Annual report 1988

Glasshouse crops research station
Naaldwijk, The Netherlands

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3. DIRECTOR'S REPORT

E. Kooistra

New buildings

The occupation of the new buildings made 1988 a special year for the Glasshouse Crops Research Station. Towards the end of 1987 the energy centre was completed, which event was memorized already in the previous Report where also a description of its facilities is given. After the energy centre came into use various kinds of teething troubles had to be solved.

In the course of the year under the review the main building was completed. Together with the offices also several laboratories were furnished, viz. the laboratories for chemical and physical research of the Department of Plant Nutrition and Substrates, the laboratories for fungal, virus, bacteria and insect research of the Department of Pests and Diseases and various laboratories for product and quality research of the Department of Horticulture and Glasshouse Climate. Also a special section was arranged for equipment, with a flowering room for flower research, cold stores for keeping quality research, climate cabinets, climate cells and preparation cells for tuberous and bulbous plants. Set-up and accessibility of the equipment were thus greatly improved which will lead to a more efficient and safer use.

The official opening was executed by Her Majesty Queen Beatrix on 9 September. This was the culmination of a great number of activities accompanying the official inauguration. The number of visitors during the open days almost reached 4,000. Also in the media the new Research Station received generous interest. The compilation of a special issue of the Netherlands Journal of Agricultural Science, with articles of staff members of the Research Station, deserves special mention.

Apart from the new buildings of the Research Station, on the same premises the new buildings of the Laboratory for Soil and Crop Research were completed. Furthermore the old building of the Research Station was totally renovated and made suitable for housing the State Advisory Service. Thus the concentration of services on the same premises was maintained: the research for commercial practice, the advisory service and the routine soil research are accommodated close together. This will strongly promote the mutual contacts and support. This concentration in a joint centre of knowledge and service, which is of great importance for the glasshouse industry, should be highly appreciated.

In view of the many changes taking place the significance of this tends to become greater in future. The privatisation of the advisory service is at hand; and the research becoming self-sufficient will also have its consequences. In view of these changes an effective centre of information and service is, in our opinion, of the utmost importance. The glasshouse industry as a whole is not in smooth waters, either, for that matter. Environmental problems, for instance, will have an unmistakable impact in the near future. However, in the past growers always had a flexible approach to problematical situations. We trust

they show enough resourcefulness also in the present time to tackle the difficulties. They must then be able to get the information they need where it is to be found.

Research

Despite the fact that removal and design as well as all the other activities connected with occupying the new buildings took up a lot of time, the research was continued undisturbed. Apart from internal shifts new projects could be started or current projects extended. The physical research of potting soils and artificial substrates, for example, which was delayed before due to several circumstances, could be started again. One of the factors facilitating this was the equipment of a laboratory for this type of research.

The evaporation research received a new impulse from the renovation and equipment of a new measuring set-up in the lysimeter glasshouse.

For the freesia research an aphid-proof gauze house was constructed with the aim to study the possibilities of propagating freesia corms, separate from flower production.

The utility value research was extended by appointing 2 new staff members.

A start was made with the study of the courgette yellow mosaic virus, which virus may form a potential danger not only for the courgette crop but also for other Cucurbitaceae.

The quality research was reinforced. First experiences with a taste panel were gained. The quality research needs further reinforcement by additional manpower.

Reduction of the nitrate content in lettuce grown in water during the winter months, received special attention. To this purpose suboptimal nitrate fertilization in particular was tested.

With respect to phytopathological research the control of western flower thrips was subject of research. Although quite a lot of research capacity was deployed already for investigation of ecologically sound production systems and methods, further reinforcement was again aimed at. Thus the section of substrate research increasingly carries out nutrition research which should contribute to reduced drainage of nutrients to groundwater and surface water. Closed, recirculating systems require a high-quality water.

For the disinfestation of recirculation water various systems were tried. Within this framework the study of the fungus Olpidium, a vector of several virus diseases, is important. At the moment this receives ample attention in research.

At the end of the year under review the Department of Economics and Management started a research programme on more ecologically sound production systems. This research is conducted in co-operation with the Agricultural Economics Research Institute (LEI).

In general terms there is a satisfactory co-operation with the various institutes and with the fellow research stations. Various projects are carried out in close co-operation with several Departments of the Agricultural University in Wageningen, and for one project arrangements were made with the State University in Groningen.

4. DEPARTMENT OF PLANT NUTRITION AND SUBSTRATES

C. Sonneveld

CHEMISTRY

Chemical soil research (C. de Kreij)

To improve the 1:1.5 volume extract, which is being used for peaty substrates, a study was conducted of the physical characteristics which play a role in the filling of one volume part of substrate. Furthermore it was investigated how the average humidity condition occurring in commercial growing practice can be simulated in the laboratory.

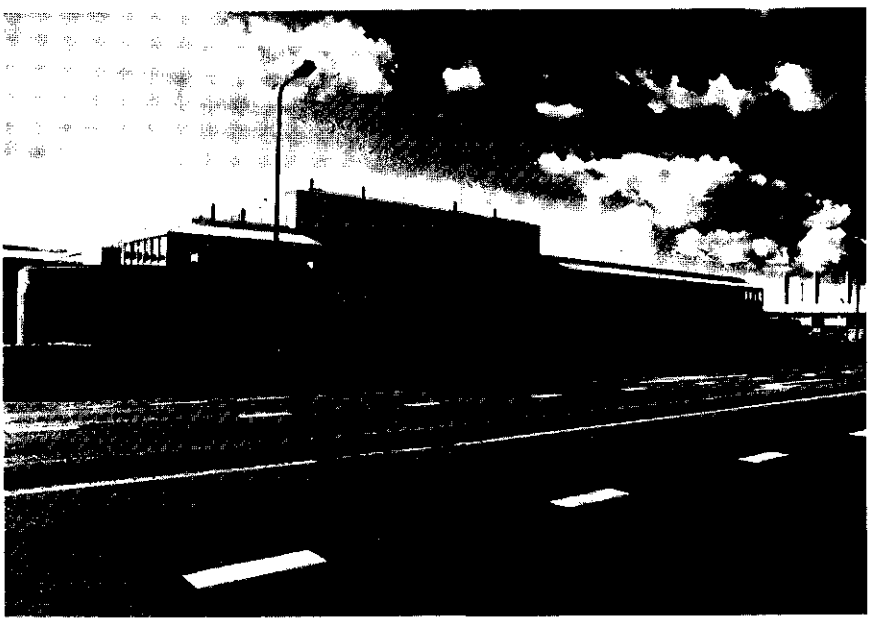
Ten methods, using 15 different peat substrates, were compared in which bulk density, water content, and volume fraction air and water were determined. For the bulk density the correlation between the methods was very high ($r>0.98$, $d.f.=13$). For the wetness ratio and the volume fraction air and water the correlation was also high, with the exception of one method in which a cylinder was filled with dry soil and given a free fall several times in between. For this method the correlation coefficient with the other methods was 0.01 to 0.84. Filling a cylinder bit by bit with a free fall of that cylinder in between resulted in a strong compaction of the peat substrate. To obtain a density corresponding to that in substrate in pot plant cultivation, the substrate should be saturated slowly from the bottom upwards. Then only minor compaction occurs.

This method has tentatively been accepted in ISHS consultations to serve as an international standard for the determination of bulk density and water/air distribution at a pressure head of -10 cm.

PLANT NUTRITION IN SOILS

Automation of fertilizer recommendations (A.L. van den Bos)

Since 1985 nutrition recommendations for several soil-grown crops were composed with the help of a computer. In 1986, 1987 and 1988 automatic additional nutrition recommendations were tested for cucumber, carnation, chrysanthemum and rose. With the exception of several minor adaptations of the nutrient solutions and guide values, the results were satisfactory. In practice a slightly higher dosage (10 to 20%) was applied than was recommended. Growers were satisfied about the way the recommendations, calculated by the computer, were set up. The guide values recommended for various crops are summarized in Table 1.



Figs. 1 and 2. The new buildings of the Glasshouse Crops Research Station, seen from the north (above) and from the south (below).

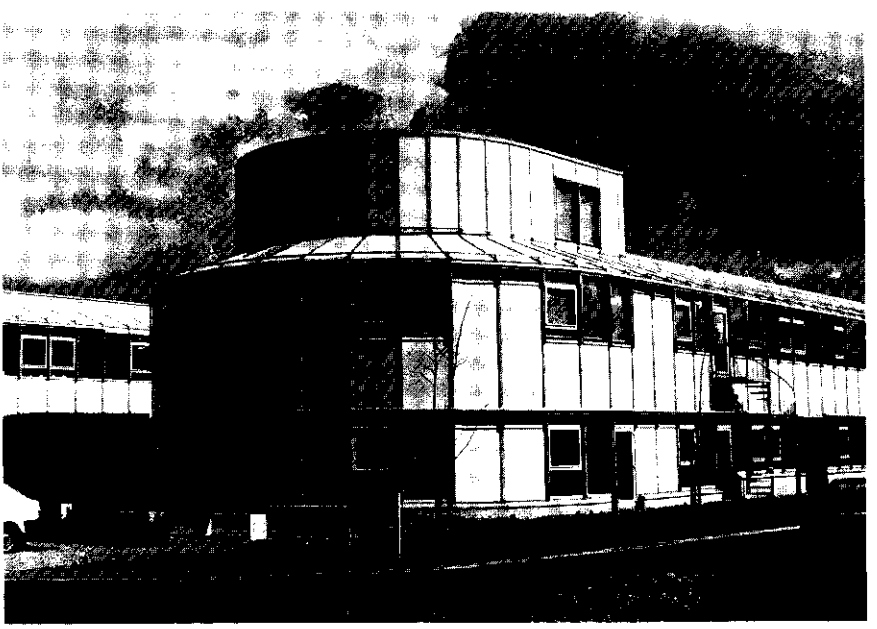


Table 1. Guide values for analytical data of 1:2 volume extract. The contents are expressed as mmol per litre of extract, EC as $dS.m^{-1}$ ($25^{o}C$)

crops	K	Ca	Mg	N	S	EC
cucumber	1.8	2.2	1.2	4.0	1.5	1.0
sweet pepper	2.0	2.5	1.2	4.5	2.0	1.1
tomato	2.2	2.5	1.7	5.0	2.5	1.4
carnation	1.5	2.5	1.2	4.0	1.5	1.1
chrysanthemum	1.0	1.5	0.8	2.0	1.5	0.8
gerbera	1.5	2.0	1.2	4.0	1.5	1.0
rose	1.5	2.0	1.2	4.0	1.5	1.0

Boron in Amaryllis (Hippeastrum) (A.L. van den Bos and M. Zevenhoven)

In March 1988 Amaryllis bulbs were again planted out in the same basins as in 1987 (see Annual Report 1987, p. 16). Borax was applied in 0, 1, 2, 4 and 8 g per m^2. The B-contents in the soil one month after application were 6, 16, 49, 90 and 223 umol per litre 1:2 extract (0.02 m $CaCl_2$), respectively. In the beginning of July B-toxicity was observed in the treatment of 8 g per m^2. At that moment the B-content in the soil was 113 umol per litre extract. In the other treatments no deficiency or toxicity symptoms could be observed. The bulbs were lifted on 11 November. Differences in bulb weight between the treatments were minimal. The B-contents in the soil at the end of the growing period were 3, 10, 15, 33 and 52 umol per litre extract. Crop samples are still under investigation. The bulbs will again be planted out in the basins in March 1989 for flowering.

Nitrogen source and crop growth (A.L. van den Bos and M. Zevenhoven)

In an experiment started in 1983 (see Annual Report 1983, p. 20) nitrate, ammonium and urea were compared as nitrogen forms added to the irrigation water for top dressings. The applied quantities of ammonia and urea amounted to 25 and 50% of the total nitrogen applied. Until May 1988 gerberas were grown as experimental crop. With gerbera high ammonium (50%) reduced chlorosis in the leaves and tended to result in a better yield. The application of urea and nitrate did not show such effects. In July 1988 matricarias (Chrysanthemum parthenium) were planted as experimental crop. The yield was not affected by the various nitrogen sources. In October corn salad was used as test crop. Neither in this crop was there any significant correlation between yield and nitrogen source.

PLANT NUTRITION AND SUBSTRATES

EC levels in a split root system for rockwool grown tomatoes (W. Voogt)

In 1987 research was started on the effects of an uneven distribution of plant nutrients in the root environment (see Annual Report 1987, p. 18). Tomatoes were grown in a split root system in 2 separated rockwool cubes. In one cube a standard concentration was maintained (EC value of about 2.5 $dS.m^{-1}$). In the other, EC values of 0.5, 2.5, 5.0, 7.5 and 10.0 $dS.m^{-1}$ were established.

The yield of the tomatoes was not influenced by the various treatments. The quality of the fruits was not affected by EC values higher than the standard value maintained in part of the root environment. The EC level of 0.5 occasionally seemed to have an adverse effect on fruit quality. The water uptake of the roots in the section with EC levels of 0.5 to 10.0 $dS.m^{-1}$ decreased from 40 to 8% of the total water consumption. However, the nutrient uptake increased from 10 to 65% (calculated for NO_3) of the total uptake, with increasing EC level.

pH and Mn levels for gerberas grown in rockwool (W. Voogt)

Gerberas were grown in rockwool at pH levels between 6.5 - 7.5, 5.5 - 6.5, and 4.5 - 5.5. These levels were combined with Mn levels in the nutrient solution of 0, 7.5 and 15 $umol.l^{-1}$. Two cultivars were used, viz. 'Amber' and 'Joyce'. The different pH levels were obtained by varying the NH_4 concentration in the nutrient solution. The experiment started in February 1987 (see Annual Report 1987, p. 16) and was ended in May 1988.

