Danish Institute of
Plant and Soil Science

Plant diseases, pests and weeds in Denmark 1992

109th annual report
Compiled by
The Research Centre for Plant Protection

Lyngby 1993

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Contents

A. DANISH RESEARCH CENTRE FOR PLANT PROTECTION

Director: E. Henning Jensen

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

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

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

Secretariat	Søren W. Bille
Department of Plant Pathology	Ib G. Dinesen (acting until 31.5.92) Bent J. Nielsen (acting from 1.6.92)
Department of Pest Management	Jørgen Jakobsen
Department of Weed Control	K.E. Thonke
Department of Pesticide Analysis and Ecotoxicology	Arne Helweg
Biotechnology Group	Peter Ulvskov

The aim of the Research Centre for Plant Protection is

- to improve the basis for preventing and controlling plant diseases, pests and weeds in agriculture by using environmentally acceptable and sustainable methods
- to develop and recommend effective preventive and control measures which are not damaging to the environment
- to implement the results gained from the research and experimental work carried out at the centre and to use results from other national or international research institutes as a basis for the advisory service
- to contribute to the creation of a background for national and international plant protection legislation

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

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

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

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

The Research Centre for Plant Protection is hosting the Biotechnology Group which at the moment employs six scientists. One of the aims is to develop diagnostic methods for plant diseases.

The Research Centre for Plant Protection is very much involved in the establishment of an information system on diseases, pests and weeds.

During 1992, many efforts have been put on the elaboration and planning of a new research programme under the Ministry of Agriculture, "Plant Protection towards year 2000". Furthermore, the Research Centre for Plant Protection has contributed to the report regarding "Sustainable Agriculture" which is presently being prepared by the Ministry of Agriculture.

The 9th Danish Plant Protection Conference was held on March 3rd and 4th, 1992 attracting about 600 participants.

B. SECRETARIAT

Head of secretariat: Søren W. Bille

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

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

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

Of the 149 employees, 86 are located at Lyngby and 63 at Flakkebjerg.

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

	S	TS	Total
Administration and common functions	2	20	22
Department of Plant Pathology	15	18	33
Department of Pest Management	12	10	22
Biotechnology Group	6	3	9
Department of Weed Control	20	31	51
Department of Pesticide Analysis and Ecotoxicology	5	7	12
Total	60	89	149

S: Scientists
TS: Technical-administrative staff

Financing and staff
Approximately 55 per cent of the activities of the Research Centre for Plant Protection are being financed by way of the government budget. The remaining part of the funds are being provided by way of research programmes financed publicly or privately as well as by different forms of economic activity. In 1992, the total expenses of the Research Centre for Plant Protection amounted to about 48 mio. Dkr.

D. DEPARTMENT OF PLANT PATHOLOGY

Head of Department: **Ib G. Dinesen** (acting until 31.5.92)
Bent J. Nielsen (acting from 1.6.92)

Scientific staff:

Karen Bech: Viruses of horticultural plants and vegetables. Production of healthy nuclear stocks of horticultural plants.
Lars Bødker: Root pathogenic fungi in peas.
Ib Dinesen: Bacterial diseases.
Mogens S. Hovmøller: Virulence analysis of mildew and yellow rust of barley and wheat.
Hanne Lipczak Jakobsen: Diseases in oil seed rape, testing of fungicides.
Lise Nistrup Jørgensen: Fungicides in cereals.
Bent Løschenkohl: Fungal diseases in horticulture, potato wart testing.
Keld Mansfeld-Giese: Bacterial ring rot of potato.
Bent J. Nielsen: Fungicides in cereals, fungicide resistance.
Sten Lykke Nielsen: Viruses of potatoes; potato micropropagation programme. Viruses of agricultural plants.
Hellfried Schulz: Root and foot rot of cereals, leaf and seed borne diseases of peas.
Jørgen Simonsen: (stationed at the Research Centre of Agriculture, Foulum) Testing of fungicides in cereals, peas and potatoes.
Sten Stetter: Threshold values for leaf diseases of cereals.
Boldt Welling: Leaf diseases of cereals and grasses.

GENERAL REPORT (Bent J. Nielsen)

The main tasks of the department are investigations, surveys and experimental work on fungus, bacterial and virus diseases, testing for disease resistance and efficacy testing of fungicides.

In 1992, great effort has been put into work on integrated plant protection systems and development of decision models with the aim of reducing the use of pesticides. This work comprises the build-up of a "PC-plant protection" system and an information database. The work has been concentrated on wheat and barley but also in other crops plant protection models are under development (oil seed rape, potatoes, vegetables).

The right dose at the right time is a key question and several experiments have been carried out with different doses of fungicides, both under field and semi field conditions.

The virulence surveys for leaf diseases in barley and wheat were continued, focusing on the mildews and rusts. The results were used as basis for forecasts of disease risks in commercial varieties.

In order to build up a network for registration of diseases, observations have been made of cereal diseases and Sclerotinia stem rot in rape. Root pathogens of peas were studied and a soil test method developed.

In winter barley, Barley yellow mosaic virus and Barley mild mosaic virus were recorded in one place in the southern part of Denmark. In other crops, much work has been done on soil borne viruses in potatoes and on the maintenance of a potato meristem culture bank.

In horticultural crops, the main work has been concentrated on glasshouse crops where virus diseases of *Kalanchoë*, *Pelargonium* and *Euphorbia pulcherrima* were investigated. Root pathogenic fungi are a problem in crops grown in recirculating irrigation systems and methods for quick detection are being investigated.

Diagnostic work comprises both routine identification of viruses, bacteria and fungi with molecular biological, serological techniques and protein electrophoresis for rapid and reliable detection of quarantine bacteria. A project on finding better ways of detecting bacteria in meristematic tissues is continued.

As part of the MSc thesis work 6 agricultural students have been working at the department. The subjects comprised *Septoria nodorum* as a seed borne disease, yellow rust of wheat, *Phoma* and *Botrytis* in oil seed rape, leaf and pod diseases in peas and *Sphaerotheca* in black current.

A Malawian agronomist spent 6 months at the department on a FAO fellowship to study seed potato micropropagation and multiplication.

I. DISEASES ON CEREALS

Virulence surveys in populations of the cereal mildews and rusts (Mogens S. Hovmøller and Boldt Welling).

The virulence surveys comprised in 1992 the pathogens *Erysiphe graminis* f.sp. *hordei*, *Erysiphe graminis* f.sp. *tritici*, *Puccinia striiformis*, and *Puccinia hordei*. The surveys were based on random samples of aerial powdery mildew spores, and random isolates of yellow rust and brown rust obtained from some few wheat and barley varieties predominantly without race-specific resistance to the rusts considered. A total of about 600 isolates of barley powdery mildew, 90 isolates of wheat powdery mildew, about 80 isolates of wheat

yellow rust, and 115 isolates of brown rust were collected. The major part of the isolates were assayed by differential sets of varieties possessing known genes for resistance to the different pathogens during summer and autumn, while the rest will be assayed in winter 1992/93.

Barley powdery mildew: Relatively large changes in the composition of the aerial pupulation occurred during 1992. The frequency of isolates virulent on varieties possessing *Mla13* (V_{a13}) increased to 50-60% and the frequencies of isolates virulent on *Mla9* (V_{a9}) increased to 30-40%. The virulences V_{a7} and V_{a12} which match genes widely used in previous years in Denmark were observed in frequencies from 70-85%, whereas the frequency of V_{La} was about 30-35%. The virulences V_{a1} and V_{a3} occurred in frequencies from 10-20%, which was not much different from observations in the two perious years. A significant decrease to about 60% was observed for the requency of V_{a6}, which matches resistances present in some of the winter barley cultivars. True 'virulence' on varieties possessing Mlo resistance was not observed. Direct exposure of varieties with Mlo resistance gave in most cases about 5% of the number of powdery mildew colonies observed on the susceptible control varieties. The relative number of colonies on Mlo-resistant varieties depended apparently on climatic conditions during exposure.

Wheat powdery mildew: Only minor changes in virulence frequencies matching to resistances present in commercial wheat varieties grown in Denmark, were observed. Virulences on varieties possessing *Pm2*, *Pm5*, *Pm6*, and/or *Pm8* were observed in frequencies from 80-100%, whereas virulence matching to *Pm4b* was observed in a frequency of about 25%

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Wheat yellow rust: Isolates of the yellow rust pathogen were collected at 4 localities from the varieties Sleipner possessing *Yr9*, and Anja with no effective race-specific yellow rust resistance. The preliminary results show only minor differences in virulence spectra between isolates within each locality. The most common phenotype, which accounted for about 80% of the isolates, was virulent on varieties possessing *Yr2* and *Yr9*, and the resistances in Stubes Dickkopf, Suwon/Omar, Hybrid 46 and Nord Desprez, respectively. Intermediate infection types were observed on Vilmorin 23 and Capelles Desprez. A few isolates were virulent on *Yr1*, *Yr6*, and Carstens V, respectively. Virulence on varieties possessing *Yr5*, *Yr7*, *Yr8*, or *Yr10* was not observed.

Barley brown rust: Brown rust on barley occurred at levels from weak to moderate. A total of 51 isolates from winter barley and 64 isolates from spring barley varieties were collected and multiplied as single postule isolates. At the end of the year, 27 isolates had been tested successfully at the international set of differential varieties. Virulence on varieties possessing *Pa1*, *Pa2*, *Pa4*, *Pa6*, *Pa8* or *Pa9* was observed in high frequencies, while 30% and 60% of the isolates were virulent on varieties with *Pa3* and *Pa5*, respectively. All isolates were avirulent on the differential variety with *Pa7*.

Seed borne diseases in cereals (Bent J. Nielsen and Lise Nistrup Jørgensen)

Bunt of wheat (*Tilletia caries*).
Tilletia caries was seen in 1992 with a little greater attack than in the previous three years. To prevent an epidemic to break out only products with very high efficiency will be approved. At the moment the only product with a biological approval against *T. caries* is Sibutol LS 28o (bitertanol 250 g/l, fuberidazol 18 g/l). With a dose of 100 ml pr. 100 kg there was 100 % control even at a very high disease pressure. New biological approval is Sibutol FS (bitertanol 375 g/l, fuberidazol 23 g/l) with 150 ml pr. 100 kg.

Stripe smut of rye (*Urocystis occulta*)
U. occulta is a rare disease in Denmark and field trials are carried out with artifical inoculation. There was 100 % control after seed treatment with 100 ml Sibutol LS 280, 150 ml Sibutol FS, 200 ml Fungazil C (imazalil 25 g/l, carboxin 400 g/l) and 250 ml Vitavax 200 F (carboxin 200 g/l, thiram 200 g/l). New biological approval is Vitavax 200 F.

