Danish Research Service
for Plant and Soil Science

Plant diseases, pests and weeds in Denmark 1987

104th annual report
Compiled by
The Research Centre for Plant Protection

Lyngby 1991

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Contents

A. DANISH RESEARCH CENTRE FOR PLANT PROTECTION

Director: E. Henning Jensen

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

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

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

Secretariat	Søren W. Bille (from October 1st)
Institute of Plant Pathology	H. Rønde Kristensen (until July 31st)
Botany Department	Arne Jensen
Zoology Department	Jørgen Jakobsen
Virology Department	Arne Thomsen (acting from august 1st)
Biotechnology project	Morten Heide
Pesticide Research Institute	E. Nøddegaard
Institute of Weed Control	K.E. Thonke
Laboratory of Pesticide Analysis	E. Henning Jensen
Plant Protection Advisory Department	A. From Nielsen

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

- to develop and recommend effective preventive and control measures which are not damaging to the environment

- to implement the results gained from the research and experimental work carried out at the centre and to use results from other national or international research institutes in the advisory work

- to contribute to the creation of a background for national and international plant protection legislation

The research carried out on the application of pesticides plays an important part in the work of the centre. Of primary importance is an agreement with the Danish Agrochemical Association concerning efficiency testing of pesticides. The testing is not required by law, but almost all marketed products have been included in the testing scheme. A pesticide,

which is found suitable for its purpose according to the official testing, is granted an approval. The costs involved are paid by the applicant.

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

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

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

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

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

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

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

The 4th Danish Plant Protection Conference was held 4th and 5th March, 1987 attracting about 614 participants.

B. SECRETARIAT

Head of secretariat: Søren W. Bille

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

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

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

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

Of about 170 employees, approx. 106 are located at Lyngby, 4 at Skejby at the Plant Protection Advisory Department and the rest, about 60, at Flakkebjerg.

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

	SO	TS	Total
Administration and common functions	2	26	28
Institute of Plant Pathology			
Botany Department	10	8	18
Virology Department	6	10	16
Zoology Department	7	11	18
Institute of Pesticide Research	11	12	23
Institute of Weed Control	16	28	44
Laboratory of Pesticide Analysis	5	10	15
Plant Protection Advisory Department	6	2	8
Total	63	107	170

SO: Scientific officers
TS: Technical-administrative staff

Financing and staff
50-60 per cent of the activities of the Research Centre for Plant Protection are being

financed by way of the government budget. The remaining part of the funds are being provided by way of research programmes financed publicly or privately as well as by different forms of economic activity. In 1987, the total expenses of the Research Centre for Plant Protection amounted to about 40 mio. Dkr.

C. ADVISORY WORK, Ghita Cordsen Nielsen and Lars A. Hobolth.

Scientific staff:

Ghita Cordsen Nielsen: Pests and diseases of agricultural plants
Lars A. Hobolth: Pests and diseases of horticultural plants

During the growing season reports on attacks and occurrence of pests and diseases were sent in by 60-80 agricultural advisers.

The following is a summary of these reports. In addition, observations made by the individual departments and the advisory service at Lyngby and Godthåb (now at Skejby) have been included as well as a survey of climatic conditions from the Agrometeorological Service at Foulum.

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

In general, the weather during the growth season was rainy, cold and with little sun. Consequently, the harvest was late. The table shows the monthly averages of temperature, precipitation and sunny hours. June was particularly cold and overcast. During all the months from April to August the number of sunny hours was below normal.

In April the weather was mostly cool and unstable during the first 2-3 weeks and after that mostly dry and sunny. The temperature for the whole of the month was normal and precipitation was below normal.

May was mostly characterized by cool weather with some rain. Sunny and dry weather only occurred for a few days around the 1st and 24th May. With an average temperature of 8.7°C May 1987 was the coldest May since 1927.

In June the weather was mostly cold and overcast. Real summer weather only occurred during the last few days of the month. With a total of 124 sunny hours in the whole of the country June 1987 had the lowest number of sunny hours registered since the start of the registrations in 1920. Temperatures were far below and precipitation much above normal.

July was mostly cool and windy, especially the latter half of the month. During the first two weeks the weather was fairly dry. The distribution of precipitation was unusual with the highest figures in Northern Jutland and on Zealand where it rained more in a few days around the 18th-19th than is normal for the whole of July. However, precipitation was below normal in the southern and western part of Jutland, in Funen and Bornholm.

During the first half of August the weather was mostly cool and rainy. In the latter half,

however, the weather was warm and sunny for a number of days. However, the average temperature for the whole of the month was well below normal.

Means of temperature, precipitation and sunny hours in Denmark in 1987:

	Temperature,°C				Precipitation,mm		Sunny hours		
	Mean	Absolute Normal	Min.	Max.	1987	Normal	1987	Normal	
April	6.1	6.1	-1.9	21.0		32	39	153	181
May	8.7	11.0	1.1	19.9	44	38	195	256	
June	11.3	14.4	3.6	22.5	95	48	124	257	
July	14.7	16.4	7.4	24.8	84	74	197	247	
August	13.6	16.3	1.1	27.9	65	81	154	221	

Diseases in agricultural crops (Ghita Cordsen Nielsen)

Cereals and grasses

The heavy precipitation in 1987 created ideal conditions for fungal diseases in practically all crops.

Overwintering of winter crops and grasses.

The severe frost damage in the last two years reduced the interest in winter barley. Only about 57,000 ha were sown for harvest in 1987, and according to the agricultural advisers severe frost damage occurred in at least one third of the area. The reason was again frost without any insulating snow layer. The worst damage was seen on light soils, and the damage to the different varieties varied considerably.

Wheat showed better survival. Only in Northwestern and Western Jutland more than 10% of the area damaged, whereas 1-5% of the area was damaged in the rest of the country. Practically no damage occurred in rye.

Italian ryegrass and grass mixtures showed poor survival in Northern, Western and Southern Jutland where 10-50% of Italian ryegrass and 5-10% of the grass had to be resown.

Cold weather

Maize showed very clear symptoms of damage because of too low temperatures, and it failed completely because of too few sunny hours. Many farmers had to use barley as whole crop or procure other kinds of fodder.

Yellow fields

The heavy precipitation led to oxygen deficiency and subsequent yellow spots in the fields, especially in barley. The symptoms were most pronounced in heavy soils, in low parts of the fields and where there had been much traffic in the field.

Manganese deficiency was found in a number of winter crop fields, but 85% and 75% of the agricultural advisers reported attacks below normal in April and May, respectively. Only four advisers considered the attacks in May to be severe.

Almost 85% estimated the manganese deficiency in spring cereals in May to be below normal. However, half the advisers described the manganese deficiency in June as normal to severe.

Barley yellow mosaic virus. Fortunately, this dangerous virus disease, which is very widespread south of the border, was not found in any winter barley fields. A careful watch

out was kept, and this year almost 30 fields were inspected. Most of them were in the southern part of the country.

Snow rot (*Typhula incarnata*). Cold weather was the main reason while winter barley did not survive the winter. Almost 85% of the agricultural advisers reported snow rot attacks below normal and mostly in second-year winter barley fields. However, sclerotia could be found in several fields, mostly in fields which were weakened.

Snow mould (*Gerlachia nivalis*). On Bornholm the attacks were widespread, but weak. In the rest of the country only one adviser, in Western Zealand, reported severe attacks while more than 85% described the attacks as below normal.

Attacks were also seen close to hedges in ryegrass fields.

Eyespot (*Pseudocercosporella herpotrichoides*). Prognoses for eyespot in rye and wheat were sent out on April 28th and May 5th, respectively. It was expected that control would be necessary in about 70% of the rye fields. This is more or less normal. Control measures were thought to be necessary in 40-50% of the wheat fields, which seems a fairly low percentage.

The advisers reported attacks in a number of fields, but 75% and 65% described the level of attack in wheat and rye, respectively, as below average.

The assessment of symptoms was difficult because of attacks of *Fusarium*, sharp eyespot and secondary fungi on the stem base.

Sharp eyespot (*Rhizoctonia cerealis*) occurred both in rye and wheat with widespread, but moderate attacks.

Take-all (*Gaeumannomyces graminis*) usually causes most damage in warm and dry summers. However, the wet weather resulted in oxygen deficiency and restricted root development, so that the attacks of take-all caused more damage than usual. More than half of the advisers reported medium to severe attacks in August. They seemed to be particularly widespread where wheat was grown after wheat.

Mildew (*Erysiphe graminis*). In winter barley, the attacks were less widespread and mostly weak. Only four advisers, reported severe attacks in May and June, respectively, in the areas: Western Jutland (2), Western Zealand (1) and Northern Jutland (1).

In spring barley the attacks were still few and weak in May. In June mildew became more widespread, but most of the attacks were weak. However, five advisers report severe attacks in July in the following areas: Eastern Jutland (2), Southern Jutland (1), Himmerland (1), and Northern Jutland (1).

Widespread attacks occurred in winter wheat as early as in May, and six advisers reported heavy attacks in many different parts of the country both in May, June and July.

Yellow rust (*Puccinia striiformis*). 1987 was a very wet and cold year, and consequently yellow rust was widespread. As early as the beginning of April the first attacks of yellow rust were seen in wheat. The attacks spread quickly to most of the country during May and June. The attacks varied considerably according to variety. 'Anja', 'Vuka' and 'Kraka' were most severely attacked. 'Kosack' was also infected, but fairly late in the growth season. No attacks were seen in 'Sleipner'.

Widespread attacks were reported in June and July. Almost 20 and 25% described the attacks as severe in June and July, respectively. In many places, attacks were seen on the flag leaf, but also on the ear in some of the fields with the most severe attacks.

Renewed attacks were seen also at the end of July because of the wet and cold weather.

Brown rust of wheat (*Puccinia recondita*). Severe attacks were seen in some fields, but usually the attack of brown rust came late in the season. Two advisers reported heavy attacks in July, but generally, the advisers reported weak attacks.

Leaf and glume blotch (*Septoria nodorum*). 1987 was not only characterized by widespread yellow rust, but also by heavy *Septoria* infections.

In June, the fungus was very widespread, but no severe attacks were reported. In July, however, almost 20% of the advisers reported heavy attacks in their area. Attacks were particularly frequent in short-stalked varieties like 'Sleipner'.

Leaf and glume blotch of wheat spread further in August and could be seen on the ears in a number of fields.

The wheat fields were still very green towards the end of July, especially the late variety 'Kosack'. Few fungicide applications took place, but a number of growers carried out one single fungicide treatment at a relatively late time.

Leaf blotch (*Septoria tritici*) occurred at least as frequently as leaf and glume blotch, particularly in 'Sleipner'. Leaf blotch is furthered by continued wet weather, as in 1987. Never before have so severe attacks of leaf blotch been seen in this country.

The fungus thrives both on high and low temperatures, as opposed to leaf and glume blotch, which requires fairly high temperatures. About 45% of the advisers reported widespread and medium to severe attacks as early as in June. In July, 25% reported severe attacks. Leaf blotch very seldom spreads to the ear.

It is very difficult to distinguish between symptoms of leaf and glume blotch and leaf blotch of wheat in the field - microscopic examinations will often be necessary.

***Fusarium* spp. (*Fusarium poae, F. culmorum, F. avenaceum, F. nivale*)** was very widespread, especially in the variety 'Sleipner', which is not very resistant. In August almost half of the advisers reported medium to severe attacks. The spikelets or whole spikes, which ripened too early and were later overgrown by an orange spore coating, were very conspicuous.

Fusarium attacks were also seen in the straw, so that the straw would break at the uppermost knee. This phenomenon was particularly noticeable in 'Sleipner'.

Grey mould (*Botrytis cinerea*) was seen in most crops including wheat and barley where brown spikelets occurred. Half the advisers considered the attack in wheat to be medium to severe. However, the attacks are not thought to have had much influence on the yield.

Leaf blotch (*Rhynchosporium secalis*) was seen in spring barley. Severe attacks occurred in many places, especially on light soils. Considerable varietal differences could be seen. 'Sewa' was one of the varieties which was most heavily attacked.

In May, severe attacks in spring barley were seen in Southern Jutland, whereas the attacks in general were weak. This was also the case with winter barley. Only one report mentioned heavy attacks. In rye attacks occurred in several localities.

In June, however, widespread attacks were seen in spring barley, and three advisers reported severe attacks: two in Western and one in Southern Jutland.

One month later, fourteen advisers reported severe attacks in spring barley.

Many growers who participated in the computer registration program "Avlerregistrering" were advised to treat against leaf fungi (leaf blotch, net blotch and saprophytic fungi) in spring barley before any serious attacks could be registered. The need for treatment was due to climatic conditions.

Net blotch (*Drechslera teres*). The attacks in winter and spring barley in May were considered weak and not very widespread.

During June and particularly July, the attacks spread, and 10% and 55%, respectively, reported medium to severe attacks for instance in Wester Zealand, Southern and Wester Jutland. In many places, the attacks were seen fairly late in the growth season.

Bunt (*Tilletia caries*) and **stripe smut** (*Urocystis occulta*). Reports were received of a few very severe attacks, where the growers had used their own untreated seed.

Loose smut (*Ustilago nuda*). The attacks were a little fewer than usual.

Ergot (*Claviceps purpurea*). Severe attacks were reported in triticale, rye and even in spring barley. Ergot is toxic to animals and humans. The cool and wet weather prolonged the flowering and created ideal conditions for the ergot fungi.

***Cephalosporium* spp.** During spring, a number of reports told of symptoms in ryegrass which looked like cephalosporium stripe. The attacked plants had a lower growth and pale leaves with yellowish brown stripes. It is very difficult to isolate the fungus from grass. However, it was isolated in two cases in 1987, and it was also isolated from wheat.

Some fields had to be reploughed, but most fields overcame the attack later. Especially ryegrass fields undersown in cereals were attacked (straw layers are particularly favourable for the fungus), whereas fewer attacks were seen in ryegrass undersown in other crops or alone.

Examinations by the seed company "Trifolium-Silo" in connection with field inspections showed that 57 out of a total of 600 fields had symptoms of Cephalosporium stripe. Only six of these fields had more than 25% plants with attacks.

Other fungal diseases in seed grass

Severe attacks of **leaf blotch** (*Rhynchosporium orthosporium*) and **leaf fleck** (*Mastigosporium muticum*) were seen in cocksfoot.

Heavy attacks of **melting-out disease** (*Drechslera poae*) were seen in many second-or third-year meadow grass fields. Widespread and, in some cases, severe attacks of **ergot** (*Claviceps purpurea*) were also seen in meadow grass because of the very wet summer. Besides, meadow grass was infected with **wood poa rust** (*Puccinia poae-nemoralis*) at the end of June. The advisers reported no or weak attacks in May, whereas three of them mentioned severe attacks in June. Heavy infections were also seen in the autumn of 1986.

The attacks of **powdery mildew** (*Erysiphe graminis*) in seed grasses were generally few and weak.

Diseases in rape

Overwintering

According to the agricultural advisers about 5% of the winter rape was damaged by frost. The frost damage in winter rape was particularly severe in Northern and Western Jutland.

Pale petals in spring rape

This was seen in several parts of the country. Later on, the seed formation was unsatisfactory in many rape fields. The cause is not quite clear, but there are indications that it may be ascribed to sulphur deficiency caused by heavy rain and low temperatures.

Deficiency symptoms

Manganese, boron and magnesium deficiency was seen in a few spring rape fields.

Club rot (*Plasmodiophora brassicae*) was no more widespread than usual. In a few places where rape is frequently grown severe attacks were seen.

Downy mildew (*Peronospora parasitica*) was fairly widespread in spring rape in June, but 80% reported attacks below normal.

Sclerotinia disease (*Sclerotinia sclerotiorum*). The wet weather in combination with a long flowering period and, later on, a pronounced tendency to lodge provided ideal conditions for the fungus. Considerable harvest losses occurred in untreated fields.

Growers of winter rape were advised to take control measures against *Sclerotinia* on Eastern Funen and in winter rape fields with late flowering on most of Zealand, and in Himmerland in fields where the infection might be expected to occur. In spring rape control was necessary in most of the country in fields where the infection was present.

In winter rape the *Sclerotinia* fungus became visible in many fields during July and August. Medium to severe attacks were reported by about 40% of the advisers. In August, 8 advisers reported heavy attacks in the following areas: Western Zealand (3), Funen (2), Eastern Jutland (2) and Southern Jutland (1).

As mentioned in the warnings, the attacks were more widespread in spring rape than in winter rape. A few uncommonly early attacks were reported. In July and August 25% and 50%, respectively, reported severe attacks, especially in the following areas: Western Zealand (5), Funen (4), Eastern Jutland (4), Southern Jutland (2) and Northern Jutland (2).

The *Sclerotinia* attacks were also severe in fields where they were not expected. This was due to much lodging, which, in combination with an unusual amount of rain, made secondary infection by mycelial growth from plant to plant possible. Thus fields with lodging were most heavily attacked. Secondary putrefactive fungi also occurred.

The monitoring makes it possible to estimate the risk of attacks caused by primary infection from germinating apothecia on the ground surface. Secondary infection from plant to plant cannot be predicted. Lodging may be prevented by choice of the right

variety and moderate use of nitrogen fertilizer.

Dark leaf spot (*Alternaria brassica, A. brassicicola*). The wet weather also furthered the growth of the leaf spot fungus. However, the attacks were generally late.

The disease became very widespread in winter rape during July where five advisers reported heavy attacks in their area.

In spring rape the fungus spread most rapidly in August where five advisers report severe attacks.

Grey mould (*Botrytis cinerea*). Due to the weather conditions this disease was widespread in many winter and spring rape fields.

Dry rot and canker (*Phoma lingam*) was found in spring rape in one locality. It is the first time the fungus has been found on spring rape during the growth season, whereas the State Seed Testing Station has often found the fungus on the seed.

