.

Virus-free meristem plants were established after heat treatment during several months. The virus-free plants are without mosaic symptoms and more vigorous. The use of MS-62 medium with additional BAP (5 mg/l) ademine sulphate 40 mg/l and gibberellic acid (3.5 x 10^{-3} mg/l) succeeded in normal developed shoots. Root development was achieved with 50 per cent MS-62 added BAP (0.1 mg/l) and IBA (0.2 mg/l).

<u>New virus attacks 1988</u> **(Niels Paludan)**

Aeschynanthus hildebrandii	Tomato bushy stunt virus
Agyranthemum frutescens	Chrysanthemum stunt viroid
Allium porrum	Tomato bushy stunt virus
Allium porrum	Tobacco ringspot virus
Allium sarivum	Garlic yellow stripe virus
Hemerocallis hybrid	Carnation mottle virus
Schefflera sp.	Carnation mottle virus
Pelargonium zonale (English origin)	Tomato spotted wilt virus

F. 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: 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 animals 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 of thrips and whiteflies in glasshouse crops, (3) to develop new methods of testing the effect of pesticides on beneficials used for biological control as well as on beneficials, which are naturally occurring in the cultivated fields and (4) to develop an information system for plant protection which is to be used as an advisory system for farmers. The database will contain information about crops/cultivars, soil treatment, weather, 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 for 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 1988.

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 100 beet fields. Despite the monitoring, control of the peach-potato aphid came too late in most parts of the country in 1988 which resulted in severe attacks of Virus Yellows in many beet fields.

Pests in peas were for the first time taken up on a large scale, and a number of observations were made.

Also the western flower thrips was included in the work of the department with the employment of Henrik Brødsgaaard from April 1988. He also took over investigations on using the predatory mite *Amblyseius* against *thrips tabaci* in cucumber after L. Stengård Hansen, who left the department in May.

Three students from the Agricultural University made for some months experiments with *Encarsia formosa* for control of the cotton whitefly *Bemisia tabaci*.

The work on developing methods to evaluate the effects of pesticides on beneficials was continued in close collaboration with the IOBC-working group.

Grower registration (Lars Monrad Hansen)

A number of warning systems are based on the growers' registrations of diseases and pests.

Grower registration in spring barley. A warning system for aphids, mildew and net blotch has been developed in collaboration with the Botany Department. Economic injury thresholds have been established for aphids and mildew. Warnings against net blotch are given according to calculations of risk based on variety susceptibility, preceding crops, soil treatment and rainfall. About 300 growers are participating.

Grower registration in wheat. A warning system, which so far only includes aphids, but which will later be extended to include also fungal disease. About 150 growers are participating.

Grower registration in beet. A warning system, which includes peach-potato aphids and black bean aphids, primarily with a view to preventing early virus atttacks. About 100 growers participate. To supplement the direct registrations made in the field, yellow tray traps and bait plants (potatotes) were placed in 16 fields. With little efficacy, however. Early occurrences of particularly peach-potato aphids were not found. To investigate a possible invasion of aphids from areas south of Denmark wind traps were placed on 4 lighthouses. Both the yellow tray traps and the wind traps were emptied once a week.

Grower registration in potatoes. Yellow tray traps were placed at 15 localities evenly distributed over the region where potatoes are grown for propagation. The tray traps were emptied twice a week and examined for the 5 aphid species which are the most important vectors of potato virus Y. The purpose is to determine the time for the main invasion of aphids to the potatoes, and a recommendation for haulm dessication will follow 10 days later.

Grower registration of slugs

In each of about 30 fields were placed 6 slug traps. They were emptied twice a week. Once a week plants were counted and also plants with notches. In about 80 per cent of the fields slugs were found. Preliminary results show that even fairly high occurrences (15 slugs/trap/day) do not cause a significant reduction of the number of plant.

The investigation was informative and will be continued with more specialized experiments with a view to establishing economic injury thresholds and finding factors conditioning a large propagation.

Pests in oil seed rape (Hans Peter Ravn)

The first and second generation of the brassica pod midge were registered by means of hatching traps set up at about ten localities in Denmark. The information on time of hatching was used to advise growers when to take measures against expected attacks by the brassica pod midge.

Since the population level seems very low at the moment the warning system was supported by daily registrations from suction traps and a few white and yellow water traps.

The number of pod midges caught in these hatching traps together with data on damaged pods, insecticide treatment and yield were collected for further calculations.

Monitoring and risk assessment of insect pests in field peas (Hans Peter Ravn)

Establishment of an advisory system for insects was started. The system is based on the farmers' own evaluation of pests densities in the field and growth stages of the crop. Once a week they send in their report on the pea and bean weevils, pea moths, pea aphids and cabbage and pea thrips.

Data are processed in a computer programme including the recommended injury threshold. Once a week a recommendation is sent to the farmer.