At high pH values severe chlorotic symptoms appeared which were strongly reduced by lowering the pH. The effect of the manganese application on the reduction of chlorosis was only slight. The number of flowers was 16 and 26% higher at the lowest pH value than at the highest pH value for the cultivars 'Joyce' and 'Amber', respectively. The manganese concentration did not affect the number of flowers.

pH and B levels for gerberas grown in rockwool (W. Voogt)

In September 1988 an experiment was started with gerberas grown in rockwool in which 2 pH values and 4 B levels were maintained. The pH values were between 5.0 - 5.5 and 6.0 - 6.5. The boron applications were such that levels of ca 10, 25, 50 and 100 $umol.l^{-1}$ in the root environment were achieved. Until the end of December only an effect of the pH value on the number of flowers could be observed. At the lower pH value flower production increased with 10%. The experiment will be terminated in December 1989.

pH values for carnations grown in rockwool (W. Voogt)

In an experiment with carnations in rockwool 5 pH values varying between 4.5 and 8.5 were compared. Planting out was done in September. The various pH values were realised by addition of different quantities of ammonium to the nutrient solution. Lower pH values resulted in better growth. Harvest will start in April 1989.

Si application with rockwool grown cucumbers (W. Voogt)

In an experiment different sources of Si were compared with cucumber as test crop. In one treatment the cucumbers were grown in a mixture of peat and rice husks and in the other treatments in rockwool slabs. In one treatment with rockwool slabs a jellied silicon compound was added to the slabs before planting and in other treatments the silicon was added in a concentration of 1 mmol.l^{-1} in the nutrient solution. A polysilicate and potassium silicate were used. In Table 2 yield and silicon contents of young leaves are listed.

Table 2. Yield and silicon contents of young leaves in an experiment with cucumbers

treatment	yield kg.m^{-2}	tissue Si mmol.kg^{-2}
Potassium silicate in solution	35.8	419
Polysilicate in solution	33.9	108
Peat/rice-husks mixture	33.7	304
Si jelly in slabs	35.1	223
Control	33.2	79

Yield and silicon contents in the plant tissue were highest in the treatment with potassium silicate in the nutrient solution.

Interaction between zinc and phosphate in beefsteak tomatoes (W. Voogt and H.G.M. Sonneveld-van Buchem)

In rockwool grown tomato crops often zinc deficiency occurs while the zinc supply is sufficient. Leaf analyses show normal zinc contents, but the phosphorus contents are high, up to 300 mmol.kg^{-1} dry matter. Results of previous experiments indicate that increasing P reduces the availability of Zn.

In order to investigate the interaction between Zn and P, an experiment was carried out with P/Zn ratios, in a rockwool grown beefsteak tomato crop. The P concentrations in the nutrient solution applied were: 0.75, 1.5, and 3.0 mmol.l^{-1}, and the Zn concentrations 5 and 15 umol.l^{-1}.

The results showed that at a Zn level of 0.75 mmol.l^{-1} the yield decreased with 5%. Zinc deficiency symptoms could not be observed. There was a strong correlation between the P level and the incidence of gold specks on the fruits. With increasing P concentrations in the nutrient solution more gold specks occurred.

Results of tissue analysis are not available yet.

Perchlorate toxicity in cucumber (W. Voogt)

During the winter season 1987/1988 the use of the Chilean potassium nitrate caused toxicity symptoms in cucumber crops in commercial practice. The symptoms shown were necrosis at the leaf margins of young leaves and sticking together of the petals. In literature it was found

that Chilean potassium nitrate may contain perchlorate, which is seriously phytotoxic.

In order to investigate whether the toxicity symptoms are due to the perchlorate or to other causes, an experiment was carried out. Cucumbers were grown in aerated nutrient solutions, with the treatments KNO_3 pure, KNO_3 with 0.4% or 0.8% ClO_4 and 2 Chilean fertilizers from nurseries where the symptoms occurred.

The results showed that the toxicity symptoms which were generated with perchlorate were similar to those resulting from the application of the Chilean fertilizers. In addition to the toxicity symptoms, the growth of shoots and roots was reduced with 20 and 40%, respectively.

It was concluded that the damage to the crop resulting from the use of Chilean potassium nitrate was caused by perchlorate. The use of Chilean potassium nitrate for cucumbers must therefore be advised against.

Interactions between K, Ca and Mg in rockwool grown cucumbers (W. Voogt)

In spring and autumn experiments were conducted in which cucumbers were grown with 12 different ratios between K, Ca and Mg in the rockwool slabs. The nutrient solution was recirculated. The K/Ca ratios varied between 2 and 0.25. The K concentration in the nutrient solution in the rockwool slabs varied from 11.0 to 1.8 mmol.l^{-1} and the Mg concentration from 1.5 to 4.5.

In the treatments with 1.5 mmol Mg per litre slight symptoms of Mg deficiency occurred, especially at the lowest K/Ca ratios. Yield and fruit quality were not affected. Consequently the conclusion is drawn that cucumbers can be grown successfully within a wide range of cation ratios.

Correlation between analyses of drainage water and of root environment (H.G.M. Sonneveld-van Buchem and W. Voogt)

An investigation was conducted of the correlation between the analytical results from the nutrient solution in the root environment and those from the drainage water. This investigation was done with strawberries grown in containers with peat substrate, with anthurium grown in beds with polyphenol foam and with cymbidium grown in containers with granulated rockwool. The peat substrate was sampled and analysed by means of the 1:1.5 volume extract. In the anthurium and cymbidium experiments the nutrient solution in the root environment was collected by means of ceramic elements. The results showed that the correlation for the EC levels between nutrient solution and drainage water was quite strong. In the strawberry experiment it was found that the EC in the drainage water was 3.8 times as high as in the peat samples (1:1.5 volume extract). For anthurium the EC in the drainage water was about the same as in the root environment. For cymbidium the variation in the observations was too small to calculate a relationship.

Comparison of the elemental concentrations showed that for the macro-elements no important shiftings appear between the nutrient solution in the root environment and the drainage water. For the micro-elements, especially for Mn, and for the pH, no clear

relationship could be established. Consequently, it seems possible to use drainage water for sampling in order to control the composition of the nutrient solution, for those crops where it is impossible to collect nutrient solution from the root environment.

Nutrient solution for courgette (H.G.M. Sonneveld-van Buchem)

The usability of a standard nutrient solution for courgette was checked in an investigation. On 2 nurseries data were collected on the course of the nutrient concentrations in the root environment. Also tissue samples were analysed.

It appeared that K and SO_4 accumulated easily in the root environment, whilst Ca and B remained rather low. Analytical results further indicated that Ca and B contents in the tissue were quite low and P fairly high.

On the basis of this investigation, the nutrient solution for courgette was adjusted.

Checking the computerised programme for the fertigation of tomatoes (H.G.M. Sonneveld-van Buchem)

The accuracy of the programme for the recommendation of nutrient solutions for tomatoes, was checked in an experiment in commercial practice. On 2 nurseries during the growing period the results of the analyses of the nutrient solution in the root environment were collected as well as data of the nutrient solution added. These data were compared with the recommended values.

It appeared that on both holdings extra Mg, NO_3 and B had to be added to reach the recommended value in the root environment. P levels in the root environment were fairly high in spite of a decreased addition.

On the basis of these results the recommended concentrations for Mg, NO_3 and B in the nutrient solution for tomatoes was increased and for P decreased.

WATER SUPPLY

Comparison of trickle irrigation systems (A.M.M. van der Burg)

The experiment in which 5 trickle irrigation systems were tested for their sensitivity to clogging (see Annual Report 1987, p. 20) was continued. Apart from capillary system with a capacity of 1 $l.h^{-1}$, which was also tested in 1987, capillaries with a capacity of 2 $l.h^{-1}$ were installed. No further modifications of the system were carried out.

In March all systems were thoroughly cleaned, resulting in a decrease of the coefficient of variance of the filthy systems. Thus the coefficient of variance of the capillary systems decreased from 20 to 5%. Further measurements showed that in July the coefficient of variance of the 1 litre capillary system started to increase again to ultimately 19% in November. The coefficient of variance of the other systems, even the 2 litre capillary system, did not show major changes during the testing period.

Fig. 3. Determination of the water content of rockwool slabs in the dripping frequency experiment with tomato

Specific effects of sodium chloride on cucumber grown on rockwool in a recirculation system (A.M.M. van der Burg)

After tomatoes and sweet peppers in previous years in 1988 cucumbers were grown. The treatments were similar to those of the 1985, 1986 and 1987 experiments (see Annual Report 1985, pp. 21-22). The basic level for nutrient supply was 2.2 $dS.m^{-1}$ for all treatments. Higher levels were realised by adding nutrient salts or NaCl. In one treatment the nutrient solution was replaced fortnightly. Treatments were carried out in a spring crop (7 January to 26 May) and in an autumn crop (3 August to 27 October).

Increasing the EC from 2.5 to 3.7 and to 5.2 in the spring crop reduced the yield with 7 and 16%, respectively. The autumn crop showed no EC effect on the yield. Increasing the EC level by means of NaCl addition in the spring crop resulted in only a minor yield reduction. In the autumn crop an increase with NaCl to an EC level of 5.2 reduced the yield with 14%. The fortnightly replacement resulted in the spring crop in a yield reduction of 8% but in the autumn crop in a small insignificant increase in yield.

EC and NaCl did not have an effect on the percentage of deviating fruits. Higher EC levels resulted in a darker colour and a longer shelf life. On these quality aspects NaCl addition had almost no effect.

The uptake of Na and Cl ions by the crop was also traced in this experiment. It was very low compared to the concentration in the nutrient solution. The average uptake of Na and Cl in the treatment with 12.5 mmol NaCl was 1.4 and 1.8 mmol.l^{-1} water absorbed, respectively.

Effect of dripping frequency on the yield of rockwool grown tomatoes (A.M.M. van der Burg)

This trial is a continuation of the 1987 research by the Department of Horticulture and Glasshouse Climate. Four irrigation frequencies were compared in which the amount of water per watering was 100, 400, 800 and 1200 cc, respectively. The total amount was the same for all treatments so that the dripping frequency was in the proportion 12:3:1.5:1. The percentage of drainage water was about 30 in all treatments. Measurements were carried out during the period 15 July - 15 November. There were almost no differences in yield between the 4 treatments. The proportion of fruits affected by blossom-end rot was high (ca. 35%), but showed no correlation with the treatments. Determination of the water content of the rockwool slab showed that the water fraction in the slab with the highest watering frequency stabilized at 0.78. In the treatment with the lowest frequency the water fraction varied from 0.55 before dripping to 0.72 after dripping.

Development of a bioassay on components of artificial substrates (D. Klapwijk and M. Zevenhoven)

Many different materials are used as components of artificial substrates and potting media. The routine chemical analysis generates information with respect to fertilisation but does not detect any possibly harmful substances.

To test different materials for possible plant damage, extracts were made during 24 hours. One part (volume) of any material was filled up with water to two parts. With the extract a cube of rockwool was saturated. Seeds of lettuce, kohlrabi and garden cress were sown on the rockwool.

The first tests have been carried out with different types of pine bark. One type was uncomposted and caused considerable damage on germination of the seeds and hampered subsequent growth.

Additional tests will be carried out with other materials used in substrates. Variations in the extraction period and the extraction temperature will be investigated.

The effect of different substrates on growth of tomato plants (D. Klapwijk and C.F.M. Wubben)

Beefsteak tomatoes were planted in July in an recirculation system with a high irrigation capacity in relation to evapotranspiration. The following substrates were used: rockwool with horizontal and with

Fig. 4. Dick Klapwijk shows Queen Beatrix the various artificial substrates currently in use in glasshouse vegetable cultivation. Behind Her Majesty is the Governor of the province of South-Holland, mr S. Patijn (left), behind mr Klapwijk are the mayor of Naaldwijk, mr J. de Bruin (left), and the director of the Research Station, mr E. Kooistra (right).

vertical fibres, a coarse and a fine peat mix, loaves of undisturbed sphagnum peat sods, glasswool, perlite, vermiculite, polyphenolic foam and hydrophyllic as well as hydrophobic rockwool granules. All plants received 3 l of substrate divided over 2 rectangular plastic pots (split root system). Other plants were supplied with one pot of each substrate while the other was filled with rockwool (horizontal fibre).

The yield varied between 2.1 and 3.0 kg.plant^{-1}. Highest yields were found on rockwool and peat mixes. On the other materials the yield was lower and improved in those split root systems where plants partly rooted in rockwool.

Problems with germination of tomato and sweet pepper in rockwool propagation cubes (D. Klapwijk and A. Loendersloot)

The moisture characteristic of rockwool is such that after saturation with a nutrient solution a propagation cube with a height of ca 3 cm has a very low air content. This may be one of the causes of

germination problems with tomato and sweet pepper seeds.

Several experiments were carried out to elucidate the cause of these problems. A correlation with seed origin could be demonstrated but it was not clear whether the cultivar or the seedhouse was involved. Tomato cv. 'Turbo' is more damaged than 'Counter' and sweet pepper 'Rumba' more than 'Luteus'.

Increasing the air content of the propagation cubes by pressing out at least 25% of the water gave a higher germination percentage. The origin of the rockwool cubes was not very important, since four different brands did not show considerable differences. The quality of the water used to prepare nutrient solutions to saturate the cubes did play a role. Prepared with tap water a better germination was found than with rain water collected from the glasshouse roofs. Non-fertilised water was better than a nutrient solution of standard concentration. Using pure water implies the addition of a nutrient solution very shortly after complete germination.