Verticillium wilt (*Verticillium dahliae*) was seen in a few cases. The symptoms are a characteristic one-sided withering of the plant.

Other crops

Samples of linseed flax with **grey mould** (*Botrytis cinerea*), *Alternaria lini* and **pasmo** (*Septoria linicola*) were sent in for examination during the growth season. Plants with symptoms of **calcium deficiency** were also seen among the samples.

Diseases on legumes

Insufficient pod setting was observed in several broad bean fields. The cause is not quite clear, but chocolate spot (*Botrytis fabae*) and thrips were found in the flowers of the plants with few pods. Too little sun may have prevented seed formation.

Potassium deficiency. A few cases of potassium deficiency were seen in peas. The symptoms are pale leaves or necrosis along the leaf edges.

Bacterial blight (*Pseudomonas syringae* pv. *pisi*) was found for the first time in Danish pea fields. The bacterium thrives in wet seasons and causes water-soaked lesions on the pea plants. Later on, the attacked area turns brown.

If the disease is found by the official inspection of seed peas, the seed cannot be exported. Sowing of peas from attacked fields is permitted in this country. In order to limit the spread of the (seed-borne) bacterium, only healthy seed should be used. In case of seed

shortage, infected seed lots should be sold to as few growers as possible.

It is difficult to say whether the diseases will become economically important in Denmark. The relatively favourable conditions for the disease in 1987 did not result in particularly severe attacks in the fields where the disease was found. This seems to indicate that the Danish climate is not especially favourable to the disease. Irrigated pea fields will probably be most exposed to the disease.

Grey mould (*Botrytis cinerea*) was very widespread in the pea fields. In June the attacks were still weak, but they became widespread during July and August, and 30-40% of the advisers reported severe attacks.

The attacks were a little less severe in semi-leafless varieties, which are better at keeping upright.

Downy mildew (*Peronospora viciae* f.sp. *pisi*) was more widespread than normal and severe attacks occurred in several fields where peas were grown too frequently, especially when there was only one year between pea crops. In June, the attacks were still weak, but in July and August attacks could be found in many fields. Ten advisers coming from different parts of the country described the attacks as severe.

The disease was also seen in broad beans, lucerne and white clover.

Powdery mildew (*Erysiphe pisi*). Only one case of this disease was seen in 1987.

Foot rot, leaf and pod spot (*Ascochyta pisi, Mycosphaerella pinodes, Phoma medicaginis* var. *pinodella*) spread from the end of July into many pea fields. In June, more than 90% of the advisers still described the attacks as insignificant or weak, whereas more than 35% reported severe attacks in August. Widespread attacks are reported from almost all regions, but especially from the following areas: Western Jutland (6), Funen (5), Eastern Jutland (4) and Southern Jutland (3).

Some advisers reported attacks, particularly, in semi-leafless varieties.
Not all discolorations in the pea fields were due to foot rot, leaf and pod spot or other fungal diseases. No fungi could be isolated from a number of discoloured spots. The reason for these so-called physiological spots has not been determined.

Fusarium wilt (*Fusarium oxysporum* f.sp. *pisi*). It is sometimes difficult to distinguish this disease from other fungi attacking the root or from yellow spots in the field because of soil structure, etc.

The advisers reported few and weak attacks. A few serious attacks were reported where peas were grown soon after peas.

Grey mould (*Botrytis fabae, Botrytis cinerea*) was very widespread in August and occurred in several places in its aggressive stage because of heavy rainfall.

Six advisers reported severe attacks in their area in August.

The National Agency of Environmental Protection allowed air spraying with several pesticides.

Leaf and pod spot (*Ascochyta fabae*). Weak to medium attacks were seen in a number of broad bean fields.

Diseases in beet

The wet weather restrained the **growth** of beet. They were sown late and did not grow for a long time. Inferior soil structure was quickly revealed as the reason why beet did not develop properly. The first sampling on August 10th showed a 48% reduction in sugar yield compared with the average of 10 years at the same time. The harvest was therefore postponed. However, the yield was not quite as bad as predicted.

Manganese deficiency was fairly widespread in beet, and about 40% of the advisers estimated the attacks as severe.

Beet yellows (*Beta* virus 4). The attacks were late and mostly weak. All advisers estimated the attacks both in June and July as below average. In Southern Jutland and Funen, however, two advisers reported widespread attacks as early as June and July. In August the attacks were fairly widespread, but very weak. The only report of severe attacks came from Bornholm, whereas five advisers mentioned medium attacks in the areas Southern Jutland, Funen and Western Jutland.

Black leg (*Phoma, Pythium, Aphanomyces* a.o.). Attacks were seen in several fields, but they were usually weak. However, heavy rainfall combined with slow growth provided excellent conditions for black leg fungi.

Powdery mildew (*Erysiphe betae*) is mostly seen in warm and dry summers, and it is not surprising that all advisers reported no or weak attacks in August.

Diseases in potatoes

Black leg (*Erwinia carotovora* var. *atroseptica*) occurred in a number of fields. In August sixteen advisers reported medium attacks and two speak of severe attacks.

Leaf roll (*Solanum* virus 14) and **streak** (*Solanum* virus 2). No serious attacks have been reported. The infection risk established by counting the aphids (virus vector) caught in

yellow water traps was generally very low.

Rattle virus. Severe attacks were seen only in a few fields. The attacks may be mistaken for symptoms of the mop top virus. **Mop top** virus was identified with certainty for the first time in Denmark in 1987 at Herning. The virus is transmitted by the **powdery scab fungus** (*Spongospora subterranea*). The symptoms are similar to those of rattle virus: brown necroses inside the tubers. Besides, round swellings may occur on the tuber.

Wart disease (*Synchytrium endobioticum*). The Government Plant Protection Service did not register any new cases in 1987. Wart disease is now only known to be present in one garden.

Late blight (*Phytophthora infestans*). The first warning of late blight was sent out on July 2. After that, more attacks than usual were registered in most parts of the country. The heavy rainfall caused a high number of primary attacks.

No advisers reported attacks in June. In July the attacks spread, and almost 60% reported widespread attacks, which were estimated as severe by more than 50% of the advisers.

A number of blight strains showed resistance to metalaxyl, but mostly in fields where the seed potatoes had been treated with Ridomil in 1986. In general, growers are advised not to use metalaxyl for seed potatoes.

Black scurf and stem canker (*Rhizoctonia solani*) had very favourable conditions in 1987. Several agricultural advisers reported severe attacks.

Pests in agricultural crops (Ghita Cordsen Nielsen)

Pests in cereals, maize and grasses

The unstable weather conditions during the summer provided excellent conditions for spread of fungal diseases, but it had the advantage of limiting pest propagation. The infestation by most pests was very limited. In some localities pest propagation took place late in the growth season. The pest attacks were generally two to four weeks later than usual.

Cereal cyst nematodes (*Heterodera avenae*) were not very widespread, and only one adviser reported severe attacks in oats and spring barley.

Crane flies (*Tipula paludosa*). Investigations of the number of leatherjackets in the ground carried out in approx. 25 grass fields suggest that attacks will be weak in 1987. Soil samples were taken in areas where attacks are often severe. In fields where beet were to follow grass the damage threshold had been exceeded, however.

In April and May, 100% and 95%, respectively, of the agricultural advisers reported no or weak and few attacks.

Wireworms (*Agriotes* spp.). Attacks were generally very weak. In a few areas, however, spots of varying size with severe attacks were found in a field - this was reported by two agricultural advisers.

Yellow cereal flies (*Opomyza florum*) were more widespread in winter crops than usual. In May, 4 agricultural advisers reported severe attacks in their areas: Funen (2), Western Jutland (1), and Northern Jutland (1).

Frit flies (*Oscinella frit*). The symptoms in winter crops may be difficult to distinguish from the symptoms caused by grass flies. The migration was observed at about 33 localities.

The frit flies started migrating about 20th May, but cold and unstable weather reduced the migration, and only 4 out of 33 localities reported migration above the injury threshold in the period where maize, oats and seed grass were susceptible.

About July 23rd the second generation started migrating at localities with grass. The first generation was delayed, and this explains why the second generation appeared about two weeks later than usual. The second generation was also very small - at all the 18 localities under observation migration was below the injury threshold.

In April, 95% of the advisers reported attacks below medium in winter crops. All the

advisers reported almost no or extremely weak attacks in oats and maize in May and June. The attacks in grass were also described as weak.

Cereal leaf beetles (*Oulema melanopus*) were fairly widespread and occurred in certain areas with severe attacks. According to the reports attacks were mostly weak to medium-severe.

Thrips (*Limothrips denticornis, L. cerealium, Haplothrips aculeatus*) were seen in part of the cereal fields, but mainly with weak attacks.

Aphids (*Rhopalosiphum padi, Sitobion avenae, Metopolophium dirhodum*). Generally, attacks were far below normal.

In spring barley and wheat respectively 240 and 198 growers sent in reports as part of the computer registration program (Avlerregistrering). According to the program control measures had to be taken by only 5% of the barley growers and 2% of the wheat growers.

The agricultural advisers reported few attacks in June, and they all described the attacks as below average. In July, the aphids spread somewhat, but 95% and 85% still spoke of the attacks in spring barley and winter wheat, respectively, as below average.

Aphids also occurred in **maize** in several places, but the attacks were mostly weak - only two reports mention severe attacks in July.

Saddle gall midges in barley (*Haplodiplosis equestris*) and **yellow and orange wheat blossom midges** (*Contarinia tritici, Sitodiplosis mosellana*). No attacks of any importance were reported.

Pests in rape

Field thrips (*Thrips angusticeps*) were found in a number of spring rape fields in May, and four reports of severe attacks were received.

The cabbage root fly (*Delia brassicae*). The first generation hatched more or less as usual from the middle of May. The egg laying was much reduced, but on the other hand it lasted for a long time - pupation did not end until the latter half of July. The second generation started migration about 14 days later than normal, but due to the cold and wet weather egg laying did not start until August 1st. In general, the attacks in **cabbage** were much weaker than usual, but at the beginning of September many larvae were found at a number of localities.

Almost all advisers reported few attacks below the normal level in winter and spring rape - only one reported severe attacks.

Attacks by cabbage root flies on rape roots are mostly seen in dry years.

Cabbage stem weevils (*Ceutorrhynchus quadridens*) were less widespread than normal, and no or weak attacks were reported. Only one report mentioned severe attacks in winter rape.

The problem of prematurely ripe straws and larvae inside the straw is beginning to worry growers, especially in cabbage. One experiment in rape with control measures against this was carried out in 1987.

Blossom beetles (*Meligethes aeneus*) were widespread both in winter and spring rape. However, most advisers estimated the attacks in winter rape as weak to medium-strong, whereas more than 20% reported severe attacks.

In a few localities damage (twisted pods) were caused by **blossom beetle larvae.**

Cabbage seed weevils (*Ceutorrhynchus assimilis*). It appears from the reports that the cabbage seed weevils were restrained by the unstable weather. About 65% of the reports mention attacks below normal, whereas only two advisers reported severe attacks.

The distribution of cabbage seed weevils corresponds more or less to the level of attack of the brassica pod midge.

Brassica pod midges (*Dasineura brassica*). The cold weather caused a delay and reduction in the migration of the first generation. A warning was sent out on May 27th. The migration of the second generation was also delayed, and a warning was sent out on July 2nd.

The reports from June and July also indicated a level of attack in winter rape below normal in 95% of the cases.

The following pests in winter and spring rape only occurred sporadically and were without any importance in 1987: **diamond-back moths** (*Plutella xylostella*), **cabbage aphids** (*Brevicoryne brassicae*), **large and small white butterflies** (*Pieris brassicae, P. rapae*) and **turnip flea beetles** (*Phyllotreta* spp.).

Swede midges (*Contarinia nasturtii*) were also less widespread than normal, but uncommonly severe attacks were seen in a few fields.

Pests on legumes

Field thrips (*Thrips angusticeps*) and **pea thrips** (*Kakothrips pisivorus*). At the early growth stages field thrips were seen in a number of pea fields. Most reports were of weak

attacks, but three advisers observed severe attacks in their area.

Pea thrips occurred later, but mostly with weak attacks. However, three reports of severe attacks were received in June. In July, most reports mentioned no or weak attacks.

Pea and bean weevils (*Sitona lineatus*). The weevil attacks were very widespread in May; 55% of the advisers reported medium to severe attacks. They were less severe and widespread in broad beans than in peas.

In August, gnawing by the new generation was widespread in pea and broad bean fields as well as in undersown clover.

Attacks in undersown clover were reported in several fields, but mostly with attack levels below normal (in almost 80% of the cases).

Complaints were also received from house-owners whose gardens and terraces had been invaded by pea and bean weevils.

The problem is getting worse because of the increasing pea area.

Flax tortrix (*Cnephasia interjectana*). Most advisers reported "no attacks" in May, while a few mentioned weak attacks. Later in the season, the attacks became a little more widespread, but in general, they remained on a very low level. Sporadic attacks also occurred in other crops, particularly in flax.

Pea moths (*Cydia nigricana*). Migration was very limited. The occurrence was examined by means of about 50 pheromone traps set up at localities with previous attacks. Pea moths in numbers above the damage threshold were found only in a few traps.

Most advisers reported no attacks in August. However, eighteen mentioned weak attacks.

Pea aphids (*Acyrthosiphon pisum*). Very few reports of attacks were received in June. In July, the aphids became more widespread, but only 22% estimated the level of attack as medium to severe. In August no reports of severe attacks were received, and as many as 85% described the attacks as below normal.

Black bean aphids (***Aphis fabae***). The attacks were few and weak. Only two advisers reported medium to severe attacks in July and August.

Pests in beet

Both sugar and fodder beet seeds were treated with furathiocarb, and a few growers used granulate.

Beet cyst nematodes (*Heterodera schachtii*). No or weak attacks were reported.

Cabbage thrips (*Thrips angusticeps*). Widespread, but fairly weak attacks were reported in May. A number of severe attacks occurred, in spite of the seed treatment with furathiocarb.

Beet leaf miners (*Pegomyia hyoscyami*). Widespread egg-laying was reported in May. 30% and 40% reported medium to severe attacks by the first generation in May and June, respectively.

In August, second-generation beet leaf miners occurred in a number of fields, but mostly with weak attacks. However, the attacks by the second generation were fairly severe on Lolland-Falster, especially near the coast.

Pygmy beetles (*Atomaria linearis*) occurred in several fields, but the attacks were generally weak - only three advisers reported medium to severe attacks. On Western Zealand a few severe attacks were seen - the pygmy beetles mostly occurred on the leaves.

Clivina fossor is a ground beetle which has in recent years been quite noticeable in beet. Severe attacks were reported again in 1987 in a few localities on Zealand and Funen.

Beet carrion beetles (*Blitophaga opaca*) were less widespread, and the attacks were weak - there was only one report of severe attacks - from Funen.

Capsids (*Calocoris norvegicus* spp.) occurred in a few fields, but the attacks were weak and mostly near the field edge. Only one adviser reported severe attacks in Funen.

Peach-potato aphids (*Myzus persicae*). Via the computer registration program "Avlerregistrering" and reports from agricultural advisers the Plant Protection Centre received estimates of attacks in 75-100 fields. Apart from that, registrations from 160 fields on Lolland-Falster, Møn and Southern Zealand were sent in via the Virus Yellows Committee.

In general, the attacks were very weak, and no general warning against virus yellows was sent out by the warning service on Lolland-Falster.

Reports of peach-potato aphids were sent in for the first time in the last week of June. The occurrences were relatively small for the next couple of weeks. In the period from 20th to 26th July, however, reports of several occurrences of peach-potato aphids were sent to the Virus Yellows Committee, and peach-potato aphids were found ind 35 fields out of 160, especially on Western Lolland. Very few reports were received from the rest of the country. However, fairly severe attacks occurred in Funen and Zealand about the middle of August.

Normally, control of peach-potato aphids is not profitable after August 1st, but due to the slow growth and the delayed harvest (sugar beet A) pesticide control was considered profitable also in the first two weeks of August.

In June, more than 95% of the advisers reported "no attacks" by peach-potato aphids. In July, the attacks are described as below normal by almost 95%. In the months of June to August, severe attacks only occurred on Bornholm - in August. Reports from two advisers mentioned more widespread attacks in Southern Jutland and in Funen in June and July.

Black bean aphids (*Aphis fabae*). The level of attack was very low. Control measures were only necessary in 10% of the fields connected with the computer registration program "Avlerregistrering". The Virus Yellows Committee found black bean aphids in only 37 of 160 fields examined in the period 9th to 16th July, and colonies were only seen in a few localities.

The advisers did not report any significant occurrences until July. The level of attack in July and August was described as insignificant or weak by almost 95% of the advisers, and no report described the attacks as severe.

Nutmeg moth larvae (*Discestra trifolii*) etc. were not very widespread and did little damage in July and August.

Pests on potatoes

Potato cyst nematodes (*Globodera rostochiensis*). One adviser reported severe attacks in August.

The attacks mostly occurred in gardens. Occurrences of potato cyst nematodes must be reported to the Government Plant Protection Service, and in case of attacks only resistant varieties may be grown on the area and only every 4 years.

Colorado beetles (*Leptinotarsa decemlineata*). The Government Plant Protection Service reported no findings of Colorado beetles in 1987.

Cutworms (*Agrotis segetum*). Flight was very limited, and the larvae had very unfavourable conditions because of the heavy rainfall. On July 8th, a Plant Protection Bulletin was sent out. It stated that Årslev in Funen and the east coast of Samsø at Onsbjerg were the only places where any considerable migration had taken place. According to the Bulletin sent out on July 17th control was necessary only in a few areas, i.e. Funen, Samsø, locally at Askov-Vejen and at a few Lammefjord localities near Fårevejle Kirkeby. Control was recommended only in carrots, beetroot and leeks on light soil, unless there had been a rainfall of 30 mm distributed over 3 to 4 days during the

period 10th to 23rd July.