In a few fields where insecticide treatment was recommended experimental plots were established for pea aphid-pea moth control.

Pea weevil investigations (Anette Eckholdt and Hans Peter Ravn)

The pea weevil invasion of the pea fields in spring was monitored. A comparison of different monitoring methods was attempted: Pheromone traps, counting leaf notches and measuring actual density of the field.

However, spring 1988 was very mild and the invasion took place over one single day.

In collaboration with the Agricultural Department, Risø, the impact of the adult pea weevils and their larvae on the N_2-fixation and yield was evaluated.

Adult males and females of the pea leaf weevil (*Sitona lineatus*) caused a significant reduction of the N_2-fixation activity (C_2H_2-reduction), the dry matter production and total N-accumulation at flowering of pot-grown Bodil peas. Males alone did not significantly influence these growth parameters. A treatment with application of 700 *Sitona* eggs/pot to obtain larvae was not successful, probably because only few eggs hatched.

In a field experiment with furathiocarb seed-treatment to control *Sitona* the N_2-fixation activity 7 weeks after emergency (early flowering) was 3 times higher in the treated than in the control pea plants. A treatment with split application of 200 kg N/ha was also included. Seed-treatment with furathiocarb and nitrogen-fertilization increased the pea seed yield 10 and 14 per cent, respectively. No interaction was observed between furathiocarb treatment and N-fertilization.

Carrot fly (*Psila rosae*) monitoring with yellow sticky traps (Alex Percy-Smith)

Monitoring of the first generation fly was carried out at 15 localities. The flight period was rather short and earlier than most years. Several growers were advised to treat their crops.

Yellow sticky traps were used at 144 localities to monitor the flight of the second generation flies. Servicing of these traps was carried out in 3 different ways. In the drained area of North West Zealand (Lammefjorden) where carrots are grown very intensively, traps were serviced by an assistant from the Research Centre for Plant Protection. On the island of Funen where most of the Danish processing carrots are grown, a student was employed to carry out the work. The growers who are more scattered throughout the country sent their traps each week to the Research Centre for Plant Protection for servicing.

Growers were given weekly evaluations of the situation. Generally there has been less fly activity in 1988 than the previous year, and at most of the monitored localities damage has been considerably less than 5 per cent of roots. Treatment frequency varied from none to 2 recommended treatments.

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

Delta traps were used at 76 localities for monitoring the codling moth in apple orchards. The work was carried out in collaboration with the advisory service and a chemical company. A preliminary threshold was used to evaluate risk and the resultant damage was very low. The number of treatments was fairly low but the number of recommended treatments based on monitoring systems was even lower.

Monitoring the turnip moth (*Agrotis segetum*) with sex traps and forecasting cutworm attacks (Alex Percy-Smith)

The turnip moth was monitored at 36 localities in Denmark and 18 localities in Skåne, Southern Sweden. As a result of the wet autumn 1987, the population at the beginning of 1988 was quite low. However, conditions for development of the first 3 larval stages were good. Thresholds were exceeded in several areas and warnings were sent to these growers to treat in the first week of July. Damage assessments have shown low levels of damage. The overwintering population is a little higher after the 1988 season than the previous year.

Development of a computer aided advisory system for pest and disease control in Denmark (N.S. Murali)

A project was initiated in 1987 with the objective of integrating all the recommendation procedures for pest and disease control in various field crops with specific information on pesticide, spraying techniques, pests, diseases, crops and beneficial organisms. The system is being developed on a personal computer using Informix SQL Version 2.10 for building the database and Microsoft C Version 5.1 for developing a user interface to the database with the help of Informix ESQL/C Version 2.1 and calculation of the recommendation requirements. Users of the system are both the agricultural advisers and the farmers. The system consists of seven user menus for: Plant protection recommendations; information on pesticides; spraying techniques; pesticide compatibility tables; special information on pests and diseases; response of beneficial organisms to pesticides; and farmers' field obervations. During the spring of 1989, the system will be field-tested at a few agricultural advisory centres.

Biological control of the cotton whitefly (*Bemisia tabaci*) (Annie Enkegaard)

The cotton whitefly is a new species in Denmark - recorded for the first time in 1987. The whitefly is a pest in glasshouses, primarily in cultures of *Poinsettia*.

Preliminary investigations on the ability of *Encarsia formosa* to parasitize the whitefly was carried out at the Zoology Department in 1988. The experiments were conducted at 25°C, 60 per cent R.H. on *Poinsettia* and showed that *E. formosa* reared on *B. tabaci* for two generations retained the ability to parasitize the whitefly.

A project regarding biological control of the cotton whitefly will be started in 1989. In the project further investigations will be carried out on *E. formosa* and other natural enemies of the cotton whitefly. The project will also include investigations on aspects of the biology of the whitefly.