At least 5 factors were involved in the possible damage: water quality, air content, nutrient concentration, cultivar and seedhouse. Probably a combination of several if not all of these factors is necessary for the problems to arise. Additional disadvantageous factors may play a role. The problems were more serious in 1987 than in 1988 and tended to occur mostly in July and October/November.

The effect of root pruning and additional root growth on production of tomato (D. Klapwijk and C.F.M. Wubben)

As young roots by hormone production can promote shoot growth, it was attempted in an experiment to vary root growth of tomato plants. Control plants, propagated in rockwool cubes, were grown in 5 l rockwool in an irrigation system with a high circulation capacity in relation to evapotranspiration. Tomatoes were planted on 8 March 1988. The experiment was terminated on 20 June. Plants had to start growing in either 5 l rockwool, two thirds or one third of this volume. When the fifth truss flowered the rockwool was replenished to 5 litres in the two latter groups. Simultaneously, in other treatments one third or two thirds of the substrate was cut off at that moment and replaced by fresh rockwool. The same treatments were carried out in the week the first fruit was picked.

Although the solar radiation was very high on the days that one or two thirds of the rockwool were cut off, no wilting occurred. The rate of flowering was not affected by any of the treatments. The average yield per plant was slightly more than 5 kg. The differences were statistically not significant.

Absorption capacity of root systems in relation to the characteristics of the substrate (B.J. van Goor, C.F.M. Wubben and A. Huijs)

Relatively little knowledge exists about the requirements to be met by the root system in different culture media. The experience is, however, that root systems can be manipulated for instance by using a solid or a liquid substrate. General aims in cultivation are to obtain sufficient uptake of necessary nutrients in the various growth stages, and to keep the energy used by the root system at a minimum. Against this background, a literature study was conducted of a number of factors

which influence the roots. These factors include nutrient and oxygen availability in the root environment but also the spatial construction of the substrate and the counterpressure this gives to the root growth.

In a first experiment variations in spatial construction of the medium were investigated by using beads of glass with diameters varying from 10 to 0.1 mm. In this way the free space, the counterpressure, the oxygen concentration and the water content of the substrate were varied systematically. On these media tomato plants were cultivated on a suitable nutrient solution with trickle irrigation. In Table 3 some preliminary results are given. There was a light tendency to higher shoot:root ratios on the larger diameters of the glass beads. Differences in root morphology were also apparent. On the water culture straight, white roots with a feathery branching were formed (only roots of the second order). On the glass beads the roots were located more in the upperside of the pots as the bead diameters became smaller. The roots were then more lignified and in any case more branched and twisted than the roots in water culture.

Table 3. Preliminary results of the experiment of tomato plants on beads of glass

Bead diameter in mm	fresh weight (g) ratio 'shoot':'root'		dry weight (g) younger roots		dry weight (g) all roots	
Experiment	I	II	I	II	I	II
10 mm	5.5	5.5	0.7	3	0.9	3.5
5	6	7	0.5	2	0.8	2.5
2	5	7.5	0.7	2	0.9	2
1	5	-	0.7	-	0.9	-
0.5	4	6	0.4	2.5	0.6	3
0.2	4	6	0.8	3	1	3
0.1	4	5	1.5	3.5	2	4
water cult.	3	5	0.9	0.7	1	0.8

Nitrate content of winter grown lettuce (B.J. van Goor)

In an experiment absorption of nitrogen in lettuce was studied in winter on nutrient film technique. Low quantities nitrate of 0.1 - 0.3 mmol.plant^{-1}.day^{-1} were given, adapted to the radiation in the preceding period. They reduced the nitrate content but also the yield of the lettuce compared to lettuce on the standard nutrient solution.

5. DEPARTMENT OF HORTICULTURE AND GLASSHOUSE CLIMATE

C.M.M. van Winden

TOMATO

Effects of plant movement on growth and production (K. Buitelaar)

Experimental shaking of plants adversely affected growth and production (see Annual Report 1987, p. 24). In a subsequent experiment the plant movement was brought about by walking alongside the plants at a short distance every day, twice a day and every other day. Cv. 'Counter' was sown on 3 November and plant movement was applied from 18 January until 12 April. In the treatments where the plants were stirred once and twice a day they were 6 and 14% shorter, respectively, and the leaf area was 22 and 33% smaller than of the untreated plants. The weaker growth of the moved plants resulted in decreased fruit set. Less fruits were harvested so that the productivity in the once a day treatment was 4% lower than in the untreated plants. Moving the plants twice a day resulted in a significant reduction of the productivity of 13% ($P<0.01$) as compared to not moving.

Vibration methods and vibration frequencies to improve fruit set (K. Buitelaar)

In 1987 vibrating three times a week instead of twice a week resulted in a slightly higher production only in the first week after harvest (see experiment described in Annual Report 1987, p. 24). In a subsequent experiment truss vibration, stem vibration and stem tapping were carried out twice and three times a week. Cv. 'Counter' was sown on 3 November. Harvest took place from 17 March until 24 June. Stem vibration resulted in a significantly lower yield than truss vibration or stem tapping ($P<0.01$). There were no significant differences in yield or keeping quality between vibrating or tapping twice or three times a week. The fruits of the second truss, however, had a somewhat better shelf life after truss vibration than after stem vibration or stem tapping.

Time of cutting the stem in grafted tomatoes with respect to Fusarium foot rot (K. Buitelaar)

Two not commonly used tomato cultivars are resistant against Fusarium crown and root rot. If these cultivars are used as rootstock the stem of the graft must be cut after grafting. In an experiment the tomato stems were cut 5 days before and 2 and 9 days after planting out. Cv. 'Estafette' was sown on 16 June and grafted onto cv. '864' on 9 July. Planting out took place on 21 July on rockwool. Cutting at 3 different times did not show any negative effects on growth and production as compared to not cutting.

Induction and prevention of loss of corolla of tomato fruits (W. van Ravestijn)

In the summer months occasionally abortion of fruit corollas occurs. In this experiment the possible role of ethylene metabolism was studied. To each fruit 0.1 ml liquid was applied (first date of application 5 July) to the corolla, or 10 x 0.1 ml between fruit and corolla. The following treatments were compared: untreated, water, Ethrel (60, 120 and 240 $mg.l^{-1}$ ethephon), aminocyclopropane-1-carboxylacid (25, 50 and 100 $mg.l^{-1}$ ACC), abscisic acid (1.5, 3 and 6 $mg.l^{-1}$ ABA), Anjer BV (7, 14 and 28 $mg.l^{-1}$ Ag^{+}), and amino-oxy-acetic acid (20, 40 and 80 $ml.l^{-1}$ AOA). To all liquids 0.5 $ml.l^{-1}$ Agral was added. The treatments did not affect the coming loose of the corollas. In the summer of 1989 trusses on the plant will be sprayed with the solutions mentioned above.

Russeting of glasshouse tomatoes in relation to fruit load and chemical and physical characteristics of the fruits (J.C. Bakker)

Fruits were harvested in the pink stage from tomatoes planted in January, February, March and April. The Ca, K and B content and the percentage dry matter were measured. Physical characteristics (puncture force and elastic modulus) were determined with a puncture test (Instron). The degree of russeting was assessed visually. Fruit load was estimated from weekly fruit diameter measurements and actual fruit yield. A positive correlation was found between the degree of russeting and the 'elastic modulus/puncture force' ratio (a measure for the compressibility of the fruit). Fruits with a high percentage dry matter had a higher puncture resistance. At high K content of the fruits the puncture resistance was reduced. No clear relations between the Ca and B content of the fruits and physical characteristics were observed. Fruits grown in periods with a relatively low fruit load generally showed more russeting. Although the percentage of variance accounted for was less than 50, the correlation coefficients were significant for 3 of the 4 planting dates.

Chemical control of swelling cracks in tomato (W. van Ravestijn)

Analogous to the control of fruit russeting in apple, GA_3 (25, 50 and 100 $mg.l^{-1}$) was sprayed to control swelling cracks in tomato. Moreover, 4-CPA (5, 10 and 20 $mg.l^{-1}$) was applied to increase the cell wall plasticity. Both small (ca 2 weeks after fruit set) and large fruits (until 6 weeks after fruit set) were sprayed. Application of the growth regulators resulted in more swelling cracks than the controls (untreated and water). The effects of GA_3 were more negative than of 4-CPA. Older fruits (5 to 6 weeks after fruit set, ca 4.5 to 6.5 cm fruit diameter) were more sensitive to the sprayings than younger fruits. The effect of the concentration was small.

Development of a growth model of tomato (A.N.M. de Koning and K. Buitelaar)

Data from an experiment carried out in 1986 (see Annual Report 1987, p. 24) were used to analyse the relation between temperature and the growth period of a tomato fruit. A good linear relationship was found.

Although the data suggested an increase of the sensitivity for temperature with increasing fruit age, a suitable weighing function was not found. The flowering rate showed a linear relationship (n = 120, r = 0.94) with the temperature (ranging from 17 to 23°C).

In the same experiment fruit growth was calculated from weekly measurements of the diameter of each fruit (see Annual Report 1987, p. 25). After-effects of temperature on fruit growth could be explained by the influence of the temperature on the assimilate partitioning. Flower abortion and delay of growth of newly set fruits acted as feedback control mechanism to prevent too generative growth. Peaks of instantaneous fruit growth were followed by peaks of the plant's fruit load. On condition that fruits were equally distributed over the developmental fruit stages, average time lapse between instantaneous fruit growth and subsequent yield was about 25 days.

Plant weight can be easily estimated by a weigh-clock. Weekly measurements on a commercial crop (round tomato on a high wire system) gave the following results: maximum plant weight 4.3 kg on 12 June, maximum growth rate 900 g fresh weight per week per plant in week 22 and a total harvest of leaves, stem and fruits of 2.7, 1.3 and 20.6 kg per plant, respectively; in percentages: 11, 5 and 85%, respectively of the total growth, excluding the roots. There was a fairly good relation between the weekly growth (fresh weight) and the weekly light sums.

Sun screen in a tomato crop (G.P.A. van Holsteijn)

The investigations to improve the summer climate by means of mobile sun screens were continued in 1988 (see Annual Report 1987, p. 25). This year experiments were carried out with beefsteak tomatoes in the so-called high wire system. It was attempted to further reduce the light loss by using a screen which intercepts less light (LS-14F as compared to LS-15F in 1987) and by limiting the closing of the screen by incorporating the glasshouse temperature in the control.

Again the experiment was carried out in 8 glasshouse compartments. The treatments were:

a. control (no screening);
b. screen 100% closed
   at glasshouse temp. 20°C, radiation > 600 $W.m^{-2}$
   at glasshouse temp. 25°C, radiation > 450 $W.m^{-2}$
   at glasshouse temp. 30°C, radiation > 300 $W.m^{-2}$
c. screen 100% closed, depending on glasshouse temp. and radiation (temp. 25°C, radiation > 650 $W.m^{-2}$)
d. screen 100% closed, depending on glasshouse temp. and radiation (temp. 25°C, radiation > 850 $W.m^{-2}$).

Cv. 'Dombito' was planted out on 24 March. The screens were closed from 18 May onwards with sunny weather and sufficiently high glasshouse temperatures. Picking started on 12 May. The experimental results were seriously influenced by diseases (including virus diseases) in part of the plants. On 8 August it was decided therefore to stop the experiment. Although the differences in yield were not statistically significant, this experiment gave clear indications that all light interception was at the expense of productivity. In both replicates yield was highest in the unscreened compartments.

Again temperature measurements were carried out on fruits and leaves. On sunny days the highest fruit temperature was measured

between 15.00 and 16.00 h. The temperature of the sunlit fruits in the unscreened compartment exceeded that in the glasshouse with screens with at most 6°C. In this year's experiment leaves in the sun were considerably cooler than under comparable conditions in 1987. Possibly this was caused by the modified cropping system. In 1987 particularly older leaves were lit directly by the sun, now only young leaves.

Under closed screens the air humidity was always lower than in the unscreened compartments, so that it was concluded that screening reduces the transpiration.

Planting distances of cherry tomatoes (K. Buitelaar)

Fruit size is important in cherry tomato cultivation and plant distance may have an effect on this. In an experiment distances of 45, 52, 59 and 66 cm within the row were compared (2.8, 2.5, 2.3 and 2.1 plants per m^2, respectively) in a rockwool crop of cv. 'Evita', sown on 3 November. Picking took place from 7 March to 17 June. Yields at the 4 distances were 8.5, 8.3, 7.6 and 7.3 $kg.m^{-2}$, respectively, and the average fruit weights 8.9, 9.7, 9.8 and 9.9 g. A higher plant density increases the costs of plant material and labour. Calculations indicate that from an economic point of view a plant distance of 52 cm is the optimum.

Quality research of tomato (J. Janse)

As usual the keeping quality trials with tomato were carried out at 20°C and a relative humidity (RH) of 80-90%. Daily the fruits were assessed visually for colour and firmness. The ripening period is the number of days between the day of harvest and the fruit reaching colour stage 100% orange. The shelf life is the number of days between the fruit reaching colour stage 100% orange and it becoming soft. Total life is the number of days between harvest and the fruit becoming inacceptably soft.