The advisers also reported no or weak attacks of cutworms on potatoes and carrots in July and August.

Other pests

Carrot flies (*Psila rosae*). The flight both of the first (May/June) and the second generation (August/September) occured several weeks later than normal. There were considerable local variations in the occurrence. Control was necessary at about one third of the localities where yellow sticky traps were used for monitoring. Attacks in celeriac were much more severe than normal.

Field slugs (*Deroceras* sp.) The wet summer offered ideal conditions for reproduction of field slugs, and field slugs were seen in many crops during the growth season. They even occurred in large numbers in cereals where the microclimate is not normally wet enough at the end of the growth season. Therefore, the growers expected attacks in winter crops during the autumn. As the sowing time was delayed, few severe attacks had been reported by the middle of September.

Several reports mentioned attacks in clover fields in July.

Survey of diseases and pests in horticultural crops in 1987 (Lars A. Hobolth)

In 1987, the horticultural advisory department received 1383 samples. The distribution according to crops and according to group of pathogen will appear from the following table, in per cent:

	Phy sio- logi- cal	Myco- logi- cal	Bacte- rio- logi- cal	Viro- logi- cal	Zoo- logi- cal	Total
Grass	0.1	0.5			0.2	0.7
Cruciferous crops	0.4	0.9		0.1	0.4	1.8
Potatoes	0.4	0.6		0.1	0.4	1.5
Fruit bushes and trees	0.9	4.6	0.6	2.6	2.3	11.1
Vegetables	3.0	10.3	1.4	0.5	5.8	21.0
Ornamentals	7.5	27.8	2.4	6.0	18.1	61.7
Without host plant		0.1			0.7	0.8
Total	12.3	44.8	4.3	9.3	27.1	97.8
Diverse						2.3

The following enquiries concerning unusual or new attacks were received in 1987:

Downy mildew of Eustoma (*Peronospora chlorae*) was found on plantlets of *Eustoma russelianum* (Lisianthus). The attack appeared as a light colouring of the attacked leaves. The attack occurred tipically on young shoots and leaves. A continued development resulted in the shoots dying.

Downy mildew of watercress (*Peronospora nasturtii aquatici*) was found in small pots with watercress (*Nasturtium officinale)* grown for sale, where the fungus caused a yellow colouring of the lower leaves of the plantlets and a few blackish spots on the leaf surface.

Downy mildew of cucumber (*Pseudoperonospora cubensis*) was again observed in the beginning of August, i.e. at the same time as in 1986. The attack did not get the same epidemic character as the preceding year, probably because the growers were ready to control the disease as soon as the first symptoms had been observed.

D. BOTANY DEPARTMENT, Arne Jensen

Head of department: Arne Jensen

Scientific staff:

Ib G. Dinesen: Bacterial diseases

Mogens Houmøller: Virulence analysis of barley and wheat powdery mildew (*Erysiphe graminis)*

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

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

Bent Løschenkohl: Fungal diseases in horticulture; fungi in recirculating watering systems, testing of resistance to potato wart diseases; testing of disinfection compounds

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

Sten Stetter: Threshold values for leaf diseases of cereals; development of EPIDAN - a computer-based system for advice on disease control

Kirsten Thinggaard: Root diseases in greenhouse crops, especially *Pythium* and *Phytophthora;* testing for races in *Bremia lactucae* (lettuce downy mildew)

Boldt Welling: Diseases of cereals and grasses.

Bacterial diseases (Ib G. Dinesen)

Bacterial ring rot of potatoes (*Corynebacterium sepedonicum*)

As all the potato material has been changed to plants based on meristematic cultures, a very careful inspection has been carried out. Not only seed tubers have been tested, but also a great number of samples of potatoes for consumption.

Bacterial leaf spot of hedera (*Xanthomonas campestris* pv. *hederae*)

Experiments were carried out on *Hedera helix* to find out under which environmental conditions this disease is severe. The first results showed that the disease incidence increased when the room temperature was increased from 15°C to 22°C. Furthermore, the disease was much more severe when the crop was sprinkled twice a day than when the irrigation took place by ebb and flow system.

Bacterial blight of peas (*Pseudomonas syringae* pv. *pisi*)

Examinations of this disease were started. They are carried out in collaboration with the State Seed Testing Station. The aim is to find out which races are most common in

Denmark, and to find out which races infect the pea varieties normally grown here.

Healthy nuclear stock plants

Bacterial tests were carried out in connection with the renewal of the nuclear stock plants at the Institute of Glasshouse Crops and the horticultural cultures grown in vitro at the Virology Department. The following plant material was tested: *Pelargonia* (265 samples), *Begonia* (244), *Chrysanthemum* (201), *Dieffenbachia* (32), *Hedera helix* (25) and *Epipremmum oureum* (16).

Fungal diseases

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

Take-all (*Gaeumannomyces graminis*). In 1987, the total number of stubble samples examined for take-all was 719. The attacks in spring barley were at a lower level than in 1985 and 1986. In winter barley, no fields were found with infection of more than 5% of the root mass. In winter wheat and winter rye, infection of more than 20% of the root mass was found in 12% and 2%, respectively, of the fields examined.

Eyespot (*Pseudocercosporella herpotrichoides*). In the spring, about 404 samples of winter crops were examined for eyespot with a view to prognoses, warning and guidance about treatment. Climatic observations showed that the primary infection possibilities were good in November/December. The infection level in the spring was generally lower than in 1985/86.

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

The summer estimates of 719 samples showed severe and more widespread attacks of eyespot than in 1986.

Sharp eyespot (*Rhizoctonia cerealis*) occurred in 56% of the fields with spring barley and in 80% of the fields with winter barley.

In 98% of the fields with winter wheat and in 97% of the fields with winter rye, sharp eyespot was found, but always with a low to moderate level of attack.

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

Computer programs which enable barley growers to make decisions on chemical control of diseases and aphids have been developed and are now in practical use. The programs have made a reduction in the use of pesticides possible while the growers are still obtaining a good profit.

The fungal part of the programs is based on experimental results, obtained by the use of the program Epidan. The parameters used by Epidan are mildew (percent main tillers infected on the third fully developed upper leaf), growth stage, crop last year, plowing quality, rainfall, prognosis for rainfall, effect of fungicides, previous fungicide treatments, cost of fungicides, cost of spraying and price of barley. A preliminary Epidan program for winter wheat was tested in 1987. It included mildew, rust and risk factors for other leaf disases, especially *Septoria* spp.

Due to the cool, rainy weather in 1987, *Septoria tritici* became widespread and severe, while *S. nodorum* occurred to a much lesser extent. The program underestimated an early development of mildew and especially the risk of *Septoria* diseases. Great losses were experienced in plots treated according to advice from Epidan compared with routine spraying two-three times with broad-spectrum fungicides. In 1988, a revised model will be tested.

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

For 3 years, experiments with variety mixtures in winter barley have been carried out at the localities Rønhave, Roskilde and Tåstrup. In 1986, the varieties Igri, Marinka, Gerbel and Hasso were examined. The attack level of net blotch and barley scald was lower in mixtures of these varieties than in the individual varieties. The level of mildew attacks was so low that the assessments were not carried out.

The highest yield increase was 2.8 hkg/ha without use of fungicides, but there were big variations between sites, which is in agreement with experiences in 1985 and 1986.

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

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

Experiments with variety mixtures of winter wheat were started in the autumn of 1986 at the localities Rønhave and Roskilde. The varieties Citadel, Kosack, Kraka and Sleipner are used as components in the mixture. It is composed of four of the varieties in all possible combinations. Different levels of fungicide treatments are a second parameter in the experiment. Preliminary results indicate a reduction of the diseases mildew and glume blotch.

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

After 0, 1 and 2 fungicide treatments with Bayleton 25 WP or Tilt 250 EC, the disease pressure of mildew was assessed at Rønhave. The mildew level was monitored in

neighbouring spring barley fields with a non-resistant variety (cv. Gunhild) and in mobile nurseries with the non-resistant variety Pallas. The mildew level has been very low for the past two years and consequently no significant results were obtained.

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

For 4 years, the occurrence of leaf pathogens and saprophytes have been monitored in untreated plots and plots sprayed with Tilt 250 EC.

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

This led to the conclusion that it was very difficult to advise farmers as to when fungicide treatment of grass for seed production was profitable.

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

A Danish national virulence survey was initiated in 1985. Until now, the investigations have been concentrated on powdery mildew in barley and wheat, and in 1987 the activities were extended to include net blotch of barley.

Two different methods are used for the powdery mildew survey whose main object was to forecast early attacks of powdery mildew in commercial varieties:

a. Determination of virulence frequencies based on colony countings on seedlings in mobile nurseries exposed at 8-10 localities two-three times per year.

b. Determination of virulence gene frequencies by genotype testing of single-colony isolates (700-800 isolates in all per year).

The differentials were near-isogenic lines on a Pallas background of barley, and near-isogenic lines of wheat on a Chancellor background, and in both cases they were supplemented with commercial varieties.

Mildew of barley

Only minor changes were found from 1986 to 1987 in the barley powdery mildew populations.

The following resistances were found to be very effective under Danish conditions: Tu (Ml-a3+Ml-(Tu2)), Ri (Ml-a3), Ru (Ml-a13) and Mlo (ml-o). The varieties Benedicte (Ml-a7+?) and Hulda (Ml-a9+?) also had quite effective resistances with corresponding low virulence frequencies.

In most cases, the frequency of Ml-a1 virulence varied on Zealand from 2 to 5 and in Jutland from 10 to 20. This reflects an increase compared with 1986. V-a9, V-a10 and V-a7 were found to have frequencies from 20 to 40 on average. V-(La) and V-(ra) were in most cases found with frequencies from 50 to 90.

In April/May, no significant difference was seen between the localities, but later on, in June and July, evident differences developed between the populations on Zealand and in Jutland. V-a1, V-a12 and to some extent V-a9 were most frequent in Jutland, and this is in accordance with observations from 1985 and 1986.

Mildew of wheat

The wheat varieties Sleipner (Pm 2+6+8), Kosack (Pm 4b) and Holger (Pm 6) had the most effective resistances found in wheat varieties on the Danish National List of Varieties. On the other hand, the most current variety Kraka (Ml-i) had virulence frequencies close to 100, or similar to that of Anja, which was used as susceptible control.

Resistance in barley varieties to net blotch (Boldt Welling and Mogens S. Houmøller)

Attacks of net blotch (*Drechslera teres*) were assessed in 42 spring barley varieties at seven localities in 1987.

The experiments revealed big differences in resistance efficiency against *D. teres*, depending on the population origin of the fungus. This was clearly demonstrated at Pajbjerg where the inoculum was infected straw of barley of three different origins.

The accumulated rainfall for May, June and July was bigger than the average of 9 years' rainfall, and this offered optimum conditions for growth of the fungus.

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

Symptoms of *P. teres* was normally of the spot type. The net type was predominant in the varieties Gunnar, Harry, Triumph, Nordal and Jenny.

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

The occurrence of 'barley yellow mosaic virus' BaYMV was investigated in 24 winter barley fields on Lolland, Falster and in the southern part of Jutland close to the Danish-German border. Samples of field-grown winter barley were tested for the presence of virus and the fungal vector *Polymyxa graminis*. The virus was not detected in any sample. *P. graminis* was found in 30% of the samples.

24 soil samples were taken from the same fields. The samples were examined using winter barley (Igri) as susceptible control. The virus (BaYMNV) was not found in any samples. *P. graminis* was observed in 46% of the soil samples.

In the course of 1987, 386 soil samples have been taken from points in a grid covering the country. The samples are being tested for the vector and the virus.

Rhizomania and its fungal vector _Polymyxa betae_ (Lilian Kloster)

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

In the course of 1987, 386 soil samples were taken from points in a grid covering the country, and at harvest in 1987, 192 soil samples were taken from beet fields. The samples will be examined for the presence of the root-parasitizing fungal vector *Polymyxa betae* and the virus BNYVV using a beet seedling bioassay.

Stem rot (_Sclerotinia sclerotiorum_) in oilseed rape (Lone Buchwaldt)

A system for forecasting attacks of stem rot in winter and spring rape includes sclerotia placed in small depots at approximately 70 different localities in Denmark. Forecasting the risk of attacks is based on information about the germination of apothecia in the depots and on climatic conditions as reported by the agricultural advisers.

In winter rape only a few apothecia germinated when most of the fields were flowering, and no warning was issued. However, when the apothecia germinated at a later stage, there was risk of attacks in fields with late flowering.

The apothecial development in spring rape was above the level where there was a risk of attacks (25-30% germination). Due to heavy precipitation, prolonged flowering and early lodging, two warnings against attacks of *S. sclerotiorum* were sent out.

Widespread and sometimes serious attacks were seen in parts of Denmark with a long tradition of growing rape. The attacks were most damaging in a spring rape variety (Global) with a high and soft stem. A large number of fields had lodged because of heavy nitrogen fertilization and excessive rainfall, which made secondary spread of the fungus possible.

Pea diseases (H. Schulz)

In 1987, severe attacks of leaf spot occurred, especially at the end of the growing season. It was mainly *Mycosphaerella pinodes* which was found.

A considerable spreading of grey mould (*Botrytis cinerea*) took place at the end of July and the beginning of August, but this stopped in September. Downy mildew (*Peronospora viciae* sp. *pisi*) was found in varying degrees in all fields, but severe attacks were mostly confined to fields in Jutland with narrow crop rotation. Attacks by *Fusarium oxysporum* f.sp. *pisi* occurred only in a few fields where weak attacks are normally seen, whereas *Fusarium* spp. could be isolated from a considerable number of diseased roots and stems. Powdery mildew (*Erysiphe pisi*) was only observed in a single field with fairly severe attacks. *Aphanomyces* root rot (*A. euteiches*) was found in one field only, but as the diagnosis is difficult, this fungus may be more widespread than assumed until now. Examination of a number of seed samples showed relatively weak seed infection by grey mould, but high infection rates of *Ascochyta* spp. and *Fusarium* spp.

Research work on the epidemiology, forecasting and a survey of the occurrence will be continued.

Diseases on sour cherry (Karen Jørgensen)

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

Microscopic examination of leaves with cherry leaf spot disease showed that *Blumeriella jaapii* develops ascospores during spring. Ascospore ejection was registered after showers from the beginning of the flowering season in mid-May to approximately 10th June 1987. Cherry leaf spot disease caused early defoliation in many orchards as a consequence of the rainy summer.

Field spread, symptoms and influence on fruit yield was followed in trees infected with *Prunus*necrotic ringspot virus (PNRV). During a three-year period 38% of 7-year-old 'Stevnsbær' planted near old PNRV diseased trees became infected. The average fruit yield was reduced to approximately 25% of that of symptomless trees.

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

Physiological races of *Bremia lactucae* were determined, and new varieties of lettuce were tested for resistance. A trial for resistance in outdoor iceberg lettuce including 14 varieties was carried out in the field as well as in the laboratory.

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

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

An investigation of *Phytophthora* and *Pythium* in 8 pot plant nurseries with recirculation of the nutrient solution was carried out. The fungi were isolated from the watering

systems, determined to species and tested for pathogenicity.

In greenhouse cucumbers grown with or without recirculation of the nutrient solution, zoospores were detected much earlier in systems with recirculation. Strategies for protection will be prepared.

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

The Danish Potato Breeding Station at Vandel sent 203 tuber samples to be examined for wart resistance. The percentage of wart attacks in the first, second and third year was 22.6, 11.0 and 33.0, respectively.

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

Populations of higher fungi in recirculating systems for pot plants were investigated during the autumn of 1987. The investigations were carried out in a nursery with seven separate reservoirs where *Cissus rhombifolia* "Ellen Danica" and *Crossandra infundibuliformis* were grown. The total number of fungi varied from 5 to 10 propagules per ml. In water from *Cissus* a yellow *Gliocladium/Penicillium* was dominant, whereas pycnidia-forming fungi were dominant in water from *Crossandra. Trichoderma viride* was dominant in the water from stock plants of *Crossandra* grown in rock wool. The investigations will be continued, concentrating on the spread of pathogenic fungi within the nursery.

Diseases in *Eustoma russelianum* (Bent Løschenkohl)

Preliminary investigations on fungal pathogens in *Eustoma russelianum (Lisianthus russellianus)* was carried out in 7 nurseries. *Fusarium* sp. and *Peronospora chlorae* were the main pathogens causing considerable losses.

***Mytothecium roridum* (Bent Løschenkohl)**

Myrothecium roridum was found in *Selaginella* spp., *Scirpus cernuus*, *Ficus pumila* and *Kalanchoë blossfeldiana* "Pollux". Investigations on the spread of the disease will be continued.

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

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

E. VIROLOGY DEPARTMENT

Head of department: **H. Rønde Kristensen** (until 31st July)
Arne Thomsen (acting from 1st August)

Scientific staff:

Jens Begtrup: Electron microscopy
Bent Engsbro: Viruses of agricultural plants; production of healthy nuclear stocks of potatoes
Morten Heide: Serological diagnosis methods
Niels Paludan: Viruses of vegetables and ornamental plants (herbaceous); production of healthy nuclear stocks
Arne Thomsen: Viruses of fruit trees, soft fruit and woody ornamental plants; production of healthy nuclear stocks

The primary work of the department is development of reliable and preferably fast and cheap methods of diagnosis, investigations of transmission and spread of virus diseases, analyses of virus molecular biological structures and importance (including extent and influence on growth and yield) and finally the department provides knowledge about methods of preventing and controlling (e.g. thermotherapy and establishment of meristem cultures, etc.) virus diseases.

Virus diseases in agricultural plants (Bent Engsbro)

Diseases of cocksfood, maize, pea, beet and barley were investigated in collaboration with the advisory service and through observations in the fields and corresponding tests.

A survey of the extent of cocksfood mottle is being made and possible differences between cocksfood cultivars investigated.