Thrips in glasshouses (Henrik Brødsgaard)

Investigations on biological control of thrips (*Thrips tabaci*) in glasshouse cucumber were continued. The objective is to find optimum conditions for the predatory mites *Amlyseius barkeri* or *A. cucumeris*.

Furthermore, a blue sticky trap has been developed for registration and monitoring of thrips, particulary the western flower thrips (*Frankliniella occidentalis*), and experiments were made on the efficiency of these traps in different potted crops and cucumber.

Mass production of predatory mites (Jørgen Jakobsen)

Experiments were made on biological control in which the predatory mites *Amblyseius barkeri* and *A. cucumeris* were used to control the thrips (*Thrips tabaci* and *Frankliniella occidentalis*). *A. barkeri* was produced commercially to a Danish company, Chr. Hansens Bio Systems.

Plant parasitic nematodes (Jørgen Jakobsen, Lars Monrad Hansen)

A number of plant and soil samples were examined for plant parasitic nematodes, mainly cyst-forming species.

A special control was performed for the primary seed potato producers in which soil samples were examined for potato cyst nematodes.

From the potato breeding station "Vandel" a number of new potato crossings were tested against resistance to potato cyst nematodes, pathotypes Ro-1 and PA-2 and PA-3. The populations of PA-2 and PA-3 have been imported from the Netherlands. Altogether about 500 crossings were tested.

For the Sugar Beet Growers' Association we have investigated soil samples from field experiments with crop rotation, especially with regard to the number of years between beet crops. The infestation rate of beet cyst nematodes were higher where beet had followed beet every year or every second year. With more than two years between beet crops the beet cyst nematode density was not influenced.

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

The work on determining the effect of pesticides on the carabid *Bembidion lampros* was continued.

The carabids can now be reared in the laboratory generation after generation. The rearing is quite labour intensive and possibilities of making it more rational are being investigated.

The development of test methods for investigating the effect of pesticides on adult carabids and larvae was continued. The tests take place in glass cells with pesticide treated sand in the bottom. For the adults the eating and egg laying capacity are registered and for the larvae the development to adult carabids. The experimental setup is still too sensitive to fluctuations in humidity.

Protective zones in cereal fields (Lise Samsøe-Petersen)

The department's part of the project initiated by the National Agency of Environmental Protection concerning protective zones was completed in 1988. Results from registrations of aphids, mildew and rust as well as investigations on the response of the ground and rove beetles to the protective zones have been compiled in 'Miljøprojekt No. 103'.

The work was partly financed by the National Agency of Environmental Protection.

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. Pitfall traps in the field during the growth season and soil samples in the grass and herb ridge in winter are some of the methods used to measure the effect of the created overwintering site.

G. PESTICIDE RESEARCH INSTITUTE

Head of institute: E. Nøddegaard

Scientific staff:

Bent Bromand: Insecticides for agricultural purposes.
Karen Husted: Fungicide resistance (until June 30, 1988)
Hanne Lipczak Jakobsen: Fungicides in oilseed rape, peas, potatoes and outdoor grown vegetables
Lise Nistrup Jørgensen: Fungicides in cereals
Andrzej Matkowski Fungicides and insecticides for fruit growing (until June 30, 1988)
Bent J. Nielsen: Fungicides in cereals
Steen Lykke Nielsen: Application technique in glasshouses (financed by special funds)
A. Nøhr Rasmussen: Fungicides, insecticides and growth regulators for soft fruit, nursery and glasshouse crops
Ernst Schadegg: Fungicides and insecticides for fruit growing (until June 30, 1988)
Jørgen Simonsen: Fungicides and insecticides for agricultural purposes

General report (E. Nøddegaard)

Approval of pesticides and plant growth regulators

According to a volontary 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 companies pay for the testing according to fixed rules and rates.

In 1984 a registered mark was introduced for use on all approved pesticides and plant growth regulators. The companies 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 various publications where approved pesticides are mentioned.

Pesticides with satisfactory effect are included in the approval list of "Plant Protection Compounds Approved for Control of Plant Diseases, Pests and Weeds, for Haulm Destruction of Seed Crops and Potatoes as well as Growth Regulation", which is revised every year and sent out 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 Chemical Pesticides, the Pesticide Research Institute shall give an opinion on the importance and application of the chemical in question, on possible alternative chemicals and methods as well as the financial consequences of a limitation in the use of the pesticides and growth regulators.

Control of fungal diseases in barley (Bent J. Nielsen and Lise Nistrup Jørgensen).

Trials have been carried out in winter and spring barley in order to obtain sufficient basis for biological approval of fungicides. One dosage is used as standard but from 1989 the trials will be carried out with three dosages (1/2, 3/4 and 1/1) as standard.

The level of diseases in barley was low in 1988 especially in winter barley where attack of powdery mildew was weak. The yield level was high with a yield increase of 6, 4 per cent after one spraying in spring barley.