1. The effect of a summer screen on the quality of tomato

Investigations of the effects of summer conditions on the quality were continued in 1988 (see Annual Report 1987, p. 27), now with beefsteak tomato as experimental crop. LS-14F was used as screening cloth. Beside the control treatment (no screening) there were 3 screening treatments, viz. screening at a glasshouse air temperature of more than 25°C and irradiation levels exceeding 850, 650 and 450 $W.m^{-2}$, respectively.

Quality observations were carried out during 12 weeks from week 21 onwards on every harvest date. In contrast to the results of the preceding year no effect of the treatment on colouring and shelf life could be observed.

The percentage fruits with yellow/green shoulders and radial cracking decreased as screening increased. Screening also seemed to reduce the incidence of russetting. Probably the effects would have been more evident if the summer would have been warmer. Besides the experiment had to be terminated prematurely due to an early incidence of virus.

The same experiment was used to study the possibilities of quality improvement by placing caps above the trusses. This appeared to reduce

the number of fruits with yellow/green shoulders to 0. For 2 of the 4 starting dates the placing of caps improved the shelf life.

2. Effect of retail packing on the quality of tomatoes

The results of many experiments indicate that handling seriously affects the shelf life of tomatoes. In an experiment carried out in co-operation with the Central Bureau of Dutch Vegetable Auctions the effects of retail packing on the degree of fruit damage and keeping quality were studied. The study was carried out at 2 packing stations and 3 exporters with packing machines which packed the fruits in nets. The colour stage was 4 to 5 according to the colour spectrum of the Central Bureau of Dutch Vegetable Auctions. The number of externally visible injuries drastically increased with retail packing, while the shelf life was almost halved. Even without retail packing, however, (too) many fruits were damaged as a consequence of handling by the grower.

3. Effect of the colour stage at harvest on the flavour of tomato

Tomatoes harvested in various colour stages were assessed for over 50 flavour aspects by the descriptive tomato panel of the Central Institute for Food Research (CIVO) in Zeist. The colour stages were 2, 5, 7 and 10 according to the colour spectrum of the Central Bureau of Dutch Vegetable Auctions. In spite of differences in time of picking it was attempted to keep the colour stage equal at the time of tasting. The experiment was carried out 4 times with beefsteak, round and cherry tomatoes.

The riper the tomatoes were harvested the more significantly spicier their taste was, less sour, sweeter and less mealy. The effect was strongest in cherry tomatoes, especially of the first 3 flavour aspects. Furthermore differences in firmness were observed in relation to the colour stage but these were probably caused by desiccation during after-ripening (storage).

In a separate storage trial the effect of duration of storage on the internal quality of round tomatoes was studied. A longer storage period resulted in mealier tomatoes. In another flavour test of beefsteak tomatoes clear differences between cultivars could be observed with respect to mealiness.

Tomato cultivar trials (J.H. Stolk, M.H. Cools and M. de Jong)

Preliminary trials

a. Bi- to trilocular types

Heated crops. Eleven new cultivars from six seedhouses were tested in duplicated trials on three sites against the standard cultivars 'Turbo', 'Counter' and 'Calypso'. Four new cultivars were recommended for further trial.
Interplanted crops. Thirteen new cultivars from eight seedhouses were tested in duplicated trials on three sites against the standard cultivars 'Compacto' and 'Criterium'. Six new cultivars were recommended for further trial.

b. Multilocular (beefsteak) types

Heated crops. Five new cultivars from three seedhouses were tested in duplicated trials on three sites against the standard cultivar 'Dombito'. Three cultivars were recommended for further trial.

Decisive trials

a. Bi- to trilocular types
Heated crops. A series of eight cultivars, including the standard cultivars 'Turbo', 'Counter' and 'Calypso', was tested in at least duplicated trials on ten sites. 'Turbo', 'Counter', 'Calypso', 'Spectra' and 'Blizzard' were given either qualified or unqualified approval.
Warm air and cold crops. A series of nine cultivars, including the standard cultivars 'Counter', 'Criterium', 'Turbo' and 'Calypso' was tested in at least duplicated trials on three sites. 'Blizzard', 'Oscar', 'Spectra', 'Counter', 'Criterium', 'Turbo' and 'Calypso' were given qualified or unqualified approval.

b. Multilocular (beefsteak) types
Heated crop. Four cultivars, including the standard cultivar 'Dombito', were tested in at least duplicated trials on six sites. Only 'Dombito' was given qualified approval.

Comparison of cherry tomato cultivars (K. Buitelaar)

In an experiment the TMV-resistant cultivar 'Evita' was compared to the non-resistant cv. 'Cherita'. Sowing took place on 3 November and planting out on 22 December on rockwool. At harvest until 17 June cv. 'Evita' yielded a significantly greater ($P<0.001$) number of fruits with a lower fruit weight. There was no significant difference in final yield. The shelf life of cv. 'Evita' was 4.6 days longer than that of cv. 'Cherita'. The acid content and the soluble solids content did not show clear differences between the cultivars.

Comparison between yellow and red tomatoes (K. Buitelaar)

The yellow tomato cv. 'W1145' was compared to the red cvs 'Turbo', 'Calypso' and 'Criterium'. Planting out took place on 3 March and harvest until 1 July. There were no significant differences in yield between the cultivars. The fruits of the yellow cv. were 10 g lighter, and also the firmness and the shelf life were less satisfactory than of the red cultivars. The flavour of the yellow tomatoes corresponded with that of cv. 'Turbo'.

CUCUMBER

Damage due to the application of Chilean potassium nitrate (J.A.M. van Uffelen)

In January 1988 on a number of nurseries deviations occurred in the early heated crop. The leaves showed aberrant growth and were partly

necrotic, and a great number of flowers stuck together and therefore failed to open. It soon became clear that in the crops concerned potassium nitrate was used which was imported from Chili. It was investigated whether the symptoms could be reproduced. To this purpose the Chilean potassium nitrate was used which was still in store on several holdings where the damage occurred.

Experimental nutrient solutions were made with Chilean potassium nitrate from the nurseries A, B and C, and for comparison with Israeli potassium nitrate. Rockwool slabs were wetted with these nutrient solutions and at the end of March cucumbers were planted on them. The cucumber plants were also regularly irrigated with the nutrient solutions. Because the light conditions were much more favourable than during the period the damage occurred the light on half the plants of each batch was reduced by ca 50% by spreading a gauze above the plants.

The experiment was terminated at the end of April. Aberrant leaves and sticking flowers occurred only to a very limited degree in the plants growing on the Chilean potassium nitrate. These plants showed, however, clear necrosis of the leaf tissue between the veins and discoloration of the leaf edges. These symptoms did not occur where Israeli potassium nitrate was applied.

From the occurrence of the symptoms it was concluded that the damage observed in commercial practice must almost certainly be ascribed to the application of Chilean potassium nitrate. It is known that potassium nitrate produced in Chili mostly contains a small percentage of perchlorate, which is supposed to be responsible for the damage.

Possibilities of applying dichlorvos (J.A.M. van Uffelen)

By far the most effective agent in the control of Western Flower Thrips is still dichlorvos. The most serious disadvantage when applied in a cucumber crop is that serious fruit abortion may occur, resulting in reduced yield. An experiment was carried out to study the effect of the different types of dichlorvos applications on the incidence of fruit abortion. The following variables were involved in the experiment:
1. the time of the day dichlorvos is applied;
2. the period between application and ventilation;
3. the number of applications of dichlorvos.

The differences in production between the treatments were small; no significant effect at all could be demonstrated. Neither the moment of application, nor the time of ventilation, nor the number of applications appeared to have caused yield differences.

The experiment indicates that in young, strong crops the application of dichlorvos has more possibilities than hitherto supposed.

The dry matter content of cucumbers with a very dark colour (J. Janse)

Cucumber fruits of a very dark colour, so-called black cucumbers, are regarded as a problem at the auction. These fruits are suspected to become soft rapidly, especially at the tail, have yellowish green flesh and a sweeter flavour. The dry matter contents of 'black' and 'green' fruits from the same plant were determined. In the dark fruits the dry matter content was 40 to 65% higher than of normal fruits. Besides, the

impression exists that growers and auctions regard good, but dark green cucumbers as black cucumbers while they are in fact of very good quality and long shelf life.

Cucumber cultivar trials (J.H. Stolk, M.H. Cools and R.G.C.M. Arkesteijn)

Preliminary trials

Heated crops
Twelve new cultivars from five seedhouses were tested in duplicated trials on two sites against the standard cultivars 'Corona', 'Ventura' and 'Lucinde' grown in soil as well as on rockwool. Five new cultivars were recommended for further trial.

Autumn crops
Thirteen new cultivars from seven seedhouses were tested in duplicated trials on four sites against the standard cultivars 'Corona', 'Ventura' and 'Jessica'. Four new cultivars were recommended for further trial.

Decisive trials

Heated crops
A series of seven cultivars, including the standards 'Ventura', 'Lucinde' and 'Corona', was tested in duplicated trials on eight sites. The cultivars 'Lucinde', 'Ventura' and 'Mustang' were given qualified or unqualified approval.

Autumn crops
A series of five cultivars, including the standard cultivars 'Jessica', 'Ventura' and 'Corona', was tested in duplicated trials on fourteen sites. The cultivars 'Nr. 132', 'Mustang', 'Ventura', 'Jessica' and 'Corona' were given qualified or unqualified approval.

LETTUCE

The effect of cooling of lettuce plants on yield and quality (R.H.M. Maaswinkel)

In the late summer of 1988 the effect of cooling of lettuce plants on production and quality was studied. The experimental factors were: 3 plant ages, 2 cooling schedules and 4 cooling periods. The plant ages were 8, 10 and 12 days; the cooling schedules were 1 and 4 °C; and the cooling periods 0, 4, 8 and 12 days cold store. Sowing (cv. 'Sitonia') was done on 29 July, 1, 3, 5, 8, 9, 11, 13 and 15 August. Harvest took place on 29 September.

Young plants with a weight of less than 0.2 g per plant appeared to be sensitive if they were cooled for longer than 8 days at 1 °C. Cooling at 4 °C gave no problems in the range investigated. Furthermore it appeared that the longer the cooling period the more the heterogeneity of the harvested heads increased.

Effect of the light intensity on the degree of red colouring of lollo rosso (R.H.M. Maaswinkel)

In autumn and spring of the 1987/1988 season the effect of the light intensity on the red colouring of lollo rosso was studied. In the autumn crop the following treatments were carried out: -25% and -10% of the light entering the glasshouse, control (natural daylight), lighting with 400 and 1,600 W installed capacity per bench with high pressure sodium lamps, and lighting with 1,000 W installed capacity with SON-T lamps. Two treatment periods were applied, starting 5 and 13 days before harvest. Lighting was done for 16 h per 24 h. The benches were ca 1.4 m^2 in size. The plants were sown on 7 September and placed on the benches on 5 October. The heads were assessed on 18 November 1987.

In the spring of 1988 similar treatments were carried out. However, in this experiment lighting was done for 20 h per 24 h, and the treatment periods were 7 and 21 days.

The results of the autumn experiment indicated that with a treatment period of 5 days only the heads of the 1,600 W/bench light intensity showed sufficient red colouring. A lighting period of 13 days resulted in an acceptable red colouring at a level of 1,000 W already.

After the autumn experiment a number of plants with pots were placed in a cold store at $0^{\circ}C$. This low temperature appeared to have no effect, within the investigated range, on the degree of red colouring.

In the spring crop sufficient red colouring was obtained at 1,000 and 1,600 W illumination. There was no difference between the 7 and 21 days' periods.

In both experiments hardly any red colouring occurred in the treatments with 10 and 25% light reduction. The red colouring in the control treatment and at 400 W was insufficient in both cropping periods.

Relation between potting soil quality and plant quality of butterhead lettuce (R.H.M. Maaswinkel)

In spring of the year under review the relation between the quality of the potting soil and the degree of heterogeneity of butterhead lettuce plants was investigated. The plants came from 17 propagation nurseries, and the experimental results showed that there were rather great differences between the plants of the various origins. It was also evident that within one propagation nursery considerable differences in chemical and physical characteristics of the potting soil from various trays may occur. However, a relation between the degree of variation in plant weight and the chemical and physical characteristics of the potting soil could not be observed.

Quality research of lettuce types (J. Janse)

1. Effect of humidity of the harvested product, packing method and cooling method on the degree of glassiness of butterhead lettuce after cooling

During the winter season 1987/1988 the incidence of glassiness after vacuum cooling posed a serious problem for several growers. This type of glassiness occurred on several sites in the leaf, whereas glassiness

originated during the cropping period mainly occurs at the leaf edges. The infected lettuce was very susceptible to rot in the trade stage.

An experiment was set up in which the effects of the degree of humidity of the lettuce, the type of packing trays, the cooling method and the cooling temperature on the phenomenon were investigated. The cooling methods applied were: no cooling, vacuum cooling and pressure cooling. The temperature at vacuum cooling was 1 or 4°C. For the 1°C vacuum cooling the lettuce was packed both in plastic trays and in cardboard boxes. Variation in humidity of the lettuce was realised by watering the heads just before harvest with varying quantities of water. Most glassiness occurred with vacuum cooling, while the cooling temperature had no effect. The humidity of the lettuce, however, was of considerable influence. The percentages of glassy heads of dry, wet and very wet heads were 4, 26 and 38, respectively. With vacuum cooling, pressure cooling and not cooling these percentages were, on average, 4, 8 and 10%, for dry, wet and very wet heads, respectively.

With wet lettuce the number of heads with glassiness in the bottom layer of the box was 7 times as great as in the top layer. Probably this was caused mainly by the quantity of water around the heads.

In a separate experiment variations between cultivars in susceptibility to glassiness were evident.