Many winter barley fields were examined for barley yellow mosaic and *Polymyxa graminis*.

Beet fields were observed for *Rhizomania* and for *Polymyxa betae*.

Virus in woody plants (Arne Thomsen)

Populus

Investigations concerning virus infection in *Populus* have been performed. Poplar Mosaic virus (PMV), Tobacco necrosis virus (TNV) and an unknown virus were isolated in infected plants, virus symptoms are observed on several cases, but tests showed that also

Populus plants without symptoms are infected.

Virus diseases in fruit bushes (Arne Thomsen)

Attacks of arabis mosaic virus were found in cultivated *Sambucus nigra* yellow-spotted leaves.

Also *Sambucus nigra* wild growing and naturally infected with arabis mosaic virus was found.

Raspberry

Attacks of raspberry leaf curl virus was found in a crossing without name of raspberry.

The plant material showed shortened shoots with curled and yellowing leaves. The indexing was made by grafting to *Rubus henryi*. No serological reaction to raspberry ringspot virus was found.

Virus diseases in ornamental plants (Niels Paludan)

Dipladenia sanderi belongs to the *Apocynaceae* family and is an attractive flowering pot plant of commercial interest in Denmark. To improve the culture, selection was carried out among 38 different clones collected from Australia and Denmark.

Virus symptoms, mainly mosaic in the leaves were registered during the selection. Typical mosaic symptoms were seen in all the clones.

Infection trials were carried out in order to find suitable indicator plants and plants for propagation, mainly within the families *Chenopodiaceae, Papilionaceae* and *Solanaceae.*

Local lesions appeared only in *Nicotiana megalosiphon* and only when virus-infected sap from *Nicotiana* plants were used as inoculum.

Systemic symptoms appeared constantly in *Nicotiana benthamiana* as a chlorotic mosaic and distortion of young leaves.

In the *Papilionaceae* family, mainly latent infection occurred. Spinach and *Catharanthus roseus* were both symptomless as well.

Physical properties. Virus-infected sap from *Nicotiana benthamiana* was used. The virus survived for 10 minutes at 65°C, but not at 75°C for 8 days at 20°C, but not for 16 days, and a dilution end point at $1:10^{-5}$.

Virus diagnosis using electron microscopy. Sap from virus-infected *Nicotiana benthamiana* was used for suspension samples. Both flexuous poty-like virus particles named Dipladenia mosaic virus (DMV) and TMV particles were observed.

The DMV was further diagnosed against 54 antisera to poty-viruses using the ISEM technique. Only one reaction was achieved to one of three antisera used against bean yellow mosaic virus (BYMV). However, cytological investigations carried out by Dr. D. Lesemann showed that the DMV is not related to BYMV.

Aphid transmission. Successful transmission of DMV was carried out with *Myzus persicae* feeding for 15 minutes on infected *Catharanthus roseus*. DMV was transferred to the *Catharanthus roseus* as a latent infection and to *Trifolium repens* causing brown streaks along the veins.

The presence of two viruses has been demonstrated in Dipladenia showing mosaic symptoms - a poty-virus which has not yet been identified, and a TMV reacting both with the tomato and the tobacco strains.

Kalanchoë blossfeldiana

Kalanchoë plants often show conspicuous leaf symptoms resembling virus attacks.

Many different virus particles have been found in diseased plants, probably associated with the developed symptoms, but so far only one latent virus has been sufficiently diagnosed.

With the results achieved this year, a strain of tomato bushy stunt virus (TBSV) causing chlorotic spots and vein clearing in two cultivars, has been diagnosed in *Kalanchoë blossfeldiana.*

The *Kalanchoë* virus found is serologically most closely related to the type strain of TBSV and based on symptoms in indicator plants closest to the pepper strain of TBSV.

The *Kalanchoë* virus is apparently a new strain of TBSV (*Kalanchoë* strain), the *Kalanchoë* plant being a new host for the TBSV.

This is the first description of TBSV occurring in Denmark.

Occurrence of viruses in recirculated nutrient solutions

The risk of spreading viruses through contaminated water has become greater in recent years due to the development of new growing systems, such as soilless cultre and recirculated nutrient solutions.

In order to investigate this new situation a survey was made of the occurrence of viruses in recirculated nutrient solutions from Danish nurseries.

Virus was found in the recirculated nutrient solution from 4 of 8 nurseries investigated, and in 11 out of a total of 91 selected samples.

The following viruses were diagnosed: Tobacco mosaic, tobacco necrosis, tomato bushy stunt and potato virus X. Virus was transferred to indicator plants (*Chenopodium quinoa*) either from concentrated and/or from non-concentrated samples.

Virus diseases in vegetables (Niels Paludan)

Iceberg lettuce tested for resistance to lettuce big vein virus (LBVV)

The big vein resistant cultivars 'Sea Green', 'Thompson', 'Pacific' and lines from Dr. E. J. Ryder, Salinas, California and the commercial cultivars 'Cavalloria', 'Nabucco', 'Pennlake', 'Saladin' and 'Tires' without known resistance were used for infection trials in the open during spring and autumn.

To achieve infection, young plantlets were placed for 24 hours in a recirculating nutrient solution together with virus-infected lettuce plants containing *Olpidium brassicae*.

The autumn experiment also included healthy plantlets planted in contaminated and non-contaminated soil, respectively.

All cultivars and lines showed different degrees of chlorotic vein banding. The plants with symptoms showed strong visible symptoms, first as vein clearing and later as vein band with curly leaves, independent of the cultivar.

The most promising cultivars/lines with fewest plants showing symptoms, with the highest weight and the best trade value were 'Pacific', 83-1016 and 83-1019.

Thus the most valuable material for cultivation was found among the resistant cultivars/lines.

When infected with LBVV the resistant cultivars/lines had a longer incubation period. This explains the better quality and growth of this plant material.

New virus attacks 1987 (Niels Paludan)

Allium porrum	Carnation mottle virus
Aster sp.	Turnip mosaic virus
Campanula poscharskyana	Chrysanthemum virus B and tomato black ring virus
Chrysanthemum frutescens	Chrysanthemum virus B and aspermy virus
Crossandra flavia	Long flexible particles
Daphne mezereum	Tomato bushy stunt virus type strain
Hibiscus rosa sinensis	Hibiscus yellow vein virus (symptomatology)
Hibiscus rosa sinensis	TMV (tomato and tobacco strains)
Kalanchoë blossfeldiana	Tomato bushy stunt virus, type strain
Pastinaca sativa	Parsnip yellow fleck virus
Pelargonium peltatum	Pelargonium ring pattern virus
Pelargonium peltatum	Pelargonium line pattern virus
Pelargonium peltatum	Pelargonium flower break virus (1985)
Pelargonium zonale	Tomato bushy stunt virus type strain
Pentas lanceolata	Cucumber mosaic virus
Prunus domestica	Chlotic leaf spot virus
Populus x berolineusis	Poplar mosaic virus
Populus x canadiensis	Poplar mosaic virus
Populus x candicous	Poplar mosaic virus
Populus x nigra	Poplar mosaic virus
Populus canadensis	Tabacco necorsis virus
Shimmiajaponica	Raspberry ringspot virus
Ribes alpinuus	Arabis mosaic virus

Re-circulated nutrient solutions from 8 nurseries using the ebb-flood system:

Potato virus X
Tobacco necrosis *Chenopodium* strain
Tobacco necrosis strain A
Tomato bushy stunt virus, type strain
TMV strains: tomato, tobacco, MDG

F. ZOOLOGY DEPARTMENT, Jørgen Jakobsen

Head of department: Jørgen Jakobsen

Scientific staff:

Peter Esbjerg: Insect pheromones and cutworm populations dynamics
Lars Monrad Hansen: Pests on cereals, beet and potatoes; grower-based monitoring of pests in cereals
Lise Stengård Hansen: Biological and integrated control of pests on glasshouse crops
N.S. Murali: Computer aided advisory system for pest and disease control
Alex Percy-Smith: Pests on field vegetables and fruit
Werner Riedel: Pests on potatoes
Lise Samsøe-Petersen: Methods for testing side effect of pesticides on beneficial arthropods

Potato cyst nematodes (*Globodera rostochiensis*) (Jørgen Jakobsen and Lars Monrad Hansen)

The department examined 489 soil samples for occurrence of potato cyst nematodes for the National Committee for Potato Breeding.

Resistance tests of new potato crosses from the breeding station at Vandel were carried out for the Danish Potato Breeding Foundation. 148 crosses were tested for resistance to Ro-1, and 51 for resistance to Pa-2 and Pa-3. The Pa strains are kept isolated in special greenhouse chambers.

In addition, soil samples have been examined for occurrence of cereal cyst nematodes (*Heterodera avenae*) and beet nematodes (*Heterodera schachtii*) sent in by agricultural advisers and growers.

Other plant-parasitic nematodes

A number of soil samples were examined for various nematode species. None of the samples showed any particular occurrence of nematodes.

Aphids in spring barley and winter wheat (Lars Monrad Hansen)

About 250 growers registered pests and diseases in spring barley. Generally, few aphids were found, and control was only recommended in 9% of the area, while 30% of the fields were actually treated against aphids.

In connection with the grower registration of aphids in winter wheat, experiments with control of aphids were carried out by the research stations at Rønhave, Ødum and

Roskilde. The experiments did not show any significant yield increases by pesticide application.

The importance of late aphid attacks in winter wheat (Jørgen Jakobsen)

The importance of attacks by three aphid species on winter wheat after growth state 10 (Feekes) was investigated by means of semi-field experiments.
The species in question were grain, bird-cherry and rose grain aphids. They were introduced at four different dates at intervals of one week starting on June 18th. The reproduction was very rapid - aphid densities of several thousands per plant in 4 weeks. Thus the attack levels found do not apply to field conditions where such high levels are very rare.

The harmful effects of the three aphid species on winter wheat were not significantly different, but grain aphids seemed to be most damaging, and bird-cherry aphids came next. Even when the attacks started at stage 10.5.2, they resulted in yield reductions of 20%.

The results stress the importance of controlling severe cases of aphid infestation in winter wheat until flowering.

Aphid registration in beet (Lars Monrad Hansen)

Peach-potato aphids were registered by growers in 106 fields. The registration did not comprise Lolland-Falster and Southern Zealand where local registration has taken place for a number of years.

Aphid densities were very low also in beet in 1987. Low occurrences of peach-potato aphids were found in 25% of the fields by August 1st. Control measures against aphids, including black bean aphids, were taken in 35% of the fields.

Insecticide-resistant peach-potato aphids (Lars Monrad Hansen and Werner Riedel)

Peach-potato aphids were sent in for examination.

No or low resistance was found in 65% of the 140 samples. Most of the remaining samples had medium resistance, but 15% had a high pesticide resistance.

There was no indication of an increase in the occurrence of resistant peach-potato aphids in relation to earlier investigations.

Registration of aphids in potato fields in Jutland (Werner Riedel)

Aphids are caught in yellow sticky traps at 15 localities in Jutland in order to estimate the risk of aphid-borne virus diseases in seed potatoes. The occurrence of relevant aphid species was uncommonly low during the whole of the registration period from June 25th to August 15th.

Influence of temperature on development and mortality of larvae of *Agrotis segetum* (Peter Esbjerg)

Duration of development of 1-5th instar larvae of *A. segetum* under eight temperature regimes, from 12 to 35°C in cabinets with constant temperature: at 35°C the development from egg to pupa was 30 days and at 12°C 198 days. The larval mortality was reduced from 90 per cent at 12°C to 30 per cent at 25°C, and at 35°C mortality increased to 98 per cent.

Influence of diet on development of larvae of *Agrotis segetum* (Peter Esbjerg)

Larvae of *A. segetum* were reared on a diet of fresh and freeze dried table beet, carrot, onion, potatoes, leek and an artificial diet. Measured by the duration of the larval part of the life cycle, onion proved to be the poorest food, while the other vegetables gave no significant differences.

Influence of soil moisture and larvae density on mortality of larvae of *Agrotis segetum* (Peter Esbjerg)

In semifield experiments survival and damage of 1-5th instar larvae were negatively correlated to soil moisture. The early instars were most sensitive to soil moisture.

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

The turnip moth was monitored at 50 localities in Denmark and some 20 localities in Skåne, Southern Sweden.

The weather in June was cool and wet and the flight period was rather later than usual.

Thresholds were exceeded in several areas and warnings were sent to these growers to treat in the third week of July. Damage assessments have shown low levels of damage.

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

Delta traps were used at 31 localities for monitoring the codling moth in apple orchards. The work was carried out in collaboration with the advisory service. A preliminary threshold was used to evaluate risk and the resultant damage was very low. The number of treatments was fairly low but the number of recommended treatments based on monitoring systems was even lower.

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

Monitoring of the first generation was carried out at 7 localities. The flight period lasted from the end of May to the middle of June. Several of the growers were advised to treat

their crops.

Yellow sticky traps were used at 96 localities to monitor the flight of the second generation flies.

Monitoring of flies in processing carrots was carried out on a special contract basis between the Research Centre for Plant Protection and 2 processing factories. Workers from the farmers' own advisory service serviced traps in carrots and celeriac grown for the fresh market. Recommendations for treatments were sent from the Research Centre directly to growers participating in the system. No treatments were necessary in carrots used for slicing, whereas treatments were necessary on about half of the area for dicing carrots. The situation for fresh market carrots was similar. The flight period was quite late due to weather conditions.

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

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

A rearing was established based on field collected adults. Larvae were reared individually to adults on different types of food. A diet consisting of eggs of house flies and a butterfly (*Sitotroga cerealla*) proved sufficient for the development from egg to adult.

Glass cells used for developing a test for adults were also tried for larvae. Results were not quite satisfactory as the larvae were very sensitive to minor fluctuations in humidity.

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

Registrations of 4 species of carabids and one staphylinid genus in the field with an untreated strip were continued during this third year of a 3-year project. Conclusions were that in the 6 meter wide untreated strip activities of the beetles had in general increased during the 3 years as compared to the pesticide treated parts of the field. But the strip did not affect activities of the species investigated in the rest of the field. The time of application of pesticides poisonous to the species proved to be more important for the populations in the field than the untreated strip.

G. THE PLANT PROTECTION ADVISORY DEPARTMENT, A. From Nielsen

Udkærsvej 15, Skejby, 8200 Århus N

Head of department: A. From Nielsen

Scientific staff:

Søren Holm: Pests and diseases of agricultural plants
Jørgen Simonsen: Fungicides and insecticides in agricultural crops

The main task of the department is to give advice on questions of plant patholoty and to test pesticides. The work is carried out in close co-operation with the staff of the National Department on Crop Husbandry in this area.

Advisory service

The work comprises replies to oral and written enquiries, diagnosis of material sent in for examination, prognoses and warnings as well as lectures and seminars.

Lectures and seminars

During the year, staff members have taken an active part in 45 meetings and seminars. Furthermore, the department was involved in ten excursions on plant pathology arranged by the agricultural advisers in different regions.

Experimental work

Pesticide testing (J. Simonsen)

The results of this testing appear in the test results of the Pesticide Research Institute.

The sensitivity of potato late blight to fenylamides (S. Holm)

The sensitivity of potato late blight to metalaxyl (active ingredient in Ridomil MZ) was tested in about 100 potato fields. A considerably reduced sensitivity (resistance at 10 ppm) was found in half the fields, and it was, in all cases, more pronounced when metalaxyl had also been used in connection with seed potatoes the year before. As a consequence, the approval of Ridomil MZ for control of potato light blight in seed potatoes has been recalled.

Frit flies (S. Holm)

Routine monitoring of frit flies in oats, maize and ryegrass was carried out by weekly registrations by agricultural advisers and research stations (about 30 sites). The registrations were used in local warnings as well as Plant Protection Bulletins.

H. PESTICIDE RESEARCH INSTITUTE, E. Nøddegaard

Head of institute: E. Nøddegaard

Scientific staff:

Bent Bromand: Insecticides in agricultural crops
Hanne Lipczak Jakobsen and Lars Bødker: Fungicides in oil-seed rape, potatoes, beet, peas and vegetables
Lise Nistrup Jørgensen and Bent J. Nielsen: Fungicides in cereals, maize and grassland
A. Nøhr Rasmussen: Fungicides, insecticides and nematicides in greenhouse and nursery crops
E. Schadegg: Fungicides and insecticides in orchards and gardens; administration; list of Approved Products

General survey by E. Nøddegaard

Approval of pesticides and plant growth regulators

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

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

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

Pesticides with satisfactory effect are included in the approval list of "Plant protection compounds approved for control of plant diseases, pests and weeds, for haulm destruction of seed crops and potatoes as well as growth regulation".

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

Evaluation of efficacy of pesticides and plant growth regulators

According to the provisions of Act No. 410 of 17th September 1980 on chemical products, the Pesticide Research Institute shall be consulted as to the efficacy of pesticides and growth regulators before the registration by the Environmental Protection Agency takes place. The efficacy is estimated on the basis of test results sent in by the companies, experience and literature studies. If necessary, further tests and investigations will be carried out.

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

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

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

Control of fungal diseases in barley (Bent J. Nielsen)

Trials were carried out in winter and spring barley in order to obtain a sufficient basis for biological approval of fungicides.

Two years' field trials with new combinations of products have now been finished. Approvals for control of powdery mildew, net blotch and scald were given to Tilt top (propiconazole + fenpropimorph), Folicur (tebuconazole), Folicur 125 EW ((tebuconazole + triadimenol), Folicur Combi (flusilazole + tridemorph) and DPX N7873 (prochloraz + fenpropimorph). Several other products also showed good effect, but have not been tested further.

So far, the field trials with ergosterol inhibitors have given no indication that fungicide resistance has developed under field conditions. Most of the products used in Denmark are combinations of DMI compounds and morpholines, which are regarded as a delaying factor with respect to resistance development.

