Pesticides Research

No. 31 1997

Pesticide Re-entry
Exposure of Workers
in Greenhouses

Erik Kirknel, A. Nøhr Rasmussen and Gitte Emde
Danish Institute of Agricultural Sciences
Flakkebjerg
DK-4200 Slagelse

Published and economic supported by:

Ministry of Environment and Energy, Denmark
Danish Environmental Protection Agency
Strandgade 29
DK-1401 København K

ISBN 87-7810-822-5
Content

Preface 4
Acknowledgement 5

Abstract 6

Sammendrag 7

1 Introduction 8

1.1 Background 8
1.2 The present project 10

2 Materials and Methods 13

2.1 Green houses, pesticides and plants 13
   2.1.1 Spray equipment 13

2.2 Assessment of exposure 13
   2.2.1 Assessment of dislodgeable foliar residue 14
   2.2.2 Assessment of exposure on inactive media as glass walls, plastic curtains, heating tubes and aluminium tables 14

2.3 Chemical analysis of pesticides 15
   2.3.1 Extraction and clean-up 15
      2.3.1.1 Dermal exposure 15
      2.3.1.2 Respiratory exposure 15
      2.3.1.3 DFR (Dislodgeable foliar residue) 15
      2.3.1.4 Inactive media 15
   2.3.2 Detection 15
      2.3.2.1 GC-conditions 15
         2.3.2.1.1 Injector 16
         2.3.2.1.2 Detectors 16
         ECD 16
         NPD 16
      2.3.2.2 HPLC-conditions 16
         Solvents and wavelengths 16
   2.3.3 Quantification’s 17
   2.3.4 Recovery 17

3 Results 19

3.1 Experiment 1 19
   Figures and tables 22
3.2 Experiment 2 24
   Figures and tables 29
3.3 Experiment 3 35
   Figures and tables 39
3.4 Experiment 4 42
   Figures and tables 44
3.5 Experiment 5 46
   Figures and tables 49

3.6 Experiment 6 51
   Figures and tables 55

3.7 Experiment 7 59
   Figures and tables 64

3.8 Experiment 8 69
   Figures and tables 73

3.9 Experiment 9 77
   Figures and tables 83

3.10 Experiment 10 95
   Figures and tables 97

3.11 Experiment 11 98
   Figures and tables 103

3.12 Experiment 12 110
   Figures and tables 114

3.13 Experiment 13 119
   Figures and tables 122

3.14 Experiment 14 125
   Figures and tables 129

3.15 Experiment 15 134
   Figures and tables 138

3.16 Experiment 16 146
   Figures and tables 148

Conclusive figures and tables, 17 (x) 152

4 Discussion 170

5 Conclusion 173

6 References 175
Preface

Exposure of workers in green houses re-entering the crop after use of pesticides has been an area of a lot of questions and few answers. In the past there has been severe accidents among workers re-entering green houses after the treating with cyan gas. The focus on inhalation exposure was therefore natural and dermal exposure after contacting the sprayed crop was not considered to be of importance.

10 years ago, pesticides were regularly used in all Danish green houses growing ornamentals and edible crops as e.g. tomatoes and cucumbers. Introducing biological control of pests especially in tomatoes and cucumbers left the ornamentals as the main crop sprayed with pesticides. Contrary to the use of pesticides on fruits and vegetables no residue limits of pesticides existed on ornamentals, only recommendations of ventilation of the green house before re-entry based on “common sense”. Very few reports have been available in the registration procedure of pesticides for the national authorities for evaluating the inhalation- and dermal exposure in this working environment.

The present project is aiming towards supplying the Danish authorities with exposure data from re-entering ornamental green houses after being treated with pesticides.

The project does not include any kind of risk assessment and this aspect will not be dealt with.

The project is economically supported by The Ministry of Environment and Ministry of Agriculture and Fisheries and was co-ordinated with project “Geno- and spermatotoxic effects on and plasma cholinesterase activity in pesticide exposed green house workers” (Report from Ministry of Environment, Abell et al., 1996).

The present project was planned, conducted and performed from 1993 to 1996 by:

Erik Kirknel, cand. agro., M.Sc. (Department of Weed Control and Pesticide Ecology),

A. Nøhr Rasmussen, cand. agro. (Department of Plant Pathology and Pest Management) and

Gitte Emde, laboratory technician (Department of Weed Control and Pesticide Ecology) all

The Ministry of Food, Agriculture and Fisheries,
Danish Institute of Agricultural Sciences,
Research Centre Flakkebjerg, Flakkebjerg,
DK-4200 Slagelse, Denmark.
Phone +45 5311 3300. Fax +45 5311 33 01.

The two projects were followed up by a steering group consisting of chairman Thomas Bach Lauritsen and later cand. pharm. Lærke Ambo Nielsen, both from The Ministry of Environment.
The members were:

Jesper Lund Larsen, Specialarbejderforbundet (Workers Union),

Peter Bliigård, Gartnerbrugets Arbejdsgiverforening (Green House Employers Union),

Aksel Stenvang, representing DEG’s Arbejdsgiverforening (Growers Union),

Jens Peter Bonde, cand. med., Arbejdsmedicinsk Klinik, Århus Kommunehospital,

Anette Abel, cand. med., Arbejdsmedicinsk Klinik, Århus Kommunehospital,

Flemming Lander, cand. med., Ph.D., Arbejdstilsynet, Odense,

A. Nøhr Rasmussen, cand.agro., Statens Planteavlfsforsøg, Afdeling for Plantepatologi og Jordbrugszoologi and

Erik Kirknel, cand. agro., M.Sc., Statens Planteavlfsforsøg, Afdeling for Ukrudtsbekæmpelse og Pesticidøkologi

Acknowledgements

The experiments were done in commercial green houses and were only possible due to the extreme degree of co-operation from the owners of the green houses and the workers.

Throughout the experiments we have (with only very few exceptions) been met with the “open door policy” and interest from both owners and workers. We will hereby express our thanks to these people, without this type of co-operation the project would not have been possible.

A special thank is devoted to our patient secretary Mrs. Sonja Graugaard.
Abstract

Re-entry experiments have been made in 8 different commercial Danish green houses with ornamentals. 5 pesticides, pirimicarb, paclobutrazol, endosulfan, methomyl and mercaptodimethur, was sprayed with hydraulic spray boom, hand held rifle or cold foggers. 12 different plant species were involved in the experiments.

Different working procedures were investigated when workers re-entered the green house after the spraying.

Whole body dosimeters were used to measure potential exposure, except for head and feet. Static and personal air monitoring was made too.

Dislodgeable foliar residues (DFR) was correlated to hand exposure. The correlation is called the transfer coefficient.

Inactive media such as glass walls, heating tubes, plastic curtains and aluminium tables were analysed for residues.

21 transfer coefficients were calculated for a range of working procedures. Within each pesticide there was a tendency to positive correlation between evaluated degree of contact with the plants and transfer coefficients. Pooling all pesticides this tendency was not apparent. Best fit for distribution of the transfer coefficients was a log-normal distribution, probably due to few individuals in each individual experiment. Geometric mean for transfer coefficients above 10 cm²/h was 1495 cm²/h +525 (lower) and +4257 (upper) for one standard deviation (n = 16), thus giving a 90-percentile of 5199 cm²/h. A default value for ornamentals in greenhouses with the working procedures described is suggested to 7000 cm²/h. The hands was the main area of exposure but the rest of the body was in some experiments exposed as much as the hands.

The respiratory exposure was rather low compared to dermal exposure. Endosulfan was measured to 60 µg/h at re-entry at respiration rate of 20 L/min. Mercaptodimethur was observed resuspended in the air at re-entry when the ornamentals were hanging above the workers. Deposition of pesticides an inactive media was most pronounced on heating tubes.

In general no pesticides were detected in the air before the spraying, despite weekly spraying of the plants.

Cold foggers did not distribute the pesticides evenly in the green houses. There was a 4.3 to 195 -fold difference between the highest and lowest deposited dosage/area. The consequences of this is discussed. For hand held rifle the factor was only 3.

For registration purposes it is argued to conduct experiments with dislodgeable foliar residues for each pesticide. This is due to the correlation between applied dosage and DFR depends on the pesticide.
Sammendrag

Forsøg er blevet udført med eksponering af vækthusgartnere i pesticidbehandlede danske potteplantegartnerier (re-entry). 5 pesticider, pirimicarb, paclobutrazol, endosulfan, methomyl og mercaptodimethur blev udsprøjet med hydraulisk sprøjtebom, håndbåren sprøjteriffel eller koldtågesprøjte. 12 forskellige potteplantearter indgik i forsøgene.

Forskellige arbejdsrutiner efter pesticidbehandling af potteplanter blev undersøgt.

Eksponering blev målt på hele kroppen undtagen hoved og fødder. Fastmonteret og personbåret luftopsamlingsudstyr, registrerede luftens indhold af pesticider.

Løst bundet pesticid på bladoverfladen (DFR = dislodgeable foliar residue) blev korreleret til håndeksponering. Korrelationen benævnes transferfaktoren.

Inaktive flader så som glasvægge, varmerør, plastskyggegardiner og aluminiumsborde blev analyseret for pesticidrester.

21 transferfaktorer blev beregnet for forskellige arbejdsrutiner. Indenfor hvert pesticid var der en tendens til positiv korrelation imellem estimeret grad af kontakt med de sprøjtede planter og transferfaktoren. Denne positive korrelation kunne ikke konstateres når transferfaktorerne ikke blev sorteret for pesticider. Transferfaktorerne var bedst fordelt log-normalt, sandsynligvis på grund af få personer i de enkelte forsøg, hvor fordelingen i et større materiale anses for log-normalt. Geometrisk gennemsnit for transferfaktorer over 10 cm²/t, var 1495 cm²/t ÷525 (nedre) og ÷4257 (øvre) for en standardafvigelse (n=16). Dette resulterer i en 90-percentil på 5199 cm²/t. Derfor foreslås en transferfaktor for vækthusarbejdere som udgangspunkt på 7000 cm²/t. Hænderne var generelt den kropsdel som modtog langt den største dosis pesticid ind på huden, men i nogle forsøg var den potentielle eksponering på krop+hænder lige så stor som på hænderne.

Eksponering via indåndingen var generelt lav sammenlignet med hudeksponeringen (3.5% af total). Men endosulfan blev registreret up til 60 µg/t ved re-entry (ved respirationsrate på 20 L/minute). Mercaptodimethur blev resuspendert i luften ved arbejde med de sprøjtede planter der hang over hovedhøjde på vækthusarbejderen. Deponering af pesticider var mest udtalt på varmerør. Generelt blev der ikke målt pesticider i luften før sprøjtningen trods ofte ugentlige sprøjtninger.

Koldtågesprøjter fordelte ikke pesticiderne tilfredsstillende i disse forsøg. Der blev registreret en 4.3 til 195 gange forskel imellem højeste og laveste dosis/areal. Konsekvensen af dette forhold er diskuterede. For håndbåren hydraulisk riffel er faktoren kun 3.

I risikovurderingen er det nødvendigt for det enkelte pesticid at have oplysninger om de løst bundne rester (DFR) ad en tidsaks. Grunden hertil er, at korrelationen imellem udsprøjet pesticiddosis og DFR er pesticidspecifik.
1 Introduction

1.1 Background

Pesticide exposure and re-entry in agriculture (and green house crops) is excellently reviewed by Joop van Hemmen et al. 1995 and is used in the following. The re-entry exposure (exposure after application of pesticides) is due to the pesticides available in the air, either residuals from the spraying or pesticides re-entering the air from sprayed crop, inactive materials like floor, glass surfaces and eventually resuspended pesticides due to worker activity in the sprayed area. But the main source of exposure is the direct contact with the sprayed crop.

Potential exposure depends on the chemical/physical properties of the pesticide, the crop and the working task. A series of factors are intrinsic for absorption of the potential exposure, of which shall not be discussed here. Therefore the most precise way of relating effects on the workers is to govern biological monitoring which requires pharmaco kinetic knowledge on the pesticide in question.

First incidents

The first incidents of detrimental effects on workers re-entering the sprayed crop was reported in the early fifties and Maddy et al. 1990, have made a review of these cases from Californian citrus fruit crops, grapes and cotton. Re-entry intervals (minimum time period between pesticide application and worker re-entry) was developed on basis of these incidents. Popendorph (1992) have listed formal re-entry intervals and their background.

The main source of exposure was the sprayed crop and Gunther et al. 1977 presented data for decay of pesticide residues on foliage. Especial attention was paid to toxic metabolites arising after the spraying and levels of dislodgeable residues was an arising new concept in worker protection.

Dislodgeable foliar residue (DFR)

For prediction of dermal exposure on the workers a “source strength” term was needed. Iwata et al. (1977) suggested a method for determining the “dislodgeable” dosage of pesticides on the sprayed crop. The method consisted of punching leaf discs and gently rinsing the discs with water containing a mild detergent. The method has been used extensively, but modified using whole leaves, different rinsing solutions etc. Dong et al. (1991) have discussed the different approaches. The most serious argument against leaf punching is the damage done to the sub cuticular tissues and the following extraction of pesticides penetrating the surface layers. The use of detergents may also interfere with a waxy foliage.

Half lives of pesticides

Van Hemmen (1995) is summarising a series of half lives of pesticides on different crops. The half lives indicated are approximate initial values based on mainly first order decay. But decay of pesticides on plant material may often be complex of nature and difficult to express in mathematical terms. Timme et al. (1986) found out that on basis of “total residues”, in 420 series of experiments, 35% made a best fit to a first order model, additional 35% for root function. But, also in this case, the decay in general was not so easy to characterise due to impact of pesticide and crop.

Transfer coefficient

The relationship between dermal exposure (dosage/time unit) and dislodgeable foliar residue (dosage/area) seems natural. The correlation
coefficient between the two parameters, the transfer coefficient with the unit cm²/h, should represent an expression of how many cm² dislodgeable foliar residue the worker was exposed to per hour. Popendorph and Leffingwell (1982) found a rather good linear relationship between the two variables over a broad range of values. But crop type and work practice were influencing the transfer coefficient. Nigg et al. (1984) and Zweig et al. (1985) found for a series of crop and pesticides transfer coefficients from 800 cm²/h to 61,000 cm²/h. The average transfer coefficient was 5,000 cm²/h, one-sided projection of the leaf area. This average value was proposed used as a default value but the need for studies in specific crop/pesticide relationship was expressed by Zweig et al. (1985).

Krieger et al. (1990, 1992) found even greater variation in transfer coefficients, from 1,000 cm²/h to 400,000 cm²/h for different work tasks. The attention on the work task was increased as a parameter of importance. (Fig. 1).

Figure 1


Respiratory exposure and risk
Very few papers exist on evaluating the hazard of re-entering the green houses after spraying with pesticides. Aerosols and vapours of pesticides may exist several days after low volume spraying (Williams 1978; Williams et al. 1980; Lindquist et al. 1987; Liesivuori et al. 1988; Brouwer et al. 1992d; Kangas et al. 1993). Based on these studies an 8 hour re-entry interval with the last 2 hours with the windows opened, could be recommended for all pesticides. Spraying pesticides with vapour pressure
above 10 mPa at 20°C it was recommended to open the windows more or less the next two days in order to prevent a build up of pesticides in the air. In normal build green houses this is probably not necessary in warm periods due to a rather high diffusion of air through the green house. In cold periods the glass panes are more tight due to water condensing between the panes. When high volume spraying of non-volatile pesticides only 8 hour re-entry interval is recommended or one hour with the windows wide open for all pesticides, Brouwer et al. (1992d). Inhalation exposure of evaporated pesticides during working is considered to be low. Resuspension of dust particles from powders could eventually be a problem during working with the sprayed plants Brouwer et al. (1990; 1993).

**Dermal exposure in green houses**

Risk of dermal exposure from imported ornamentals even after long periods after the spraying was shown to be considerable (Morse, 1982). Measurable cholinesterase inhibition was the result in workers handling chrysanthemum cutting treated 10-20 days earlier with granules of aldicarb (Löbel and Schunk, 1982).

**in Finland**

In Finland Jauhiainen et al. (1992) and Kangas et al. (1992, 1993) studied exposure of especially mevinphos on workers handling roses and chrysanthemum. Good correlation was observed between decay of pesticides on leaves and dermal exposure. The transfer coefficient was 133 cm²/h, but the exposure was measured on the bare hands covered with a glove. The results can therefore not directly be compared to true potential exposure, which is exposure on the glove. But the results indicate a true transfer coefficient may be 10 to 100 times higher (1% to 10% penetration of the gloves).

**in Sweden**

In Swedish experiments in green houses, Nilsson (1996a and b) and Papantoni (1995) have developed a new and very interesting DFR technique, using wettex discs to remove small volumes of ethanol applied to the leaf. Transfer coefficients were developed when harvesting cucumbers sprayed with vinclozolin. In four experiments transfer coefficients were calculated to be from 180 to 670 cm²/h. The method avoid damaging the sub cuticular layers, but will maybe extract some of the wax on the cuticle.

**in Germany and**

In German green houses methamidophos sprayed on gherkins, roses and gerbera’s resulted in a transfer coefficient of 700 cm²/h (Goediche, 1989). Half lives of different pesticides sprayed on different crops was determined by Goediche (1987; 1988a; 1988b; 1989) and Goediche et al. (1989).

**in Holland.**

Various pesticides were sprayed on roses and carnations in Dutch green houses. Sorting and bundling of roses led to lower transfer coefficients than on carnations when harvested. For roses 1200-6250 cm²/h, for carnation 2800-10000 cm²/h (Brouwer et al. 1992a; 1992b; 1992c; 1993) and van Hemmen et al. (1992).

### 1.2 The present project

The present project was performed in order to investigate potential exposure of workers re-entering ornamental green houses after spraying with pesticides. It was realised that the project could far from describe every possible combination of pesticides, crop, spray equipment, working procedures, climate etc. All scenarios could not be covered. But it was
emphasised to select key parameters important for exposure. The results could subsequently be used together with results from the literature in the procedures of pesticide registration in suggesting a model for exposure.

**The model is based on transfer coefficients**

Although the above described transfer coefficients seems to be dependent on a range of other key parameters as pesticide, crop etc., it was decided to concentrate the expression of exposure to this unit. The choice was easy because all the present literature operate with transfer coefficients as the key parameter in exposure. The ultimate best method in measuring exposure would be biological monitoring. This is only possible for pesticides with known pharmaco kinetic and would only be valid for few pesticides.

**Transfer coeff. for a variety of working tasks**

Different working procedures was investigated and characterised with transfer coefficients. This was important when eventually counteractions should be taken, such as changing working procedures and recommending protective gear. But no pesticide is registered for use in a green house where the only working procedure would be tagging plants or moving tables! Therefore we have been concentrating on developing a transfer coefficient of “worst case” under normal working conditions.

**Full body dosimeter**

Transfer coefficients are in the literature normally based on dermal hand exposure and dislodgeable foliar residues from the sprayed plants. This is also the case in this study. But not only the crop is sprayed and not only the hands are exposed in a re-enter situation. Therefore a whole body dosimeter was used as described under the chapter “materials and methods”.

**Inactive media**

Glass from the walls, plastic curtains, heating tubes, and the tables, so called inactive surfaces was analysed for residues after the spraying. These results could give information’s on the “background exposure” when the crop is removed from the green house and maybe explain some of the potential exposure detected on other parts of the body than the hands.

**Air monitoring**

Air monitoring has been done in all of the experiments and in some instances for a long period of time. Air monitoring means both static and personal air monitoring. The literature indicates that this route of exposure is of minor importance. We have the point of view that all the workers in the green house, and not only the ones working directly with the sprayed crop will be exposed to inhalation exposure and documentation on this aspect should be weighted with high priority.

**Commercial green houses**

To understand the design and description of the individual experiment one should realise the working conditions in most Danish green houses. The green houses are relatively small, the working procedures are very flexible and the duration of the individual working procedure in question is often very short. Short exposure time is in general a source to errors and should be avoided. One of the reasons for this is the low amount of pesticide deposited on the dosimeter and atypical working pattern.

Flexibility in the working procedures for the workers has also often resulted in changes in the planned activities such as cancelling parts of an experiment.

**Spray equipment**

Spray equipment as a factor of importance in exposure has also been investigated. This does not mean that all types of spray equipment
systematically has been tested in this respect. For example has the velocity of a spray boom been measured to indicate the dosage sprayed per area unit. But we have not investigated the spray pattern of the nozzles mounted on the spray boom. These information can be obtained elsewhere. We have analysed the distribution of the spray solution from the use of questionable equipment as handhold rifles, and the extensive used cold foggers because this type of spray equipment obviously will give rise to questions about the uniformity of the dosage applied.

Not all the mentioned parameters are investigated in each experiment, but only those found important.

Climatic measurements are reported when present. These data have not been utilised systematically but are included in the report for reasons of documentation.

The results are presented experiment by experiment and access to raw data should in general by possible consulting the illustrations. Figures are preferred because the dynamic expression is more pronounced here than in tables. A uniformed text design enable a relatively fast comparison between the individual experiments.
2 Materials and methods

2.1 Green houses, pesticides and plants

The experiments were conducted in 9 different green houses, eight of them commercial and one (experiment 16) belonging to Department of Weed Control and Pesticide Ecology. Details of the individual green house is described in each experiment.

The study was to a large extent based on the OECD draft guidelines for exposure studies by Graham Chester, Zeneca (unpublished).

5 different pesticides (Pirimicarb, paclobutrazol, endosulfan, methomyl and mercaptodimethur) were sprayed on ornamentals.

12 plant species were sprayed namely Mini-roses, Kalanchoë blossfeldiana, Hedera helix, cut-roses, Begonia elatior, Dracaena marginata, Codiaeum variegatum, Polyschias balfouriana, Cordyline purple, Dendranthema indicum-hybride, Aeschynanthus spp. and Columnea spp.

2.1.1 Spray equipment

3 types of spray equipment were used: hydraulic spray boom, hand held hydraulic rifle and cold foggers. Further details at the individual experiments.

2.2 Assessment of exposure

Dermal exposure

A full body dosimeter was used except for the head and the foot region, T-shirt type JBS no. 300-14 with long sleeves and long trousers type JBS no. 310-21, all cotton, normal underwear. All cotton was pre-washed in a normal 90ºC wash and one 90ºC without soap due to interfering compounds in the analysis. Gloves type Maco, delivered by S.F.K., Avedøreholmen 96-98, Copenhagen, phone 36399393 all cotton, were used in assessing hand exposure. The gloves were analysed intact and individual, while T-shirt and trousers were cut according to fig. 17.1. Immediately after exposure and sectioning the samples were stored at -20ºC until analysis.

Respiratory exposure

Both static air monitoring and personal air monitoring were done. Sorbent sampling tubes type SKC XAD-2, 226-30-16 The tube has an inner orifice of 10 mm. Flow rate when sampling was 1 L/min as recommended by the producer: SKC Unit II, Sunrise Park, Higher Shaftsbury Road, Blandford Forum, Dorset. DT II 8ST, UK, phone 1258480188. 1 L/min gives a flow rate of 21.2 cm/sec. This flow is found satisfactory although flow rates on 125 cm/sec normally are recommended to catch aerosols inhaled at 20 L/min respiratory rate, immediately after spraying. 1 hour after the spraying the aerosols of this size is absent from the spray zone and what remains of aerosol and particles in the air will be sampled event at this low
The sample tube is constructed as a sample train. After entering the tube the air is filtered through a glass fibre filter withholding aerosols and particles. Next an XAD-2 Sorbent layer (270 mg), a polyurethane plug for separating this layer to the next XAD-2 Sorbent layer (140 mg) and finally a polyurethane plug. The second XAD-2 layer is used as a break-through check. XAD-2 absorbs the pesticide gases, that means both pesticides found in the gas phase in the sample area but also eventually pesticide in the gas phase released from aerosols or carried on particles (dust) and sampled on the glass filter.

The pump was from the same company type SKC-224-PCXR7, fully programmable and could run continuously from 1400 minutes up to 2200 minutes depending on the condition of the battery. The pump was equipped with a rotameter for observing severe malfunctioning but was calibrated before and after use with a sample tube mounted on the suction side in order to establish the same resistance in the air flow as when sampling.

After sampling the tubes were stored at -20°C until analysis.

2.2.1 Assessment of dislodgeable foliar residue (DFR)

Samples of leaves were produced by the leaf punching method described by Iwata et al. (1977). The leaf puncher was available in three different sizes 12 mm, 18 mm and 25 mm diameter. Depending upon the leaf geometry, one of the sizes were used. At least 20 punches and 4 replications per sampling were made. Immediately after sampling the discs were placed in a 50 ml Pyrex tube Teflon capped with 20 ml of destilled water. The tubes were tilted for 30 minutes on a Swelab instrument type 440, Bie and Berntsen, Sandagervej, Copenhagen, phone 42948822. The tubes were gently tilted from horizontal position ± 30ºC with a frequency of 15 cycles/min. After 30 minutes the leaves were removed with tweezers and 5 ml dichloromethane (Rathburn un 1593 or Merck no. 106050) was added. After vigorously shaking the tubes were stored at 5°C until analyses.

2.2.2 Assessment of exposure on inactive media as glass walls, plastic curtains, heating tubes and aluminium tables

The inactive media were rinsed or extracted with ethanol: 96% commercial grade (Danisco no. 633600). The sample sizes are indicated in the individual experiments. Due to the different properties of the inactive media from green house to green house, it was not tried to make a total residual analysis. For example some heating tubes were painted others not. The paint was of different type, age and thickness. Recovery was impossible to measure under these circumstances. The results should only reflect residues loose bound. The rinse was done with a spray bottle 1-2 minutes with a surplus of solvent. The extract was stored at -20°C until analysis. Plastic curtains were extracted just like the body dosimeter.

Field recovery No field recovery was done due to immediate storage of the samples in a portable freezer.
2.3 Chemical analysis of pesticides

2.3.1 Extraction and clean-up

2.3.1.1 Dermal exposure

Sections of T-shirts and trousers were extracted in 1 L of ethanol in 2 L Pyrex glass bottles. The bottles were rolled horizontally for 2 h. Each glove were extracted in a 0.5 L Pyrex glass bottle in a similar way. Depending upon the concentration in the extract, 10 to 350 ml sub-sample was filtered through anhydrous, Na$_2$SO$_4$, (Merck no. 6649 heated to 450ºC for 4 hours) evaporated to dryness and resuspended in 5 ml cyclohexane/ethylacetate 1:1 (Cyclohexane, Merck no. 9666 or Fluka no. 28932, ethylacetate Rathburn 1173).

The sample was cleaned-up on a gel column 45 cm long x 1.5 cm diameter Biobead SX-3 (Biorad 200-400 Merck, no. 152-2750) in cyclohexane/ethylacetate 1:1. The sample was evaporated to dryness and resuspended in 2 ml ethylacetate for GC analysis or appropriate mix of methanol/water (Mallinckrodt no. 3041) for HPLC analysis.

2.3.1.2 Respiratory exposure

All five layers of the SKC sample tube were individually extracted in 4 ml ethyl acetate and treated ultrasonically intermittent for 2 h. Stored at +5ºC overnight and analysed.

2.3.1.3 DFR

The field sample with 20 ml water and 5 ml dichloromethane was extracted liquid-liquid with 3 x 10 ml dichloromethane, filtered through anhydrous Na$_2$SO$_4$, evaporated to dryness. For pesticides analysed on GC/ECD, the samples were cleaned-up on gelfiltration as described for dermal exposure. For pesticides analysed on GC/NPD the samples were resuspended in 2 ml ethyl acetate and analysed.

2.3.1.4 Inactive media

Filter paper used for measuring deposition of pesticides were placed in 30 ml methanol, shake well for 5 minutes, stored overnight at +5ºC with appropriate solvent for GC-analysis (ethylacetate) and HPLC (methanol/water or acetonitrile/water) (Merck 14291).

2.3.2 Detection

2.3.2.1 GC-conditions

The typical GC-conditions for the HP-5890 were as follows, but the oven temperature program could deviate slightly due to problems with separating interfering peaks.
2.3.2.1.1 Injector

The HPGC 5890 was equipped with a temperature programmable injector type Gerstel, CIS-3. This type of injector ensures reduced thermal decomposition in the injector and allows large injection volumes (this model up to 10 µl with practically no solvent peak). Initial temperature: 85°C. Initial time: 30 s. Solvent purging: 30 s. Splitless time 60 s. Injector temperature programme: 12°C/s. Final temp: 250°C. Final time: 600 s.