2. Keeping quality of oakleaf lettuce and lollo rossa

From trade circles there were complaints about a weak keeping quality of several new lettuce types, viz. oakleaf lettuce and lollo rossa. One had the impression that the packing method might have to do with this. In spring 1988 an experiment was carried out in which the effect of turning the butts of the heads upwards or downwards on the keeping quality was studied. The 2 lettuce types came from 7 sites and storage took place at 12°C and 80% RH.

Turning the butt downwards in the tray resulted for both types in increasing loss of weight and browning of the butt during storage. With oakleaf lettuce turning the butt downwards resulted in less rot, in contrast to lollo rossa. The plastic wrappings used were probably the main cause, because with oakleaf lettuce the wrappings were open at the butt, while with lollo rossa they were more or less closed. After storage lollo rossa appeared to be more susceptible to rot and discoloration of the butt than oakleaf lettuce.

Lettuce cultivar trials (J.H. Stolk, M.H. Cools and M. de Jong)

Preliminary trials with butterhead lettuce

New cultivars were tested in four cropping seasons representative of commercial practice. The trials were carried out in duplicate on at least three sites per cropping season. Seedhouses were allowed to submit a maximum of two cultivars for each crop. The trial result are shown in Table 4.

Table 4. Results of preliminary trials with butterhead lettuce (season 1987/1988)

Cropping season	Standard cultivars	Number of new cvs	Number of seed-houses	Number of new cvs for further trial
Autumn crop 1987	'Claret' 'Nanda'	12	7	5
Winter crop 1987/88	'Claret' 'Indira' 'Saffier'	12	6	5
Spring crop 1988	'Norden' 'Plaza'	12	7	4
Late spring crop 1988	'Sitonia'	4	3	2

Preliminary trials with butterhead lettuce cultivars with a low NO_3 level

In the autumn crop and in the winter crop the NO_3 content of Dutch glasshouse lettuce is high. On short notice there is a need for cultivars with a reduced NO_3 content. Therefore tests with new cultivars which the seedhouses claimed were less NO_3 rich, were carried out during the cropping season 1987/1988. The results are shown in Table 5.

Table 5. Results of preliminary trials with butterhead lettuce cultivars with a low NO_3 content

Cropping season	Standard cultivars	Number of new cvs	Number of seed-houses	Number of new cvs for further trial
Autumn crop 1987	'Nanda' 'Claret'	7	4	1
Winter crop 1988	'Claret' 'Indira' 'Saffier'	6	3	2

Decisive trials with butterhead lettuce

Table 6. Results of the decisive trials with butterhead lettuce (season 1987/1988)

Cropping season	Number of trial sites	Standard cvs	Number of new cvs	Number of seed-houses*	Recommended cvs
Early autumn crop 1987	5	'Animo' 'Sitonia'	3	3	'Animo' 'Sitonia' 'Panine' 'Cortina'
Autumn crop 1987	15	'Claret' 'Nanda'	4	4	'Karlo' 'Animo' 'Medoc' 'Nanda' 'Claret'
Winter crop 1987/1988	14	'Karlo'	4	5	'Claret' 'Indira' 'Saffier' 'Vicky'
Spring crop 1988	6	'Norden' 'Plaza'	3	3	'Norden' 'Patricia' 'Plaza'
Late spring crop 1988	3	'Sitonia'	3	2	'Cortina' 'Rosano' 'Sitonia'

*including those supplying the standard cultivars

Preliminary trials with iceberg lettuce

In two cropping seasons, representative of commercial practice, new cultivars were tested on at least three sites per cropping season. Seedhouses were allowed to submit two new cultivars for each cropping season.

In the autumn crop of 1987, sown between 2 and 8 September, seven new cultivars were tested against the standard cultivars 'Bastion' and 'Paulette'. Only two new cultivars were recommended for further trial. In the spring crop of 1988, sown between mid-November 1987 and the end of February 1988, five new cultivars were tested against the standard cultivars 'Kellys' and 'Polar'. Only one cultivar was recommended for further trial.

Decisive trials with iceberg lettuce

In two cropping seasons, representative of commercial practice, new cultivars were tested in decisive trials. The results are given in Table 7.

Table 7. Results of the decisive trials with iceberg lettuce

Cropping season	Number of trial sites	Standard cvs	Number of new cvs	Number of seed-houses	Recommended cvs
Autumn crop 1987	3	'Bastion' 'Paulette'	4	3	'Bastion' 'Paulette' 'EY7731'
Spring crop 1988	6	'Kellys' 'Polar'	2	3	'Kellys' 'Polar'

SWEET PEPPER

Effect of the conditions during raising of sweet pepper seedlings on production (J.A.M. van Uffelen)

In commercial practice much discussion is going on about 'fast' and 'slow' plants. A fast plant is a plant which has grown to the planting stage in a short time, whereas a slow plant takes relatively long to reach that stage. In an experiment variations in aerial temperature and additional lighting were realised in order to influence the growing rate. Furthermore various sowing dates were maintained. The cultivar used was 'Delphin'.

The experiment consisted of the following treatments:
a. raising at 'high' and at 'low' temperature;
b. additional lighting/no additional lighting;
c. sowing on 7, 13 and 19 October.
The plants of sowing date 7 October were not lit, those of 19 October were all lit, while the plants of sowing date 13 October were partly lit and partly unlit.

Due to adjustments of the heating installation the temperature was considerably lower than the setpoint on several days. Hence the differences between 'warm' and 'cold' were often smaller than the set values.

On 10 December observations of the plant material were carried out. The following conclusions could be drawn:
The plant length is clearly affected by the temperature. For plant weight and leaf area, however, the effects are not evident. The influence of additional lighting is considerable so that even the plants of the later sowing dates on 4 December were suitable for planting. Thus by using additional lighting the planting stage can be

reached in a considerably shorter time.

With the plant material described above a cropping experiment was set up. On 10 December all plants of the treatments of the raising experiment were planted out in quadruplicate on rockwool. From the start fruits were harvested in the red stage. As was apparent before, the size of the plants at the moment of planting out is an important factor for the production. However, extra effects of additional lighting seemed to be apparent. The yield of the plants which were sown on 19 October and which received additional lighting was considerably higher than of sowing date 7 October which were not lit, although these plants were heavier at the moment of planting out.

Influencing the fruit set of sweet pepper (J.A.M. van Uffelen)

Fruit set and hence also the yield of a sweet pepper crop is irregular. This adversely affects the labour pattern and also the price-making process. A more equable fruit set and production of sweet pepper should therefore be aimed at. In an experiment it was attempted to promote fruit set with the following treatments:
a. 3 times per week (stem) vibration;
b. spraying growth regulator on the flowers in bloom once a week (0.1% Tomatotone);
c. applying fruit thinning so as to prevent too heavy plant load;
d. control.
The treatments were applied in quadruplicate from mid-January until mid-July. Planting out took place on 10 December on rockwool (cv. 'Delphin'). Fruits were harvested in the red stage.

None of the treatments positively affected fruit set, yield or regularity of production. When the experiment was terminated on 30 August yield was highest in the control treatment. Differences in fruit weight were small. Only where fruit thinning was applied the fruits were slightly bigger. It was remarkable that as a consequence of vibration the number of seeds per fruit increased considerably. Both the number of seeds and the total seed weight was ca 35% higher.

Relationship between number of the first fruit set, and early and total yield (J.A.M. van Uffelen)

The number of the first fruit set may differ strongly between plants but also between different sweet pepper crops. In a crop plants occur with 2 but also with 12 fruits. In both cases fruit set stops as soon as these fruits reach a size of several centimeters. Only when these fruits have grown to their ultimate size fruit set resumes. The effect of the number of the first setting on volume and pattern of yield throughout the cropping season was studied. In a sweet pepper crop of 40 plants the number of the first setting was determined. This ranged from 2 to 11 fruits per plant. The harvest data per plant were recorded until 6 September. When the experiment was terminated the following conclusions could be drawn:
- the plants with the greatest first setting not only gave the highest early yield but on average also the highest total yield
- the number of the first setting did not affect regularity of yield
- yield differences between plants amounted to more than 100% and were independent of the number of the first setting.

The effects of temperature on flowering, fruit set and fruit development of sweet pepper (J.C. Bakker)

The effects of temperature on flowering, fruit set and fruit development of October sown sweet pepper (cv. 'Delphin') were investigated in a glasshouse experiment. Twelve day/night temperature regimes (16/15, 16/21, 20/12, 20/15, 20/18, 20/21, 24/12, 24/15, 24/18, 24/21, 28/15, and 28/21°C) were applied during the early post-planting period (from early December to mid-April). Patterns of flowering and fruit set were comparable at similar 24 h mean temperatures.

Total number of flowers per plant and percentage fruit set were significantly related to 24-h mean temperature as well as to the day/night temperature amplitude. Mean fruit weight was related to 24-h mean temperature as well as to the day/night amplitude. For these variables the effect of the day/night amplitude was of minor importance compared to the 24-h mean temperature.

No effect of the day/night amplitude was found on the number of fruits per plant, leaf area/fruit ratio, fruit length, pericarp thickness, length/width ratio, length of the attached style and the total growth period of fruits. The temperature coefficient for the total fruit growth period from flowering to red harvest ranged between 1.5 and 1.9.

It is concluded that the temperature regime (day/night amplitude) is of minor importance compared to the effect of the 24-h mean temperature for fruit set, fruit development and the growth period of sweet pepper.

The effects of air humidity on growth and fruit production of sweet pepper (J.C. Bakker)

The effects of day and night humidity levels on autumn and spring grown sweet pepper were investigated in 2 glasshouse experiments. In the autumn experiment 4 different humidity levels during the night were compared. In the spring experiment a high or low humidity by day was combined with either a high or a low humidity during the night. The vapour pressure deficits (VPDs) achieved over the period in which the treatments were applied, varied from 0.33 to 0.79 kPa by day, from 0.27 to 0.86 by night and the 24-h mean varied from 0.30 to 0.78 kPa. Temperature differences between the treatments were not more than 0.5°C. No detrimental effects of humidity on growth were observed. Neither vegetative growth nor early or total yields were significantly correlated with humidity by day, night or 24-h mean, but the average fruit weight was increased by high humidity by night.

Effect of the air humidity in combination with the composition and concentration of the nutrient solution, on yield, the incidence of black spot, and the keeping quality of sweet pepper in an autumn crop (G.W.H. Welles, J. Janse, C. de Kreij, J.C. Bakker and J.A.M. van Uffelen)

In an autumn crop (planting date 13 July) with the black spot susceptible cv. 'Bruinsma Wonder', 4 air humidity regimes were maintained from the start of fruit set onwards (15 August). The treatments were identical to those applied in the spring experiment

with eggplant, on the understanding that screening was only applied at night. The experiment consisted of 12 nutrient treatments in combination with the environmental treatments. The nutrient treatments comprised 2 K/Ca ratios (0.8 and 2.8), 3 Mg concentrations (1.4, 2.5 and 5.1 mmol.l^{-1}), 3 NH_4 concentrations (0, 1.5 and 4.5 mmol.l^{-1}) and 4 constant EC levels (1.4, 2.9, 4.6 and 6.0 dS.m^{-1}). During the experimental period the average air humidity levels ranged from 69 to 79%. In analogy to the results of previous experiments no significant effect of the air humidity on the yield could be demonstrated in this experiment. With respect to the nutrient treatments it was observed that the lowest concentration (1.4 dS.m^{-1}) gave the highest production. At higher EC levels the fruits were smaller and the risk of the incidence of blossom-end rot was slightly greater. A low K/Ca ratio, a low NH_4 level as well as Mg levels of 1.4 and 5.1 mmol.l^{-1} all resulted in a higher production.

The fruits of both the climate and the nutrient treatments showed differences in the degree of black spot incidence and in keeping quality. The highest percentage fruits with black spot was found in the L/H climate treatment (low humidity by day, high by night). Clearly less black spot was found in the high K/Ca ratio treatment (2.8), the high NH_4 concentration and a Mg concentration of 2.5 mmol.l^{-1}. The keeping quality, expressed in the number of days between harvest and the fruits becoming soft, at a low ammonium level and a low EC was superior to that of the other nutrient treatments. The interactions found between the various nutrient levels with respect to black spot and keeping quality will be more closely evaluated after analyses of the fruit and crop samples.

The effects of air humidity on flowering, fruit set, seed set and fruit growth of sweet pepper (J.C. Bakker)

The effects of day and night humidity on flowering, fruit set, seed set and fruit growth of sweet pepper (cv. 'Delphin') were investigated in a glasshouse experiment. A continuously high or low humidity and alternating high and low humidity levels by day and night were applied during the arly post-planting period from early December until mid-April. The vapour pressure deficit (VPD) of the glasshouse air varied from 0.33 to 0.66 kPa by day, from 0.27 to 0.86 kPa by night and the 24-h average from 0.30 to 0.75 kPa. Numbers of flowers and fruits showed a significant positive correlation with VPD by night. Fruit set and number of seeds per fruit were increased by low VPD by day. No significant effect of VPD was found on fruit shape (length/width ratio), number of cavities per fruit, pericarp thickness, dry matter content and fruit maturation rate.

Harvest delay of autumn sweet pepper by Ethrel sprayings (W. van Ravestijn)

As a sequel to last year's experiment (see Annual Report 1987, p. 40) it was attempted to improve the late yield of a late sweet pepper crop (cv. 'Rumba', planting date 16 July) by inducing flower abscission before the desired setting period.