Winter barley is sprayed twice against powdery mildew at an early stage to protect spring barley from severe attacks, but the yield benefit in winter barley was in 1988 as in 1987 negligible.

Several new compounds have been tested with good results. Biological approval has been given to flusilazol (200 g/ha) for control of powdery mildew, net blotch and scald in barley. The efficacy against powdery mildew can be a little weak under high disease pressure, and the combination with fenpropimorph (DPX N 7876) clearly improves the effect against mildew. Prochloraz + cyproconazol (300 g x 80 g per ha) and triadimenol + tridemorph (125 g x 375 g per ha) were approved against mildew in barley. The approval of tridemorph against mildew in barley has now been changed from 524 g per ha to 374 g per ha (= 0.5 l Calixin) and for tenuconazole + triadimenol the approved dosage has been changed from 250 g + 125 g to 200 g + 100 g (= 0,8 l Folicur Combi).

Two years trials' with Tilt top and Rival have shown that dosages of 0.5 l to 0.,8 l are sufficient to give an effective control of mildew in barley without loosing yield.

Against net blotch and scald 0.8 l to 1.0 l was nessessary to give a long lasting control.

In general the best control was obtained with split application with Tilt top and Rival (ex. 2 x 0.5 l or 3 x 0.3 l).

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

1988 was a year with an average degree of leaf disease pressure (yellow rust, *Septoria* and mildew). It was possible to make a reasonable evaluation of the tested products against yellow rust and *Septoria*. Yield increases due to control of leaf diseases were, as an average of 23 trials, 9.8 hkg/ha after 2 applications with fungicides (Feekes 6 and Feekes 10). Yield increases due to control of eyespot were generally small and gave, as an average of 14 trials, 2.8 hkg/ha.

Eyespot control was relatively poor (40 per cent) in our trials in 1988. The diseases had optimum conditions for infections during autumn and winter, but a dry May stopped the diseases from developing severe attacks. Sportak 45ec was applied for eyespot control at various growth stages from Feekes stage 1 in the autumn until Feekes stages 5-6 in the spring. Autumn and spring applications gave equally good control. Split application (2 x 0.5 l) at Feekes 3 and Feekes 6 in spring gave better control (45 per cent control) than one single application using 1.0 l. Split application using 0.5 l in autumn and 0.5 l in spring increased control further (59 per cent).

Tilt top (125 g propiconazol + 375 g fenpropimorph) and Rival (225 g prochloraz + 375 g fenpropimorph) were tested at full and reduced rates. On mildew 1.0 l Tilt top, used curatively, gave equal control to 0.3 l Tilt top used preventively. Similarly, 1.5 l of Rival, used curatively, gave equal control to 0.5 l Rival used preventively.

Little or no dose-response was found for yellow rust when control was carried out preventively, whereas for *Septoria* a significant reduction in efficacy was found when using 0.3 l Tilt top or 0.5 l Rival compared to full rate. In most cases the results showed good possibilities of using reduced dosages without negative effect on control or yield.

<u>Control of fungal diseases on oilseed rape, peas, potatoes and outdoor grown vegetables</u> (Hanne Lipczak Jakobsen).

In 1988, 58 field and glasshouse experiments were made.

Oilseed rape: fungicides for spraying against stem rot (*Sclerotinia sclerotiorum*), dark leaf spot (*Alternaria* spp.) and grey mould (*Botrytis cinerea*) were tested.

Peas: the main leaf fungi were leaf and pod spot (*Ascochyta* spp.), downy mildew (*Peronospora viciae* f. sp. *pisi*) and grey mould (*Botrytis cinerea*). 2 sprayings at bloom and late bloom were made in all experiments. Seed treatment products were tested against seed- and soilborne fungi, using infected seed and infected soil.

Potatoes: experiments with several sprayings against late blight (*Phytophtora infestans*) were made. Seed treatment products with effect against black scurf and stem canker (*Rhizoctonia solani*) were tested.

Flax: seed treatment products were tested against seedborne diseases. The main disease was *Alternaria linicola*.

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

Pests in agriculture and field vegetables (Bent Bromand).

In 1988, 57 field trials have been carried out. In winter wheat and spring barley the main pests were the grain aphid, the rosegrain aphid and the bird-cherry aphid. In winter rye tests were carried out against grain thrips, barley thrips and *Haplothrips aculeatus*. Frit flies were dealt with in cereals, maize and grass, and in red and white clover the problem was clover seed weevils and clover leaf weevils. In sugar beet seed treatment and/or spraying were carried out against the pygmy beetle, field thrips and mango flies. Against field thrips and flea beetles in oilseed rape seed treatment was applied and blossom beetles, seed pod weevils and brassica pod midges were controlled by spraying. In peas the greatest problem is the pea and bean weevil, but trials were also carried out with pea aphids and pea moths.