2.3.2.1.2 Detectors

ECD

Column: HP-5 cat. no. 19091J-012. Inner diameter: 0.32 mm. Film thickness 0.17 µm. 25 m long. Column gas: 1.44 ml N₂/min

Make-up gas: 60 ml N₂/min
Anode purge: 6 ml N₂/min.
Det. temp: 300°C

Oven initial: 40°C in 90 s
Temperature programme: 15°C/min. to 270°C
Final time: 5 min.

NPD

Column: HP-1. Cat. no. 19091Z-105. Inner diameter: 0.2 mm Film thickness: 0.33 µm. 3 m long
Column gas: 1 ml N₂/min

H₂: 3-4 ml/min
Make-up gas: 30 ml N₂/ml
Det. temp: 220°C

Oven initial: 100°C in 90 s
Temperature programme: 25°C/min. to 250°C
Final time: 0 s

2.3.2.2 HPLC-conditions

The HPLC, HP 1050, was equipped with a diode array detector, DAD and a quaternary pump. Column: HP Sperisorb-ODS-1, no. 79924-01-584, 5 µm, 250 mm x 4 mm.
Flow: 1 ml/min

Solvents and wavelengths

Endosulfan
80% acetonitrile/20% water. 215 nm
2.3.3 Quantification

Quantification were done by external standards. Calibration curves were produced using normally 5-7 external standards.

Limit of detection (LOD) was calculated according to Miller and Miller (1988). 95% confidence interval was used. LOD is the lowest dosage to be detected but does not include any specification on recovery.

Limit of quantification (LOQ) was “the lowest concentration of the analyte that can be determined with an acceptable level of accuracy (recovery) and precision (standard deviation)”.

Both LOD and LOQ are in accordance with the Welac guidance Document No. WGD 2, Accreditation for chemical laboratories. (Anon., 1993).

It should be noted that few of the results are below LOQ but indicated in the results.

2.3.4 Recovery

<table>
<thead>
<tr>
<th></th>
<th>Recovery from spiking</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pirimicarb</strong></td>
<td></td>
</tr>
<tr>
<td>All GC/NPD</td>
<td></td>
</tr>
<tr>
<td>T-shirt and trousers</td>
<td>56.0% (std: 5.5)</td>
</tr>
<tr>
<td>Gloves</td>
<td>65.2% (std: 3.9)</td>
</tr>
<tr>
<td>DFR</td>
<td>90.0% (std: 5.0)</td>
</tr>
<tr>
<td>Air samples</td>
<td>72.6% (std: 1.2)</td>
</tr>
</tbody>
</table>

| **Paclobutrazol** |                       |
| All GC/NPD |                       |
| T-shirt and trousers | 81.9% (std: 6.3) |
| Gloves | 60.8% (std: 7.3) |
| DFR | 97.2% (std: 4.1) |
| Air samples | 70.0% (std: 5.1) |

| **ɑ-Endosulfan** |                       |
| All GC/ECD |                       |
| T-shirt and trousers | 39.6% (std: 2.1) |
| Gloves | 55.2% (std: 3.1) |
| DFR | 84.2% (std: 0.8) |
| Air samples (+HPLC) | 75.8% (std: 3.9) |
### δ-Endosulfan

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Recovery (%)</th>
<th>Std (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All GC/ECD</td>
<td>95.7%</td>
<td>3.7</td>
</tr>
<tr>
<td>T-shirt and trousers</td>
<td>97.6%</td>
<td>5.8</td>
</tr>
<tr>
<td>Gloves</td>
<td>76.6%</td>
<td>2.7</td>
</tr>
<tr>
<td>Air samples (+HPLC)</td>
<td>79.4%</td>
<td>5.2</td>
</tr>
</tbody>
</table>

### Methomyl

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Recovery (%)</th>
<th>Std (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-shirt and trousers (HPLC)</td>
<td>78.0%</td>
<td>10.3</td>
</tr>
<tr>
<td>Gloves (HPLC)</td>
<td>68.4%</td>
<td>5.4</td>
</tr>
<tr>
<td>DFR (HPLC)</td>
<td>94.6%</td>
<td>4.7</td>
</tr>
<tr>
<td>Air samples (GC/NPD)</td>
<td>91.3%</td>
<td>3.9</td>
</tr>
</tbody>
</table>

### Mercaptodimethur

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Recovery (%)</th>
<th>Std (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-shirt and trousers (HPLC)</td>
<td>87.8%</td>
<td>2.2</td>
</tr>
<tr>
<td>Gloves (HPLC)</td>
<td>77.8%</td>
<td>4.6</td>
</tr>
<tr>
<td>DFR (HPLC)</td>
<td>94.7%</td>
<td>2.4</td>
</tr>
<tr>
<td>Air samples (GC/NPD)</td>
<td>67.7%</td>
<td>3.9</td>
</tr>
</tbody>
</table>

All results are adjusted for recovery.
3 Results

3.1 Experiment no. 1

Experiment started: 1-10-1993
Experiment finished: 4-10-1993

Abstract

Mini roses grown in plastic pots was sprayed pirimicarb with an automatic hydraulic boom sprayer.

One working procedure was investigated. Four persons were trimming rose cuttings for propagation with a pair of scissors. No DFR was measured.

At reentry the air only contained few µg/h of pirimicarb at respiration rate of 20 L/minutes.

Exposure of four workers trimming rose cuttings after 3810 minutes reentry interval was 146 µg/8 hours (geometric mean and 1400 µg/8 hours as the 90% fractile). The 90% fractile is calculated on a very limited number of workers and should be interpreted carefully.

Spray data

Sprayed: 1-10-1993, 15.00 pm
Reentry after: 3810 minutes
Pesticide: Pirimor G (50% pirimicarb)
Spray equipment: Automatic hydraulic spray boom
Nozzle type: Tee jet 11001
Spray pressure: 4.5-5 bar
Position of spray equipment: The spray boom had nozzles directed forward in an angle of 45° to the table surface. The orifice of the nozzles were at a distance of 40 cm from the culture. The culture was sprayed twice. At the second spray the direction of the spray boom was reversed and so was the nozzles in order to get a better penetration of the spray solution into the culture.

Spray conc.: 50 g x 50%/100 L = 0.25 %
Spray volume: Normal volume: 79 L/378 m² = 209 L/1000 m²
Reduced volume (increased boom speed): 60.5 L/378 m² = 160 L/1000 m² (76% of normal volume)
Spray dosage: Normal dosage: 209 L x 0.25 %/1000 m² = 52.3 g pirimicarb/1000 m²
Reduced dosage: 160 L x 0.25 %/1000 m² = 40 g pirimicarb/1000 m²
Area sprayed: 6336 m²

Physical parameters of the green house

Area: 132 m x 48 m = 6336 m²
Cross section area: (48 m x 3.2 m)+(2.9 m x 0.5 x 48 m) = 223.2 m²
Volume: 132 m x 223.2 m = 29462 m³
Fans: 3 meters above the plants ventilators was mounted in order to increase wind velocity between the plants and in this way reduce the humidity. If R.H. exceeded 78%, the ventilators started.
Top windows: Yes, only opened very little in the course of the experiment
Tables: Aluminium tables 3.5 x 1.5 m = 5.25 m²/table

Culture

The experiment was made in different varieties of potted roses (Rosa-hybride) belonging to the groups Parade® and Patiohit®. Most of the plants were grown in 10.5 cm pots, each with four cuttings. At the spraying the plant height was approximately 20 cm high from rim of pot to the top of the plant. The plants were cut 2 times during the period of production. The cutted material was used for cuttings.

Working procedure

After the spraying Friday afternoon, the culture was left until Monday morning when the upper part of the roses was machine cut. The cuttings were delivered in buckets built into the tables where the workers were sitting.

The investigated working procedure started when these cuttings were manually trimmed with a pair of scissors. The cuttings were held in the left hand. All workers were right handed.

Results

Air samples

Air samples were taken before the spraying, when the spraying was done and 64 minutes, 450 minutes, 1050 minutes, 1245 minutes and 2745 minutes after the spraying. The sampling tubes were placed immediately above the surface of the culture, oriented with the sampler inlet downwards. One pump was placed in each of the two areas sprayed, normal dosage and reduced dosage.

Air sampling before spraying showed less than 3.5 µg/hour at 20 L/min respiration rate. The pumping period was 135 min.
Fig. 1.1 shows the sum of concentration of particles and gasses up to 2 days after spraying. At this point, the exposure via inhalation were below 2 µg/hour at a respiration rate of 20 L/min for the normal spray dosage. The first sampling, 64 min. after spraying was performed during the spraying i.e. in the spray mist. Both dosages seems to be at the same level while spraying. 450 min. after the spraying, the air above the culture receiving the reduced dosage, is clearly reduced compared to the normal dosage. After one day no difference between the two curves is seen.

**Exposure**

Due to the type of work, only hand exposure was registered. The exposure time was 240 minutes. The results is illustrated in fig. 1.2. The total exposure was for the four persons: 57.1, 97.6, 183.2 and 494.4 µg pirimicarb/8 hour. The geometric mean is calculated to 146 µg/8 hour (± standard deviation = 382 and 56 µg pirimicarb/8 hour). The 90% fractile is calculated to 1.4 mg/8 hour. Arith. mean: 207±199.

**Climatic conditions**

The temperature during the experiment was 20-24°C. R.H. was measured to be from 70-85%.

Fig. 1.3 illustrates the light intensity corrected for physical shadows. It is seen that at this time of the year, the net light influx is rather low and is started around 07.00 am and finished around 17.30 pm. Fig. 1.3 also illustrates that the top mounted windows practically speaking, was closed during the period.
Figure 1.1
Pirimicarb (sum of particles aerosols and gasses) in the air after spraying mini roses with hydraulic boom sprayer. Samples taken 10 cm above the sprayed plants.

Pirimicarb (sum af partikler, aerosoler og gasser) i luften efter sprøjtning af miniroser med hydraulisk bomsprøjte. Prøver taget 10 cm over de sprojtede planter.
Figure 1.2
Exposure on hands of 4 persons trimming rose cuttings with a pair of scissors. Reentry 3810 minutes after spraying. Sum of both hands for each person: Geom. mean: 146 µg pirimicarb ± 382 µg and 56 µg pirimicarb/8 h. 90% fractile 1400 µg pirimicarb/8 h.

Håndeksponering på 4 personer der trimmer rosenstiklinger med saks. Reentry 3810 minutter efter sprøjtningen. Sum for begge hænder for hver person: Geom. gennemsnit.: 146 µg pirimicarb ± 382 µg og 56 µg pirimicarb/8 t. 90% fractil: 1400 µg pirimicarb/8 t.

Figure 1.3
Light intensity in klux and percentage opening of the two top mounted windows (average percentage).
Lysintensitet i klux og gennemsnitlig procent åbning af vinduerne.
3.2 Experiment no. 2

Experiment started: 29-04-1996 and 06-05-1994
Experiment finished: 09-05-1994

Abstract

Cultures of mini roses were sprayed pirimicarb with a hydraulic boom sprayer.

Reentry was done after 3725 minutes (2.6 days) and 13834 minutes (9.6 days). Out of the 9.6 days the rose cutting were placed at 5°C storage after being cut. At 3725 minutes DFR was 0.60 µg pirimicarb/50 cm² leaf area (=60% of LOQ). At 13834 minutes DFR was 0.35 µg/cm² leaf area (=30% of LOQ).

One working procedure was investigated, with a pair of scissors rose cuttings were trimmed for propagation. Only hand exposure was registered. Transfer coefficient for 3725 minutes reentry was 4466 cm²/h and for reentry after 13824 minutes was 1323 cm²/h, geometric mean, 2097 cm²/h using 90% fractile for exposure of the five workers.

Pirimicarb in air samples at reentry after 3725 minutes was 2 to 3 µg/8 h at respiration rate of 20 L/minute.

Pirimicarb was found on heating tubes, aluminium tables and glass walls after spraying. A fast disappearance was registered. At reentry 3725 minutes after spraying the residues were 0.05%, 1.3% and 0.01% of initial spray dosage respectively

Spray data

Sprayed: 29-04-1996 or 06-05-1994, 15.40 pm
Reentry after: 3725 minutes (sprayed 06-05-1996) or 13824 minutes (=9.6 days), sprayed 29-04-1996, cut after 3700 minutes and left at 5°C for one week before trimming
Pesticide: Pirimor G (50% pirimicarb)
Spray equipment: Automatic hydraulic boom sprayer
Nozzle type: Tee-jet 11001
Spray pressure: 5.5 bar
Position of spray equipment: The spray boom had nozzles directed forward in an angle of 45° to the table surface. The orifice of the nozzles were at a distance of 40 cm from the culture. The culture was sprayed twice. At the second spray the direction of the spray boom was reversed and so was the nozzles in order to get a better penetration of the spray solution into the culture.
Spray conc.: 50 g x 50%/100 L = 0.25 ‰
Spray volume: 296.8 L/1000 m²
Spray dosage: 296.8 L x 0.25‰/1000 m² = 74.2 g/1000 m²
Area sprayed: 6336 m²

Physical parameters of the green house

Area: 132 m x 48 m = 6336 m²
Cross section area: (48 m x 3.2 m)+(2.9 m x 0.5 x 48 m) = 223.2 m²
Volume: 132 m x 223.2 m = 29462 m³
Fans: 3 meters above the plants ventilators was mounted in order to increase wind velocity between the plants and in this way reduce the humidity. If R.H. exceeded 78%, the ventilators started.
Top windows: Yes
Tables: Aluminium tables 3.5 x 1.5 m = 5.25 m²/table

Culture

The experiment was made in different varieties of potted roses (Rosa-hybride) belonging to the groups Parade® and Patiohit®. Most of the plants were grown in 10.5 cm pots, each with four cuttings. At the spraying the plant height was approximately 20 cm high from rim of pot to the top of the plant. The plants were cut 2 times during the period of production. The cutted material was used for cuttings.

Working procedure

After the spraying Friday afternoon, the culture was left until Monday morning when the upper part of the roses was machine cut. The cuttings were delivered in buckets built into the tables where the workers were sitting.

The investigated working procedure started when these cuttings were manually trimmed with a pair of scissors. The cuttings were held in the left hand.

Results

Air samples

Air samples were taken 0.5 m above the rose culture, 300 min. before and 20, 60, 140, 525, 1220, 2750, 4195, and 5635 minutes after the spraying. LOQ = 6 µg pirimicarb/sample for 20 L/min. All figures in fig. 2.1 are above LOQ, except gas measurements for the last two samples (4195 and 5635 minutes).
Fig. 2.1 clearly illustrates the domination of particles and aerosols compared to the gasses. Only from 60 min. to 500 min. after spraying there seems to be a log-normal relationship. The inhalation expose at reentry seems to be in the area of 2.4 µg pirimicarb/8 hours at an inhalation rate of 20 L/minutes. Reentry in this context means that the workers are in the spraying zone (and not in the area where the workers were trimming the rose cuttings).

**DFR**

Samples were taken 205 min before spraying and 65, 200, 545, 1250, 2810, and 3725 min after spraying. 20 discs each with an area of 2.5 cm² were randomly sampled.

Fig. 2.2 shows the DFR. LOQ = 1 µg pirimicarb/50 cm² leaf area or 0.2 g pirimicarb/1000 m² greenhouse. This amounts to 0.27% of the initial spray dosage. LOQ is reached after 1000 min. and, therefore, the DFR indicated below 1 µg/50 cm² is not validated in the method.

At reentry 3725 min. after spraying DFR was 0.60 µg pirimicarb/50 cm² (60% of LOQ). 60 min. after spraying DFR is between 3 and 4 µg pirimicarb/50 cm² (= 1% of initial sprayed dosage). Worker 6 was trimming leaves sprayed 06-05-1994.

DFR was also measured on rose leaves sprayed 29-4-95 with the same spray dosage. The DFR was approximately 30% of LOQ and therefore not quantified, but apparently lower than 3725 min after spraying 06/05/1994.

The leaves sprayed 29-04-94 were cut 3700 min. after spraying, left at low temperature (5°C) for one week and trimmed by workers 1-5.

**Exposure**

Exposure was measured on a full body dosimeter consisting of long sleeved T-shirt and long trousers of cotton. Hand exposure was measured on cotton gloves. LOQ was 10 µg pirimicarb/8 h for hands, T-shirt and pants.

Five workers (worker 1-5, fig 2.3) all right handed, were trimming rose cuttings sprayed 9.6 days earlier (29-04-1995). Only exposure on the hands could be detected. Geometric mean for these five workers was 74 µg pirimicarb/8 hours, ± one standard deviation from 92 to 74 µg pirimicarb/8 hours. 90% fractile was 117 µg pirimicarb/8 hour.

Fig. 2.3 clearly reflects the working procedure: the scissors were held in the right hand and the cuttings in the left hand.

Worker no. 6 was working with cuttings sprayed 2.6 days earlier (06-05-1994). Fig. 2.3 shows a 4 to 7 times higher exposure. In this case, the right hand on this right handed worker received the highest load. The exposure time for both groups was 505-510 min.

**Transfer coefficients**
All exposure of pirimicarb by this working procedure was concentrated on the hands.

One worker was exposed to pirimicarb 3725 min. (2.6 days) after spraying. DFR was 0.6 µg pirimicarb/50 cm², fig. 2.2 and the exposure was 428.7 µg pirimicarb/8 hours, fig 2.3.

Transfer coefficient for hand exposure was:

\[ 428.7 \mu g \times 50 \text{ cm}^2/8 \text{ h} \times 0.6 \mu g = 4466 \text{ cm}^2/\text{h}. \]

Five workers were exposed to pirimicarb sprayed 13805 min. (9.6 days) before reentry. DFR was 0.35 µg pirimicarb/50 cm² and exposure was 74.09 µg pirimicarb/8 hours (geometric mean).

The transfer coefficient is calculated to:

\[ 74.09 \mu g \times 50 \text{ cm}^2/8 \text{ h} \times 0.35 \mu g = 1323 \text{ cm}^2/\text{h} \]

But using the 90% fractile of this group of five workers, 117.45 µg pirimicarb/8 h, the transfer coefficient is calculated to:

\[ 117.45 \mu g \times 50 \text{ cm}^2/8 \text{ h} \times 0.35 \mu g = 2097 \text{ cm}^2/\text{h} \]

It should be emphasised that DFR is well below LOQ and best estimates.

**Analysis of inactive media in the green house**

**Heating tubes**

Painted heating tubes, horizontally mounted along the glass wall, approximately 1.2 m above the floor, were analysed for residues of pirimicarb. The sampling area was of 30 cm's length on a 42 mm diam. steel tube. The samples were taken 230 min. before the spraying, 40 minutes and 3965 minutes after the spraying. The first sampling after the spraying was taken at exactly the same place as before the spraying. The consecutive sampling was done at a new place.

Fig. 2.4 illustrates the disappearance of pirimicarb. The dosage after 40 minutes averages 2.7 µg pirimicarb/126 cm² (=0.2 g pirimicarb/1000 m² = 0.3% of initial spray dosage).

Recovery was not done on the painted heating tubes, because the layer of paint was heterogeneous and we only wanted to express what was loosely bound to the surface of the tubes. This is probably the reason for the relatively low load on tubes compared to the glass walls. But also the high temperature on the heating tubes will of course evaporate pirimicarb.

**Aluminium tables**

The rim of the tables were investigated for spray deposits. The rim was constructed of aluminium profiles 15 cm high and 2.5 cm wide. Samples
were taken on a 30 long piece of the rim. Horizontal area was then 75 cm². Vertical area: 450 cm².

Samples were taken 145 minutes before spraying and 25 minutes and 4020 minutes after spraying. The first sampling after spraying was taken at exactly the same place as before spraying. The consecutive five samples were taken at new places.

Fig. 2.5 illustrates the disappearance of pirimicarb from the rim of the tables in the greenhouse. The plants have been sprayed one week before and the level of pirimicarb before spraying is indicated. The level before spraying is assumed to be of the same magnitude after one week (10080 min.) and in order to support the picture of disappearance of pirimicarb, this level is used. If the horizontal area is receiving the majority of the dosage: 20 µg pirimicarb/25 cm² ~ 2.67 g/1000 m² = 3.6% of initial dosage sprayed on the plants, is found after 25 min. The reason for this low dosage is that the plant to a high degree was covering the table rim for the spray mist.

The background after one week was approximately 0.5% of the initial dosage. The disappearance of pirimicarb within one week was tenfold which means, a half life of 2 days.

Glass wall

225 cm² of the vertical glass wall was rinsed with ethanol in order to remove deposits of pirimicarb. Samples were taken before the spraying and 60 minutes and 3995 minutes after the spraying. The first sampling after spraying was taken at exactly the same place as was washed before spraying. The consecutive samples was taken at a new place.

Fig. 2.6 illustrates the disappearance of pirimicarb from the glass. The sample before spraying was well below even LOD. The plants were sprayed one week before spraying and this finding was accepted as a background after one week. Therefore, it is used at time 10080 min. after spraying to support the illustration of disappearance of pirimicarb.

After 60 minutes 20 µg/225 cm² was detected which corresponds to 0.9 g/1000 m² (= 1.2 % of the initial dosage sprayed on the plants). The level is the same as at the table rims after 2.5 days, but much lower after one week.

Climatic conditions

The temperature during the experiment was 22-24°C, R.H. varied between 70-85%. Light intensity in klux corrected for physical shadows and the average percentage opening of the two top mounted windows is illustrated on fig. 2.7.

Fig. 2.7 shows a rather high net flux of radiation in the period after the spraying. It is also seen that the windows practically speaking was closed after the spraying, until the next day at 10-11 am. when the windows because of the rising influx start to open.
Figure 2.1

Pirimicarb in the air after spraying mini roses with hydraulic boom sprayer. Samples taken 50 cm above the plants. At the last two sample times, the gasses were below LOQ. Samples taken before spraying were below LOD.

Indhold af pirimicarb i luften efter sprøjtning af miniroser med hydraulisk bomsprøjte. Prøver taget 50 cm over planterne. Prøver taget før sprøjtningen samt ved de sidste to prøveudtagninger var indholdet i prøverne mindre end LOQ.
Figure 2.2
DFR from pirimicarb sprayed roses with hydraulic boom sprayer. DFR in brackets originates from roses sprayed 29.04.1994, harvested 02.05.1994 and kept at 5°C until reentry 09.05.1994. Spray procedure 29.04.1994 identical to spray procedure 06.05.1994.

DFR fra roser sprøjtet med pirimicarb. DFR i parentes stammer fra roser sprøjtet d. 29.04.1994, høstet 02.05.1994 og opbevaret ved 5°C indtil re-entry d. 09.05.1994. Sprøjting d. 29.04.1994 foretaget som d. 06.05.1994.
Figure 2.3
Exposure on hands after trimming pirimicarb sprayed rose cuttings. Workers no. 1 to 5, trimming cuttings 13824 minutes after spraying (9.6 days. 7 days out of the 9.6 days on cold storage). Worker no. 6 was trimming cuttings 3725 minutes (2.6 days) after spraying. Worker 1-5: Geometric mean: 74 µg pirimicarb/8 h ± one std. = 74 to 92 µg pirimicarb/8 h. 90% fractile = 117 µg pirimicarb/8 h.

Eksponering med pirimicarb på hænderne ved trimning af rosenstiklinger. Person 1 til 5 trimmede stiklinger 13824 minutter efter udsprøjtning (=9.6 dage. 7 dage ud af 9.6 dage på køl.). Person nr. 6 trimmede stiklinger 3725 minutter (=2.6 dage) efter sprøjtning. Person 1 til 5: Geometrisk gennemsnit: 74 µg pirimicarb/8t ± en standardafvigelse = 74 - 92 µg pirimicarb/8t. 90%fraktil = 117 µg pirimicarb/8t.
Figure 2.4
Residues of pirimicarb on heating tubes after spraying with hydraulic boom sprayer at a distance of 5 meters. The greenhouse was sprayed 29.04.1994 and 06.05.1994. The figures in brackets are transferred from just before spraying 29.04.1994 and not actual measurements on the time indicated on the scale.

Rester af pirimicarb på varmerør efter sprøjtning med hydraulisk bomspøjte i en afstand på 5 m. Væksthuset blev sprøjtet d. 29.04.1994 og d. 06.05.1994. Tallene i parentes er overført fra før sprøjtning og ikke målinger foretaget som vist.
Figure 2.5
Residues of pirimicarb on the aluminium table rim. The plants were sprayed 29-04-1994 and 06-05-1994. The figures in brackets are data transferred from just before spraying 29-04-1994 and not actual measurements on the time indicated of the scale.

Rester af pirimicarb på aluminiumsbordkanter. Planterne blev sprojet d. 29.04.1994 og d. 06.05.1994. Tallene i parentes er overført fra før sprojtning og ikke målinger foretaget som vist.
Figure 2.6
Residues of pirimicarb on the glass wall. The greenhouse was sprayed 29.04.1994 and 06.05.1994. The figures in brackets are data transferred from just before spraying 29.04.1994 and not actual measurements on the time indicated on the scale.

Rester af pirimicarb på glasvægge. Planterne blev sprøjtet d. 29.04.1994 og d. 06.05.1994. Tallene i parentes er overført fra før sprøjtning og ikke målinger foretaget som vist.

Figure 2.7
Light intensity in klux and the average percentage opening of the two top mounted windows.
Lysintensitet i klux og gennemsnitlig procent åbning af vinduerne.
3.3 Experiment no. 3

Experiment started: 01-01-1995
Experiment finished: 03-03-1995

Abstract

Cultures of Kalanchoë blossfeldiana were grown in plastic pots placed on aluminium tables.

At reentry, 2573 min after the spraying, DFR was measured to be 8 µg pirimicarb/62.5 cm² leaf area.

Two persons were making cuttings for propagation at the tables. No hand exposure could be detected and therefore is transfer coefficient not available.

Air samples taken in the green house at reentry showed 0.5 µg pirimicarb/h at a respiration rate of 20 L/minute. Personal monitoring of air showed a 5 to times higher value, especial of the fraction particles and aerosols, indication the working procedure as reason for this higher level.

Heating tubes, glass walls and aluminium tables were analysed for residues shortly after the spraying and compared to initial spray dosage the respectively deposits were 0.45%, 0.04% and 1.1%. A rapid disappearance of pirimicarb was observed.

Spray data

Sprayed: 01-03-1995, 01.00 pm
Reentry after: 2573 minutes
Pesticide: Pirimor G (50% pirimicarb)
Spray equipment: Hand-held hydraulic rifle
Nozzle type: 1553 (25-30)
Spray pressure: 75 bar
Position of spray equipment: Pump, hose and rifle was in the green house when sprayed. Manual indirect (75 bar!) spraying.

Spray conc.: 75 g x 50%/50 L = 0.5 %
Spray volume: 446 l/1000 m²
Spray dosage: 446 L x 0.5/1000 x 1000 m² = 223 g/1000 m²
Area sprayed: 168 m²

Physical parameters of the green house

Area: 20.9 m x 10 m = 209 m²
Cross section area: \((10 \, m \times 2.5 \, m) + (2.5 \, m \times 0.5 \times 10 \, m) = 37.5\, m^2\)

Volume: \(20.9 \, m \times 37.5 \, m^2 = 784 \, m^3\)

Fans: No

Top windows: Yes

Cultures

The experiment was carried out in different varieties of Kalanchoë blossfeldiana.

Working procedure

Two persons were making cuttings for propagation. The working procedure was performed at the tables which has been sprayed.

Results

Air samples

Air samples have been taken 1.60 m above the floor, 30 cm above the sprayed plants. Air samples were taken just before the spraying, 35 minutes, 203 minutes, 1253 minutes and 2543 minutes after the spraying. The results are seen in fig 3.1. At reentry 2573 minutes after the spraying the level of pirimicarb/hour at a respiration rather of 20 L/min was approximately 0.5 \(\mu g\) pirimicarb.

DFR

Dislodgeable foliar residue was measured 180 minutes before the spraying and 153 minutes, 2783 minutes and 2913 minutes after the spraying. The results are illustrated in fig. 3.2. The spray volume was in excess. DFR was 40 \(\mu g\) pirimicarb/62.5 cm\(^2\) leaf area and corresponds to 6.4 g pirimicarb/1000 m\(^2\) (=2.9% of the initial spray dosage).

At reentry, 2573 minutes after the spraying, DFR was approximately 8 \(\mu g\) pirimicarb/62.5 cm\(^2\) leaf area.

Exposure

Two workers carried a full body dosimeter through the entire experiment, 155 minutes. LOQ = 50 \(\mu g/8\) h.