Loose smut of barley (*Ustilago nuda*).
In 1992, there was very severe attack of *U. nuda* in winter barley mainly due to the optimal conditions for disease infections in the summer 1991. Many fields had 5-10 % attack and in some fields attack up to 30-40 % was seen. Especially some varieties were always severely attacked (e.g. trixi). The level of attack was low - moderate in spring barley. The only active ingredient on the Danish market is carboxin, and with Fungazil C the control in winter barley was 88 %. With other products, which are not registered yet, there was a control of almost 100 % (different Raxil-formulations with tebucanazol). The biological approval for the older products Vitavax 390 F (carboxin 390 g/l) and Vitavax 75 (carboxin 750 g/kg) has been withdrawn due to low efficacy.

Leaf stripe of barley (*Drechslera graminea*).
With imazalil as active ingredient in many products and with a treatment frequency of 80-90% of the Danish barley, it has been possible to keep *D. graminea* at a very low level in the fields. Other active ingredients have also shown prommising results. Good control was obtained with Fungazil A (imazalil 50 g/l), Raxil 040 LS (tebuconazole 20 g/l, triazoxide 20g/l), Raxil 035 ES (tebuconazole 15 g/l, imazalil 20 g/l), Fungazil bejdse (imazalil 50 g/l) and Dividend 37,5 (difenoconazole 37.5 g/l). The efficency against *D. graminea* was too low when tebuconazole was used alone.

On the Danish variety list there are several varieties with high resistance against *D. graminea* and in these cases it is not necessary to use chemical seed treatment.

Identification of race-specific resistance to brown rust in Danish spring barley varieties (Boldt Welling).

Race-specific resistance to brown rust were in 1991 investigated in 73 commercial spring barley varieties by use of 8 differential isolates of *Puccinia hordei*. In 1992 additional differential isolates were collected from varieties, which were resistant to the 8 differential isolates used in 1991. The new isolates will be tested in winter 1992/93.

Preventive and curative effect of fungicides and test for rainfastness (Lise Nistrup Jørgensen)

Trials were carried out as semifield trials or greenhouse trials. Plants were artificially inoculated with different diseases (*Septoria tritici*, *Septoria nodorum*, *Puccinia striiformis* or *Puccinia hordei*).

The residual effect from different dosages of Tilt top (propiconazol + fenpropimorph) were tested using artificial inoculation of *Septoria nodorum*. The effect of 1/8 of the normal dose lasted for 10 days, 1/2 and 1/4 of the normal dose for 15 days. At this last date of inoculation the full dose still gave 94% control.

Puccinia spp. was controlled preventively or curatively by different DMI products. Full control was obtained for all tested dosages up to 5 days before symptoms appeared. At the end of the latent period no dose response could be seen, indicating that timing is more important than the dose.

Rainfastness was tested for Tilt 250 (propiconazol) and Tilt top (propiconazol + fenpropimorp) using *Septoria nodorum* as disease. The trial showed that Tilt 250ec had a reduced effect if rain was applied after 1/2 hour and in some cases also 1 1/2 hour after the fungicide had been applied. The trial was carried out using 4 different dosages of the products. The reduction in effect was seen regardless of the used dose.

Root and foot rot diseases in winter wheat (Hellfried Schulz & Sten Stetter)

Eyespot (*Pseudocercosporella herpotrichoides*)
The winter 91/92 was again relatively mild and the risk of eyespot was very similar to that of 1991.

Chemical treatment with half dose was recommended in 36 per cent, and with full dose in 16 per cent of the 89 examined wheat fields.

The summer was unusually dry and this had a restrictive influence on the development of the disease. Moderate attacks were only registered in 3 per cent of 64 examined field at growth stage 75. The examined fields are distributed all over the country.

In 1992, further observations of *Tapesia yallundae* were made in overwintering stubble in Denmark.

Sharp eyespot (*Rhizoctonia cerealis*)
In 1992, sharp eyespot occurred in 66 per cent of the examined fields but the attacks were on a very low level and often limited to the outer leaf sheet.

Fusarium foot rot (*Fusarium culmorum*)
Fusarium foot rot was more common in 1992 than in the previous years. In 75 per cent of 51 examined fields, from 1 to 20 per cent of the straws were attacked by Fusarium. Mixed infections of eyespot, sharp eyespot and Fusarium on the single haulms were very seldom in 1992.

Take all (*Gaeumannomyces graminis*) occurred in 1992 in only 5 per cent of the 61 examined fields with moderate attacks. Especially in the 2nd of two successive years with winter wheat. the rest of the fields were healthy with only 1-5 per cent of the root mass attacked.

Research concerning MBC-resistance and prochloraz-resistance of eyespot fungi (*Pseudocercosporella herpotrichoides*) (H. Schulz and L. Nistrup Jørgensen)

In July 1991, straw with symptoms of eyspot were collected randomly from several fields throughout Denmark. Isolates are tested on prochloraz (0.01, 0.1, 1.0, 10.0 ppm). So far, no indication of resistance to eyespot has been found, despite the fact that the effect of prochloraz in the fields is low. R-types have on average an ED_{50} value = 1.22 and W-type an ED_{50} value of 0.23.

Control of diseases in cereals. (Lise Nistrup Jørgensen, Bent J. Nielsen, Jørgen Simonsen and Sten Stetter).

A total of 33 trials in winter wheat, 2 trials in winter rye, 22 trials in winter barley and 18 trials in spring barley were carried out testing different fungicides' efficacy for control of diseases. Many of the trials were designed to provide background for approval of products, to give information on reduced dosages and to test different spraying strategies, including PC-Plant Protection, which is a computer based model developed by the Research Centre for Plant Protection.

The following DMI-products were tested in the trials : Triadimenol, propiconazole, flusilazole, tebuconazole, prochloraz, cyproconazole, tetraconazole, epoxyconazole, fenpropimorph plus products which contain combinations of the mentioned products.

In spring moderate attacks of eyespot (*Pseudocercosporella herpotrichoides*) were found. Because of an extremely dry summer, the disease almost stopped developing any further beyond the middle of May. On average, of 14 trials in winter wheat and 2 in winter rye, a full dose of Sportak 45ec (1.0 l) applied at GS 31 gave 65% control with yield increased of 1.1 hkg/ha. Several different timings for eyespot control were tested. The obtained effects from these different timings did not give significant differences in control.

Septoria tritici was, as in most seasons, widespread in early spring. The disease stopped its development because of the extremely dry summer. Low attack was seen up to 3rd leaf, and only in a few cases small attacks were seen on 2nd leaf. As an average of 12 trials 2.8 per cent attack was found at GS 65-75. Many DMI products showed good effect on the disease (tebuconazole, flusilazole, propiconazole, prochloraz, tetraconazole, epoxyconazole).

Erysiphe graminis in wheat occurred in several of the trials. As an average of 23 trials 11 per cent was found in untreated at GS 65-75. Of the tested products the performance was relatively low for prochloraz, flusilazole and propiconazole.

Puccinia striiformis was seen in 11 of the trials with an average attack of 25.9 per cent. Despite the extremely dry season the disease continuously developed slightly during May and June. All products, apart from prochloraz, gave a high level of control. The results confirmed previous years' results, showing that timing is more important than dose for optimal control.

After 2 applications of a fungicide in wheat the yield increase was on average in 1992 2.8 hkg/ha, which is very low compared with other seasons.

Rhynchosporum secalis in winter barley. The disease was widespread in 1992. On average, of 18 trials the disease level was 12 per cent. Best control was obtained using flusilazole and combinations of fenpropimorph with tebuconazole or epoxyonazole. Optimal timing is very important for good control of this disease. An application at GS 31-32 gave best control, which lasted to the end of the season. Dosages lower than 1/2 rate gave too low effect, if it was not followed up by further applications.

Drechslera teres was not seen to any significant level in the trials in 1992.

Erysiphe graminis in barley. Mildew was only found i 4 out of 22 trials in winter barley with low attack (0.5%). In spring barley, mildew was found in 6 of the 18 trials with an average attack of 5.0 per cent. All products gave relatively good control of the low levels of disease.

Puccinia hordei in winter barley developed relatively late in the season. On average, of 10 trials 10 per cent attack was found at GS 65-75. In spring barley brown rust was only seen in 2 trials at very low levels. Apart from prochloraz all tested products gave good control of this disease.

Winter Wheat Project. (Lise Nistrup Jørgensen, Bo Secher & Jørgen Olesen).

A Danish research project has been initiated with the aim of developing an integrated crop production model for winter wheat. The model will form the basis for a recommendation system which provides an economically sound winter wheat production with a low environmental impact. The project is interdisciplinary and involves cooperation of many researchers.

Within the project, research will be carried out on the main interactions between crop production factors. Multifactorial field trials will be established for model validation. During the project period, results will be implemented in the existing recommendation models.

The project is expected to last 5-6 years.

In 1992, 3 multifactorial field trials were carried out, only one trial got significant levels of disease (mildew). Primarily results from this trial show that variety, seed rate, nitrogen level and N strategy are factors which influence the level of diseases.

The influence of climatic conditions on the spread of *Septoria* spp. in wheat (Lise Nistrup Jørgensen, Boldt Welling, Jens Grønbech and Bo Secher).

The aim of the project has been to investigate the influence of different rain forms on the spread of *Septoria* spp. and the influence of spore germination in fields and in rain simulators under controlled conditions. The importance of variety, growth stages, splash, size of rain drops and intensity are some of the factors which has been studied.

Because of an extremely dry season in 1992, the results have been rather limited, as the disease never spread to 2nd and 1st leaves in 1992.

A simple forecast model for *Septoria* spp. in wheat was developed based on historical precipitation data and growth stage (1980-1989). It was found that the number of days with precipitation $\geq$ 1 mm, calculated during a 30 day period with start at the beginning of stem elongation (Zadoks 32), was well correlated to severe attacks of *Septoria* spp. later in the season. A threshold of 8-9 days with rainfall $\geq$ 1 mm was suggested to be a threshold for *Septoria* treatment or not. The forecasting model gave good results in 1992.

Barley yellow mosaic (Sten Lykke Nielsen)

Barley Yellow Mosaic Virus and Barley Mild Mosaic Virus were recorded in winter barley from a field in the southern part of Denmark. The diagnosis of the viruses was made on visual symptoms, immunosorbent electron microscopy and ELISA-tests. This is the first record of the two viruses in Denmark.

