Danish Research Service
for Plant and Soil Science

# Plant diseases, pests and weeds in Denmark 1986

103rd annual report
Compiled by
The Research Centre for Plant Protection

Lyngby 1988

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Contents
Page

## A. INSTITUTE OF PLANT PATHOLOGY

### I. STAFF

Director of Institute

H. Rønde Kristensen

**Botany Department**

Head of Department: Ib G. Dinesen (acting)

**Scientific staff:**

Morgens Houmøller

Virulence analysis of barley and wheat powdery mildew (Erysiphe graminis)

Arne Jensen (from December 1)

Returned from assignment as vegetable plant protection officer in Zambia

Henrik Albert Jørgensen (until November 30)

Diagnostics of fungi; diseases of horticultural crops and root rot of sugar beet; Dutch elm disease; registration of scientific literature

Karen Jørgensen

Diseases of sour cherries; bacterial diseases of glasshouse crops and fruit trees

Lilian Kloster

Studies on the occurrence of *Polymyxa graminis* and *P. betae*, vectors for barley yellow mosaic virus and *Rhizomania.*

Bent Løschenkohl (from February 1)

Fungal diseases in horticulture; horticultural nuclear stockplants; fungi in recirculating watering systems; testing of resistance to potato wart disease; testing of resistance to potato wart disease; testing of disinfection compounds; white rot in onion.

Hellfried Schulz

Root and foot rot of cereals; take-all decline; survey and diagnosis of fungal diseases in peas

Sten Stetter

Threshold values for leaf diseases of cereals; development of EPIDAN - a computer-based sytem for advice on disease control.

Kirsten Thinggaard

Root diseases in greenhouse crops, especially *Pythium* and *Phytophthora*. Testing for races in *Bremia lactucae* (lettuce downy mildew)

Boldt Welling

Diseases of cereals and grasses; storage fungi on grain

**Biotechnology Project**

Project leader: Ib G. Dinesen

**Scientific staff:**

Lone Buchwaldt

Fungal toxins

Tine Hoff

Gene transfer

Elisabeth Johansen

Gene probes

Henning Kaufholz

Tissue culture

Helle Krogaard

Tissue culture

Gert B. Poulsen

Tissue culture

**Virology Department**

Head of Department: H. Rønde Kristensen

**Scientific staff:**

Jens Begtrup

Electron microscopy

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

Arne Thomsen

Viruses of fruit trees, soft fruit and woody ornamental plants; production of healthy nuclear stocks

**Zoology Department**

Head of Department: Jørgen Jakobsen

**Scientific staff:**

Peter Esbjerg

Insect pheromones and cutworm population dynamics

Lars Monrad Hansen

Soil-borne pests on beet and potatoes; grower-based monitoring of pests in cereals

Lise Stengaard Hansen

Biological and integrated control of pests on glasshouse crops

Jørgen Jakobsen

Plant-parasitic nematodes

Fritjof Lind

Pests on oil-seed rape; threshold values for pests in cereals; methods for testing insecticides

Jørgen Reitzel (until November 30)

Aphid population dynamics, particularly on potato and cereal crops; mass production of parasitic and predatory species of insects and mites used for biological control of pests in glasshouses

Lise Samsøe-Petersen

Methods for testing side effects of pesticides on beneficial arthropods

**Advisory service**

Ghita Cordsen Nielsen

Pests and diseases of agricultural plants

Lars A. Hobolth

Pests and diseases of horticultural plants

## II. GENERAL SURVEY OF PLANT PATHOLOGY SUBJECTS 1986, H. RØNDE KRISTENSEN

In 1986 26 research workers and 30 laboratory attendants and other staff members were employed at the Institute of Plant Pathology.

Furthermore, 8 students and 8 laboratory trainees as well as 1 person working under the Government Employment Scheme participated in the work carried out by the institute.

Bent Løschenkohl was transferred (from the Pesticide Research Institute) to the Botany Department from February 1, and Henrik Albert Jørgensen left the department on November 30 after working for 36 years with plant pathology.

S. S. Ahsan from Pakistan spent 4 months working at the Virology Department.

Jørgen Reitzel left the Zoology Department after nearly 25 years, and F. Lind left the department on December 31.

Muhammed Riaz Jamil from Pakistan visited the Zoology Department for 2 months.

Over the years, testing of samples from various trials for fungal diseases has been carried out at the Botany Department.

The threshold investigations concerning leaf fungi in cereals were continued as well as the virulence monitoring, which included examination of the strain spectrum of barley and wheat mildew from different parts of Denmark.

Soil samples from fields with winter barley and beet were analysed for the presence of *Polymyxa graminis* and *Polymyxa beta*, respectively.

Numerous new Danish potato hybrids were tested for resistance against potato wart disease.

The work on development of a suitable system of forecasting attacks of *Sclerotinia sclerotiorum* in rape was continued, and in view of the much increased area with fodder peas, a survey of the distribution of fungal diseases in this crop was worked out, and seed was tested for seed-borne fungi.

Furthermore, numerous seed-borne isolates of *Botrytis* spp. were tested for fungicide resistance (MBC resistance).

In cultures of greenhouse-grown lettuce examinations of different strains of *Bremia lactacae* were carried out, and guidance was given as to the choice of resistant varieties. Bacterial as well as fungal diseases in a number of pot plants have been included in the investigations carried out by the Botany Department, especially in connection with the establishment of healthy nuclear plants.

Water from nurseries using recirculated nutrient solutions in soilless cultures was examined for content of root-pathogenic fungi (*Phytophthora* and *Pythinum* species).

In cooperation with the Botany Department the Zoology Department carried out registrations of mildew, rust and aphids in a great number of spring barley fields; this work was the basis for direct guidance about control measures and for Plant Protection Bulletins.

Density determination in June/July of aphids in spring barley and wheat was carried out in order to determine the economic damage threshold.

As an aid in establishing the right time for haulm destruction in potato fields (to prevent late infection by potato viruses), aphid samples from yellow tray traps placed in different localities were analysed.

For many years, the Zoology Department has carried out routine examinations for potato cyst nematodes in soil samples; a great number of these samples originated from the Plant Protection Service. Since September 1986, this Service has been carrying out these examinations in their own laboratories.

In rape, a survey was made of the most important pests by examining plant samples and insect catches in traps.

Besides, economic damage thresholds and forecasting methods have been developed at the Zoology Department.

Various investigations have also been carried out concerning the pea and bean weevil in peas as well as cutworms in carrots.

A special research project aimed at development of standard methods of controlling the effect of pesticides on beneficial arthropods.

Also the flower thrips, *Frankliniella occidentalis*, has been involved in trials with chemical as well as biological control.

At the Virology Department the work on the development of various diagnostic methods was continued with special emphasis on the methods of dot immunobinding and ELISA.

The ISEM method combining the use of the electron microscopy with serology has been much used; during the year, about 3500 ISEM analyses were carried out.

At present, 225 antisera are available at the Department, so that a quick diagnosis is often possible.

In the electrophoretic field, work is in progress regarding the analysis of viroids.

Curative work was carried out on a fairly large scale using heat therapy as well as tissue culture.

In this connection, long-time storage in vitro took place using the following plant genera: *Arabis, Begonia, Campanula, Chrysanthemum, Dieffenbachia, Dipladenia, Euphorbia, Hemerocallis, Kalanchoë, Lavandula, Pelargonium, Pentas* and *Phlox*.

The EEC project (COST 87) with micro-propagation of the apple rootstock MM 26 was continued and extended to include M IX as a model plant.

A similar EEC project concerning micro-propagation of Pelargonium in connection with the elimination of pathogens was concluded after three years' experiments.

At the same time, a new project regarding micro-propagation of forestry plants using *Betula* and *Quercus* as model plants was initiated.

At the Virology Department, antiviral components has been added to the growth media used for the tissue culture experiments.

To a limited extent, monitoring of virus diseases took place in cocksfoot, maize, peas, wheat, barley and beet.

Special interest was attached to the examinations of winter barley and beet fields for barley yellow mosaic and rhizomania. However, none of these diseases have been found in Denmark so far.

In commercial orchards, surveys have been carried out concerning *Prunus* ringspot, cherry rasp leaf and little cherry.

Furthermore, re-testing of nuclear stocks of apples, pears and cherries was initiated.

In September 1986, plum pox (Sharka) was recorded for the first time in Denmark. This finding resulted in a considerable amount of extra work for the Virology Department - especially in the field of diagnostics.

**Advisory work**

In 1986 the staff members made altogether 77 journeys abroad visiting the following countries: Belgium, England, Finland, France, Germany, Greenland, Indonesia, Kenya, the Netherlands, Norway, Poland, Portugal, Sweden, Switzerland, Tanzania, the United States and Yugoslavia.

Among the subjects dealt with during these travels were potato ringrot, virus yellows and rhizomania of beet, fruit tree viruses, soil-borne viruses, diseases of grasses, pathogenic Pythium species, viroids and their detection, resistance biology, integrated control of fungal diseases, biological control of fungi, biological control of thrips, pheromones, pesticides and beneficial organisms, entomology in the tropics, potato tissue culture, meristem culture of woody plants and international cooperation about plant protection.

Several visitors from abroad visited the Institute of Plant Pathology. In 1986 visits by colleagues from the following countries were received: Belgium, Burma, China, Czechoslovakia, Egypt, England, Finland, France, Germany, Hungary, Ireland, Israel, Italy, the Netherlands, Norway, Pakistan, Scotland, Switzerland, Somalia, Spain, Sri Lanka and Sweden.

**Plant Health Control and Propagation of Healthy Plants**

On May 21st the Plant Health Council celebrated its 40th anniversary.

The council was set up by the Ministry of Agriculture in 1946, the same year as the Plant Protection Service was established as a separate institution directly under the Ministry of Agriculture. Originally, the Council acted as a governing committee to the Service, but today the Council is an advisory body assisting the Minister of Agriculture and the Plant Protection Service in their efforts to control and prevent the introduction and spread of agents harmful to plants, and giving advice on other questions of plant health.

During the past forty years the Council has taken up numerous problems and has had a great influence on Danish plant health legislation.

The Council has furthermore participated in international cooperation regarding the control of harmful organisms threatening plants.

Over the years the chairman of the Council has been a permanent representative of Denmark in the council of European and Mediterranean Plant Protection Organization (EPPO) and he has several times been a member of the executive committee as well as several other committees, such as the editorial board, the phytosanitary panel, etc.

Since Denmark joined the EEC, members of the Danish Plant Health Council have participated in a large number of meetings in Brussels in connection with the preparation of the EEC Plant Health Directive, and for two periods, the former vice-chairman of the Council functioned as chairman of the working group on plant health set up by the Council of Ministers.

At present, the secretary of the Danish Plant Health Council and the Council's legal adviser are members of the EEC standing committee on plant health.

The Plant Health Council can be involved in all questions concerning plant health; but the main concern of the Council is matters relating to dangerous organisms, i.e. those under public control.

At the moment, this category includes black rust of wheat (the growing of all susceptible *Berberis* species is prohibited), mildew and rust of barley (compulsory treatments of fields with winter barley), wild oats, potato wart, potato ring rot, the Colorado potato beetle, potato cyst nematodes, the carnation leaf roller, fireblight, the San José scale and the muskrat.

The first comprehensive plant disease law dates from 1927. In 1957 another law was passed about the control of dangerous plant diseases and pests.

The present legislation is based on "Law about agents harmful to plants" from 1984.

During 1986 the Plant Health Council treated questions regarding Dutch elm disease, fireblight, red core of strawberry, potato ring rot, barley yellow mosaic, rhizomania, potato cyst nematodes, the American flower thrips and several other matters.

Dutch elm disease spread to more areas in 1986, especially in the eastern part of Jutland.

Eradication of this disease is considered impossible, but the spread can be considerably delayed by immediate removal of diseased trees.

Fireblight was not very severe in 1986, and there was only one record of the Colorado beetle.

Neither red core of strawberry nor barley yellow mosaic or rhizomania have so far been found in Denmark. Legislation preventing the introduction of these pathogens is under preparation.

In 1986, the American flower thrips damaged cultures of *Gerbera, Chrysanthemum, Saintpaulia* and roses.

In the autumn of 1986 Plum pox (Sharka) was found in a fruit tree variety trial where 9 varieties were infected. All diseased trees were destroyed, and comprehensive measures were taken to ensure complete eradication of the disease.

The potato meristem programme, which was initiated in 1977, has been successfully concluded, and in accordance with an order from the Ministry of Agriculture, a total replacement of all seed potatoes in the Danish commercial potato production took place during 1985 and 1986. Consequently, all the seed potatoes which are planted out, originates from the meristem programme.

The Nursery Control Commission carried on as usual in 1986.

The compulsory plant health control comprised 2243 enterprises in 1986 where the total number of inspections carried out by the Plant Protection Service amounted to 6100.

There has been a considerable decrease in the number of attacks of pests and diseases registered during the last few years.

The production of healthy nuclear plants which is a result of a cooperation between the Nursery Control Commission, The Institute for Plant Pathology and other relevant horticultural research institutes reached quite considerable dimensions.

At present, healthy plant material is available for 262 varieties of plant genera for use outdoors as well as in greenhouses.

## III. ADVISORY WORK. Ghita Cordsen Nielsen and Lars A. Hobolth.

As in previous years, the advisory work was carried out both at Lyngby and at the Plant Protection Advisory Department at Godthåb, Skanderborg, which primarily deals with the enquiries from Jutland.

As for articles and reports, see the list of publications.

The department again sent out handbooks in plant protection for use by growers and agricultural advisors.

45 Plant Protection Bulletins were issued in 1986.

Weather conditions (Jørgen E. Olesen, the Agrometeorological Service)

As a whole, January was somewhat colder and had more precipitation than usual. The cold weather was particularly pronounced during the first third of the month, where there was a heavy snowfall. During the rest of the month the weather was mostly mild and without much snow. By the end of the month, the weather was dry and windy, so that soil drift occurred in several places.

In February the weather was very cold, dry and sunny. The average temperature for the whole of the country was 4.8°C below normal. The 3 mm precipitation made February 1986 the driest February ever registered. The cold weather without much snow cover had the effect that the fields were more or less unprotected against the cold during most of the month.

The very cold weather in February continued for the first few days of March. Then mild air from the Atlantic invaded the country. As a whole, the weather was grey and dry for the first 3 weeks of March and then unstable with heavy rainfall. Thus the temperature for the whole of the month was a little below and the precipitation much above normal.

April was mostly cold for the first three weeks. Sunny weather did not occur until the last week, where day temperatures of up to 15° were registered in areas away from the coast. From the 10th to the 15th the weather was cold with frost during the day in many places and night temperature down to $10^{o}$C below zero.

In May the temperature fluctuated around the normal average temperature for the month. During the first 4-5 days the weather was dry, sunny and warm, whereas it was changeable during the rest of the month. Thus the May rainfall was considerably above normal.

During the first half of June the weather was cold and unsettled. For the last two weeks it was dry, sunny and warm. The temperature for the whole of the month was close to normal, whereas the rainfall was considerably below normal.

The hot and sunny weather of June continued for a few days in July. The weather during rest of the month was dry and cold. The average temperature for the whole of the country was 0.7°C below normal, and the rainfall was 23 mm below normal. However, the rainfall was very unsteady and mostly in connection with thunderstorms. Thus a fierce thunderstorm on the 24th was accompanied by more than 100 mm rainfall at several places in Storstrøms Amt (Southern Zeeland, Lolland, Falster, etc.)

During the first half of August the weather was mostly dry and sunny. Then there was a cool and grey spell with some rain. On the 25th temperatures near zero was registered in several places in Central Jutland.

In September both temperature and rainfall were considerably below normal. The average day-and-night temperature only rose above normal during the last few days of the month. The highest maximum temperature registered in any part of the country was 18.2°C, which is the lowest ever registered for the month of September.

For the first two weeks of October the weather was mostly dry and warm, whereas it was unsettled and rainy for the last two weeks.

The temperature and precipitation in November was somewhat above normal, and the weather was influenced by mild and sometimes moist air from the Atlantic. However, frost occurred in most places at the beginningof the month.

December was mild until the 19th. The rest of the month was colder, and a there was a light snowfall in most places by the end of the month.

| | Temperature °C | | No. of sunny hours | |
|---|---|---|---|---|
| | 1986 | Normal | 1986 | Normal |
| January | -1.5 | -0.1 | 53 | 41 |
| February | -5.2 | -0.4 | 115 | 65 |
| March | 1.4 | 1.6 | 80 | 127 |
| April | 4.5 | 6.1 | 140 | 181 |
| May | 11.5 | 11.1 | 225 | 256 |
| June | 14.3 | 14.4 | 268 | 257 |
| July | 15.8 | 16.5 | 214 | 247 |
| August | 14.7 | 16.2 | 192 | 221 |
| September | 10.8 | 13.0 | 151 | 166 |
| October | 9.3 | 8.6 | 103 | 98 |
| November | 6.8 | 4.9 | 42 | 42 |
| December | 2.5 | 2.1 | 34 | 28 |
| Annual average | 7.1 | 7.8 | | |
| Hours in all | | | 1621 | 1729 |

| | Precipitation in mm | | Deviations from normal | | |
|---|---|---|---|---|---|
| | 1986 | normal | Jutland | Islands | Bornholm |
| January | 85 | 55 | 32 | 25 | 49 |
| February | 3 | 39 | -39 | -31 | -21 |
| March | 57 | 34 | 29 | 9 | 22 |
| April | 30 | 39 | -9 | -8 | 24 |
| May | 48 | 38 | 12 | 4 | -1 |
| June | 28 | 48 | -20 | -21 | 1 |
| July | 51 | 74 | -36 | 6 | 20 |
| August | 73 | 81 | 1 | -29 | -21 |
| September | 42 | 72 | -37 | -16 | -10 |
| October | 94 | 70 | 25 | 23 | -7 |
| November | 76 | 60 | 17 | 11 | 12 |
| December | 79 | 55 | 29 | 14 | 20 |
| Total precipitation | 666 | 665 | 4 | -13 | 88 |

## 1. Diseases in agricultural crops 1986

Ghita Cordsen Nielsen

### Cereals and grasses

**Overwintering.** As in 1984/85, a great part of the winter cereals suffered from severe frost when there was no snow cover. No connection between the time of sowing and frost damage could be seen. About 70% of the winter barley and 19% of the winter wheat had to be resown whereas only 3% of the winter rye was severely damaged. Approximately 50% of the seed crops and 30% of grass fields with Italian ryegrass had to be resown.

**Barley yellow mosaic virus.** See page 35.

**Barley yellow dwarf virus.** Only one severe attack was registered.

**Snow rot** (*Typhula incarnata*). Severe attacks were only mentioned in two reports.

**Snow mould** (*Gerlachia nivalis*). The attacks were neither severe nor widespread.

**Eyespot** (*Pseudocercosporella herpotrichoides*) was considerably less prominent than in 1985. In the autumn, the climatic conditions were favourable for the fungus from the beginning of October to the end of December, but in the spring, the weather was too dry for infection and development. In winter rye 10% of the fields investigated had more than 20% attacked plants. In winter wheat 16% of the fields had more than 20% attacks, and only a few fields were severely damaged.

**Sharp eyespot** (*Rhizoctonia cerealis*). See page 33.

**Take all** (*Gaeumannomyces graminis*). The attacks were rather insignificant compared with the preceding years. In winter wheat 5% of the fields had attacks of some importance. In winter rye and winter barley the attacks were insignificant. See page 32.

**Mildew** (*Erysiphe graminis*). In winter barley, where many fields suffered from frost damage, the mildew attacks were weak. The reason may also be the two obligatory fungicide treatments in the early spring.

In general, the mildew attacks in spring barley were extremely weak, and chemical control was only profitable in fields with the most susceptible varities. As to investigations of the virulence gene frequencies, see page 34.

**Yellow rust** (*Puccinia striiformis*) was only observed in wheat, and the attacks were limited and weak on all localities except one.

**Brown rust of wheat** (*Puccinia recondita*). In general, only weak attacks were seen. In a few fields, severe attacks were found, but they came late.

**Brown rust of barley** (*P. hordei*) was seen in a few fields.

**Net blotch** (*Drechslera teres*) was found to be less widespread and less severe than usual, both in winter and spring barley. It was mostly seen in winter barley grown after winter barley.

**Scald** (*Rhyncosporium secalis*). The trend was the same as for net blotch.

**Speckled leaf spot** (*Septoria tritici*) was often found in winter wheat, but only on the lower leaves.

**Glume blotch of wheat** (*Septoria nodorum*) was of very little significance due to the dry weather in June/July.

**Bunt of wheat** (*Tilletia caries*). Two reports of attacks were received.

Legumes

**Abnormal germination in peas** occurred in several fields. The plants affected were small, had thickened roots and leaves with light veins. In some fields, resowing was necessary. The cause is not clear.