Reentry was done 2573 min. after spraying. Nothing was measured on the hands. The only body part exposed to pirimicarb on person 1 was the right arm, 73 \(\mu g\) pirimicarb/8 h. On person 2, 68 \(\mu g\) pirimicarb/8 h was detected on the chest.
This is an interesting finding. DFR was found in relatively large quantities, but practically nothing on the workers. The spray volume was used in excess. Kalanchoë blossfeldiana is almost a succulent and might have absorbed the systemic pirimicarb to a very high degree.

The DFR samples were taken by punching the leaves and maybe extracted the absorbed insecticide from the plant sap. If this is so, a rapid metabolism occur in the plant by looking at fig. 3.2.

The two persons have carried air pumps for monitoring pirimicarb in the air while working.

The sample tube were fixed on the two persons in the breathing zone. Person 1 was measured for 95 minutes and person 2 for 150 minutes. The results are illustrated in fig. 3.3. The figures are 5 to 6 times higher than the background illustrated in fig. 3.1, which shows less than 0.5 µg pirimicarb/hour at 20 L/minutes at reentry.

Transfer coefficients

Nothing was found on the hands, therefore transfer coefficients are not calculated.

Analysis of inactive media in the green house

Heating tubes

Heating tubes mounted along the glass wall 1.70 m above the floor was analysed for pirimicarb 90 minutes before spraying and 145 minutes, 2720 minutes and 2982 minutes after the spraying. The results are illustrated in fig. 3.4. 13 µg pirimicarb/129 cm² tube area, was detected after the first 60 minutes (horizontal cross section), which equals 1 g/1000 m², (=0.45% of initial spray dosage). The tubes were not sprayed directly, but were only 2.5 metres away from the sprayed tables. A rapid disappearance of pirimicarb is observed.

Glass walls

Glass walls, 20 cm × 20 cm were analysed for residues of pirimicarb 90 minutes before spraying and 130 minutes, 2730 minutes and 2980 minutes after the spraying. The results are seen in fig. 3.5.

No residues could be detected before spraying, LOD was 0.08 µg/sample.

3.4 µg pirimicarb/400 cm² glass wall after 90 minutes after the spraying, corresponds to 0.09 g/1000 m² (=0.04% of initial spray dosage).
Tables

The rim of the aluminium tables were analysed for residues of pirimicarb. The vertical side of the rim, 13.5 cm × 30 cm were extracted with ethanol 60 minutes before spraying, 140 minutes, 2730 minutes and 2930 minutes after the spraying. The results are illustrated in fig 3.6. No residues of pirimicarb were detected before the spraying. LOD = 0.08 µg pirimicarb/ sample.

60 minutes after the spraying was detected 100 µg pirimicarb/405 cm² table rim equals to 2.5 g/1000 m² (=1.1% of initial spray dosage). The reasons for this apparently low residue on the table rim are a the table rim had only a vertical surface, excess volume of spray solution and a heavy plant cover.

Climatic conditions

The green house was not equipped with automatic registration of the climatic parameters. Only temperature was registered with a thermometer hung up just above the plants.

The temperature varied from 01-03-1995 10.00 am to 03-03-1995 16.00 pm between 19 and 22°C.
Figure 3.1
Pirimicarb in the air after spraying Kalanchoë with high pressure rifle sprayer. Samples taken 1.6 m above the floor and 30 cm above the plants.

Figure 3.2
DFR of pirimicarb on Kalanchoë after spraying with high pressure hydraulic rifle.
Figure 3.3
Pirimicarb in the air detected by personal air monitors from two workers cutting Kalanchoë sprayed with high pressure hydraulic rifle.

Pirimicarb i luften målt i åndedrætszonen på to personer der fremstiller stiklinger på Kalanchoë sprøjtet med højtryksriffel.

Figure 3.4
Residues of pirimicarb on painted heating tubes after spraying with high pressure hydraulic rifle sprayer.

Rester af pirimicarb på malede varmerør efter sprøjting med højtryksriffel.
**Figure 3.5**
Residues of pirimicarb on glass walls after spraying with high pressure rifle sprayer.

Rester af pirimicarb på glasvægge efter sprøjtning med højtryksriffel.

**Figure 3.6**
Residues of pirimicarb on the vertical rim after spraying with high pressure hydraulic rifle sprayer.

Rester af pirimicarb på lodrette bordkanter efter sprøjtning med højtryksriffel.
3.4 Experiment no. 4

Experiment started: 02-06-1995
Experiment finished: 05-06-1995

Abstract

Mini roses grown in plastic pots was sprayed pirimicarb and methomyl in the same spray solution with an automatic hydraulic boom sprayer.

Only air sampling was done. Methomyl was below 1 µg/8 h at a respiration rate of 20 L/minute 1170 minutes after the spraying. Pirimicarb was detected 3.22 µg/h at respiration rate of 20 L/minute 1170 minutes after the spraying. After 2750 minutes 0.46 µg pirimicarb/h at respiration rate of 20 L/minute was detected.

Spray data

<table>
<thead>
<tr>
<th>Spray data</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed:</td>
<td>02-06-1995, 03.40 pm</td>
</tr>
<tr>
<td>Reentry after:</td>
<td>No reentry</td>
</tr>
<tr>
<td>Pesticide:</td>
<td>A mixture of:</td>
</tr>
<tr>
<td></td>
<td>Pirimor G (50% pirimicarb) and</td>
</tr>
<tr>
<td></td>
<td>Lannate 20 (20% methomyl)</td>
</tr>
<tr>
<td>Spray equipment:</td>
<td>Automatic hydraulic spray boom</td>
</tr>
<tr>
<td>Nozzle type:</td>
<td>Tee-jet 11001</td>
</tr>
<tr>
<td>Spray pressure:</td>
<td>4.5-5 bar</td>
</tr>
<tr>
<td>Position of spray equipment:</td>
<td>The spray boom had nozzles directed forward in an angle of 45° to the</td>
</tr>
<tr>
<td></td>
<td>table surface. The orifice of the nozzles were at a distance of 40 cm</td>
</tr>
<tr>
<td></td>
<td>from the culture. The culture was sprayed twice. At the second spray</td>
</tr>
<tr>
<td></td>
<td>the direction of the spray boom was reversed and so was the nozzles in</td>
</tr>
<tr>
<td></td>
<td>order to get a better penetration of the spray solution into the culture.</td>
</tr>
<tr>
<td>Spray conc.:</td>
<td>Pirimicarb:</td>
</tr>
<tr>
<td></td>
<td>50 g x 50%/100 L = 0.25 %</td>
</tr>
<tr>
<td></td>
<td>Methomyl:</td>
</tr>
<tr>
<td></td>
<td>50 g x 20%/100 L = 0.1 %</td>
</tr>
<tr>
<td>Spray volume:</td>
<td>298 L/1000 m²</td>
</tr>
<tr>
<td>Spray dosage:</td>
<td>Pirimicarb:</td>
</tr>
<tr>
<td></td>
<td>298 L x 0.25 %/1000 m² = 74.5 g/1000 m²</td>
</tr>
<tr>
<td></td>
<td>Methomyl:</td>
</tr>
<tr>
<td></td>
<td>298 L x 0.1 %/1000 m² = 29.8 g/1000 m²</td>
</tr>
<tr>
<td>Area sprayed:</td>
<td>6336 m²</td>
</tr>
</tbody>
</table>
Physical parameters of the green house

Area: 132 m x 48 m = 6336 m²
Cross section area: (48 m x 3.2 m) + (2.9 m x 0.5 x 48 m) = 223.2 m²
Volume: 132 m x 223.2 m = 29462 m³
Fans: 3 meters above the plants ventilators was mounted in order to increase wind velocity between the plants and in this way reduce the humidity. If R.H. exceeded 78%, the ventilators started.
Top windows: Yes
Tables: Aluminium tables 3.5 x 1.5 m = 5.25 m²/table

Culture

The experiment was made in different varieties of potted roses (Rosa-hybride) belonging to the groups Parade® and Patiohit®. Most of the plants were grown in 10.5 cm pots, each with four cuttings. At the spraying the plant height was approximately 20 cm high from rim of pot to the top of the plant. The plants were cut 2 times during the period of production. The cutted material was used for cuttings.

Working procedure

No working procedure was measured, only monitoring of pesticide in the air.

Results

Air samples

Air samplers have been placed 50 cm above the sprayed plants. Samples have been collected 60 minutes before the spraying, 60 minutes, 170 minutes, 500 minutes, 1170 minutes, 1580 minutes, 2750 minutes and 4025 minutes after spraying. The results are illustrated in fig. 4.1 and fig. 4.2.

Methomyl could be detected after 1170 min. at 1.34 µg methomyl/8 h after spraying, LOQ=1 µg methomyl/8 hour at respiration 20 L/min. At 1580 minutes after the spraying the concentration in the air was below 1 µg methomyl/8 h. Pirimicarb was present in the air even 4025 minutes after spraying, pirimicarb was below LOQ, but raised in the consecutive sampling just above LOQ. Pirimicarb is measured mainly as gasses, which is in contrast to experiment no. 2, where particles and aerosols were dominating.

Taken in consideration the dosage sprayed, the two insecticides appear at the same relative concentration in the air and disappear at approximately the same rate from the air.
Climatic data

During the experiment the temperature and % RH was from 22-25°C and 63-85% RH. Fig. 4.3 illustrates the light intensity in klux and percent opening of the windows during the experiment.

Figure 4.1
Methomyl in the air after spraying mini roses with a mixture of pirimicarb and methomyl.

Methomyl i luften efter sprøjtning af roser med en blanding af pirimicarb og methomyl.
Figure 4.2
Pirimicarb in the air after spraying mini roses with a mixture of pirimicarb and methomyl.

Figure 4.3
Light intensity in klux and percentage opening of the two top mounted windows (average percentage).

Lysintensitet i klux og procent åbning af vinduer.
3.5 Experiment no. 5

Experiment started: 28-03-1996
Experiment finished: 29-03-1996

Abstract

Hedera helix grown in plastic pots was sprayed pirimicarb with a hydraulic boom sprayer.

At reentry, 910 minutes after the spraying, DFR was measured to be 200 µg pirimicarb/50.9 cm² leaf area.

Spacing the pots placed on aluminium tables resulted in a transfer coefficient of 540 cm²/h.

The dosage of pirimicarb inhaled was < 10 µg pirimicarb/h at a respiration rate of 20 L/minute.

Spray data

Sprayed: 28-03-1996, 04.05 pm
Reentry after: 910 minutes after the spraying
Pesticide: Pirimor G (50% pirimicarb)
Spray equipment: Automatic hydraulic boom sprayer
Nozzle type: Hardi 1553-14
Spray pressure: 3.5 bar
Position of spray equipment: Spray equipment was moving on rails mounted above the aluminium tables.
Spray conc.: 60 g x 50%/40 L = 0.75 ‰
Spray volume: 32.5 L/150 m² = 217 L/1000 m²
Spray dosage: 217 L x 0.75 ‰/1000 m² = 163 g pirimicarb/1000 m²
Area sprayed: 150 m²

Physical parameters of the greenhouse

Only a small part of a conventional greenhouse was used in the experiment. The greenhouse was equipped with aluminium tables, 1.6 m x 3.6 m. Access to the plants was either done by pushing the tables together or one could get transported on a cart on rails hanging just above the plants. The tables were pressed together while spraying leaving no space between them. This prevented the sides of the aluminium tables to be contaminated by the spray solution.
Cultures

The plants were Hedera helix grown in plastic pots.

Working procedure

One person was manually spacing the pots due to the growth of the plants, while she was removing withered leaves from the plant.

Results

Air samples

Air samplers were placed between the potted plants, sampling 10 cm above the surface of the culture. Air samples were taken before the spraying, 60 minutes, 390 minutes, 895 minutes and 1302 minutes after the spraying.

LOQ was 20 µg/sample at a respiration rate of 20 L/minutes. Nothing could be detected before the spraying in a sampling period of 293 minutes which means < 4 µg pirimicarb/h at a respiration rate of 20 L/minutes. Fig. 5.1 illustrates the results.

DFR

DFR was measured before spraying and 910 minutes and 1300 minutes after the spraying. 20 discs of each 2.54 cm² leaf area was selected evenly distributed in the sprayed area.

No DFR was measured before the spraying, not even on LOD-level. LOD was 0.32 µg pirimicarb/50.9 cm² leaf area.

Due to a very short reentry interval, 910 minutes, and still wet leaves even 420 minutes after the spraying, only two samplings were done. Fig. 5.2 illustrates the results.

At reentry DFR was measured to be 200 µg pirimicarb/50.9 cm² leaf area, which corresponds to 43 g pirimicarb/1000 m² (=26% of initial spray dosage) green house. This DFR is compared to other DFR values in these experiments a relative high value.

Exposure

Reentry was done 910 minutes after the spraying. The working procedure lasted for 345 minutes. Fig 5.3 illustrates exposure on the body parts.

86% of the total exposure was detected on the hands and only 14% on the rest of the body. The relative high dosage received on an 8 hour basis with a systemic insecticide as pirimicarb is probably due to the short reentry
interval, but also due to the high detected DFR compared to what has been seen in roses in experiment 6.

**Personal air monitoring**

The worker was equipped with personal air monitor positioned at the breathing zone. Air samples were taken during the period of working except for 60 minutes due to malfunctioning of the pump, namely 285 minutes. The amount of pirimicarb was measured. The amount of pirimicarb measured was 50% of LOD and therefore not quantified in the validated method. 50% of LOD was 5 µg/h at respiration rate of 20 L/minutes.

**Transfer coefficients**

DFR at start and end of reentry was measured to be 219 and 180 µg pirimicarb/50.9 cm² leaf area. An average of 200 µg pirimicarb/50.9 cm² leaf area is used in calculation of the transfer coefficient.

Transfer coefficient for only hand exposure:

19730 µg x 0.86 x 50.9 cm²/8 h x 200 µg = 540 cm²/h

**Climatic conditions**

Three climatic parameters are illustrated on fig. 5.4 from 28-03-1996, 06.00 am to 29-03-1996, 08.00 am.
Figure 5.1
Pirimicarb in the air after spraying Hedera helix with hydraulic boom sprayer. Samples taken 10 cm above the sprayed plants. The third sampling lasted longer than programmed due to malfunctioning of the pump.

Pirimicarb i luften efter sprøjtnings af Hedera helix med hydraulisk bomsprøjte. Prøverne taget 10 cm over planterne. Den tredie prøveudtagning varede længere end programmeret på grund af fejl funktionering af pumpen.

Figure 5.2
DFR of pirimicarb on Hedera helix after spraying with hydraulic boom sprayer.

DFR af pirimicarb på Hedera helix efter sprøjtning med hydraulic bomsprøjte
Figure 5.3
Percentage distribution of pirimicarb on the body parts of one person spacing pots with Hedera helix sprayed with hydraulic boom sprayer.

Fordeling af pirimicarb på kroppen af en person der stiller Hedera helix på afstand sprøjtet med hydraulisk bomsprojte.

Figure 5.4
Minimum and maximum °C, %R.H. and klux.

Minimum og maksimum af tre klimatiske parametre i væksthus fra d. 28.03.1996 kl. 06.00 til 29.03.1996 kl. 08.00.
3.6 Experiment no. 6

Experiment started: 14-05-1993
Experiment finished: 15-05-1993

Abstract

Cultures of cut-roses for cutting, was sprayed pirimicarb with a hand held hydraulic rifle.

At reentry, 1376 minutes after spraying, DFR was measured to be 1.15 µg pirimicarb/75 cm² leaf area.

Two working procedures were investigated. One was cutting roses for flowers, another removing rose buds. The transfer coefficients for these working procedures were 4553 cm²/h and 4838 cm²/h respectively.

Air samples at reentry showed 1.46 µg pirimicarb/8 h at a respiration rate of 20 L/minute.

Heating tubes were washed with ethanol and a deposit of 1.9 µg pirimicarb/136 cm² horizontal cross section area was measured at reentry. This amounts to 2.0% of initial spray dosage.

Large volumes of spray solutions were used and the dripping off the roses on the ground was investigated. 1.72% (s=1.90%) of initial spray dosage was collected on inactive sampling media 305 minutes after the spraying.

Spray data

Sprayed: 14-05-1996, 08.55 am
Reentry after: 1376 minutes
Pesticide: Pirimor G (50% pirimicarb)
Spray equipment: Hand held hydraulic rifle with 3 nozzles
Nozzle type: Hardi 1553-18
Spray pressure: 2 bar
Position of spray equipment: The three-nozzle hand held rifle was mounted on a hydraulic hose. The pump was placed outside the green house
Spray conc.: 50 g x 50%/10 L = 0.25 ‰ pirimicarb
Spray volume: 250 L/708 m² = 353 L/100 m²
Spray dosage: 353 L x 0.25 ‰/1000 m²= 88.25 g/1000 m²
Area sprayed: 708 m²

Physical parameters of the green house

Area: 11.8 m x 60 m = 708 m²
Cross section area: (11.8 m x 2 m)+(2.8 m x 0.5 x 11.8 m)= 40.12 m²
Culture

In the green house was grown roses for flower cutting. The culture was approximately 1.6 m high. Six rows of flower beds were separated by walking paths 0.6 m wide.

Working procedure

Two persons were working in the green house, both doing two different working procedures. First both persons were cutting roses in the culture for 43 minutes. After this they removed buds from the roses in the culture for 70 minutes.

Results

Air samples

Air monitors were mounted in the middle of the green house 1.7 m above the ground. Samples were taken in a period of 1060 minutes before the spraying. LOQ was 20 µg pirimicarb/sample at a respiration rate of 20 L/minutes. No pirimicarb was detected before the spraying (< 1.1 µg pirimicarb/h at respiration rate of 20 L/minutes).

Samples were also taken from after spraying to 254 minutes, 1405 minutes and 1648 minutes after spraying. Fig. 6-1 illustrates the results.

The finding 1648 minutes after the spraying was < 0.1 LOQ. LOQ was at this sampling interval calculated to 0.26 µg pirimicarb/h at 20 L/minute respiration rate.

The reason for this fast disappearance of pirimicarb in the air was probably due to the high temperature and the open windows during the entire experiment.

DFR

4 x 30 pieces of 2.5 cm² leaf discs were punched from the roses, evenly sampled all over the green house.

Samples taken before spraying the roses, contained less than LOD = 0.3 µg pirimicarb/75 cm² leaf area.

Samples were also taken 320 minutes and 1475 minutes after spraying. The results are illustrated on fig 6.2
At reentry 1376 minutes after the spraying, DFR was calculated to be 1.15 µg pirimicarb/75 cm² leaf area, which corresponds to 0.15 g pirimicarb/1000 m² greenhouse (=0.17% of initial spray dosage.

**Exposure**

Cutting roses resulted in a total body exposure of 3500 and 4200 µg pirimicarb/8 h for the two workers. Working in the dense culture of roses, resulted in larger exposure on the "body+hands" compared to only "hands". Only 5.3% and 21.9% of the total exposure on the two workers, could be measured on the hands. Fig. 6.3 illustrates the results.

Removing the buds from the roses, resulted in a lower total exposure, 670 and 1600 µg pirimicarb/8 hour for the two workers. 57.6% and 48.7% was detected on the hands. Fig. 6.4 illustrates the results.

**Transfer coefficients**

At reentry, 1376 minutes after spraying, DFR was calculated to 1.15 µg pirimicarb/75 cm² leaf area.

For two persons cutting roses, the transfer coefficient for hand exposure was:

Arith. mean:

\[
\frac{558.5\mu g}{8\text{ h}} \times \frac{75\text{ cm}^2}{1.15\mu g} = 4553\text{ cm}^2 / \text{h}
\]

Geom. mean:

\[
\frac{416\mu g}{8\text{ h}} \times \frac{75\text{ cm}^2}{1.15\mu g} = 3391\text{ cm}^2 / \text{h}
\]

For two persons removing buds from roses, the transfer coefficient for hand exposure was:

Arith. mean:

\[
\frac{593.5\mu g}{8\text{ h}} \times \frac{75\text{ cm}^2}{1.15\mu g} = 4838\text{ cm}^2 / \text{h}
\]

Geom. mean:

\[
\frac{558.2\mu g}{8\text{ h}} \times \frac{75\text{ cm}^2}{1.15\mu g} = 4553\text{ cm}^2 / \text{h}
\]
Analysis of inactive media in the green house

Heating tubes

Heating tubes mounted on the side wall of the green house were placed 0.7 m above the floor. The tubes were rinsed with ethanol before the spraying and 335 minutes and 1430 minutes after the spraying. The horizontal cross section area was 136 cm² for each rinse site and four replications was distributed evenly along the one side of the green house. LOD was 0.6 µg pirimicarb/136 cm² horizontal cross section area of the tube.

The findings are illustrated in fig. 6.5

Nothing could be detected before the spraying.

335 minutes after the spraying, the average deposition on heating tubes was 24.4 µg pirimicarb/136 cm² horizontal cross section area, which corresponds to 1.79 g pirimicarb/1000 m² green house (=2% of initial spray dosage).

Compared to DFR this dosage is in the same range at reentry.

Spray pattern

The large spray volume used in this experiment, would presumably result in dripping leaves after the spraying. In order to investigate this residue of pirimicarb on an "inactive soil surface", 62 petri-dishes were placed evenly distributed in the greenhouse in level with the soil underneath the roses. 305 minutes after the spraying, when all petri-dishes were dried up, the dishes were collected, rinsed with ethanol and stored for analysis. The 62 analysis showed an average deposition of 1.52 g pirimicarb/1000 m² green house and a standard deviation of 1.68 g/1000 m² (=1.72 % and 1.9% respectively of the initial spray dosage). This level is almost the same as found at reentry on heating tubes.

Climatic conditions

The green house was not equipped with any automatic registration of climatic parameters.

Only minimum and maximum temperature was registered during the experiment.

The minimum temperature 15-05-96 was 18.7°C, the maximum temperature 31.9°C.

No clouds were present during the experiment.

The windows were opened during the entire experiment.
Figure 6.1
Pirimicarb in the air after spraying roses with a hand held hydraulic rifle.

Figure 6.2
DFR of pirimicarb on cut-roses after spraying with a hand held hydraulic rifle.
Figure 6.3
Percentage distribution of pirimicarb on the body parts of two persons cutting roses sprayed with a hand held hydraulic rifle. No indications: < LOQ.

Fordeling af pirimicarb på kroppen af to personer der skærer snitroser sprøjtet med håndbåren hydraulisk riffel. Ingen indikation: < LOQ.
Figure 6.4
Percentage distribution of pirimicarb on the body parts of two persons removing rose buds on roses sprayed with a hand held hydraulic rifle. No indications: < LOQ.

Fordeling af pirimicarb på kroppen af to personer der fjerner knopper på snitroser sprøjtet med håndbåren hydraulisk riffel. Ingen indikation: < LOQ.
Figure 6.5

Residues of pirimicarb on heating tubes after spraying with a hand held hydraulic rifle.

Rester af pirimicarb på varmerør efter sprøjtning med håndbåren hydraulisk riffel.
3.7 Experiment no. 7

Experiment started: 10-08-1994
Experiment finished: 11-08-1994

Abstract

Cultures of mini roses were grown in plastic pots and sprayed with paclobutrazol. The plants were ready for packing and sale the next day.

At reentry, 690 minutes after the spraying, DFR was detected to be 0.6 µg paclobutrazol/40 cm² leaf.

Three working procedures were investigated. Machine packing, manual packing and tagging the pots with a plastic stick (=quality control mark). Using arithmetic mean for exposure, the respective transfer coefficients were 276 cm²/h, 1000 cm²/h and 505 cm²/h.

Air samples at reentry showed < 32 µg paclobutrazol/8 h at respiration rate 20 L/minute. In the area of packing the plants, the air contained < 35 µg/8 h at respiration rate 20 L/minute. Personal air monitoring was made when two workers were tagging the plants. Less than 130 µg paclobutrazol/8 h at respiration rate of 20 L/minute was detected. In all the air analysis, not even traces were registered of paclobutrazol.

Paclobutrazol was found on the heating tubes and table rims of the aluminium tables. At reentry, the deposits of paclobutrazol was respectively 25.8% and 33.7% of initial spray dosage.

Spray data

Sprayed: 10-08-1994, 07.20 pm
Reentry after: 690 minutes
Pesticide: Bonzi (paclobutrazol 0.39%)
Spray equipment: Automatic hydraulic spray boom
Nozzle type: Tee-jet 11001
Spray pressure: 5.5 bar
Position of spray equipment: The spray boom was mounted on rails above the plants. The speed of the spray boom determined the spray dosage. The spray boom had nozzles placed at a distance of 40 cm above the plants. The spray direction was downwards. The plants were only sprayed once.

Spray conc.: 900 g x 0.39%/200 L = 0.0175 %
Spray volume: Normal volume (greenhouse no 1 and no 2): 91.8 L/1000 m²
Reduced volume (greenhouse no 1): 59.4 L/1000 m²
Spray dosage: Normal dosage = 91.8 L x 0.0175 ‰/1000 m² = 1.61 g paclobutrazol/1000 m²  
Reduced dosage = 59.4 L x 0.0175 pr/1000 m² = 1.04 g paclobutrazol/1000 m²  
Area sprayed: Greenhouse no 1: 376 m² (normal) + 150 m² (reduced)  
Greenhouse no 2: 150 m² (normal)  

Physical parameters of the green houses  
Area: 100 m x 20 m = 2000 m²  
Cross section area: (20 m x 3.2 m)+(2.9 m x 0.5 x 20 m) = 93 m²  
Volume: 93 m² x 100 m = 9300 m³  
Fans: 3 meters above the plants ventilators was mounted in order to increase wind velocity between the plants and in this way reduce the humidity. If R.H. exceeded 78%, the ventilators started.  
Top windows: Yes  

Cultures  
The experiment was made in different varieties of potted roses (Rosa-hybride) belonging to the groups Parade® and Patiohit®. Most of the plants were grown in 10.5 cm pots, each with four cuttings. At the spraying the plant height was approximately 20 cm high from rim of pot to the top of the plant. The plants were cut 2 times during the period of production. The cutted material was used for cuttings.  

Working procedure  
This experiment investigated mainly three working procedures. Two types of packing mini roses, manual and machine packing. The plants packed came from both green houses. The manual procedure consisted in removing withered leaves from the plants and packing the plants in boxes. At the machine packing procedure, the pots and plants were cleaned by compressed air. But the plants were still packed in boxes manually. One person was switching between these two procedures. The third person was tagging the pots by inserting plastic tags in the soil. Tagging was made only in the reduced spray dosage area in green house no 1.  

Results  
Air samples  
Air samples were taken 50 cm above the sprayed plants 245 minutes before and 59 minutes, 145 minutes and 640 minutes after the spraying.
LOQ = 33 µg paclobutrazol/sample at a respiration rate of to 20 L/min. None of the samples were above LOQ. Therefore, the three samples are < 268 µg paclobutrazol/8 h, 184 µg paclobutrazol/8 h and 32 µg paclobutrazol/8 h, all respiration rate of 20 L/minutes.

Air samples were also taken near the outlet of the dust filter attached to the recirculated air from the machine packing procedure. The sampling time was 457 minutes, resulting in < 35 µg paclobutrazol/8 h at respiration rate 20 L/min.

The sampling time and exposure level for the two persons tagging the pots were 120 minutes and < 132 µg paclobutrazol/8 hour and 128 minutes and <124 µg paclobutrazol/8 h at respiration rate 20 L/min. The analyses did not in any of the samples show even traces (= < LOD) of paclobutrazol, which means that the results are only determined by limits of the method.

**DFR**

Leaves of the mini roses were collected for analysis 70 minutes, 910 minutes and 1300 minutes after the spraying in the reduced spray dosage area. Fig. 7.1 shows the DFR of spraying the roses with paclobutrazol. LOQ = 0.24 µg paclobutrazol/40 cm² leaf area. This amounts to 0.06 g paclobutrazol/1000 m² (=5.77% of the initial spray dosage). In greenhouse no. 1 reentry was done after 690 min. Greenhouse no. 2 was sprayed with the dosage 1.61 g paclobutrazol/1000 m². DFR in greenhouse no. 2, 865 minutes after the spraying, reflects this higher spray dosage. No other samples than these four DFR samples was taken in greenhouse no. 2.

**Exposure**

Full body dosimeter was used on all the persons in this experiment. The period of exposure was for all workers 7 to 8 hours.

Fig. 7.2 illustrates the exposure of the packers. Mainly hand exposure was detected. Persons 1 to 6 packed manually all the time. Persons 8 and 9 was packing by help from machine as described above. Person no. 7 changed between the two working procedures.

For manual packers were geometric mean 82.3 µg paclobutrazol/8 h, limits for one standard deviation 35.4-191.1. 90% fractile was 450. Arithmetic mean 107.95 ± 80.44.