Finally trials have been carried out with the cabbage root fly and the carrot fly.

Besides testing of pesticides a warning system for first and second generation of of the cabbage root fly has been developed.

Fruit growing (E. Schadegg and Steen Lykke Nielsen).

Chemicals were tested for control of apple scab, *Gloeosporium*, apple mildew, brown rot on cherry, tortrix moth, winter moth, fruit tree red spider mite, apple rust mite, plum sawfly, cherry blackfly and pear sucker. The control of apple scab obtained with reduced doses of 8 fungicides was tested. The doses tested were 3/4 and 1/2 of the recommended doses. An electronic apple scab warning equipment was tested compared to a traditional preventive spray scheme for control of apple scab. There was found no significant difference between the effect of the two treatments although use of the warning equipment saved 7 applications.

Application technique in glasshouses (Steen Lykke Nielsen).

The distribution of spray liquid in the glasshouses and the deposition on the plants when applications were carried out with a pulse jet machine, and high and low pressure sprayer was investigated. Fogging gave no deposition of spray liquid on the ventral side of the leaves and only a diminutive deposition on the vertical surfaces. The biological efficiency is in close accordance with this pattern of distribution. The control of pests living on the ventral side of the leaves is very poor. The high and low pressure applications gave a deposit on the ventral side of the leaves of only 1-2 per cent of the total deposit. Even though the number of drops per cm2 on the ventral side of the leaves was more than 40, which should be enough to ensure an adequate effect.

H. INSTITUTE OF WEED CONTROL
Forsøgsvej 1, Flakkebjerg, DK-4200 Slagelse

Head of institute: K. E. Thonke

Distribution of main tasks:

Weed biology and non-chemical weed control methods (**Jakob Vester, Jesper Rasmussen, Bo Melander, Svend Christensen, Chr. Holm-Nielsen**)
Testing and approval of herbicides and growth regulators (**E. Juhl Petersen, Peder Elbæk Jensen, Hans Jørgensen**)
Applied research with chemical weed control in agricultural crops (**Peter Kryger Jensen**)
Weed control in horticultural crops (**Georg Noyé, Anette Binder**)
Weed control in forestry and windbreaks (**Thomas Rubow, Ole Hansen**)
Research on factors affecting the efficiency of soil herbicides (**Johannes Røyrvik**)
Research on factors affecting the efficiency of leaf applied herbicides (**Per Kudsk, Jens Kristensen, Torben Olesen, Solvejg Kopp Mathiassen**)
Spray technique and drift research (**Ole Permin**)
Advisory service (**Ole Permin, Marianne Baandrup**)

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

The Ministry of Agriculture took over a neighbouring farm in January 1988, which means that the institute now holds 83.6 acres of farmland. The expansion of land enables us to carry out more intensive research work including perennial permanent trials. A substantial number of trials are placed outside the institute on agricultural, horticultural and forest land all around Denmark. The buildings of the institute contain offices, laboratories, climate chambers, green houses, aviary for pot trials, library, work shops, garages and barn.

The institute continued its research and testing work within the field of weed biology and control including herbicide testing and approval. In addition, the institute is responsible for research, testing and approval of growth regulators for agricultural crops.

Weed biology and non-chemical weed control methods

Weed biology, distribution and spreading (Chr. Holm-Nielsen)

The counting of the weed seed production and the examination of the seedbank have now been completed. The examination was made in a soil, which has been grown for 5 years solely with barley. 4 different soil treatments have been used in combination with herbicide spraying.

The results of the investigations of the weed flora development were compared with the investigations made on fields, where the farmers have used ploughed or non-ploughed cultivation. The conclusion is that the weed flora is less diverse with a non-ploughed cultivation. Some species disappeared completely in many cases from such fields, compared to the neighbouring fields where they were growing in ploughed soil. But in the course of some years some species developed substantially, especially without spraying with herbicides. The ploughing is an excellent preservation method of seeds of several species.

New methods are being developed for determination of the weed seed production as well as for identification and quantification of the seed bank.

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.

Non-chemical weed control (Jakob Vester and Jesper Rasmussen)

A triennial project made on behalf of the National Agency of Environmental Protection dealing with non-chemical weed control in municipal areas has been completed by the end of 1988. The quality of cover materials and their ability to prevent weed seeds from germinating have been investigated. The germination of weeds is strongly correlated to the content of material dust. Fractions of 0-5 mm should be below 10% of the total weight and fractions of 0-20 mm should stay below 30% in order to prevent germination. Application of cover crops and materials around 10 different bushes and trees has provided satisfactory effect. The cover crop *Phacelia* has only to a small extent hampered the growth of the bushes and trees.

On firm grounds (flagstones or gravel) 5-10 times of flame treatment a year have been necessary in order to achieve the best control effect on weeds. The required number of treatments particularly depends on the quantity of rain in July. A motorized hoe (8-10 km/h) has offered a better effect on gravel grounds than flame treatment and with between one third and half of the treatments.