**Grey mould** (*Botrytis cinerea*) was much less of a problem in peas than in 1985, due to dry spells in June and July. The disease mostly occurred in irrigated fields.

**Other fungal diseases on peas** (*Ascochyta pisi, Mycosphaerella pinodes* and *Phoma medicaginis*) were not important either, according to reports from the agricultural advisers.

*Sclerotinia sclerotiorum* is reported to have occurred in a few cases and was often found in seed samples.

**Downy mildew** (*Peronospora pisi*) is mostly seen in areas with long tradition for pea growing. In general, the disease was not widespread, but a few severe attacks were recorded in June.

**Fusarium wilt** (*Fusarium oxysporium* f. sp. *pisi*) was not widespread, and only two reports in July mentioned more severe cases connected with insufficient crop rotation.

**Chocolate spots** (*Botrytis fabae*) **and leaf spot of broad beans** (*Ascochyta fabae*) was only of minor importance in 1986. Leaf spots were often seen, but it turned out that they were caused by herbicides.

**Clover rot** (*Sclerotinia trifoliorum*) was recorded in 4 fields with red clover. In all cases the attacks were weak.

Oil seed rape and other cruciferous crops

**Overwintering** of winter rape was not too good. About 20% had to be ploughed in and resown.

**Club root** (*Plasmodiophora brassicae*) was found in spring rape with medium to severe attacks in some regions, but most of the reports only mention weak or no attacks. The infected plants were more easily observed in 1986 due to drought at midsummer.

**Downy mildew** (*Peronospora parasitica*) is mostly seen in winter rape in the autumn. In June 1986 the attacks in spring rape were more widespread and severe than usual, and spraying with Maneb was tried in several cases.

**Stem rot** (*Sclerotinia sclerotiorum*) was limited by the weather conditions in June, and severe attacks were only observed in two areas. See also p. 36.

**Leaf spot** (*Alternaria brassicae*) **and** *A. brassicicola*) was of very little importance. In August, a few cases of severe attacks were observed in spring rape adjacent to winter rape.

**Canker** (*Phoma lingam*) in winter rape was rare and insignificant.

**Verticillium wilt** (*V. dahliae*) was observed in spring rape with a severe attack in one locality. The disease is widespread in Southern Sweden, but not yet in Denmark

## Beet

**Overwintering** of plants for seed was poor. In storage, beet kept quite well in spite of the cold winter.

**Manganese deficiency** was fairly widespread, and about one third of the reports described the symptoms as rather prominent.

**Virus yellows (Beta virus 4)** was less widespread than usual, and the attacks were very weak in general. More severe attacks than usual were found in coastal areas of Lolland where most of the sugar beet is grown.

**Rhizomania.** See page 36.

**Damping-off and root rot** (*Pythium spp., Phoma betae* a. o.) were seen, but mostly with weak attacks.

**Powdery mildew** (*Erysiphe betae*) started in July, but rainy weather in August-September made fungicide control unnecessary.

## Potatoes

**Overwintering** in clamps was satisfactory.

**Leaf roll (Solanum virus 14) and streak (Solanum virus 2).** These diseases were not widespread, and the attacks were extremely mild.

**Rattle virus.** Very severe attacks were seen in a few fields.

**Black leg** (*Erwinia carotovora* var. atroseptica) was reported to be rather serious in a few areas, but on the whole, the disease was not widespread or severe.

**Potato wart** (*Synchytrium endobioticum*) was not reported to have been found in any new localities. The disease is only registered as occurring in 5 gardens.

**Late blight** (*Phytophthora infestans*). The first warning was sent out on the 27th June. The first fairly widespread attacks were found in mid-July in irrigated fields with the varieties Bintje, Hansa, Kaptah and Sirtema. These attacks did not cause serious damage because of the dry weather. In August-September stronger attacks were recorded.

**Stem canker and black scurf** (*Rhizoctonia solani*) was quite widespread in the spring.

## 2. Pests on agricultural crops

### Cereals and grasses

**Cereal nematodes** (*Heterodera avenae*)

Very few severe attacks were reported in spring barley and oats.

**Crane flies** (*Tipula paludosa*)

The number of leatherjackets found in the soil in the autumn of 1985 indicated that the level of attack would be fairly moderate in 1986. However, the damage threshold had been passed in several cases where beet was grown after grass.

In April and May, respectively 92% and 76% of the agricultural advisers reported attacks below medium. Severe attacks were only seen in Højer and Sindal in grass on low ground.

**Wireworms** (*Agriotes spp.*)

The attacks were mostly scattered and weak, but a few severe attacks were seen, mostly in fields where grass had been the preceding crop.

**Bibionid flies** (*Bibio hortulanus*) was not any problem in 1986 either.

**Saddle gall midges on barley** (*Haplodiplosis equestris*) **and wheat blossom midges** (*Contarinia tritici, Sitodiplosis mosellana*)

No reports were received of any serious attacks.

**Bird-cherry aphids** (*Rhopalosiphum padi*), **grain aphids** (*Sitobion avenae*) **and rose-grain aphids** (*Metopolophium dirhodum*)

As usual, the attacks started in the southern part of the country. In general, the attacks were less severe than usual, but big variations occurred. In recent years, reports have mostly been received of *Sitobion* on wheat and *Rhopalosiphum* on barley. In 1986, *Metapolophium* could be found on the wheat straws, but not on the ears.

The computer-based advisory service to farmers was continued, and the main results are shown on page 51.

**Rosy rustic moths** (*Hydraecia micacea*)

On several locations more serious attacks than usual were registered in maize.

**Cereal leaf beetles** (*Oulema melanopa*) were widespread in barley and wheat. About 30% of the agricultural advisers give reports of medium-strong attacks.

**Grain thrips** (*Limothrips cerealium* a.o.) were found in a number of fields, especially in rye, where the light sheaths were easily seen. Only 23% of the reports speak of medium-severe attacks in rye.

**Frit flies** (*Oscinella frit*)

Migration of the first generation started 17th-19th May and culminated about the 20th June, which was a little later than usual. Because of the unstable weather, the second generation did not start migrating until about 21st July with a culmination about the 18th August. Control of the third generation by the end of August in seed grass was not necessary because of rainy weather.

It appears from the reports of the agricultural advisers that frit flies were not very widespread and only weak attacks occurred in winter crops, grass, maize and oats. Reports of severe attacks in winter crops in April were only received from one adviser, whereas two others registered serious attacks in June on grass.

**Yellow cereal flies** (*Opomyza florum*) **and wheat bulb flies** (*Delia coarctata*) were observed in several winter crop fields with severe attacks in May.

<u>Pests on legumes</u>

**Pea and bean weevils** (*Sitona lineatus*)

58% and 27% of the agricultural advisers give reports of medium to severe attacks in peas and broad beans, respectively. This is an increase compared with the previous year.

The pea and bean weevils were fairly widespread in clover already in May. However, the attacks were not severe. In August, on the other hand, more than 60% of the reports mention very widespread and medium-severe attacks of pea and bean weevils in clover.

1986 must be described as the year with the most serious attacks of pea and bean weevils. In late summer many complaints were received about massive invasions of pea and bean weevils in gardens.

**Cabbage thrips** (*Thrips angusticeps*) **and pea thrips** (*Kakothrips pisivorus*) on peas were found in a number of fields in May and July, but mostly with no or weak attacks.

**Pea moths** (*Cydia nigricana*) were not seen very much in 1986. In pheromone traps placed in about 200 pea fields the damage threshold was only exceeded in a few cases. A few cases of severe attacks were seen at Kolind and Ikast.

**Pea aphids** (*Acyrthosiphon pisum*) occurred in many fields, but only 14% of the advisers report medium-severe attacks in July.

**Black bean aphids** (*Aphis fabae*) were very widespread in broad beans, mostly with medium attacks.

Pests on rape

**Thrips** (*Thrips angusticeps*) were fairly widespread in spring rape, and a few severe attacks were reported in May.

**Blossom beetles** (*Meligethes aeneus*) were very widespread in winter and spring rape. The beetle attacks were weak-medium in winter rape, whereas there were a number of severe attacks in spring rape.

**Cabbage seed weevils** (*Ceutorhynchus assimilis*)

It appears from the reports that the attacks of cabbage seed weevil attacks were weak in winter and spring rape.

**Brassica pod midges** (*Dasyneura brassicae*)

In about 86% of the reports, the attacks are described as below the average in winter rape in spite of good overwintering conditions. A warning about the 1st generation was issued on 21st May, which is a little earlier than usual. The migration of the 2nd generation started 25th-28th June.

**Cabbage stem weevils** (*Ceutorhynchus quadridens*)

According to the reports, the occurrence of cabbage stem weevils was limited, and the attacks were weak, but several fairly severe attacks were seen.

**Cabbage root flies** (*Delia radicum*) were noticed more than usual. The reason was probably not greater populations, but rather the drought from the middle of June. If the roots are damaged, the plants will more quickly be suffering from water deficiency.

The following pests in winter and spring rape were only seen in small numbers and were without importance in 1986: **Diamond-back moth** (*Plutella xylostella*), **swede midges** (*Contarinia nasturtii*), **cabbage aphids** (*Brevicoryne brassicae*),

**large white butterflies** (*Pieris brassicae, P. rapae*) and **cabbage stem flea beetles** (*Psylliodes chrysocephalus*).

Pests on root crops

**Beet cyst nematodes** (*Heterodera schachtii*)

The attacks in 1986 were few and insignificant.

**Cabbage thrips** (*Thrips angusticeps*)

About half the sugar beet growers and several fodder beet growers saw for the first time in 1986 the effect in practice of the new seed dressings Promet (furathiocarb) and carbofuran.

Thrips were fairly widespread in beetroot, and 44% of the agricultural advisers report medium-severe attacks. In several places control measures had to be taken in spite of treatments with the new seed dressings.

**Mangold flies** (*Pegomyia hyoscyami*)

In May, reports were received from several advisers that mangolds were laying more eggs than had been seen in many years. Although not all eggs were hatched, the attack by the 1st generation was much more severe than usual. The 2nd generation in the middle of August was also considerable, and control was necessary in several cases where the tops were to be utilized.

The new seed treatments had a clear effect on the number of 1st-generation larvae.

**Pygmy beetles** (*Atomaria linearis*) were observed in a number of fields, and 18% report medium-severe attacks.

*Clivina fossor* is a fairly new pest - a carabid without a Danish name. It was observed in a few beetroot fields. They were mistaken for pigmy mangold beetles. However, this beetle is much smaller.

**Beet carrion beetles** (*Blitophaga opaca*) were less widespread and only occurred in weak attacks, especially at the field edges, just like the **potato capsids** (*Calocoris norvegicus* a.o.).

**Peach-potato aphids** (*Myzus persicae*)

The first reports of peach-potato aphids were received from Lolland-Falster

during the week starting June 16th. One week later reports were also received from Western Zealand and Funen.

In June, all agricultural advisers reported no or weak attacks, whereas 77% report attacks below average in July and August. Consequently, the attacks of beet yellows were weak.

Investigations of samples with peach-potato ahids showed high insecticide resistance in several areas.

**Black bean aphids** (*Aphis fabae*) were widespread in beet fields. In June, the attacks were fairly weak, and in July-August they were of medium strength, but with a number of severe attacks. According to the reports, control was difficult.

**Cabbage moths** (*Mamestra brassicae* a.o.) occurred in several areas, but with few serious attacks.

**Potato cyst nematodes** (*Heterodera rostochiensis*)

5 agricultural advisers reported weak attacks in August. One adviser speaks of medium attacks, and one of severe attacks. They mostly occur in gardens.

**Colorado beetles** (*Leptinotarsa decemlineata*)

The Government Plant Protection Service reports that only in one garden at Nakskov were 2 surviving colorado beetles found on bait plants in 1986. The bait plants were put there by the Protection Service, as some thousand beetles had been found in that place in 1985.

**Cutworms** (*Agrotis segetum*)

The situation in 1986 was most unusual. Catches in the pheromone traps started 10-12 days later than normal, and they were very small. This was the case in almost all 60 localities with traps. Thus control was only to be considered on very light soils with redbeet, carrots and leek, where the only rainfall was during the first two weeks of July. The agricultural advisers reported no or weak attacks, except for one severe attack in potatoes and carrots.

**Carrot flies** (*Psila rosae*)

Migration was very limited at the trap localities - except on the island of Samsø.

## Other pests

**Field slugs** (*Agriolimax agrestis*)

As severe attacks occurred in the autumn of 1985, attacks were expected in 1986. However, by mid-September no reports had been received of severe attacks although the rainfall in August-September was considerable. The drought in June-July must have kept down the reproduction.

In the spring there was only one report about a severe attack in spring rape sown after white clover. The spring rape had to be resown.

## 3. Diseases in horticultural plants 1986

Lars A. Hobolth

The percentual distribution of registered enquiries appears from Table 1. It appears that the increase in enquiries about special subjects which was seen in 1985 continued in 1986. For instance, there is a marked increase in the number of mycological enquiries compared with the average for the 5 preceding years.

Table 1. Percentual distribution of registered enquiries

| | Physiological | Mycological | Bacteriological | Virological | Zoological | Diverse | Unexplained |
|---|---|---|---|---|---|---|---|
| Average of 5 years 1981-1986 | 13.1 | 42.4 | 8.5 | 5.2 | 25.6 | 4.7 | 0.5 |
| 1986 (Total: 1870) | 9.3 | 48.0 | 5.8 | 6.0 | 27.9 | 2.6 | 0.16 |

**Climatic damage**

The low temperatures during the winter appear not to have damaged the woody plants when no other factors contributed to weakening the plants. Dead branches occurred in blackcurrant, but the damage was mostly seen in fairly old orchards where the berries had been machine-harvested. Many strawberry plants were either killed or much weakened by the black frost during the later part of the winter. It was obvious that where the snow had not melted during the warmer period, the plants thrived when spring came. The cold spring resulted in very insufficient pollination of the strawberries, and for many growers the bad weather conditions in the early summer as well as the overwintering resulted in yield reduction of about one third in 1986 compared to normal years.

Many other outdoor crops suffered under the cold spring, especially heat-requiring cultures like sugar maize and large cucumbers.

In the cases where flower bulbs were kept in clamps before being forced, damage sometimes occurred because frost had penetrated into the clamps.

**Fungal diseases**

**Club rot** (*Plasmodiophora brassicae*) occurred relatively late in the different cabbage varieties. The late appearance of the disease is probably due to the cold spring where the soil temperature did not rise so high that the fungus became

active. Later in the year, attacks were seen in normal strength in the infected areas.

*Pythium* spp. According to the registrations most damage occurred in greenhouses. Very different cultures are attacked by the fungus. Among the potted plants the following may be mentioned: Azalea, chrysanthemum, cyclamen, gerbera, pelargonium and monstera. In a number of cases, it is possible to ascribe the attack to faults in the cultural technique. In other cases, however, the seed or seedling seem to have been infected from the beginning.

**Blight** (*Phytophthora infestans*). Attacks on solanum pot plants were registered, especially on the fruits, where the fungus produces brown rot, so that it can be seen on tomatoes.

*Phytophthora porri* caused quite considerable damage in leek cultures. The attacks were seen both in early and late varieties, but with the strongest attacks in late crops.

*Phytophthora* spp. is fairly common in many nurseries with potted plants. Among the cultures where the disease is found particularly often are cyclamen, gerbera, hibiscus, poinsettia and primula.

**Downy black mildew** (*Peronospora sparsa*) was found very early in the year both in greenhouses and outdoors. Apparently, the cold start of the summer was ideal for the fungus.

**Downy mildew of peas** (*Peronospora pisi*) was fairly widespread by the end of the summer, where attacks were seen both in peas for canning and for the green market trade.

**Downy mildew of cabbage** (*Peronospora parasitica*) was registered as widespread in many cruciferous crops. A number of attacks in broccoli showed that the symptoms in this crop are very similar to those seen in cauliflower.

**Downy mildew of cucumber** (*Pseudoperonospora cubensis*) started with scattered attacks late in July and increased during August. The severe attacks meant that the yield of large cucumbers was considerably reduced. During August and September, the disease was furthermore observed on cucumber in greenhouses. To GASA, Odense, the attacks meant that the quantities they received were far below expectations based on the area with cucumber.

**Grey mould** (*Botrytis cinerea*) is quite common both outdoors and in greenhouses. In the fields the fungus reduced the yield of strawberries. Apart

from the usual attacks on the fruits, the lower parts of the plants were also attacked during the spring, so that leaf and flower stems broke just above the root collar. In greenhouses, attacks were seen on the following plants: azalea, begonia, chrysanthemum, cyclamen and pelargonium. Many of the attacks on greenhouse cultures may be explained by the fact that the greenhouses have become more tightly sealed in order to reduce heating expenses.

**Smoulder** (*Botrytis narcissicola*) ruined many pot plant cultures of narcissi. The attacks were first noticed in connection with the forcing where one or several bulbs may fail completely, or the development may be much retarded. Some attacks may be ascribed to the material used while others have developed later.

*Thielaviopsis basicola*

Attacks were found on cyclamen and poinsettia. As regards cyclamen, it was noted that one of the reasons for the attack may have been deep potting.

*Penicillium* sp. was registered in a number of Egyptian onions. It is typical that the most severe attacks were seen in onion sets, where the attack is seen as a brown discolouring of the uttermost couple of turgid scales.

*Cylindrocladium scoparium* is a fungus which is quite often seen in azalea cultures. The first sign of an attack is usually the withering of one or more branches.

**Shoot blight of poplar** (*Fusicladium radiosum*)

The weather in the spring and early summer was favourable to this disease. Thus many rows of poplars had periods with dead black leaves and shoot tips.

*Fusarium* spp. is a serious disease both in the field and in greenhouses. The attacks are most often found where the plants are weakened in some way. Thus it has been noted that in Egyptian onions attacks mainly occur where the soil has at some point been waterlogged, so that the roots have not been able to breathe. In leeks, most of the attacks were seen in connection with insufficient crop rotation. Many greenhouse cultures are attacked. Among them are aster, begonia, campanula, coffea, crassula, cyclamen, hibiscus and monstera.

*Myrothecium roridum* was found both in kalanchoë and in gardenia. In kalanchoë, most of the attacks were found in the variety 'Pollux'. The attack usually occurs around the stem, which becomes black. At the beginning, the attack is very superficial, but after some time, it penetrates so deeply into the plant, that it collapses.

*Phyllosticta dracaenae* is found on imported seedlings from Africa both on dracaena and on codiaeum. The attacks may spread very wide at the high relative humidity during rooting.

*Cryptocline cyclaminis* (syn.: *Gloeosporium cyclaminis*)

A few scattered attacks were seen in different cyclamen cultures. The attack seems to start at an early point of the cultivation and stop almost entirely when the plants are later grown under drier conditions.

*Pestalotia funerea* is a fairly common fungus which may cause withering of small plants and shoots of larger plants. Damage by this fungus was registered in azalea, camelia, rhododendron and thuja.

**Leaf disease of plane** (*Gnomonia veneta*) was very widespread during the early summer. The rainy weather seems to have been ideal for spreading the fungus.

**Black scurf** (*Rhizoctonia solani*) causes much damage in small plants. The most severe damage, for instance on begonia, usually occurs when the cuttings are taken, as the fungus is favoured by the high humidity.

**Pear scab** (*Venturia pirina*) was very common, especially in private gardens. Usually, the attack started around the main nerves of the leaves and resulted in withering of the leaf.

**Strawberry mildew** (*Sphaerotheca macularis*)

Severe attacks were seen in Zephyr where both leaves and fruits were damaged. In other varieties, the attacks were limited to the leaves.

**American gooseberry mildew** (*Sphaerotheca mors-uvae*) was very widespread in blackcurrant where bushes with white shoot tips were quite common.

**Blackcurrant rust** (*Cronartium ribicola*) was mostly seen in private gardens, but a number of attacks were seen in commercial orchards.

## 4. Pests in horticultural plants 1986

**Leaf and bud nematodes** (*Aphelenchoides fragariae*) were found in many strawberry-growing areas. The many registrations may be connected with the fact that many plants were damaged during the winter, so that more attention was paid to the growth of the plants.

**Millepedes** (*Blaniulus guttulatus*) caused damage to strawberries and potatoes as well as windfalls. In many cases, it appeared that insufficiently decomposed manure had been used for the cultures, so that large quantities of millepedes were introduced in this way.