For machine packers was arithmetic mean 36.0 µg paclobutrazol/8 h. For person no. 7 was the exposure 29.8 µg paclobutrazol/8 hour.

The two persons tagging the plants, workers no 10 and no 11 on fig. 7.2, were only registered to be exposed on their right hands 36.8 and 44 µg paclobutrazol/8 h. The finger tips of their gloves were cut off in order to better being able to manipulate the plastic tags. Finger wash with ethanol was done on these persons. These samples were below LOQ. LOQ was 33 µg paclobutrazol/8 h.
Their right hand was the only in contact with the sprayed plants, and therefore no exposure was registered on the left hand.

**Transfer coefficients**

The packing procedure used plants from both the reduced spray dosage and the normal spray dosage. An average of the two are used in calculating the transfer coefficient, see fig 7.1. DFR for packing procedure is then 0.6 $\mu$g paclobutrazol/40 cm$^2$. The transfer coefficient for the six manual packers, calculated on

- **Arithmetic mean:**
  \[107.95 \times 40 \times 0.6 \times 1000 = 1000 \text{ cm}^2/\text{h}\]

- **Geometric mean:**
  \[82.3 \times 40 \times 0.6 \times 686 = 686 \text{ cm}^2/\text{h}\]

- **90% fractile:**
  \[450 \times 40 \times 0.6 \times 3750 = 3750 \text{ cm}^2/\text{h}\]

For the two packers using machine packing the transfer coefficient was the arithmetic mean

\[36.1 \times 40 \times 0.6 \times 300 = 300 \text{ cm}^2/\text{h}\]

For the one person working both with manual and machine packing, the transfer coefficient was

\[29.8 \times 40 \times 0.6 \times 248 = 248 \text{ cm}^2/\text{h}\]

Fig. 7.1 shows DFR as 0.40 $\mu$g paclobutrazol/40 cm$^2$ (taken at the reduced spray dosage) when reentry was done after 690 min.

The two persons, working in the reduced spray dosage area tagging the plants had an average of 40.4 $\mu$g paclobutrazol/8 hours. The transfer coefficient is calculated to

\[40.4 \times 40 \times 0.4 \times 505 = 505 \text{ cm}^2/\text{h}\]

**Analysis of inactive media in the green house**

**Heating tubes**

Painted heating tubes were analysed for residues of paclobutrazol. The sampling area was 30 cm of a 4.2 cm diameter steel tube. The sample was taken 180 minutes before the spraying and 65 minutes and 955 minutes after the spraying. The first sampling after the spraying was done at the same place as before spraying. The consecutive sampling was done on new places.

Fig. 7.3 illustrates the residues of paclobutrazol found before and after the spraying. The average concentration before the spraying was 3.61 $\mu$g
paclorbutrazol/126 cm² and 3.86 μg paclorbutrazol/126 cm² 955 minutes after spraying. 65 minutes after spraying the level was on LOQ 0.7 μg paclorbutrazol/126 cm². This illustrates that paclorbutrazol is "hanging in the air" at least 65 minutes after the spraying and then the deposition takes place.

3.61 and 3.86 μg paclorbutrazol/126 cm² is equal to 0.29 g paclorbutrazol/1000 m² and 0.31 g paclorbutrazol/1000 m², respectively. Compared to the initial spay deposits (weighed average of the two spray dosages: 1.20 g/1000 m²): 24.2% and 25.8%, respectively.

Tables

The rim of the tables were analysed for residues of paclorbutrazol. The rim was constructed of aluminium profiles, 15 cm high and 2.5 cm wide.

Samples were taken on a 30 cm long piece of the rim. Horizontal area was 75 cm², vertical area: 450 cm². Samples were taken 135 minutes before the spraying, 75 minutes and 1000 minutes after the spraying. Samples taken 75 minutes after the spraying were taken the same place as before the spraying. Samples taken 1000 minutes after the spraying were taken at another place.

Fig. 7.4 illustrates the residues of paclorbutrazol from the rim of the tables. The level of paclorbutrazol before the spraying was below LOD. After the spraying, the level 1000 minutes after spraying (16.7 hours), was at least as high as the level before the spraying plus the level 75 minutes after the spraying.

Assuming the horizontal area of the rim is receiving most of the paclorbutrazol measured, 2.6 μg paclorbutrazol/75 cm² = 0.35 g paclorbutrazol/1000 m² (=33.7% of initial reduced spray dosage). Compared to the culture in experiment no 8, it was more open, and probably therefore is found higher deposits on the table rim in this experiment.

Climatic conditions

Light intensity and percentage opening of the windows is illustrated in fig 7.5. The temperature varied between 22-25°C and the relative humidity between 75-88% during the experiment.
**Figure 7.1**
DFR from paclobutrazol sprayed roses using a hydraulic spray boom.

DFR af paclobutrazol sprojet på roser med hydraulisk sprojtebom.
Figure 7.2
Exposure on the hands of 9 persons working with packing of potted mini roses and 2 workers placing plastic tags in the pots sprayed with paclobutrazol the day before. *Persons no. 5 and 7 have only been measured on the right hand due to practical reasons. The left hand on these two persons is simulated. Only persons no. 4 and no. 9 were exposed on other places of the body. No. 4 was exposed to 40 µg paclobutrazol/8 h on the trousers. No. 9 was exposed to 39.2 µg paclobutrazol/8 h on the trousers. LOQ for trousers: 35 µg paclobutrazol/8 h.

Håndeksponering af 9 personer der pakker pottede minirosen og 2 personer der stikker plastikmærker i pottejorden. Planterne sprøjtede dagen før med paclobutrazol. *Personerne nr. 5 og 7 blev kun målt på højre hånd på grund af praktiske årsager, venstre hånd er simulert. Kun personerne nr. 4 og 9 var eksponeret på andre steder af kroppen. Nr. 4 havde 40 µg paclobutrazol/8t, nr. 9 havde 39.2 µg paclobutrazol/8t på bukserne. LOQ for bukser: 35 µg paclobutrazol/8t.
Figure 7.3
Residues of paclobutrazol on painted heating tubes before and after spraying. Sampling 75 minutes after the spraying was done the same place as before the spraying. Sampling 955 min. after spraying were done at different places.

Figure 7.4
Paclobutrazol residues found on the table rim. Samples taken 75 minutes after the spraying were taken the same place as before the spraying. Samples taken 1005 minutes after the spraying were taken other places.

Figure 7.5
Light intensity in klux and percentage opening (average percentage) of the two top mounted windows.

Lysintensitet i klux og procent åbning af vinduerne.
3.8 **Experiment no. 8**

Experiment started: 10-08-1994  
Experiment finished: 11-08-1994

**Abstract**

Cultures of mini roses were grown in plastic pots and sprayed paclobutrazol with a hydraulic spray boom.

At reentry, 690 min after the spraying, DFR was 0.44 µg paclobutrazol/50 cm².

Removing buds from the roses resulted in a transfer coefficient of 1295 cm²/h.

Manually pushing aluminium tables, exposed the two workers in experiment to 63.2 and 73.6 µg paclobutrazol/8 h. This dosage was at the same level as the worker removing buds from the roses.

Handling the automatic washing machine for cleaning aluminium tables, resulted in exposure far below LOD.

All air samples were detected below LOQ = 33 µg paclobutrazol/sample. 160 minutes after the spraying the air was measured to contain < 32 µg paclobutrazol/8 h at respiration rate of 20 L/minute. Air samples at reentry taken from the worker removing buds from the roses, contained < 206 µg paclobutrazol/8 h at respiration rate 20 L/minute. The two workers operating the washing machine was detected < 140 µg paclobutrazol/8 h at respiration rate 20 L/minute.

Paclobutrazol was found on the heating tubes and the table rims of the aluminium tables. Respectively at 990 minutes and 1005 minutes after the spraying, paclobutrazol was found on heating tubes and aluminium tables at 17.9% and 13.1% of initial spray dosage.

**Spray data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed:</td>
<td>10-08-1994, 07.00 pm</td>
</tr>
<tr>
<td>Reentry after:</td>
<td>690 minutes</td>
</tr>
<tr>
<td>Pesticide:</td>
<td>Bonzi (0.39% paclobutrazol)</td>
</tr>
<tr>
<td>Spray equipment:</td>
<td>Automatic hydraulic spray boom</td>
</tr>
<tr>
<td>Nozzle type:</td>
<td>Tee-jet 11001</td>
</tr>
<tr>
<td>Spray pressure:</td>
<td>5.5 bar</td>
</tr>
<tr>
<td>Position of spray equipment:</td>
<td>The spray boom was mounted on rails above the plants. The spray boom had nozzles placed at a distance of 40 cm above the plants. The spray direction was downwards. The plants were only sprayed once.</td>
</tr>
<tr>
<td>Spray conc.:</td>
<td>900 g x 0.39%/200 L = 0.0175 %</td>
</tr>
<tr>
<td>Spray volume:</td>
<td>80.1 L/1000 m²</td>
</tr>
</tbody>
</table>
Spray dosage: \(80.1 \text{ L} \times 0.0175 \% / 1000 \text{ m}^2 = 1.4 \text{ g paclobutrazol}/1000 \text{ m}^2\)

Area sprayed: 107 m²

**Physical parameters of the greenhouse**

Area: \(126 \text{ m} \times 48 \text{ m} = 6048 \text{ m}^2\)

Cross section area:
\[(3.2 \text{ m} \times 48 \text{ m}) + (2.9 \text{ m} \times 0.5 \times 48 \text{ m}) = 223.2 \text{ m}^2\]

Volume: \(223.2 \text{ m}^2 \times 126 \text{ m} = 28123.2 \text{ m}^3\)

Fans: 3 meters above the plants ventilators was mounted in order to increase wind velocity between the plants and in this way reduce the humidity. If R.H. exceeded 78%, the ventilators started.

Top windows: Yes

**Cultures**

The experiment was made in different varieties of potted roses (Rosa-hybride) belonging to the groups Parade® and Patiohit®. Most of the plants were grown in 10.5 cm pots, each with four cuttings. At the spraying the plant height was approximately 20 cm high from rim of pot to the top of the plant. The plants were cut 2 times during the period of production. The cutted material was used for cuttings.

**Working procedure**

Three working procedures have been investigated.

Two persons (person 1 and 2) have been controlling the automatic equipment that gives the individual pots more space due to growth on the tables. The greenhouse is regularly sprayed with paclobutrazol. It is rather difficult and not reproducible to characterise the degree of deposits of paclobutrazol for the tables. The experiment is some sort of "background measurement" for this type of greenhouse.

One person (person 3) was removing buds from the roses the day after spraying. Reentry interval 690 minutes.

Two persons (persons 4 and 5) were moving aluminium tables manually. The deposits of paclobutrazol on the tables have not been characterised as mentioned above. This procedure is also to be seen as some sort of "background measurement".
Results

Air samples

Air samples were taken 50 cm above the sprayed plants before and after the spraying. LOQ = 33 µg/sample corrected to 20 L/minutes respiration rate. None of the samples were above LOQ.

Before spraying the plants, the dosage of paclobutrazol at respiration rate of 20 L/minute was in an eight hour period < 72 µg paclobutrazol. Immediately after spraying the dosage was < 273 µg paclobutrazol/8 hour at respiration rate 20 L/minutes, the sampling time was 58 minutes. 160 minutes after the spraying, the air was sampled for a period of 500 minutes which led to <32 µg/8 hour at respiration rate of 20 L/minute.

The air analyses did not at any instances show traces of paclobutrazol. This is partly due to the extreme low dosage used in the spraying and low vapour pressure.

DFR

Fig. 8.1 shows DFR of paclobutrazol on mini roses. LOQ = 0.25 µg paclobutrazol/50 cm² leaf, or 0.05 g paclobutrazol/1000 m² (=3.26% of initial spray dosage.

LOQ is reached after approximately 1000 minutes. Samples taken before and 1365 minutes after the spraying were far below LOQ. DFR at reentry (690 minutes after the spraying) was 0.44 µg paclobutrazol/50 cm². DFR values are only interesting for person no 3, who was working with the sprayed plants.

Exposure

Exposure was measured on a full body dosimeter on person no 3. Workers no 1, 2, 4 and 5 were only investigated for hand exposure. Worker no 3 had the finger tips on the gloves cut off in order to be able to manipulate the buds. Wash of bare hands with ethanol was done on worker no 3. Person no 3 made reentry to the sprayed plants 690 minutes after the spraying.

Fig. 8.2 illustrates the results. Persons no 1 and 2 were detected to be exposed far from LOQ.

Person no 3 was exposed to dosages around LOQ. The sum of paclobutrazol was 91.2 µg/8 hour.

Persons no 4 and 5 were also exposed near LOQ 63.2 to 73.6 µg paclobutrazol/8 h by moving tables, where some of the tables had been sprayed with paclobutrazol up to two weeks ago.

Air samples have been collected for persons 1, 2 and 3. None of the samples were above LOQ. The sampling time on persons 1 and 2 was 113 min. which leads to < 140 µg paclobutrazol/8 hours.
Person no. 3 was exposed to < 206 µg paclobutrazol/8 hours with a sampling time of 77 minutes.

The reason for these rather high levels is mainly due to the short working periods available in the experiment.

**Transfer coefficients**

Reentry for the person no 3 was done 690 minutes after the spraying. Fig. 8.1 shows DFR to be 0.44 µg paclobutrazol/50 cm².

Removing buds from mini roses resulted in exposure of 91.2 µg paclobutrazol/8 h, fig. 8.2.

Therefore, the transfer coefficient for this work is calculated to 91.2 µg x 50 cm²/8 h x 0.44 µg = 1295 cm²/h.

**Analysis of inactive media in the green house**

**Heating tubes**

Painted heating tubes were analysed for residues of paclobutrazol. The sampling area was 30 cm of a 4.2 cm diameter steel tube.

The samples were taken 165 minutes before spraying and 75 minutes and 990 minutes after the spraying. The first sampling after the spraying was done at the same place as before the spraying. The consecutive sampling was done at a new place.

Fig. 8.3 illustrates the residues found of paclobutrazol before and after the spraying. If the 31 µg paclobutrazol found before spraying is considered as an outlier (which of course might not be the case), the average concentration before spraying was 4.88 µg paclobutrazol/126 cm² and 3.17 µg paclobutrazol/126 cm² 990 minutes after the spraying, which is 27.6% and 17.9%, respectively, of the initial spray dosage. The findings looks relatively high, especially when taken in consideration that the tubes are placed at least 5 m away from the spray zone and exposed to heat and light. The same result has been found in experiment no 7. Paclobutrazol is used in small concentrations (dosage/area), but is rather stable in biologically inactive media.

**Tables**

The rim of the tables were analysed for spray deposits. The rim was constructed of aluminium profiles 15 cm high and 2.5 cm wide. Samples were taken on a 30 cm long piece of the rim. Horizontal area was 75 cm², vertical area 450 cm². Samples were taken 95 minutes before the spraying and 70 minutes and 1005 minutes after the spraying.
Samples taken 70 minutes after the spraying were taken at the same place as before the spraying. Samples taken 1005 minutes after the spraying were taken another place.

Fig. 8.4 illustrates the residues of paclobutrazol from the rim of the tables. The concentration of paclobutrazol before the spraying and 70 minutes after the spraying were below LOQ. This could be a reflection of the tables being washed frequently. 105 minutes after the spraying the concentration of paclobutrazol was well above LOQ.

Assuming the horizontal area receiving most of this residue: 1.5 µg paclobutrazol/75 cm² = 0.2 g paclobutrazol/1000 m² (= 13.1% of initial spray dosage).

Climatic conditions

The temperature in the greenhouse was on 11-08-1994, 01.00 am to 11-08-1994, 02.00 pm between 22-24°C. RH between 70-86%.

Light intensity in klux corrected for physical shadows and the percentage opening of two top mounted windows (average percentages) are illustrated in fig. 8.4. The light flux was relatively low, but the temperature rather high and the demand for ventilation is reflected in the lower curve.

Figure 8.1
DFR from paclobutrazol sprayed mini roses with a hydraulic spray boom.

DFR fra minirosen sprøjtet paclobutrazol med hydraulisk bomsprøje.
Figure 8.2
Exposure of 5 persons working in a greenhouse sprayed with paclobutrazol. The persons no. 1 and no. 2 were working with automatic spacing the mini rose pots on aluminium tables. Person no. 3 was removing buds from the mini roses. The persons no. 4 and no. 5 were moving the tables. The persons no. 1, 2, 4 and 5 were only measured for hand exposure. The person no. 3 had a full body dosimeter, but only hand exposure was observed.

Eksponering af 5 personer der arbejder i vækthus sprojet med paclobutrazol. Person nr 1 og 2 passer automatisk "stille-på-afstand". Person nr. 3 fjerner knopper fra minirosen. Person nr. 4 og 5 flytter borde. Personerne nr. 1, 2, 4 og 5 blev kun målt for håndeksponering. Person nr. 3 blev målt på hele kroppen men kun på hænderne blev der registreret eksponering.
**Figure 8.3**
Residues of paclobutrazol on painted heating tubes after spraying mini roses. Sampling 75 minutes after the spraying was done at the same place as before spraying. Sampling 990 minutes after spraying was done at different places.

Figure 8.4
Paclobutrazol residues on the table rim. Samples taken 70 minutes after the spraying were taken the same place as before the spraying. Samples taken 1005 minutes after the spraying were taken other places.


Figure 8.5
Light intensity in klux and percentage opening of the two top mounted windows (average percentage).
Lysintensitet i klux og procent åbning af vinduerne.
3.9 Experiment no. 9

Experiment started: 04-11-1994
Experiment finished: 07-11-1994

Abstract

Cultures of Begonia elatior were grown in plastic pots on aluminium tables and sprayed with endosulfan by cold fogging.

At reentry, 3785 minutes after the spraying, DFR was detected to be 3.87 µg endosulfan/100 cm².

Two working procedure were investigated. The production of cuttings for propagation purpose, resulted in a transfercoefficient of 2990 cm²/h. Packing Begonia elatior at the aluminium tables, resulted in a transfer coefficient of 2638 cm²/h. Geometric mean was used in calculation of the potential exposure/h.

The air above the plants at reentry contained 60 µg endosulfan/h at respiration rate of 20 L/minute, almost solely in the gas phase. Personal monitoring of air in the breathing zone at reentry was from 67% to 20% of the concentration of endosulfan measured above the plants at reentry.

At reentry, heating tubes, aluminium table rims, glass walls and curtains contained 0.17%, 0.98%, 0.13% and 2.4% of the initial spray dosage.

A ten fold difference in deposition on filterpapers of endosulfan was measured in this green house sprayed with cold fogger.

Spray data

Sprayed: 04-11-1994, 06.00 pm
Reentry after: 3785 minutes
Pesticide: Thiodan (35% endosulfan)
Spray equipment: Cold fogger, Twin star.
Nozzle type:  
Spray pressure:  
Position of spray equipment: The cold fogger was hung up 3 m above the floor at the end of the greenhouse. The spray equipment should cover the entire green house, 134 m deep.
Spray conc.: 0.387%
Spray volume: 30 L/1635 m² = 18.25 L/1000 m²
Spray dosage: 18.25 L x 0.387%/1000 m² = 71 g/1000 m²
Area sprayed: 1635 m²

Physical parameters of the green house

Area: 12.2 m x 134 m = 1635 m²
Cross section area: \((12.2 \, \text{m} \times 2.6 \, \text{m})+(12.2 \, \text{m} \times 2.9 \, \text{m} \times 0.5 \, \text{m})\) = 49.41 m\(^2\)

Volume: 49.41 m\(^2\) x 134 m = 6621 m\(^3\)

Fans: Yes

Top windows: Yes

Tables: Aluminium tables with thin rim was used in the green house

**Cultures**

The experiment was carried out in different varieties of Begonia elatior-hybride.

**Working procedure**

Two working procedures were investigated. The first procedure was the production of cuttings from Begonia elatior grown in pots. Nine persons were involved in this experiment. Other eight persons were manually packing the Begonia plants in plastic containers. The two working procedures were carried out in the same green house.

**Results**

**Air samples**

Air samples were taken 195 minutes before the spraying, during the spraying and 375 minutes, 1125 minutes, 1725 minutes, 2580 minutes, 3225 minutes and 3785 minutes after the spraying.

The air samplers were placed 1.6 m above the ground level in the middle of the green house. One sampler at a distance of 40 m and a second sampler 110 m from the cold fogger.

Fig. 9.1 and fig. 9.2 shows the results. The air samplers nearest to the cold fogger has registered the highest dosage in the first sampling period, 2278 \(\mu\)g endosulfan/h at 20 L/minutes respiration rate, almost 3 times higher than the samplers 110 m away from the sprayer. This is in agreement with the spray deposition from fig. 9.x. Particles and aerosols are the main fraction 40 m from the sprayer just after spraying, vice versa at 110 m from the sprayer. The second sampling 110 m away from the sprayer stopped after 144 minutes. Was programmed to be 750 minutes sampling time, see fig 9.1, 40 m away from the sprayer. The 144 minutes sample is taken in the beginning of the 750 minutes sampling period and naturally higher. The fourth sample 40 m away from the sprayer was lost.

**DFR**

Samples were taken 120 minutes before the spraying, 1005 minutes, 1575 minutes, 2430 minutes, 3075 minutes and 3660 minutes after the spraying. Twenty discs, each with an area of 5 cm\(^2\) were sampled evenly distributed.
Fig. 9.3 show the DFR. All results were above LOQ. The ratio of the two isomers \(\alpha\) and \(\beta\) endosulfan is 70:30 in the spray solution. The percentage of \(\alpha\)-isomers in the DFR samples was from 13% to 47%. This could indicate a faster uptake of \(\alpha\)-endosulfan compared to \(\beta\)-endosulfan either in the wax surface of the leaf or a deeper penetration.

(If one assume the relation between the \(\alpha\)-isomer and \(\beta\)-isomer still should be 70:30 in the DFR, an e.g. 20\% \(\alpha\)-isomer (2430 minutes after the spraying): 80\% \(\beta\)-isomer relation, the \(\alpha\)-isomer/\(\beta\)-isomer would be 186:80 (=70:30) and the total endosulfan \(186 + 80 = 267\) or 2.67 times the total found amount of endosulfan. Conclusively, DFR should at least be multiplied with 2.67 and will reduce the transfer coefficient proportional. It will be seen later on that the transfer coefficient is relatively high in this experiment compared to other similar experiments. The recovery of \(\alpha\)- and \(\beta\)-endosulfan from the water used to extract DFR were 84.2 and 76.6\%, respectively. The reason for the increase in DFR at reentry is not obvious. The use of DFR in this experiment should be done carefully.)

**Exposure**

**Cutters**
Exposure was measured on a full body dosimeter and some of the persons were equipped with air samplers.

The results are shown in fig. 9.4, and table 9.1. The exposure is relatively high in this experiment and characterised by exposure on the body ÷ hands.

This exposure is probably coming from the contact with the tables. All the time the workers are contacting the tables when working, both with the front and the back of the body. But the most important route of absorption is the hands, because they are unprotected, table 9.1. Effective protection of the hands in this type of work is rather impossible. The respiration exposure, fig. 9.5, is seen to be 5 times lower as measured above the sprayed plants at reentry. It does not look like an increase in exposure due to manipulation of the plants.

**Packers**
The results from the packers are illustrated in fig. 9.5, fig. 9.6 and table 9.2. The average load is higher compared to cutters. The body ÷ hands exposure is smaller. Geometric mean for hand exposure is at the same level as for cutters, but if one looks at the 90\% fractile for packers, it is almost 3 times as high. This illustrates the big variation in exposure on the hands in this working procedure. Respiration exposure, fig. 9.5, is 1/3 to 2/3 of the background level in this green house.

**Cutters and packers**
The potential exposure is 40 \% higher in the cutting procedure than the packing procedure. But if one calculate the actual exposure the picture is changed. The potential exposure on the hands are the same on the two procedures but if the 90\% fractile of the distribution is calculated, one can
see in table 9.1 and 9.2 that due to the great variation in results from packers hand exposure, the penetrated dosage is far bigger.

The distribution between the two isomers, $\alpha$- and $\beta$-endosulfan is illustrated in table 9.3. The ratio of $\alpha$- and $\beta$-endosulfan in the spray solution was 67.04% $\alpha$-endosulfan.

Table 9.3 illustrates a rather uniform ratio of $\alpha$-endosulfan on the body minus hands regardless of working procedure. The average ratio for $\alpha$-endosulfan is 84% for cutters and 86 for packers.

The reason for this might be different adsorption/transfer mechanisms between the isomers from the items contaminated in the green house and the worker.

The ratio on the hand exposure is on the other hand lower to almost the same relative degree. The results from DFR indicated a very low ratio for $\alpha$-endosulfan, maybe a more intense transfer to wax or plant sap. If one use this model on hands in table 9.3, the working procedure with the most intense contact with the plants gives the lowest $\alpha$-endosulfan ratio. Cutters are using their left hand manipulation the plants. The right hand carries a knife or they move the pots around with the right hand. Maybe this example illustrates the influence of the pesticide on the transfer coefficients.

The exposure via inhalation at reentry 3785 minutes after the spraying is for both samplers, fig 9.1 and fig 9.2, 60 $\mu$g endosulfan/h at a respiration rate of 20 L/minute. The exposure constitutes of the gas phase. Only few per cent particles and aerosols.

**Transfer coefficients**

As mentioned above, transfer coefficients for endosulfan consisting of two isomers, maybe behaving so differently so they actually should be regarded as two different pesticides.

It has been decided to try to define only one transfer coefficient for endosulfan for each working procedure. The transfer coefficients are only calculated on basis of hand exposure.

DFR is considered to be 3.87 $\mu$g endosulfan/100 cm² leaf area at reentry, fig. 9.3. DFR has unexpectedly increased at reentry but we have decided to use this DFR at reentry despite it seems peculiar! Again: The transfer coefficients derived from this DFR should be handled with care!

For cutters, the exposure was measured to 926 $\mu$g/8 h (geometric mean). Transfer coefficient is then:

$$926 \mu g \times 100 \text{ cm}^2/8 \text{ h} \times 3.87 \mu g = 2990 \text{ cm}^2/\text{h}.$$  

For packers, the exposure was measured to 817 $\mu$g/8 h (geometric mean). Transfer coefficients is then:

$$817 \mu g \times 100 \text{ cm}^2/8 \text{ h} \times 3.87 \mu g = 2638 \text{ cm}^2/\text{h}$$
Analysis of inactive media in the green house

Heating tubes

Painted heating tubes, horizontally mounted along an inner glass wall 1.2 m above the floor, were analysed for residues of endosulfan before and after the spraying. The sampling area was 120 cm² (tube diameter 4 cm, 30 cm long).

Before the spraying the tube was washed off with ethanol, 20 minutes later the same sample site was washed off again.

First sampling 960 minutes after the spraying was performed on the same site as before the spraying. Consecutive sampling 1620 minutes and 3640 minutes after the spraying, were done other places.

Fig. 9.7 illustrates the results. It is clearly demonstrated that the painted heating tubes retain residues of endosulfan after being rinsed with ethanol. Even after the second extraction before the spraying, approximately 1% of initial spray dosage is still to be extracted. The sampling done 960 minutes after the spraying amounts to 5.4% of initial spray dosage.

Tables

The rim of the tables were analysed for residues of endosulfan. The rim of the aluminium table was constructed of a flat piece of 11 cm high piece of aluminium. No horizontal surface except for a few mm. A 30 cm long piece of the rim, 330 cm², was washed with ethanol just before spraying and 980 minutes, 1605 minutes and 3630 minutes after the spraying. The first sample after the spraying was taken the same place as before the spraying. The consecutive samples were all taken in other places.

Fig. 9.8 illustrates the disappearance of endosulfan on the table rim. The plants have been sprayed with endosulfan one month before.

The rims washed off, were parallel to the spray direction and not directly exposed to the spray. But the first sample, despite the rim is placed vertical, received 2.7% of the initial spray dosage. A background level from the previous spraying was on average 12 µg endosulfan/330 cm² which accounts to 0.4% of initial spray dosage.

Glass walls

Glass walls were analysed for residues of endosulfan. 225 cm² squares were rinsed with ethanol. The samples were taken 1.4 m above the floor. The glass wall was analysed for residues of endosulfan before and after the spraying.