II. DISEASES ON PEA, RAPE, BEET AND POTATO

Leaf and pod diseases in pea (Hellfried Schulz)

(*Ascochyta* spp., *Botrytis cinerea* and *Peronospora viceae* f.sp. *pisi*)
In 1992, 3 field trials with spraying against leaf and pod diseases were carried out with Maneb 2 kg/ha, Dithane DG (mancozeb) 2 kg/ha, Folicur 250 EW (tebuconazol) 1.5 l/ha and DK 921 with 3 doses. Application mid June and early July.

There were no attacks of leaf and pod spot, grey mould and downy mildew in these trials and no significant yield increase was obtained by spraying.

In 1992, only weak attacks of downy mildew were observed at the beginning of June. The unusually dry weather conditions in July led to an early and quick ripening of the field peas and no further development of downy mildew and other pea diseases were observed in pea fields.

Control of fungal diseases in oilseed rape (Lars Bødker and Hanne Lipczak Jakobsen)

In 1992, nine trials were carried out testing various fungicides against fungal diseases in oilseed rape.
Due to very dry growth conditions, dark leaf spot (*Alternaria* spp.), grey mould (*Botrytis cinerea*) and stem rot (*Sclerotinia sclerotiorum*) were not seen in the trials at the time of harvest. A significant effect of Sportak 45 EC against light leaf spot (*Cylindrosporium concentricum*) was seen in one trial. However, the treatment did not lead to a significant yield increase.

Forecasting of stem rot (*Sclerotinia sclerotiorum*) in oilseed rape (Hanne Lipscak Jacobsen)

In Denmark, a forecasting system has been based on registration of carpogenic germination of sclerotia in depots in fields of oilseed rape all over the country. This forecasting system

will be overtaken by a forecasting model, which is made on the basis of information from the field depots.

Bacterial ring rot (*Clavibacter michiganensis* subsp. *sepedonicus*) of potato (Ib G. Dinesen and Keld Mansfeld-Giese)

A project concerning biological investigations of the ring rot pathogen was initiated in 1992 following the reoccurring incidents of ring rot in Danish seed potatoes. In field and greenhouse trials the amount of disease spread, possible ways of transmission and survival are studied.

An EC funding of a research proposal entitled: "The development and application of nucleic acid probe technology for rapid and reliable detection and identification of quarantine bacteria" was started under the CAMAR programme. The project is a co-work between 11 laboratories in Europe. One of the aims is to introduce the DNA-hybridization for screening purposes.

Test for bacterial ring rot of the various breeding generations and export lots of potato are continuously carried out. This work is carried out primarily for the Plant Directorate. Yearly, about 2000 samples are analyzed.

Virus diseases of potato (Steen Lykke Nielsen)

Spraing caused by Tobacco Rattle Virus (TRV) and Potato Mop-Top Virus (PMTV)
Potato cultivars were tested for their susceptibility to internal spraing caused by TRV and PMTV by growing the tubers in virus infested soils and recording the incidence of spraing at harvest and two months later. The incidence of spraing was very high in susceptible cultivars at harvest in both trials. The TRV and PMTV trials both comprised 16 cultivars. Development of spraing during the growing season has been recorded in cultivars susceptible to TRV and PMTV. The development of spraing during storage is recorded in the same cultivars. The influence of different temperatures in and the length of the wound healing period before storage on the development of spraing is included.

Establishment of disease-free stocks of potatoes
In the potato meristem culture program 3 cultivars have been established as pathogen-free stocks.

Fungicides and potato diseases (Jørgen Simonsen)

Phytophthora infestans

A number of trials on control of late blight were performed. However, absence of rain from mid May until August created a situation not seen for hundred years, and late blight infections were delayed one month, despite frequent irrigations and inoculation twice in all trials. Since the need for control came very late and crop growth was accelerated 2-3 weeks by hot and dry weather the results remained modest.

3 new compounds looked promising, trials will be continued.

Reinvestigation on Tattoo (Propamocarb/mancozeb) showed that 2 l every 10 days is equivalent to recommended 4 l/ha at 2 weeks intervals, but 1 l weekly was less effective.

Investigations on synergistic effect of a new untraditional product mixed with traditional ones will be continued.

Dithiocarbamates are questioned because release of the toxic ethylenethiourea. Trials with no or low use of dithiocarbamates then were performed simultaneously in the four Scandinavian countries. Among good results from 4 non-dithiocarbamates Shirlan (fluazinam) clearly was best. Trials will be continued.

Late blight control at different intervals (fixed as well as flexible) was made in 6 potato varieties. Sporulation and infection depend on climatic conditions, and field resistance differs much between varieties, so these factors should properly combined be able to tell if/when treatment is necessary through the season. In several varieties it is already seen that the number of treatments might be cut by 30 or 50%, sometimes even more, compared to present almost weekly routine. Trials are continued.

Rhizoctonia solani

Seed dressing against black scurf occasionally has been reported to cause off flavour, especially early in the season, but products and concentrations pointed out varied much. 12 product/methods were compared in one trial. 3 of them had lower characters of taste early July, somewhat less 1 month later but normal in September at maturity. One of these had not earlier been connected with off flavour. Investigations will be continued.

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

The Danish Potato Breeding Station at Vandel sent 111 tuber samples, and the Swedish Breeding Station Svalöf sent 103 tuber samples to be examined for wart resistance.

III. DISEASES OF HORTICULTURAL CROPS

Virus diseases in ornamental plants (Karen Bech)

Kalanchoë blossfeldiana

The mosaic disease which causes dark green raised areas in leaves is called Kalanchoë green islands mosaic KGIM in Denmark.

The virus is for the first time sap-transmitted to the index plants *Chenopodium quinoa* and *C. amaranticolor*. No symptoms were registered in *Nicotiana tabacum* cv. 'Samsun' and 'Xanthi', *N. clevelandii*, *N. benthamiana*, *N. occidentalis*, *Cucumis sativus*, *Pisum sativum* and *Phaseolus vulgaris*. Symptoms on *Chenopodium* are local chloroses.

KGIM symptoms are induced in healthy *Kalanchoë* plants 'Attraction' by sap inoculation of young plants and by grafting 'Attraction' on the *Kalanchoë* cultivars to be tested. Sap inoculation to 'Attraction' was used for the first screening of 18 *Kalanchoë* cultivars without symptoms of KGIM. Three of these cultivars were latently infected with KGIM. For further description please see: Diagnostic Work: Identification of the causal agent of *Kalanchoë* green islands.

Pelargonium

An infection trial is set up to compare diagnostic methods. *Pelargonium zonale* cv. 'Pink Cloud' and 'Perlenkette Orange' plants were infected with Pelargonium flower break virus (PFBV), Pelargonium line pattern virus (PLPV) and Tomato ringspot virus (TomRV). Every month the infected *P. zonale* are registered for symptoms, leaves from the infected Geraniums are inoculated to *Chenopodium quinoa* to register symptom development, and samples are taken for serological tests: ELISA-test for PFBV and TomRV, and ISEM-test for PLPV.

Incidence of PFBV in *P. zonale* was tested by ELISA. The virus is spread to the very top of the plants. An antiserum for PLPV detection is under production.

Euphorbia pulcherrima

To inactivate Poinsettia mosaic virus in *Euphorbia pulcherrima* apical meristems are excised and grown in Murashige and Skoog´s medium.

Tomato spotted wilt virus (TSWV)

This virus is not found in Denmark, but is widespread especially in countries with a warmer climate. The virus was detected in *Begonia, Aphelandra* and *Sinningia* sent from abroad for testing at the Research Centre for Plant Protection. All plants were destroyed after testing.

Virus diseases in vegetables (Karen Bech)

Lettuce big vein

From a 1972 trial with lettuce big vein soil with lettuce roots and *Olpidium brassicae* were dried and stored at room temperature. In 1980 - after 8 years storage - lettuce was planted into the infested soil, and big vein symptoms developed. The soil was again dried and stored at room temperature until 1991 where the susceptible lettuce cv. 'Nabucco' and 'Tires' were planted in November. Symptoms occurred 11 weeks after planting in greenhouse.

Cucumber

In 1988 green blisters on fruits of large cucumbers cv. 'Langelands kæmpe gigant' were observed for the first time in spots on Samsø. Later in the growing season the blisters become yellow and the raised areas cause problems with peel removement. In a 1992 sample Cucumber mosaic virus could not be detected in the fruits and no symptoms occurred on index plants.

IV. DIAGNOSTIC WORK

Immunodiagnostic assay for *Septoria nodorum* and *Septoria tritici* in wheat (Lise Nistrup Jørgensen & Karen Husted)

Dupont's ELISA-kits on *Septoria nodorum* and *Septoria tritici* were tested at the Plant Protection Centre for the first time in the season 1992.

The method gave with a few exceptions good and stable readings. From 5 localities the *Septoria tritici* kit gave good correlations between ELISA readings and leaf level with attack. Both in these 5 trials and in a trial using artificial inoculation presymptomatic readings could be seen. In the trial using artificial inoculation clear readings with *Septoria tritici* were found 10 days before symptom expression. Spores left from artificial inoculation gave small readings. The ELISA method could not be used to quantify differences in level of visual attack. This was also seen where fungicides had been used. The method gave, however, clear differences in both the level of attack and ELISA readings between the 2 grown varieties Sleipner (susceptible) and Nova (resistant).

In one trial with artificial inoculation of *Septoria nodorum* no correlation was found between severity of *Septoria nodorum* and ELISA readings. Spores left on the leaves in the fungicide treated plots gave similar high readings, despite no visual attack, as untreated plots with severe visual attacks.

The ELISA method for *Septoria* spp. was not found to interfere with mildew and yellow rust attacks on the tested leaves.

Immunodiagnostic assay for cereal eyespot (K. Husted, H. Schulz, & L. Nistrup Jørgensen)

The Du Pont Advisor for detection of cereal eyespot *(Pseudocercosporella herpotrichoides)* was investigated under Danish conditions for the second year. The correlation in spring between the normal visual assessment and the antigen level measured by the ELISA-kit was like last year quite low. Because of the unusual dry summer, the eyespot development was very poor, if any. This means that it was possible to correlate the antigen level in spring time to the disease level in summer time, a correlation which is supposed to be the best one to use when a threshold value expressed in antigen units is established.