**Thrips** (*Thysanoptera*) caused damage to many different plants. Attacks by the common thrips species were seen in cyclamens, carnations and roses. Besides the wellknown thrips species, another flower thrips (*Frankliniella occidentalis*) appeared. This thrips stays inside the flowers where it is well protected against control. Investigations show that it is extremely resistant to many kinds of control agents. This thrips species has been found on dendranthema, gerbera, schlumbergera, rose and saintpaulia.

**Chafer beetles** (*Phyllopertha horticola*) are still quite common on the light soils in the middle of Jutland where the gnawing of the larvae are seen in lawns and sports areas.

**Blossom beetles** (*Meligethes aeneus*) are particularly noticeable when the second generation appears as it attacks many different crops. Damage was seen on cauliflower and fuchsia.

**Pea and bean weevils** (*Sitona lineata*). These weevils seem to increase in number all the time. It is not unusual to see damage to the foliage of the small plants. Later the damage is seen for instance on fuchsia and strawberries.

**Cabbage stem weevils** (*Ceutorhynchus quadridens*) have a preference for Chinese cabbage where the larvae are found deep inside the head.

*(Arge pullata)* are still causing damage at the known localities. It has not been registered in any new areas in 1986.

(*Spodoptera littoralis*) has again been imported together with cuttings from Eastern Mediterranean regions. The pest is noticed as the larvae are voracious, and control is difficult.

**St.-Mark's flies** (*Sciaridae*) may cause damage in many cultures, especially when cuttings are used for reproduction in greenhouses. Frequently, damage done by the larvae is the reason why secondary parasites attack the plants. Poinsettia and chrysanthemum are favourite feeds for the flies.

**Gall mites** (*Eriophyes*) were registered on many different plants. Outdoors, attacks were seen on acer, alnus, fraxinus, plum and pear. In greenhouses, laurel and yucca were attacked.

## IV. BOTANY DEPARTMENT, Ib G. Dinesen, Acting Head of Dept.

### Experimental work

### Bacterial diseases (Ib G. Dinesen and Karen Jørgensen)

**Bacterial ringrot of potato** (*Corynebacterium sepedonicum*)

As in 1985, the number of samples for testing was rather low. The material tested was plantlets produced at the Virology Department, which amounted to about 300 samples. 350 samples were tested for the Plant Protection Service.

**Healthy nuclear stock plants**

In connection with the renewal of the nuclear stock plants at the Institute of Glasshouse Crops, the bases of cuttings were examined for plant-pathogenic bacteria. *Dieffenbachia maculata* were examined for *Erwinia chrysanthemi* and *Pelargonium hortorum* for *Xanthomonas pelargonii. Hedera helix, Ficus benjamina, Nephrolepis exaltata* and *Schefflera arboricola* were also tested. All the samples were free from plant-pathogenic bacteria.

The Institute of Glasshouse Crops was visited regularly to make sure that the nuclear stock plants were still free from symptoms.

22 varieties of *Begonia elatior* are now being cleaned by meristem-tip culture. The tube plants are examined twice for *Xanthomonas begoniae* before delivery to the Institute of Glasshouse Crops.

Amongst the future nuclear stock plants are *Pelargonium* cultivars, clones of *Epipremnum aureum* and a *Dieffenbachia* variety. These were examined for plant-pathogenic bacteria.

### Fungal diseases

**Take-all and eyespot in cereals (H. Schulz)**

**Take-all** (*Gaeumannomyces graminis*). In 1986, the total number of stubble samples examined for take-all was 1010. The attacks in spring barley were at a lower level than in 1985. In winter barley, no fields were found with infection of more than 20% of the root mass. In winter wheat and winter rye, infection of more than 20% of the root mass was found in as little as 3% of the fields examined.

**Eyespot** (*Pseudocercosporella herpotrichoides*). In the spring, about 350 samples of winter crops were examined for eyespot with a view to prognoses, warning

and guidance about treatment. Climatic observations and spore counts showed that the primary infection possibilities were at the beginning of October. The infection level in the spring was generally the same as in the year 1984/85.

It was estimated that treatment was necessary in about 50% of the wheat fields and about 40% of the rye fields.

The summer estimates of 1010 samples showed weaker and less widespread attacks of eyespot than in 1985.

**Sharp eyespot** (*Rhizoctonia cerealis*) occurred in 60% of the fields with spring barley and in 35% of the fields with winter barley.

In 80% of the fields with winter wheat and in 47% of the fields with winter rye, sharp eyespot was found, but always with a rather low level of attack.

**Economic threshold values for leaf diseases in cereals (Sten Stetter)**

Epidan is a computer-based program which enables the farmer to treat spring barley fields with about half the normal quantity of fungicides, and consequently with a higher financial yield. The program is part of a larger computer program called "Optimal Plantebeskyttelse" (optimal plant protection), which was tested by agricultural advisers in 1986. In 1987 this program will be in general use by most advisers.

Now and in the near future, only a few computers are used in Danish agriculture, and the program can be used on less than 1000 barley fields. Therefore, a simplified system - Mini-Epidan - will be published in 1987. Mini-Epidan has some limitations, but can still be used on most barley fields by farmers who do not own a computer.

A similar program for winter wheat is being developed, and the first experimental program will be tested in plot experiments in 1987.

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

For 3 years, experiments with variety mixtures in winter barley have been carried out at the localities Rønhave, Roskilde and Tåstrup. In 1986 the varieties Igri, Marinka, Gerbel and Hasso were examined. The attack level of net blotch and barley scald was lower in mixtures of these varieties than in the individual varieties. The level of mildew attacks was low in all varieties.

The highest yield increase was 2.0 hkg/ha without use of fungicides, but there were big variations between localities, which is in agreement with experiences from 1984 and 1985.

Treatment with the fungicides Bayleton 25 WP or Tilt 250 EC was not profitable.

**Mildew disease pressure in winter barley after different numbers of fungicide applications (Boldt Welling, Jørgen Simonsen and Fynbo Hansen)**

After 0, 1 and 2 fungicide treatments with Bayleton 25 WP or Tilt 250 EC, the disease pressure of mildew was assessed at the localities Rønhave and Foulum. The mildew level was monitored in neighbouring spring barley fields without resistance (cv. Gunhild) and in mobile nurseries with the non-resistant variety Pallas. In the past two years, the mildew level was very low giving insignificant results.

**Storage fungi (Boldt Welling and Anita Idoff)**

Studies of the content of storage fungi in samples were carried out in cooperation with the National Institute of Natural Sciences. The results were published in leaflets 603 and 622, 1986, from the Institute.

**Diseases in grass for seed production (Boldt Welling and Anton Nordestgård)**

For 3 years, the occurrence of leaf pathogens and saprofytes have been monitored in untreated plots and plots sprayed with Tilt 250 EC.

It was very difficult to find any correlation between disease occurrence and yield. Sometimes there was a positive correlation, and sometimes it was negative.

It was concluded that it was very difficult to advise farmers as to when fungicide treatment of grass for seed production was profitable.

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

A Danish national virulence survey was initiated in 1985. Until now, the investigations have concentrated on powdery mildew in barley and wheat, but very soon the activities will be extended to include net blotch and spot blotch of barley.

Two different methods are used:

a. Estimate of virulence frequencies based on colony countings on seedlings in mobile nurseries exposed at 8-10 localities several times a year.

b. Determination of virulence gene frequencies by genotype testing of single-colony isolates.

In both cases, the differentials were near-isogenic lines on a Pallas background of barley, and near-isogenic lines of wheat on a Chancellor background.

**Mildew of barley**

The results showed that the efficiency of specific powdery mildew resistance varied very much among the varieties. Totally resistant varieties were found as well as some which were just as susceptible as Pallas, which is the susceptible control.

Frequencies of Ml-a13 (Rupee) and Ml-a3 (Ricardo) virulence were below 5% in general. Thus varieties containing Rupee or Ricardo resistance and Apex with ml-0 resistance had the most effective powdery mildew resistance among the Danish spring barley varieties. On the other hand, varieties containing Ml-a6 (Spontaneum) or Ml-g (Weihenstephan) were extremely susceptible to the Danish powdery mildew population, which was demonstrated by virulence frequencies near 100.

**Mildew of wheat**

Widely grown varieties such as Kraka, Anja, Vuka and Disponent were all very susceptible to the Danish population of wheat powdery mildew. Among the varieties on the Danish list of recommended varieties, Kosack and Sleipner had the most effective powdery mildew resistance in 1986.

**Barley yellow mosaic virus and its fungal vector *Polymyxa graminis* (Lilian Kloster)**

The occurrence of 'barley yellow mosaic virus' BaYMV was investigated in 27 winter barley fields on Zealand, Lolland, Falster and in the southern part of Jutland close to the Danish-German border. Samples of field-grown winter barley were tested for the presence of virus and the fungal vector *Polymyxa graminis*. The virus was not detected in any sample. *P. graminis* was found in 4 out of 15 samples.

70 soil samples were taken by the end of 1985 and in May 1986 from fields where winter barley had been grown at least one time during the past 4 years. The samples were examined using winter barley (Igri) as susceptible control. The

virus (BaYMV) was not found in any samples. *P. graminis* was observed in 39 of the 70 soil samples corresponding to 56% of the fields examined.

**Rhizomania and its fungal vector Polymyxa betae (Lilian Kloster)**

The occurrence of the 'beet necrotic yellow vein virus' (BNYVV) causing *Rhizomania* in *Beta vulgaris* was examined at 29 localities with beets. The virus was not detected in any sample. Fur further detail, see the Virology Department section of this report.

Soil samples from 97 and 29 beet fields were examined in 1985 and 1986, respectively, for the root-parasitizing fungal vector *Polymyxa betae* Keskin using a beet seedling bioassay. *P. betae* was present in 85% of the soils examined in 1985 and in 79% in 1986. The fungus was not observed in roots of young sugar beet plants grown in the field in 1985, probably because of damage to the roots during transport. At harvest in 1986 *P. betae* was found in the roots in 5 out of 8 sugar beet samples. No difference in the degree of attack from the fungal vector was observed neither (a) when untreated or seed-dressed sugar beet seeds were used, nor (b) in beet seedlings of varieties tolerant or susceptible to the virus.

**Fungal diseases in rape (Lone Buchwaldt)**

Warnings were issued against attacks of stem rot (*Sclerotinia sclerotiorum*) in winter and spring rape. In 1986, respectively 29 and 33 agricultural advisers reported on apothecia sprouting from overwintering sclerotia in depots laid down all over the country in winter and spring rape. Based on this information and data on precipitation, prognoses concerning the risk of attacks in winter rape were sent out on the 21st May and on the 1st July concerning spring rape. There were very few apothecia in winter rape because of little precipitation and low temperatures, which removed the risk of attacks. In spring rape, however, the first prognosis mentioned risks of attacks in Central and Southern Zealand, in Northwestern Jutland and around Horsens. During the following weeks with dry weather, the risk was reduced, and attacks of stem rot were only seen in a few fields in Central and Southern Zealand.

Control measures against other diseases like grey mould, downy mildew and dark leaf spot was not necessary.

**Pea diseases (H. Schulz)**

In 1986 the pea diseases grey mould (*Botrytis cinerea*) and leaf spot (*Ascochyta* spp.) occurred with relatively weak attacks in the fields. Weak attacks of downy mildew (*Peronospora pisi*) were seen in a few fields. Attacks of *Fusarium solani* f.sp. *pisi, Fusarium oxysporum* f.sp. *pisi, Rhizoctonia solani, Cylindrocarpon* sp. as

well as various other Fusarium fungi were seen in fields where peas had frequently been grown.

Generally, only very weak attacks of the known diseases in peas were found by systematic observations in a large number of fields and in connection with the experiments with fungicide control.

Examinations of a number of seed samples harvested in 1986 showed relatively weak seed infections by grey mould, *Ascochyta* spp. as well as various *Fusarium* fungi, compared with 1985.

**Diseases on sour cherry (Karen Jørgensen)**

Investigations of the diseases occurring in sour cherry are carried out in cooperation with the Institute of Pomology.

Microscopic examination of leaves with cherry leaf spot disease showed that *Blumeriella jaapii* develop ascospores during the spring. The ascospores constitute the primary inoculum and are ejected shortly after rain.

Sensitivity of blossom wilt (*Monilia laxa*) to fungicides was tested in the laboratory. Benzimidazoles and six other fungicides that inhibit either nuclear processes or sterol biosynthesis were tested. The isolates were sensitive to benzimidazoles as well as to the other fungicides investigated.

In cooperation with the Virology Department the spread of Prunus necrotic ringspot virus was investigated. The virus appears in spots. Within a few years the virus will spread to several of the adjoining trees.

**Downy mildew (*Bremia lactucae*) in lettuce (Kirsten Thinggaard and Henrik Alb. Jørgensen)**

New varieties of lettuce for use in Danish glasshouses and in the field were tested for resistance.

The physiological races of *Bremia lactuace* received from growers with attacks were determined in the laboratory, and advice about the choice of cultivars was given to the growers.

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

Root rot caused by *Phytophthora* and *Pythium* is a problem in vegetables as well as in potted plants grown in greenhouses.

An investigation of root-pathogenic *Phytophthora* and *Pythium* species in nurseries with recirculating watering systems was started in 1986. The biology of the fungi is examined, including their dispersal and multiplication in the growing systems. A strategy for protection against *Phytophthora* and *Pythium* will be prepared.

**Diagnostic work (H. A. Jørgensen, Bent Løschenkohl, Karen Jørgensen and Ib G. Dinesen)**

In the course of the year, the Botany Department received 441 plant samples for diagnoses of bacterial and fungal diseases. It was mostly a matter of horticultural plants.

## V. VIROLOGY DEPARTMENT, H. Rønde Kristensen

### 1. Experimental work

The most important work of the department is the development of reliable and preferably quick and cheap diagnostic methods, investigating the transmission and spread of virus diseases (including their influence on growth and yield), and procuring knowledge about methods for prevention and control (e.g. thermotherapy and tissue culture, etc.) of virus diseases.

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.

The ELISA method has also been used in many tests as well as the dot-immuno-binding technique, which has been adopted for detection of viruses in seeds. In the diagnostic work, electrophoresis (agarose-electrophoresis and polyacrylamino-electrophoresis) has also been applied.

The investigations of virus diseases in agricultural plants have been continued, especially with regard to potatoes, beetroot and cereals.

The work on virus diseases of nursery plants (fruit trees and soft fruits included testing, in particular by use of indicator plants). Furthermore, therapeutic work was carried out, involving thermotherapy and tissue cultures.

In tomatoes and pepper, the work on different strains of tobacco mosaic was continued, and in ornamental plants, experiments were carried out with viruses of *Pelargonium, Begonia, Aeschynanthus, Dipladenia, Arabis, Pentas* and *Hemerocallis*.

During the year, members of the scientific staff at the Virology Department undertook 28 journeys abroad, and the department received visitors from 17 countries.

The number of publications issued by staff members was 51.

**Potato mop-top (Bent Engsbro)**

The first time internal rust was observed as a serious disease in the tubers of the potato variety 'Saturna' was in 1974, only a few years after the introduction of this variety, and in 1985 the Institute of Plant Pathology was involved in investigations of the disease.

According to our varietal trials and our knowledge about rattle virus, the cause could not be the strain of rattle virus common in Denmark, as the 'Saturna' variety had demonstrated high tolerance towards this strain in all the trials carried out here as well as in Sweden.

Therefore, soil samples from infested fields were investigated in both 1985 and 1986 for other strains of rattle virus, but none were found.

The soil samples were air-dried for two months at room temperature, and N. tabacum Debneyi was used as bait plant.

Samples from both roots and leaves of the bait plants were mechanically transmitted to test plants by sap inoculation. Systemic symptoms typical of potato mop-top occurred in *N. t.* Debneyi and *N.* clevelandii. In *N. t.* Xanthii, a faint mosaic could be seen in the leaves.

Local lesions along the veins occurred in *Ch. quinoa* and *Ch. amaranticolor.*

From the tobacco varieties the virus could be mechanically transmitted, but not from *Chenopodium.*

Under our conditions, symptoms have not been observed on the potato tops.

Samples from test plants were sent to B.B.A., Braunschweig.

Dr. D. Lesemann kindly made the ISEM test and confirmed that potato mop-top virus was present. However, particles of potato mop-top could not be seen in the electron microscope, probably because of the low concentration of virus. The presence of this virus was later confirmed at our own laboratory by ISEM by means of antiserum kindly provided by Dr. P. R. Mills, Belfast.

Examinations for *Spongospora subterranea*, which is the vector of potato mop-top virus, showed no attacks on the tubers of the 'Saturna' potato variety, but the fungus was present on the roots.

In the summer of 1986 experiments with eradication of the disease in infested fields were carried out using the chemicals D-95 (250 l/ha) and Basamid (400 kg/ha). No effect was seen with D-95, but internal rust in the tubers decreased from 45 to 15% by the use of Basamid.

In 1986, varietal trials carried out in infested fields showed that the 'Saturna' potato variety was the most susceptible, with 27% infected tubers. Weak infections of 1-7% of the tubers were found in 4 of the 20 varieties investigated.

The potato mop-top disease has now spread to a number of areas, especially in the middle of Jutland, but so far, it has only been a problem on the 'Saturna' variety.

This is the first report on potato mop top in Denmark.

Virus diseases in fruit trees (Arne Thomsen)

**Plum pox virus**

Attacks of plum pox virus were registered for the first time in Denmark in September 1986.

The attacks were found in 9 plum varieties in a four-year-old experimental plantation on the island of Funen. It has not yet been possible to detect the source of infection, but in order to prevent further infection, action has been taken to clear away all the trees of the plantation.

**Apple root stock meristem-tip culture**

Adventitious shoots are developed in vitro from apple mosaicinfected leaves of apple, root stock 'M 26' and 'Virginia Crab'.

Rooted shoots will be investigated for virus infection and genetic stability.

Plants with roots have been established from meristem-tip cultures of four different clones of the apple root stock 'M IX'.

In identical multiplication medium, a great difference in multiplication rate is found among the clones. In all four cultures, pathogenic bacterial infection is found.

Virus diseases in fruit bushes (Arne Thomsen)

**Blackberry, meristem-tip culture**

In 1982, 25 meristem-tip cultures were established from blackberry with raspberry ringspot virus. Tests carried out in 1984 showed no infection in 20 plants which had survived.

## Virus diseases in hedge plants (Arne Thomsen)

*Ligustrum vulgara,* Arabis - and raspberry mosaic virus

Arabis mosaic virus in combination with raspberry ringspot virus was found in Ligustrum vulgara by indicator plants and electron microscopy. The symptoms in Ligustrum were pale green mottling on the leaves and reduced growth of the plants.

## Forest plants (A. Thomsen)

*Betula pendula*, **meristem-tip culture**

In connection with the EEC (Cost 87) programme, rooted plants of material of Betula pendula have been produced. The multiplication rate was high. The number was 4-7 new shoots per single shoot if the shoot tip and nodal segments were used. If the basal part (callus) was used, about 50 meristem shoots per shoot could be obtained. All plantlets were rooted.

*Quercus robur* **meristem-tip culture**

In connection with the EEC (Cost 87) programme, experiments with meristem-tip culture have been started. It seems to be much more difficult to establish meristem-tip culture of *Quercus* than of *Betula*.

## Virus diseases in vegetables (Niels Paludan)

**Inactivation of tobacco mosaic virus (TMV) in plant sap**

An effective inactivation of 4 different TMV strains in infected plant sap was achieved in 1985 by trinatrium phosphate (1%) with addition of the detergent 'Teepol'-610 (1%) during 1 hour's treatment.

This year, the glutar-aldehyde 'Glucid' (10%) was compared with trinatrium phosphate (10%) with addition of the detergent 'Lissapol Plus' (1%), which is identical with 'Agral'. The treatments took place immediately after mixing, and after 5 and 15 minutes, respectively. Detached leaves of Nicotiana t. 'Xanthi' were used for local lesion assay.

The results showed that neither of the solutions were able to cause sufficient inactivation of the TMV strains.

The trinatrium phosphate was more effective than the 'Glucid', with an effective inactivation of the TMV strains MDG, pepper-8 and tobacco after 15 minutes, but only in the dilutions $20^{-5}$ and $20^{-6}$. The tomato strain was too resistant for a complete inactivation.

**Inactivation of different TMV strains in pepper seed**

One-year-old pepper seed harvested from infected plants were used for inactivation experiments comprising 10% trinatriumphosphate and 1% detergent 'Lissapol Plus' with 2 hours' treatment.

Complete inactivation was achieved for the TMV strains tomato, tobacco and pepper-8, while the virus concentration of MDG was much reduced.