Before the spraying, the glass wall was rinsed off with ethanol twice, both times the same place. The first sampling 960 minutes after the spraying was done on the same site as before spraying. Consecutive samples 1635 minutes and 3660 minutes after the spraying was done at new places.
Fig. 9.9 illustrates the results. The first sample before the spraying was in average 1.16 µg endosulfan/250 cm², which is 0.073% of initial spray dosage. The second sample before spraying was well below LOD, which was 0.5 µg endosulfan/225 cm². In average the spray deposited 7.96 µg endosulfan/225 cm² (0.5% of initial spray dosage). 1635 minutes and 3660 minutes after the spraying, the total residues were 4.16 and 2.08 µg endosulfan/225 cm², respectively. The last two samples represent 0.26% and 0.13% of initial spray dosage, respectively. Contrary to the results from the painted heating tubes, it looks like (not surprisingly), that the first rinse with ethanol has removed most of the residues.

**Curtains**

Patches of curtain usually used for shadowing in green houses, were hung up vertically on the wall at four different distances from the spray equipment. The patches, 20 cm × 20 cm, hang 2.5 m above the floor. At 1060 minutes, 2430 minutes and 3735 minutes after the spraying one patch per site was removed for analysis.

Fig. 9.10 and fig. 9.11 illustrates the results. After nearly two days, the average reduction of residue amounts to 20%, fig. 9.10. Fig. 9.11 illustrates higher residues (depositions) near the cold fogger, decreasing to site no. 3, and a tendency to increasing residues in the far end of the green house. The reason for this is speculative. One could imagine a wave effect, the wave being stopped at the rear wall, but the results from the deposition experiment, although deposited at a lower level, does not support this mechanism. The average residues at the three sampling times compared to initial spray dosage were 2.5%, 2.2% and 2.0%, respectively. Compared to the glass wall residues, the residues found at reentry on the curtains were 15 times higher.

**Spray pattern**

Before the spraying, 10 filter papers were placed in level with the top of the Begonia culture. The filter papers were evenly distributed longitudinal in the green house, at a distance of one third of the width of the green house from the wall. The filter papers were collected the day after the spraying at 10.30 am.

Fig. 9.12 clearly illustrates the uneven distribution of endosulfan in the green house. There is a tenfold difference between the highest and the lowest concentration (dosage/area). In the middle of the green house was a construction 2.5 m high, probably a mayor coefficient in preventing the ventilators to distribute the fog evenly in the green house.

The average dosage on the 10 filter papers was 827.8 µg endosulfan/100 cm². The initial spray dosage was, as mentioned above, 71 g/1000 m² (=710 µg/100 cm²). The average dosage deposited is probably highest in the middle of the green house, but is not measured in this experiment. The uneven distribution seen here will naturally cause the same uneven exposure at reentry.
Climatic conditions

The temperature in the green house from 04-11-1994, 03.00 pm to 07-11-1994, 03.00 pm was between 21-24°C.

%RH was registered to be between 78-87%.

Light in klux and w/m² is illustrated on fig. 9.13.

Figure 9.1
Endosulfan in the air after spraying Begonia elatior with cold fogger.
Sampler placed 1.6 m above the ground 40 m away from the cold fogger.
Fourth sample was lost.

Endosulfan i luften efter sprøjting af Begonia elatior med koldtågesprøjte.
Prøveudtagning foretaget 1.6 m over gulv og 40 m fra koldtågesprøjte.
Fjerde prøve tabt.
Figure 9.2
Endosulfan in the air after spraying Begonia elatior with cold fogger.
Sampler placed 1.6 m above the ground 110 m away from the cold fogger.
Second sampling only lasted 144 minutes due to malfunctioning of the pump.

Figure 9.3
DFR from endosulfan sprayed Begonia elatior with cold fogger.

DFR fra endosulfansprøjtede Begonia elatior med koldtågesprøjte.
Figure 9.4
Exposure on nine persons manually cutting endosulfan sprayed Begonia elatior sprayed with cold fogger.

Eksponering af 9 personer som manuelt fremstiller stiklinger fra Begonia elatior sprøjtede med endosulfan.

Figure 9.5
Endosulfan in the air measured in the breathing zone of workers packing or cutting endosulfan sprayed Begonia elatior with cold fogger.

Endosulfan i luften målt i åndingszonen af personer som pakker eller laver stiklinger af koldtågesprojtede Begonia elatior.
Figure 9.6
Exposure on eight persons manually packing endosulfan sprayed Begonia elatior sprayed with cold fogger.

Eksponering af 8 personer som manuelt pakker endosulfansprøjtede Begonia elatior. Sprøjtringen udført med koldtågesprøjte.
Figure 9.7
Residues on heating tubes of endosulfan before and after spraying with cold fogger. Before the spraying, two sets of samples were taken the same place. The first sample after spraying was also taken the place as before spraying. Consecutive samples were taken other places.

Rester af endosulfan på varmerør før og efter sprøjting med koldtågesprøjte. Før sprøjtingen blev udtaget to prøver det samme sted. Den første prøve efter sprøjtingen blev ligeledes taget det samme sted. De følgende prøver blev udtaget forskellige steder.
μg endosulfan on 330 cm²
central table rim

Figure 9.8
Residues of endosulfan on aluminium tables sprayed with a cold fogger. Samples before spraying and first sample after spraying taken the same place. Consecutive sampling performed other places.

Rester af endosulfan på bordkanter før og efter sprøjning med koldtågesprøjte. Før sprøjningen og første prøve efter sprøjningen blev taget det samme sted. De følgende prøver blev udtaget forskellige steder.
Figure 9.9
Residues of endosulfan on glass walls before and after spraying with cold fogger. Before spraying, two sets of samples were taken the same place. The first sample after the spraying was also taken this place. Consecutive samples were taken other places.

Rester af endosulfan på glasvægge før og efter sprøjting med koldtågesprøjte. Før sprøjtingen blev udtaget to prøver det samme sted. Den første prøve efter sprøjtingen blev ligeledes taget det samme sted. De følgende prøver blev udtaged forskellige steder.
Figure 9.10
Deposition and disappearance of endosulfan from plastic curtains exposed to cold fogger sprayer. Four sampling sites at different distances from the sprayer.

Afsætning og fund af endosulfan fra plastkyggegardiner eksponeret for endosulfan udsprøjet med koldtågesprøjte. Fire udtagningssteder i forskellig afstand fra sprøjteudstyret.
Figure 9.11
Deposition and disappearance of endosulfan from plastic curtains exposed to cold fogger sprayer. Four sampling sites at different distances from the sprayer.

Afsættning og fund af endosulfan fra plastskyggegardiner eksponeret for endosulfan udsprojet med koldtågesprojet. Fire udtagningssteder i forskellig afstand fra sprojetudstyret.
Figure 9.12
Longitudinal distribution of endosulfan by cold fogger in one side of the green house. Deposited endosulfan related to initial spray dosage (=71 g/1000 m²). Average deposited on 10 pieces of 100 cm² filter paper = 82.8 g/1000 m²).

Langsgående fordeling af endosulfan sprøjtet med koldtågesprøjte i den ene side af væksthus. Afsat dosis sat i forhold til udsprøjtet dosis (=71 g/1000 m²). Gennemsnitlig afsat dosis på 100 cm² = 82.8 g/1000 m².

Figure 9.13
Light in klux (measured inside the green house) and w/m² after the spraying.

Lysintensitet i klux (målt inde i væksthuset) og w/ m² efter sprøjting.
Table 9.1  
Eight hours potential exposure in µg of endosulfan for nine persons cutting Begonia elatior, geometric mean, 90% fractile and a suggested penetration to the skin leading to actual exposure. For “Body÷hands”, “Hands” and “Total”, geometric means, s and 90% fractile are calculated on the numbers from the individual body parts. n=9, f=8.  

Otte timers potentiel eksponering i µg endosulfan for 9 personer der fremstiller stiklinger af Begonia elatior, geometrisk gennemsnit, 90% fraktil, en foreslået penetrering igennem arbejdsbeklædning samt følgende hudeksponering. For “Krop÷hænder”, “Hænder” og “Total” er geometrisk gennemsnit, s og 90%-fraktil beregnet på deltallene fra de enkelte kropsdele. n=9, f=8.

<table>
<thead>
<tr>
<th></th>
<th>Geom. mean</th>
<th>Log s</th>
<th>90% fract.</th>
<th>Penetration</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right arm</td>
<td>202.57</td>
<td>0.163</td>
<td>406.4</td>
<td>5%</td>
<td>20.32</td>
</tr>
<tr>
<td>Left arm</td>
<td>303.01</td>
<td>0.339</td>
<td>1292.9</td>
<td>5%</td>
<td>64.65</td>
</tr>
<tr>
<td>Chest</td>
<td>582.61</td>
<td>0.207</td>
<td>1416.4</td>
<td>5%</td>
<td>70.82</td>
</tr>
<tr>
<td>Back</td>
<td>493.09</td>
<td>0.132</td>
<td>868.6</td>
<td>5%</td>
<td>43.43</td>
</tr>
<tr>
<td>Hip</td>
<td>241.32</td>
<td>0.150</td>
<td>458.9</td>
<td>5%</td>
<td>22.95</td>
</tr>
<tr>
<td>Right leg</td>
<td>331.85</td>
<td>0.109</td>
<td>528.8</td>
<td>5%</td>
<td>26.44</td>
</tr>
<tr>
<td>Left leg</td>
<td>319.59</td>
<td>0.082</td>
<td>454.5</td>
<td>5%</td>
<td>22.73</td>
</tr>
<tr>
<td>Right hand</td>
<td>297.82</td>
<td>0.160</td>
<td>591.8</td>
<td>100%</td>
<td>591.8</td>
</tr>
<tr>
<td>Left hand</td>
<td>607.73</td>
<td>0.221</td>
<td>1568.1</td>
<td>100%</td>
<td>1568.1</td>
</tr>
<tr>
<td>Body-hands</td>
<td>2569.29</td>
<td>0.149</td>
<td>4855.6</td>
<td>5%</td>
<td>242.78</td>
</tr>
<tr>
<td>Hands</td>
<td>925.68</td>
<td>0.175</td>
<td>1955.7</td>
<td>100%</td>
<td>1955.7</td>
</tr>
<tr>
<td>Total</td>
<td>3586.66</td>
<td>0.114</td>
<td>5844.7</td>
<td>(37.6%)</td>
<td>2197.78</td>
</tr>
</tbody>
</table>
Table 9.2
Eight hours potential exposure in µg of endosulfan for eight persons packing Begonia elatior, geometric mean, 90% fractile and a suggested penetration to the skin leading to actual exposure. For “Body + hands”, “Hands”, “Hands” and “Total”, geometric mean, s and 90% fractile are calculated on the numbers from the individual body parts. n=8, f=7.

<table>
<thead>
<tr>
<th></th>
<th>Geom. mean</th>
<th>Log s</th>
<th>90% fract.</th>
<th>Penetration</th>
<th>Dosage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right arm</td>
<td>130.62</td>
<td>0.139</td>
<td>240.4</td>
<td>5%</td>
<td>12.00</td>
</tr>
<tr>
<td>Left arm</td>
<td>133.97</td>
<td>0.074</td>
<td>185.6</td>
<td>5%</td>
<td>9.28</td>
</tr>
<tr>
<td>Chest</td>
<td>261.40</td>
<td>0.105</td>
<td>412.9</td>
<td>5%</td>
<td>20.65</td>
</tr>
<tr>
<td>Back</td>
<td>280.46</td>
<td>0.138</td>
<td>513.0</td>
<td>5%</td>
<td>25.65</td>
</tr>
<tr>
<td>Hip</td>
<td>229.07</td>
<td>0.262</td>
<td>720.5</td>
<td>5%</td>
<td>36.03</td>
</tr>
<tr>
<td>Right leg</td>
<td>194.28</td>
<td>0.123</td>
<td>332.5</td>
<td>5%</td>
<td>16.63</td>
</tr>
<tr>
<td>Left leg</td>
<td>195.41</td>
<td>0.104</td>
<td>308.0</td>
<td>5%</td>
<td>15.40</td>
</tr>
<tr>
<td>Right hand</td>
<td>398.83</td>
<td>0.457</td>
<td>2938.6</td>
<td>100%</td>
<td>2938.60</td>
</tr>
<tr>
<td>Left hand</td>
<td>408.24</td>
<td>0.403</td>
<td>2379.0</td>
<td>100%</td>
<td>2379.00</td>
</tr>
<tr>
<td>Body-hands</td>
<td>1494.29</td>
<td>0.048</td>
<td>1844.5</td>
<td>5%</td>
<td>92.23</td>
</tr>
<tr>
<td>Hands</td>
<td>817.48</td>
<td>0.426</td>
<td>5266.0</td>
<td>100%</td>
<td>5266.00</td>
</tr>
<tr>
<td>Total</td>
<td>2560.13</td>
<td>0.190</td>
<td>5876.9</td>
<td>(91.2%)</td>
<td>5358.23</td>
</tr>
</tbody>
</table>

Table 9.3
% α-endosulfan in samples from body dosimeter from cutters and packers.

Procent α-endosulfan i prøver fra kropsdosimeteret fra personer som fremstillar stiklinger og pakker Begonia elatior.

<table>
<thead>
<tr>
<th></th>
<th>Cutters</th>
<th>Packers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg.:</td>
<td>Std.</td>
</tr>
<tr>
<td>Right arm</td>
<td>85.94</td>
<td>3.5</td>
</tr>
<tr>
<td>Left arm</td>
<td>79.21</td>
<td>27</td>
</tr>
<tr>
<td>Chest</td>
<td>81.40</td>
<td>5.3</td>
</tr>
<tr>
<td>Back</td>
<td>84.94</td>
<td>3.9</td>
</tr>
<tr>
<td>Hip</td>
<td>78.75</td>
<td>4.5</td>
</tr>
<tr>
<td>Right leg</td>
<td>86.20</td>
<td>6.6</td>
</tr>
<tr>
<td>Left leg</td>
<td>89.11</td>
<td>2.8</td>
</tr>
<tr>
<td>Right hand</td>
<td>50.29</td>
<td>6.5</td>
</tr>
<tr>
<td>Left hand</td>
<td>42.27</td>
<td>3.3</td>
</tr>
</tbody>
</table>
3.10 Experiment no. 10

Experiment started: 02-06-1995  
Experiment finished: 05-06-1995

Abstract

Cultures of Begonia elatior were grown in plastic pots on aluminium tables and sprayed with endosulfan by cold fogging

The experiment should be seen in conjunction with experiment no 9, but performed during the summer season.

Air samples were taken during the spraying and after the spraying. Gasses constitutes the largest fraction in the samples. Particles and aerosols was only 7.8% 945 after the start of the spraying. The results as a whole are looking like the air samples taken in the winter season.

Spray data

Sprayed: 02-06-1995, 06.15-09.15 pm  
Reentry after: No reentry  
Pesticide: Thiodan (35% endosulfan)  
Spray equipment: Cold fogger, Twin Star  
Nozzle type:  
Spray pressure:  
Position of spray equipment: The cold fogger was hung up 3 m above the floor at the end of the green house. The spray equipment should cover the entire green house, 134 m deep

Spray conc.: 0.387%  
Spray volume: 30 L/1635 m² = 18.25 L/1000 m²  
Spray dosage: 18.25 L x 0.387%/1000 m² = 71 g/1000 m²  
Area sprayed: 1635 m²

Physical parameters of the green house

Area: 12.2 m x 134 m = 1635 m²  
Cross section area: (12.2 m x 2.6 m)+(12.2 m x 2.9 m x 0.5 m) = 49.41 m²  
Volume: 49.41 m x 134 m = 6621 m³  
Fans: Yes  
Top windows: Yes  
Tables: Aluminium tables with thin rim was used in the green house

Cultures
The experiment was carried out in different varieties of Begonia elatior-hybride.

Results

Air samples

The sampler was placed in the middle of the green house, 1.7 m above the floor.

Only air samples have been made in this experiment. Sampling was done during the first 60 minutes of the spraying which lasted 180 minutes. Nothing was registered in this sample (LOQ = 2 µg/sample).

The next sampling started 60 minutes after starting the spraying and 300 minutes forward. This sample was in this way taken when the sprayer still was spraying for 120 more minutes plus 180 minutes. Three samples were taken 945 minutes, 2395 minutes and 3835 minutes after starting the spraying.

The results are illustrated in fig. 10.1.

The levels of the sum of α- and β-endosulfan is almost the same as seen in experiment 9 six month earlier with endosulfan. Similar is also the disappearance of the sum of endosulfan and the disappearance of particles and aerosols.

Climatic conditions

In the period 02-06-1995, 06.00 pm to 05-06-1995, 10.00 am, the temperature and %R.H. in the green house varied between 21-22°C and 56-90% R.H., respectively.

The solar energy in w/m² and the % opening of the windows are illustrated in fig. 10.2.
Figure 10.1
Endosulfan in the air after spraying Begonia elatior with cold fogger. 
LOQ = 2 µg/sample.

Endosulfan i luften efter sprøjtning af Begonia elatior med koldtågesprøjte. 
LOQ = 2 µg/prøve.

Figure 10.2
Light intensity in w/m² and % opening of the windows.

Lysintensitet i w/ m² og procent åbning af vinduerne.
3.11 Experiment no. 11

Experiment started: 29-09-1995
Experiment finished: 02-10-1995

Abstract

Cultures of different varieties of ornamental flowers, among them Dracaena marginata and Codiaeum variegatum, were grown in plastic pots on aluminium tables.

At reentry, 3465 minutes after the spraying of methomyl with a cold fogger, DFR was detected to be 1.56 µg methomyl/100 cm² leaf and 2.2 µg methomyl/50 cm² leaf on the respective two plant species mentioned.

Two workers were while standing at the aluminium tables, manually cleaning the plants for withered leaves and packing the plants in card board boxes. No methomyl (<20 µg methomyl/8 h) could be detected on the hands, therefore no transfer coefficient was calculated. The rest of the body was exposed to 246 µg and 1150 µg methomyl/8 h packing the respective plant species.

Air samples from the green house at reentry was in the range of 3 µg methomyl/h at a respiration rate of 20 L/minute. The personal monitoring of methomyl in the breathing zone at reentry, was below LOQ due to a too short working period.

The disappearance of methomyl on heating tubes and plastic curtains after the spraying, could not be demonstrated in the experiment. 6.25% and 0.8% of the initial spray dosage was still present at reentry on the heating tubes and plastic curtains respectively.

930 minutes after the spraying, filter papers were collected from the tables in order to demonstrate the distribution of the deposition of methomyl. Only 19% of the initial spray dosage was recovered. A 5.6-fold difference of deposition could be registered in the green house.

Spray data

Sprayed: 29-09-1995, 06.15 pm - 09.15 pm
Reentry after: 3465 minutes after the spraying
Pesticide: Lannate 20 L (20% methomyl)
Spray equipment: Cold fogger, Twin Star
Nozzle type: No 92
Spray pressure:

Position of spray equipment: The cold fogger was a twin-nozzle type and placed in the middle of the green house, spraying in longitudinal direction with each nozzle in opposite direction.

Spray conc.: 750 ml x 20% x 1000/25 L = 6 ‰
Spray volume: 25 L/2000 m² = 12.5 L/1000 m²
Spray dosage: 12.5 L x 6 ‰/1000 m² = 75 g/1000 m²
Area sprayed:

Physical parameters of the green house

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area:</td>
<td>100 m x 20 m = 2000 m²</td>
</tr>
<tr>
<td>Cross section area:</td>
<td>(3 m x 20 m) + (4.6 m x 20 m x 0.5) = 106 m²</td>
</tr>
<tr>
<td>Volume:</td>
<td>106 m² x 100 m = 10600 m³</td>
</tr>
<tr>
<td>Fans:</td>
<td>Yes</td>
</tr>
<tr>
<td>Top windows:</td>
<td>Yes</td>
</tr>
<tr>
<td>Tables:</td>
<td>Aluminium tables, 1.6 m x 9.13 m, packed close together. The tables were lined up in two rows each row along one of the side walls in the green house.</td>
</tr>
</tbody>
</table>

Cultures

In the green house was growing a variety of different ornamental plant species, mainly imported cuttings. The working procedures in the experiment mainly dealt with two types, different varieties of Dracaena marginata with narrow and the long leaves and the broad leaf species Codiaeum variegatum 'Aucubaefolia'.

Working procedure

The two species were grown in plastic pots on the aluminium tables. From here they were manually packed in cardboard boxes. While packing the plants, the workers removed wilted leaves from the pots and the plants. The body of the workers were physically in close contact with the tables while packing.

Results

Air samples

The air sampler was placed in the middle of the green house, 1.7 m above the floor, and 24 m away from the two nozzles, approximately 25 m from the spray equipment. Air samples were taken before the spraying and 240 minutes (while the spraying was done plus 60 more minutes), 360 minutes, 720 minutes, 1185 minutes, 2645 minutes and 4081 minutes after the start of the spraying.

LOQ was 3 µg methomyl/sample. Nothing could be detected before the spraying. Fig. 11.1 illustrates the findings. The air sample taken while the spraying was performed plus 60 minutes more, showed large quantities of methomyl in the filter indicating particles and aerosols. 60 minutes after the sprayer was stopped (the sample taken from 240 minutes to 360 minutes after start of the spraying), nothing was found in the filter. This is in good agreement with findings in experiment no 12. At reentry gasses of
methomyl were detected in the range of 3 µg/h at a respiration rate of 20 L/minute.

DFR

Leaf samples for DFR analysis were taken for both plant species, Dracaena marginata and Croton variegatum. D. marginata was impossible to punch due to high fibre contents. In stead of taking samples by punching, the area of this slim leafed plant was measured manually. 100 cm² leaf was used in the analysis for D. marginata, 50.9 cm² (20 pieces, 2.54 cm diameter punches) for C. variegatum.

Both species were analysed before the spraying. D. marginata was analysed 1020 minutes, 2490 minutes and 3555 minutes after the spraying. C. variegatum was analysed 975 minutes, 2495 minutes and 3497 minutes after the spraying.

The results are illustrated in fig. 11.2 and fig. 11.3.

The DFR measured on D. marginata was at re-entry 1.56 µg methomyl/100 cm² in average of four samples. This figure corresponds to 0.156 g methomyl/1000 m² (=0.2% of initial spray dosage). The DFR measured on C. variegatum was 2.2 µg methomyl/50.9 cm² at re-entry, as an average of four samples. Similar this corresponds to 0.43 g methomyl/1000 m² (=0.57% of initial spray dosage). The relatively low findings are probably due to the systemic property of this pesticide.

DFR determined by gently removing pesticides by washing the sprayed leaves with water, is an attempt to express the loose bound residues after the spraying. There is no doubt that DFR is pesticide- and plant species specific. Pesticides have different polarity, plants have different degrees of wax covering the leaf surface, etc.

It has been tried in this experiment to use another method for DFR, a more gentle way of removing residues from the surface of the leaf. A hand covered with a cotton glove was gently sweeping on the surface of the leaves. One stroke with the hand was 50-60 cm, 80 stroke/minutes and sampling time 10 minutes The sampling was done on both plant species. 3555 minutes after the spraying. LOQ was 30 µg/glove. Not even traces around LOD were detected. DFR made by washing the leaf with water was in the area of 2-4 µg methomyl/100 cm² and 30 µg methomyl represents only 700-1500 cm². The results indicate that the washing and punching procedure removes more residues from the leaf than is loosely present on the surface when spraying with methomyl, probably due to the systemic properties of methomyl.

Exposure

3465 min after the spraying, re-entry was done in the sprayed green house. The results are illustrated on fig. 11.4 and fig. 11.5.
Nothing could be detected on the hands of the two persons. LOQ for gloves was 20 µg methomyl/8 h.

The exposure originates from body contact with tables when packing. The systemic insecticide methomyl has already penetrated the surface of the leaves and is not accessible only by contacting the plants.

If a penetration factor of 5% is assumed for body + hands, the exposure on the body is rather low, 57 µg methomyl/8 h and 12 µg methomyl/8 h for packing Croton spp. and D. marginata, respectively. The variations in these figures are rather an individual variation in a green house sprayed with such an uneven distribution as the cold fogger.

The air was monitored in the breathing zone of the two persons re-entering the green house 02-09-1995. The sample time was 410 minutes and 459 minutes respectively. Not even traces of methomyl was detected, mainly due to the relatively short sampling period. Detection of methomyl in the background seen in fig. 11.1, was due to a much longer sample period.

**Transfer coefficients**

Transfer coefficients are calculated to zero due to not detected exposure on the hands. This is probably a pesticide specific case.

**Analysis of inactive media in the green house**

**Heating tubes**

Heating tubes were mounted in the middle of the green house, 2.2 m above the floor. They were rinsed with ethanol in order to remove any residues before the spraying. The residues were detected to be 3.4 µg methomyl/144.9 cm², horizontal cross section of the tube, as an average of four sampling sites. A control rinse 60 minutes later was detected to be 2.4 µg methomyl/144.9 cm². All samples taken after the spraying was taken on places rinsed before the spraying. Samples after spraying were taken 945 minutes, 2475 minutes and 3490 minutes after spraying. There were two sampling sites in the direction of each of the two spray directions. In one direction the sample sites were placed 39 m and 22 m from the nozzle, in the opposite spray direction the sample sites were placed at a distance of 12 m and 42 m from the nozzle.

Fig. 11.6 illustrates the results of the residue analysis. It is clearly demonstrated that the disappearance of methomyl on the heating tubes is extremely slow. It is also seen from fig. 11.6 that there is a rather good correlation between distance from the sprayer and deposition on the sample sites. 79.3 µg methomyl/144.9 cm² calculated average 945 minutes after the spraying corresponds to 5.47 g/1000 m² (= 7.3% of the initial spray dosage).

**Curtains**

Pieces of plastic curtain, 20 cm x 20 cm were mounted vertically along one of the side walls in the glass house, parallel to the spray direction, 1.4 m
above the floor. The distance between the sprayer and the glass wall was 10 m (=middle of the green house). Four sample sites, two on each side in the spray direction as described for heating tube sampling. The distances from the sprayer were in the one spray direction 40 m and 15 m and in the other direction the distance was 22 m and 12 m.

Fig. 11.7 illustrates the findings. As seen for residues on heating tubes fig. 11.6, the disappearance of methomyl is not obvious in this experiment. The variation between the replicates is also much smaller than it has been observed on residues on the heating tubes. The reason is obvious, the curtain patches were not placed in the direction of the sprayer but 10 m parallel aside. 24.5 µg methomyl/400 cm² patch is equal to 0.6 g methomyl/1000 m² (=0.8% of initial spray dosage).

Spray pattern

Two rows of filter papers (one row on each row of tables, see fig. 11.8), were placed on pots, in level with the top of the plants. The filter papers were collected for analysis 930 minutes after the spraying.

Fig. 11.8 shows the positions of the filter papers and fig. 11.9 the deposited pesticide on the filter papers in percentage of average deposition. The average deposited methomyl was 90.72 µg methomyl/63.62 cm² which corresponds to 14.26 g methomyl/1000 m² (=19% of the initial spray dosage).

It is clearly illustrated in fig. 11.9, that the highest deposition in both spraying directions is at filter paper no 3 and no 18. The cold fogger was presumably turned a little bit to the left, resulting in this skew distribution.

Climatic conditions

The temperature in the green house and R.H. during the experiment was registered to be 21-27°C and 64-86 %RH, respectively. Solar energy and % opening of the windows is illustrated in fig. 11.10
**Figure 11.1**
*Methomyl in the air while spraying and after spraying with a cold fogger. No particles and aerosols detected after the first sampling*

*Methomyl i luften under sprojtning og efter sprøjting med koldtågesprøjte. Ingen partikler eller aerosoler påvist efter den første prøveudtagning.*

**Figure 11.2**
*DFR from methomyl sprayed on C. variegatum. Sprayed with cold fogger.*

*DFR af methomyl sprøjtet på C. variegatum med koldtågesprøjte.*
Figure 11.3
DFR from methomyl sprayed D. marginata. Sprayed with cold fogger.

DFR af methomyl sprøjtet på D. marginata med koldtågesprøjte.

% exposure packing mostly Croton spp.
for 8 h. Total exposure = 1150 µg methomyl

Figure 11.4
Exposure of methomyl on the body of one person packing mostly C. variegatum after spraying the green house with cold fogger.

Fordeling af eksponering af methomyl på kroppen af 1 person der pakker fortrinsvis C. variegatum efter sprøjtning med koldtågesprøjte.
Figure 11.5
Exposure of methomyl on the body of one person packing mostly D. marginata after spraying the green house with cold fogger.

Fordeling af eksponering af methomyl på kroppen af 1 person der pakker fortrinsvis D. marginata efter sprøjtning med koldtågesprøjte.
Figure 11.6
Deposition and disappearance of methomyl on heating tubes placed at different distances in meters from the cold fogger.