Applications of 0.5 ml.l^{-1} Ethrel (= 240 mg.l^{-1} ethephon) + 0.5 mg.l^{-1} Agral were carried out. The plants were sprayed once in the

period between weeks 25 and 31. The control plants were left untreated. The use of Ethrel resulted at the moment of fruit thinning (12 August, week 32) in 50-99% less fruit pruning in weight than untreated. The late sprayings resulted in yield reduction (20 to 25%).

In 1989 attempts will be made to improve the yield by using lower concentrations in the early sprayings.

Improving the late fruit set of autumn sweet pepper by plant sprayings with Tomatotone (W. van Ravestijn)

In a late sweet pepper crop (cv. 'Rumba', planting date 16 July) it was attempted to improve the late fruit set by means of plant sprayings with 0.625 ml.l^{-1} Tomatotone (= 1.25 mg.l^{-1} 4-CPA) + 0.5 ml.l^{-1} Agral (see also Annual Report 1987, p. 40). The plants were sprayed once, twice or three times in the period between weeks 30 and 36, the control plants were left unsprayed.

Spraying more than once resulted in ca 10% more fruits, but the yield did not improve in weight when compared to untreated due to the lower fruit weight. This research will not be continued.

Quality research of sweet pepper (J. Janse)

1. Relationship between fruit characteristics and keeping quality of 4 colours of sweet pepper

Previous storage research pointed out that there are great differences in keeping quality between sweet pepper fruits from different sites. It is important to know whether there are fruit characteristics which are related to the keeping quality so that a prognosis can be formulated of the keeping quality of produce supplied at the auction. To this purpose extensive research was carried out.

Both in April and in June red, green, orange and yellow sweet peppers were collected from ca 7 nurseries for each colour. Various measurements were carried out, viz. on firmness at the start of storage, keeping quality, fruit weight, length, width, number of cavities, pericarp thickness, number of seeds, seed weight, internal growth, black spot, soluble solids content, acid and a number of flavour aspects. By means of regression analysis the interrelationships between the characteristics observed were explored for each colour.

Keeping quality. Storage took place at 20°C and 90% relative humidity (RH). For red, green, yellow and orange fruits the average shelf life was 14.5, 14.4, 9.1 and 7.1 days, respectively. It appears that yellow and orange sweet peppers have a shorter shelf life. The correlations per colour between keeping quality and the various fruit characteristics were rather disappointing. In all colours, except yellow, there was a significantly positive relation between keeping quality and firmness at the start of storage (r=0.70 to 0.88). A high correlation between these 2 aspects was also found in previous experiments.

In contrast to what was expected no clear relationship could be demonstrated between pericarp thickness and keeping quality. Neither could pericarp thickness explain the differences in keeping quality between the colours. Orange sweet peppers, for example, had relatively

thick pericarps but a short shelf life.

Black spot. Mainly in red sweet pepper much black spot occurs, especially on the inside of the fruit. The percentages of fruits with internal or external black spot, averaged out over all sites, were 46, 4, 0 and 21%, for red, green, yellow and orange, respectively. On the inside there were on average 3 times as many black spots as on the outside. In June 20% of the red sweet peppers suffered of black spot, while they showed no external symptoms.

In orange sweet peppers more black spot occurred at a greater length/width ratio, higher acid content and a smaller number of seeds per fruit. For red sweet pepper fruits there was in June likewise a negative correlation between the number of seeds and black spot.

Internal quality and flavour. The dry matter content, the soluble solids content and the acid content were about 25, 40 and 60% lower in green sweet peppers than in the other colours. Red fruits contained the highest percentage dry matter (8.4%) and acid (3.7 mmol H_3O^+/100 g sap). The fruits were assessed for various flavour aspects by a sensorial panel. The green fruits were found to be the most crisp and the least sweet. They also had the most 'green' and unripe flavour, contained the least aroma and were regarded the least pleasant by the members of the panel. The red fruits were also sufficiently crisp, contained the most aroma and were found to be the tastiest by the panel. The orange and yellow sweet pepper fruits did not show significant differences in the various flavour aspects. Fruits of these colours scored lowest for crispness, which corresponds well with the manual firmness assessment. During 'open days' of the Research Station sweet pepper fruits of the 4 colours were assessed for crispness, sweetness and pleasantness by almost 200 persons. The results were largely identical to those of the panel.

2. Black spot of sweet pepper during storage

In green sweet pepper black spot cannot or hardly be detected, but the phenomenon becomes visible in the coloured stage. In several storage trials it was studied whether the black spot infection of red fruits changes during storage. Storage took place at 20°C and 80% RH. The results indicate that the percentage of fruits with visible external black spots slightly increased during storage. The number of externally and internally visible black spots per fruit was 1.5 to 2 times as high after storage. Consequently, in the post-harvest stage more black spots become visible.

3. Sensory flavour research of sweet pepper

During the year under review a number of flavour tests were carried out in which the panel members (25) assessed the fruits for various aspects. The results of the sensorial experiments are briefly given below.

- colour. The blindfolded panel members found very significant differences in flavour between fruits of 4 colours (red, green, yellow and orange); especially the green fruits were deviant in taste.
- Ethrel. Application of Ethrel to sweet pepper plants resulted in

fruits which tasted significantly less sweet, more 'green' and unripe, less aromatic and, in the opinion of the panel members, less pleasant, than the control fruits of untreated plants. In fact, sweet peppers treated with Ethrel have the flavour of green fruits and the colour of red fruits. The soluble solids content of these fruits was 20% lower.

Sweet pepper cultivar trials (J.H. Stolk, L. Hogendonk and R.G.C.M. Arkesteijn)

Preliminary trials

Heated crop. Eight new cultivars, five of the green/red and 3 of the green/yellow type, from 4 propagation nurseries, were tested in duplicate on 3 sites. The standard cultivars were 'Delphin', 'Plutona' and 'Luteus', respectively. The following cultivars were recommended for further trial: green/red type: '35-02', '35-03' and 'E 782' green/yellow type: 'Samanta' and 'Adele'.
Autumn crop. Fifteen new cultivars, 8 of the green/red type, 6 of the green/yellow type and 1 of the green/orange type, from 4 seedhouses, were tested in duplicate on 3 sites. The standard cultivars were 'Propa-Rumba', 'Tarantella', 'Luteus', 'Panda' and 'Ariane', respectively. The cultivars recommended for further trial will become known in the course of 1989.

Decisive trials

Heated crop. A series of 6 cultivars, including the standard cultivars 'Plutona' and 'Delphin' was tested on 9 sites with a total of 20 repeats. All new cultivars were superior to the standard cultivars. The new cultivars to be recommended are 'Valeta', 'Pantser', 'Evident' and 'Madara'. They are all of the green/red type.

EGGPLANT

Effect of the air humidity in combination with the nutrient composition on yield and the incidence of browning of the calyx of eggplant (G.W.H. Welles, J.C. Bakker, C. Sonneveld and R.H.M. Maaswinkel)

In 8 glasshouse compartments, equipped with double covers, 4 air humidity regimes were maintained and 11 nutrient treatments. Whether or not applying a humidity gap in the thermal screen and whether or not promoting the evaporation of water during the day, night or 24-h period resulted in the following climate treatments:
1. continuous high air humidity (H/H)
2. low air humidity by day, high at night (L/H)
3. high air humidity by day, low at night (H/L)
4. continuous low air humidity (L/L)

From planting out (cv. 'Dobrix') on 7 December 4 K/Ca/Mg, 4 NO_3/SO_4 and 3 NO_3/NH_4 levels were maintained in the root environment (recirculation system with rockwool slabs in gutters).

Within the range of air humidities investigated (3-6 g water vapour

per kg air on 24-h basis) no clear effect on flowering and fruit set was observed. With respect to early productivity the highest yield was observed in treatments 2 and 3, and with respect to total yield in treatment 2. The nutrient treatments did not result in significant yield differences. In February and March calyx browning was observed on a broad scale. The nutrient treatments did not show significant differences in the degree of calyx browning. A very evident effect of the air humidity on the calyx browning could be observed: the higher the 24-h humidity, the lower the incidence of calyx browning. Based on these results, virtually total prevention of the problem of calyx browning can be obtained by maintaining a high air humidity, both during the day and during the night. For a combination of reduced susceptibility to calyx browning and optimal yield a high humidity during the night combined with a sufficiently high humidity by day is to be recommended. A water vapour deficit of 5.5 g water vapour per kg air during the day and 3.5 to 4.0 g water vapour per kg air during the night will meet this requirement.

Quality research of eggplant (J. Janse)

The optimum temperature for the eggplant crop has been subject of discussion in recent years. In 1987 cooling experiments were carried out in which cold storage seemed to have adverse effects on quality, in particular calyx and fruit rot. In another experiment cold storage appeared to have positive effects on quality.

During transport and storage eggplant fruits are often being exposed to ethylene, to which they are very sensitive. Previous experiments with cucumber pointed out that lower temperatures make the fruits less sensitive to ethylene.

This aspect was investigated in an experiment carried out in co-operation with the Sprenger Institute in Wageningen and the Advisory Service. Three temperatures (7, 13 and 18°C) were combined with 4 ethylene concentrations (0, 0.2, 0.6 and 1.0 ppm). The treatment periods were 3 and 5 days, respectively. Subsequently the fruits were stored for an additional period of 7 days at 18°C and 80% RH. During the storage period the fruits were regularly assessed for various quality aspects.

Detached calyces. In the 3 days' treatment there were only detached calyces at 18°C in combination with 0.6 or 1.0 ppm ethylene. With these concentrations 7 and 50% of the calyces, respectively, had become detached. During subsequent storage the percentage of fruits with detached calyces increased as the ethylene concentration was higher, especially at 13°C and at 18°C. The table below shows the percentage of detached calyces after 7 days' subsequent storage.

Table 8. Percentage of detached calyces at different storage conditions, after 7 days' subsequent storage

temperature (°C) ethylene(ppm)	7	13	18
0	3%	3%	0%
0.2	0%	13%	0%
0.6	0%	13%	93%
1.0	0%	40%	100%

With a treatment period of five days the effect was even stronger, both directly after the treatment period and in the after-storage. Cooling at 7°C made the fruits insensitive to ethylene.

Calyx yellowing and browning. Even without ethylene a lower temperature resulted in less calyx yellowing and browning. A higher ethylene concentration in the 3 days' experiment gave more yellow and brown calyces, especially at 18°C. In the 5 days' treatment this effect was clear both at 13 and at 18°C. At 7°C ethylene had no effect.

Calyx rot. At 7°C this phenomenon was not influenced by ethylene. During subsequent storage after 3 days' treatment at 13 and 18°C more rot occurred at a higher temperature and a higher ethylene concentration. After longer treatments this tendency was apparent earlier and to a higher degree.

Fig. 5. Effects of a high ethylene level and a high storage temperature on eggplant fruits: fruit rot, and detached and rotten calyces

Stem rot. During subsequent storage more stem rot occurred when temperature, ethylene concentration and treatment duration increased.

Fruit rot. Especially after one week's storage there were many rotten fruits at a higher temperature and ethylene concentration.

Firmness. After the treatment period no effect of the temperature or ethylene level on firmness could be observed. During subsequent storage the fruits were firmer at the 13°C treatment temperature, but especially at 18°C as the ethylene concentration increased. This was possibly caused by lignification induced by ethylene.

The experimental results indicate that the critical value of ethylene for eggplant at 7°C and 3 days' treatment is above 1.0 ppm, at 13°C it is ca 0.2 ppm, while at 18°C it is even lower.

Calyx browning during storage

Calyx browning arises during the cropping period and may be controlled by a number of measures. One of the questions to be answered is whether cropping measures also affect the continuation of calyx browning during the post-harvest stage.

Fruits from a study of calyx browning during the cropping period were stored at 20°C and over 95% RH. The experimental results indicated that calyx browning already present at the start of storage hardly or not at all continued during storage. This was possibly caused by the high RH in the storage room. Observations at the auctions pointed out that calyx browning does continue in the post-harvest stage.

Eggplant cultivar trials (J.H. Stolk and R.G.C.M. Arkesteijn)

In the heated crop 3 new cultivars, '780', '781' and 'Leandra', were tested at 5 sites in duplicated trials against the standard cultivar 'Dobrix'. Due to various circumstances only 2 of the 5 experiments yielded workable results. However, these results showed such great promise that it was decided to repeat the tests in 1989 on a larger scale. In the tests with workable results the new cultivars appeared to give a considerable yield increase (up to 14%).

Exploratory cultivar trials with mini eggplant (R.H.M. Maaswinkel)

In autumn 1988 exploratory cultivar trials were carried out with mini eggplant. Sowing was done on 25 May and planting out on 28 June in soil. Twelve cultivars of the white type and 9 cultivars of the purple type were tested. The standard cultivar was 'Dobrix'.

On 25 August and 22 September fruits of a number of cultivars were stored for 12 days. The keeping quality (firmness and degree of calyx browning) of the suitable white cultivars ('Nr. 81237', 'Nr. 128' and 'Witte Eierplant') was significantly superior to that of the standard cultivar 'Dobrix'. Of the cultivars of the purple type the firmness of the 3 Japanese hybrids was significantly inferior to that of the standard cultivar 'Dobrix'. With regard to browning of the calyx, however, they were better than 'Dobrix'.

The experimental results indicated that 3 cultivars with white fruits were suitable for limited introduction into commercial practice,

with regard to type and productivity, viz. 'Nr. 81237', 'Nr. 128' and 'Witte Eierplant'. The results of the cultivars of the purple type were insufficient.