Identification of the causal agent of Kalanchoë green island (K. Husted)

The project was initiated to identify the agent causing green islands in *Kalanchoë blossfeldiana*. The disease can, at the moment, only be detected by grafting to healthy *Kalanchoë* plants. The virus has been isolated, cloned and partly sequenced. Antiserum against the virus particles has been raised and used in ISEM and ELISA. A DNA-RNA hybridization method using one of the cDNA clones has been established as well.

V. OTHER WORK

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

A disinfectant, Bactol 15, was tested, but did not obtain official approval.
A disinfectant, Deosan Flora, was tested in recirculating watering systems for pot plants and obtained official approval.

E. DEPARTMENT OF PEST MANAGEMENT

Head of Department: Jørgen Jakobsen

Scientific staff:

Bent Bromand: Insecticides for agricultural crops.
Jens Bligaard: Pests on field vegetables.
Henrik Brødsgaard: Biological control of pests in glasshouses.
Annie Enkegaard: Biological and integrated control of the cotton whitefly (Bemisia tabaci).
Lars Monrad Hansen: Pests on cereals, beet, potatoes. Warning systems.
Søren Holm: Pests and diseases of agricultural crops.
N.S. Murali and Bo Secher*: Computer aided advisory system for pest and disease control.
Mette Kjøbek Petersen: Temporarily employed.
Alex Percy-Smith: Pests on field vegetables and fruit (on temporary leave 1992-1993).
Hans Peter Ravn: Insect pests in field peas and codling moths in apple orchards.
Werner Riedel*: Beneficial arthropods in cereal crops (Finished PhD-studies 29/2-92).
A. Nøhr Rasmussen: Fungicides, insecticides and growth regulators for soft fruit, nursery and glasshouse crops.
Lise Samsøe-Petersen: Methods for testing side effect on beneficial arthropods (until 31/12-92).

* PhD-students
MSc-students: Karen Henriksen, Ole Bloch Hansen, Christian Gadegård, Lisbeth Møllerhøj
MSc's working under Government employment scheme: Steen Gyldenkærne, Uffe Juul

The department is the principal centre for plant protection research regarding pests in agriculture and horticulture in Denmark. Even so the staff of scientific personnel is relatively small. Therefore, participation in international conferences and working groups is essential for the department. The staff members participate in a number of working groups, especially those organized by the IOBC and in the Nordic network of agricultural research.

The main task of the department is development of components for IP - Integrated Plant Production. These activities are performed in close collaboration with other departments within the Danish Institute of Plant and Soil Science located throughout Denmark.

The computer-based advisory system - PC Plant Protection - is now fully developed and ready for practical implementation. The system covers not only pests but also weeds and diseases. It will be distributed by the Danish Advisory Service in 1993. The system is

complete for cereals whereas we is still working on the incorporation into the system of other important agricultural crops in Denmark.

An important part of the basis for the advisory system originate from results obtained from the department's testings of pesticides. The main purpose of this work is to make tests of pesticides for chemical companies with a view to an official approval but more specific investigations are also conducted.

Another of the department's tasks is development of biological integrated control programmes for pests in glasshouses, mainly in ornamentals which is the most important glasshouse production in Denmark.

Biological integrated control programmes in glasshouse crops are highly needed considering the intensive use of pesticides causing problems for the working conditions, the costs of intensive use of pesticides, mainly insecticides, and because intensive use of pesticides means rapid development of resistance to pesticides in a number of pest species.

Research in biological integrated control methods is one of the priority research areas of the department. We have, therefore, invested in a new construction, a "mini glasshouse", comprising twenty-four cabinets in which temperature and relative humidity can be controlled in four combinations: "low" and "high" temperature with "low" and "high" relative humidity.

The department has been involved in the establishment of a new centre under the Environmental Research Programme. A joint project has been organized together with participants from the University of Copenhagen, Aarhus University, the Royal Veterinary and Agricultural University and the National Environmental Research Institute. The project will be launched in the beginning of 1993.

The sub-project carried out at the department will deal with the importance of soil type, temperature and farming practices on the (wellbeing) occurrence of selected key predators of aphids in the arable land.

Pests on cereals, oilseed rape, beet and potatoes. Damage thresholds, forecasting/warning models (Lars Monrad Hansen)

Aphids in cereals

Aphids are one of the major pests in cereal crops. There are great variations in occurrence between years. In 1992, the aphid attack was moderate/strong in severity and extension. Injuries, however, seem limited, probably due to the very dry spring and summer. A control model for aphids (*Sitobion avenae*) in winter wheat is being developed.

Slugs (*Deroceras* sp.) in cereals and oilseed rape
Due to the extremely dry summer a considerable number of slugs died. Consequently, occurrence in autumn crops was very low and did not give rise to serious problems. No trials were carried out with slugs in 1992.

Peach-potato aphid (*Myzus persicae*) in beet
The peach-potato aphid is one of the most serious pests in beet. In 1992, a number of fields were examined for occurrence of peach-potato aphids, which were tested for resistance. The preliminary results seem to indicate that the level of resistance is increasing, but test numbers are too low to permit conclusive interpretations. Investigations will be carried out in 1993 to verify these results.

Pests in oilseed rape
The brassica pod midge (*Dasyneura brassicae*) is one of the three serious pests on winter oilseed rape. The occurrence in 1992 was very moderate although a few fields were severely attacked. Injury thresholds and prognosis/warning systems for brassica pod midge are being developed.

The two MSc-students (Ane Frost Andersen and Helle Borum) have, for their final thesis for the Agricultural University, investigated the occurrence and distribution of the cabbage seed beetle (*Ceutorhynchus assimilis*) in relation to woods and hedges. They have also investigated the possibilities of developing a more simple monitoring method.

In spring oilseed rape, the blossom beetle (*Meligethes aeneus*) is the most serious pest. A simple method (frequency counting) to determine the size of the population is being developed.

Aphids in potatoes
Aphids are of great importance as carriers of different virus diseases. By means of yellow water traps and wind traps occurrence of the most important species is monitored with a view to warning of risk of infection.

Pest and diseases in organically grown crops (Søren Holm)

Major pests and diseases found in 1990-92 were bean weevil (*Sitona lineata*), in pea, late blight (*Phytophthora infestans*), black scurf (*Rhizoctonia solani*) and wireworms (*Agriotes lineatus*) in potatoes and stinking smut (*Tilletia caries*) in wheat.

Of minor importance were: - On barley: Powdery mildew (*Erysiphe graminis*), leaf blotch (*Rhyncosporium secalis*), net blotch (*Drechslera teres*), cereal leaf beetle (*Lema melanopus*) and aphids; - on wheat: Eyespot (*Cercosporella herpotrichoides*), powdery mildew (*Erysiphe graminis*), *Septoria* spp., shoot fly (*Opomyza florum*) and aphids; - in pea: leaf

and pod disease (*Ascochyta* spp.), downy mildew (*Peronospora viciae*) and aphids. In barley-pea mixtures the percentage of aphids and mildew on barley and the percentage of aphids on pea were only half compared to barley and pea in pure stand.

PC-Plant Protection: An Information Database for Pests and Diseases (N.S. Murali and Bo J.M. Secher)

The project, supported by the Ministry of the Environment, was initiated in 1987 with the aim of developing a PC-based plant protection advisory system for farmers and agricultural advisors. The system consists of the following modules:
- plant protection recommendations based on the field observations,
- information on pesticides and pesticide compatibility,
- information on spraying techniques,
- biological information on pests, diseases and beneficial organisms, and
- field log.

For cereals, recommendations are based on biological and climatic models, while for other crops standard label recommendations are given. During the last three years, the system has been evaluated by both farmers and advisors. The results show a reduction in pesticide usage up to 30 % without affecting the gross margin. The system is due for release in spring 1993.

The field registration system "Avlerregistrering" for monitoring and control of pests and diseases in field crops has been in operation since 1983. The system is used by farmers without computers. The farmers send field observations by post or fax and receive plant protection recommendation by post or can use an Audiotex, a telephone based voice response system, to enter field observation and obtain recommendations immediately. Recommendations are based on the same models used in the PC-Plant Protection. Data obtained from the monitoring is used by the Centre to evaluate the regional pest and disease status.

Nordic Project on Brassica Vegetable Pests (Jens Bligaard)

In connection with the NKJ-project 'Reducing the use of insecticides in Brassica vegetable crops - with special emphasis on the cabbage root fly (*Delia radicum*)' a mass rearing of the cabbage root fly has been established.

In order to investigate the effect of attack of larvae of the cabbage root fly on cauliflower, experiments have been carried out under semifield conditions. Cauliflower plants were inoculated with eggs from the mass rearing at different growth stages and with different

number of eggs. A simple non destructive method for measuring plant biomass was developed, and the plant biomass was determined regularly during the growing season.

The preliminary results indicate that the susceptibility to attack depends heavily on growth stage.

A monitoring and warning system based on felt traps by some 40 farmers has been run in 1992. The unusually dry and warm weather resulted in an egglaying activity much lower than in normal years. Only a few farmers had serious problems with cabbage root flies this year.

Pests in agricultural crops and field vegetables (Bent Bromand)

In 1992, 37 field trials were carried out and 2 insecticides were given approval against different pests, see table below.

9 trials were carried out with control of aphids in winter wheat and 7 trials with aphids in spring barley. In winter wheat only weak attacks occurred for a short period of time and very low yield increases were obtained. In spring barley aphids were more numerous and yield increases of 3-4 hkg per ha were obtained. Split doses, model spraying and different damage thresholds were incorporated in the trials.

In sugar beet, trials were carried out with insecticides incorporated in the pellets before sowing. Very promising results were again obtained with imidachloprid against pygmy beetles and aphids, but the effect was not as good against mangol flies, maybe due to two months with very little rain from spring to mid July. Spraying trials were carried out against aphids and mangol flies. Good results were obtained with cyfluthrin against mangol flies and triazamat were superior to pirimicarb against aphids in beet.

In oilseed rape, good results were found using pyrethroids against blossom beetles, but tau-fluvalinate gave poor control of the brassica pod midge and the seed pod weevil.

In pea, spraying was carried out against pea aphids and pea moths with IS 056 B, which contains a mixture of pirimicarb and deltamithrine. The effect against aphids was good, but it only lasted for about 2 weeks. The compound had good effect against pea moths.

In a semifield setup, trials with seed treatment with imidachloprid, chlorfenvinphos and diazinon was carried out against the carrot fly and the cabbage root fly. The results were not too promising but the trials will be repeated in 1993.

Newly approved insecticides (1st January 1993). * not registered in Denmark.