The approved dose gave sufficient control of the diseases in most cases, and under optimum conditions effective control can be obtained with lower doses. In spring barley, doses down to 0.3 l of Tilt top (propiconazole + fenpropimorph) and 0.5 l of Rival ((prochloraz + fenpropimorph)showed good effect against powdery mildew.

Split doses (3 x 0.3 l of Tilt top or Rival) gave the best results against leaf diseases in barley.

Winter barley is sprayed twice at an early stage to protect spring barley from severe attacks, but the yield benefit in winter barley from those two sprayings was negligible.

In spring barley, there was a positive net yield return in two thirds of the field trials after spraying with Tilt products at full rates.

Control of fungal diseases in winter wheat (Lise Nistrup Jørgensen)

The main objective of the trials carried out in winter wheat was to obtain sufficient information for biological approval of fungicides.

1987 was a year with a high degree of leaf disease pressure (yellow rust,*Septoria* and mildew), and fairly accurate evaluations of the products tested were possible. The average yield increase in 24 trials caused by control of leaf diseases was 17.3 hkg/ha after two fungicide applications (Feekes 6 and Feekes 10). The yield increases due to control of eyespot were generally low and only just economic.

Eyespot control was generally poor in 1987 because of heavy infection in the autumn and late in the spring. Sportak 45 EC (prochloraz) was applied for eyespot control at various growth stages from Feekes stage 1 in the autumn until Feekes stages 5-6 in the spring. The best control was obtained with application at growth stages 5-6 (45% control) og by split application (2 x 0,5 l) at Feekes 3 and Feekes 6 (51% control).

All coformulations tested gave a high and almost even level of leaf disease control. A special plan for testing different ergosterol inhibitors was continued for another year. Corbel (fenpropimorph) proved to be by far the best mildew product, followed by Folicur (tebuconazole), Bayfidan (triadimenol) and SN 108266 (cyproconazole). Most of the products (excluding Sportak and Calixin) gave high and lasting control of yellow rust. *Septoria* spp. was best controlled by Folicur, DPX H 6573 (flusilazole), Tilt 250 EC (propiconazole) and Sportak 45 EC (prochloraz). Tilt top (propiconazol + g fenpropimorph) and Rival (prochloraz + fenpropimorph) were tested at full and reduced rates. Most of the tests indicated that good results could be obtained with reduced dosages.

Fungicide resistance in powdery mildew (*Erysiphe graminis*) in cereals (Bent J. Nielsen) (Until 1st May: Connie Nina Christensen, from 1st May: Karen Husted)

This project includes a surveyance of resistance development in cereal mildew (*Erysiphe graminis*) against ergosterol-inhibiting fungicides.

The testing of the barley and wheat mildew collected in 1986 was finished. As usual,

he test tube method was used. The sensitivity in barley powdery mildew against propiconazole seemed to be higher in 1986 than in 1985.

There was no clear correlation between the fungicide treatments in the fields and the sensitivity of the mildew collected in the different fields.

The sensitivity of barley powdery mildew tended to rise during the season, but for wheat mildew there was no clear progression during the season.

A new laboratory test method - the leaf segment method - was introduced. Partly because of skepticism about the test tube method, and partly because of the possibility of collaboration with the Danish virulence project (Mogens Houmøller), where an analogous method is used.

Both propiconazole, given as Tilt 250 EC root drench, and triadimenol and triadimenol, in the form of Baytan seed dressing, were used when adapting the method to our conditions. Triadimenol was chosen as test fungicide. The plants were grown in vermiculite with addition of a Hewitt solution as nutrient. Leaf segments were cut off and placed on water agar, and inoculation took place through a small settling tower.

The modified method was used for testing a large number of wheat powdery mildew single-colony isolates, whereas problems with very small attacks of barley powdery mildew meant that the method could not be used satisfactorily for testing the isolates collected.

The wheat powdery mildew isolates from different localities in Denmark all showed high sensitivity against triadimenol. However, the ED-50 values measured varied, which indicates a potential for development of lower sensitivity.

By use of a direct method, where propiconazole-treated barley and wheat plants were placed at different localities with the aim of picking up mildew from the population in the area, sensitivity was also found to be high and the mildew population to be fairly uniform all over Denmark as far as fungicide resistance is concerned.

Some preliminary fitness tests did not show any difference in infectivity, sporulation or spore germination when measured on two very sensitive isolates as well as on two isolates with lower sensitivity.

Control of fungal diseases on oil seed rape, potatoes and outdoor vegetables (Hanne Lipczak Jakobsen and Lars Bødker)

Damping off in spring rape

Four products were tested in four experiments. Germination increased and the amount of damping off symptoms decreased due to seed treatment.

On the basis of two years' testing, Vitavax RS (carboxin + thiram + lindan) was approved.

Stem rot (*Sclerotinia sclerotiorum*) in rape

Five products were tested in winter and spring rape. Satisfactory attacks were seen in three experiments (13-30% attacked plants), where all tested products showed very satisfactory effect. Ronilan Fl. (vinclozoline) and Sportak 45 EC (prochloraz) were approved on the basis of one and three years of testing, respectively.

Black spot (*Alternaria* spp.) and grey mould (*Botrytis cinerea*) in rape

Five products were tested in winter and spring rape. Because of continuous precipitation and cool weather throughout the summer, severe attacks of black spot were seen late in the season discolouring the fields. All tested products showed good effect against black spot. Rovral Flo (iprodione) was approved on the basis of the four years of testing. Grey mould was seen only in spring rape and the attacks varied according to locality. Iprodione and vinclozolin had satisfactory effect against the pathogen.

Seed treatment in peas

Eleven products for seed treatment were tested in eight experiments. Two of the products had combined effect against diseases and pests. On an average, all the seed treatment products lowered germination slightly but gave increased yield.

Seed treatment had no effect as to downy mildew (*Peronospora viciae* f. sp. *pisi*) except for products containing metalaxyl or mancozeb. Seed treatment had no significant effect as to damping off, discoloration of stem base and roots, or tuber formation.

Fungal diseases in peas

Four products were tested in six experiments. Due to continuous rainfall throughout the summer, severe attacks of *Ascochyta* spp. were seen in July and August causing serious discoloration of pods and yield losses. Spraying at bloom and two weeks later gave satisfactory control of the disease when using maneb, iprodione, chlorothalonile

or tolylfluanide. The yield increases due to treatment were highly significant.

Black scurf (*Rhizoctonia solani*) in potatoes

Nine products for treatment of seed potatoes were tested in three experiments. Four of the products are liquid and were applied with special spraying equipment mounted on the drill machinery.

Many products had a good effect assessed on the basis of percentage of sprouts, stems and tubers attacked. Due to significance in yield and on the basis of two years of testing, Rizolex 25 FW (todofosmethyl) and Monceren 250 FC (pencycuron)were approved.

Downy mildew (*Pseudoperonospora cubensis*) in large cucumbers

Three products were tested in two experiments. Downy mildew is a new disease in Denmark. It was seen for the first time in 1986. Severe attacks in 1986 and 1987 caused serious yield losses.

Ridomil MZ 63 WP (metalaxyl + mancozeb) gave the best effect, and the product was approved on the basis of only one year of testing, which is an exception from the general rule of a minimum of two years' testing.

Seed- and soilborne diseases of flax

Seven products for seed treatment were tested in six experiments. Captan and captan + iprodion had significantly good effect on germination, but no difference between the products was seen as to yield because of too many plants in the fields.

Pests in agriculture and field vegetables (Bent Bromand)

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

The aphid attacks were weak and late. In wheat a maximum of 60% attacked straw were reached at the end of July. This was generally also the case in barley. Only in one trial was a level of 91% attacked straw found with a resulting yield reduction of 3-5 hkg per ha. Six experiments were carried out with a number of synthetic pyrethroids, pirimicarb and oxydemeton.

Thrips (*Thrips*) in winter rye

Three trials were carried out with synthetic pyrethroids and fenitrothion. The spraying (Feekes 9-10) resulted in good control of the thrips, but only with small yield increases.

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

One trial with seed treatment, spraying before plowing and spraying after germination gave poor results due to weak attacks in the cold and rainy weather. Pyrethroid application during the spring in spring-sown wheat and oat gave good control when applied at the 1½ leaf stage. Seed treatment in spring with cyfluthrin had no effect. The flying of frit flies was monitored in blue sticky traps.

Esfenvalerat treatment of undersown grass 8-10 days after cutting gave 4-8% yield increase.

Pests in seed grasses

Pesticide experiments were carried out in perennial ryegrass, red fescue (Veni) and Kentucky bluegrass (Trampas). Fenitrothion and lambda-cyhalothrin treatments gave good results. Grass samples were treated in a Berlese apparatus, and numerous mites were found. They were predatory mites, *Tydeus* spp., *Eupodidae* and various nymphs, none of which can be regarded as pest species.

Clover seed weevils (*Apion* spp.) and clover leaf weevils (*Hypera nigrirostris* and *H. meles*) in white clover and red clover for seed

Trials were carried out with fenitrothion, cypermethrin, lambdacyhalothrin and deltamethrin. During the wet season it was very difficult to find the correct time for treatment. Hatching of the new generation in hatching bags in the laboratory, however, showed that fenitrothion had better effect on *Apion* spp. whereas the pyrethroids were better for control of *Hypera* spp. All the chemicals tested were found to have a strong effect on parasites in red clover, but not in white clover.

The importance of peach-potato (*Myzus persicae*) and black bean aphids (*Aphis fabae*) for control and spread of virus diseases in sugar beet

Three trials were carried out with pirimicarb and lambdacyhalothrin. Especially lambda-cyhalothrin gave good control of the virus, but due to late and weak aphid attacks, no yield increase was obtained.

Mangold fly (*Pegomya hyascyami*) in beet

Three experiments were carried out with fenitrothion, pyrethroids and *Bacillus thuringiensis* ß-exotoxin. In general, the phosphorous compounds took effect most quickly. However, the overall effect of the pyrethoids was good. *Bacillus thuringiensis* ß-exotoxin had no effect on the pest.

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

During the spring, three experiments with control of the pest were carried out. The following active ingredients were used, often in combination with fungicides: lindan, isophenphos, furathiocarb and carbosulfan. All the chemicals tested gave good control of flea beetles, and especially furathiocarb and carbosulfan of thrips as well. None of the chemicals had any effect on late attacks by the cabbage stem weevel (*Ceutorrhynchus pallidactylus*). In the tests, the powder compounds were used together with sacrust, whereas this was not the case with liquid products.

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

The experimental work on pyrethroids was continued. Generally, pyrethroids had a good effect against the three pests.

In trials with the brassica pod midge the main stems of 20 plants in each plot were marked with coloured tesa strips below the lowest fully open flower. Five days later, the same plants were marked above the highest fully open flower. In this way 13-15 pods on each stem are distinguished as dating from a period where the pesticides have good effect.

Seed treatment and spraying against field thrips (*Thrips angusticeps*) and pea, bean and clover weevils (*Sitona lineatus*) in peas

Furathiocarb, tefluthrin and carbosulfan were used for seed treatment. Pesticides containing esfenvalerat, lambdacyhalothrin and deltamethrin were applied. Very few field thrips were seen, whereas severe attacks by pea, bean and clover weevils occurred.

Seed treatment with furathiocarb and carbosulfan gave good control, and tefluthrin gave medium control of this pest estimated on the basis of the amount of damage on the leaves and the propagation of larvae in the soil. The pyrethroids reduced leaf damage and the number of larvae in the soil was reduced by about 50 per cent. However, one important observation was made: In mid-July the attacks of pea aphids (*Acyrthosiphon pisum*) in all plots were assessed. It turned out that, in general, the number of aphids in treated plots was only about half the number in the control. Seed treatment and pyrethroid application had additional effect. It is remarkable that seed treatment should have effect on aphids three months after sowing and pyrethroids two months after application on small plants.

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

Three spraying experiments were carried out. The pesticides were applied after

catching pea moth males in pheromone traps or by initial attacks of pea aphids. Pirimicarb, fenitrothion, two formulations of oxydemeton-methyl and six pyrethroids were tested. All the chemicals showed good initial effect on pea aphids. The effect lasted for about five weeks. Oxydemethon-methyl was applied at the beginning of flowering to avoid harm to honeybees. This was two weeks earlier than in the remaining plots, and consequently the effect did not last long enough.

Cabbage root fly (*Delia radicum*) in cauliflower and chinese cabbage

Experiments were made with seed treatment, granule incorporation, treatment of plants before transplanting, soil drenching before transplanting and spraying. The very low number of eggs and the late time of egglaying due to wet and cold weather caused great variations in the results.

A warning system for the cabbage root fly based on egglaying in egg traps was worked out. The system has been in use for three years, and in 1987 it was used for detecting a delay in egglaying.

Apple growing (E. Schadegg)

Fungal diseases

Apple scab (*Venturia inaequalis*)

Testing of fungicides for control of apple scab was carried out in two apple plantations at Roskilde and Tuse, respectively. The summer weather provided optimum infection conditions for scab. As early as in June the level of infection in the control plots at Roskilde was more than 80%, whereas the level of infection at Tuse was 44%.

A total of ten fungicides were tested, three of which were tested for the first time. The remaining seven fungicides had been tested the previous years, too. Approvals were given to Baycor Combi (bitertanol 12.5%, tolylfluanid 50%), SC 109 (penconazol 33 g/l), (dithianon 330 g/l), and Systhane 40 WP (mycobutalin 40%).

Occasioned by a new law regarding reduction of the consumption of pesticides, a dosage experiment with seven fungicides in the approved dose and 3/4 dose was carried out.

The results show that for three fungicides, Orthocid 83 (captan), Cadol M 63 (dithianon) and Rondo , a 25% reduction of the approved dose can be considered realistic.

Baycor 25 WP, Dithane M 45 and Rubigan showed reduced effect against apple scab at 3/4 dose compard to 1/1 dose. However, the results do not exclude the possibility

of a reduction of the doses of these fungicides if the infection level is low. The effect of sulphur was totally insufficient with both doses.
In two experiments, the control of apple scab obtained by spraying after a fungus warning instrument compared to a standard spraying scheme were carried out. Two different warning instruments, Biomat SWG from Berghof in GFR and SMS Paar from Graz in Austria were tested. The former was placed at Roskilde, where a very heavy infection of apple scab in the control plots was registered, and the latter at Vindinge, where the infection was moderate.

Neither at Roskilde nor at Vindinge could any significant difference be observed in the scab infection after treatment according to the warning instrument and the standard spraying scheme. At Roskilde and Vindinge, respectively 11 and 10 applications took place according to the warning instrument, and 13 and 13 according to the standard spraying schedule.

Brown rot in sour cherries (*Monilia laxa*)

The experiments were carried out at the same two localities as in previous years, i.e. at Nagelsti and Præstø.

The level of infection was very high. At Præstø, two experiments were carried out. In one experiment the fungicides were applied to the same plot as in 1986, and in the other the fungicides were applied to trees which had not previously been used for experiments. The efficiency was a little higher in the former than in the latter experiment, but significant differences were found only for Saprol and Topsin F.

Approval was given to Ronilan fl. (vinclozolin 50%), Rovral Flo (iprodion 24.5%), Octave (prochloraz-Mn-complex 50%) and Baycor Combi (bitertanol 12.5%, tolyfluanid 50%).

Cherry leaf spot (*Blumeriella jaapii*)

Five fungicides were tested for control of cherry leaf spot. Approval was given to Capidol (captan 40%). The test was carried out in the variety Kelleris 16. In August the level of infection reached 54% in the control plots.

Winter moths (*Cheimatobia* spp.) and leaf rollers (*Tortricidae*)

Four experiments were carried out for control of leaf rollers and winter moths. Sufficient infestation was observed only in two of the experiments. Approval was given to Trebon (ethofenprox 30%), S 1844 5 FW (esfenvalerat 5%), Sumialfa (esfenvalerat 5%) and FCR 45 45 025 W (cyfluthrin 2.5%). The control obtained with a compound containing *Bacillus thuringiensis* was a little lower than that obtained with pyrethroids.

Apple rollers (*Laspeyresia pomonella*)

Eight pesticides were tested, three of which were biological compounds containing as the active ingredient *Bacillus thuringiensis*. Due to a low infestation level the experiments could not form the basis of approval.

Apple sawfly (*Hoplocampo testudinea*)

In two experiments four insecticides (azinphosmethyl, ethofenprox, esfenvalerat and cyfluthrin) were tested for control of the larvae of the apple sawfly. The control obtained with the four insecticides was comparable to the one obtained with the standard Gusathion MWP 25 (azinphos-methyl 25%).

Plum sawfly (*Hyaloptenus pruni*)

Seven insecticides were tested for control of plum sawflies. Pirimor (pirimicarb 50% and FCR 4545 025 W (cyfluthrin 2.5%) gave the best control. The effect of Sumirody 5 EC (fenpropathrin 5%) dropped abruptly eight days after the application.

Fruit tree red spider mites (*Panonychus ulmi*)

A total of seven experiments were carried out. An experiment was made with the time of application of Apollo 50 SC (clofentenzine 50%) and M 96 oil emulsion (mineral oil 96%). Three dates were tested, viz. April 3, April 30 and May 28.

The efficiency of Apollo 50 SC applied on the two first dates was 99 and 97, respectively, while the efficiency of the last application was only 69. The bad effect is probably due to the fact that part of the eggs had already hatched at the time of application. M 96 oil emulsion gave the best control at the two last spraying dates.

Plictran 80 (cyhexatin 80%) was tested for summer spraying against fruit tree red spider mites with 1 kg/ha and 0.75 kg/ha. The effect of 3/4 dose was somewhat inferior. The effect of Nissorum 10 WP (hexythiazox 10%) was like that of Plictran 80, but the effect shows much later. The effect of Thiodan emulsion (endosulfan 35%) was not quite satisfactory. Dibeta ABC 6162 (thuringiensin 1.5%), which is a *Bacillus thuringiensis* compound, reached an effect of 79%. However, the effect dropped rapidly.