The investigations on mechanical and thermal weed control in agricultural and horticultural crops are continued. Weed harrowing and row crop cleaning have been tried in small grains and peas. In maize a combination of both thermal and mechanical treatment has been investigated. In vegetables the investigations have dealt with flame treatment before germination, weed harrowing and comparison of row crop hoes. A new developed row crop hoe, the row brush hoe, has been tested and compared with an ordinary row crop hoe.

Testing of herbicides and growth regulators in agriculture

Testing of herbicides and growth regulators in agriculture (P. Elbæk Jensen, E. Juhl Petersen and Hans Jørgensen)

The testing of applied herbicides are still concentrated on compounds for use in vinter crops. Some interest has also been put on compounds for control of weeds in beet and peas, and especially the combination of more compounds is of great interest.

20 compounds were approved. Most of them were tested on the request of the National Agency of Environmental Protection.

For the season of 1989, the National Agency of Environmental Protection has approved a number of compounds containing cleaning isomers of mechlorprop and dichlorprop. Most of these products have been tested and approved by the Research Centre for Plant Protection before being authorized.

Tests have also been made on some sulfonylurea derivatives and a large number of them were approved. Few of them showed some differences of the effect on the individual weed species and it seems that the development goes towards sulfonylurea products with shorter persistence in the soil.

Re-evaluation and effect evaluation (E. Juhl Petersen, G. Noyé and T. Rubow)

The re-evaluation in accordance with government Statutory Order 791 of Dec. 1987 was not commenced in 1988 as regards effects.

Effect evaluation was made in connection with application for approval of new products. A total of 28 compounds against weeds, algae as well as growth regulators were tested for their effect. Only a single compound was dismissed on account of lack of documentation.

Applied research with chemical weed control in agricultural crops

Split application of herbicides in peas (Peter Kryger Jensen)

In 1988, a trial with split application of herbicides in peas was performed. In the trial the split application at an interval of 10 days between the sprayings was compared with the application of the same total dosage at one time.

The trial included 3 treatments:

1. Split application

2. Treatment with full dosage at the same time as the first part of the split application.

3. Treatment with full dosage at the same time as the last part of the split application.

The trial included 4 of the normally recommended herbicide mixtures for use in peas, all in 3 dosages. In general, the split application showed an increased effect compared to both of the two single application treatments.

Weed control in horticultural crops

Newly approved herbicides and herbicides in testing for use in horticultural crops (Georg Noyé)

In the 1988 growing season, 33 herbicides were put forward for testing. The distribution between crops was 5 in onions, 4 in cabbage, 1 in spinach, 6 in green peas, 3 in sweet corn, 5 in beetroots, 2 in orchards, 10 in different nursery crops, 7 herbicides in 14 different lawn grasses.

The below mentioned herbicides have all obtained approval for use, or extended approval for use by the Danish Research Service for Plant and Soil Science.

1. Laddok (atrazine 200 g/l + bentazon 200 g/l) has had its approval extended to include also sweet corn.

2. Fusilade EW (fluazifop-P-butyl) has been given the same approval as Fusilade and PP 005 (Noyé 1986 b).

3. Basta (glufosinate 200 g/l) has had its approval extended to include also weed control applied pre crop emergence in beetroot.

4. Roundup (glyphosat 360 g/l) has had its approval extended to include weed control applied pre crop emergence in beetroot.

Weed control in forestry and windbreaks

Forestry, windbreaks and marginal land (Thomas Rubow and Ole Hansen)

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 the results of 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 soil herbicides

The persistence of the herbicides in soil (J. Røyrvik)

Decomposition of triasulfuron (Logran) and DPX A 7881 in the soil

Experiments have been made on the decomposition of the soil herbicides triasulfuron (Logran) and DPX A 7881 in the soil. They were started in spring 1987. The soil samples were taken at 2 months interval for biological tests in greenhouse.

The test plants were spring oil seed rape (Global) and white mustard (Bixley). Experiments on the decomposition of the soil herbicides chlorsulfuron (Glean), diflufenican and isozaben (Flexidor) in the soil have also been made. They were started in autumn 1987. Samples were also taken for biological tests in the greenhouse. The test plant was spring oil seed rape (Topas). Clorsulfuron and triasulfuron have been tested for several years and their persistence is relatively long. Also DPX A 7881, diflufenican and isoxaben seem to have a relatively long time of persistence.