**Virus diseases in ornamental plants (Niels Paludan and Arne Thomsen)**

*Pelargonium x hortorum.*

The COST-87 programme concerning the elimination of pelargonium flower break virus (PFBV) and tomato ringspot virus (TomRV) by tissue culture and heat treatment was finished in 1986. A total of 826 ISEM tests were carried out at the Institute of Plant Pathology in Lyngby.

In untreated material the PFBV was not present in 48 per cent of 108 in vitro plants or in 75 per cent of 151 potted plants. The corresponding figures for TomRV were 44 and 22 per cent, respectively.

In heat-treated material the PFBV was not present in 97 per cent of 62 in vitro plants or in 100 per cent of 38 potted plants. The corresponding figures for TomRV were 97 and 92 per cent, respectively.

*Begonia elatior*

**Infection trials** using sap and dry inoculation with 0.03M and 0.2M phosphate buffer to *Nicotiana megalosiphon* and *Chenopodium quinoa* were carried out from 5 different begonia plants showing leaf curl. Based on 2 repetitions only 1 reaction in Chenopodium was achieved using dry inoculation and 0.2M buffer. The virus transmitted was identified as carnation mottle virus by the ISEM method.

**Storage** of *Begonia tuberhybrida* 'Pendula' in vitro plants during 1 year at 12°C (16 hours of illumination followed by 8 hours of darkness) was carried out successfully in a 50 per cent MS-62 medium without any growth substances. 83 per cent of the plants survived as vital plants which could be used for further multiplication.

*Aeschynanthus hildebrandii*

TMV-infected *Aeschynanthus* was diagnosed further. The virus strains tomato-MDG (Para) and pepper-8 were all identified. The TMV-MDG strain could be transmitted by both *Nicotiana glauca* and *Eryngium bourgatie*, but not by tomato.

Storage experiments with in vitro plants during 1 year showed a high survival rate (96 per cent) at 20°C in a 50 per cent MS-62 medium without any growth substances. All plants died at 3 and 12°C.

*Dipladenia sanderi*

Infection trials using both sap and dry inoculation to different indicator plants have shown that *Nicotiana benthamiana* is sensitive and develops mosaic symptoms after 28 days. Poty-like particles were observed by EM, and physical investigations showed: TIP less than 50°C, DEP undiluted sap and LIV 2 but not 4 days. The virus was sap-transmitted to *N. megalosiphon* causing many chlorotic spots.

Serological reaction was achieved with a bean yellow mosaic virus antiserum from Renate Köenig as well as from a Danish Gladiolus BYMW-isolate.

Furthermore, TMV was transmitted to *N. benthamiana* (the tomato and tobacco strain of TMV), and TMV-particles were observed by ISEM directly in sap from *Dipladenia* leaf. TMV infection in *N.b.* caused a very strong yellow chlorosis and curling of the leaves followed by wilting.

Mixed infection of the 2 viruses was found in N.b. plants. In some of these plants only mild mosaic and a slight deformation occurred after about 1 month, while very strong symptoms (chlorosis and curling) developed in other plants after only 1 week.

*Arabis caucasica*

Meristem-tip plants have been established from untreated and heat- treated plants infected with tomato black ring virus. The virus was inactivated after 2 months at 34°C (96 per cent), but neither from 2 months at 30°C nor from untreated plants.

*Pentas lanceolata*

Meristem-tip plants have been established most favourably in a 50 per cent MS-62 medium in combination with 1 mg Kinetin and 0.2 mg IBM. Vitrification was prevented by sealing the tubes with loose caps.

The plant material was infected with tomato ringspot virus, but none of the 109 meristem-tip plants established were virus-free by the tissue culture.

*Hemerocallis* sp.

Meristem-tip plants have been established in a 50 per cent MS-62 medium with addition of 1 mg Kinetin and 0.2 mg IBM, without any transplantations.

The mother plants were grown in a sterile medium (Grodan) to prevent contamination of the meristem tips, which were all located at the base of the plant. The excised plant material was desinfected by means of 3 per cent Korsolin over a period of 200 minutes.

None of 23 meristem-tip plants established were free from arabis mosaic virus.

**Water samples**

Samples of recirculated nutrient water from 9 different nurseries have been collected every months from June 1986. The samples were tested for viruses by biotest in combination with ISEM. Each sample was sap-inoculated direcly to *Chenopodium quinoa* before and after concentration of 80 ml water, by 2 hours' centrifugation at 80.000 G, the sediment resolved in 2 ml.

Virus was found in the water from 3 nurseries and was diagnosed as TMV strain A, TMV strain tobacco, tomato and MDG and a virus not yet identified, respectively.

**Nuclear stock plants**

In 1986 the following species and varieties of ligneous ornamentals were examined and found free from virus:

*Ilex aquifolium*
*Ligustrum vulgare* 'Lodense'
*Lonicera xylosteum*
*Philadelphus* 'Aureus'
*Philadelphus coronarius*
*Philadelphus microphyllus*
*Philadelphus pubescens*
*Philadelphus* 'Schneesturm'
*Philadelphus* 'Watereri'
*Populus trichocarpa*
*Populus* 'Oxford'
*Populus* 'Pindstrup'

*Populus* 'Verreken'
*Rhododendron* 'Coccinea speciosa'
*Rhododendron* 'Fanny'
*Rhododendron* 'Hortulanus H. Witte'
*Rhododendron* 'Irene Koster'
*Rhododendron* 'Pallas'
*Rhododendron* 'Persil'
*Rhododendron* 'Satan'

**Electron Microscopy (Jens Begtrup)**

During the year, more than 4000 EM analyses were carried out with the ISEM technique. The EEC programme (COST 87) was finished with good results, and new projects were started.

The immunogold technique and testing with monoclonal antibodies were tried out for a period in the daily work with ISEM, but none of the methods was any improvement as regards a quick survey of virus diseases. The monoclonal antibodies are too specific for routine work, which requires a wider spectrum of not too specific antibodies. The immunogold method is best for section work and is only in very rare cases OK for ISEM work (when the concentration is very low).

The two soil-borne viruses barley yellow mosaic and beet necrotic yellow vein still have not been detected in Denmark. Many samples were examined with ISEM - with negative results.

Of the new viruses in Denmark revealed by means of the ISEM technique, the following should be mentioned: pelargonium flower-break in Aeschynanthus. *Helenium* virus-S in *Helenium* sp. An unknown rod-shaped approximately 750-nm-long virus in *Dipladenia*. Our antiserumbank has been increased by 20 new numbers (the total number is approximately 200).

A method of rotating the grids during the ISEM procedure increased the number of virus particles by about 10%.

**Serology and biochemistry (Morten Heide)**

The aim of the laboratory is to develop diagnostic procedures for the detection of plant pathogenic bacteria and virus.

**Immunological routine-testing methods**

Dot immunobinding (DIB) is immunological detection of antigens fixed on membranes. DIB was tested on a range of bacteria and virus. The method was

evaluated for potato viruses (PLV, PVM, PVS, PVX and PVY) for a number of seed-borne viruses (Barley stripe mosaic virus, bean common mosaic virus, pea seed-borne mosaic virus, squash mosaic virus) and for three different bacteria (*Corynebacterium sepedonicum, Agrobacterium tumefasciens, Xanthomonas campestris*). DIB was found generally applicable for routine testing for plant diseases where high-grade antiserum is available. The sensitivity and detection limits of the method was found to be within the same range as for ELISA for most diseases.

A range of experiments were carried out to evaluate different procedures to be recommended for routine application.

**Electrophoretical methods**

Species and isolate differentiation for bacteria and fungi was carried out by electrophoresis of protein extracts.

For species differentiation of not closely related species, SDS Polyacrylamid gelelectrophoresis and Comassie protein staining was found suitable for routine indexing of isolates.

For differentiation of closely related species (e.g. in the case of *Pyrenophora teres* and *Pyrenophora graminea*), isoelectric focusing combined with isoenzyme staining was used with success.

**Anti-serum bank**

The institution maintains an anti-serum bank against plant-pathogenic bacteria and virus. Routinely, antisera are produced against current plant-pathogenic pests, and samples are exchanged with institutions domestic and abroad. The bank presently includes more than 480 numbers covering more than 100 organisms.

**2. New attacks 1986, Niels Paludan and Arne Thomsen.**

| | |
|---|---|
| *Aeschynanthus hildebrandii* | TMV-MDG-strain |
| *Agapanthus praecox* | Nerine virus X |
| *Campanula poscharskyana* | Poty-like virus particles |
| *Cucumis sativus* | Pale fruit |
| *Dieffenbachia picta* | Dasheen mosaic virus (1981) |
| *Forsythia intermedia* | Arabis mosaic virus |
| *Hedera helix* | Raspberry ringspot virus |
| *Mahonia aguifolium* | Nepo virus |
| *Narcissus poeticus* | Arabis mosaic virus |
| *Pelargonium x hortorum* | TMV-tomato strain |

| | |
|---|---|
| *Pereskia grandiflora* | Cactus virus X |
| *Philadelphus coronarius* | Raspberry ringspot virus |
| *Prunus domestica* | Plum pox virus |

## VI. ZOOLOGY DEPARTMENT, J. Jakobsen

### 1. Routine examinations

Soil samples from seed potato fields and nurseries were examined for content of potato cyst nematodes.

The number of samples from seed potato fields was 4,600. Potato cyst nematodes were found in 44 samples. Altogether 6,400 samples were examined.

For the "Vandel" potato breeding station, new potato crossings were tested for resistance against potato cyst nematodes. Most of the crossings were tested against pathotype Ro-1, and a number of selected crossings were also tested against PA-2 and PA-3. The tests against resistance to PA-2 and PA-3 are based on potato cyst nematodes originating from the Netherlands.

A number of soil samples were tested for occurrence of cereal cyst nematodes and beet cyst nematodes.

### 2. Experimental work

**Plant parasitic nematodes (Lars Monrad Hansen)**

Soil samples from fields on two sites in Jutland where long-term experiments with different types of growing systems will take place have been examined for cyst-forming and migrating plant- parasitic nematodes.

**Interaction between growth of spring wheat and cereal cyst nematodes (Werner Riedel)**

The influence of cereal cyst nematodes on the development and yield of spring wheat was examined in greenhouse and field experiments. Attacks of cereal cyst nematodes strongly influence the growth of the roots. The development of roots below 40 cm was much retarded on the infested plants compared with roots of healthy plants.

**Registration of virus-transmitting aphids in selected seed potato fields (J. Reitzel)**

In 15 potato fields in Jutland, aphids were trapped in yellow trays with water and detergent from the end of June to the end of August. The aphids caught in the traps were collected twice a week, and those belonging to important virus vector species were counted. Peach potato aphids and *Myzus euphorbia* are the most important species acting as virus vectors in Danish potato fields. Information about the aphids caught was sent to the Plant Protection Service where it

was part of the data used for fixing the date for haulm destruction of seed potatoes to prevent infection with virus diseases.

**Identification of insecticide resistance in populations of peach potato aphids from beet fields**

In connection with the general warning service established by the growers' association in the sugar beet growing area in the southern part of Zealand and on the island south of Zealand, samples of peach-potato aphids were examined for resistance against insecticides.

The examinations are based on the registrations of the esterase quantities in the aphids. A number of the samples showed a high level of resistance to insecticides. In several cases, the resistant populations of peach-potato aphids originated from glasshouses situated close to sugar beet fields.

**Aphids in cereals (Jørgen Jakobsen)**

Semi-field experiments were carried out to estimate the damage threshold for the three important species of aphids in cereals: the bird-cherry aphid, the grain aphid and the rose-grain aphid.

Aphids were introduced at different growth stages of barley (from 7 to 10.5 Feekes), and the effect on the yield was registered.

In another experiment, aphids were introduced at growth stage 7, and parts of the aphid-infested plants were treated with insecticide (Vydate) at weekly intervals.

The experiments showed that a reduction in yield could be registered after aphid attacks until G.S. 10. Besides, the results indicate that the plant can compensate for up to two weeks' attacks by aphids at the early growth stages (up to 7 Feekes).

The most damaging species to barley was the bird-cherry aphid, followed by the grain aphid and the rose-grain aphid.

The results cannot be applied directly to field conditions, but they give an indication of the threshold levels of aphid attacks on barley.

**Registration of aphids and fungal diseases in spring barley (Lars Monrad Hansen)**

An electronic data processing system for estimating the need for control measures against diseases and pests in spring barley fields has been developed. It has been in use since 1983.

The language of the system is DATAFLEX, and it is fed into a microcomputer Supermicro-32 provided with the operative system CP/M-80.

A total of 326 growers took part in the registration in 1986. The average number of registrations was 4.7. Experiences from recent years show that in order to participate in a registration system like this the growers must be prepared to make registrations approximately five times during the season (20th May-15th July). A little less if there are only few pests and diseases, and a little more if they are widespread.

**Aphids**

The average percentages of straws with aphids for all untreated fields were:

| Week number: | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|
| Aphid percentage: | 0 | 1 | 3 | 8 | 10 | 14 |

On the whole, aphids cannot be said to be a serious problem in 1986.

**Mildew**

The average percentages of straws with mildew in all untreated fields was:

| Week number: | 22 | 23 | 24 | 25 | 26 | 28 |
|---|---|---|---|---|---|---|
| Mildew percentage: | 2 | 7 | 9 | 10 | 8 | 5 |

The attacks of mildew were also limited in 1986.

**Rust and net blotch**

The occurrence of rust and net blotch fungi was very moderate, and control measures were only recommended in one case.

**Warnings**

The registrations received during the weeks number 23-27 were used as a basis for weekly 'Plant Protection Bulletins' giving a survey of the occurrence of aphids and mildew in the various regions. These Bulletins are also sent to the agricultural advisers, who may use them for their telephone and TV information service. In this way, the growers may get a fairly correct idea of the aphid and fungus occurrence in the individual regions, so that growers who are not part of the system may have an idea of when it is time to examine their fields in order to decide about control measures.

**Insecticides**

On an average, 0.5 insecticide treatments took place in the fields where the registrations were made.

51% of the fields had 0 insecticide treatments
49% of the fields had 1 insecticide treatment
2% of the fields had 2 insecticide treatments

Generally, it could be said that in a number of cases insecticides were applied although the damage threshold had not been passed. The insecticides were all applied in connection with control of fungal diseases. About 50% of the fields were treated with insecticides, but actually it was only necessary in about 30%. Results from recent years show that insecticides are applied in 50-60% of the spring barley fields in years resembling 1986 where the occurrence of aphids and other pests is on the whole very limited.

**Fungicides**

On an average, each field received 1.0 fungicide treatments. This corresponds to the national average. The treatments were as follows:

27% of the fields received 0 fungicide treatment
48% of the fields received 1 fungicide treatment
24% of the fields received 2 fungicide treatments
1% of the fields received 3 fungicide treatments

**Pests in oil seed rape (Fritjof Lind)**

First and second generation of brassica pod midges were registered by means of hatching traps set up on several localities in Denmark. Information about the hatching time was used to warn growers of the risk of attacks by brassica pod midges.

Besides, a number of traps were placed in fields with winter oil seed rape to trap second-generation brassica pod midges. A number of pod midges and plant samples were collected, and information about the yield was given by the growers. Calculations were made to establish the correlation between the number of midges, pesticide treatment and yield.

**Investigations of leaf weevil occurrence in field peas (Carsten Strøm & Jan Westh Christensen)**

The migration of leaf weevils into pea fields in the spring was investigated by means of yellow sticky traps, and the population density in the pea field during the growing season was registered by means of pitfall and emergence traps. The number of eggs and larvae in the soil samples was counted.

The migration into the field lasted for about 4 weeks with the highest migration at the end of May. The density of eggs was around 50,000 per m, and

the number of second-generation adults was 600 to 800 per m in the two years investigated (1985-86).

A good correlation was found between the number of leaf weevils trapped on the yellow sticky traps and the population density in the field.

**Monitoring of the turnip moth (*Agrotis segetum*) with sex traps and forecasting of cutworm attacks (Peter Esbjerg)**

The turnip moth was monitored on some 40 localities with field vegetables using 3 traps at each locality. In comparison with 1984, there was a considerable decrease in the catches all over the country. However, two forecasts were issued for localities with catches of 10-15 moths per 3 traps per night or more for at least a week in combination with almost no precipitation for 2-3 weeks. Damage assessments of treated/untreated carrots and at harvest revealed very few and low attacks - so low that the treatment could have been omitted at a number of localities. Presumably, the reason for this was the considerable mortality of 1st-2nd instar larvae caused by low temperatures.

**Cutworm mortality and growth as a function of food, temperature and soil moisture (Peter Esbjerg)**

As part of a project supported by the Danish Council for Agricultural and Veterinary Research, the food value of different root crops was investigated using individual cutworms in incubators. Besides, experiments were carried out to examine food preference as well as growth and mortality at different temperatures (in incubators). As expected, the preliminary results indicated that the growth rate was very much dependent on the temperature. However, it turned out that mortality was much more dependent on temperature than anticipated. Carrots were preferred to onions and red beet, and feeding on onions seems to lead to a lower growth rate than for example feeding on carrots.

A semi-field setup of 240 buckets with carrots and released cutworms was used to investigate the influence of varying soil moisture. Increasing soil moisture also increased the mortality among cutworms, but small cutworms were much less sensitive than larger ones.

**Carrot-fly (*Psila rosae*) forecasting based on catches in orange sticky traps (P. Esbjerg)**

Yellow sticky traps were used for a 10-week period (July-September) for monitoring the flight of carrot flies in carrot fields (5 traps per field). As basis for the decisions about the control, some preliminary threshold values were used. If the weekly catch in 5 traps was below 16-17 flies, no treatment took place. If

it was above 35 flies, treatment was always recommended, but by figures between these limits the recommendation depended on local conditions and experience. In 1986, which was not favourable to the carrot fly, 60-65% of the growers included in the monitoring could omit control measures, and nobody experienced anything but very slight local damage.

**Sex traps for monitoring of the codling moth (*Laspeyresia pomonella*) (Peter Esbjerg and Søren Laursen)**

By means of sex traps (1-2 Hoechst delta traps per hectare) in 30 apple orchards it was demonstrated that the catches of codling moths vary very much in quantity and time between different localities in Denmark. A preliminary control threshold of 20 moths per 2 traps per week was used. Treatment was omitted in 50% of the orchards, but the growers' damage assessments indicated that the threshold level was too low.

**Mass production of the predatory mite *Amblyseius barkeri* (Jørgen Jakobsen)**

A method for mass production of the predatory mite based on flour mites (*Acarus siro*) was developed.

The flour mites are reared on wheat bran to which is added dry yeast and wheat germs. The production takes place in bags made of plastic foil and terylene kept at a high relative humidity (70-80 RH) at 25°C.

The number of predatory mites produced per ml bran reached about 100 mites, with a total production time of 6 weeks.

**Biological/integrated pest control in greenhouse vegetables (L. Stengård Hansen)**

Investigations were concentrated on the use of the predatory mite *Amblyseius barkeri (=Amblyseius mckenziei)* for control of thrips on cucumber.

Predatory mites were released in 14 commercial greenhouses (totalling 9,000 m) with cucumber. 300-400 predatory mites/m were introduced in 2-3 instalments. The experiment had to be interrupted in 2 greenhouses as the thrips attack developed very rapidly and no predatory mites were found on the plants. The experiment had to be abandoned in another greenhouse as chemical control of leaf miners (*Liriomyza bryoniae*) became necessary. No chemical thrips control took place in the other greenhouses, in some cases because they did not occur there.

**The Western flower thrips (Jørgen Jakobsen)**

This thrips species has occurred in Danish glasshouses since 1985 - mainly in *Saintpaulia, Gerbera* and roses.

It is extremely difficult to control the Western flower thrips with insecticides. In cooperation with the Pesticide Research Institute a number of insecticides have been tested against the flower thrips. Only chlorfenvinphos gave acceptable control.

**Biological control of the Western flower thrips**

Preliminary experiments were carried out to examine the possibility of using the predatory mite *Amblyseius barkeri* for control of the Western flower thrips in glasshouses.

50 and 500 predatory mites per m were introduced into greenhouses with Saintpaulia plants infested with thrips - about 50 thrips per plant. They were released 5 times at weekly intervals. Seven weeks after the first introduction of predatory mites the number of thrips in the plants was 15% and 5% of the numbers found on untreated plants.

**Development of laboratory test methods for examining the effect of pesticides on the carabid *Bembidion lampros* (L. Samsøe-Petersen)**

*Bembidion lampros* occurs in high numbers in cultivated areas, and it is an important aphid predator.