Apple rust mites (*Aculus schlechtendali*)

A series of experiments with apple rust mites was started, partly to find an experimental method for testing pesticides and partly to find pesticides to control this pest.
Six insecticides and six fungicides were tested. Kelthane E 30 (dicofol 30.6%), Mitac 20 (amitraz 21.5%) and Plictran 80 (cyhexatin 80%) had a high efficiency and the

effect lasted a long time. During the first week after application the effect of Dithane M 45 (mancozeb 80%) ascended to 100% after which it dropped quickly. Baycor 25 WP (bitertanol 25%), Rondo (pyrifenox 5%, captan 60%), Cadol M 63 (dithianon 25%), Rubigan (fenarimol 12.1%), Delan SC 750 (dithianon 75%), Systhane 40 WP (mycobutanie 40%), Topas C 50 WP (penconazol 2.5%, captan 17.5%) showed no or insignificant effect.

Control of fungal diseases on black currant (A. Nøhr Rasmussen)

During the years 1985-87 a series of experiments with control of fungal diseases on black currant were carried out at the Pesticide Research Institute. The purpose was to compare pesticides approved by the Danish Research Service for Plant and Soil Science.

The spraying equipment used was an axial air mist blower with ordinary swivel spray nozzles with hollow cones. In a few cases, a knapsack mist sprayer was used. The experiments were carried out with 1200 l/ha, 8-12 bushes per plot, and replicates.

An average of three experiments with control of leaf spot antracnose showed no significant differences between the compounds with the active ingredients captan, dithianon, mancozeb, maneb, penconazol + captan and thiram, which had effects ranging between 83 and 99%. However, the effect of benomyl and thiophanat-methyl was considerably lower: only 41%.

The following active ingredients were examined in two experiments with control of white-pine blister rust: captan, fenarimol, penconazol + captan, thiophanat-methyl and thiram. The effect varied between 85 and 100%, but the differences were not statistically significant.

Three experiments were carried out to examine the effect of benomyl, fenarimol, penconazol + captan, thiophanat-methyl and triadimefon on American gooseberry mildew. Generally, the compounds had little effect. Fenarimol and penconazol + captan had the best effect: respectively 42 and 47%, whereas the effect of benomyl, thiophanat-methyl and triadimefon was only between 8 and 13%.

Three experiments were made with control of grey mould. Three different formulations of iprodione (Rovral 50 WP, Rovral Akva Fl and Rovral Flo) were examined. All three compounds resulted in significant yield increases compared to the control, but no difference was seen between the effect of the individual formulations.

Evaluation of pesticide application for use on greenhouse crops (Steen Lykke Nielsen)

The distribution and deposition of spraying liquids with various kinds of equipment was examined. The deposition and its effect on selected pests and diseases was

estimated.

Measuring droplets

Pulse jet machines and high-pressure hydraulic sprayers produce very small droplets which necessitates a special technique for catching and preserving them. Different kinds of silicone oils, paraffin oils, salad oils, and Vaseline/oil mixtures were tested but found to be unsuitable. This was also the case with water-sensitive paper. Magnesium oxide-coated glass plates were found to be the best measuring method although it cannot register droplets with a diameter smaller than 10 um.

Pulse-jet engines

The distribution of spray liquid from thermal fogging was measured by placing magnesium oxide-coated horizontally or vertically orientated glass plates at various points all over the greenhouse. More than 95% of the droplets registered were deposited on the horizontal glass plates with the coated side upwards. No drops at all were deposited on the underside of the horizontal glass plates. This shows that the droplets are deposited exclusively by sedimentation. The most even distribution of spray liquid was obtained by pulling the pulse jet machine lengthwise through the greenhouse while fogging, instead of fogging from stationary positions.

Fogging with horizontally placed shades improved the deposition and distribution of spray liquid, but moving the air with overhead fans did not influence the distribution.

The biological efficiency of thermal fogging seemed to be correlated with the main living place of the pest on the host, i.e., the exposure of the pest. Complete control was obtained of aphids (*Myzus persicae*), incomplete control of thrips (*Frankliniella occidentalis*), very low control of spider mites (*Tetranychus urticae*) and no control at all of whiteflies (*Trialeurodes vaporariorum*).

High-pressure hydraulic sprayers

This applicator deposited the main part of the spray liquid on the upper side of the horizontal coated glass, but the deposition on the underside of the horizontal glass plates, and the vertical glass plates was better than that obtained with the pulse jet machine.

Fumigators

4 fumigators were tested for control of aphids and whiteflies.

Calcium cyanide gave complete control of the two pests, while sulfotep, lindan and fenitrothion only controlled aphids.

New pesticides tested in 1983 (E. Schadegg)

The Pesticide Research Institute, Lyngby, evaluated 131 fungicides and 81 insecticides. 45 of these were standard compounds. 291 experiments were carried out to asses the effect of the pesticides on 97 pests and diseases.

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

Fungicides:

Seed dressings

Seed-borne fungal diseases:
Vitavax RS
Fusarium spp.:
Sibutol LS 80
Bunt (*Tilletia caries*):
Sibutol LS 80
Leaf and glume botch (*Septoria nodorum*):
Sibutol LS 80
Loose smut (*Ustilago nuda*):
Ferrax JF 10657, Raxil seed dressing LS
Leaf stripe (*Drechslera graminea*):
Baytan seed dressing IM, Ferrax JF 10657, Raxil seed dressing LS
Stripe smut (*Urocystis occulta*):
Sibutol LS 80

Spraying compounds

Leaf rust (*Melampsoridium betulinum*):
Calirus, Baycor 300 EC, Plantvax 20, Topas 100 EC
Brown rust (*Puccinia recondita*):
DPX N 7873, Folicur, Folicur 125 W, Folicur Combi, Tilt Top, Bayfidan + Dairin, Rival
Net blotch (*Drechslera teres*):
DPX N 7873, Folicur, Folicur 125 W, Folicur Combi, Tilt Top
Brown rust (*Puccinia hordei*):
Tilt Top, Rival
Rust on black currant (*Cronartium ribicola*):
KVK Captan F, Rubigan, Topas C 50 WP
Grey mould in ornamentals (*Botrytis cinerea*):
Octave, Rovral Akva Fl.
Grey mould in black currant (*Botrytis cinerea*):
Rovral Flo.

Yellow rust on wheat (*Puccinia striiformis*):
DPX N 7873, Folicur, Folicur 125 W, Folicur Combi, Tilt Top, Bayfidan + Dairin

Glume blotch (*Septoria nodorum*):
DPX N 7873, Folicur, Folicur 125 W, Folicur Combi, Tilt Top, Bayfidan + Dairin
Leaf spot (*Septoria tritici*):
DPX N 7873, Folicur, Folicur 125 W, Folicur Combi, Tilt Top, Bayfidan + Dairin
Powdery mildew (*Erysiphe graminis*):
DPX N 7873, Folicur, Folicur 125 EW, Bayfidan + Dairin
Powdery mildew in ornamentals (*Oidium begonia*):
Octave, Rubigan
Brown rot in cherries (*Monilinia laxa*):
Baycor Combi, Capidol, Octave, Ronila Fl., Rovral Flo.
Black scurf (*Rhizoctonia solani*):
Monceren 250 FC, Risolex 25 FW
Black currant leaf spot (*Drepanopeziza ribis*):
KVK Captan F.
Leaf blotch af barley (*Rhynchosporium secalis*):
DPX N 7873, Folicur, Folicur 125 W, Folicur Combi, Tilt Top, Bayfidan + Dairin
Dark leaf spot (*Alternaria brassicae*):
Rovral Flo.
Stem rot (*Alternaria brassicae*):
Ronilan Fl., Sportak 45 EC
Snow rot (*Typhula incarnata*):
Basitac 75 WP, Bayfidan, Bayleton 25 WP
Apple scab (*Venturia inqequalis*):
Baycor Combi, Delan SC 75, Sc 109, Systhane 40 WP

Insecticides:

Seed dressings

Flea beetles (*Phyllotreta* spp.):
Oftanol T, Rapcol TC 46 DS, Vitavax RS
Cabbage thrips (*Thrips angusticeps*):
Oftanol T, Rapcol TC 46 DS, Vitavax RS
Pea and bean weevil (*Sitona lineatus*):

Other formulations

Leaf miner (*Phytomyza syngeneciae*):
FCR 4545 025 W
Peach potato aphid (*Myzus persicae*):
EK 1086, FCR 4545 025 W, Sumirody

Frit fly in grain and maize (*Oscinella frit*):
Karate EW, Sumialfa 5 FW
Frit fly in grass (*Oscinella frit*):
Sumialfa 5 FW
Winter moth (*Cheimatobia*):
FCR 4545 025 W, Sumialfa Trebon
Blossom beetle (*Meligethes aennes*):
FCR 4545 025 W, EK 868, Sumialfa 5 FW
Grain aphid (*Sitobion avenae*):
FCR 4545 025 EW, Sumialfa 5 FW
Leaf rollers (*Torticidae*):
FCR 45 45 025 W, Sumialfa Trebon
Glasshouse whitefly (*Trialeurodes vaporariorum*):
BX Koncentrat, EK 1086, FCR 4545 025 W
Rust mites (*Aculus schlechtendali*):
Mitac
Brassica pod midge (*Dasineura brassicae*):
FCR 45 45 025 W, EK 868, Sumialfa 5 FW
Pea and bean weevil (*Sitona lineatus*):
Karate EW, Sumialfa 5 FW
Leaf miner (*Liriomyza bryoniae*):
FCR 4545 025 W
Pea aphid (*Acyrthosiphon pisum*):
FCR 4545 025 EW, Karate EW, Sumialfa 5 FW

I. INSTITUTE OF WEED CONTROL, K.E. Thonke

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Head of institute: K.E. Thonke

Scientific staff:

Jakob Vester, Jesper Rasmussen, C. Holm Nielsen: Weed biology and non-chemical weed control methods
E. Juhl Petersen, Peder Elbæk Jensen: Testing and approval of herbicides and growth regulators
Georg Noyé: Weed control in horticultural crops
Thomas Rubow, Ole Hansen: Weed control in forestry and windbreaks
Johannes Røyrvik: Research on factors affecting the efficiency of soil herbicides
Per Kudsk, Torben Olesen, Peter Kryger Jensen: Research on factors affecting the efficiency of leaf applied herbicides
Ole Permin: Spray technique and drift research
Marianne Baandrup, Egon Juhl Petersen: Advisory service

I. FIELD OF ACTIVITY

It is the responsibility of the institute to carry out research and experiments in the field of weed biology and weed control in its widest sense, including herbicide testing and approval. The institute is also responsible for research, testing and approval of growth regulators in agricultural crops. In 1987, a new department was established which is to work in the field of "non-chemical weed control". The department was established partly to comply with the demands in the government Action Plan on pesticides stipulating a 50 per cent reduction in the use of pesticides before 1997 and partly to meet a need for advice on non-chemical weed control methods enabling more farmers to start organic farming.

II. AGRICULTURE

1. Development work in agricultural crops, field experiments including spraying techniques

Control of Common Couch and Wild Oats (Ole Permin)

Common couch. Experiments have been made on the importance of the seed reproduction for the re-establishment of couch in areas where couch has been eradicated. The investigation comprises: 1. Viability of couch seeds laid in different soil depths. 2. The germination ability of the seed at harvest in various crops over the growing season. 3. The development of the seed sprout in various crops from sowing till harvest.

Results from experiments carried out in 1987 investigating growth and development of seed plants of common couch from sowing till harvest in various crops are shown in Table 1. The number of seed plants germinated in June and at harvest can illustrate the competition between the crops and plants of germinated seeds of common couch. In peas and spring barley the number of seed plants decreased considerably as opposed to in maize or on locations where couch grew without competition.

Seed plants of common couch growing without competition have been examined in order to determine development of rhizomes in late September and around 1st November when maize, field beans and beet were harvested.

The result shows that during the growing season of some crops, rhizomes of common couch seed plants are developed. If the seed plants are not controlled in the stubble after harvest far more plants will be able to form rhizomes. Much more attention should therefore be paid to seed plants of common couch than has previously been assumed, especially when a winter crop is started.

Table 1 Development of rhizomes from seed plants of common couch in different crops, 1987.

	Harvest date	Seed plants per 1.5 m² 15/6	at harvest	No. leaf per plant	No. rhizo-mes per plant	Rhizome length per plant	No. buds per rhizome
Pea	11/9	53	10	4.6	1.0	5.7	4.2
Spring barley	16/9	30	13	1.3	0.07	2	1
Spring oilseed rape	11/9	49	40	1.6	0	0	0
Couch	29/9	23	19	9.0	4.6	11.8	4.9
Flax	13/10	24	30	1.4	0.23	8.5	3.7
Field beans	4/11	16	10	3.9	0.7	3.0	(0.6)
Beet	3/11	-	5	2	1.0	13.8	3.8
Maize	4/11	16	39	7.7	1.79	14.8	3.6
Couch	30/10	16	66	5.7	2.6	9.7	3.0

Experiments have been made investigating the lasting action of chemical products against couch in beet and spring oilseed rape. The couch is planted the year before in small plots. The long term effect is assessed in spring barley the year after the treatment.

Wipers mounted under the combiner to coat Roundup on common couch can be an environmentally compatible and probably also economical method. 3 types of wipers, Weedwiper, Quick-Killer and Weedkiller and spraying bar were tested, and spraying with Roundup before harvest was used as measuring basis.

In an experiment treated at harvest in 1986 the effect was not satisfactory when regrowth was measured in 1987. The experiments continue.

Wild Oat-Grass. Investigations started in 1980 on how quickly cultivated ground can be emptied of viable wild oat-grass seeds continue. The seeds are dug up from different depths and placed to sprout on the soil surface in plots given traditional or reduced treatment.

In 1987, only few sprouts were found of wild oat seed which had been lying in the ground from after harvest in 1980.

Other crops. According to German investigations, CO_2 added to the spraying liquids improve the effect of plant protection compounds. The influence on the effect of herbicides on weeds and yields has been investigated in winter wheat and spring barley.

Oxitril was used in winter wheat and in spring barley MCPA + dichlorprop, in 2 doses, i.e. with and without CO_2. The CO_2 added did not improve the effect against the weeds or increased the yield.

An investigation in spring barley on the influence of the weed size on the control effect of a reduced herbicide dose was conducted. The tolerance of triticale and winter wheat to a number of soil herbicides and leaf herbicides applied in 3 doses was tested by spraying 2 m^2 plots in autumn as well as spring.

In projects with alternative cultures the effect of a number of soil herbicides in combination with watering immediately after the spraying has been tried in 2 doses. Similarly, the tolerance of the crops to a number of leaf herbicides in varying doses has been investigated. Oil seed flax, field beans, buckwheat, borage and fenugreek are used as test crops.

The tolerance of peas has been tested in experiments with combinations of soil and leaf compounds. In small informative plots, the effect on peas of soil compounds combined with leaf compounds and with penetration oil added or mixed with insecticides has been tested.

Herbicides for for defoliation have been tested in peas, field beans, oilseed flax and spring oilseed rape.

Spraying technique

In small informative plots the straw-shortening effect of Cerone applied with and without wetter has been investigated by sprayings varying quantities of liquid on plants with and wihout dew early in the morning and later in the day on dry plants.

It appears from the results that spraying early in the morning gives a greater reduction of the straw length than spraying later in the day. No difference was found, however, in the straw-shortening effect between sprayings performed on plants with or without dew early in the morning.

In ethephon sprayings using quantities of 320, 200 and 120 l/ha an improved effect was obtained each time the quantity was reduced. At the same time, the drop size was reduced. This result was obtained independently of the time of spraying, of whether or not there was dew on the plants and of whether wetter was added to the ethephon.

Distribution material mixed into the spray liquid increased the effect of ethephon (Cerone). Sprayings early in the morning when there was dew on the plants tended to decrease the effect of ethephon if wetter was not added.

In an interdisciplinary project between the National Office of Crop Husbandry, the Pesticide Research Institute and the Danish Agricultural Engineering Institute a number of experiments with herbicides and fungicides have been made. 4 nozzle sizes have been tested in Plan I at 3 pressure levels, giving a variation in the liquid quantity from 55 to 497 l/ha. In plan II, 4 types of nozzle were tested a 3 different pressures.

Liquid quantity, Pressure and Size of Nozzle

By reducing the quantity of liquid e.g. from 200 ti 100 l/ha the concentration in the spraying liquid is doubled. If a smaller nozzle is used to reduce the liquid quantity, smaller drops and an improved deposition of liquid on the plants are achieved. Previous experiments with hormone compounds against weeds in cereals have shown that an equally good effect can be achieved with liquid quantities of 100-125 l of liquid per ha as with a larger liquid quantity. A liquid pressure of 1.5 bar gave the same fine effect as higher pressures. Only with the smallest size of nozzle 4110-10 a reduced effect on the weeds was observed.

Fig. 1 shows the result of an experiment from 1987 in spring barley with Faneron 50 WP, which is a contact herbicide. The liquid quantity varied from 55 to 497 l/ha at a forward speed of 7 km/hour. The experiment showed that the lowest pressure of 1.5 bar and the smallest nozzle 4110-10 does not give as good an effect as 3 or 6 bar. The other nozzles, however, produced full effect both at 1.5, 3.0 and 6.0 bar and with a liquid quantity of down to approx. 100 l/ha.

Figure 1.