Product and active ingredients	Company	Dosage per ha	Approval against
Mavrik 2 F * tau-fluvalinate 240 g/l	Sandoz A/S	0.2 l	Aphids in cereals
WL 085 871* Alphacypermethrin 150 g/kg	Shell Kemi A/S	88,33 g	*Sitobium avenae* *Rhopalosiphum padi* *Metopolophium dirhodum* *Meligethes aeneus* *Ceuthorhynchus assimilis*

Monitoring the carrot fly (*Psila rosae*) with yellow sticky traps (Hans Peter Ravn).

Monitoring was in 1992 for the first time totally run by the local advisors and processing companies. During the season contact was, however, maintained between the Research Centre for Plant Protection and the advisors. The monitoring data was after the end of the season sent to the Research Centre for further processing and interpretation.

The flight period for the first generation started in the middle of May and peaked during the last days of May and first days of June. The second generation was registered from the middle of July. It peaked in the first half of August. Due to rather low and scattered flight activity the variation between localities was, however, large.

In general, the flight activity was low in 1992, spraying with insecticides was less than usual and attacks occurred in a few places only.

Monitoring the turnip moth (*Agrotis segetum*) by means of pheromone traps and forecasting cutworm attacks (Hans Peter Ravn)

The turnip moth was monitored at 70 localities in Denmark in 1992. Due to very warm and dry weather conditions development and survival of the eggs and larvae were enhanced very much. The flight activity was very intense.

The flight period for the first generation started at the end of May, a peak was registered around 10th of June. A general warning recommending insecticide treatment was sent out on the 30th of June (some days earlier in some parts of the country).

Continuing drought and high temperatures made it necessary to send out a second general warning recommending an insecticide treatment to take place on July 16-17. Finally on July 30, monitoring in general was called off since no further treatments would be necessary.

At 8 localities, monitoring was continued until November when the flight activity finally stopped. The second generation peaked around the 1st of September.

The forecasting of cutworm attacks was carried out in close cooperation with Prof. Peter Esbjerg at the Royal Vet.- and Agricultural University.

Monitoring the codling moth (*Cydia pomonella*) by means of pheromone traps (Hans Peter Ravn)

More than 400 delta traps were used at approx. 100 localities in 1992. The monitoring system was run by the growers and the advisors. After the end of the season, monitoring data has been sent to the Research Centre for Plant Protection.

Due to the very warm and dry weather conditions flight activity of the codling moth was very intense in 1992. Control was carried out several times at most localities. The flight started in the last half of May and continued intensively during June with peaks according to the daily temperature conditions. In August, a second generation occurred. In general this is not the case under Danish conditions.

Tortricids in appel orchards (Hans Peter Ravn and A. Nøhr Rasmussen)

In 1992, a preliminary study has been carried out to investigate to which extent tortricid moth - a potential insect pest on apples - occurred in the experimental orchard of Roskilde.

Two sets of delta traps equipped with pheromone dispensers of sex pheromones of ten tortricid moths: *Archips podana, A. rosana, Pammene rhediella, Syndemis musculana, Cydia pomonella, Hedya dimidioalba, Spilonota ocellana, Ptycholoma lecheana, Adoxophyes orana* and *Pandemis heparana*. The catch by the traps was registered every week.

More than 3,500 specimens of tortricids were caught. Most abundant were *Spilonota ocellana, Hedya dimidioalba, Pandemis heparana, Archips rosana* and *Archips podana*. Also quite many *Cydia pomonella* were registered. The rest of the species were caught in

numbers less than 20 per trap over the whole season. *Adoxophyes orana* was not registered in the plantation.

This investigation was carried out in cooperation with the Research Centre for Horticulture.

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

The area grown with field peas seems to have stabilised at a level of more than 100,000 ha in Denmark. There is still a need to clarify the impact of the most common insect pests on the pea plants.

In semi-field facilities experiments have been carried out to elucidate the effect of the pea and bean weevil (*Sitona lineatus*) and pea aphid (*Achyrtosiphon pisum*) on the plant growth and yield.

In 1992, extremely dry and warm weather conditions favoured development of the pea moth (*Cydia nigricana*). Pod samples from 59 fields were analyzed with respect to attacked pods, weight loss and a comparison was made with the pheromone trap catch in the same fields.

Studies of carrot fly (*Psila rosae*) attraction to yellow sticky traps (Ole Bloch Hansen and Karen Eberhardt Henriksen)

80 yellow sticky traps were placed along and in hedges on 32 ha. grown with carrots. In some places only very few flies were caught on traps in the field even though the traps were situated right opposite to spots in the hedge where many flies were caught.

In connection with these studies, investigations were made of carrot fly attractants applied to yellow sticky traps. These studies were made in co-operation with Guy Poppy, Rothamsted Exp. St.

'Systems-analysis investigations of flora and fauna in the cultivated land elucidated by model studies' (Mette Kjøbek Petersen)

Mette Kjøbek Petersen has been the coordinator of this project under the Danish Strategic Environmental Research Programme. The department participates in the project together with participants from the University of Copenhagen, the University of Aarhus, the Royal Veterinary and Agricultural University and the National Environmental Research Institute.

The project will be initiated in 1993 with scientist Hans Peter Ravn as project leader and Mette Kjøbek Petersen as scientist.

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

A laboratory test for adult females of the Staphylinid beetle *Aleochara bilineata* has been developed earlier according to the principles of the IOBC Working Group "Pesticides and Beneficial Organisms" (Samsøe-Petersen 1987). The work on this species, resumed during 1989, was continued in 1992.
The laboratory test was used for the 7th joint pesticide testing programme of the IOBC WG.

To ensure the possibility of future contract tests for chemical companies, GLP was developed and implemented during 1992. Furthermore, development of other tests was continued.

To achieve a more comprehensive picture of the effect of pesticides under field conditions it should be possible to conduct additional tests after the initial laboratory test.
Experiments with a test for *A. bilineata* under semifield conditions were continued in 1992. The setup for the semifield test was further developed in the laboratory and the semifield facilities of the department.

Furthermore experiments were continued to develop and document the original laboratory test to take place in different soil types instead of sand, and to develop a test for effects of pesticides on pupae of *A. bilineata*.

Development of biological pest control programme on pot Gerbera Henrik F. Brødsgaard & Annie Enkegaard

The pest species attacking Gerbera in Denmark are in the order of their economic importance: 1) Thrips (*Frankliniella occidentalis*, *Thrips tabaci*), 2) whiteflies (*Trialeurodes vaporariorum*, *Bemisia tabaci*), 3) spider mites (*Tetranychus urticae*), 4) fungus gnats (*Sciaridae*), 5) leaf miners (*Liriomyza* spp., *Phytomyza* spp.), 6) aphids (*Myzus persicae*), 7) tarsonemid mites (*Tarsonemidae*), 8) scales, 9) mealybugs, 10) slugs and 11) nematodes. The four latter usually have no economic importance due to the short cultivation time and/or the high hygienic standard of the growth media.

The research project is divided into three phases:
i) Investigations of the effect of beneficial organisms on pests, conducted as single-factor investigations. ii) Investigations of the effect of beneficial organisms on complexes of pests, including interferences between the beneficial animals. iii) Implementation of an integrated control programme in practical glasshouse productions.

In 1992, 24 fully climatically controllable glasshouse cages (mini-glasshouses) of $1m^3$ each were established. In this facility the dependence of the control effect on the relative air

humidity and the population density of the pest at the time of introducing the beneficials will be investigated. Furthermore we expect, as an extra gain, to obtain useful information about the biology of the pests (propagation rate, development speed and behaviour) on Gerbera as well as the functional and numerical response of the beneficials.
Time schedule: 1992 through 1997.

Testing and approval of fungicides and insecticides in horticultural crops (A. Nøhr Rasmussen)

The Danish Research Service for Plant and Soil Science grant approval to chemicals and biological plant protection products for control of plant diseases, pests and weeds when satisfactory trial results are available. The trials are carried out as a result of requests from chemical companies and they are performed according to Danish guidelines for testing pesticides.

With validity from the 1st January 1993 several insecticides/acaricides have been granted an approval. The approved products with dosages, active ingredients and the insect pests which they have been approved against are listed below.

Product and a.i.	Approved against	Dosage
Insecticides/acaricides		
Bio 1020 metarizium anisopliae 100% Bayer Danmark A/S	Larvae of Vine weevil in pot plants in glasshouse	1.0 kg/m^3 soil
CR 18390 clofentezin 500 g/l Schering A/S	Winter eggs of Fruit tree Red spider mite	0.4 l/ha
Dimilin diflubenzuron 250 g/kg KVK Agro A/S	Larvae of Winter moths Larvae of Leaf rollers Larvae of Codling moth	0.6 kg/ha 0.6 kg/ha 0.6 kg/ha
Euparen M 50 WP tolylfluanid 500 g/kg Bayer Danmark A/S	Apple rust mite	3.0 kg/ha
Mitac 20 amitraz 200 g/l Schering A/S	Pear sucker	4.0 l/ha

F. DEPARTMENT OF WEED CONTROL

Head of Department: K. E. Thonke

Scientific staff:

Peter Kryger Jensen: Applied research with chemical weed control in agriculture including work on crop and weed competition and control thresholds.

Peder Elbæk Jensen, Per Rydahl Nielsen and Martin Skovbo Hansen: Testing and approval of herbicides and growth regulators in agriculture.

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

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

Per Kudsk, Jens Kristensen, Solvejg Kopp Mathiassen and Hanne Juul Pedersen: Research on factors affecting the efficiency of herbicides.

Bo Melander, C. Holm-Nielsen and Ilse A. Rasmussen: Population dynamics of weeds.

Jesper Rasmussen, Svend Christensen and Anders Nemming: Weed biology and non-chemical weed control methods.

Ebbe Nordbo, Peter Kryger Jensen & Ole Permin: Research on spray technique and drift.

Ole Permin, Marianne Baandrup and Per Rydahl Nielsen: Advisory service.

At the end of 1992 the staff includes 20 scientists and 31 assistants.

The department's objectives are:

- To gain knowledge promoting strategies to decrease the need for weed control in plant production.

- To gain knowledge promoting the modelling and practical introduction of strategies for mechanical weed control.

- To gain knowledge quantifying the efficacy of herbicides as to model and optimize their use.

- To participate in integrated plant production projects.

- The continuous development of a computerbased advisory systems for weed control.