Research on factors affecting the efficiency of leaf applied herbicides

Experiments in pots and controlled environment cabinets (Per Kudsk, Solveig Mathiassen & Jens Kristensen)

Interactions between herbicides

The influence of bentazon on the activity of the selective cyclohexonedione graminicides sethoxydim, cycloxydim and clethodim was investigated on pot-grown barley plants. Bentazon significantly reduced the activity of all 3 graminicides, however sethoxydim activity was reduced more than the activity of cycloxydim and clethodim. Whereas addition of 1, 2 or 4 per cent of a mineral oil additive reduced the severity of the antagonism of sethoxydim by bentazon increasingly with increasing concentration of the oil, no influence of the oil was found on the antagonism of bentazon on cycloxydim and clethodim activity.

Addition of 10 or 20 g ai MCPA ha $^{-1}$ to chlorsulfuron and metsulfuron methyl was found to reduce the effect of the two sulfonylurea herbicides on *Stellaria media* L. Applied alone the doses of MCPA had no significant effect on the growth of the test plant and, consequently, the results could be analysed using a parallel-line assay technique. On *Sinapis alba* L. it was not possible to detect the antagonistic effect of MCPA on the sulfonylurea herbicides when using ADM as reference model which indicates that this model is not suitable for detecting interactions between herbicides having different mode of action.

A nonionic surfactant or a mineral oil additive significantly increased the activity of imazamethabenz on wild oat (*Avena fatua* L.). Whereas tank mixturing with chlorsulfuron and bentazon did not reduce the effect of imazamethabenz, a significant reduction was observed in tank mixtures with MCPA. Volume rate was found not to influence the activity of imazamethabenz on wild oat.

Effect of various additives on the rainfastness of DPX-L5300 and thiameturon methyl

Addition of various additives were found to increase the rainfastness of DPX-L5300 and thiameturon methyl on *Sinapis alba* L. substantially. Some differences between the two herbicides were observed in the ability of the additives to enhance rainfastness, however, with both herbicides a significantly improved rainfastness was found when adding 1 per cent (w/w) of a vegetable oil. With an organosilicone surfactant and a synthetic latex very pronounced differences in their ability to increase the rainfastness of the two herbicides were found.

Environmental influence on the effects of different herbicides.

In 1988, three environmental cabinets were taken into use. In these cabinets temperature, humidity and light intensity can be controlled with very high accuracy. Futhermore, the climatic parameters can be changed continuously, which makes it possible to simulate a climate close to natural conditions. Several experiments have been made, of which two will be mentioned:

In one experiment the effect of ioxinil+bromoxynil was evaluated. The herbicide was applied at three different times during the day, in three different types of simulated natural climates. The experiment shows, that the best effect of the herbicide was obtained, when it was applied at the middle of the day. Furthermore, it was shown that the effect of the herbicide increased, when it was used in a warm climate, regardless of the time of application.
In another experiment the effect of bentazone was examined. It was applied at three different times during the day. The effect of water stress was also investigated. The results showed, that the effect of bentazone was reduced, when the test plants suffered from water stress. The best effect of the bentazone application was obtained, when the herbicide was applied in the morning. This effect was even more pronounced, when the test plants were subjected to water stress.

Influence of formulation and additives on the rainfastness of the bisdithiocarbamate fungicides (In cooperation with E. Kirknel, Laboratory for Pesticide Analysis)

The influence of formulation and additives on the rainfastness of maneb and mancozeb was examined on outdoor and indoor pot-grown pea and potato plants. Fungicide residues on the plants were determined using chemical analyses. Flowable formulations of both fungicides were generally more rainfast than the wettable powder formulations. Addition of various additives increased the rainfastness of the fungicides on both plant species, however, oil additives were found only to increase rainfastness on pea. Increasing the amount of rain reduced the rainfastness irrespective of formulation and additive. High rain intensities were found to wash off more fungicide than low rain intensities on peas, however addition of an oil additive reduced the influence of rain intensity.

Spray technique and drift research

Pests and weeds in Denmark (O. Permin)

Application technology:

The effect of herbicides and fungicides applied in cereals at different spray volumes from 55 to 500 l/ha has been investigated. The Pesticide Research Institute, The Danish Agricultural Advisor Centre, Danish Agricultural Enginering Institute and Institute of Weed Control have contributed to this work. The variation in spray volume is obtained using 4 different sizes of nozzles at 3 pressures, 1.5-3.0 and 6.0 bar. The effect of fungicides applied by means of different types of hydraulic nozzles and crop tilter has furthermore been investigated. New types of sprayers like Girojet, Danfoil, Minivariant and Twin were also investigated in a series of experiments.

The evaluation includes measurements of deposit in the plant canopy and measurements of drift by using a tracer in the spray liquid.

The following conclusions are drawn from the results based mainly on an average of 1-4 experiments.

Ordinary hydraulic fieldsprayer at a driving speed of 7 km/hours: The lowest spray volume for application of systemical and contact herbicides in cereals is 100-125 l/ha. Good control is obtained by using flat spray nozzles Hardi no. 4110-14 and 4110-16 at pressures of 1.5 bar. Higher pressures such as 3.0 and 6.0 bar or nozzles size 4110-24 did not increase the effect against weeds.