Consequently, it has been chosen as test species among the indicator species which will be collected at the Zoology Department with a view to developing standard methods for determining pesticide effect on beneficial arthropods.

The project includes developing a method for continuous laboratory rearing of the species. Beetles gathered in the field are kept under different physical conditions and given different kinds of nutrition. Eggs are collected and used for rearing larvae. It has proved possible to rear several larvae to adults in the same box, and besides, adult beetles reared in the laboratory have laid egg.

The test method is based on glass chambers whose floor is covered with sand. The sand is treated with pesticides, and a couple of adult carabids are introduced into each glass chamber. Their eating and egg-laying capacity over a period is registered.

**Development of method for determining the effect of pesticides on the parasitic wasp *Encarsia formosa*** (Fibi Habtu)

A semi-field test method for determination of pesticide effect on *E. formosa* was developed as part of Fibi Habtu's thesis for the University of Copenhagen.

**The influence of protective zones without pesticides on beetles occurring in cereals (L. Samsøe-Petersen)**

As part of a 3-year project organized and partly financed by the Centre for Soil Ecology, beetles from a field (winter wheat in 1986) at the Gjorslev estate at Stevns are collected and determined.

The purpose of the examinations is to decide the importance of omitting pesticide treatment at the field edges - especially where the area is bordered by hedges with trees.

By means of pitfall traps, catch samples are collected in the period April to October. Besides, the population densities of the beetles are determined by means of a new method: 30-cm-high metal rings are knocked into the ground, and the beetles in the area thus isolated are collected.

Collections take place from the field edges which have been treated with pesticides and from the untreated field strips as well as in the normally treated parts of the field. Moreover, the occurrence of aphids, mildew and rust is registered.

## B. PESTICIDE RESEARCH INSTITUTE

### I. STAFF

Director of Institute

**Scientific staff:**

Bent Bromand

Insecticides for agricultural purposes

Connie Nina Christensen[1] (from June 1)

Fungicide resistance in plant pathogens; occurrence and importance of powdery mildew in cereals

Bent Løschenkohl (till Jan. 31) and Hellfried Schulz (part-time)

Fungicides for control of diseases in oil-seed rape, potatoes, beet, peas and vegetables

Bent J. Nielsen and Lise Nistrup Jørgensen

Fungicides for control of diseases in cereals, maize and grassland

Steen Lykke Nielsen[1]

Reducing the use of pesticides by changing dose and spraying time for apple trees and blackcurrants

A. Nøhr Rasmussen

Fungicides, insecticides and nematicides for greenhouse and nursery purposes

Ernst Schadegg

Fungicides and insecticides for use in orchards and gardens; administration; List of Approved Products

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[1]Paid by means of special funds

## II. GENERAL SURVEY, by E. Nøddegaard

### Approval of pesticides and plant growth regulators

According to the present regulations, the Pesticide Research Institute carries out the tests and investigations necessary to form the basis for approval of pesticides and growth regulators. The testing and approval is based on a voluntary agreement with the Danish Agrochemical Association and the Ministry of Agriculture (The Danish Research Service for Plant and Soil Science). The latest agreement is from 1983, and in 1984, a supplementary agreement was made on testing and approval of tank mixtures (2 or more compounds mixed at spraying).

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 firms may place this mark on the labels of approved pesticides, and it may 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 "Pesticides and growth regulators approved for control of plant diseases, pests and weeds, and for haulm destruction of seed crops and potatoes".

The approval list is revised every year and sent out in January. A supplement to the list is sent out in April. Only pesticides registered by the National Agency of Environmental Protection for use according to the approval may be entered into the list.

### Evaluation of efficacy of pesticides and plant growth regulators

According to the provisions of Act No. 410 of 17th September 1980 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. The efficacy is evaluated on the basis of test results sent in by the companies, experience and literature studies. If necessary, further tests and investigations will be carried out.

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

According to the agreement of 29th October 1982 between the Office of Chemicals and Pesticides under the Environmental Protection Agency and the Plant Protection Centre the Pesticide Research Institute shall assist the Agency by the re-evaluation of pesticides and growth regulators classified by the Toxicological Board.

The Institute shall give an opinion on the importance and application of the pesticide in question, on possible alternative pesticides and methods as well as the financial consequences of a limitation in the use of the pesticide. The opinion is given on the basis of current knowledge, experience, test results and other documentation. If necessary, other parties may be involved in the investigations.

## III. AGRICULTURE

### Experimental work

### Fungal diseases (Bent J. Nielsen and Lise Nistrup Jørgensen)

**Control of net blotch** (*Drechslera teres*), **scald** (*Rhynchosporium secalis*) **and powdery mildew** (*Erysiphe graminis*) **in barley**

The trials are carried out in winter barley and spring barley to obtain a sufficient basis for approval of fungicides.

**Powdery mildew** (*Erysiphe graminis*)

The propagation and spread of overwintered mildew from winter barley normally starts during April, and if untreated, it may develop rapidly during May and June.

However, very little mildew survived the very cold winter of 1985/86 with long periods of black frost. As it was followed by a spring which did not favour the propagation and spread of mildew, only 0.8% attacks were seen by the end of June in 19 field experiments. This is considerably below what was seen in the previous years (1984: 21.7%, 1985: 27.5%).

In spring barley the attacks started in June, but they were moderate, and in 23 field trials the average percentage of attacks by the beginning of July was 8.9%. This was half as much as in 1984 and 1985. In susceptible varieties (Vega, Cerise) the attacks were very severe in the second half of June.
In recent years, the risk of resistance development has increased the interest in products against mildew consisting of agents with different modes of action. The result of combining two compounds with an effect against mildew may be a product with a good effect against mildew for as much as 30-45 days. This is the case with mixed products containing tridemorph (Dorin, DPX, N 7873, Tilt turbo) or mixed products with fenpropimorph (Rival, Tilt Top). A new compound, ethyltrinol (Folicur) has effect in two stages of the ergosterol synthesis, i.e. both as a DMI and morpholin type. Different formulations have been tested and shown good effect.

Most of the other fungicides which have been tested for use against barley mildew have had good effect. However, a poor effect of Afugan, flusilasol (DPX H 6573) and Bayfidan was seen in this year's experiments. Similar results were seen by the tests in 1985.

Pesticide dosages according to requirements has also been studied with great interest. Powdery mildew in spring barley is a disease which may be controlled by use of reduced dosages under certain conditions. In 1986 tests have been made in spring barley with different dosages of Tilt turbo, Tilt Top, Folicur Combi and Rival. Reducing the dosages of Tilt turbo, Tilt Top or Folicur Combi from 1.0 to 0.75 l did not influence the effect against powdery mildew in barley. Nor did it result in any significant yield decrease. The experiments have only been carried out in 1986 under moderate disease pressure, and further experiments should be carried out.

Rival has been tried at 1.5 and 1.0 l, and 1.0 l must be considered sufficient against powdery mildew in barley.

**Net blotch** (*Dreschlera teres*)

In recent years net blotch has mainly occurred in winter barley, where it may cause some damage in June. In 1986 the attacks were moderate with 8.5% attacked plants in an average of 19 trials. This was more than what was seen in last year's trials. In certain cases the attack amounted to 20-30%. In spring barley attacks were only seen in a few experiments, and they were fairly weak.

**Scald** (*Rhynchosporium secalis*)

The scald attacks in winter barley started at the beginning of June and peaked later in the month with up to 30% attacked plants in certain areas. On an average the attacks amounted to 8% in 19 trials, which corresponded to the level of attack in 1985. Simultaneous occurrence of both net blotch and scald led to severe damage in exposed fields, stressing the necessity for efficient products for use if the problem arises.

In spring barley the attacks averaged 0.1% (23 trials), and widespread attacks were seen only in a few fields.

**Net blotch** and **scald** may cause serious damage, especially in winter barley, and it is important that the fungicides used have good effect. The supply of compounds is being restricted considerably, and only DPX N 7873, the Folicur products, Rival, Tilt Top, Tilt turbo and Sportak 45 EC have had a satisfactory effect, i.e. products containing flusilasol, ethyltrianol, prochloraz and propiconazol. A tridemorph and particularly fenpropimorph content may increase the effect. Dairin in combination with Bayfidan has given good control, especially of scald. These results are in accordance with findings in previous experiments.

Reduced dosage for control of net blotch and scald may weaken the effect. Especially when the other component is tridemorph, the effect becomes too weak.
If net blotch or scald is a problem in winter barley, a reduction of the dosage is not recommended for the time being.
More experiments will be carried out in the future in order to throw light on the problems in connection with reduced dosages.

**Yield**

In view of the moderate attacks of leaf diseases in spring barley in 1986, many of the treatments which took place were not profitable.

Out of 23 experiments in spring barley in 1986 treatment was unprofitable in 65% if the costs of pesticides and application were estimated as corresponding to 2.9 hkg. In the experiments carried out by the Crop Husbandry Department the treatments in 66% of 48 spring barley experiments turned out to be unprofitable.
In 1984 treatment was unprofitable in 25% of the 20 spring barley trials, and in 1985 in 43% of 23 spring barley trials.
Powdery mildew is a serious disease in spring barley, and the rare occurrence of powdery mildew in 1986 is the reason for the high number of trials with unprofitable treatments.

According to the present regulations, winter barley has to be treated twice. This is done in order to protect spring barley against overwintering powdery mildew. For winter barley as such the treatments have not been very economic as 58% of the treatments were unprofitable.

**Eyespot on wheat (*Pseudocercosporella herpotrichoides*) (Lise Nistrup Jørgensen and Bent J. Nielsen)**

19 experiments with control of eyespot were carried out in 1986.

The need for treatment against eyespot was estimated on the basis of plant samples received in April. Treatment was considered necessary in 44% of all wheat fields (Schulz, personal communication). However, the early summer offered very poor conditions for the development of the fungus, and therefore only weak attacks were found in several of the trials when they were inspected in July.

A new system of assessing the eyespot attacks was started in July: The straws were divided into 4 categories of attack, and a new method of index calculation was introduced. The index corresponds to the previously used sum figure for the categories 3 and 4 for medium and severe attacks, whereas the index gives higher figures by weak attacks.

$$\text{Disease index} = \frac{(0 \times a) + (1 \times b) + (2 \times c) + (3 \times d)}{(a + b + c + d)} \times \frac{100}{3}$$

A, b, c and d are the number of shoots. The four categories in the formula have the values 0, 1, 2 and 3.

Based on the results of the experiments of the year Prochloraz (Sportak 45 ec) must still be considered the only efficient product for control of eyespot. The alternative products which have been tested (Folicur, PC 1003, DPX N 7872) have shown to weak effect.

The effect of Prochloraz was the same whether it was applied in the autumn or in the spring. A more differentiated time schedule showed best control at Feekes stage 5.

Eyespot control only gave small and insignificant yield increases in 1986.

**Control of leaf diseases in winter wheat**

Mildew (*Erysiphe graminis), Septoria* spp. **and** *Puccinia* spp. **on wheat**

The attacks of leaf fungi - especially mildew - occurred late in the season and were weak. However, it was possible to get a fairly good impression of the effect on mildew of the various products as the very susceptible Kanzler variety was grown in several of the fields.

The attacks of glume blotch and leaf spot were weak in 1986, and although the diseases occurred in many trials, there was little possibility of estimating the effect of the products on these diseases. Only weak attacks of yellow and brown rust were seen in a few trials.

In 1986 a number of new products were tested for control of fungal diseases on leaves. A relatively new phenomenon was the high number of mixed products registered. Since a considerable number of the components are unknown, a test plan covering all the ergesterol inhibitors was set up in order to get a basis for estimating the potential of the mixtures. It turned out that it is possible to make a rough division into two groups: (1) Those which give good mildew control, and (2) compounds with weak effect on mildew.

The following products belong to group 1: Tilt 250 ec, Folicur, SN 108 266, PC 1002, Impact and Corbel.

The following belong to group 2: Bayfidan, Sportak 45 ec, DPX H 6573, Vigil and Calixin.

The morpholins Corbel and Calixin plus Bayfidan and Vigil were the only products with a weak effect on the relatively moderate attacks of Septoria. The other products tested gave a uniform good control. Most treatments gave significant yield increases, but not sufficient to be financially profitable.
A number of new mixed products (Tilt turbo, Folicur Combi, Rival, Tilt top and DPX N7873) were tested. In several cases, experiments were made with two different dosages. It appears from the results that the mixtures examined gave the same good effect against mildew and Septoria spp. with corresponding yield increases. This also applies in most of the cases where lower doses have been applied. In fields with severe attacks of mildew, however, the high doses gave better control and higher yield increases than reduced doses.

In 27 experiments with 2 sprayings against leaf fungi the average yield increase obtained was not financially profitable.

**Control of fungal diseases on potatoes, root crops, industrial crops and vegetables grown outdoors (Lise Nistrup Jørgensen and H. Schulz)**

**Seed treatment of peas**

11 products for seed treatment were examined in 8 experiments on peas. The treatments did not have any effect as to germination, tuber formation, colouring of roots or yield.

**Treatment of potatoes against black scurf** (*Rhizoctonia solani*)

6 products for treatment of potatoes have been tested in 3 experiments. Several of the new seed dressings are liquid, and special spraying equipment is required. Many products had a good effect assessed on the basis of the percentages of sprouts, stems and tubers attacked. No significant difference in yield could be seen. The method of applying liquid products should be improved. No new products were approved in 1986.

**Control of diseases in rape**

3 products were tested in winter and spring rape. Weak attacks of *Sclerotinia sclerotiorum* were seen. The yield increases by treatment were not significant. Rovral flo was approved for control of stem rot.

**Control of diseases in peas**

4 new products were tested in 6 experiments. Experiments were made with 2 different times of treatment. The attacks of grey mould (*Botrytis cinerea*), leaf and pod spot (*Ascochyta pisi*) and stem rot (*Sclerotinia sclerotiorum*) were very limited and did not give any possibility of assessing the efficiency of the products. No significant yield increases were obtained during the experiments.

**Control of potato blight** (*Phytophthora infestans*)

5 products were tested in 5 experiments. Satisfactory attacks were seen in all the experiments. PLK Trimangol fl. was approved on the basis of 2 years' testing, whereas Dairin SC 480, which has been tested for several years, still did not demonstrate sufficient effect. The treatments resulted in satisfactory yield increases.

**Control of downy mildew on onions** (*Peronospora destructor*)

4 products were tested in 2 experiments. Ridomil MZ and Sandofan M8 gave the best effect. Ridomil MZ was the first product approved for control of downy mildew on onions.

**Fungicide resistance of plant-pathogenic fungi (Until 31st March: Kirsten Junker, from 1st June: Connie Nina Christensen)**

This project includes a surveyance of resistance development in cereal mildew (Erysiphe graminis) against ergosterol-inhibiting fungicides. Mildew was collected regularly in selected fields, partly regionally and partly countrywide. The sensitivity of mildew is tested on plants grown in glass tubes with addition of different dosages of fungicide (propiconazol).

So far, the investigations seem to indicate that there is a considerable variation in the sensitivity of samples taken out at the same time in the same field. Any connection between attacks in the field, fungicide treatments and the sensitivity of mildew could not be ascertained.

The sensitivity of barley mildew fell from 1984 to 1985, and it is markedly lower than the sensitivity of isolates from the late sixties. The final results from 1986 are not available at the moment.

Examinations of wheat mildew received from different parts of the country show a somewhat reduced sensitivity in populations from Northern Jutland. No significant difference was seen in the sensitivity of populations from various parts of the country.

In order to be able to register the development in the sensitivity of the mildew population to propiconazol, the population was exposed to different selective pressure under laboratory conditions. At the same time the latent period was registered. The method has not yet been fully developed.

**Investigation of pathotypes and tests for fungicide resistance en eyespot (*Pseudocercosporella herpotrichoides*) (Lise Nistrup Jørgensen)**

With a view to the potential risk of eyespot resistance to prochloraz, our only approved eyespot product, a monitoring programme was set up in 1986.

346 isolates of eyespot (*Pseudocercosporella herpotrichoides*), collected from wheat trials on the islands of Zealand and Lolland-Falster in 1985 and 1986, were tested for sensitivity to benomyl (2 ppm) and prochloraz (0.01-2.00 ppm). The samples were taken in July with a maximum of 20 isolates from each treatment in a field. Samples were taken from plots treated with prochloraz and with benzimidazol, as well as from untreated plots.

Small pieces from eyespot lesions were placed on PDA. From the resulting cultures, tests were made with mycelial inoculum on PDA (control) and PDA + chemical.

The average $ED_{50}$ value of prochloraz was found to be about 0.1 ppm varying from 0.005 to >2 ppm prochloraz.

Approximately 10% of isolates from 1986 had an $ED_{50}$ between 0 and 0.01 ppm, approx. 40% between 0.01 and 0.1 ppm, approx. 25% between 0.1 and 1.0 ppm, while 20% had an $ED_{50}$ value greater than 1.0 ppm.

61% of the isolates were determined as R-type and 33% as W-type. It was not possible to assess 5% as either R- or W-type. Prochloraz has not, in contrast to other ergosterol inhibitors which were tested, shown a significant difference in inhibiting effect between R and W pathotypes.

Isolates from 3 localities with prochloraz-treated and untreated spots showed no significant difference in sensitivity to prochloraz for isolates from treated plots when compared to isolates from untreated plots.

## Pests in agriculture and field vegetables (Bent Bromand)

**Bird-cherry aphids** (*Rhopalosiphum padi*), **rose-grain aphids** (*Metopolophium dirhodum*) **and grain aphids** (*Sitobion avenae*) **in winter wheat and spring barley**

In winter wheat 6 experiments were carried out with a number of pyrethroids and dimethoat compounds. The aphid attacks started in the beginning of July, and 100% plants attacked was reached by the end of the month. At the beginning, the grain aphid was the dominant species, but later the rose-grain aphid was dominating, which was a quite unusual situation. Good results with 5-10 hkg/ha in yield increase were obtained. In spring barley, 3 field trials were carried out with mainly the same chemicals as in winter wheat. Fairly weak attacks by the bird-cherry aphid occurred, and yield increases from 1.9-5.0 hkg/ha were obtained.

**Thrips** (*Haplothrips aculeatus* **and** *Limothrips denticornis*) **in rye**

3 field trials were carried out with fenitrothion and 3 pyrethroids. Due to rainy weather, spraying took place at stage 10.2 Feekes, which was later than originally intended. Good effect of spraying with pyrethroids was achieved, but with insignificant increases in yield.

**Frit flies** (*Oscinella frit*) **in cereals, maize and undersown grass**

In a single trial with seed treatment on winter wheat with lindan, phoxim and furathiocarb only the latter improved emergence. There were no differences in the percentage of attacked shoots or in the number of larvae in the shoots.
In maize, spraying at the 2-3-leaf stage with Ripcord, Decis, Cybolt 100 E and Sumithion 50 gave good effect with 5-6% increase in yield.

3 trials were carried out in undersown grass. Spraying took place 7-10 days after the cover crop had been harvested. The effect of 6 tested pyrethroids was very fine, and yield increases of up to 14% were registered with 1 spraying.

**Spraying against various pests in grass for seed**

7 trials were carried out with various pyrethroids and fenitrothion due to previous trials with good results after spraying with Ambush. Attacks of the following pests could be expected: Aphids, various species of thrips, frit flies, *Siteroptes graminum* and the larvae of *Ochsenheimeria vacculella.*
From mid-May to mid-July, grass samples were treated in a Berlese apparatus every week. Contrary to 1985, few thrips were found whereas the number of mites increased to several hundreds in 100 g grass at the end of the test period. Other pests were present in small numbers only, and no increase in yield was found.

**The potato aphid (*Aulacorthum solani*) and the peach-potato aphid (*Myzus persicae*) in potatoes**

Trials were carried out with fenitrothion, pyrethroids and a mixture of Karate and Pirimor. Two trials resulted in poor effect of the spraying in general both on the aphids and in a virus test made on the tubers in a glasshouse test. In another trial, poor effect was registered on the aphids, but yield increases of up to 10% was obtained.

**Soil-borne pests in sugar beet**

In cooperation with the Danish Sugar Factories and the Zoology Department, experiments were made with seed dressing and spraying against soil-borne pests, such as collembola, millipedes, symphilids, pygmy beetles, wireworms and thrips. Moderate attacks of thrips occurred in the beginning of May, and good control was obtained with seed treatment with furathiocarb. The same compound had effect on the mangold fly until the end of June.