In 1992 strategic and applied research have been undertaken in the following domains:

Basic research	
Weed biology	soil seed bank germination biology development/competition seed production dispersion
Control	mechanical weed control optimizing of herbicide effect optimizing of spray technique
Applied research	
	indirect control chemical control strategies, trial mechanical control strategies weed control in cultivation systems spray technique
Advisory service	computerbased advisory systems

Publication and advisory activities in 1992 covered lectures for advisers and growers, publications and participation in symposia and conferences. "PC-Plantprotection" was made accessible to Danish farmers in 1992 through the "Integrated Farm Management System" developed by the Danish Agricultural Advisory Centre and in 1993 it will be enlarged with sections on pests and diseases. In 1992 a new edition of a handbook on "Weed Control in Agriculture" has been prepared (in Danish "Ukrudtsbekæmpelse i landbruget").

Applied research on chemical weed control in agriculture and weed biology (Peter Kryger Jensen)

Biological effect with field sprayers and nozzle types

New field sprayers on the Danish market have been tested for biological efficacy against weeds, pests and diseases, as well as in drift studies. The new sprayers have been compared to the traditional hydraulic Hardi sprayer with flat fan nozzles and volume rates of 150-250 l/ha. The last years have included further trials with two new sprayers, the Hardi Twin and the Danfoil. Both sprayers are operating with air assistance and with volume rates of 30-100 l/ha.

Traditional flat fan nozzles, delivering different spray qualities, have been compared in trials on herbicide efficacy and tolerance. Twin-fluid and low-drift nozzles have been compared to commonly used flat fan nozzles in herbicide efficacy trials.

Split application of herbicides

Split application of herbicides has in three-years´ trials proved to improve weed control in pea, when compared to a single application at the same total dose. The improved weed control was considered to be mainly due to the fact that split application makes it possible to target a larger proportion at the weeds on the sensitive cotyledon stage than is possible with a single application, which must be delayed until the majority of weeds have emerged. The first treatment with split application is therefore carried out on an earlier crop growth stage than normally recommended with herbicide mixtures containing cyanazine. Trials elucidating the crop tolerance at these earlier than normally recommended growth stages have been carried out with cyanazine mixtures without revealing problems. On the contrary, the best herbicde tolerance to foliage-applied herbicides in pea was found at the one-node stage before the first leaves were unfolded, and the tolerance decreased with increasing growth stage. The split application method is now recommended for weed control in pea and research is continued in other crops.

Light induction of weed seeds under field conditions

Seeds of a number of weed species - and among them many important weeds - require light induction for germination to take place. The intensity of daylight penetrating the soil decreases rapidly with depth, and the intensity below a few millimeters of soil is insufficient to induce germination of light dependent weed seeds. Trials during 1990-1992 have shown that the short light flash during seedbed preparation in daylight may satisfy the demand for light induction in proprotion of the seedbank. The number of emerged weeds was reduced and the emergence time was delayed with seedbed preparation and sowing carried out in darkness as compared to the treatments carried out in daylight.

Testing and approval of herbicides and growth regulators in agriculture (Peder Elbæk Jensen, Per Rydahl (1/1-31/7 1992) and Martin Skovbo Hansen (1/8-31/12 1992)

Contrary to many other countries, Denmark operate with two independent procedures regarding the testing and approval of new pesticides. On one hand, only effective pesticides can be registered by the environmental authorities. On the other hand, the producers and importers of pesticides have shown interest in achieving approvals (quality-marks for marketing purposes) regarding the effect resulting from specific combinations of: dosage, adjuvants, tankmixers, timing and pest spectrum. The criteria for approval imply that new products must be as least as effective to pests, and still as little harmful to the crop, as comparable products already on the market.

Herbicides containing new active ingredients are tested in field trials for two succeeding growth seasons. Each year 6 trials are conducted: 3 trials for harvest, testing the 1/1- and 2/1 dosage according to company recommendations. This is to evaluate any possible damage to the crop. Also 3 so called efficency trials are conducted, testing 1/4, 1/2 and 1/1 dosage. The effect is evaluated by counting and weighing weeds by species in 3 x 0,25 m^2 rings per plot. In this way results of at least 12 trials are achieved. This information is used in database systems (see elsewhere in this paper) to guide farmers to meet the political demands of reducing the pesticide use. New herbicides containing known active ingredients are normally tested to a minor extent, only.

The requests by companies are becoming still more specific regarding the weed spectrum. In order to attain the desired weed populations, most trials are located at farmers´, distributed all over Denmark.

This season much effort has been put into the field of annual monocotyledons, eg. *Poa annua, Alopecúrus myosurídes* and *Ápera spica-vénti*. Results of 1991/92 indicate, that acceptable effects can be achieved with reduced dosages by early autumn applications. Tests concerning control of *Aethusa cynapium* and *Amsinckia intermedia* are successfully made in sugar beet and pea, respectively.

In 1991/92 the Department of Weed Control was requested to conduct test concerning 41 approvals. As some products were notified for various purposes, the number products/combination of products were only 33. By the end of 1992, 17 approvals had been granted. Not all of these products have been registered yet.

The new active ingredients approved 1991-92 are listed in the Table below.

New ingredients for weed control approved 1991-92

Active ingredient	Crops	Selected "problem" Weeds
aclonifen	pea	2 cotyledon
carbetamid	winter rape	1+2 cotyledon
diflufenican*	winter crops	1+2 cotyledon
DPX 66037	sugar beet	2 cotyledon
fenaxaprop-ethyl	barley	wild oat-grass
flumipropyn	winter crops	2 cotyledon

Active ingredient	Crops	Selected "problem" Weeds
prosulfocarb	winter crops	1+2 cotyledon
quimerac	sugar beet	Galium aparine
rimsulfuron	potatoes	2 cotyledon+couch grass
trinxapac ethyl	winter crops	growth regulator

* Co-formulated with other active ingredients.

Weed control and approval of herbicides in horticultural crops including vegetables, orchard and nursery culture (Georg Noyé and Anette Binder).

In 1992 work on testing of herbicides and developing new strategies for weed control has continued, especially in crops where herbicides are being revoked through the reevaluation (carried out by the National Agency of Environmental Protection).

This year we launched a research program on weed control for use in an integrated vegetable production system. In Sweden, Norway, Finland and Denmark a series of experiments with new herbicides for control of weeds in *Umbelliferae* cultures (carrot, parsnip) were carried out. The co-operation is financed by the Nordic Council of Ministers.

16 herbicides were received for testing in the growing season of 1992. The distribution according to crop was 3 in onions, 1 in carrots, 4 in sweet corn, 7 in different nursery crops, and 1 in black current.

The chemicals listed below all obtained an approval for use. Products with * have not yet been registered.

* 1. Aclonifen (aclonifen) 600 g/l) was approved for use in carrots.

2. Laddok TE (bentazon 200 g + terbutylazin 200 g/l) was approved for use in sweet corn.

3. Karmex DF (diuron 800 g/kg) had the approval extended to include cultures of *Cotoneaster, Cornus,* and *Taxus.*

4. Karmex DF + Gesatop 500 FW/DLG Simazin (diuron 800 g/kg + simazin 50%) were approved for control of seed weeds in cultures of *Abies nordmanniana, Picca abies, Pinus mugo,* and *P. nigra.*

Weed control and approval of herbicides in forestry and windbreaks (Thomas Rubow)

The reevaluation of herbicides has been finished in 1992.

The result has led to a very serious situation for forestry, especially for the production of Christmas trees and decoration greenery, which is of high economic importance.

Within a few years the main herbicides for these purposes will disappear from the Danish market, because of recall of approval by the Ministry of Environment, and their typical substitutes have been put under severe restrictions on maximum doses.

In 1991 greenhouse experiments were carried out including the addition of additives (Sun oil) to terbuthylazine and simazine in order to increase their effect on weeds. The promising results of the investigations have not been confirmed in outdoor experiments this year (conifer plantations, windbreaks).

The approvals of new sulfunylurea herbicides like tribenuron methyl and primisulfuron have shown positive results, but these herbicides have not yet been registered for forestry use.

In the late summer, several experiments have been initiated including application of glyphosate (Roundup) in low doses, as split-applications and applied on non-conventional times of the year.

RESEARCH ON FACTORS AFFECTING HERBICIDE EFFICACY

(Per Kudsk, Solvejg Kopp Mathiassen, Hanne Juul Pedersen and Jens Kristensen)

Joint action of sulfonylurea herbicides and MCPA

The joint action of mixtures of the sulfonylurea herbicides chlorsulfuron, metsulfuron and tribenuron and MCPA as dimethylamine salt was assessed on *Stellaria media* L. and *Lamium purpureum* L. ADM analyses revealed that mixtures of the sulfonylureas and MCPA were less potent than expected on *S. media,* and parallel-line assay analyses showed that the activity of the sulfonylurea herbicides in mixtures with MCPA was reduced on *S. media* and *L. purpureum.*

The antagonism was found to be dependent on the ratio of the two herbicides. Activity decreased with increasing MCPA ratios in the mixtures. Sequential spraying and application of the herbicides seperately or together in droplets using a microsyringe revealed that the antagonism was only present when the herbicides were applied in the same droplet.

Influence of adjuvants on the foliar activity of isoproturon

The potential for enhancing the foliar activity of isoproturon by application in mixture with broadleaf herbicides or adjuvants was examined in pot trials using *Lolium multiflorum*, *Alopecurus myosuroides*, *Apera spica-venti* and *Poa annua* as test plants. The activity of isoproturon was significantly increased on all plant species when applied in mixture with ioxynil + mecoprop (both as esters). In addition, 0.5% Frigate, a cationic surfactant, 0.2% Silwet-L77, an organosilicone surfactant, and 1% Binol, a rape seed oil, increased the activity on *A. myosuroides* and *P. annua* whereas 0.1% Lissapol Bio, a nonionic surfactant, and 0.5% Genapol LRO, an anionic surfactant, had no influence on the activity.

Variation in efficacy of tribenuron during the growth season

A dose range of tribenuron in mixture with 0.05% Lisssapol Bio was applied to pot grown *Sinapis alba* at 8 dates from June to October. Plants were sown at 8 dates from June until October, and the application was made when the third leaf was 1-2 cm long. Mean temperature on the application dates was between 13.6 and 21.6^0 C, and the average of relative humidity varied between 65.5 and 80.8%. The plants were harvested when the untreated control plants weighted approximately 40 g/pot.

The ED_{50} values of the different dates varied by a factor 3. The lowest values were found when temperature and humidity were high at the time of application. Variation in the ED_{50} values indicated that the activity of tribenuron was influenced by temperature as well as humidity.