Afssætning og fund af methomyl på varmerør i forskellig afstand fra koldtågesprøjte.
Figure 11.7
Deposition and disappearance of methomyl on plastic curtains placed at 16 m to 41 m distance from cold fogger.

Afsætning og fund af methomyl på plastskyggegardiner i forskellig afstand fra koldtågesprøjte.

Filter paper no:

<table>
<thead>
<tr>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th></th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
</tbody>
</table>

Figure 11.8
Horizontal cross section of green house. Length 100 m, width 20 m. C.f. = cold fogger. Numbers are numbers on filter papers placed for measuring deposition. Filter papers placed equidistant from each other. See fig. 11.9.

Horisontalt snit af væksthus. Længde 100 m, bredde 20 m. C.f. = koldtågesprøjte. Tallene indikerer placering af filterpapir til afærtningsmålinger. Se fig. 11.9. Filterpapirerne er placeret med ens indbyrdes afstand.
Figure 11.9
Deposited methomyl after spraying with cold fogger in greenhouse. “Filter paper no”, see fig. 11.8

Afsat methomyl efter sprøjting med koldtågesprøjte i væksthus.
“Filterpapir nr.” se fig. 11.8.
Figure 11.10
Solar energy in w/m² measured outside the green house and % opening of the windows.

Solenergi i w/m² målt uden for vækthuset og procent åbning af vinduerne.
3.12 Experiment no. 12

Experiment started: 20-10-1995
Experiment finished: 26-10-1995

Abstract

In the green house was grown a variety of ornamentals, mainly imported cuttings. Polyscias balfouriana was the dominating specie. The plants were sprayed with methomyl using a cold fogger.

At reentry, 7800 minutes after the spraying, DFR on P. balfouriana was 2.7 µg methomyl/50.9 cm².

Two workers standing at the aluminium tables with the sprayed plants, were removing wilted leaves from the plants and manually packing in card board boxes. Two different plant species were handled by the respective two workers. Packing P. balfouriana or Cordyline purple resulted in the respective transfer coefficients 8.2 cm²/h and 10.1 cm²/h.

Air samples 1155 minutes before reentry (sample period 2805 minutes) indicated a concentration of less than 4 µg methomyl/h at a respiration rate of 20 L/minute. Personal air monitoring showed < 10 µg methomyl/435 minutes at a respiration rate of 20 L/minute.

Heating tubes were rinsed with ethanol and analysed for methomyl. 8040 minutes after the spraying no significant disappearance of methomyl could be detected. At reentry 3.3 g methomyl/1000 m² (=4% of the initial spray dosage) could still be detected.

840 minutes after the spraying filter papers were collected in order to investigate the distribution of the spraying. 11.9% of the initial spray dosage was recovered. The difference between the highest and the lowest concentration deposited was a factor of 4.3.

Spray data

Sprayed: 20-10-1995, 06.00 pm-09.00 pm
Reentry after: 7800 minutes
Pesticide: Lannate 20 L(20% methomyl)
Spray equipment: Cold fogger, Twin Star
Nozzle type: No 92
Spray pressure: -
Position of spray equipment: The cold fogger was a twin-nozzle type and placed in the middle of the green house, spraying in longitudinal direction with each nozzle in the opposite direction.

Spray conc.: 750 ml x 20%/25 L = 6 %
Spray volume: 25 L/1800 m² = 13.9 L/1000 m²
Spray dosage: 13.9 L x 6 %/1000 m² = 83.4 g/1000 m²
Area sprayed: 1800 m²

Physical parameters of the green house

Area: 100 m x 18 m = 1800 m²
Cross section area: (18 m x 3.1 m) + (4.9 m x 0.5 x 18 m) = 99.9 m²
Volume: 100 m x 99.9 m² = 9990 m³
Fans: Yes
Top windows: Yes
Tables: 8 m x 1.6 m aluminium tables. The tables were arranged in four groups, separated by a middle and a transverse passage. The fourth group of tables included a canteen, 11.8 m x 8 m x 2.3 m, see fig 12.6.

Cultures

In the green house was growing a variety of different plant species, mainly imported cuttings. The dominating specie was Polyscias balfouriana on which DFR was determined.

Working procedure

Two persons were manually packing either Polyscias balfouriana or Cordyline purple grown in plastic pots, at the aluminium tables. Wilted leaves were removed when packing.

Results

Air samples

Air samples before spraying were not taken. The air sampler was placed 1.8 m above the floor in the middle of the green house, 26 m away from one of the two nozzles. The samples were taken while the spraying was done, 240 minutes, 480 minutes, 960 minutes, 2400 minutes, 3840 minutes and 6645 minutes after the spraying. The results are illustrated in fig 12.1. 60 minutes after the spraying the air contained 18% particles and aerosols of the total methomyl detected. But the consecutive samples did only consist of methomyl gasses. At reentry, 7800 minutes after start of spraying, the air still contained 4 µg methomyl/h at 20 L respiration/minute.

DFR

DFR was measured on P. balfouriana 180 minutes before the spraying and no methomyl was detected. 840 minutes, 3810 and 7965 minutes after spraying DFR was measured and the results are illustrated in fig. 12.2. At reentry 7800 minutes after the spraying, the average DFR was detected to
be 2.7 µg methomyl/50.9 cm². 30 µg methomyl/50.9 m² corresponds to 5.9 g methomyl/1000 m² (=7.1% of the initial spray dosage).

**Exposure**

Re-entry was made 7800 minutes after the spraying. Full body dosimeter was used to measure exposure. The results are seen in fig. 12.3. and fig. 12.4.

Practically nothing is measured on the hands and only 146 µg methomyl and 285 µg methomyl were detected on the remaining parts of the body when manually packing P. balfouriana or C. purple respectively.

The two persons packing, were carrying personal air monitors. LOQ was 10 µg methomyl/sample. The air was monitored for 435 minutes for both persons. No methomyl could be detected in this sampling period.

**Transfer coefficients**

Probably due to the systemic property of methomyl, very little residues were measured on the hands. The transfer coefficient is only calculated based on hand exposure. Transfer coefficient based on DFR of P. balfouriana.

Packing mainly P. balfouriana:

\[ 3.5 \mu g \times 50.9 \text{ cm}^2 / 2.7 \mu g \times 8 \text{ h} = 8.2 \text{ cm}^2/\text{h}. \]

Packing mainly C. purple:

\[ 4.3 \mu g \times 50.9 \text{ cm}^2 / 2.7 \mu g \times 8 \text{ h} = 10.1 \text{ cm}^2/\text{h}. \]

The transfer coefficients for manually packing these two plant species sprayed with methomyl was practically zero.

**Analysis of inactive media in the green house**

**Heating tubes**

Heating tubes with an outside diameter of 7.61 cm, were placed along the glass wall in the green house, 2.15 m to 2.5 m above the floor. Before the spraying all consecutive sampling sites were rinsed with ethanol. When the tubes were dry after rinsing, a new rinse was performed in order to measure any residues after the first rinse. 855 minutes, 3800 minutes and 8040 minutes after the spraying, the tubes were rinsed new places every time.

The results are illustrated in fig. 12.5.

The average residues in the first ethanol rinse were 14.7 µg methomyl/152.2 cm² tube. The second rinse 15.7 µg methomyl/152.2 cm². This illustrates an incomplete extraction of the painted heating tubes. The residues after the spraying does not decline significantly with time. 50.7 µg methomyl/152.2
1 cm² corresponds to 3.3 g methomyl/1000 m² (=4.0% of the initial spray dosage).

**Spray pattern**

Two rows of filter papers, one row on each row of tables (see fig. 12.6), were placed on pots in level with the top of the plants. The filter papers were collected 840 minutes after the spraying. The deposited methomyl is illustrated on fig. 12.7. It is seen in fig. 12.7 that filter paper 3 to 5 have the highest dosage. The difference between the highest and lowest dosage is a factor of 4.3.

The average residue was equal to 9.89 µg methomyl/1000 m² and corresponds to 11.9% of the initial spray dosage.

**Climatic conditions**

The temperature in the green house varied between 20-27°C, and % RH varied between 65-90%. The windows were closed during the experiment.

Light intensity in klux after start of the spraying is illustrated in fig. 12.8.
Figure 12.1
Methomyl in the air while spraying and after spraying with a cold fogger.

Methomyl i luften under og efter sprøjtning med koldtågesprøjte.

Figure 12.2
DFR from methomyl sprayed Polyscia balfouriana with a cold fogger.

DFR af methomyl sprøjet på Polyscia balfouriana med koldtågesprøjte.
Figure 12.3
Exposure of methomyl on the body of one person manually packing mainly Polyscia balfouriana after spraying with a cold fogger.

Eksponering af kroppen med methomyl på 1 person der manuelt pakker fortrinsvis Polyscia balfouriana efter sprøjtning med koldtågesprøjte.
Figure 12.4
Exposure of methomyl on the body of one person manually packing mainly Cordyline purple spraying with a cold fogger.

Eksponering af kroppen med methomyl på 1 person der manuelt pakker fortrinsvis Cordyline purple efter sprøjting med koldtågesprøjte.
Figure 12.5
Deposition and disappearance of methomyl on heating tubes after spraying with cold fogger.

Afsetning og fund af methomyl på varmerør efter sprojning med koldtågesproje.

Figure 12.6
Horizontal cross section of green house with four groups of tables and a canteen. Length = 100 m. Width = 18 m. C.f. = cold fogger. The distance between the filter paper approximately 7-8 meters and equidistant from each other.

Horisontalt snit af væksthus med 4 grupper af borde og en kantine. Længde 100 m, bredde 18 m. C.f. = koldtågesproje. Tallene indikerer placering af filterpapir til afsætningsmålinger. Se fig. 12.7. Filterpapirerne er placeret med 7-8 meters afstand.
Figure 12.7
Deposited methomyl on filter papers (see fig. 12.6 for position of filter papers) 840 minutes after spraying with cold fogger.

Afsat methomyl 840 minutter efter sprøjtning med koldtågesprøjte i væksthus. “Filterpapir nr.” se fig. 12.6.

Figure 12.8
Light intensity in the greenhouse after start of the spraying.

Lysintensitet i vækshuset efter sprøjting
3.13 **Experiment no. 13**

Experiment started: 21-04-1995  
Experiment finished: 24-04-1995

**Abstract**

Cultures of *Dendranthema indicum-hybride* was sprayed with mercaptodimethur using a cold fogger.

Mercaptodimethur is rather stable on the surface of chrysanthemum leaves. 3780 minutes after the spraying no significant disappearance of mercaptodimethur could be detected.

Air samples taken 810 minutes after the spraying showed < 2 µg/sampling period.

The cold fogger deposited 72.3% of the total deposited spray dosage on 7.7% of the green house area, which is very unsatisfactory and could lead to uncontrolled worker exposure.

**Spray data**

Sprayed: 21-04-1995, 05.30 pm to 06.30 pm.  
Reentry after: -  
Pesticide: Mesurol WP 50 (50% mercaptodimethur)  
Spray equipment: Cold fogger, Twin nozzle. IGBA.  
Nozzle type: 1.0  
Spray pressure: -  
Position of spray equipment: The cold fogger placed in the middle of the green house with the nozzles directed in 180° opposite direction (see fig. x)  
Spray conc.: 500 g x 50%/20 L = 12.5 ‰  
Spray volume: 20 L/3072 m² = 6.51 L/1000 m²  
Spray dosage: 6.51 L x 12.5 ‰/1000 m² = 81.4 g/1000 m²  
Area sprayed: 3072 m²

**Physical parameters of the green house**

Area: 128 m x 24 m = 3072 m²  
Cross section area: (3.15 m x 24 m) + (2.7 m x 12 m x 0.5) x 2 = 75.6 m² + 16.2 m² x 2 = 108 m²  
Volume: 108 m² x 128 m = 13824 m³  
Fans: Yes  
Top windows: Yes  
Curtain: A horizontal curtain mounted 3.15 m above the floor limits the volume of the green house (to 3.15 m x 24 m x 128 m = 9677 m³)
Cultures

The experiment is carried out in different varieties of Dendranthema indicum-hybride growing in 10 cm pots. The plant height was approximately 18 cm measured from the pot rim to the top of the plant.

Results

Air samples

Air samplers were placed 1.6 m above the floor at a distance of 17 m from the cold fogger, see fig. 13.1.

Air was sampled in a period of 210 minutes before the spraying. LOQ was 2 µg mercaptodimethur/sample. No residues could be detected.

Air samples were taken during the spray and 150 minutes, 390 minutes, 810 minutes, 1005 minutes, 1365 minutes, 1830 minutes, 2550 minutes and 3270 minutes after the spraying. The results are illustrated in fig. 13.2.

Only particles and aerosols were detected even during the spraying. From 390 minutes to 810 minutes after the spraying, nothing was found in the air above 2 µg mercaptodimethur/sampling period.

DFR

Leaf samples were taken 270 minutes before the spraying and 930 minutes and 3780 minutes after the spraying.

Fig. 13.1 illustrates the plots were DFR were sampled. Each sample (1 to 4) consisted of 2 plots placed symmetric to the longitudinal axis of the greenhouse. One plot consisted of punches from 3 plants. DFR is the average of 2 plots.

Fig. 13.3 shows DFR after the spraying. No residues were detected in samples before the spraying.

Comparing the figures 13.1, 13.3 and 13.4 (see later) it is seen that there is a good correlation between deposited mercaptodimethur and DFR. The variation in the detected DFR is far less than the variation in the detected deposition (see fig 13.4 and later). The reason for this is that the filter papers used for measuring deposition were placed in the middle of the greenhouse in the spray direction, but the DFR samples were taken in an angle of at least 30° to the spray direction for DFR 2 and DFR 3.
Spray pattern

Twenty-six filter papers 80 mm in diameter were placed in the middle of the greenhouse 21/4-95 02.00 pm., separated by equal distances. After spraying, the filter papers were collected 22/4-95 10.00 am.

Fig. 13.4 illustrates the distribution of mercaptodimethur on this longitudinal row of filter papers. Filter paper no. 14 and no. 15 received 72.3% of the total deposited dosage! The average deposition was 316.74 µg/50.3 cm², which corresponds to 63 g/1000 m² (=77.45% of the initial spray dosage). The average dosage/50.3 cm² for the filter papers 1-9 and 20-26 were 22.25 µg (=7.0% of the average deposited dosage) and 24.34 µg (=7.6% of the average deposited dosage) mercaptodimethur, respectively. In other words, 62% of the filter papers received only 7.3% of the deposited spray dosage!

Evaluation of worker exposure to pesticide is extremely difficult under such low spraying quality, because DFR is a very vital parameter when calculating the transfer coefficients. It could lead to worst case scenarios in the registration procedure, when evaluating DFR from spraying conditions like these. If not, the worker could risk a many fold higher exposure than predicted. This is one of the reasons why spray patterns have been included in some of the experiments.

Climatic conditions

750 minutes after the spraying (22-04-95, 07.00 am) the windows were opened 15% for 60 minutes. The rest of the day the windows were 10% opened.

The temperature during the experiment varied between 17 and 25°C and R.H. between 35 and 89%.

The light intensity in klux, measured under the glass roof is illustrated in fig. 13.5.
Figure 13.1
Horizontal cross section of the green house. Length = 128 m, width = 24 m. A.s.=Air sampler, placed 17 m from the nozzles. C.f.=Cold fogger with spray directions. O=DFR, (3 pots taken each plot). Filter paper no. refers to fig. 13.4. The filter papers were placed on the tables in the middle of the green house and equidistant from each other.

Horisontalt snit af væksthus. Længde = 128 m, bredde = 24 m. A.s. = luftpumpe placeret 17 m fra koldtågesprojet (=C. f.). Pil er sprojetretning. O = DFR-prøver, 3 potter på hvert sted. Filterpapir nummeret refererer til fig. 13.4. Filterpapirerne var placeret på bordene i midten af væksthuset og med ens indbyrdes afstand.

<table>
<thead>
<tr>
<th>DFR no:</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td></td>
<td>O</td>
<td>C.f.</td>
</tr>
<tr>
<td></td>
<td>O</td>
<td></td>
<td>O</td>
<td>A.s.</td>
</tr>
</tbody>
</table>

Filter paper no:

2. 3. 8. 9. 10 11. to 15. 16. 17. 18. 24. 25.

**Figure 13.2**
Mercaptodimethur in the air after spraying with cold fogger.

Mercaptodimethur i luften efter sprojen med koldtågesproje.
Figure 13.3
DFR from mercaptodimethur sprayed chrysanthemum with a cold fogger, at different distances from the sprayer (see fig. 13.1).

DFR af mercaptodimethur på chrysanthemum i forskellig afstand fra koldtågesprojet.

Figure 13.4
Deposition and distribution of mercaptodimethur on filter papers placed longitudinal in the middle of the green house. Sprayed with a cold fogger.

Afsetning og fordeling af mercaptodimethur på filterpapir på langs og i midten af væksthuset efter sprøjning med koldtågesprojet.
Figure 13.5
Light intensity in klux under the glass roof after the spraying.

Lysintensitet i klux målt inde i vækthuset efter sprojning.
3.14 **Experiment no. 14**

Experiment started: 22-09-1995  
Experiment finished: 25-09-1995

**Abstract**

Cultures of mainly Columnea hybridae 'Kolibri' (with short runners) and Aeschynanthus hybridae “Mona Lisa” (with long runners), were sprayed with mercaptodimethur with a hydraulic hand held high pressure rifle. The plants were hung up in frames up to 2.4 m above the floor.

At reentry, 3915 minutes after spraying for Aeschynanthus and 3965 minutes for Columnea, DFR was detected to be 122.5 µg mercaptodimethur/49 cm² and 137.9 µg mercaptodimethur/49 cm², respectively.

The working procedure consisted of reaching for the pots, putting the pots in plastic bags and pack them in card board boxes. The transfer coefficient for Aeschynanthus and Columnnea was 1555 cm²/h and 1168 cm²/h respectively. But the total body exposure gave a different picture: Packing Aeschynanthus resulted in a total exposure on the body of 58520 µg mercaptodimethur/8 h. The figures for Columnnea was 28805 µg mercaptodimethur/8 h.

Static air samples at reentry was below 1.4 µg mercaptodimethur/h at a respiration rate of 20 L/minute. But personal monitoring in the breathing zone indicated, despite of a very short sampling period, packing Aeschynanthus (with long runners) gave a respiratory exposure of 111 µg mercaptodimethur/h at a respiration rate of 20 L/minute. Packing Columnea resulted in < 50 µg mercaptodimethur/h at a respiration rate of 20 L/minute.

The concentration of mercaptodimethur on the heating tubes (dosage/area), was 53% of the total deposited dosage in the green house 325 minutes after the spraying. Half time of mercaptodimethur was approximately 3000 minutes (=2 days).

27% of the initial spray dosage was recovered after 315 minutes. The difference in deposition (dosage/area) was detected to be 3-fold.

**Spray data**

Sprayed: 22-09-1995, 04.15 pm  
Reentry after: 3915 minutes for Aeschynanthus and 3965 minutes for Columnea  
Pesticide: Mesurol 50 WP (50% mercaptodimethur)  
Spray equipment: Hand held high pressure rifle with to paral-nozzles directed the same way.  
Nozzle type: Tee-jet, TN 14  
Spray pressure: 50-60 bar  
Position of spray equipment: The entire spray equipment was placed in the sprayed green house. The spray operator
was walking along the racks were the plant were hanging.

Spray conc.: 263 g x 50%/175 L = 0.75 ‰  
Spray volume: 175 L/410 m² = 427 L/1000 m²  
Spray dosage: 0.75 ‰ x 427 L/1000 m² = 320 g/1000 m²  
Area sprayed: 410 m²

Physical parameters of the green house

Area: 32.8 x 12.5 m = 410 m²  
Cross section area: 69 m² (irregular shaped, but "normal" roof shape.  
Volume: 69 m² x 32.8 m = 2263 m³  
Fans: No  
Top windows: Yes

Cultures

Two cultures, Columnea hybride 'Kolibri' and different varieties of Aeschynanthus hybride “Mona Lisa” were the main culture in the green house.

The plants were grown in pots which were hung up in a frame in three horizontal levels: 0.8 m, 1.6 m and 2.4 m above the floor.

Working procedure

Two experiments were done with the same working procedure, packing the plants in card board boxes. The packing procedure consisted of picking the pots either with the hands for the lowest hung pots or with a stick from the highest hung pots, put them in plastic bags and pack them into boxes. The plastic bags were carried in a belt on the front of the worker. The worker seemed to be potential highly exposed to dust in the head region when removing the pots from the highest level. No exposure studies was unfortunately done on head exposure. Two plant species were packed, Aeschynanthus with long runners and Columnea with the short runners. The same person was packing the two cultures. The packing of Aeschynanthus lasted for 35 minutes and for Columnea for 26 minutes. (One of the disadvantages of making this kind of study in small commercial green houses!)

Results

Air samples

Air samples have been taken 1.4 m above the floor in the middle of the green house. LOQ was 1 µg mercaptodimethur/sample. No residues was detected in the air before the spraying. Sampling was started immediately after finishing the spraying and then for 45 minutes. Consecutive samples were taken 105 minutes, 295 minutes, 1125 minutes, 2565 minutes and
3915 minutes after the spraying. The results are illustrated in fig. 14.1. Comparing experiment no 13, one observes a much lower concentration in the air in experiment no 14, despite a much higher spray dosage in experiment 13. But as seen in experiment 13, a rapid disappearance of mercaptodimethur is observed. The detection of 1.4 µg mercaptodimethur 2565 minutes after spraying is due to the long lasting sample period (=1440 minutes).

**DFR**

Leaf samples were taken before the spraying. No residues were found on the leaves. Samples on Columnea was taken 365 minutes, 1185 minutes and 3915 minutes after the spraying. Samples on Aeschynanthus were taken 405 minutes, 1215 minutes and 3915 minutes after the spraying.

The results are illustrated on fig. 14.2 and fig. 14.3. DFR of mercaptodimethur was detected slightly higher on Columnea with the short runners. The residues detected seems not to decrease significantly. The average DFR for the two cultures at reentry was 130.2 µg mercaptodimethur/49 cm² leaf which corresponds to 26 g mercaptodimethur/1000 m² (=8.1% of the initial spray dosage).

**Exposure**

Fig. 14.4 and fig. 14.5 illustrate the results from the packing procedure. Packing the voluminous Aeschynanthus with the long runners, gives rise to a rather high exposure: almost 60 mg mercaptodimethur/8 h. There is a rather equal distribution of exposure on the "body+hands" and the hands. When packing, the worker are slinging the runners around the right arm when putting the flower pot in the plastic bag. 20% of the exposure originates from the right arm. The pesticide is obviously loosely bound because we are observing such a high exposure on a body part, not actually in tight contact with the sprayed plants. Columnea with the short runners are packed differently, the worker did not sling the runners around the arm, only 3.5% exposure was detected on the right arm. The hands are relatively higher exposed when packing Columnea, but actual exposure on the hands is almost the same, 31 mg mercaptodimethur for Aeschynanthus and 26 mg mercaptodimethur for Columnea per 8 h.

While packing, the worker was equipped with personal air sampler. The actual working time in this experiment is very low. Further more the pump malfunctioned the first 20 minutes of exposure packing Aeschynanthus. The pump was only functioning for 16 minutes. The sample was measured to 1.4 µg mercaptodimethur particles and aerosols, just around LOQ. This corresponds to 111 µg mercaptodimethur/h at a respiration rate of 20 L/minute.

Packing Columnea did not result in inhalation exposure above 1 µg mercaptodimethur within the 26 minutes the exposure time and this means < 50 µg mercaptodimethur/h at a respiration rate of 20 L/minute.

**Transfer coefficients**
Transfer coefficients are only calculated on basis of hand exposure. Transfer coefficient for Aeschynanthus is calculated to:

\[ 58520 \mu g \times 53.16\% \times 49 \text{ cm}^2/8 \text{ h} \times 122.5 \mu g = 1555 \text{ cm}^2/\text{h}. \]

Transfer coefficient for Columnea is calculated to:

\[ 28805 \mu g \times 91.27\% \times 49 \text{ cm}^2/8 \text{ h} \times 137.9 \mu g = 1168 \text{ cm}^2/\text{h}. \]

The experiment illustrates that the only use of transfer coefficients in evaluating exposure, should be done carefully. 60 mg pesticide/8 h is the highest exposure measured in this series of experiments, but the corresponding transfer coefficients are in the lower end.

**Analysis of inactive media in the green house**

**Heating tubes**

44 mm diameter steel tubes used for heating the green house, were mounted on the south glass wall, 1 m above the floor. The glass wall was on the inside covered with transparent plastic in order to avoid direct sun radiation. Before the spraying all the sites for consecutive sampling were rinsed with ethanol. A following rinse of the tubes with ethanol was performed in order to control the first rinse. Samples were taken on these rinsed sites 325 minutes, 1155 minutes and 3980 minutes after the spraying. The results are illustrated in fig. 14.6.

No residues were found before the spraying or in the control rinse either. LOQ was 0.6 \( \mu g \) mercaptodimethur/sample. The deposited dosage on the tubes measured 325 minutes after the spraying was in average 947 \( \mu g \) mercaptodimethur/207.5 cm\(^2\) = 45.6 g/1000 m\(^2\) (=14.3\% of the initial spray dosage). This does not mean the tubes only have retained 14.3\% of the sprayed dosage, because the spray volume is high and is close to the drip-off volume.

**Spray pattern**

10 pieces of 9 cm diameter filter paper were mounted in horizontal position 1 m above the floor. The filter papers were placed between the plants in the middle of the green house evenly distributed. 315 minutes after the spraying, the filter papers were collected.

Fig. 14.7 illustrates the deposition of mercaptodimethur.

The average deposition was 549.8 \( \mu g \)/63.6 cm\(^2\) which is 27\% of initial spray dosage.

**Climatic conditions**

The green house did not have any automatic registration of the climatic conditions. But an ordinary thermometer was hung up in the culture 1.6 m
above the floor. The temperatures varied from 22-09-1995 to 25-09-1995 between 18°C to 34°C. Registration of light intensity and opening of the windows were not possible. But the days were clear sunshine, no clouds and therefore high light influx.

Figure 14.1
Mercaptodimethur in the air after spraying with a high pressure hydraulic rifle.

Mercaptodimethur i luften after sprojting med hydraulisk højtryksriffel.
Figure 14.2
DFR of mercaptodimethur on Columnea hybride "Kolibri" (with short runners) sprayed with high pressure hydraulic rifle.

DFR af mercaptodimethur på Columnea hybride "Kolibri" (med korte ranker) sprøjtet med hydraulisk højtryksriffel.

Figure 14.3
DFR of mercaptodimethur on Aeschynanthus hybride "Mona Lisa" (with long runners) sprayed with high pressure hydraulic rifle.

DFR af mercaptodimethur på Aeschynanthus hybride "Mona Lisa" (med lange ranker) sprøjtet med hydraulisk højtryksriffel.
Figure 14.4
Exposure of one person packing mercaptodimethur sprayed Columnea hybride “Kolibri” (with short runners) with high pressure hydraulic rifle.

Eksponering af 1 person der pakker Columnea hybride “Kolibri” (med korte ranker), sprøjtet mercaptodimethur med hydraulisk højtryksrifl.
Figure 14.5
Exposure of one person packing mercaptodimethur sprayed Aeschynanthus (with long runners) with high pressure hydraulic rifle.

Eksponering af 1 person der pakker Aeschynanthus hybride “Mona Lisa” (med lange ranker), sprøjtet mercaptodimethur med hydraulisk højtryksriffel.
**Figure 14.6**
Deposition and disappearance of mercaptodimethur on heating tubes sprayed with a high pressure hydraulic rifle.

Afseætning og fund af mercaptodimethur på varmerør sprøjtet med hydraulisk højtryksrifel.

**Figure 14.7**
Distribution of mercaptodimethur when sprayed with a high pressure hydraulic rifle.

Fordeling af mercaptodimethur ved udsprøjning med hydraulisk højtryksrifel.
3.15 Experiment no. 15

Experiment started: 22-03-1996
Experiment finished: 29-03-1996

Abstract

Hedera helix were sprayed mercaptodimethur with a cold fogger. The plants were hung up in racks up to 2.5 m above the floor.

Reentry was done 3780 minutes and 8115 minutes after the start of the spraying. No significant decline in DFR was observed within 9945 minutes. The overall average of DFR was 70.4 µg mercaptodimethur/50 cm² leaf (=14% of the initial spray dosage).

The working procedure at both re-entries, was cutting and packing Hedera spp. in card board boxes. At the first reentry less cutting was done compared to the second reentry. The is reflected in the transfer coefficients. After 3780 minutes the transfer coefficient was 4150 cm²/h, after 8115 minutes the transfer coefficient was 7067 cm²/h.