COURGETTE

Effect of heat treatment of the seeds on the germination of courgette seeds (G. Heij)

On several holdings a serious infection with courgette yellow mosaic virus (CYMV) occurred. Although evidence of virus transmission with the seeds is not conclusive, it seems probable that the seed is a source of infection. Heat treatment of cucumber seeds indicated that this eliminates the cucumber green mottle mosaic virus (CGMMV). It is expected that heat treatment of courgette seeds excludes seed infection of CYMV. To demonstrate that courgette seeds still possess sufficient germinative and developing capacity after temperature treatment, seeds of cv. 'Storr's Green' were placed in drying ovens for 12, 24, 48 and 72 h at temperatures of 65, 70, 75, 80 and 85°C. Subsequently the seeds were sown.

It can be concluded that courgette seeds which were heated for a long period at high temperatures do not lose their germinative capacity. However, emergence of the seedlings suffered several days' delay and, depending on the treatment temperature and duration, the cotyledons and/or the first and second leaf showed some damage. Subsequent leaves did not show any injury, and the damage observed did not adversely affect further development of the plants. Since CYMV and CGMMV both belong to the same type of virus, it is to be expected that, analogous to the CGMMV experiment, the courgette seed is free from CYMV after a temperature treatment of 75°C during 72 h, so that the risk of transmission via the seed is strongly reduced or even prevented.

Investigation of the occurrence of 'double fruits' in courgette (G. Heij)

In the axils of the bottom leaves of courgette often double fruits are found. From an economic point of view these fruits are worthless, and it may be supposed that they adversely affect the development of good fruits. Since these double fruits only occur in the bottom leaf axils a possible cause is suspected to be the temperature during raising.

In an experiment courgette seeds (cv. 'Storr's Green') were sown in rockwool blocks on 7 December 1987, and raised at 25°C and 17°C (24-h temperatures). After emergence, 4 days after sowing, the blocks of the 25°C treatment were placed in 3 separate glasshouse compartments, each with a different 24-h temperature, viz. 12, 17 and 22°C. On 14 December (7 days after sowing) the blocks of the 17°C treatment were placed in 12, 17 and 22°C compartments. On 15 January plants of all treatments were planted out in a glasshouse in order to be able to observe possible double fruits. Leaf axils of a number of plants from each treatment were studied microscopically for the initiation of male, female or double flowers. At the high raising temperatures (22 and 17°C) no double fruits were observed until the 14th axil. Also during the cropping period in the glasshouse no double fruits were observed in

plants of the 3 raising temperatures.

The most remarkable aspect of this experiment was that plants which germinated at 17°C, i.e. 3 days later than those at 25°C, showed a totally aberrant growth and development. The cotyledons strongly curled and the development lagged ca 4 weeks behind those of 25°C at all raising temperatures. A raising temperature of 12°C is completely unsuited for commercial practice. At this temperature growth of the plants is very slow.

Effect of the fruit size on the yield of courgette plants (G. Heij)

Courgette fruits which are supplied from mediterranean countries to the West European markets have an average fruit weight of ca 150 g. Dutch courgettes generally have a fruit weight of ca 350 g. Harvesting bigger fruits may result in differences in yield with plants from which small fruits are picked. To determine the yield and the number of aborted fruits, when courgette fruits of different sizes are harvested, courgette plants (cv. 'Storr's Green') were planted out on 28 July at a planting distance of 1.60 x 0.85 m. Harvest was done in 4 stages, viz. a. flowering fruitlet, b. fruits with a fruit weight of ca 100 g, c. of ca 350 g, and d. of ca 700 g. First harvest was on 11 August, last on 24 October. The total number of harvested fruits per square metre for the 4 treatments was 17.7 (fruitlet), 13.2 (100 g), 9.6 (350 g) and 6.8 (700 g). The number of aborted fruits was highest when the picking stage was at 700 g. The total number of initiated fruits in the 'flowering fruitlet' treatment was 18. The flowering fruitlet had a short shelf life; soon Botrytis occurred on the flowers. Between the other 3 treatments there were no differences in keeping quality. The experiment will be repeated, with modifications, in a spring crop.

MELON

Induction of bisexual flowers in a summer crop of melon (W. van Ravestijn)

This experiment is a sequel to the one carried out in 1987 (see Annual Report 1987, p. 52). Sowing was done on 6 June (cv. 'Haon'). Sprayings were conducted with 0.5 $ml.l^{-1}$ Ethrel (= 240 $mg.l^{-1}$ ethephon) + 0.5 $mg.l^{-1}$ Agral. The plants were sprayed once (on 4, 11 or 18 July) or twice (on 4 and 11, 4 and 18, or 11 and 18 July). The control plants were left untreated or they were sprayed once with water + Agral. Although Ethrel sprayings may result in more than 5 times as many stem fruits as the controls, this did not lead to earlier or higher yields. However, Ethrel sprayings did result in a slightly better external quality.

Sensory research of melon (J. Janse)

In 3 cultivar trials melons of the Charentais type were assessed for sensory characteristics with the aid of a taste panel of 25 persons. In all experiments there were very significant differences between the cultivars in firmness, sweetness, flavour and pleasantness. The cvs

'Haros' and 'Pallium' scored low with respect to taste. In one test the correlation between sweetness and pleasantness was extremely high. Furthermore there were significant positive correlations between soluble solids content on the one hand, and sweetness, flavour and pleasantness, respectively, on the other.

Melon cultivar trials (K. Buitelaar)

Comparison of melon cultivars of the Charentais type in a late crop

Charentais melons have a high yield and a very good taste, but their keeping quality is limited. Fifteen Charentais melon cultivars were compared to Ogen melon. Sowing was done on 4 July and planting out on rockwool on 25 July in a density of 2.5 plants per m^2. Harvest took place from 23 September until 10 October. Yield varied between the cultivars from 3.5 to 5.6 fruits per m^2, the average fruit weight from 439 to 761 g and the soluble solids content from 7.1 to 10.2%. Shelf life ranged from 4 to 10 days. The cultivars 'Pallium', 'Haros' and 'Jador' were recommended for further trial.

Comparison of melon cultivars in an early spring crop

Advancement of the melon crop is attractive because of the favourable prices in April and May. A series of 14 cultivars, mainly of the Charentais type, was tested in an early spring crop. Sowing was done on 18 December, and planting out on 20 January on rockwool. Picking took place from 5 April until 11 May. Considerable differences in earliness between the cultivars were observed. The yield ranged from 1.1 to 6.8 fruits per m^2 (at a density of 2.5 plants per m^2) and the average fruit weight from 410 to 1350 g. The soluble solids content varied between the cultivars from 11.4 to 16.7%. Most Charentais types had a short shelf life. Maintaining side shoots at 120 or 180 cm height did not affect yield, average fruit weight or soluble solids content. The cultivars recommended for further trial are 'Haros' and 'Jet'.

ENDIVE

The effect of spraying with calcium nitrate on the incidence of tipburn in an autumn crop of curly endive (R.H.M. Maaswinkel)

In the autumn of 1987 the effect of spraying calcium nitrate on the incidence of tipburn in curly endive was studied. The following 9 treatments were applied: no spraying, spraying once or twice a week with 0.25% calcium nitrate, and spraying once or twice a week with 0.50% calcium nitrate; all sprayings were carried out 2 and 6 weeks after planting. Planting out took place on 23 September, harvest on 15 December (cv. 'Nr. 542').

At harvest the degree of tipburn was small in all treatments, so that no conclusions could be drawn about the effectivity of calcium nitrate against tipburn.

Yellowing of the heart in autumn and spring crops of curly endive (R.H.M. Maaswinkel)

In a 1987 autumn crop at the Research Station and a 1988 spring crop on 3 commercial holdings the effects of tying up the heads and covering the plants on the yellowing of curly endive was investigated. The experiment at the Research Station consisted of the following 5 treatments: untreated, tying up the heads 3 and 5 days before harvest with rubber bands, covering the plants 5 days before harvest with LS76 and with aluminised cloth. On the commercial holdings, apart from the untreated control the following 10 treatments were applied: tying up with rubber bands, covering the plants with Agryl p50, with polystyrene sheets, with LS76, and with an aluminised cloth, all of which were carried out 3 and 6 days before harvest. Planting date at the Research Station was 23 September, harvest date 15 December 1987. On the commercial holdings planting out took place between 25 November 1987 and 22 January 1988 and harvest between 23 February and 28 March 1988. The results of the experiment at the Research Station indicated that the best yellowing was obtained by tying up the heads with rubber bands 5 days before harvest. Results of the holdings pointed out that satisfactory yellowing was obtained by tying up the heads with rubber bands 6 days before harvest, or covering them with polystyrene sheets or with Agryl p50. Moreover, yellowing was better with polystyrene sheets than with Agryl p50 or tying up the heads with rubber bands.

Endive cultivar trials (J.H. Stolk, M.H. Cools and A.B. Jansen)

During the winter season 1987/1988 seven endive cultivars and selections of the cvs 'Breedblad Volhart Winter' and 'Nummer Vijf' were tested in a definitive trial on 5 sites with a total of 11 repeats. As standards the selections 'Volto' and 'Brevo' of the cv. 'Breedblad Volhart Winter' were used. Finally the following cultivars could be recommended for the winter crop, with or without qualifications: 'Brevo', 'Volto' and 'Wivona' (all selections of the cv. 'Breedblad Volhart Winter').

BLANCHING CELERY

Blanching celery cultivar trials (G. Heij)

To gain more insight into the range of cultivars available from Dutch seedhouses a cultivar test was carried out with blanching and green celery types.

On 16 March 9 blanching celery and 5 green celery cultivars were planted out. Planting distance was 25 x 30 cm and harvest took place on 19 May. During harvest of 25 plants of each experimental plot (a total of 75 plants per cultivar) the following data were collected: total length (cm), gross weight per plant, net weight per plant (after cleaning and cutting down to 38 cm) and the amount of waste per plant. Before harvest a number of plant characteristics were described. After harvest a number of wrapped plants of each cultivars were stored during 2 weeks at 12°C. The keeping quality was determined and ratings were given for the incidence of rot, the colour of the stems and the colour

of the butts.

The green celery was also harvested on 19 May 1988. This date was in fact too early because the growing period is ca 10 days longer for this crop than for blanching celery.

Harvest data indicated that 5 blanching celery cultivars had a significantly higher net weight. Of these 5 cultivars 'Loret' and 'Golden Spartan' appeared to have a good utility value. Since consumers more and more prefer green celery, also 5 cultivars of this type were compared. The shelf life is longer (pale stems occur later) and moreover the taste is different from that of blanching celery. The cvs 'Tender Crisp', 'E3755' and 'Claret' had a good utility value. In a subsequent trial 2 blanching celery cultivars will be compared with the 3 remaining green celery cultivars.

BROCCOLI

Effect of the planting distance on the yield of broccoli (G. Heij)

The results of last year's experiment (see Annual Report 1987, p. 47) indicated that cv. 'Dandy Early' possesses good utility value. Moreover, plants of this cv. have short leaves and a satisfactory main umbel, which characteristics seem to make it suitable for high plant densities.

To determine optimum plant distance for broccoli, cv. 'Clipper' and the new cv. 'Dandy Early' were sown on 20 December 1987 and planted out on 2 February 1988 in densities of 7, 9, 11, 13 and 15 plants.m^{-2}. Distance between the rows in all cases was 30 cm, distances within the row ranged from 20 to 48 cm. Temperature setpoints were 5/10^{o}C (night/day) until 1 March, subsequently 10/15^{o}C.

The data collected pointed out that cv. 'Clipper' had smaller main umbels (diameter 5.5 cm) than 'Dandy Early' (6.1 cm). No difference in earliness could be observed between the cultivars. Cv. 'Dandy Early' only yielded main umbels whilst 'Clipper' also produced ca 0.3 kg.m^{-2} side shoots. The correlation between yield and plant density appeared to be a linear one for both cultivars. With respect to the main umbels the response of both cvs on plant density was almost identical. In this experiment the yield of lateral umbels was very low. In commercial practice it is about 2 to 3 times as high. The relatively high temperature setpoints must be held responsible for this. Especially in the second half of the cropping period the 24-h temperatures maintained were ca 5^{o}C higher than under practical conditions, because previous research had shown that a high 24-h temperature prevents the initiation of lateral umbels and consequently a higher plant density can be realised. At the highest plant densities the yield per square metre is still low so that from an economic point of view (labour, cropping period) the broccoli crop cannot be regarded as successful.

Utility value research of broccoli (G. Heij)

Ten broccoli cultivars which produce a relatively small plant with a high main umbel were planted out on 2 February 1988 in 6 cm soil

blocks. The earliest cultivars were harvested on 31 March, the latest on 4 May 1988. Assessments and harvest data indicated several cultivars with a reasonable utility value. Total yield, however, is very low, only 0.75 kg.m^{-2} at a density of 6 plants.m^{-2}. By selecting a relatively high 24-h temperature (see Annual Report 1987, pp. 47-48) no lateral umbels were formed. On the basis of yield data none of the cultivars tested could be recommended.

CHINESE CABBAGE

The incidence of internal tipburn in chinese cabbage (K. Buitelaar)

Towards harvest time internal tipburn may occur in chinese cabbage crops so that the heads become unsaleable. Accurate water supply and restricting the irradiation were thought to have a preventive effect. In 3 of 4 glasshouse compartments equipped with a lamellar screen, the screen was closed at radiation levels of more than 450 W.m^{-2}, 600 W.m^{-2} and 750 W.m^{-2}, respectively. In each compartment half of the plants were watered 3 to 5 minutes every day, the other half 3 to 5 minutes every other day. From 17 June onwards these treatments were carried out with cv. 'Spectrum', planted out on 17 May. Screening did not have a clear influence on temperature and relative humidity. At harvest on 12 July in the unscreened compartment, and in the compartments screened at 750, 600 and 450 W.m^{-2}, the percentages of heads with internal tipburn were 77, 57, 40 and 43, respectively, and in the compartments with standard and extra watering 53 and 55, respectively. There was no significant correlation between screening and watering treatments, on the one hand, and the head weight, on the other.