Influence of water quality on the performance of glyphosate

The influence of various cations applied as their chloride salts on glyphosate performance was examined on pot grown barley plants. Calcium, ferri and magnesium ions reduced the activity of glyphosate whereas sodium had no effect. Addition of diammonium sulphate fully overcame the antagonistic effect of calcium but did not reduce the adverse effect of ferri ions. This was related to the formation and precipitation of calcium sulphate. The isopropylamine salt of glyphosate was more susceptible to the presence of calcium in the spray solution than the trimethylsulfonium salt of glyphosate whether the two salts were applied as technical grades or as commercial formulations.

Antagonism of fluazifop-p-butyl and haloxyfop-ethoxyethyl by broadleaf herbicides

In red fescue fluazifop-p-butyl used to control volunteer cereals and couch grass is often applied in mixture with a broadleaf herbicide consisting of MCPA, mecoprop and clopyralid. Recently, haloxyfop-ethoxyethyl has been introduced for use in red fescue,

however not in mixture the above-mentioned broadleaf herbicide. In order to examine whether the two aryloxyphenoxyalkanoic acids responded differently to the addition of the broadleaf herbicide pot grown barley plants were sprayed with the two herbicides alone and in mixture broadleaf herbicide. The results revealed that the broadleaf herbicide antagonized both grass weed herbicides. Application of each of the components in broadleaf herbicide revealed that MCPA was more antagonistic than mecoprop. Clopyralid did not reduce the activity of any of the aryloxyphenoxyalkanoic acids.

POPULATION DYNAMICS OF WEEDS

Grass weeds population dynamics and thresholds (Bo Melander)

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

In recent years, the area with winter crops in Denmark has risen considerably. More winter crops are expected to change the composition of weed species in the fields. In order to investigate the changes as well as other aspects concerning weed problems in winter crops a 5-year project was started in 1988. The project mainly includes research on the population dynamics and the economic importance of the weeds: Couch (*Elymus repens*), Silky Bent-grass (*Apera spica-venti*), Cleavers (*Galium aparine*), Annual Meadow Grass (*Poa annua*) and Black Grass (*Alopecurus myosuroides*).

Since 1989 research work on the competitive ability of *Elymus repens* in rye, wheat, winter barley, spring barley, pea and oilseed rape has taken place. So far results from 3 years' work have shown severe yield reductions in pea, oilseed rape and partly spring barley. In contrast, the winter cereals were far less affected by competition from *Elymus repens*.

The investigations on *Elymus repens* infestations also give information about other biological aspects like the emergence patterns of shots, production

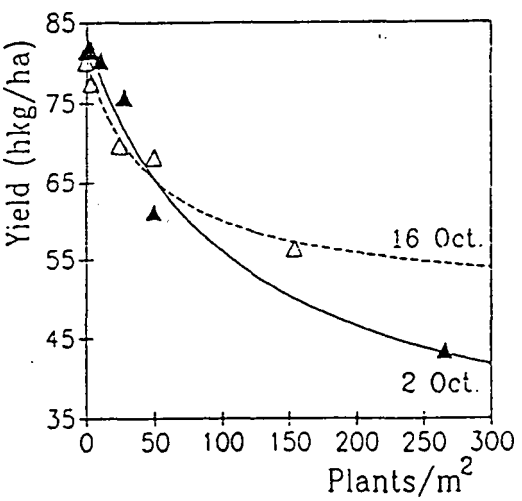


Figure 1
The relationship between density of *Alopecurus myosuroides* and kernel-yield in winter wheat drilled 2nd and 16th October, respectively.

of secondary shots, in fluences on the yield components of the crops, etc.

In the autumn 1990 and 1991 competition studies in the field were started with *Apera spica-venti* in winter wheat and rye drilled at two different dates, and with *Aleopecurus myosuroides* in winter wheat also drilled at two different dates. Yield losses in the crops, emergence patterns of the grass seedlings, grass seed production in relation to increasing grass density and mortality of grass plants will be of main interest.

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

Main project
Investigation of methods for seed-identification and quantification of the seed-bank of cultivated soil.

As an implication hereof:
Preparation of a key for weed seed identification with specifications and photos.

Secondary project
Investigation of the soil cultivation effect on the weed reproduction rate for some weed species.
Involved in weed production on different weed control systems and intensities.

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

A project supported by the Danish Agricultural and Veterinary Research Council was started in 1989. The aim of the project is to establish the fate of weed seed production as a result of reduced herbicide usage. Experiments are conducted with sown-in weeds in cereals, treated with various herbicides in a range of doses. The seed production is measured, and seed rain is determined in untreated plots. Seed viability is tested in germination-tests.

The results show that for *Chenopodium album* in spring barley, seed production is linearly related to weed dry weight. The relationship is influenced by the use of herbicides, but mainly at very low dry weights. Reducing herbicide dose to an extent where weed control is still satisfying with respect to yield etc. will not cause an increase of the weed seed in the soil seed bank. In the present experiments, this was achieved at ½ of the normal dose (N) of 4 different herbicides one year and 1/4 N of 3 of these herbicides the next year. Percentage reduction compared to untreated is shown in Fig. 2 for any weight and seed production with *C. album* in 1991.

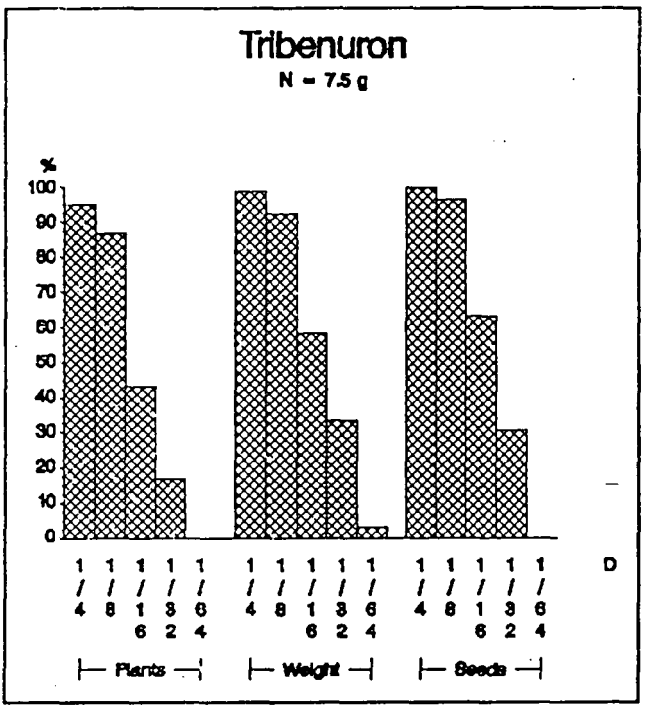


Figure 2
C. album 1991. Percentage control (%) compared to untreated plots, of number of plants, dry weight and seeds harvested. D = proportion of normal dose (N) per hectare.

Preliminary results indicate that the same principles apply to *Polygonum lapathifolium* and *P. persicaria* in spring barley. Research is also being carried out with *Papaver rhoeas* in winter wheat.

WEED BIOLOGY AND NON-CHEMICAL WEED CONTROL METHODS

Mechanical weed control in agricultural crops (Jesper Rasmussen)

The main objective is to improve our basic knowledge on mechanical control of seedling weeds in agricultural crops. Four different principles are developed in cereals and seed legumes:

harrowing before crop emergence, early post-emergence harrowing, late selective inter-row cultivations with finger-weeders and tractor hoeing at narrow row spacings.

Studies are concentrated on three main issues: modelling crop yield response of early post-emergence harrowing, optimizing the intensity of selective harrowing with respect to weed control and testing mechanical strategies which include different mechanical principles. Combination of different mechanical principles can give high degrees of weed control without associated crop damages. An example is given in Fig. 3.

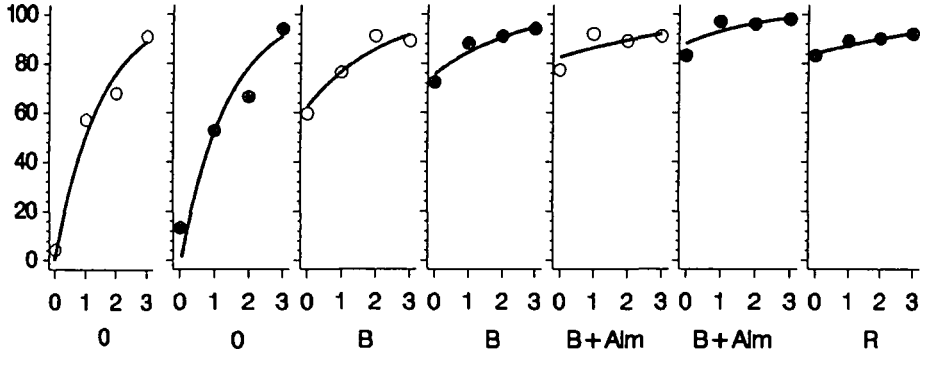


Figure 3
Relationship between number of selective harrowings and percentage of weed control in an experiment conducted in spring barley 1992. 0= No other treatment than selective harrowing; B= one harrowing before crop emergence and selective harrowing; B+Alm: One harrowing before crop emergence, one early post-emergence harrowing and selective harrowing; rad= one tractor hoeing and selective harrowing. Panels with dots denote rows spaced 20 cm apart and panels with circles denote rows spaced 12 cm apart.

Integrated weed management in winter wheat (Svend Christensen and Peter Kryger Jensen)

An interdisciplinary research project is initiated at the Danish Institute of Plant and Soil Science. The project aims at developing an integrated crop production program for winter wheat. A model is developed including the major crop management factors: soil cultivation, fertilization, sowing date, seeding rate and the need for controlling pest, diseases and weeds.

Department of Weed Control is responsible for the investigations on the crop/weed interference: varietal weed suppression; the impact of sowing date and seeding rate; estimation of the variety and species parameters of competitiveness.

In close collaboration with the other researchers involved in the project a comprehensive model including these factors is developed.

Variable crop management system (Svend Christensen and Jens Kristensen)

A collaborative research project between the Danish Institute of Plant and Soil Science, Danish Agricultural Advisory Centre and Risø National Laboratory is initiated aiming at developing an applied system for varying fertilizer and hebicide application due to the variations in fields. The role of the Department of Weed Control in the project is to develop a novel mapping system for weeds.

Non-destructive assessments of growth parameters and weed cover (Svend Christensen)

Spectral reflectance measured with a prototype device (constructed by Jens Kristensen) has been used successfully to derive light interception (fPAR) and biomass of spring barley varieties. The research demonstrated that growth parameters of the varieties could be estimated more precisely by means of spectral reflectance measurements than by destructive measurements.