Static air monitoring at reentry showed < 0.8 µg mercaptodimethur/h at respiration rate of 20 L/minute. Personal air monitoring at reentry 3780 minutes after the start of the spraying, showed 45.8 µg mercaptodimethur/h at respiration rate of 20 L/minute. The personal air monitoring at reentry 8115 minutes after start of the spraying, showed 138.2 µg/h at respiration rate of 20 L/minute. Total body exposure was 58682 µg and 88656 µg mercaptodimethur/8 h for the two reentry intervals.

The heating tubes were analysed for residues of mercaptodimethur. The deposition varied considerably due to the spraying technique, but was well correlated to investigations of depositions also made. The residues on the heating tubes disappeared much faster than seen on the leaves, probably due to the high temperature on the surface of the tubes.

Deposition of the pesticide was investigated and the concentrations (dosage/area) observed varied 35-fold.

Spray data

Sprayed: At first position:
22-03-1996, 04.00 pm to 07.00 pm.

At second position:
22-03-1996, 07.00 pm to 10.00 pm.

Reentry after:
3780 minutes and 8115 after the start of the spraying.

Pesticide: Mesurol WP 50 (50% mercaptodimethur)
Spray equipment: Cold fogger, Motan Twin-star
Nozzle type: 120
Spray pressure: -
Position of -
spray equipment: The green house was divided up in two and sprayed from two positions due to 1) the spray equipment and 2) the size of the green house. The first position was in the end of the green house, the second position in the middle of the green house (see fig. 15.1)

Spray conc.: 200 x 50%/7.7 L = 13 \%/7.7 L = 13 \%
Spray volume: 7.7 L/1000 m²
Spray dosage: 7.7 L x 13 \%/1000 m² = 100 g mercapto dimethur/1000 m²
Area sprayed: 5198 m²

Physical parameters of the green house

Area: 46 m x 113 m = 5198 m²
Cross section area: 4 green houses x ((11.5 m x 3.5 m)+(11.5 m x 3.5 m x 0.5)) = 241.5 m² (Fig. 15.1)
Volume: 113 m x 241.5 m² = 27290 m³
Fans: Yes
Top windows: Yes

Cultures

The plants in the experiment were different species of Hedera, grown in plastic pots and hung up as described under working procedure.

Working procedure

One person was manually packing Hedera spp. in card board boxes and making cuttings.

The plants were hung up in V-shape racks in five vertical levels. The upper level was 2.5 meter, the lower level 0.9 m above the floor. The worker was in this way walking in a tunnel-like path, surrounding her with plants.

The plants were directly packed in the boxes.

This working procedure was used when reentry was made the day after the spraying and 7 days after the spraying. The working procedure 7 days after spraying was less packing and more cutting.

Results

Air samples

Air pumps were placed in the middle of the green house 1.7 m above the floor, see fig. 15.1.
No residues of mercaptodimethur could be detected in the air before the spraying. Air samples were collected 180 minutes, 600 minutes, 1200
minutes, and 1800 minutes after the start of the spraying. The results are presented in fig. 15.2.

It is seen that particles and aerosols constitutes the major part of the total detected mercaptodimethur.

**DFR**

Leaf samples were only taken in the first sprayed half of the green house, (the left half on fig. 15.1). Leaf samples were taken evenly distributed over the entire area. The DFR is illustrated in fig. 15.3

7.9 $\mu$g mercaptodimethur/50 cm² leaf was detected before the spraying. Leaf samples were collected for analysis of DFR, 1080 minutes, 2520 minutes, 4050 minutes, 8430 minutes, and 9945 minutes after the spraying. No decline in DFR was seen within this period (6.9 days). The overall average of DFR was 70.4 $\mu$g mercaptodimethur/50 cm² leaf, which equals 14 g mercaptodimethur/1000 m² (=14% of the initial spray dosage).

**Exposure**

Reentry in the green house was done at 3780 minutes and 8115 minutes after the start of the spraying. The working procedures were almost the same, packing and making cuttings of Hedera spp., except for more emphasis on making cuttings 8115 minutes after the start of the spraying, compared to 3780 minutes after the start of spraying. The results are illustrated in fig. 15.4 and fig. 15.5.

At both reentry, the hand exposure dominates over the exposure of the rest of the body. DFR, see fig. 15.3, did not differ between the two reentry, but the total exposure was approximately 50% higher at reentry 8115 minutes after start of the spraying compared to the earlier reentry. This increase in exposure is mainly due to increased hand exposure, and probably a reflection of more cutting at the later reentry.

At the first reentry the total inhalation exposure (particles, aerosols and gasses) of mercaptodimethur at a respiration rate of 20 L/minutes, was detected to be 45.8 $\mu$g/h. 90.9% was in the fraction of particles and aerosols.

At the second reentry a total of 138.2 $\mu$g mercaptodimethur at 20 L/minutes was detected, 94.2% was particles and aerosols.

The stationary air sampling illustrated in fig. 15.2, showed a concentration of below 0.8 $\mu$g mercaptodimethur/h at a respiration rate of 20 L/minutes, dominated by a gaseous fraction.

It is concluded that the dramatically increased concentration of mercaptodimethur in the personal air monitors, was due to the working activity at reentry.

**Transfer coefficients**
No significant decline in DFR could be detected within 9945 minutes after start of the spraying. The overall average was 70.4 µg mercaptodimethur/50 cm² leaf.

At reentry 3780 minutes after the start of the spraying, the exposure on the hands was 46747 µg mercaptodimethur/8 h.

The transfer coefficient is then calculated to:

\[
46747 \, \text{µg} \times 50 \, \text{cm}^2/8 \, \text{h} \times 70.4 \, \text{µg} = 4150 \, \text{cm}^2/\text{h}
\]

At reentry 8115 minutes after the start of the spraying, the exposure on the hands was 79600 µg/8 h.

The transfer coefficient is then calculated to:

\[
79600 \, \text{µg} \times 50 \, \text{cm}^2/8 \, \text{h} \times 70.4 \, \text{µg} = 7067 \, \text{cm}^2/\text{h}
\]

**Analysis of inactive media in the green house**

**Heating tubes**

Heating tubes were placed 1 m above the floor at the entire length of the green house. Samples were taken at the distances of 8 m, 50 m, 82 m, and 113 m from the end of the green house, see fig. 15.1. The first sample after the spraying was taken the same place as the sample before the spraying. Consecutive samples were taken other places, not rinsed before the spraying. The results are illustrated in fig 15.6. There is a good correlation between the residues on the tubes found after the spraying and what have been found on filter papers showing the spray pattern (see later, fig. 15.7)

\[
79.50 \, \text{µg mercaptodimethur}/126 \, \text{cm}^2 \, \text{horizontal tube area} \text{ is equal to } 6.3 \, \text{g mercaptodimethur}/1000 \, \text{m}^2 \,(=6.3\% \text{ of the initial spray dosage}). \text{ The disappearance of mercaptodimethur on heating tubes, is clearly much faster than has been registered on leaves, see fig. 15.3.}
\]

The reason for this is probably that the heating tubes throughout the experiment had a temperature between 40-50°C.

**Spray pattern**

48 filter papers were distributed in four rows, 8 m, 50 m, 82 m and 113 m from the end of the green house, for measuring the spray deposition. They were placed 2 m above the floor in the four rows perpendicular to the longitudinal axis of the green house, see fig. 15.7. The cold fogger were placed at the end wall at the first spray interval, and eight meters away from the first row of filter papers.

The cold fogger was placed 54 meters from the end wall of the green house at the second spray interval. The filter papers were removed 1035 minutes after the start of the spraying. There was a coefficient of 35 between the
highest and the lowest deposition. Under such spraying conditions it is extremely difficult to evaluate the exposure of workers at reentry.

The average deposition of the filter papers was 18.3 g mercaptodimethyl-mercaptur/1000 m², which corresponds to 18.3% of initial spray deposition.

**Climatic conditions**

Only maximum and minimum of climatic important parameters were registered. Fig. 15.8, 15.9 and 15.10 illustrates the climatic conditions. The windows were opened 100% the morning after the spraying between 07.00 am to 08.00 am.

*Figure 15.1*

*Horizontal cross section of the green house(s)*. c.f. = cold fogger. a.p. = air pump. h.t.s. = samples taken on heating tubes.

*Horisontalt snit af væksthuse(e)*. c.f. = koldtågesprøjte. a.p. = luftpumpe. h.t.s. = prøver udtaget på varmerør.
Figure 15.2
Mercaptodimethur in the air after spraying Hedera with cold fogger (see fig. 15.1).

Mercaptodimethur i luften efter sprojning af Hedera med koldtågesprøjte (se fig. 15.1).

Figure 15.3
DFR from mercaptodimethur sprayed on Hedera with a cold fogger.

DFR af mercaptodimethur på Hedera sprojet med koldtågesprøjte.
Figure 15.4
Exposure of mercaptodimethur on the body of one person packing and cutting Hedera after spraying the green house with cold fogger. The packing was dominating compared to the reentry illustrated in fig. 15.5. Reentry was done 3780 minutes after the spraying.

Eksponering af kroppen på 1 person som pakker og fremstiller stiklinger af Hedera der er sprøjtet med koldtågesprøjte. Pakningen dominerede i forhold til eksemplet i fig. 15.5. Re-entry blev foretaget 3780 minutter efter sprøjtingen.
Figure 15.5
Exposure of mercaptodimethur on the body of one person packing and cutting Hedera after spraying the greenhouse with cold fogger. The cutting was dominating compared to the reentry illustrated in fig. 15.4. Reentry was done 8115 minutes after spraying.

Eksponering af kroppen på 1 person som pakker og fremstiller stiklinger af Hedera der er sprøjtet med koldtågesprøjte. Fremstilling af stiklinger dominerede i forhold til eksemplet i fig. 15.4. Re-entry blev foretaget 8115 minutter efter sprøjtingen.
Deposition and disappearance of μg mercaptodimethur/126 cm² heating tubes.

Figure 15.6
Deposition and disappearance of mercaptodimethur on heating tubes at different distances from the first cold fogger position. First c.f. = The first position for the cold fogger. Second c.f. = The second position for the cold fogger.

Figure 15.7
Deposition of mercaptodimethur on filter papers (placed in four rows at indicated distances from the end of the green house) after the spraying with cold fogger in the green house. Filter papers collected 1035 minutes after the start of the spraying. C.f. = cold fogger.

Afsetning af mercaptodimethur på filterpapir efter sprøjtning med koldtågesproje. Filterpapirerne blev placeret i fire rækker i de indikerede afstande fra endevæggen. Filterpapirerne blev indsamlet 1035 minutter efter start af sprøjtningen.
Figure 15.8
Minimum and maximum % relative humidity in the green house.

Minimum og maksimum procent relativ fugtighed i væksthuset.

Figure 15.9
Minimum and maximum temperature in the green house.

Minimum og maksimum temperatur i vækshuset.
Figure 15.10
Light intensity in the green house measured outside the house. Light intensity 0 klux started 06.30 pm and finished 06.00 am.

Lysintensitet målt uden for vækshuset. Lysintensitet 0 kl. 06.30 og 18.00.
3.16 **Experiment no. 16**

Experiment 1 started: 26-03-1996  
Experiment 1 finished: 03-04-1996  

Experiment 2 started: 07-05-1996  
Experiment 2 finished: 17-05-1996  

**Abstract**

Begonia elatior and Hedera helix was sprayed with either pirimicarb, mercaptodimethur, methomyl or iprodion in a spray cabinet. DFR was determined at different time elapse after the spraying.

DFR was related to the initial spray dosage 1200 minutes after the spraying (=%DFR 1200).

The variation in '%DFR 1200' between the plant species was from 1.9 to 4-fold. This variation also included climatic variations because the two experiments were made at different times in the spring although the climate was almost the same. The most influential parameter was the pesticide. '%DFR 1200' detected on Begonia spp. varied between pirimicarb and methomyl 68-fold.

**Spray data**

**Experiment 1**  
Plant specie: Hedera helix in plastic pots.  
Sprayed: 26-03-1996, 01.00 pm  
Sampling: Samples taken before the spraying and after the spraying: 1260 minutes, 1740 minutes, 2820 minutes, 8400 minutes and 11550 minutes.  
Replications: 4 replications, one pot is one replication and 20 pieces of a 5 cm² punch per pot.

**Experiment 2**  
Sprayed: 07-05-1996, 02.30 pm  
Plant specie: Begonia elatior in plastic pots  
Sampling: Samples taken before the spraying and after the spraying: 1170 minutes, 2895 minutes, 5580 minutes, 8460 minutes and 14220 minutes.  
Replications: 4 replications, one pot is one replication and 20 pieces of a 5 cm² punch per pot.  
Spray equipment: Automatic hydraulic boom sprayer.  
Nozzle type: Hardi, flat fan, 4110-30  
Spray pressure: 1.7 bar
Spray equipment: The plants were sprayed in an experimental spray cabin.

Spray volume: 240 L/1000 m²

Pesticide: Pirimor G (50% pirimicarb)
Spray conc.: 0.05% x 50% = 0.025% pirimicarb
Spray dosage: 240 L x 0.025%/1000 m² = 60 g/1000 m²

Pesticide: Mesurol 50 WP (50% mercaptodimethur)
Spray conc.: 0.1% x 50% = 0.05% mercaptodimethur
Spray dosage: 240 L x 0.05%/1000 m² = 120 g/1000 m²

Pesticide: Lannate 20 L (20% methomyl)
Spray conc.: 0.1% x 20% = 0.02% methomyl
Spray dosage: 240 L x 0.02%/1000 m² = 48 g/1000 m²

Pesticide: Rovral flo (25% iprodion)
Spray conc.: 0.2% x 25% = 0.05% iprodion
Spray dosage: 240 L x 0.05%/1000 m² = 120 g/1000 m²

Results

DFR

DFR was detected and the results from the four pesticides, two plant species and the five sampling after the spraying is illustrated in fig. 16.1, 16.2, 16.3 and 16.4.

DFR (g/1000 m²) from the first sampling times, was related in percent to the initial spray dosage (g/1000 m²). The first sampling after the spraying was for Begonia elatior 1170 minutes, for Hedera helix 1260 minutes.

%DFR of the initial spray dosage '1200' minutes after the spraying for

Pirimicarb, fig 16.1:
Begonia elatior: 0.63 g x 100/60 g = 1.05
Hedera helix: 1.48 g x 100/60 g = 2.47

Mercaptodimethur, fig 16.2:
Begonia elatior: 13.43 g x 100/120 g = 11.2
Hedera helix: 25.18 g x 100/120 g = 21

Methomyl, fig 16.3:
Begonia elatior: 8.69 x 100/48 g = 71.7
Hedera helix: 34.4 x 100/48 g = 18.1

Iprodion, fig 16.4:
Begonia elatior: 31.8 x 100/120 g = 34.1
Hedera helix: 40.93 x 100/120 g = 26.5

The idea behind the experiment is to demonstrate the influence of plant specie, leaf area index, undefined climatic differences (which is "normal" conditions in practice) and pesticide on DFR. At 2880 minutes (two days) after the spraying, there is a 1.3 to 4 fold difference between the two plant
species (leaf area, climate) in DFR. But the most influential parameter is in this experiment the pesticide. Between pirimicarb and methomyl for Begonia spp., there is a 68-fold difference. Iprodion shows a different ad(ab)sorption kinetic on the two plant species.

These results indicate the necessity of using the actual pesticide when developing DFR values.

**Climatic conditions**

The temperatures varied between 12 and 30°C in the green house 30 cm above the plants during the two experiments.

![Diagram](image)

**Figure 16.1**

g DFR of pirimicarb/1000 m² leaf for two ornamentals sprayed with an automatic hydraulic boom sprayer. % DFR (1200) for Hedera helix: 2.47 and for Begonia elatior: 1.05.

g DFR af pirimicarb/1000 m² blad for to potteplantearter sprojet med hydraulisk bomsprøjte. % DFR (1200) for Hedera helix: 2.47 og for Begonia elatior: 1.05.
**Figure 16.2**
g DFR of mercaptodimethur/1000 m² leaf for two ornamentals sprayed with an automatic hydraulic boom sprayer. % DFR (1200) for Hedera helix: 21 and for Begonia elatior: 11.2.

g DFR af mercaptodimethur/1000 m² blad for to potteplantearter sprojet med hydraulisk bomsprøjte. % DFR (1200) for Hedera helix: 21 og for Begonia elatior: 11.2.
Figure 16.3

$g \text{ DFR of methomyl/1000 m}^2 \text{ leaf}$ for two ornamentals sprayed with an automatic hydraulic boom sprayer. % DFR (1200) for Hedera helix: 71.7 and for Begonia elatior: 18.1.

$g \text{ DFR af methomyl/1000 m}^2 \text{ blad for to potteplantearter sprojtet med hydraulisk bomsproje. % DFR (1200) for Hedera helix: 71.7 og for Begonia elatior: 18.1.}$
**Figure 16.4**
g DFR of iprodion/1000 m² leaf for two ornamentals sprayed with an automatic hydraulic boom sprayer. % DFR (1200) for Hedera helix: 34.1 and for Begonia elatior: 26.5.

g DFR of methomyl/1000 m² blad for to potteplantearter sprøjtet med hydraulisk bomsprøjt. % DFR (1200) for Hedera helix: 71.7 og for Begonia elatior: 18.1.
### Table 17.1

*Summary of experiments 1 to 15. Oversigt over eksperimenterne 1 til 15.*

<table>
<thead>
<tr>
<th>Experim.</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
<th>No 4</th>
<th>No 5</th>
<th>No 6</th>
<th>No 7</th>
<th>No 8</th>
<th>No 9</th>
<th>No 10</th>
<th>No 11</th>
<th>No 12</th>
<th>No 13</th>
<th>No 14</th>
<th>No 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pesticide</td>
<td>Pirimicarb</td>
<td>Pirimicarb</td>
<td>Pirimicarb</td>
<td>Pirimicarb</td>
<td>Pirimicarb</td>
<td>Paclobutrazol</td>
<td>Paclobutrazol</td>
<td>Endosulfan</td>
<td>Endosulfan</td>
<td>Methomyl</td>
<td>Methomyl</td>
<td>Mercaptodimethur</td>
<td>Mercaptodimethur</td>
<td>Mercaptodimethur</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Methomyl</td>
<td>Pirimicarb</td>
<td>Paclobutrazol</td>
<td>Endosulfan</td>
<td>Paclobutrazol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reentry time</td>
<td>3810 minutes</td>
<td>3725 minutes</td>
<td>2573 minutes</td>
<td>910 minutes</td>
<td>1376 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>3785 minutes</td>
<td>-</td>
<td>3465 minutes</td>
<td>7800 minutes</td>
<td>-</td>
<td>3915 minutes</td>
<td>3780 minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13834 minutes</td>
<td>-</td>
<td>1376 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>3785 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>690 minutes</td>
<td>3965 minutes</td>
<td>8115 minutes</td>
<td></td>
</tr>
<tr>
<td>Spr. eqiupm.</td>
<td>Hydr. spr. boom</td>
<td>Hydr. spr. boom</td>
<td>H.h. hydr. rifle</td>
<td>Hydr. spr. boom</td>
<td>H.h. hydr. Rifle</td>
<td>Hydr. sp boom</td>
<td>Hydr. spr. boom</td>
<td>Cold fogger</td>
<td>Cold fogger</td>
<td>Cold fogger</td>
<td>Cold fogger</td>
<td>Cold fogger</td>
<td>H.h. hydr. rifle</td>
<td>Cold fogger</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hydr. spr. boom</td>
<td>Hydr. spr. boom</td>
<td>H.h. hydr. rifle</td>
<td>Hydr. spr. boom</td>
<td>Hydr. spr. boom</td>
<td>Cold fogger</td>
<td>Cold fogger</td>
<td>H.h. hydr. rifle</td>
<td>Cold fogger</td>
<td>H.h. hydr. rifle</td>
<td>Cold fogger</td>
<td>H.h. hydr. rifle</td>
<td>Cold fogger</td>
<td>H.h. hydr. rifle</td>
<td>Cold fogger</td>
</tr>
<tr>
<td>Experim.</td>
<td>No 1</td>
<td>No 2</td>
<td>No 3</td>
<td>No 4</td>
<td>No 5</td>
<td>No 6</td>
<td>No 7</td>
<td>No 8</td>
<td>No 9</td>
<td>No 10</td>
<td>No 11</td>
<td>No 12</td>
<td>No 13</td>
<td>No 14</td>
<td>No 15</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>g/1000 m²</td>
<td>40 and 52.3</td>
<td>74.2</td>
<td>223</td>
<td>74.5</td>
<td>163</td>
<td>88.25</td>
<td>1.04 and 1.61</td>
<td>1.4</td>
<td>71</td>
<td>71</td>
<td>75</td>
<td>83.4</td>
<td>81.4</td>
<td>320</td>
<td>100</td>
</tr>
<tr>
<td>74.2</td>
<td>29.8</td>
<td>88.25</td>
<td>1.04 and 1.61</td>
<td>1.4</td>
<td>71</td>
<td>320</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.04 and 1.61</td>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plant sp.</td>
<td>Mini roses</td>
<td>Mini roses</td>
<td>Kalanchoe blossfeldiana</td>
<td>Mini roses</td>
<td>Hedera helix</td>
<td>Cut roses</td>
<td>Mini roses</td>
<td>Mini roses</td>
<td>Begonia elatior</td>
<td>Begonia elatior</td>
<td>Dracaena marginata</td>
<td>Polyscias balfouri-ana</td>
<td>Dendrathema indicum-hybride</td>
<td>Aeschynanthus hybridae</td>
<td>Hedera spp.</td>
</tr>
<tr>
<td>Mini roses</td>
<td>Mini roses</td>
<td>Cut roses</td>
<td>Mini roses</td>
<td>Mini roses</td>
<td>Begonia elatior</td>
<td>Codiaeum variegatum</td>
<td>Cordyline purple</td>
<td>Columnea hybridae</td>
<td>Hedera spp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mini roses</td>
<td>Mini roses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mini roses</td>
<td>Mini roses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 17.1 continue. Fortsat*
<table>
<thead>
<tr>
<th>Experim.</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
<th>No 4</th>
<th>No 5</th>
<th>No 6</th>
<th>No 7</th>
<th>No 8</th>
<th>No 9</th>
<th>No 10</th>
<th>No 11</th>
<th>No 12</th>
<th>No 13</th>
<th>No 14</th>
<th>No 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man. + mach. packing</td>
<td>Mowing tables</td>
<td>Tagging plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td>Jun</td>
<td>May</td>
<td>Aug</td>
<td>Aug</td>
<td>Nov</td>
<td>Oct</td>
<td>Oct</td>
<td>Sep</td>
<td>Mar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aug</td>
<td>Aug</td>
<td>Aug</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 17.1 continued. Fortsat

<table>
<thead>
<tr>
<th>Experim.</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
<th>No 4</th>
<th>No 5</th>
<th>No 6</th>
<th>No 7</th>
<th>No 8</th>
<th>No 9</th>
<th>No 10</th>
<th>No 11</th>
<th>No 12</th>
<th>No 13</th>
<th>No 14</th>
<th>No 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stat. air (20 L/min.) at reentry:</td>
<td>&lt;2 µg/h</td>
<td>2.4 µg/h</td>
<td>0.5 µg/h</td>
<td>3.22 µg/h, at 1170 min.</td>
<td>10 µg/h</td>
<td>1.46 µg/h</td>
<td>&lt;LOQ = 4.4 µg/h</td>
<td>&lt;LOQ = 4 µg/h</td>
<td>60 µg/h</td>
<td>22.4 µg/h, 3825 minutes after the spraying</td>
<td>3 µg/h</td>
<td>2 µg/h</td>
<td>7 µg/h, 390 min. after the spraying</td>
<td>&lt;0.04 µg/h</td>
<td>0.8 µg, 1800 min. aft. spr.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.4 µg/h</td>
<td>1.3 µg/h, at 1170 min.</td>
<td>1.46 µg/h</td>
<td>&lt;LOQ = 4.4 µg/h</td>
<td>&lt;LOQ = 4 µg/h</td>
<td>60 µg/h</td>
<td>3 µg/h</td>
<td>2 µg/h</td>
<td>&lt;0.04 µg/h</td>
<td>0.8 µg, 1800 min. aft. spr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;LOQ = 4 µg/h</td>
<td>&lt;LOQ = 4 µg/h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DFR µg/100 cm$^2$ at reentry:</td>
<td>N.m.</td>
<td>1.2 µg</td>
<td>12.8 µg</td>
<td>N.m.</td>
<td>392.9 µg</td>
<td>1.5 µg</td>
<td>1.5 µg</td>
<td>-</td>
<td>3.87 µg</td>
<td>-</td>
<td>1.56 µg</td>
<td>5.3 µg</td>
<td>16 to 49 µg, 3700 min. after the spraying</td>
<td>250 µg</td>
<td>140.8 µg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.7 µg</td>
<td>N.m.</td>
<td>1.5 µg</td>
<td>1.5 µg</td>
<td>0.88 µg</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5 µg</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.0 µg</td>
<td></td>
</tr>
<tr>
<td>Experim.</td>
<td>No 1</td>
<td>No 2</td>
<td>No 3</td>
<td>No 4</td>
<td>No 5</td>
<td>No 6</td>
<td>No 7</td>
<td>No 8</td>
<td>No 9</td>
<td>No 10</td>
<td>No 11</td>
<td>No 12</td>
<td>No 13</td>
<td>No 14</td>
<td>No 15</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>Number of workers</strong></td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
<td>156</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>9</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exposure, arith. or indiv. hand/8 h:</strong></td>
<td>206.7 µg</td>
<td>428 µg</td>
<td>N.d.</td>
<td>N.m.</td>
<td>16968 µg</td>
<td>931 and 186 µg</td>
<td>107.95 µg</td>
<td>&lt;LOQ = 33 µg</td>
<td>991</td>
<td>N.d.</td>
<td>3.5 µg</td>
<td>N.m.</td>
<td>31109 µg</td>
<td>46747 µg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75.5 µg</td>
<td>N.m.</td>
<td>391 and 795 µg</td>
<td>20.8 and 51.2 µg</td>
<td>91.2 µg</td>
<td>1310</td>
<td>N.d.</td>
<td>4.3 µg</td>
<td>26290 µg</td>
<td>79600 µg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>29.8 µg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>63.2 and 73.6 µg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>36.8 and 44.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exposure g mean hand/8 h:</strong></td>
<td>146 µg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>416</td>
<td>82.3 µg</td>
<td>-</td>
<td>925.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>74 µg</td>
<td>-</td>
<td>557</td>
<td>32.6</td>
<td>-</td>
<td>817.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>68.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Exposure, 90% fractile hand/8 h</strong></td>
<td>1400 µg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>450 µg</td>
<td>-</td>
<td>1955.7 µg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>117 µg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5266 µg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Table 17.1 continued. Fortsat

<table>
<thead>
<tr>
<th>Experim.</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
<th>No 4</th>
<th>No 5</th>
<th>No 6</th>
<th>No 7</th>
<th>No 8</th>
<th>No 9</th>
<th>No 10</th>
<th>No 11</th>
<th>No 12</th>
<th>No 13</th>
<th>No 14</th>
<th>No 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure body/8 h:</td>
<td>N.m.</td>
<td>N.d.</td>
<td>68 and 73 µg</td>
<td>-</td>
<td>2762 µg</td>
<td>3315 and 3315 µg</td>
<td>N.d. (see fig. 7.2)</td>
<td>N.m.</td>
<td>Geom. mean: 2569.3</td>
<td>90% fractile: 4855.6</td>
<td>-</td>
<td>246 µg</td>
<td>281 µg</td>
<td>N.m.</td>
<td>27411 µg</td>
</tr>
<tr>
<td></td>
<td>N.d.</td>
<td>-</td>
<td>288 and 837 µg</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Geom. mean: 1494.3</td>
<td>90% fractile: 1844.5</td>
<td>1150 µg</td>
<td>142 µg</td>
<td>2516 µg</td>
<td>9043 µg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>-</td>
<td>N.m</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 17.1 continued. Fortsat

<table>
<thead>
<tr>
<th>Experim.</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
<th>No 4</th>
<th>No 5</th>
<th>No 6</th>
<th>No 7</th>
<th>No 8</th>
<th>No 9</th>
<th>No 10</th>
<th>No 11</th>
<th>No 12</th>
<th>No 13</th>
<th>No 14</th>
<th>No 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer coefficient, cm²/h</td>
<td>DFR n.m.</td>
<td>4466</td>
<td>No hand exposure</td>
<td>No hand exp., no DFR</td>
<td>540</td>
<td>Arithm. mean: 4553 Geom. mean: 3391</td>
<td>Arithm. mean: 1000 Geom. mean: 686 90% fractile: 3750</td>
<td>-</td>
<td>Arithm. mean: 3201 Geom. mean: 2990 90% fractile: 6317</td>
<td>-</td>
<td>=0, No hand exp.</td>
<td>8.2</td>
<td>No hand exposure</td>
<td>1555</td>
<td>4150</td>
</tr>
<tr>
<td>Arithm. mean: 1349 Geom. mean: 1323 90% fractile: 2097</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No hand exp., no DFR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Arithm. mean: 4838 Geom. mean: 4551</td>
<td>Arithm. mean: 300 Geom. mean: 272</td>
<td>1295</td>
<td>Arithm. mean: 4231 Geom. mean: 2638 90% fractile: 17009</td>
<td>-</td>
<td>=0, No hand exp.</td>
<td>10.1</td>
<td></td>
<td>1168</td>
<td>7067</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 17.1 continued. Fortsat

<table>
<thead>
<tr>
<th>Experim.</th>
<th>No 1</th>
<th>No 2</th>
<th>No 3</th>
<th>No 4</th>
<th>No 5</th>
<th>No 6</th>
<th>No 7</th>
<th>No 8</th>
<th>No 9</th>
<th>No 10</th>
<th>No 11</th>
<th>No 12</th>
<th>No 13</th>
<th>No 14</th>
<th>No 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pers. air monitoring at reentry:</td>
<td>N.m.</td>
<td>N.m.</td>
<td>2.5 and 2.9 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 4.4 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 2.9 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 1.3 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 0.5 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 1.4 µg/h</td>
<td>N.m.</td>
<td>0.5 µg/h</td>
</tr>
<tr>
<td></td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>&lt;LOQ = 25.8 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 25.8 µg/h</td>
<td>N.m.</td>
<td>LOQ = 0.4 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 0.4 µg/h</td>
<td>N.m.</td>
<td>&lt;LOQ = 1.4 µg/h</td>
<td>N.m.</td>
<td>&lt;50 µg/h (short pumping period)</td>
</tr>
<tr>
<td>Heating tubes % residues at reentry of the initial spray dosage:</td>
<td>N.m.</td>
<td>.05</td>
<td>.2</td>
<td>N.m.</td>
<td>N.m.</td>
<td>2</td>
<td>25.8</td>
<td>N.m.</td>
<td>.17</td>
<td>N.m.</td>
<td>6.25</td>
<td>4</td>
<td>N.m.</td>
<td>4.4</td>
<td>2.7</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>N.m.</td>
<td>N.m.</td>
<td>.17</td>
<td>N.m.</td>
<td>6.25</td>
<td>4</td>
<td>4.4</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tables % residues at reentry of the initial spray dosage:</td>
<td>N.m.</td>
<td>1.3</td>
<td>.06</td>
<td>N.m.</td>
<td>N.m.</td>
<td>33.7</td>
<td>N.m.</td>
<td>.98</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
</tr>
<tr>
<td></td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
</tr>
<tr>
<td>Experim.</td>
<td>No 1</td>
<td>No 2</td>
<td>No 3</td>
<td>No 4</td>
<td>No 5</td>
<td>No 6</td>
<td>No 7</td>
<td>No 8</td>
<td>No 9</td>
<td>No 10</td>
<td>No 11</td>
<td>No 12</td>
<td>No 13</td>
<td>No 14</td>
<td>No 15</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>curtains % residues at reentry of the initial spray dosage:</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>2.4</td>
<td>N.m.</td>
<td>.8</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
</tr>
<tr>
<td>walls % residues at reentry of the initial spray dosage:</td>
<td>N.m.</td>
<td>.01</td>
<td>.003</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>.13</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
</tr>
</tbody>
</table>

Table 17.1 continued. Fortsat
Table 17.2
Potential exposure at re-entry and static air monitoring for 5 pesticides sprayed in green houses.
Potentiel eksponering ved re-entry og luftmålinger for 5 pesticider sprøjtet i vækshuse.