The lowest spray volume for application of fungicides against mildew (*Erysiphe* *graminis*) in cereals is 150 to 200 l/ha. Good control is obtained by using nozzle size Hardi no. 4110-14 at 3 bar, or 4110-16 at 1.5 or 3.0 bar.

The effect of using 3 different sizes of nozzles, with a pressure and a driving speed of 7 km/hour giving a spray volume of about 200 l/ha, was investigated by spraying against eyespot (*Pseudocercosporella herpotrichoides*) in winter wheat with prochloraz (Sportak). An average of 3 experiments showed a tendency towards a better effect using lower pressure and larger size of nozzle. The best effect was achieved using nozzle size Hardi no. 4110-24 with a capacity of 1.5 l/min. at 1.5 bar, compared to 4110-16 at 3 bar or 4110-14 at 6 bar.

I. LABORATORY OF PESTICIDE ANALYSIS
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Scientific staff:

Susanne Elmholt: The effect of pesticides on the microflora
Gitte Felding: Registration 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 suitable 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 mostly used. These are determined by scintillation counter.

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

The Effect of Fungicides on the Fungal Flora and on the Decomposition of Straw in Soil. (Susanne Elmholt)

In 1988, a number of pure culture experiments have been made and the effects of Tilt 250EC, Sportak 45EC and Calixin have been tested on 30 saprofytic fungi, primarily different species of *Fusarium*. The results show, that in pure culture *Fusarium* is much more sensitive to Tilt and Sportak than to Calixin. The selection of fungicides for a field trial was based on the results of the pure culture tests, 2 different doses (normal and 5 x normal) of Calixin and Sportak 45EC have been used. The fungal flora on the leaves was examined during the growing season and compared with the flora on the straw at harvest. The flora on the straw at harvest is called "initial flora". In the laboratory we are examining the importance of this initial flora on the decomposition of straw by measuring the microbial activity and the composition of the fungal flora. Furthermore, the influence of various fungicides on the decomposition of ^{14}C-labelled straw has been investigated. The following fungicides have been examined in normal and 10 x normal concentration: Tilt turbo, Tilt 250 EC, Calixine, Rival, Sportak 45EC and Corbel. No significant effects due to the fungicide treatment in realistic doses occurred in these experiments.

The occurrence of pesticides in groundwater and drain water (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 are evolved 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, they are emptied 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 on soil capacity for degradation is determined. In the latest 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.

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

Concentration of pesticides in air and deposits in glasshouses after puls fog application.

Using fluorescent tracer, technique experiments were carried out in large glass houses using puls fog. Air samples at a rate of 2 l/min were taken up to two hours after application. Deposits on filter paper placed to collect upward, downward and side deposition were analysed. In cooperation with the Pesticide Research Institute.

Deposition of pesticides on spraying personnel.

Using fluorescent tracer experiments were carried out in the field measuring the amount of tracer the tractor driver got in contact with under normal agricultural spraying conditions. Only 0.5 per cent of the total amount of tracer was inhaled. 72 per cent of the total amount taken up was found on the hands. In cooperation with the Danish Agricultural Engineering Institute.

Effect of Ethephon on rats and residue of Ethephon in urine

The National Institute of Animal Science are feeding rats with Ethephon and measuring different biological parameters. Lab. for Pesticide Analysis has analysed the urine which is the main pathway for Ethephon, and found, as a control, dose related residues of Ethephon.

Herbicides and growth regulators in plants, soil and water (Peder Odgaard).

The chemical analysis in connection with different experimental work is continued. In addition, a number of analyses are carried out to elucidate crop injuries, etc. Two cases are of more general interest:

Chlorsulfuron, precipitation

In a rape field some damage appeared after a Fusilade (fluazifop-butyl) treatment. The symptoms indicated that chlorsulfuron could have been present in the sprayer tank. Moreover, the equipment previously had been used for a Glean treatment, although it was thoroughly flushed afterwards.

A remnant of the spray mixture was retained for analysis. It was found that fluazifop-butyl was present in the expected concentration, but also chlorsulfuron, 3 mg/l, could be detected. So it is likely that chlorsulfuron was precipitated, and later again dissolved by fluazifop-butyl and its formulating agents.

Clopyralid residues in straw.

Ryegrass for seed production was sprayed in 1987 with a clopyralid-holding herbicide compound. The straw was ploughed down in the autumn and clopyralid residues from the straw was suspected to have injured peas in 1988.

Samples of straw were digged up and analysed for clopyralid, which was also found, but the concentrations were not correlated to the extent of pea injury on the same spots.

For verification a pot experiment with small amounts of clopyralid mixed in the soil was established at the Institute of Weed Control. Peas grown in the pots showed the same symptoms as observed in the actual field.

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