**The black bean aphid (*Aphis fabae*) and the peach-potato aphid (*Myzus persicae*) in beets in relation to virus control**

3 field trials were carried out with Karate EC, Pirimor G and a mixture of Karate and Pirimor. Generally, low effect was found on the black bean aphid. Very few peach-potato aphids were found, and in October 16.7% of the plants were attacked by virus in the untreated plots and 12-13% in the various treatments.

**Mangold flies (*Pegomya hyoscyami*) in beet**

In beet 3 trials were carried out with Sumithion 50, Sumicombi 30 FW, Trigard and KVK Permethrin. The phosphorus compounds reached about 100% effect in a few days, whereas it took 8 days to reach the same level of effect with the other compounds.

**Black bean aphids (*Aphis fabae*) in beet**

Due to the poor effect of treatments against the black bean aphid in 1985, 3 trials were carried out with 8 approved compounds: pirimicarb, dimethoate, parathion, fenitrothion, formothion, oxydemeton-methyl and phosphamidon. Pirimicarb reduced the percentage of attacked plants from 45.6 in the control to 14.4. The other compounds reduced the attack to 17.2-19.4%.

**Blossom beetles** (*Meligethes aeneus*), **cabbage seed weevils** (*Ceutorrhynchus assimilis*), **cabbage stem weevil** (*Ceutorrhynchus pallidactylus*) **and brassica pod midges** (*Dasineura brassica*) **in oilseed rape**

The experimental work with pyrethroids against pests in oilseed rape continued in 1986. Generally, pyrethroids had a good effect on the four pests. For the blossom beetle, a good effect was achieved at half the normal dose, provided the timing was correct. By spraying against the blossom beetle, the number of larvae per plant was reduced from 3.4 to 1.4-1.9.

**Seed treatment and granules against flea beetles** (*Phyllotreta* spp.) **and thrips** (*Thrips angusticeps*) **in winter and spring oilseed rape**

7 trials were carried out. Generally, the thrips attacks were weak, but in several cases, especially in spring oilseed rape, heavy attacks were seen. Carbofuran, furathiocarb and carbosulfan had good effect against both pests. In the experiments, the powder compounds were used together with sacrust, whereas this was not the case with liquid products.

**Seed treatment and spraying against the pea and bean weevil** (*Sitona lineatus*)

Products containing furathiocarb had a very good effect as seed treatment, whereas lindan was ineffective. Furathiocarb prevents propagation of larvae on the nodules of the roots. Several pyrethroids used for spraying had good effect, and the damage to the leaves was reduced. 5-10% yield increase was achieved both with seed treatment and spraying.

**Pea moths** (*Cydia nigricana*) **and pea aphids** (*Acyrthosiphon pisum*) **in peas**

5 spraying experiments were carried out. The treatments were applied after catch of pea moth males in pheromone traps or by initial attacks of pea aphids. Only pyrethroids have been tested, all with good effect against the aphids. Generally, the pea moth attacks were weak, but all the pyrethroids tested were effective. Normally, one spray is sufficient for control of both pests.

**Spraying against flax tortrix** (*Cnephasia interjectana*) **in peas**

Sumithian 50, Karate EC and Cymbush were tested in three experiments. Only weak attacks occurred. Some effect was noticed, but the number of shoots spun together was only halved.

**Control of the cabbage rootfly** (*Delia radicum*) **on cauliflower**

Several experiments were made with seed treatment, granule incorporation, soil drenching before planting and spraying, but with varying results. The best effect was obtained with chlorfevinphos and carbofuran granules. The effect of seed

treatment does not last long enough to give sufficient control. Carbofuran granules give good control against the first generation in May, but when the second generation occurs in July-August, the effect is no more than 4 weeks.
A warning system has been set up based on cabbage rootfly egglaying in egg traps. About 20 growers report twice a week on egglaying, and warnings are sent out to agricultural advisers about the first and second generations.

**Cutworms (*Agrotis segetum*) in carrots and red beets**

Experiments were carried out with Orthene 75SP, Sumicidin 10FW, Ambush and Karate. 1 or 2 sprayings were placed according to the catch of males in pheromone traps. Precipitation, number of days with rain and soil type is also taken into consideration. Sumicidin 10FW was approved as the first pyrethroid against this pest.

**Procuring samples for residue analyses**

The following samples were taken out for residue analyses: Potatoes: 28, oilseed rape: 60.

## IV. FRUIT GROWING (E. Schadegg)

### Fungal diseases

**Apple scab** (*Venturia inaequalis*)

In 1986 we have tested 7 new fungicides for control of apple scab. Many of the chemicals look promising, but they have only been tested for one year, and another year is needed before the question of approval may be decided. Only two of the new chemicals had a significantly poorer effect than the other fungicides tested. The approved fungicides Rubigan, Topas C 50 WP and Cadol M 63 also had a satisfactory effect. However, the effect of Rubigan on fruit scab was a little poorer than that of other approved fungicides. This year Captan fl. was approved as the first liquid captan compound.

The attack of apple scab in our experimental orchard at Vindinge was moderate, whereas the attack was above average at Edelgave, where one of the experiments were carried out.

*Gloeosporium* **on apple**

Captal fl. was approved for control of *Gloeosporium* on apple. Like other Captan compounds, Captan fl. turned out to offer good protection against *Gloeosporium*. Besides, Baycor 25 WP was approved for control of *Gloeosporium*.

**Blossom wilt on cherries** (*Monilinia laxa*)

The experiments continued on the same sites as in 1985. The attack was very severe. Oktave, Ronilan fl. and Rovral Akva fl. had a satisfactory effect. However, these chemicals have only been tested for one year. The chemicals which seemed satisfactory in 1985 turned out to have good effect also in 1986. Rubigan and Benlate had satisfactory effect both at Præstø and Lolland. Baycor 25 WP seemed a little less efficient on Lolland whereas Saprol had less good effect at both sites than in 1985. Among the benzimidal compounds, Topsin M and Benlate had a fairly good effect whereas the effect of Derosal varied somewhat.

**Cherry leaf spot** (*Blumeriella jaapii*)

Experiments were made with the varieties Kelleris 16 and Stevns berries. The attacks on Kelleris 16 were vigorous and moderate on Stevns berries. All the compounds tested had a satisfactory effect. There was no significant difference between the chemicals.

4 chemicals were approved. This is the first time that any agents controlling cherry leaf spot have been approved.

**Leaf rollers**

Several experiments with control of summer fruit tortrix moths and codling moths were carried out. The attacks were weak in all the experiments. However, Ban 86 was approved as this compound is produced by making a small change in the formulation of Sumicidin 10 FW whose effect is wellknown.

Biobit, which is a biological agent, showed a better effect than in the previous years. However, the effect is too low, especially in cold weather, and frequent applications are necessary for a good result.

**Fruit tree red spider mites**

The changing weather made it very difficult to carry out long-term experiments with fruit tree red spider mites. The hatching of the winter eggs took place as normal, but in most experiments only 1 or 2 countings could be made before treatment, and then the rainy weather reduced the red spider mite population considerably. In August we were able to carry out 2 experiments on a mixed summer population. In one experiment various pyrethroids were examined. The products approved were: Akarstin 25 WP, Nissorum 10 WP and Talstar. Talstar is identical with Brigade, and the active ingredient is biphenate.
With certain types of acaricides, treatment is recommended at a late point in the embryonic development, i.e. just before or at the start of the hatching. Daily observations are necessary in order to find the right time of treatment. The hatching time may even vary in different parts of the same orchard. For that reason we tried to find out whether early application of Apollo and an oil emulsion might give the same result. Spraying took place in March, April and at the start of the hatching.

It appears from the results that both chemicals are very well suited for spraying some time before the hatching starts, and they can keep down the population of red spider mites for 1 or 2 months. The experiments will be continued in 1987.

**Apple aphid**

There were not many aphids in 1986. The few vigorous attacks subsided after a few days. Since the pesticides tested had a reasonable effect, but slightly lower than the standard compound, they will be tested for one more year before reaching a decision about approval.

## Reduced use of pesticides for control of pests and diseases in fruit trees and bushes (Steen Lykke Nielsen)

**Reduced application of pesticide for control of apple scab** (*Venturia inaequalis*)

An electronic fungus warning system was tested. Application of the curative fungicide bitertanol according to the warning equipment saved 4 out of 14 standard preventive applications, and the control of apple scab obtained was the same.

Tests to investigate the possibility of reducing the dose of fungicide in the spring, before the foliage was fully developed, were unsuccessful, because the approved dose of bitertanol (Baycor 25 WP) is an overdose. Application of half the recommended dose during the whole season gave just as good a control of the apple scab as the approved dose.

The influence which the presence of dew on the foliage may have on the effect of the applications was investigated. No difference was found between the amounts of fluorescent dye deposited on dew-covered and on dry leaves. Nor was any difference found between the control of apple scab obtained by spraying on dew-covered and on dry leaves.

The influence of the driving speed on the quality of mist spraying was investigated. Driving 2 and 3 times faster than the optimal driving speed greatly reduced the deposit of spray liquid on the trees, although the same spray volume was applied regardless of the driving speed.

**Preventive and curative chemical treatment for control of black currant leaf spot** (*Drepanopeziza ribis*)

A sterol-biosynthesis-inhibiting fungicide, penconazole/captan (Topas C 50 WP) was tested to investigate its preventive and curative effect on black currant leaf spot (*Drepanopeziza ribis* (Kleb.) Hohnel). The curative treatment was started when the first visible symptoms on the leaves were observed. The curative treatment gave a significantly lower control of the diseases than the preventive treatment.

Halving the dose of Topas C 50 WP and the spray volume at the first 4 sprayings of the preventive treatments before full leaf coverage and applying full dose and spray volume at the last 6 sprayings gave just as good control of the leaf spot as applying full dose and spray volume all the time.

**Pear leaf blister mite** (*Phytoptus pyri*) **and plum leaf gall mite** (*Phytoptus similis*)

Tests of chemicals for control of the two gall mites were started at two orchards which had suffered from heavy infestations the year before. The experiments failed, however, because only diminutive infestations occurred in 1986.

**Blossom blight on cherry** (*Monilinia laxa*)

Tests of chemicals for control of blossom blight on cherry was made in cooperation with E. Schadegg. The tests are described in his section.

Glasshouse Crops (A. Nøhr Rasmussen)

**Chemical control of Western flower thrips** (*Frankliniella occidentalis*, **Pergande) on** *Saintpaulia* **and** *Gerbera*

During 1985 and 1986, 3 experiments with chemical control of the Western flower thrips (*Frankliniella occidentalis*, Pergande) in *Saintpaulia* and *Gerbera* were carried out at the Research Centre for Plant Protection at Lyngby. The experiments included 13 different pesticides, 8 of which were applied in normal and triple dosage. The sprayings were applied with 0.2 l liquid per square metre.
Generally, the effect of all the pesticides was insufficient in both cultures, with the exception of Shell Birlane 24 EC, which gave 95% effect in *Saintpaulia* after 3 applications with a 0.16% solution and over 80% effect in *Gerbera* after one treatment.

In *Saintpaulia*, the best effect of the other pesticides tested was seen with Baythroid 50 EC, Sumirody, MK 0936 (avermectin) and Orthene 75 SP. However, their effect varied, so that they had an effect of 80-85% in one of the experiments, but only about 50% in another.

The other pesticides tested, viz. Decis, Egodan Parathion 35 EC, Fastac, Hostathion, Midol Feni 30, Ripcord and Sumialfa had an effect of 60% or less.
The mixture of Sumirody and Orthene 75 SP increased the effect compared with Sumirody, but the effect was not any better than with Orthene 75 SP alone.
It has not been possible to estimate with any certainty what is the harmful effect of the pesticides on the plants.

## V. NEW PESTICIDES TESTED IN 1986 (E. Schadegg)

In 1986, the Pesticide Research Institute, Lyngby, evaluated a total of 235 chemicals. The chemicals included 99 fungicides and 60 insecticides for agricultural experiments, and 19 fungicides and 14 insecticides for horticultural experiments. 76 standard compounds were used.

The compounds listed below were approved by the National Research Service for Plant and Soil Science:

### 1. Compounds for seed treatment

| | |
|---|---|
| Bunt of wheat (*Tilletia caries*) | Thiadin 325<br>Panoctine 35 |
| Loose smut (*Ustilago nuda*) | Baytan seed dressing IM<br>Cillus Vitavax 390 |
| Stripe smut of rye (*Urocystis occulta*) | OE 8302 |

### 2. Fungicides

| | |
|---|---|
| American gooseberry mildew on blackcurrant (*Sphaerotheca mors-uvae*) | Bayfidan 0.50 EW |
| Apple scab (*Venturia inaequalis*) | Captan fl. |
| Blossom wilt on cherries (*Monilia laxa*) | Baycor 25 WP<br>Rubigan |
| Cherry leaf spot and shot hole (*Blumeriella jaapii*) | Baycor 25 WP<br>Delan SC<50<br>Rubigan<br>Topas C 50 WP |
| Downy mildew on onions (*Peronospora destructor*) | Ridomil MZ 63 WP |
| *Gloeosporium* on apples | Captan fl.<br>Baycor 25 WP |
| Mildew on winter barley (*Erysiphe graminis*) | Afugan |
| Potato late blight (*Phytophthora infestans*) | PLK Trimangol fl. |

| | |
|---|---|
| Stem rot of rape (*Sclerotinia sclerotiorum*) | Rovral flo. |
| **3. Insecticides** | |
| Aphids on wheat (*Sitobion avenae*) | Decis<br>Ripcord |
| Beet leaf miners (*Pegomya hyoscyami*) | KVK permethrin |
| Black bean aphids (*Aphis fabae*) | KVK dimethoat 400 |
| Blossom beetles (*Meligethes aeneus*) | Karate EW<br>Sumicidin Fl. |
| Brassica pod midge (*Dasyneura brassicae*) | Karate EW<br>Sumicidin Fl.<br>Talstar |
| Cabbage seed weevils (*Ceuthorrhynchus assimilis*) | Karate EW<br>Sumicidin Fl. |
| Cutworms (*Agrotis segetum*) | Sumicidin 10 FW<br>Sumicidin Fl. |
| Frit flies on cereals, grass, maize (*Oscinella frit*) | Cybolt 100 EC<br>Decis<br>Sumicidin Fl. |
| Frit flies on grass (*Oscinella frit*) | Karate EW |
| Fruit tree red spider mites (*Panonuchus ulmi*) | Talstar<br>Akarstin<br>Nissorum 10 FW |
| Glasshouse whiteflies on vegetables and ornamentals (*Trialeurodes vaporariorum*) | Sumialfa |
| Grain aphids (*Sitobion avenae*) | Karate EW<br>Sumicidin Fl.<br>Talstar<br>Perfektion 20 EC |
| Leaf miners on vegetables (*Liriomyza bryoniae*) | EK 1086 |

| | |
|---|---|
| Leaf rollers (*Tortricidae*) | Sumicidin Fl. |
| Pea and bean weevils (*Sitona lineatus*) | Cymbush<br>Fastac<br>Karate EC |
| Pea aphids (*Acyrthosiphon pisum*) | Decis<br>Sumicidin Fl. |
| Peach-potato aphids on ornamentals (*Myzus persicae*) | Sumicidin Fl. |
| Peach-potato aphids on vegetables (*Myzus persicae*) | Sumicidin Fl.<br>Sumialfa |
| Red spider mites (*Tetranychus urticae*) on blackcurrants and strawberries | Nissorum 10 WP |
| Red spider mites (*Tetranychus urticae*) on strawberries and nursery stock | Nissorum 10 WP<br>Plictran 80 |
| Scales on ornamentals (*Chrysomphalus ficus*) | Shell Phosdrin<br>Orthene 75 SP |
| Winter moth larvae (*Cheimatobia* spp.) | Sumicidin Fl. |

**4. Growth regulators**

| | |
|---|---|
| Potted plants:<br>Azalea, roses, *Euphorbia pulcherrima, Beloperone guttata, Solanum pseudocapsicum, Exacum affine* | PP 333 |

## C. PLANT PROTECTION ADVISORY DEPARTMENT, GODTHÅB

Låsbyvej 18, DK-8660 Skanderborg
(A. From Nielsen)

The main tasks are advisory work concerning plant protection of agricultural crops, field experiments with pesticides for use in agriculture, diseases and physiological conditions of potatoes. These tasks are carried out in close cooperation with the staff of the National Department of Crop Husbandry in this area.

### Advisory work

This work includes written and telephone enquiries, diagnoses of plant samples, etc., and prognosis and warning service.

### Lectures and seminars

During the year, staff members gave lectures at 43 meetings and courses. Furthermore, staff members have taken part in 10 field excursions arranged by the local agricultural advisers in the various regions.

### Experimental work

#### Experiment with pesticides (J. Simonsen)

Field experiments with pesticides for agricultural use have increased considerably. The results of this work are included in the results from the Pesticide Research Institute.

#### Frit flies *(Oscinella* spp.) (S. Holm)

In 1986 frit flies were caught in blue water traps at 30 localities, primarily in ryegrass and oat fields.

The results were used partly to assist the agricultural advisers in the local area, and partly for the general warning service.

Blue water traps give only a rough estimate of the flying activity, but the great variations indicate that local registration and warning is necessary.

#### Crane flies (*Tipula paludosa*) (S. Holm)

In the autumn of 1986, a number of grass fields at different localitites in Jutland were investigated for the amount of larvae. The larvae were extracted from the soil by means of a salt solution. The general occurrence of larvae was low, as expectec based on the weather conditions during August and September.

**Potato late blight** (*Phytophthora infestans*) **(S. Holm)**

For a number of years, the warning for potato late blight has been given based on prognosis made by the "Negative prognosis" and the "Blitecaster". In 1986, the "Negative prognosis" is furthermore based on data from 10 automatic weather stations throughout the country. The calculation is made by the Agrometeorological Service at Foulum.

Some isolates of potato late blight resistant to metalaxyl have been found, expecially in fields with potatoes for industrial use where metalaxyl + mancozeb has been used.

In order to reduce the risk of building up resistant populations, metalaxyl is only recommended as a protective fungicide and not in seed potatoes.

## D. INSTITUTE OF WEED CONTROL

Flakkebjerg, DK-4200 Slagelse
(K. E. Thonke)

### I. FIELD OF ACTIVITY

The institute continued its research and testing within the area 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.

#### Distribution of main tasks

**Agricultural crops** in the area of the institute, root-propagated weeds and spraying techniques (Ole Permin).
**Testing** and experiments **in agricultural crops** (Egon Juhl Petersen and Peder Elbæk Jensen).
**Horticulture**, vegetables, fruit and nursery cultures (Georg Noyé).
**Forestry**, windbreaks and coverts (Thomas Rubow).
**Weed biology**, distribution and spread (C. Holm-Nielsen).
**Aftereffect of herbicides** in soil (Johannes Røyrvik).
**Experiments in containers and climate chambers** (Per Nielsen Kudsk, Torben Olesen and Jens Lindegaard Kristensen).
**Non-chemical weed control** (Jakob Vester).
**Damage thresholds for weed control** (Peter Kryger Jensen).
**The advisory service** (Karen Ravn).

## II. AGRICULTURE

### 1. Field experiments in connection with research, testing and advisory work as well as spraying techniques

**Control of Elymus repens (common couch) (Ole Permin)**

Experiments were carried out with fluazifop-butyl (Fusilade) to establish the length of the effect on common couch at different dosages. The common couch, which was planted out in lengths of 15 cm with a known amount per plot, was sprayed twice in a beetroot crop. The year after the spraying, the long-term effect was registered in spring barley, by for instance weighing the total rhizome mass. A dosage of 1.5 l fluazifop-butyl (Fusilade), combined with ploughing, gave full effect. Smaller dosages, for instance 1.0 l/ha, had a tendency to give less effect, whereas the effect of 0.75 l fluazifop-butyl (Fusilade) was significantly smaller than both 1.0 and 1.5 l per ha. Compared with the untreated control, regrowth after 0.75 and 1.0 fluazifop-butyl (Fusilade) was reduced by the same percentage in the ploughed and the unploughed part of the field. Regrowth of the remaining couch plants consisted of stems with spikes in the sections which had been ploughed. The experiments will be continued with more herbicides.

Herbicides for control of common couch and wild oat-grass were tested in an experiment with 17 different crop species, where the tolerance of the cultivated plants was assessed. In 1986, the effect of fluazifop-butyl (Fusilade) and haloxyfop-ethoxyethyl (Gallant) was examined in the following crops: *Brassica napus* var. oliefera, *Carum carvi, Linum usitatissimum, Pisum sativum, Vicia faba, Lupinus luteus, Trifolium repens, Trifolium pratense, Medicago sativa, Hordeum vulgare, Triticum aestivum, Lolium multiflorum, Poa pratensis, Festuca pratensis, Festuca rubra, Beta vulgaris, Brassica napus* var. napobrassica. *Lupinus luteus* was slightly damaged, but otherwise no damage was seen on the dicotyledonous species. *Festuca rubra* was tolerant to both products whereas the other monocotyledonous species were completely damaged.