<table>
<thead>
<tr>
<th>Exp. no.</th>
<th>Pesticide</th>
<th>g/1000 m²</th>
<th>Working procedure</th>
<th>Re-entry time minutes after spraying</th>
<th>Static air monitoring at 20 L/minutes µg/h</th>
<th>Personal air monitoring at 20 L/minutes µg/h</th>
<th>Exposure on hands, geom. mean* or arithm. mean µg/h</th>
<th>Exposure on body ÷ hands, geom. mean* or arithm. mean µg/h</th>
<th>Total µg/h</th>
<th>% resp./hands/body+hands</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Endosulfan</td>
<td>71</td>
<td>-</td>
<td>-</td>
<td>22.4 (3825 min. after spr.)</td>
<td>N.m.</td>
<td>N.m.</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>Endosulfan</td>
<td>71</td>
<td>C.</td>
<td>3785</td>
<td>60</td>
<td>12.2</td>
<td>116</td>
<td>321</td>
<td>497</td>
<td>12/23/66</td>
</tr>
<tr>
<td>9</td>
<td>Endosulfan</td>
<td>71</td>
<td>M.p.</td>
<td>3785</td>
<td>60</td>
<td>33.5</td>
<td>102</td>
<td>187</td>
<td>349</td>
<td>17/29/54</td>
</tr>
<tr>
<td>13</td>
<td>Mercaptodimethur</td>
<td>81.4</td>
<td>-</td>
<td>-</td>
<td>&lt;0.3 (11365 min. after spr.)</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>Mercaptodimethur</td>
<td>320</td>
<td>M.p.</td>
<td>3915</td>
<td>&lt;0.04</td>
<td>111</td>
<td>3889</td>
<td>3426</td>
<td>7426</td>
<td>1/52/46</td>
</tr>
<tr>
<td>14</td>
<td>Mercaptodimethur</td>
<td>320</td>
<td>M.p.</td>
<td>3965</td>
<td>&lt;0.04</td>
<td>&lt;50</td>
<td>3286</td>
<td>315</td>
<td>3601</td>
<td>-91/9</td>
</tr>
<tr>
<td>15</td>
<td>Mercaptodimethur</td>
<td>100</td>
<td>M.p. (+c)</td>
<td>3780</td>
<td>0.8 (1800 min. after spr.)</td>
<td>45.8</td>
<td>5843</td>
<td>1489</td>
<td>7378</td>
<td>1/79/20</td>
</tr>
<tr>
<td>15</td>
<td>Mercaptodimethur</td>
<td>100</td>
<td>C. (+m.p.)</td>
<td>8115</td>
<td>0.8 (1800 min. after spr.)</td>
<td>138.2</td>
<td>9950</td>
<td>1130</td>
<td>11218</td>
<td>1/87/10</td>
</tr>
<tr>
<td>11</td>
<td>Methomyl</td>
<td>75</td>
<td>M.p.</td>
<td>3465</td>
<td>3</td>
<td>&lt;0.5</td>
<td>&lt;2.5</td>
<td>31</td>
<td>31</td>
<td>+/-100</td>
</tr>
<tr>
<td>11</td>
<td>Methomyl</td>
<td>75</td>
<td>M.p.</td>
<td>3465</td>
<td>3</td>
<td>&lt;0.5</td>
<td>&lt;2.5</td>
<td>144</td>
<td>144</td>
<td>+/-100</td>
</tr>
<tr>
<td>12</td>
<td>Methomyl</td>
<td>83.4</td>
<td>M.p.</td>
<td>7800</td>
<td>2</td>
<td>&lt;1.4</td>
<td>&lt;0.5</td>
<td>35</td>
<td>35</td>
<td>+/-100</td>
</tr>
<tr>
<td>12</td>
<td>Methomyl</td>
<td>83.4</td>
<td>M.p.</td>
<td>7800</td>
<td>2</td>
<td>&lt;1.4</td>
<td>&lt;0.5</td>
<td>18</td>
<td>18</td>
<td>+/-100</td>
</tr>
<tr>
<td>4</td>
<td>Methomyl</td>
<td>29.8</td>
<td>M.p.</td>
<td>-</td>
<td>1.3 (1170 min. after spr.)</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Paclobutrazol</td>
<td>1.04-1.61</td>
<td>M.p.</td>
<td>690</td>
<td>&lt;4.4</td>
<td>&lt;4.4</td>
<td>10.3</td>
<td>&lt;1</td>
<td>10.3</td>
<td>-100/-</td>
</tr>
<tr>
<td>7</td>
<td>Paclobutrazol</td>
<td>1.04-1.61</td>
<td>M.a.p.</td>
<td>690</td>
<td>&lt;4.4</td>
<td>&lt;4.4</td>
<td>4.1</td>
<td>&lt;1</td>
<td>4.1</td>
<td>-100/-</td>
</tr>
</tbody>
</table>

N.m. = not measured
C = cutting
M.p. = manually packing
M.a.p. = machine packing
Tag = tagging
Aut. sp. = automatic spacing
R. bud = remove buds
M.t. = moving tables
M.trim. = manually trimming
Man. sp. = manually spacing
* = geometric mean used when individuals >2
<table>
<thead>
<tr>
<th>Exp. no.</th>
<th>Pesticide</th>
<th>g/1000 m²</th>
<th>Working procedure</th>
<th>Re-entry time minutes after spraying</th>
<th>Static at 20 L/min. µg/h</th>
<th>Personal at 20 L/min. µg/h</th>
<th>Exposure on hands, geom. mean* or auth. mean µg/h</th>
<th>Exposure on body + hands geom. mean* or auth. mean µg/h</th>
<th>Total µg/h</th>
<th>% resp./hands/body-hands</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Paclobutrazol</td>
<td>1.04-1.61</td>
<td>M.p. + ma.p.</td>
<td>690</td>
<td>&lt;4.4</td>
<td>&lt;4.4</td>
<td>3.7</td>
<td>&lt;1</td>
<td>3.7</td>
<td>-100/-</td>
</tr>
<tr>
<td>7</td>
<td>Paclobutrazol</td>
<td>1.04</td>
<td>Tag.</td>
<td>690</td>
<td>&lt;4</td>
<td>&lt;17</td>
<td>5.1</td>
<td>&lt;1</td>
<td>5.1</td>
<td>-100/-</td>
</tr>
<tr>
<td>8</td>
<td>Paclobutrazol</td>
<td>1.4</td>
<td>Aut. sp.</td>
<td>690</td>
<td>&lt;4</td>
<td>&lt;17.5</td>
<td>&lt;4.1</td>
<td>N.m.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Paclobutrazol</td>
<td>1.4</td>
<td>R. bud</td>
<td>690</td>
<td>&lt;4</td>
<td>&lt;25.8</td>
<td>11.4</td>
<td>&lt;1</td>
<td>11.4</td>
<td>-100/-</td>
</tr>
<tr>
<td>8</td>
<td>Paclobutrazol</td>
<td>1.4</td>
<td>M.t.</td>
<td>690</td>
<td>&lt;4</td>
<td>N.m.</td>
<td>8.5</td>
<td>N.m.</td>
<td>8.5</td>
<td>-100/-</td>
</tr>
<tr>
<td>1</td>
<td>Pirimicarb</td>
<td>40-52.3</td>
<td>M. trim.</td>
<td>3810</td>
<td>&lt;2</td>
<td>N.m.</td>
<td>18.3</td>
<td>N.m.</td>
<td>18.3</td>
<td>-100/-</td>
</tr>
<tr>
<td>2</td>
<td>Pirimicarb</td>
<td>74.2</td>
<td>M. trim.</td>
<td>3725</td>
<td>2.4</td>
<td>N.m.</td>
<td>53.5</td>
<td>&lt;1</td>
<td>53.5</td>
<td>-100/-</td>
</tr>
<tr>
<td>2</td>
<td>Pirimicarb</td>
<td>74.2</td>
<td>M. trim.</td>
<td>13834</td>
<td>2.4</td>
<td>N.m.</td>
<td>9.3</td>
<td>&lt;1</td>
<td>9.3</td>
<td>-100/-</td>
</tr>
<tr>
<td>3</td>
<td>Pirimicarb</td>
<td>223</td>
<td>C.</td>
<td>2573</td>
<td>0.5</td>
<td>2.6</td>
<td>&lt;6.3</td>
<td>8.8</td>
<td>11.4</td>
<td>23/-77</td>
</tr>
<tr>
<td>4</td>
<td>Pirimicarb</td>
<td>74.5</td>
<td>-</td>
<td>-</td>
<td>3.22 (1170 min. after spr.)</td>
<td>N.m.</td>
<td>N.m.</td>
<td>N.m.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Pirimicarb</td>
<td>163</td>
<td>Man. sp.</td>
<td>910</td>
<td>10</td>
<td>&lt;4.2</td>
<td>2121</td>
<td>345</td>
<td>2466</td>
<td>-86/14</td>
</tr>
<tr>
<td>6</td>
<td>Pirimicarb</td>
<td>88.25</td>
<td>C.</td>
<td>1376</td>
<td>1.46</td>
<td>N.m.</td>
<td>52</td>
<td>414</td>
<td>466</td>
<td>-11/89</td>
</tr>
<tr>
<td>6</td>
<td>Pirimicarb</td>
<td>88.25</td>
<td>R.bud.</td>
<td>1376</td>
<td>1.46</td>
<td>N.m.</td>
<td>70</td>
<td>70</td>
<td>140</td>
<td>-50/50</td>
</tr>
</tbody>
</table>
Table 17.3
% DFR of applied dosage 1000 minutes after the spraying of 5 pesticides.

% DFR af udsprøjet dosis 1000 minutter efter udsprøjning.

<table>
<thead>
<tr>
<th>Exp. no.</th>
<th>Pesticide</th>
<th>g.a.i. applied/1000 m²</th>
<th>DFR µg/100 cm² 1000 min. after spraying</th>
<th>% DFR of applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Endosulfan</td>
<td>71</td>
<td>7</td>
<td>1.0</td>
</tr>
<tr>
<td>15</td>
<td>Mercaptodimethur</td>
<td>100</td>
<td>134.5</td>
<td>13.5</td>
</tr>
<tr>
<td>14</td>
<td>Mercaptodimethur</td>
<td>320</td>
<td>364.0</td>
<td>11.4</td>
</tr>
<tr>
<td>14</td>
<td>Mercaptodimethur</td>
<td>320</td>
<td>460.0</td>
<td>14.4</td>
</tr>
<tr>
<td>11</td>
<td>Methomyl</td>
<td>75</td>
<td>4.6</td>
<td>0.6</td>
</tr>
<tr>
<td>11</td>
<td>Methomyl</td>
<td>75</td>
<td>17.7</td>
<td>2.4</td>
</tr>
<tr>
<td>12</td>
<td>Methomyl</td>
<td>83.4</td>
<td>55</td>
<td>6.6</td>
</tr>
<tr>
<td>7</td>
<td>Paclobutrazol</td>
<td>1.61</td>
<td>1.5</td>
<td>9.3</td>
</tr>
<tr>
<td>7</td>
<td>Paclobutrazol</td>
<td>1.04</td>
<td>1</td>
<td>9.6</td>
</tr>
<tr>
<td>8</td>
<td>Paclobutrazol</td>
<td>1.4</td>
<td>0.88</td>
<td>6.3</td>
</tr>
<tr>
<td>2</td>
<td>Pirimicarb</td>
<td>74.2</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>6</td>
<td>Pirimicarb</td>
<td>88.25</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>5</td>
<td>Pirimicarb</td>
<td>163</td>
<td>393</td>
<td>24.1*</td>
</tr>
<tr>
<td>3</td>
<td>Pirimicarb</td>
<td>223</td>
<td>48</td>
<td>2.2</td>
</tr>
</tbody>
</table>

* At re-entry 910 minutes after the spraying the plants were still wet.
Figure 17.1
Sectioning of T-shirt and trousers after exposure.

Opdeling af T-shirt og bukser efter eksponering.
Figure 17.2
Transfer coefficients and working procedures for five pesticides sprayed on different ornamentals.

Transferfaktorer og arbejdsrutiner for 5 pesticider udsprøjtet på forskellige potteplanter.
Figure 17.3: Hand exposure and working procedures for five pesticides sprayed on different ornamentals.
Figure 17.4
Transfer coefficients, based on geometric mean, and working procedures for five pesticides sprayed on different ornamentals, not sorted for working procedures.

Transferfaktorer, baseret på geometrisk gennemsnit, og arbejdsrutiner for 5 pesticider spræjet på forskellige potteplanter, ikke sorteret for arbejdsrutiner.
Figure 17.5
Transfer coefficients and working procedures for five pesticides sprayed on different ornamentals. * = Kalanchoë.

Transferfaktorer og arbejdsrutiner for 5 pesticider sprøjtet på forskellige potteplanter. * = Kalanchoë.
Figure 17.6
µg DFR approximately 1000 minutes after the spraying/100 cm² leaf and g pesticide applied/1000 m² for all 5 pesticides. Average = 0.12 g DFR/1 g applied dosage.
A: Parameter estimate, \( y = 1.1183 \times x \) (forced to 0,0), \( s = 0.1777 \), Prob > |\( T \)| = 0.0001.
B: Lower 95% mean, C: Upper 95% mean (on \( y = f(x) \)).
D: Lower 95% predict, E: Upper 95% predict.

µg DFR/100 cm² blad ca 1000 minutter efter udsprøjtningen og g pesticid udsprøjet/1000 m² for alle 5 pesticider. Gennemsnit = 0.12 g DFR/1 g udsprøjet pesticid.
A: Parameter estimat, \( y = 1.1183 \times x \) (tvunget gennem 0,0), \( s = 0.1777 \),
Prob > |\( T \)| = 0.0001
B: Nedre grænse for 95% gennemsnit. C: Øvre grænse for 95% gennemsnit (for \( y = f(x) \)).
D: Nedre grænse 95% predikteret. E: Øvre grænse 95% predikteret.
4 Discussion

Exposure

In average of all experiments, the potential exposure on respiration, hands and body+hands was 2.4%, 63.3% and 34.3% respectively, table 17.2. If worker are working with bare hands and a 10% penetration of pesticides through clothing is assumed, the figures for pesticides reaching the skin and inhaled, changes to 3.5%, 91.6% and 4.9% respectively. The hands are clearly the body part exposed to pesticides at re-entry in greenhouses. These figures are subject to great variation in the individual experiment, as can be seen in table 17.2.

Transfer coefficients

The range of transfer coefficients found is in good agreement with both the Dutch, Swedish (even the Swede’s use a different DFR technique), German and Finnish results (although the Finnish experiments were reporting exposure on the bare hand but covered with a glove). The transfer coefficients ranged from 0-7067 cm²/h (Fig. 17.2). Arithmetic mean = 1755 cm²/h, s = 1985 cm²/h (n = 21) for all transfer coefficients (Geometric mean not calculated due to zero values). Table 17.1 summarises the 15 experiments in commercial green houses.

Table 17.2 and 17.3 show selected data from table 17.1. Figure 17.3 illustrates the huge variation in hand exposure in μg/8 h at re-entry. The difference in 25000-fold.

If methomyl and pirimicarb on Kalanchöe is excluded (extremely low transfer coefficients) the arithmetic mean was 2303 cm²/h ± one standard deviation = 1979 cm²/h, geometric mean was 1495 cm²/h ± one standard deviation = +525 (lower) and +4257 (upper) cm²/h (n = 16) and thus give a 90-percentile of 5199 cm²/h. The distribution of the transfer coefficients above 10 cm²/h, was tested on SAS, univariate procedure with a Shapiro-Wilk test. The normal distribution was tested and Pr<W was 0.0501. If log-normal distribution was tested, Pr<W was 0.4124. Log-normal distribution should be preferred due to a better fit although the normal distribution is significant just above 95% limits. The reason for a better fit for the log-normal distribution could be due to the relatively few workers behind the majority of the transfer coefficients in the individual experiment, Fig. 17.4.

The experiment with methomyl is somewhat unexpected and disagreeing with Bolelj et al (1991). We found relatively high dosages of methomyl on the body + hands (142-1150 μg methomyl/8 h) but only few μg methomyl/8 h on the hands. Working with tomatoes and cucumbers Bolelj et al. found up to 2.9 mg methomyl/8 h. It could indicate a very plant specific dependant DFR. Experiment 16 did only show a 1.3 to 4 fold difference between four ornamental species and four pesticides. The use of the leaf punch method will probably tend to increase the DFR, especially for the systemic pesticides when the sub cuticular layers are extracted by the water. The DFR in experiment 11 and 12 could be “sap-DFR” and therefore not available for surface contact of the plants. In experiment 11, a dry cotton glove was wiped over the leaves for 10 minutes, only touching the surface of the plant and was not in contact with the subcuticular layers. No methomyl could be detected by this gentle method of removing methomyl from the surface.
Transfer coefficients are pesticide dependant

When pooling all pesticides no significant correlation could be observed between working procedures and transfer coefficient, Fig. 17.2. But within each pesticide there was a clear tendency to correlation between transfer coefficients and degree of contact with the plants (i.e. working procedures) Fig 17.5. This means that the transfer coefficients in this series of experiments seems to be pesticide dependant. No statistical evaluation has been tried due to the small number of experiments.

Exposure on body + hands

Transfer coefficients are only based on hand exposure in these experiments and in the literature. And the transfer coefficient is the key target in this investigation. But in almost all the experiments, body exposure beside the hand exposure has been registered (Table 17.3). In experiment 15, the exposure of the body of mercaptodimethur was 10-20% of the total exposure, in experiment 14 the body exposure accounted for 46% of the total exposure. Endosulfan and pirimicarb show similar distributions. Normally workers are wearing light clothing and if dry this ensure a reduced transport of pesticide to the skin. If this is not the case, dermal exposure through unprotected skin and humid/wet skin should be considered. This is some of the reasons why we have raised the default transfer coefficients above what has been calculated only by hand exposure.

Applied dosage and DFR

A significant correlation between applied dosage and DFR within each pesticide is not present due to the interference from plant species. But Table 17.3 and Figure 17.6 show DFR approximately 1000 minutes after the spraying of all pesticides/100 cm² leaf area. The correlation is positive and significant different from 0. The average value is 12% of applied dosage found as DFR 1000 minutes after the spraying. Figure 17.6 shows that there is a big variance in DFR in the experiments made, when applying the same dosage. Influential parameters are plant species, pesticide and application technique. Totally it means there is a positive significant correlation but the variation in DFR is too big to be able to set a default value between g applied pesticide and DFR.

Respiratory exposure

The respiratory exposure seems low at re-entry for methomyl, paclobutrazol and pirimicarb (Table 17.2). Endosulfan is registered up to 60 µg endosulfan/h when static air samples were made. Mercaptodimethur is in experiment 14 and 15 resuspended in the air when workers are handling the plants. In general, no measurable amounts of pesticides occurred in the air after spraying, despite depositions of pesticides on inactive media after spraying was registered.

Inactive media

Deposition of pesticides on inactive media was measured on heating tubes, tables, glass walls and curtains. When analysed, we could always report residues to a smaller or larger extent. Most was detected of methomyl and pirimicarb on heating tubes. These two pesticides were applied with cold fogger. When using spray boom for application, pirimicarb was deposited in very small dosages, but the use of hand held rifle increased (off course) the deposition up to 10-fold on heating tubes. The percentages of deposited pesticides at re-entry in Table 17.1 seems low, compared to the applied dosage.

Spray pattern

The spray deposition pattern was investigated in experiment 9, 11, 12, 13, and 15 using cold foggers and experiment 14 using hand held rifle. The
differences between the lowest and the highest deposition using cold fogger was 10, 5.6, 4.3, 195 and 35-fold. For the hand held rifle in experiment 14, it was only 3 fold. The deposition of pesticides is closely related to dislodgeable foliar residues. Exposure of workers beyond the predicted average DFR-level could introduce a health risk. On the other hand one could incorporate the variation in deposition using cold foggers and this would be reflected in the risk assessment of the worker. This would eventually lead to restrictions in the use of some pesticides in green houses. A 10-fold variation in deposition of pesticides is unacceptable. If pest control is satisfactory under such spray conditions, it indicates the average pesticide consumption is too high.

Experiment 16 shows the influence of plant specie and pesticide on DFR. At 1200 minutes after the spraying there was a 1.9 to 4-fold difference in DFR between the plant species within the individual pesticide. The most important parameter in this experiment seems to be the pesticide, with a 68-fold difference per g. a.i. applied leading to the conclusion that a default value of DFR related to applied dosage is difficult to obtain. Fig. 17.5 support this view. DFR should be investigated with the actual pesticide.
5 Conclusion

Re-entry experiments have been made in 8 Danish commercial green houses growing potted flowers and cut roses. The investigated parameters were 5 pesticides, 11 working procedures, 3 different spray equipment’s and a variety of plant species. 50 individual workers have been detected for exposure.

In average of all experiments, the potential exposure on respiration, hands and body+hands was 2.4%, 63.3% and 34.3% respectively. If worker are working with bare hands and a 10% penetration of pesticides through clothing is assumed, the figures for pesticides reaching the skin and inhaled changes to 3.5%, 91.6% and 4.9% respectively. The hands are clearly the body part exposed to pesticides at re-entry in greenhouses. These figures are subject to great variation in the individual experiment.

The measured transfer coefficients ranged from 0 to 7067 cm²/h ± one standard deviation = 1937 cm²/h for all transfer coefficients (n=21). Excluding transfer coefficients below 10 (practically zero due to no DFR), arithmetic mean was 2303 cm²/h ± 1979 cm²/h, geometric mean was 1495 cm²/h ± one standard deviation = ± 525 (lower) and +4257 (upper) cm²/h (n=16), thus leading to a 90-percentile of 5199 cm²/h. Log-normal distribution of the transfer coefficients made a better fit than a normal distribution. Only hand exposure was used in calculating the transfer coefficients due to the normally not protected hands. Working between the tables in the green houses resulted in many cases in exposure comparable to hand exposure. If the workers were wearing short pants, the dosage should be considered as interesting as the hand exposure. The correlation between the transfer coefficient and working procedure was poor when pooling all pesticides.

There was a better correlation within the individual pesticides. Making cuttings or removing buds were correlated to the higher transfer coefficients, packing and spacing the plants at the tables were correlated to lower transfer coefficients. DFR one day after the spraying compared to initial spray dosage seems to be pesticide dependant.

Differences in DFR between plant species have been registered, but seems to be of less importance with few exceptions.

Stationary air monitoring at re-entry showed that exposure via inhalation is less important except for endosulfan which was measured to be 60 µg/h at a respiration rate of 20 L/min. Personal air monitoring showed further more in the experiments with mercaptodimethur that the concentration in air increased to between 45.8 and 138.2 µg/h at a respiration rate of 20 L/m. due to the working activity.

Heating tubes, tables and to a lesser extent glass walls were contaminated with residues after the spraying. Endosulfan was found to be absorbed in plastic curtains and the residues persisted for a long time. In general, the air before the spraying in the green houses did not contain high concentrations of pesticides.
Spray patterns of cold foggers have revealed a depression in spray quality. The differences in concentrations (dosage/area) have been measured for cold foggers to be from 4.3 to 195-fold. In the last case, 72.3% of the total deposited dosage was found on 7.7% of the sprayed area. This uneven distribution could lead to uncontrolled exposure of the workers, or the models used to estimate exposure in green houses should include this kind of worst-case scenarios. The consequence would be a model which in an increasing number of cases exceeds the accepted AOEL value. Reduction in the number of pesticides allowed in green houses would be the result.

In summary, the transfer coefficients registered in this type of green houses is on the same level as the Dutch, Swedish, German and Finnish transfer coefficients in the same working area doing other working procedures, namely 5000-7000 cm²/h as the worst case. The DFR values should be detected for each individual pesticide up to one week after the spraying. It should be investigated in a shorter series of experiments, how many and which plant species should be sprayed in order to obtain a picture that covers the practical situation.

Based on the present results and the literature a model for assessing exposure in green houses with ornamentals is suggested:

1) **Default value of transfer coefficient** should be no less than 7000 cm²/h for working with ornamentals under green house conditions.

2) **DFR of each individual pesticide** should be documented if used in green houses. The duration of the experiment should be 7 days and dislodgeable foliar residue studies should be present on at least 3-4 plant species. The number of species should be investigated in a small scale experiment.

3) For non-systemic pesticides, data on personal air monitoring when working should be required. Increased exposure seems probable for this type of pesticides, especially were the culture is placed above the worker.

4) When working between tables and in dense cultures personal protection should be considered, especially on uncovered parts of the body.
6 References