Fanerone in spring barley

Experiment 215 Forward speed 7 km/hour

Yding 1987

Spray liquid l/ha

bar 1,5	3,0	6,0
55	79	113
103	154	219
137	188	274
257	360	497

Nozzle 4110-

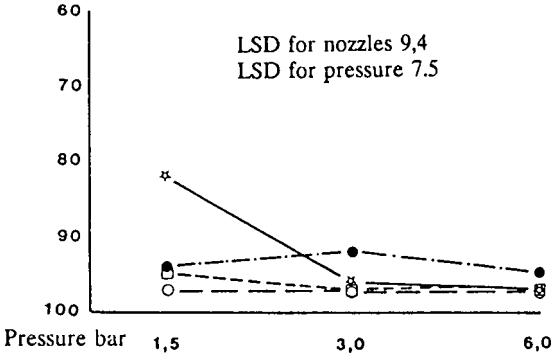
-10

-14

-16

-24

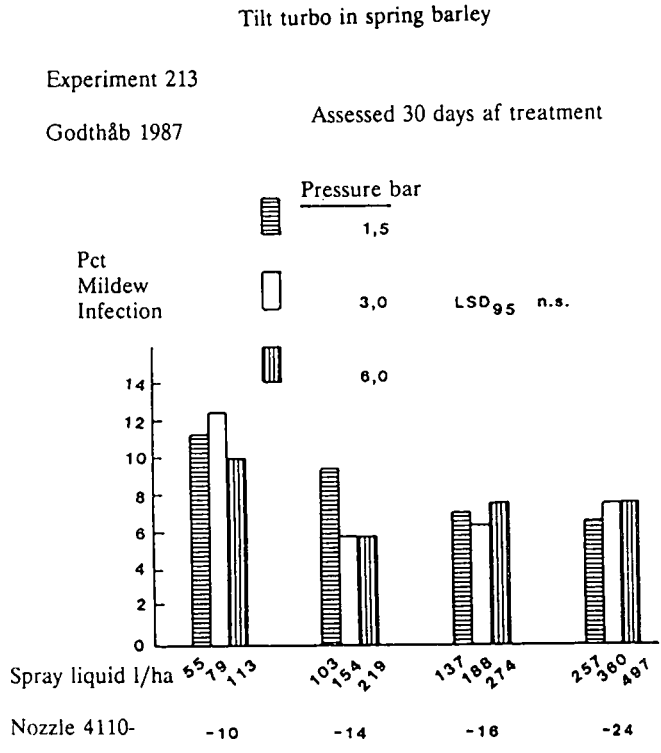
Weeds % effect



Spraying herbicides which are gentle to cereals with an ordinary sprayer against dicotyledonous weeds it seems possible to reduce the liquid quantity to 100-150 l/ha. A reduction of the liquid quantity alone does not allow a reduction of the dose, but a considerable improvement of the economy of the application is achieved.

Spraying treatment with a systemic fungicide Tilt turbo 0.5 l/ha in spring barley tends to reduce the effect on mildew at liquid quantity of about 100 l/ha and less using nozzle 4110-10 or 4110-14 at 1.5 bar, Fig. 2, but differences are not significant. The size of nozzle and consequently the size of drops and the liquid quantity can be modified much without this influencing the long term effect on the mildew. From beginning cell elongation of the cereal, i.e. from growth stage 5-6 (Feekes) not less than approx. 200 l of liquid per ha should be used.

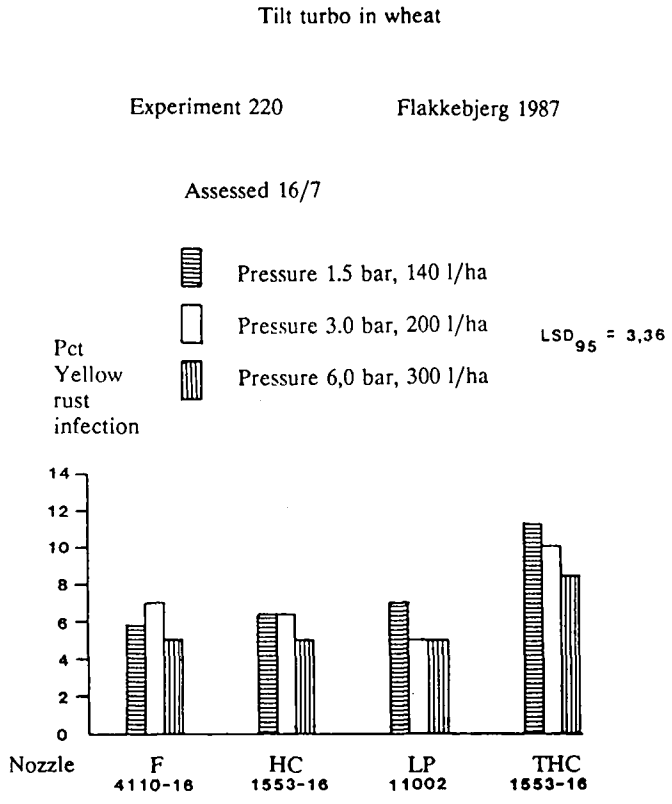
Figure 2.



Different types of nozzle

To be able to measure differences in the biological effect when different types of hydraulic nozzles were used, the effect of the flat spray nozzles (F), the whirl chamber nozzles, (HC), low pressure nozzles (LP) and large drop nozzles (THC) has been tested at 3 pressures: 1.5-3.0 and 6.0 bar. The result appears from Fig. 3, which shows the effect of Tilt turbo on yellow rust in winter wheat.

Figure 3.



Differences in the drop size are small between flat spray nozzles, whirl chamber nozzles and LP nozzles, whereas the large drop nozzle distributes substantially larger drops, and not at all small drops. This may be the reason for a significantly reduced effect against yellow rust of the large drop nozzles at all three pressures. The large drop nozzle effectively reduces the drift to a minimum and is very suitable for the first rounds in a field. Considering a degree of attack of 44 per cent in untreated, the reduction of the effect of the large drop nozzles is only small.

In plan III several new nozzles are tested: air mixing, inclination of hydraulic nozzles and the effect of spraying at the ear by means of a bar which opens the crop. The adjustments are combined with reduced doses.

New spraying systems

Investigations of the deposit of spray liquid on the plant population show that only small quantities of the liquid is deposited on the lower part of the plants.

To increase the deposition of the spray liquid on the lower and central parts of the plants where mildew always starts, experiments are made in which the nozzles are turned compared to vertical position and the crop opener.

Table 2. Effect of Tilt turbo on fungal infections in spring barley. Mean of 3 doses. Experiment 216, Flakkebjerg 1987.

Spraying system	Mil-dew* 16/7	Scald** 16/7	Dead 28/7	Yield hkg/ha
F. 4110-14.3 bar, 150 l/ha	5.5	0.6	24	63.3
F. 4110-14.3 bar, 150 l/ha at 60° angle	7.4	0.5	25	62.7
F. 4110-14.3 bar, 150 l/ha with crop opener ½ crop height	5.1	0.5	22	63.4
Pneum. nozzle, 56 l/ha with crop opener ½ crop height	11.3	1.2	32	59.1
Ld. 4110-10 1.5 bar, 55 l/ha with crop opener ½ crop height	7.0	0.5	31	60.5
LSD untreated	3.0	0.3	7	1.6

* 32.7 per cent attack by mildew in untreated
** 7.2 per cent attack of scald in untreated

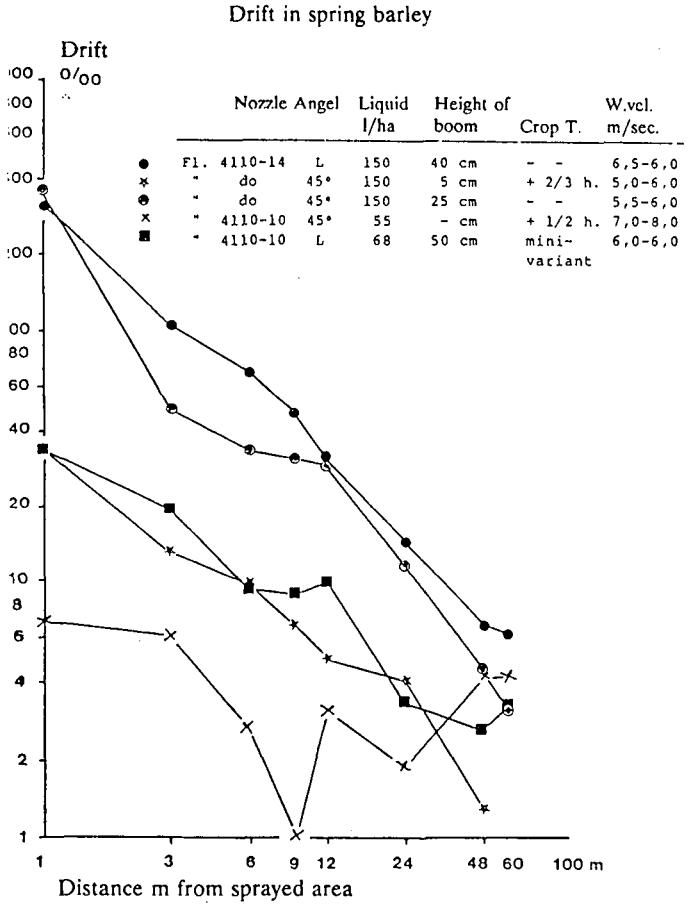
The crop opener is a pipe which kept at 1/3 or ½ the crop height and which opens the crop when moved forward. The nozzles, which are also lowered down into the crop, are mounted right behind the crop opener. The liquid is sprayed directly on the lower parts of the plants.

In Table 2 are shown the results from 1 experiment in 1987 investigating the effect against fungal diseases in spring barley. It has not been possible with any of the various systems to improve the effect against fungal infections on barley compared to usually standard with nozzle 4110-14, 3 bar and 150 l per ha., but a small liquid quantity of 50 l/ha distributed with a pneumatic nozzle or 4110-10 and using a crop opener gave a poor effect against the infection. The attack was severe, 32.7 per cent mildew in untreated. This demonstrates that treatment was carried out too late. Early treatment increased in 1986 effect with the

small quantity of liquid and using the same systems.

The extent of the drift is reduced very considerably with a crop opener, which will appear from Fig. 4.

Figure 4.



The spraying has been carried out across the wind direction at a 12 m spraying width. The angle of the nozzles was either vertical (V) or turned 45° backwards. The crop opener used is the "Crop Tilter" already on the market, positioned either in 2/3 or ½ of the plant height. A new special spraying equipment from Hardi the Minivariant has been tested. Crop Tilter working in 2/3 of the plant height where the nozzles are turned 45° backwards, has reduced the drift to approx. 1/10 compared to usual standard with nozzle 14, 40 cm

bar height and 150 l of liquid per ha. The greatest reduction of the drift was achieved with the Crop Tilter positioned in half crop height, but resistance against the boom was so heavy that in some cases the safety device against collisions was released.

It may be necessary to reduce the extent of the drift to protect neighbouring crops, i.e. ornamental plants or edible crops close to the sprayed area, against damaging compounds. The eyes of the public are turned towards the farmer and the way he sprays, and often the farmer must carry out a treatment if it is to be carried out in time. With Crop Tilter the number of spray days can be increased. An increased deposition on stems and leaves, except for the uppermost part of the plant, has been registered, but this has not given a better effect in all cases. Early sprayings at weak attacks gave the best effect. The reduction of the drift by means of Crop Tilter also gives a more even distribution and consequently a more reliable effect.

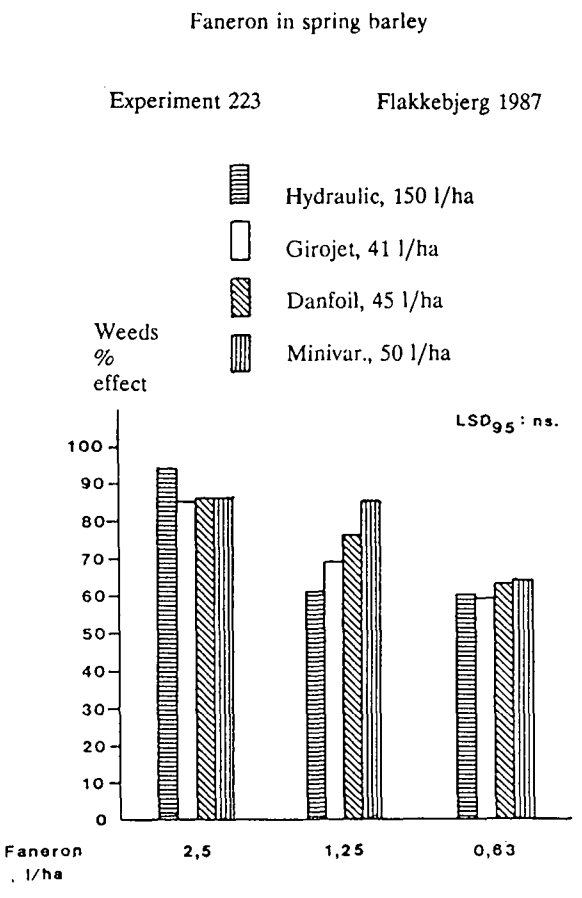
Special sprayers

Plan IV comprises other types of sprayers: Danfoil which operates according to the same principles as an air mist blower. Girojet is supplied with a rotation distributors. Variant is an air-assisted hydraulic sprayer. The liquid quantity used in these types of sprayers lies between 30 and 50 l of per ha. The effect is compared with a effect of the hydraulic field sprayer using 150 l per ha.

The results from an experiment testing Faneron against weeds in spring barley, Fig. 5, show that by using small quantities of liquid in the special sprayers the same effect is achieved as with a hydraulic field sprayer at full, half and quarter dose of Faneron.

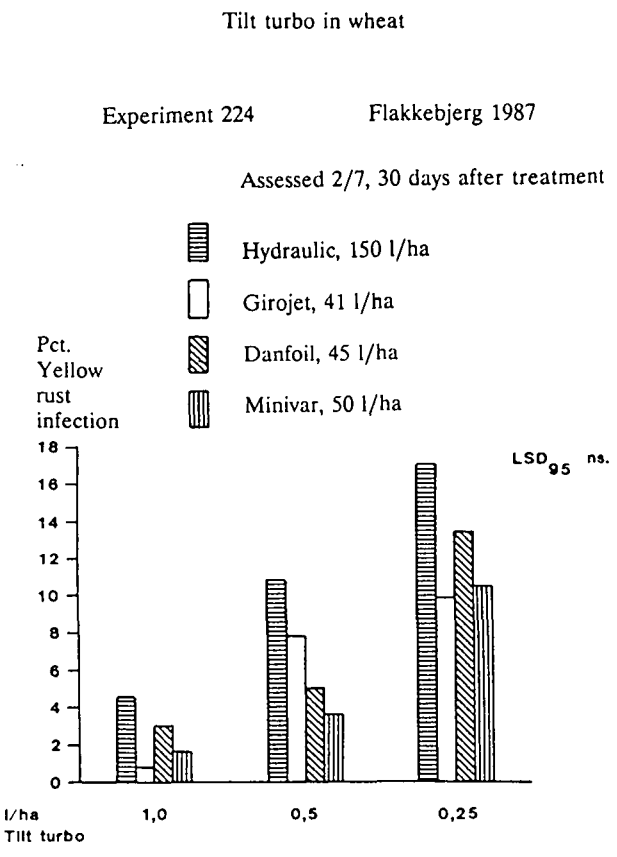
An experiment testing the effect against fungal diseases in winter wheat, Fig. 6, show that the effect tended to improve with the special sprayers at both full, half and quarter dose of Tilt turbo compared with an ordinary field sprayer and 150 l of water per ha. The forward speed was 7 km/t in the experiments testing the special sprayers.

Figure 5.



When air flows with the liquid into the plant population, as in the Danfoil and Minivariant systems, a deeper penetration and a better deposition of drops on the plants should be possible. By means of a tracer "Helios" the deposition on leaves and stems has been investigated in sprayings of spring barley at stage 10, i.e. immediately before the earing up. With both Danfoil and Minivariant a better deposition was seen on the uppermost leaves and parts of the stem compared with the ordinary field sprayer. Barley plants have soft stems and are pressed together by the airstream. This may explain why the deposition on the lower plant parts did not increase.

Figure 6.



The result is to be considered as an example only. Rigid crops may give another result. Minivariant offers many possibilities of adjusting the direction of the nozzles and the air velocity. Danfoil and Minivariant operate according to very different principles. Tests conducted in 1986 showed that drifting was greater with Danfoil than that with an ordinary field sprayer. A test conducted in 1987 shows a very significantly reduced drifting with Minivariant, Fig. 4. The testing is being continued.

2. Testing compounds

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

In 1986-87, 61 herbicides, 2 desiccants and 2 growth regulators were registered for testing. When the results were made up 26 herbicides, 1 desiccant and 2 growth regulators were approved. Most of the herbicides, 14, were for use in cereal, the rest for use in seed grass, beet, oilseed rape, peas, maize and potatoes.

8 of the 14 products were approved and marketed, and they could be included in the list of approved plant protection compounds for 1988. Among the new products are Basagan MP, which is a mixture of bentazon and mechlorprop for use in winter crops in the spring and Laddok, which is a mixture of atrazin and bentazon. This compound may, with timely use, solve problems caused by groundsel in perennial maize growing. Betaflow is a new formulation of phenmedipham. It is flowable i.e. its active ingredient is a water suspension with certain axillary materials added to stabilize the product. This means that organic solvents have been avoided. The remaining approved products are various combinations of known active ingredients.

In the course of 1987, 11 approved products were withdrawn from the market. A certain renewal of the range of products on the market will usually take place , often due to commercial considerations, but with the withdrawal of Lasso (alachlor) am active ingredient has disappeared from the Danish market. Lasso was used for control of corn marigold and chamomile in oilseed rape.

The approval work has been characterised by the fact that old compounds such as Dinoseb, DNOC and TCA are disappearing from the market.

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

According to an agreement with the National Agency of Environmental Protection 12 herbicides and 2 growth regulators were tested for efficacy. By the end of the year 10 herbicides and 2 growth regulators are awaiting an evaluation.