The method cannot discriminate weeds from a crop. However results obtained in an additive competition experiment with spring barley and weeds showed that weed cover could be estimated as the ratio of fPAR between pure stands of weeds and the crop-weed mixtures. The weed cover assessment was a good predictor of yield loss.

Weed control in organic farming (Anders Nemming)

Through the collaboration 18 organic farms in Denmark are studied intensively by research institutes.

With The National Institute of Agricultural Engineering, the Department of Weed Control monitors the prevailing weed situation, the current goals of weed control and obtained weed control effects.

Trials with weed harrowing in cereals and flame treatment in beet, vegetables and cereals on organic farms.

Flame cultivation is a very labour-saving and profitable aid when growing vegetables and other row crops without pesticides.

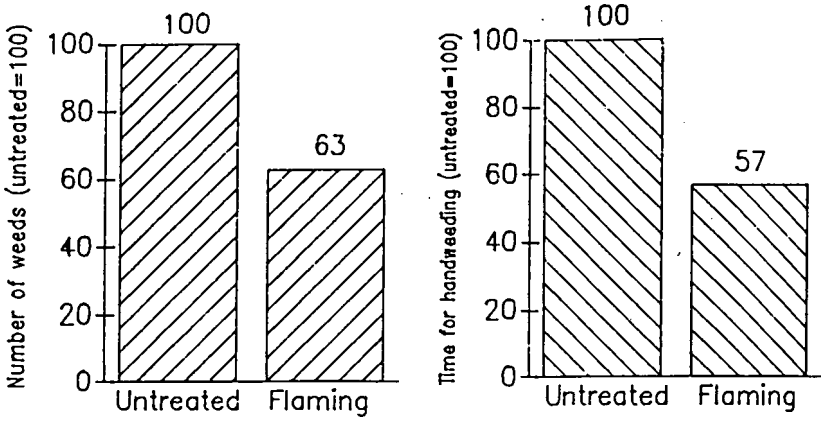


Figure 4
An example of results from pre-crop-emergence flame treatment in beet.

The Figure shows a reductive effect in number of weed and reduction of time consumption for following hand weeding. The results are from trials on an organic farm during the last three years.

RESEARCH ON SPRAY TECHNIQUE AND DRIFT

The influence of wind on spray application efficiency and herbicidal effects. (Ebbe Nordbo)

Following the general trend of a reduction of pesticide doses for each field a greater concern needs to be given to variability of the spray liquid deposited on each single plant. Continued studies have shown the deposition pr. cm^2 plant surface to range at least a factor 1:10 from the least to the best covered single plant, even under fairly favourable spraying conditions. Also it has been noted how the tractor and spray equipment in meeting the natural wind generates specific spatial patterns of deposition, according to the relative wind direction. As the over-all control level obtained depends on the frequency of plants having received a certain threshold quantity (and quality) of spray, a major aim of application technique development is to reduce this variability.

Field investigations have been carried out to elucidate the influence of tractor speed, wind speed, wind direction, and air-assistance on the spray pattern. Effects of foliage structure and orientation on deposition have been studied in laboratory investigations.

Drift and deposition studies have been carried out with a range of modified or air-assisted flat fan nozzles and twin-fluid nozzles.

A wind tunnel is being constructed and equipped with a mobile spray boom for model deposition and drift studies.

ADVISORY SERVICE

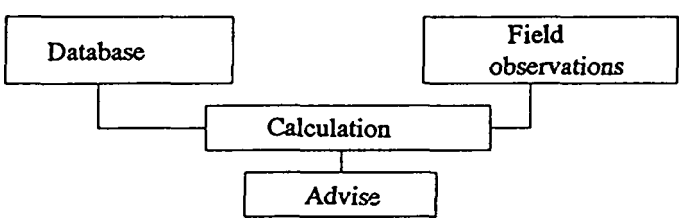
PC-Plant Protection, Weeds (Per Rydahl and Marianne Baandrup (1/1-1/9 1992))

This computerbased advisory system has been developed to ensure satisfactory chemical weed control with a minimum input of herbicides.

Based on inputs by the user, PC-Plant Protection selects suitable herbicides and calculates the minimum doses that will give a satisfactory control on the actual weed infestation. The system presents herbicide names, actual doses and actual prices. In most cases, the user then may chose among several proposals from the system.

The system has been extended to cover minor agricultural crops and also offers general information on a wide range of weed control topics, relevant to users of herbicides.

The system was released in 1991, and this year, marketing efforts have been made i.e. articles, leaflets and a video film.



Flow chart of PC-Plant Protection

Figure 5

Weed control (Ole Permin)

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

This work enables organisations to bring out new knowledge gained from research to the user without delay. Also the work includes 1) the organizing of advanced courses training advisors in weed control handling, and 2) compilation of new results from research in cooperation with the Danish Agricultural Advisory Centre working out strategies for weed control in different crops.

G. DEPARTMENT OF PESTICIDE ANALYSIS AND ECOTOXICOLOGY

Head of Department: Arne Helweg

Scientific staff:

Susanne Elmholt (until 16.6.92): Effect of pesticides on the soil microflora
Gitte Felding: Determination of leaching of pesticides
Inge S. Fomsgaard (from 15.8.92): Degradation of pesticides in subsurface soil
Arne Helweg: Degradation and adsorption of pesticides in soil
Erik Kirknel: Fungicides and insecticides in plants and in precipitation
Peder Odgaard: Lysimeter studies with pesticides

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

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

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

3. Chemical analyses of infiltrated water in field and lysimeter studies to determine the risk of leaching of pesticides out of the root zone.

4. Determination of pesticide run-off and pesticides in precipitation.

5. Determine the influence of pesticides on soil microorganisms.

6. Participation in determination of pesticide transport and deposition during spraying and determine exposure of spraying personnel to pesticides.

The department is equipped with analytical instruments: gaschromatographs with EC-, NP, HW- and FP-detectors and gaschromatograph with MS. To determine drift of pesticides, fluorescent compounds are used. Adsorption, degradation and leaching in lysimeter experiments are followed by ^{14}C-labelled compounds and determined by scintillation counting.

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

Effect of pesticides on the soil microflora and on the decomposition of organic material (Susanne Elmholt)

Side-effects of pesticides, especially fungicides, on the composition and the activity of the soil microflora have been studied. Furthermore, the composition of fungi in organically cultivated soils has been studied with special regard to *Penicillium* and *Fusarium*.

Leaching of pesticides from fields and forestry (Gitte Felding)

On 5 selected localities stainless steeltubes have been set up. The tubes (3 at each locality) have been placed in soil for collection of water, leaving the root zone. Samples are taken during the winter and analyzed by GC/MS.

In water samples from the 2 plantations the content of atrazine, hexazinone and degradation products of both has been determined. In water samples from the 3 agricultural soils the content of phenoxy herbicides has been determined.

A deterministic model CMLS (Chemical Movement in Layered Soils) has been used to simulate the leaching from the forestry and fields.

Run off from arable soil
The pesticide content in run-off from a sloping locality grown with winter wheat and sprayed with mechlorprop is being studied.

Investigation of the risk for groundwater contamination with selected pesticides in sandy soil (Inge Fomsgaard)

A project has just been started in cooperation with the Danish Geological Survey and the National Environmental Research Institute where the risk of groundwater contamination with ETU, mecoprop, atrazine and hexazinone in sandy soil will be investigated. Subsoil samples have been taken in the unsaturated zone which will be incubating for several years.

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

The degradation of ^{14}C-mecoprop (ethyl-hexyl ester) has been determined at different soil temperatures and moisture contents and in sterile and non sterile soil showing relatively fast degradation as shown for mecoprop K-salt.

Adsorption of 6 soil applied herbicides have been determined in 6 Danish soil types by use of ^{14}C-labelled pesticides.

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

Pesticides in precipitation
Samples of rainwater have been collected in two areas and analysed for some pyrethroid insecticides. Highest concentrations found were below 0.1 μg/l.

Deposition of pesticides on spraying personnel
In cooperation with the Danish Agricultural Engineering Institute research in contamination of spraying personnel is continued to elucidate to which degree contamination was reduced using protectives. A significant reduction in contamination was obtained using few precautions in changing the machinery and protective clothing.

Decomposition of dithiocarbamates on potato leaves in field experiments
Decomposition studies were mainly concerned with the influence of sunlight i.e. experiments were conducted in periods without precipitation. Different formulations of dithiocarbamates were investigated.

Leaching of ^{14}C-labelled pesticides determined in lysimeter experiments (Peder Odgaard & Arne Helweg)

Lysimeter experiments have been carried out to elucidate the leaching of autumn used mecoprop (ethyl-hexyl ester).

^{14}C-mecoprop was applied in November to lysimeters with a surface area of 0.5 m^2 and a soil depth of 1-1.1 m (coarse sandy soil).

Until mid-March the following year the accumulated ^{14}C-amounts found in the leachate were below 1 % of applied ^{14}C in the two lysimeters. Thus showing much less leaching of the ester than of the salt formulation.

D. BIOTECHNOLOGY GROUP

Head of group: Peter Ulvskov

Scientific staff:

Merete Albrechtsen
Bernhard Borkhardt
Elisabeth Johansen
Søren V.S. Nielsen
Gert B. Poulsen

Use of molecular tools and transgenic plants in breeding

Research in biotechnology is expected to influence strategies for breeding for better crop plants. This research activity will also produce a number of molecular tools for the diagnosis of plant pathogenic microorganisms. Used in combination with tissue culture methods strains of certified pathogen-free stock plants can be produced.

The aims of this project are to:

- Develop new and introduce well known molecular methods
- Establish strategies for the manipulation of important crop plants *in vitro*
- Identify genes for traits agronomic importance
- Develop methods for the rapid and efficient diagnosis of plant pathogens

These objectives are pursued in the following research activities:

- Methods for the transformation and regeneration of pea, rape, and potato are developed using gene transfer with the soil bacterium *Agrobacterium tumefaciens* as well as transfer using direct up-take of DNA into protoplasts.
- The molecular basis of silique opening in rape is investigated in an attempt to engineer a shatter resistent rape plant.
- Plant virus genomes are analyzed in a number of relevant viruses. The genetic information is used for the development of specific probes for virus diagnosis. The introduction of virus resistance in crop plants is pursued using the coat prote in mediated virus resistence strategy.
- Fundamental research in the molecular basis of virus host recognition is undertaken in an attempt to discover new avenue towards engineered virus resistence in crop plants.
- Methods based on antibodies or DNA-probes are developed or used routinely for the detection of vira, viroids, and plant pathogenic fungi.

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