**Control of wild oats (*Avena fatua*) (O. Permin)**

The investigations to find out how quickly land, cultivated under plough-free cultivation, is emptied of viable *Avena fatua* seeds, were continued. 2500 per $m^2$ Avena fatua seeds were laid at depths of 5, 15 and 30 cm, in the autumn of 1980.

Direct sowing and without any preparation of the stubble field in the autumn, gave the smallest number of wild oat plants and then only from a depth of 5 cm. The more the soil had been prepared, the greater the number of wild oat plants. The highest number of plants was seen where the field had been ploughed.

During the first three years wild oat plants also sprouted from seeds laid in a depth of 15 cm, but not from seeds laid in a depth of 30 cm. No wild oat plants have sprouted from the seeds after 5 years.

In the spring of 1986, the wild oat seeds, from varying depths, were dug up and placed on the ground surface for germination. Only in the case of direct sowing without stubble preparation, did wild oat seeds from the 30-cm-deep layer germinate with 9 per $m^2$.

**Tolerance tests in winter crops (O. Permin)**

Tolerance tests were made with increasing dosages of chlorotoluron (Dicuran) in 6 varieties of winter wheat. The tests showed a pronounced difference in the tolerance of the varieties. The following varieties are listed in order of decreasing tolerance: Kraka, Kanzler, Falke, Anja and Longbow.

The tolerance of triticale and *Triticum aestivum* (Kraka) to a number of soil and leaf-applied herbicides at 3 dosages was examined by treatments in the autumn on 2 $m^2$ plots. *Triticale* (Lasko) seemed, on the whole to be more sensitive to the herbicides used than wheat (*Triticum aestivum*).

The effect of hormone products of the ester type was examined in small plots with application in the autumn when the winter wheat had 1, 2, 3, 5 and 5 leaves. Damage which reduced the overwintering ability, was seen. However, no considerable damage was seen with hormone compounds of the ester type.

**Tolerance tests in peas (O. Permin)**

The tolerance of peas to combinations of soil and leaf-applied herbicides was investigated. Supplementary application of leaf-applied herbicides may be necessary in case the soil herbicides do not have a satisfactory effect. A certain yield decrease was seen after an application of leaf herbicides having previously been treated with cyanazin (Bladex). When leaf-applied herbicides were applied after a previous treatment with napcopamid (stomp), there was a significant decrease in the yield.

Treatments for the control of common couch (*Elymus repens*) and pests often coincide, and, in practice, a mixture of the compounds will often be used. Preliminary experiments in small plots showed that the insecticides Cymbush, Sumicidin and Pirimor did not increase the damage to peas when applied in combination with bentazon + MCPA (Basagran MCPA). However, the damage was increased when mixed with bentazon + MCPA (Basagran MCPA) and fluazifop-butyl (Fusilade).

**Tolerance tests in other crops (O. Permin)**

Preliminary experiments with a number of herbicides for control of dicotyledonous annual weeds were carried out in broad beans and fibre flax. Experiments will be carried out with increasing dosages of soil and leaf-applied herbicides as well as soil herbicides in combination with watering at different rates in order to establish the tolerance of the crops to the treatment and its effect on weeds. Herbicides for desiccation of broad beans were tested.

A number of new herbicides which may be used as alternatives to Dinoseb control of dicotyledonous weeds in peas were examined in tolerance tests with 17 different crop species, including lupin, broad beans, oilseed flax, caraway, spring rape, clover and grasses. The purpose of the experiments is to see how other crops tolerate the compounds, so that their suitability as an undersown crop and the possibilities of controlling the crops may be estimated.

**Herbicide spraying technique (O. Permin)**

Experiments were carried out using 4 different sizes of flat spray nozzles 4410-10, -14, -16, and -14 (made by Hardi) at 3 different pressures: 1.5, 3.0 and 6.0 bar, with the quantity of liquid varying from 57 to 497 l/ha. When bromophenoxim (Faneron) was applied against dicotyledonous weeds in spring barley, the effect on the weeds was significantly smaller with nozzle 4410-10 at 1.5 bar.

The special sprayers Danfoil, Girojet and CDA (micromax) and the hydraulic field sprayer (flat spray nozzles) were tested in experiments with 1 n, 1/2 n and 1/4 n dosage of MCPA-dichlorprop (D-propemix 67) in spring barley against dicotyledonous weeds. No significant difference in the effect on weeds was seen between the various types of special sprayers or nozzles.

**Spraying technique in connection with fungicides (O. Permin)**

The effect of a fungicide may depend on how much and where it is deposited on the cultivated plants. The tracer Helios was added to Tilt 250 EC to examine to what degree the effect of fungicides distributed with a special sprayer is related to the deposition of the spray liquid in different places on the plants. It turned out that the hydraulic sprayer with 150 l/ha seemed to have the best effect against mildew whereas the effect of the CDA sprayer was significantly smaller.

In the experiment concerning deposition on different plant parts, the plants were divided into 4 sections with separate leaves and stems before a qualitative analysis was carried out. In addition, the deposited amount per area was registered by means of filter paper. Measured in $ng/cm^2$, the results showed that

the deposit was significantly larger on the top leaf when Girojet or CDA sprayers were used instead of hydraulic sprayers. The Danfoil deposited significantly less.

Girojet and CDA deposited more on the top part of the stems than the hydraulic sprayer, and less on the two lower parts.

Registrations of deposit by area show a considerably smaller deposit with Danfoil and CDA than with hydraulic sprayers. The registrations were made by means of 40 cm pieces of filter paper. However, the registration method must be improved, since air currents may carry small droplets, for instance from Danfoil, away from the filter paper.

The deposit in ng per $cm^2$ corresponds to g per ha.

This shows that especially Danfoil deposits a considerably larger amount on the leaves and stems, both at the top and a little further down in the plants. Girojet and CDA leave a relatively larger deposit on the upper part of the plants than the hydraulic sprayer.

The registration of the biological effect of fungicides applied with special sprayers will continue.

Experiments with a crop tilter in winter wheat showed increased effect against mildew and Septoria when a crop tilter was used. It was seen that more fungicide was deposited on the stems, both in winter wheat and spring barley, when using a crop tilter.

The influence of distribution from the CDA on the effect of growth regulators in spring barley, was investigated in experiments using mixtures of ethephon (Cerone), spreader (Sandowitt) and propiconazol (Tilt 250 EC). When compared with the effect of application from an ordinary field sprayer with flat spray nozzles and 200 l/ha, there was a tendency to a greater reduction in straw length when the chemicals were applied by the CDA sprayer with a Micromox distributor head and 10 l water/ha.

The drift was registered by means of the tracer Na fluoreceine. The Danfoil 45 l/ha, Girojet 41 l/ha, CDA 30 l/ha and ordinary field sprayers were used in spring barley at stage 10-10.1. The drift was registered at distances of 1, 3, 6, 9, 12, 24, 36, 48, 60 and 72 m from the area sprayed. At a distance of 1 m the drift from Danfoil was less than from ordinary field sprayers. At a distance of 12 m and more, the drift was larger from the special sprayers than the ordinary field sprayers.

## 2. Testing of compounds

**Testing of herbicides, desiccatants and growth regulators in agricultural crops (E. Juhl Petersen and P. Elbæk Jensen)**

A great number of herbicides for use in winter crops was also registered for evaluation in 1986, and from the autumn of 1985 a number of trials were carried out in the 3 winter crops: wheat, barley and rye.

Very heavy frosts occurred during the winter 1985-86, and half of the winter barley trials were lost. The surviving winter seed corn trials, however, were not so badly damaged by the frost as the year before, and the yield was fairly good.

The capacity for carrying out field trials was increased in 1986 by the employment of an agricultural research assistant and the purchase of another car. The existing team split up, and two work teams were formed, each having one car and respectively 2 and 3 research technicians and 1 assistant.

The purpose of increasing the capacity was to carry out more experiments with a view to developing strategies for weed control. Furthermore, a greater number of herbicide tests could be carried out at more sites and under more varied conditions, and moreover, they could be tested on a larger number of species. In 1986 the development of strategies concentrated on maize, grass seed and *Amsinckia* sp. (which is a new and difficult weed species).

*Amsinckia* is a new weed in Denmark. It does not cause any serious problem in cereals as it can be controlled by two types of herbicides. In dicotyledonous crops the problems have been considerable, as *Amsinckia* is a very competitive plant and may replace the crop if it is not controlled. Promising results were obtained with most of the herbicides tested in fodder beet and peas.

In maize production, the main problem was atrazine-resistant groundsel plants as well as black nightshade and green foxtail. Experiments to control other weeds were also carried out.

In grass seed production weeds will repeatedly occur as a problem as the crop is perennial and the tolerance to herbicides is lower than in cereal crops. At the same time, the seed must not be contaminated by other species which consequently have to be removed. Special efforts were made to find suitable methods for control of mono- and dicotyledonous weeds.

In cereal crops, the testing of various derivatives of chlorsulfuron continued. The Du Pont product L 5300 was of interest as it has considerably shorter

persistence than Glean 20DF and is consequently less dangerous to subsequent crops. DPX L 5300 seems to have the same effect on the weed species which can be controlled by Glean 20 DF and possibly a better effect on field pansies.

Charlock germinating in the spring in winter barley showed that the effect of some of the active ingredients, diflufenican and isoxaben, is retained in the soil, from the time of application just after sowing of the winter crop, until the spring.

Therefore, the further testing of these two agents will include observations for phytotoxic persistence.

Experiments were carried out to examine spring weed control - in winter and spring cereals - using hormone mixtures containing mechlorprop or dichlorprop from which the inactive isomer of the propionates had been removed. It turned out that the new propionates at a dose of 55% of the old proprionates, had the same weed control effect.

Although the use of the new propionates does not involve any actual reduction of the active ingredients, plants and soil are nevertheless exposed to smaller quantities of alien chemical agents.

The trials included desiccatants and growth regulators.

The two new growth regulators paclobutrazol and triapentenol had a good straw-shortening effect on several crops. There was not much lodging in 1986, and therefore an estimation of the preventive effect against lodging was difficult.

Experiments with desiccation in peas showed that among the compounds tested Reglone (diquat) had the quickest effect, but the use of Reglone for this purpose is not yet allowed.

By the end of the year, 25 herbicides and one desiccant were approved. Only 9 of these are on the market.

**Reevaluation of previously registered products and biological efficacy data in connection with registration of new pesticides (E. Juhl Petersen, G. Noyé and T. Rubow)**

In 1986 the National Agency of Environmental Protection did not ask for reevaluation of any previously registered products.

However, there was an increasing number of requests for efficacy data in connection with applications to the Agency for registration of new herbicides. 41

products were considered, and in most cases the documentation was sufficiently good for recommending registration. The 41 products all contain known active ingredients, and in a number of cases, it was a matter of extending the field of application of products which had already entered the market.

## 2III. HORTICULTURE

Georg Noyé

In 1986 the horticultural department chiefly concentrated on three main subjects: The official testing af herbicides, herbicides to replace diquat-dibromid preemergence and herbicides to control resistant weed species, especially *Senecio vulgaris* in different row crops.

### Testing of herbicides

In 1986, 25 herbicides and 2 desiccatants were submitted for testing.

The distribution among the crops was as follows: 3 in chives, 2 in onions, 1 in leeks, 1 in carrots, 2 in cabbage, 1 in caraway, 7 in green peas, 1 in beetroot, 1 in celeriac, 1 in strawberries, and 5 i 9 different vegetables, 1 in asparagus, 1 in lawns, 12 in nursery crops, 3 in orchards, and 4 in fruit bushes.

The belowmentioned chemicals all obtained approval - or extended approval- for use, by the Danish Research Service for Plant and Soil Science.

1. Holtox (22.5% atrazine + 22.5% cyanazine) was approved for control of seed weeds in some varieties of transplanted nursery crops and in shrubberies.

2. Fusilade (25% fluazifop-butyl). - The approval was extended to include Elymus repens in strawberries.

3. PP005 (12.5% fluazifop-butyl). - The approval was extended to include caraway, asparagus, carrots, leeks, beetroot and celeriac.

4. Gallant 125EE (125 g haloxyfop ethoxyethyl). - The approval was extended to include strawberries as well as Abies nordmanniana, Picea abies, Sorbus and Spiraea in both nurseries and shrubberies.

5. Afalon (50% linuron). - The approval was extended to include peas.

6. Goal 25 WP (25% oxyfluorfen). - The approval was extended to include certain nursery crops in transplant beds.

7. Stomp (33.5% pendimethalin). - The approval was extended to include several woody plants.

As yet, only Afalon, Holtox F, Fusilade and Stomp have been approved for use by the National Agency of Environmental Protection.

**Substitutes for diquat-dibromid (Reglone)**

A series of trials to compare Reglone with other herbicides for weed control, pre crop emergence, started in 1984. The trials were also carried out in 8-9 crops in 1985-86.

The use of a foliage-applied herbicide, pre crop emergence, is most frequent in horticultural crops where it is often difficult to control weeds after crop emergence. In agricultural crops, the method is usually used in connection with direct drilling, but in certain years it may be necessary to spray overwintered weeds, such as *Stellaria media* and *Poa annua* pre sowing/emergence of beet and oilseed rape.

The trials show the contact effect and to some extent the systemic effect of the chemicals. Furthermore, the soil effect is examined.

In drilled onions, the results from 1985 were confirmed (Noyé, 1986a). Totril and Buctril had a milder effect than Reglone when controlling dicotyledonous weeds. Monocotyledons may be controlled by Roundup pre crop emergence.

The pea trial shows that all the herbicides may be used prior to emergence. Roundup, applied post crop emergence, caused sprout damage in germination tests carried out on the harvested peas.

In chrysanthemum, both Roundup and Totril may substitute Reglone. When using Basta, the time of emergence must be taken into account.

In radish, the last chance for treatment is at the point of emergence. Basta and low dosages of Roundup and Totril may replace Reglone.

Spinach tolerates Totril just as well as Reglone, but Roundup and Basta may also be used as long as the time of emergence is respected.

In curly kale, all the chemicals may replace Reglone, pre crop emergence. Roundup and Basta have given particularly good results.

Caraway seems to tolerate all the herbicides, although large dosages of Totril cause more damage than Reglone.

Oilseed rape has tolerated Basta well, and especially Roundup, post crop emergence. Applied pre emergence, all the herbicides may be used.

In fodder beet, the time of emergence is critical for tolerance of all the herbicides.

**Resistant weeds**

A number of experiments were carried out in nurseries to examine the resistance of *Senecio vulgaris* to herbicides of the triazine type, and to find other herbicides suitable for this purpose.

The experiments did not show any marked tendency that *Senecio* had developed a strong resistance to triazine, but the population density was so considerable that the traditional simazine treatment did not have any satisfactory effect on the weeds.

A number of herbicides were tested, and particularly diuron and oxyfluorfen had a better effect on *Senecio* than simazin.

## IV. CONTROLLED ENVIRONMENT EXPERIMENTS

P. Kudsk and T. Olesen

### Herbicide sensitivity to rain after spraying

A number of experiments concerning the rainfastness of herbicides were carried out in 1986 by means of the rain simulator constructed in 1985.

Since rainfall after spraying does not influence the mode of action, but only the proportion of active agents reaching the site of action, it was possible to use a parallel line assay when calculating the results. This makes it possible to estimate the loss of active agent during a shower.

Glyphosat (Roundup) and fluazifop-butyl (Fusilade) were examined, and the results showed that a longer dry spell was required after an application of glyphosate (> 6 hours) than after treatment with fluazifop-butyl (about 2 hours). It was also found that more than 0.5 mm rainfall would wash off glyphosate whereas less than 2 mm did not wash off any considerable proportion of fluazifop-butyl.

The addition of 0.5% Frigate (Tallow Amine Ethoxylate 800 g/l) to glyphosate led to a significant increase in the effect on barley, both with and without rainfall.

A container experiment sprayed with chlorsulfuron (Glean) showed that 4 hours' dry weather between application and rainfall was not sufficient to ensure a satisfactory effect. Rain 30 minutes after the spraying resulted in an effect corresponding to a loss of 60-80% of active ingredient, depending on the length and quantity of the rainfall.

Difenzoquat (Avenge), however, requires a dry period of over 6 hours in order to obtain a satisfactory effect on *Avena fatua.*

### The influence of additives and admixtures on the herbicide effect

These examinations were started to find the best combinations of herbicide and additive mixtures. One of the aims is to reduce the present herbicide dosage.

In a container experiment, barley treated with glyphosate (Roundup) showed that the dosage of glyphosate could be reduced by 75% when adding 0.5% Frigate. However, subsequent experiments with *Elymus repens* showed that Frigate does not increase the effect of Roundup to the same degree as in barley.

The herbicides and herbicide mixtures used in sugar beet were tested in mixtures with ammonium sulphate, as experiments with other herbicides have shown that

ammonium sulphate may increase the effect of herbicides. This experiment did not show any significantly increased effect by adding ammonium sulphate.

A container experiment was carried out to find out partly whether it was possible to mix difenzoquat (Avenge) and propiconazol+tridemorph (Tilt turbo) without loss of effect, and partly to examine the effect of two different Avenge formulations on *Avena fatua*. The experiment showed that the fungicide propiconazol+tridemorph did not cause any significant change in the effect of difenzoquat. It was found that Avenge 150 had a significantly better effect than Avenge.

A subsequent experiment with difenzoquat (Avenge) was carried out to partly establish the effect on *Avena fatua* when mixed with propiconazol+ tridemorph (Tilt turbo), triadimefon (Bayleton 25 WP) or fenpropimorph+prochloraz (Rival), and partly by applying 2 quantities of liquid (100 and 300 l/ha). The results showed that a reduction in the quantity of liquid to 100 l/ha caused a significant increase in the effect of difenzoquat. The larger quantity of liquid increased the effect on *Avena fatua* significantly when mixed with propiconazol+tridemorph and fenpropimorph+prochloraz, whereas no increase in the effect was seen when fungicides were mixed with the smaller quantity of liquid. It has not been possible to explain the increased effect, but it may very well be caused by the organic solvents in the fungicides.

A container experiment was carried out to examine the effect of the mixture bentaxon+cyanazin (Basagran 480+Bladex 500 SC) when mixed with cypermethrin (Cymbush, Ripcord) on rape, which is an increasing problem in peas, and mustard. The tolerance of the peas was also examined. The results showed that cypermethrin caused a significant increase in the effect of the herbicide mixture. This is probably due to a reduction in the surface tension. The increase in the effect was biggest when the plants were under drought stress.

**The influence of fungicides containing maneb on the effect of hormone products and chlorsulfuron**

The effect and rainfastness of a mixture of MCPA and dichlorprop, as well as chlorsulfuron was examined in a number of experiments partly when applied alone and in a tank mixture with fungicides containing maneb. The test plants used in the experiments were white mustard (*Sinapis alba*), rape (*Brassica napus*) and fat hen (*Chenopodium album*).

The experiments showed that both the effect and the rainfastness of the herbicides used were reduced when they were applied in tank mixtures with powdered formulations of the fungicides. However, effect was not influenced by an application of a mixture containing a liquid formulation of maneb. The results

seem to indicate that it is the formulation rather than the maneb itself which reduces the effect of the herbicides.

Consequently, growers are advised not to use maneb in connection with weed control, especially if reduced herbicide dosages are used.

**Experiments in controlled environment chambers with new active ingredients**

The influence of temperature and relative humidity on the effect of the two sulfunylurea herbicides DPX-L5300 and CGA 131'036 was examined in controlled environment chambers using white mustard (*Sinapis alba*) as a test plant.

The effect of CGA 131'036 depended just as much on the temperature and relative humidity as did that of chlorsulfuron and metsulfuron. Whereas the effect of DPX-L5300 depended mostly on the temperature and was only slightly influenced by changes in the relative humidity. The addition of 0.1% Citowett to the spraying liquid removed, to some extent, the dependence on the relative humidity.

In another experiment, the rainfastness of DPX-L5300 with and without addition of 0.1% Citowett was examined under varying climatic conditions. The experiment showed that the rainfastness of DPX-L5300, when applied alone, was greatest at low relative humidity, whereas the relative humidity did not have any influence on the rainfastness if 0.1% Citowett was added to the spraying liquid.