Reevaluation (E. Juhl Petersen, G. Noyé and T. Rubow)

In connection with the reevaluation of previously registered products ordered by the National Agency of Environmental Protection, information was given on the use of difenzoquat, bromophenoxim, ioxynil, bromocynil and metribuzin.

III. HORTICULTURE

George Noyé

The experimental activities in 1987 very much reflected the inquiries received in 1985 and 1986 on control of troublesome weed species in different crops, e.g. control of and groundsel (*Senecio vulgaris*) in nursery crops.

Efforts to find suitable herbicides to replace diquat/paraquat pre crop emergence have taken up a considerable part of the experimental work in 1987.

The advisory work in 1987 was characterized by the very good effect of soil herbicides. In general, the effect obtained with leaf applied herbicides was also good. Due to much rain in 1987 the weeds have shown great ability to reestablish at regrowth and when newly established which has caused a very great need for a late control.

Testing of herbicides

In the 1987 growing season 34 herbicides and 2 dissicants were submitted for testing.

The distribution between crops was 5 in onions, 3 in carrots, 4 in cabbage, 2 in spinach, 4 in green peas, 3 in sweet corn, 1 i strawberries, 5 in lawns, 16 in plant nursery crops, 1 in orchards and 9 in fruit bushes.

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

1. Asalox SG (usulam-sodium salt 800 g/kg) has been given approval for the ocntrol of oilseed rape, chamomile and polygonum species in spinach.

2. KVK Herbatox-BV plænemiddel (2,4-D, 100 g/l + mechlorprop 250 g/l + dicamba 10 g/l) has as the first herbicide combination been given approval for the control of weeds in lawns.

3. Matrigon (clopyralid 100 g/l) has had its approval extended to include also cabbage.

4. Teridox (dimethachlor 500 g/l) has had extended to include also weed control of groundsel in cabbage.

5. Basta (glufosinat 200 g/l) has been given approval for weed control applied pre- crop emergence in potatos, onions, leeks, carrots and spinach. Basta has also been given approval in fruit orchards and non crop areas. The approval include burning down potato top and raspberry suckers.

6. Roundup (glyphosat 360 g/l) has had its approval extended to including also weed control pre crop emergence in onions and carrots.

7. Totril (ioxynil 250 g/l) has had extended its approval to include pre crop emergence weed control in onions, leeks and carrots.

8. Gardoprim 500 FW (terbutylazin 500 g/l) has had extended its approvl to includie also some varieties of nursery crops as well as the same varieties in shubberies.

IV. CONTROLLED ENVIRONMENT EXPERIMENTS

Per Nielsen Kudsk, Torben Olesen and Peter Kryger Jensen

Effects of CO_2-Enriched water on the Performance of Herbicides and Growth Regulators

The influence of carbondioxid-enriched water on the effect of 9 herbicides and 2 growth regulators was examined in a number of pot trials. To enrich the spray solution the CARBORAIN system was used. The results from a trial including 9 herbicides showed that the effect of chlorsulfuron, phenmedipham and a mixture of oxitril and bromoxynil was significantly reduced when applied in carbondioxid-enriched water whereas the activity of the other herbicides was not affected. In a following experiment it was found that carbondioxid-enriched water significantly reduced the effect of phenmedipham, whereas a positive effect was found on the performance of chlorsulfuron. The effect of oxitril + bromoxynil was not influenced. Carbondioxid-enriched water did not influence the effect of the growth regulators, ethephon and ethephon plus mepiquat. With CARBORAIN it was possible to add 1.5 to 2.0 g carbondioxid l/water, but 80 to 90% was lost during spraying. It was concluded that the efficacy of the herbicides and growth regulators examined was not improved by addition of carbondioxid to the spray solution.

The influence of dew on the activity of various herbicides

The influence of natural and simulated dew on the activity of difenzoquat, glyphosate and MCPA + dichlorprop was examined in six pot trials. The results showed that the activity of difenzoquat and glyphosate on wild oat and barley, respectively was not influenced by the presence of dew on the leaves irrespectively of the amount of dew and the application volume rate. However, on white mustard (*Sinapis alba* L.) a reduced activity was found when glyphosate and MCPA + dichlorprop was applied at a high volume rate (278 to 307 l/ha) on plants with a heavy dew deposit on the leaves. The observed influence of dew on herbicidal activity corresponded, with the exception of the difenzoquat experiment, with the differences found in the amount of herbicide retained on the dry and wet plants. In general, the results of the experiments substantiated the experience from practice that it is possible to apply herbicides on plants with a light dew deposit without loss of efficacy

if reduced volume rates are used.

The influence of simulated rain on the performance of DPX-L5300

Pot trials were conducted in greenhouse to determine the influence of simulated rainfall on the performance of DPX-L5300 [Methyl 2 {3-(4-methoxy-6-methyl-3,3,5-triazin-2-yl)-3-methylureidosulphonyl} benzoate] applied in mixtures with 0.1% of a non-ionic surfactant on white mustard (*Sinapis alba* L.). The results showed that rain intensity had no significant influence, when 1 mm rain was applied at 1, 3 and 9 mm h^{-1}, respectively. The rain-free period required to full effect greatly depended on the amount of rain. A simulated rainfall of 0.1 mm applied ½ hour after spraying had no influence on the effect, whereas a rain-free period of 3 hours was required to obtain maximum effect when 0.3 mm rain was applied and 6 hours were needed when 1 or 3 mm rain was applied.

The influence of the stage of development of sugar beet and beetroots on the tolerance against relevant herbicides

The influence of the stage of development of sugar beet and beetroot on the tolerance against a range of herbicides and herbicide combinations were investigated in 2 pot trials. For sugar beet as well as for beetroot the tolerance against all investigated herbicides and herbicide combinations were, en general, at a minimum at the cotyledon stage. On sugar beet the tolerance was best on plants at the 2 leaf stage. On beetroots, plants at the 2 and 4 leaf stage were equally tolerant. Of the examined herbicides and herbicide combinations, Goltix + Sunoil and Betanal + Goltix caused least damage, while addition of Sunoil to Betanal + Goltix increased the damage in sugar beet as well as in beetroots. In mixtures where Nortron or Pyramin were included, the susceptibility of the sugar beet was higher compared to the Betanal + Goltix mixture.

The influence of temperature and humidity on the activity and rainfastness of DPX-L5300 applied alone and with a surfactant

The effect of temperature, humidity and simulated rain on the activity of DPX-L5300 applied alone and with 0.1% Citowett, a non-ionic surfactant, was assessed using a parallel-line assay technique. Whether the surfactant was added or not the activity on white mustard (*Sinapis alba* L) was significantly lower at 7.2°C-85% RH whereas no difference in efficacy was found at 22.2°C-35% RH and 22.2°C-85% RH indicating that temperature influenced activity more than humidity. Rain applied ½ h and 4 h after spraying generally reduced the activity of DPX-L5300 applied alone, however, the reduction was significantly less at 22.2°C-35% RH than at the two other regimes.While addition of a surfactant to the spray solution improved the rainfastness at 22.2°C-85% RH a reduciton was observed at 22.2°C-35% RH. At 7.2°C-60% RH no difference was found.

V. FORESTRY, WINDBREAKS

Thomas Rubow and Ole Hansen

Much of the research and trial work has been concentrated on finding supplementary compounds and substitutes for two of the most important herbicides in forestry, atrazine and hexazinon, which are increasingly presenting drawbacks concerning effect and environment (resistance development, risk of leaching).

A rapidly growing interest in the production of diciduous trees has intensified the need for compounds and methods of selective control against dicotyledonous weeds in diciduous crops. Investigations and experiments have been iniciated based on experience gained from work with windbreaks.

On many locations of natural and recreative importance a certain delimitation or extensive use is necessary to avoid that the area develops into useless and undesireable shrubs. Moors, commons, meadow and marsh are such areas. As a continued agricultural production in these areas is unlikely, other preservation measures, i.e. control of deciduous trees, may become necessary. Informative experiments testing mechanical-chemical control (stump treatment) of asp on protected moorland have been started. In addition, this preservation programme may be based on experience gained over many years with control of other deciduous tree species occurring as weeds in forest crops.

VI. WEED BIOLOGY

Non-chemical weed control

Jakob Vester and Jesper Rasmussen

In 1987, flame cultivation for control of weeds in recreative areas was tested on church yards and by local authorities. Different tools and strategies have been compared. At the Institute of Weed Research 10 species of bushes and trees were planted in spring and mechanical weeding was compared with unweeded, mulching with 2 chip materials and phacelia as covercrop. 18 different cover materials were compared in small outdoor plots and in the laboratory in order to make a standardised description of the materials.

Flame cultivation for desiccation of potato haulm with the use of modified machinery and an increased forward speed was tested in conventional as well as in organic farm productions. Reglone treatment and mechanical haulm stripping were compared.

In cereals, the effect of hoeing and weed harrowing were investigated. The experiments were carried out partly as tolerance tests, the weeds being removed from some plots by means of herbicides. The hoeing was carried out in the cereal at row distances of 12.5,

25 and 50 cm.

In maize hoeing and flame cultivation were tested and compared with herbicide cultivation. A row brush was compared with an ordinary hoe in different crops. 15 different weed harrows and hoes have been tested on oilseed rape plants sown repeatedly over the growing season. The machinery was compared at different forward speeds.

Weed biology - extension and dispersion

C. Holm-Nielsen assisted by S. Thorup

A seed reference assortment of about 380 species has been collected. It represents the most common as well as more rare species existing in the weed seed bank of the arable land.

The seeds are kept in small microscope transparent cellophane bags and put into photo pockets. The entire assortment has been photographed and exists as slides. An indication of the size in mm is made on the photo.

For an investigation of samples taken from the soil's seed bank a seed searching technique has been found. The above-mentioned seed reference assortment is necessary for the identification.

A proper technique for taking samples is still missing, in particular when they are to related to the ground area.

The weed counts carried out in the spring and just before harvest at farms where crops have been grown (in non-ploughed but cultivated soil/direct drilling) for more than 30 years were continued in the same form as in preceding years.

Six years' investigation of the development of the weed flora in 2 experiments made solely on barley land and in relation to soil preparation with and without herbicide treatment was completed in the autumn 1987. The results are not ready yet.

The original plans for the investigation were extended in both experiments and included examination of the seed bank of the soil, taking soil samples in the autumn 1986.

Furthermore, the seed production of the weed plants in the experiment on Zealand was measured immediately before harvest of barley in 1985, 1986 and 1987.

VII. THE PERSISTENCE OF HERBICIDES IN SOIL

J. Røyrvik

Degradation of chlorsulfuron (Glean and triasulfuron (Logran, CGA 131'036) under controlled conditions.

Degradation experiments have been conducted with the soil herbicides chlorsulfuron (Glean) and triasulfuron (Logran) under controlled conditions and with different doses, times of spraying, water contents in the soil and temperatures. The water contents were half dry soil, 5% and humid soil, 20% (field capacity) and the temperatures 10°C and 20°C. The test plant used was winter oilseed rape (cv. Korina). The results from the biological test gave the following half-life periods for chlorsulfuron, 7.8 and 7.5 months at 10°C, respectively 5 and 20% wanter, and 2.2 and 2.0 months at 20°C.

The corresponding half-life periods for triasulfuron was 7.3 and 4.0 months at 10°C and 1.2 and 0.9 months at 20°C. The humid soil gave, as could be expected, the fastest degradation, but there was no great difference between humid soil and half dry soil. Temperature seems to be by far more important in the degradation of the two herbicides. The low temperature of 10°C gave a very slow degradation whereas at 20°C the half-life period was relatively short.

VII. INFORMATION DATA BASE ON PLANT PROTECTION ADVISORY, WEEDS

Marianne Baandrup

At the Institute of Weed Control a project initiated by the Joint Committee for Agricultural Research and Experiments was initiated in 1986 with the purpose of developing an information data base for weeds and weed control.

The development takes place in cooperation with the Agral Meteorological Service and the National Department of Plant Production.

This weed information data base consists of a library, giving general information on crops, weed species, herbicides, spray application and mixtures; and an advisory part, giving recommendations on herbicides and doses against weed problems in the field.

Weed species and size

The weed information data base selects the herbicide on the basis of the composition of the weed flora and calculates a reduced dose, which will provide a good and satisfactory effect, taking into consideration the sensitivity of the different weed species and their

growth stages (number of leaves).

Testing 1987

Over the growing season 1987 the advisory part of the information data base was tested in field trials. A number of extension officers conducted experiments in spring barley according to the recommendations made by the data base.

From the information on weed species, their number and growth stage, the programme selected herbicides and adjusted doses according to these factors.

By way of comparison a DPM-compound (MCPA + dichlorprop) was applied.

10 experiments were conducted and the results are shown in Table 1.

The best effect against weeds was obtained with the compound selected by the information data base in normal dose (plot c), followed by the selected compound in the adjusted dose (plot d). The average reduction of the dose was 23%.

In plot e the compound selected by the data base was applied in a dose which depended on the total number of weeds, cf foot note of the table. The average reduction of the dose was more than 60%

Compared to this the DPM-compound in normal dose (plot b) resulted in a weed control of 74% whereas the early morning spraying was too insufficient. Where chickweed was widespread the effect of the DPM-compound was particularly poor (fig. 1).

The data base selects the herbicide on the bases of the prevailing conditions, whereas these conditions were not taken into consideration when the DPM-compound was chosen as a standard compound.

The results from this year are promising and the experimental work with the advisory part will be continued in collaboration with the Department of Plant Production so as to make the weed information data base give as good and useful recommendations and advice as possible.

Table 1. Data base selected herbicide in spring barley

	Relative dose	Weed number per m^2	% effect	% coverage at harvest	Hkg kernel per ha
10 experiments 1987					
a. Untreated	-	135	0	36	47.3
b. DPM-compount (N)	100	36	74	5	3.3
c. Data base selected compound (N)	100	8	95	2	3.9
d. Data base selected compound, reduc. dose	77	14	90	2	3.3
e. Data base selected, dose depend. on weed No. *	38	25	82	5	2.8
f. DPM-coumpound (½N) morning application	50	63	54	7	3.0
					LSD 1.8

* > 300 weed plants/m^2 = ¾ N dose
100-300 weed plants/m^2 = ½ N dose
< 100 weed plants/m^2 = ¼ N dose

J. LABORATORY OF PESTICIDE ANALYSIS

Forsøgsvej 1, Flakkebjerg, DK-4200 Slagelse

Scientific staff:

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

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

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

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

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

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

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

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

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

FIELD AND LABORATORY INVESTIGATIONS

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

In 1987, a determination to species has been made of a large number of isolates of *Penicillium* and an identification of residue concentrations of fungicides in soil (E. Kirknel). In 1987, a small field experiment with Tilt and subsequent investigations of the biomass, microbial activity, decomposition of organic "model" substance (gelatine) and straw was conducted. A degradation of straw will be carried out in a "litter-bag" experiment. Therefore, it has been necessary to conduct preliminary experiments to adjust the qualitative methods to the "litter-bag" method. Furthermore, the influence of various fungicides on the decomposition of ^{14}C-labelled straw was measured.

Determination of pesticides in groundwater and drain water (Gitte Felding)

In collaboration with the The Danish Geological Survey and local extension officers we have selected homogeneous coarse sandy soils with a high level of groundwater. Samples were taken near Ølgod and Løgumkloster. Goundwater samples were taken below 2 maize fields, one of which has been sprayed with atrazine for three successive years, the other for about 10 years. The content of atrazine, desethylatrazine and desisopropylatrazine was analyzed in the groundwater. Soil samples, about 10, were taken from the soil surface down to the groundwater level and analyzed for possible content of atrazine to study whether a "front" is passing down through the soil to the groundwater.

Pesticide leaching (Gitte Felding and Arne Helweg)

In collaboration with The Danish Geological Survey and local extension officers we have selected some heavy clay soils grown with beet and winter barley and some clayish forest soils with conifers. In order to measure pesticide leaching from the root zone perforated tubes - 3 per locality - were placed to collect the water leaving the root zone. The tubes were emptied during winter, and hexazinon, atrazine, phenoxyherbicides and carbofuron occurrence was determined by the GC/MS method.

Degradation and effect of pesticdes in soil (Arne Helweg)

A series of experiments measuring the degradation and adsorption of MCPA, dichlorprop, 2.4-dichlorophenol, TCA and parathion in soil samples taken below the root zone have been finished. The results showed a degradation rate of about 1/10 of the rate in surface soil. Determination of the composition of the soil air to the depth of 2 m has also been finished. Also the influence of soil temperature and water content on the degradation of MCPA was analyzed in soil from the plough layer.

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

In collaboration with the National Institute of Animal Science the effect of growth regulators (Cerone) on residues in animal products and on reproduction was determined. Methods of analysis were prepared.

In collaboration with the Government Bee Research Service investigations were made to study whether insecticides are brought into the hives. Bees, honey, larvae, wax and pollen was analyzed for pesticide residues.

Metam-Na in soil was analyzed.

Spray technical experiments with fluorescent tracer compounds were performed in climate chambers and in the field.

Winter crops were analyzed from autumn to spring for residues of prochloraz to support an evaluation of the importance of timing of application.

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

Analyses were made of growth regulators in nutrient solutions from irrigation systems. The purpose was to reveal whether the growth regulators remain in the nutrient solutions making it possible to give advice about their re-use, even in other cultures. Up to now ancymidol (Reducymol) has been analyzed.

In spray technical experiments performed in the field (deposition on plants and wind drift) a considerable number of measurements have been carried out with fluorescent tracer. In this connection a comparison was performed of objects used to collect spray liquid to control the applied quantity per area unit.

To be able to make routine analyses of residual herbicide on the plant surface in a large number of experimental plots (pot experiments) it is necessary to have fast methods of analysis. One of the herbicides currently being investigated is the wild oat difenzoquat (Avenge). An operative method has been found for this compound.

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