## V. FORESTRY, WINDBREAKS

T. Rubow

### Conifers

Over the years, the tolerance trials have been greatly extended to include additional tree species and not only older, but also newer herbicides. Only a small part of this work has been requested by other institutions or companies. The herbicides in question were MCPA, clopyralid, glyphosat, triclopyr, diflufenican, hexazinon, atrazin and terbuthylazin as well as a number of tank mixtures using several of these products.

### Deciduous trees

Selective control of well-established dicotyledonous weeds (raspberry, bramble, willow herb, common nettle etc.) in deciduous plantations is almost impossible using common spraying methods. The increased interest in production of deciduous trees has intensified the need for efficient control measures.

Various method studies on different implements designed to give a tool for less harmful (e.g. screened) leaf herbicide application are being investigated. Several methods, e.g. contact application or special CDA sprayers, seem promising.

### Hogweed

4-5 years ago, giant hogweed (*Heracleum mantegazzianum*) was a very common and much discussed problem, and the institute received a great number of enquiries concerning control measures. Although advice on this subject can be found in a number of publications (Short Bulletins, Grønt blad, Guidance on Control Measures, Landsbladet, Natur og Miljø, the daily press, etc.), the interest in the problem seems to be increasing.

Glyphosate (Roundup, Grassat 5) is the only herbicide on the Danish market which control hogweed effectively. Since this herbicide destroys all the vegetation with which it comes into contact, this is not always suitable, and a new herbicide, triclopyr, which is less harmful to grass, is being tested. The results are promising.

### Growth regulation

For several years, the development of Caucasian firs as christmas trees has been studied, and it seems that one of the greatest problems which leads to inferior quality, or even rejection of the trees, is too rapid a top growth from a certain age resulting in trees which are too open. During 1986, experiments with

chemical growth retardation were started. Growth regulator (etephon) was applied to the top shoots different times during the shoot elongation period.

**Department for non-chemical weed control** (J. Vester)

As environmental considerations increase the demand for alternatives to herbicide treatment, there is a renewed interest in the use of flames for weed control, both in agriculture and horticulture. Flame treatment is particularly suitable when growing vegetables and fruit, but it may also be used for beet or potatoes, or in various specialized productions like, for instance, seed crops or medicinal plants.

In Denmark, flame treatment is mostly used in connection with organic farm production of vegetables, where it may save many hours of manual weeding. However, the effect and capacity of the machinery is not satisfactory. It is hoped that the forward speed may be increased from the present 1-4 km/h to 8-10 km/h. So far, none of the agricultural machinery on the market has been quite satisfactory.

Based on experiences from 1985, a number of experiments with selective flame treatment were carried out for the Institute, by farmers. In the fields near the Institute, experiments were carried out with surface treatment techniques, and improvements were made.

Experiments with selective flame treatment were mostly carried out in onion set cultures. In addition, selective flame treatment was tried on seed onions, fodder maize, potatoes, redcurrant and blackcurrant.

Surface treatments were tried in onion sets and maize before and shortly after emergence. Besides, the effect of various burner types and screens were tested. These experiments were mostly carried out on test plants of rape and white mustard.

As there is still no acceptable commercial machinery on the market, the equipment used for the tests, as in 1985, was all designed and constructed at the Weed Research Institute.

The long distances necessitated the use of handborne equipment to carry out the selective flame treatment. The machines are usually provided with leaf lifters insulated with ceramic fibre. In this case, the flames are only wind-protected. The experiments, with 3 replicates per treatment, were carried out as field trials. These weed and yield determinations were made in two sections per plot.

The development of new techniques and machinery at the Weed Research Institute has made flame treatment at speeds of 6-9 km/h possible. The early known technique operated at a speed of 3-4 km/h. The increased speed was obtained without increasing the gas consumption, which is 50-60 kg/ha. This improvement has made flame treatment for use as non-selective surface treatments much more interesting. It may be used for pre-emergence treatment or as an alternative or supplement to hoeing.

By non-selective surface treatment, all foliage above ground is destroyed. The newly developed technique has made the effect on the leaves independent of protective layers of, for instance hair or wax. The effect of the earlier unscreened burners on leaves and stems was much reduced. However, it must be admitted that flame treatment still does not have any effect on plant material below the ground surface. Thus the growth point on rosette plants and grasses is so well protected that one or more flame treatments have a very limited effect on the number of plants.

**Selective flame cultivation**

Selective flame cultivation may be carried out in several crops, for instance onions, maize, potatoes and beet. However, the method may damage the crop. In mechanically planted onions the average yield loss due to damage resulting in uneven growth, is 10-15%. Corresponding yield losses were found in 1985 due to selective flame treatment of onion sets (Vester 1986). In many cases, flame treatment provides sufficient weed control in onion sets. However, the control of certain weeds (rosette plants and grasses) is difficult as their growth points are protected. Supplementary treatment - either chemical or manual - is necessary for these species.

Flame treatment in onions will often be somewhat more expensive and labour-consuming than chemical weeding, and since it may also result in a considerable growth retardation, the method is not of interest in conventional onion production. However, selective flame treatment may be an attractive method for ecological and other kinds of production where the alternative is manual weeding. Flame treatment is much cheaper than manual hoeing and weeding. Moreover, flame treatment makes it possible to cultivate much larger areas without the use of herbicides, for the enormous amount of manual work in May and June considerably limits the quantity of ecological vegetables which can be grown on the individual farms.

Strategy for flame treatment in onion sets:

1. Onions may be treated with flames until they are 5 cm, without any damage to the crop. The intensity of surface treatment may vary from 90 to 100 kg gas/ha without any risk of damage. High intensity is recommended for species like camomile and shepherd's purse which are difficult to control. All treatments should be carried out at the cotyledon stage of the weed. At slow emergence of the onion sets, two treatments are recommended, the latter at 5 cm onion height. By this two-stage treatment most weeds are treated at the cotyledon stage.

2. When the onions are 15-20 cm, the flame treatment may be repeated. At the first treatment, it may be necessary to reduce the intensity to 40 kg/ha to protect the onions. This may be necessary if the treatments are started very early in order to treat the weeds while they are small. The treatments are continued as required with an intensity of 50-60 kg gas/ha until mid-June. After this time, traffic in the field will cause considerable mechanical damage to the crop. At this point or earlier, supplementary mechanical control or hoeing may be necessary if problematic weed species occur in the field.

**The effect on the weed species**

Flame treatment only gives a superficial scorching to the plants, and consequently protected growth points will not be destroyed. Thus all grass species can easily survive one or more flame treatments. In the case of rosette plants, like camomile and shepherd's purse, 2-3 rosettes will usually protect the growth point situated at ground level. All these species can be controlled for a period through several scorchings, but the reduction in the number of plants is limited.

Consequently, factors like food reserves in the roots, water and food supply, will probably have a great influence on the effect of the flame treatments.

The ability of the crop to compete at this point, decides whether the development of the weakened plants is stopped, or supplementary chemical, mechanical or manual weeding becomes necessary.

However, if a considerable quantity of such "problem weeds" are spotted early in the growing season, it will often be a good idea to take efficient chemical or mechanical control measures at once and continue with flame treatment afterwards.

The effect of flame treatment is most easily ascertained by the so-called "finger pressure method". A leaf is slightly compressed between two fingers. If this leaves a permanent dark green mark, it indicates comprehensive cell damage.

With a little experience, the finger pressure method is the best way of testing forward speed, burner adjustment, gas pressure, etc.

Table 2. Sensitivity of various weed species to flame treatments. Preliminary assessments. Differences mainly due to different regrowth abilities.

| | | |
|---|---|---|
| 1. | Sensitive (Treatment effective at 2 true leaves) | |
| | White goosefoot | (*Chenopodium album*) |
| | Chickweed | (*Stellaria media*) |
| | Cleavers | (*Galium aparine*) |
| | Groundsel | (*Senecio vulgaris*) |
| | Red dead-nettle | (*Lamium purpureum*) |
| | Black bindweed | (*Polygonum convolvulus*) |
| | Red shank | (*Polygonum persicaria*) |
| 2. | Medium sensitivity (Treatment preferably at cotyledon stage) | |
| | Field pansy | (*Viola arvensis*) |
| | Charlock | (*Sinapis arvensis*) |
| | Black nightshade | (*Solanum nigrum*) |
| 3. | Tolerant (Repeated flame treatments destroy parts above ground, but growth point survives on many plants) | |
| | Corn marigold | (*Chrysanthemum segetum*) |
| | Scentless camomile | (*Matricaria inodora*) |
| | Shepherd's purse | (*Capsella bursa pastoris*) |
| | Annual meadow grass | (*Poa annua*) |

Potato haulm desiccation

Flame treatment may be used for potato haulm desiccation and seems to have an effect comparable to Reglone treatment. In cultivars with vigorous growth, previous mechanical topping of the potatoes will in any case be advisable. However, the advantages of flame treatment compared with Reglone are limited due to the slow speed used in the experiments (2-3 km/h). The speed must therefore be doubled, and the equivalent effect can be achieved by increasing the heat capacity of the flame applicator. A doubling of the heat capacity seems to have already been obtained by simple screening and insulation of the gas burners.

The method is being further developed at the Weed Research Institute. The aim is a forward speed of 6 km/h. The experiments are paid for by the Nordic Council of Ministers.

**Technical investigations**

Until now, flame cultivation has been carried out at a relatively slow forward speed (2-4 km/h). This speed is not acceptable to most farmers and vegetable growers, who want a speed of 8-10 km/h. The experiments at the Weed Research Institute have concentrated on developing a technique which allows a higher speed. A number of tests comparing different burner types, under different conditions, were carried out, and new equipment was designed and tested.

Parallel with the technical construction and testing, experiments were carried out to examine the biological possibilities and limitations of flame treatment.

4 different gas burners were used for this field test series. The test material was naturally occurring weeds, and sown test plants (i.e. rape (*Brassica napus*) and white mustard (*Sinapis alba*)). Unless otherwise stated, the burners used for the experiment were screened by means of an insulated steel box. Experiments of three replicates each were carried out, and the results were estimated in 2 x 0.25 $m^2$ per plot.

**Evaluation of efficacy (E. Juhl Petersen, G. Noyé and T. Rubow)**

In 1986 the Environmental Protection Agency did not ask for reevaluation of the older compounds.

However, there was a marked increase in the number of efficacy evaluations in connection with applications to the Environmental Protection Agency for registration of new herbicides, desiccators and growth regulators. A total of 41 compounds were tested, and in most cases the documentation was such that approval could be recommended. The 41 products all contain known active ingredients, and in a number of cases it was a matter of extending the use of products which were already on the market.

**Damage thresholds for weed control (P. Kryger Jensen)**

The project concerning damage thresholds is based on a series of yield registrations in connection with weed control in the main agricultural crops. It includes more than 1000 experiments in spring crops, 400 in winter crops and 100 in spring rape.

The experimental results include information about the total weed quantity per m and the number of occurrence of the most dominating weed species. Yield and

yield increase by weed control was registered as well as the water content of the cereal both in treated and untreated plots.

Based on these experiments, the relationship between weed quantity and yield loss is established both for the total weed population and for the most important individual weed species. Moreover, the relationship between weed occurrence and water content in the harvested cereal is examined.

Normative damage thresholds for weed control are set up on the basis of these results. Factors like value of yield loss, drying costs and difficult harvesting are taken into consideration when fixing the damage thresholds; and likewise the long-term effect of weed control on reduced seed production.

## VI. WEED BIOLOGY, DISTRIBUTION AND SPREADING

C. Holm-Nielsen

A reference collection of weed seeds for identification of seed from the soil seed bank is being prepared.

Investigations of the development of the weed flora by continuous barley growing in relation to soil treatment with and without herbicide application were continued and combined with examinations of weed seed production started in 1982.

The results of 4 years' data collection were published at the 3rd Plant Protection Conference.

The main conclusion was:

The weed flora in the two experiments, in Jutland and on Zealand, differed considerably, although the soil type was the same.

In the experiment in Jutland, the density of *Tripleurospermum indorum* increased during the experiment, but less than that of the two weed species on Zealand mentioned below.

*Stellaria media* had developed into a dense cover, especially in experiments where neither ploughing nor herbicides were used. In July 1985, the green biomass in this experiment weighed about one quarter of the total mass of weeds-equivalent to about 5.5 t per ha.

*Sinapis arvensis* showed a similar increase which, at the counts in May, was most pronounced in plots without ploughing, but at the determination of the green biomass in July, the difference between ploughed and non-ploughed plots had almost disappeared.

The seed yield in the experiment on Zealand was much reduced because of the enormous weed population, whereas the seed yield in Jutland was much less influenced, due to the smaller weed density in this crop.

## E. LABORATORY FOR PESTICIDE ANALYSIS

Flakkebjerg, 4200 Slagelse

**Scientific staff:**

**Susanne Elmholt:** The effect of pesticides on the microflora

**Gitte Felding:** Registration of pesticides in groundwater

**Arne Helweg:** Degradation of pesticides etc. in soil

**Erik Kirknel:** Fungicides and insecticides in plants

**Peder Odgaard:** Herbicides in plants

### I. FIELD OF ACTIVITY

The main tasks are examinations of pesticides as to persistence, degradation and leaching in soil and their uptake, transportation and metabolizing in plants. Besides, the influence of pesticides on the nutritive value of some crops and on the microorganisms of the soil is examined.

### II. EFFECT OF PESTICIDES ON MICROFLORA

**Effect of fungicides on the fungi in field trials with cereal crops (Susanne Elmholt)**

In 1986 field trials in winter wheat were carried out in 5 blocks with 2 dosages of Tilt 250 EC (0.5 and 5.0 l/ha) and in a control. The treatments took place on the 27th May and 17th June - half the dosage was applied each time. The depositions on the soil in all the plots were registered at both times of application. Soil samples for isolation of microorganisms were taken out 10 times during the period 22nd May to 11th August to depths of 0-1 cm and 1-2 cm. Soil fungi were isolated by plate dilution and soil washing. Besides, biological activity was registered, including $CO_2$ evolution. Fungi on green leaves (Cladosporium spp.) were registered.

Apart from the field experiments, methodological studies were carried out in connection with isolation techniques. Experiments were made with inhibition of fungi in pure cultures with fungicides, and with germination of barley in pots to which had been added straw, treated with fungicide.

## III. REGISTRATION OF PESTICIDES IN GROUNDWATER

**Results of atrazin registration in groundwater below maize fields (Gitte Felding)**

In cooperation with DGU (The Danish Geological Survey) and local agricultural advisers, we have chosen homogeneous localities with a cover layer of sand and a high level of groundwater. In the autumn of 1985, samples were taken from a locality near Ølgod and in February 1986 from near Løgumkloster.

Groundwater samples were taken below 2 maize fields, one of which has been sprayed with atrazin for only 3 successive years, the other for a minimum of 6 years.

Groundwater analyses from the maize field where the pesticide has been used for the longest time show an atrazin content in 9 out of 13 samples of 0.01-0.06 g/l (ppb). Thus the results indicate that the maximum permissible value of 0.1 ppb for one particular pesticide in drinking water is not exceeded, even in high-level groundwater after long-term treatment with atrazin.

Fairly large quantities of slurry have been added every year to the field from which the samples were taken. Thus these findings may not apply in all cases where atrazin is used, as test results from other countries seem to indicate that atrazin is degraded twice as quickly in soil to which 100 tonnes of slurry per ha have been added as in soil without addition ofslurry. The investigations will be continued with water sampling for atrazin analysis below forest areas where this herbicide has been applied.

## IV. DEGRADATION OF PESTICIDES ETC. IN SOIL

**Degradation of pesticides in deep soil layers (Arne Helweg)**

In 1986, this project comprised the degradation of 2.4-dichlorphenol (a degradation product of the phenoxyherbicides 2.4-D and dichlorprop), of parathion and of TCA, which is a mobile herbicide used both in the spring and in the autumn. Degradation was registered both in melt water sand and in moraine sand at concentrations of 0.05 and 5 mg $kg^{-1}$.

The results show that at the low concentration (0.05 mg $kg^{-1}$) all 3 compounds are degraded, both in melt water sand and in moraine sand, however, only at a rate between 1/10 and 1/20 of the degradation rate in the plough layer, estimated on the basis of the liberation of $^{14}C$ in $CO_2$.

At a concentration of 5 mg $kg^{-1}$, some degradation of all three compounds occurred in the melt water sand (about and under 5% of the degradation rate in

soil from the plough layer). In the moraine sand, however, the degradation was very small, especially of 2.4-dichlorphenol and TCA, where only a few per cent of the $^{14}C$ was liberated in $CO_2$ after 1 and a little more than 2 years' incubation, respectively.

The investigations included a number of adsorption determinations showing that adsorption in soil layers below the root zone is considerably lower than in soil from the plough layer. Thus MCPA $K_d$ values of 0.7, 0.9 and 1.0, respectively, were seen in 3 soil samples from the plough layer, whereas samples from below the root zone had values of 0.3 and 0.4. The $K_d$ value for TCA was 0 in all soil samples.

**Influence of the agricultural use of pesticides on microbial activity in soil (Arne Helweg)**

A number of experiments have been carried out for companies in order to investigate the effect of unregistered pesticides on the microbial activity in soil. The experiments included registration of the influence on ammonification, nitrification, respiration and microbial $N_2$-fixation in 2 types of soil.

## V. FUNGICIDES AND INSECTICIDES IN PLANTS

**Fungicide uptake in barley under varying climatic conditions (Erik Kirknel)**

In 1986 experiments were carried out with two cultivars, Galant and Catrin, at the experimental farm of the Carlsberg Laboratories at Ringsted. The fields were treated with 1 x and 1/3 x normal dosage of Tilt turbo either together with the herbicide treatment in the middle of May, or later in June. By the early treatment, the dosage was always half the amount mentioned above. By the later treatment, the dosage was either half the quantity mentioned or the dosages mentioned. Samples were taken out for residual analyses, leaves for identification of saprophytic fungi (performed by Susanne Elmholt). Furthermore, mildew attacks were estimated before the last spraying. The Carlsberg Laboratories determined the thousand grain weight and grain size. As expected, Catrin gave a better yield than Galant, and the treatments were more profitable. Split-up treatments seem to be at least as profitable as fewer treatments with larger doses. As little as one sixth of normal dosage had a considerable effect on the yield. A few attacks of mildew occurred just before the last treatment. In the control, a denser population of Cladosporium was seen than in the experimental plots. These investigations are not sufficient to establish any certain correlation between the occurrence of saprophytic fungi on barley leaves and the dosage or the time of treatment.

**Influence of pesticides on nutritional value of cereals and potatoes (Erik Kirknel)**

The feeding experiments with rats fed on potatoes treated with normal doses of Maneb, Ridomil or Pirimor or all three in combination were finished. No changes in the true digestibility, biological value or digestible energy could be found by the experiments.

**Other tasks (Erik Kirknel)**

The samples collected in 1985 in connection with the project concerning the influence of pesticides on honey bees financed by the Joint Council for Agricultural Research and Experiments have been analysed. The results of the analyses show that the bees introduce larger quantities of Cypermethrin into the hives than previously assumed. The bees examined had quantities of Cypermethrin on or in them corresponding to what is seen in connection with parathion poisoning, i.e. 1-2 ppm. The size of the samples of wax, larvae, pollen and honey was smaller than originally intended, and they could not be analysed. Besides, the project included a number of analyses of dead bees suspected of having died from bee poisoning with organophosphates. When the results of the analysis was communicated to a farmer who was under suspicion of having caused the poisoning, certain questions were clarified.

The experiments were carried out late in the summer in a late-sown mustard field to avoid that the bees flew to other fields than the experimental one.
As usual, the laboratory carried out analysis of trace compounds (fluorescent dyes) for colleagues at the Research Centre. Analyses were carried out for Per Kudsk and Steen Lykke-Nielsen.

## VI. HERBICIDES IN PLANTS

**Herbicides in plant material (Peder Odgaard)**

Residual dichlorprop, MCPA, and dicamba have been investigated from 3 years' crops of barley experimentally sprayed with these herbicides. Samples were taken successively from treatment until whole-crop harvesting (for silage). In the first year, samples were also ensiled in glass jars for 2, 8 and 32 weeks, and then analyzed. The analytical work was finished in 1986.

Fodder peas for nutrition experiments at the National Institute of Animal Science (Poultry and Rabbits Dept.) have been analyzed for diquat content.

**Other analytical work (Peder Odgaard)**

Reports have been prepared in 15 cases where soil samples were sent in for examination of their herbicide content. The main object is to throw light on what has caused damage to ornamental plants or field crops. Besides, an estimate is often wanted of the risk to new-established cultures.

The investigations of spray wind drift and spray deposition in cereal crops continued in collaboration with the Weed Control Research Institute.

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