BEAN

Utility value research of dwarf French bean (G. Heij)

In May and June, when the early heated crop of French beans is nearly finished and field grown crops are not productive yet, the auction price of French bean is rather high. It is therefore an attractive alternative for warm air heated nurseries to set up a short crop of French beans with a reasonable yield. One of the alternatives is growing pole snap beans, another is growing dwarf French beans.

On 28 March 10 dwarf French bean cultivars were sown. Planting date was 5 April in a density of 30 x 40 cm. First picking was on 1 June 1988. Each cultivar was harvested in 2 gos. After harvest pods of each cultivar were stored at 12°C and 80% RH. Subsequently colour and firmness of the pods were determined.

The harvest data indicate that if once-over harvesting is applied there are no differences between the cultivars: all cvs yielded ca 2 kg.m^{-2}. With respect to keeping quality cvs 'Comprise', 'Rubio', 'Montano' and 'Celero' were less satisfactory than the others. Cvs 'Arosa', 'No. 1006' and 'Montano' produced tall, heavy, dark green pods. In general the quality is somewhat inferior to that of pole snap bean. The dwarf French bean yields more bent and pale pods, and is more susceptible to Botrytis infection during the cropping period.

Utility value research of pole snap bean (G. Heij)

In a spring crop 4 pole snap bean cultivars were compared. On 25 March 1988 cvs 'RZ 826', 'Farba', 'Jos Huizer 70.4' and 'Jos Huizer 70.9' were sown in rockwool blocks and placed in the glasshouse on rockwool slabs on 31 March. Planting was done in 4 rows per 3.20 m glasshouse bay, with a distance within the row of 50 cm.

First harvest was on 18 May, the last on 2 June 1988. Yield observations point out that cv. '70.4' is slightly less early than the other cultivars whilst the differences in yield on 2 June are very small (2.82 kg.m^{-2} for cv. 'Farba' and 3.17 kg.m^{-2} for cv. '70.9'). Furthermore, cv. '70.9' stood out for its greyish green pods. Experimental data indicate that in a cropping period of 2 months a reasonable yield may be obtained.

Utility value research of yard-long bean in an autumn crop (G. Heij)

In an autumn crop cultivar trials were carried out with 2 types of yard-long beans. Cultivars with light green pods were 'Guirlande' (Royal Sluis) and 'Linea' (Nickerson Zwaan). These were compared with the cv. 'Liana' (Royal Sluis, with dark green pods). Sowing was done on 1 July 1988, planting out on 7 July in 3 rows per 3.20 m glasshouse bay with a 42 cm distance within the row. First harvest was on 1 September, last on 27 October 1988.

The total net yields of the light green cultivars 'Guirlande' and 'Linea' were 2.8 and 3.0 kg.m^{-2}, respectively. These cultivars are identical with regard to crop development, pod shape and pod colour. 'Liana' had a total net yield of 2.5 kg.m^{-2}. In the second half of the cropping period this cultivar yielded more short pods. Consequently the percentage second grade of this dark green cultivar was somewhat higher, viz. 12% compared to 8.7% of the light green cultivars.

Also for the light green cultivars it is true that the later the harvest date and the shorter the days were, the shorter the pods became. With respect to cropping period and yield the autumn crop of yard-long bean seems to be a good alternative. However, some heating has to be applied because the flowers at the tips of the pods may give rise to Botrytis.

Climbing French bean cultivar trials (J.H. Stolk, R.G.C.M. Arkesteijn and L. Hogendonk)

Preliminary trials

In the autumn crop of 1988, 12 mostly new pole slicing beans were tested in duplicate on 3 sites against the standard cultivar 'Helda'. The pods and the crops were assessed by an assessment committee and the yield was determined. The results will be discussed in the spring of 1989 in order to compile a series of cultivars for the definitive trials. In the autumn crop of 1988, 10 mostly new pole snap bean cultivars were tested in duplicate on 3 sites against the standard cultivars 'Farba' and 'Glastada'. The pods and the crops were assessed by an assessment committee and the yield was determined. The results will be discussed in the spring of 1989 in order to compile a series of cultivars for the definitive trials.

RADISH

Utility value research of red white-tipped radishes (G. Heij. L. Hogendonk and J.H. Stolk)

In 6 trials 14 red white-tipped radish cultivars were compared and tested for their utility value. In the spring crop, sown on 2 February 1988, only 3 cultivars had a good utility value, viz. 'Lanquette', 'Nun 4405' and 'Niz 61.299'.

In the summer trials the cultivars compared, which are generally grown outdoors in France, appeared to have insufficient utility value under Dutch conditions in greenhouses. Main disqualifications for the spring and summer crop included poor tuber form, long leaves and a high incidence of sponginess. Moreover, these cultivars hardly deserve the qualification white-tipped radish, because the tubers had, both in summer and in autumn, a white tip of at most only 15% of their length. Much breeding work will have to be carried out to obtain a long, white-tipped radish with satisfactory utility value under Dutch circumstances.

Utility value research of 'giant' radish types (G. Heij, L. Hogendonk and J.H. Stolk)

To widen the range of available radish types one of the alternatives discussed is the so-called 'giant' radish. This is a round, red radish type with a tuber diameter of ca 5 cm. In 5 experiments with sowing dates from June to September 8 cultivars of this type were tested for their utility value. With regard to leaf length and tuber width a sowing distance of 12 x 12 cm should be maintained. Cropping period exceeds that of standard round, red radish with 1 week in summer and 3 weeks in autumn.

The experimental data indicate that 2 cultivars had a good utility value, viz. 'Nun 2033' and 'RZ 88-2547'. One cultivar, 'Raxe', had a less satisfactory utility value since its tubers were more heterogeneous at harvest than those of the other cultivars. In 1989 on several holdings some practical experience will be acquired with this type of radish. The utility value research will be continued.

Radish cultivar trials (J.H. Stolk, L. Hogendonk and R.G.C.M. Arkesteijn)

Preliminary trials

In 1988 a year-round programme was started for the preliminary cultivar trials of radish. In consultation with the NTS (Federation of Dutch Horticultural Study Groups) Radish Committee the growing period was divided into six main periods per year on the basis of the sowing dates. It was furthermore suggested in this consultation which cultivars should be used as standard cultivars. In all periods 4 preliminary trials will be carried out in duplicate on commercial holdings in the East and the West of the country. Sowing will be done according to methods currently used in practice. In the harvest stage the radishes will be assessed for various characteristics by an

assessment committee. Also the susceptibility to sponginess will be determined by cutting 20 tubers per experimental plot.

GHERKIN

Gherkin cultivar trials (J.H. Stolk and R.G.C.M. Arkesteijn)

In 1987 preliminary trials were carried out with parthenocarpic and non-parthenocarpic cultivars. The best cultivars from these trials and several new cultivars were tested again in 1988 on 3 sites in duplicated trials. The series consisted of 10 cultivars and the standard cultivar 'Osiris'. Fruit length was a very important fruit characteristic, to determine which the length/width ratio of fruits of all experimental plots was recorded twice in the course of the growing season. Besides also the productivity and fruit and crop characteristics were assessed. The results will be discussed in January 1989.

KOHLRABI

Kohlrabi cultivar trials (J.H. Stolk, M.H. Cools, A.B. Jansen and M. de Jong)

Preliminary trials

In the autumn crop of 1988 seven new hybrids were tested in duplicated trials on 3 sites against the standard cultivars 'Foran', 'Quickstar', 'Trero', 'Proloog' and 'Express Forcer'. Crop and tuber observations were conducted by an assessment committee. Leaf length and tuber diameter were recorded. Also several samples were assessed sensorially for fibrousness. The results will be published in the spring of 1989.

Definitive trials

A series of 5 cultivars, including the standard cultivars 'Express Forcer', 'Quick Star' and 'Foran', was tested in a heated crop on 4 sites in a total of 10 repeats. One of the 4 experiments was carried out with kohlrabi growing on water. The cultivars 'Lippe', 'Foran', 'Quick Star' and 'Express Forcer' were recommended.

CARROT

Improving the root/foliage ratio of carrot by means of Ethrel application (W. van Ravestijn)

In order to obtain a better root/foliage ratio of carrot, sprayings were given of Ethrel (1 $ml.l^{-1}$ = 480 $mg.l^{-1}$ ethephon) + Agral (0.5 $ml.l^{-1}$). Sprayings were carried out once (in week 10, 12 or 14) or twice (in weeks 10 + 12, weeks 10 + 14, or weeks 12 + 14). The control treatment was left unsprayed.

Sowing was done in week 51 of 1987 (cv. 'Zoete Amsterdamse Bak').

The Ethrel sprayings resulted in reduced foliage weight and constant root weight as compared to untreated. Although double sprayings are more effective than single ones, with regard to labour single are recommended. The results of this and previous experiments indicated that the right moment for spraying is when the root weight reaches 10% of the final harvestable produce. This is after 65 to 75% of the cropping period. In this experiment this was the case in week 12. This research will not be continued.

PEPINO

The effect of Tomatotone on the fruit set of pepino (W. van Ravestijn)

In 2 preliminary trials (planting dates 19 January and 9 February 1988), cuttings and seed grown plant, respectively, were used to investigate the effect of flower sprayings with Tomatotone (20 $mg.l^{-1}$ a.i. 4-chlorophenoxyacetic acid, 4-CPA) on the fruit growth. Cvs 'Bushman' (cutting and seed-grown), 'El Camino' (cuttings), 'Schmidt' (cuttings and seed-grown) and several private selections were used as test plants. A virus infection caused the experiment to be ended prematurely.

4-CPA may affect fruit setting both positively and negatively. The role the virus played in this is not known.

CHRYSANTHEMUM

Study of soilless chrysanthemum cultivation (A.P. van der Hoeven)

As a sequel to the investigation of the possibilities of soilless chrysanthemum cultivation (see Annual Report 1987, pp. 55-56) 3 experiments were carried out in 1987/1988. In all experiments the nutrient water was recirculated and composed according to the standard method of preparation for chrysanthemums on NFT. Target value for EC was 2.2 $dS.m^{-1}$ and for pH 5.5. The nutrient water was pumped round for 15 minutes per half hour by day and for 15 minutes per hour at night, except in the rockwool crop where the feeding water was not pumped round at night. In the chrysanthemum crops with NFT the following systems were tested:

1. open gutter, 20 cm wide;
2. 20 cm wide gutter covered with a lid with plant holes;
3. open gutter, 10 cm wide;
4. narrow gutter with planting strips;
5. imitation concrete floor.

Furthermore experiments were carried out with new and used rockwool slabs, of 2.5 cm high and 17 cm wide, and of 7.5 cm high and 20 cm wide. Cuttings in both rockwool and soil blocks were used, of which those in soil blocks were much more satisfactory. Of the nutrient film systems the gutter with lid gave the best results, and the gutter with planting strip, with the cuttings rooted in water, the poorest. The results with the thick rockwool slab were equal to or slightly better

than those with nutrient film and much better than those with the thin slabs. Especially on the thin slabs which were used once, growth was poor. Probably they were too wet for much of the time so that the roots could not function properly. In spite of the application of fungicides to the feeding water once in every 2 or 3 weeks, infection by Pythium spp. could not be prevented completely.

Growing chrysanthemums with or without artificial lighting (A.P. van der Hoeven and E.M. Nederhoff)

To obtain more information about the effects of photosynthetic lighting in chrysanthemum cultivation, in the winter season of 1987/1988 an experiment was carried out on a commercial holding. Cuttings of cvs 'Cassa', 'Daymark' and 'Cappa Dark', which were rooted in soil blocks, were planted out on places with and without photosynthetic lighting. Planting densities were 48, 56, 64 and 72 cuttings per 1.25 m bed. Lighting was done with one SON-T 400 Watt lamp per 16 m^2 glasshouse area, resulting in a lighting capacity of ca 5 Watt PAR per m^2 (2,000 lux). During the vegetative stage and during the interruption, lighting was applied for 20 h (no lighting from 17.00 to 21.00 h) and during the generative stage for 11 h per 24-h period (no lighting from 17.00 to 06.00 h). During and for a short time after irrigation and with sunny weather no lighting was applied for several hours a day. Cropping measures, such as start and interruption of the short-day treatment, for both the lit and the unlit chrysanthemums, were carried out in such a way that the chances of an equal crop length at harvest were greatest. Therefore the start of the short-day period was 2 weeks later and the interruption of the short-day treatment was 4 days later for the unlit crops than for the lit ones. Furthermore, the lit chrysanthemums received ca 50 l water extra per m^2. For crop observation purposes additional plots were available with a high plant density, from which plants were lifted every 2 or 3 weeks for measurements and determination of the growth rate in the various treatments.

The table shows correlations between the growth rates measured and the light quantities received. With respect to order of magnitude the calculated efficiency corresponds with results from measurements in tomato crops. The efficiency of lit plants appears to be greater than that of unlit plants. This may partly be explained by the greater leaf area of lit plants. Furthermore the total amount of light received was greater in the unlit treatments, because the additional weeks of the extended cropping period were rich in light (end of February/beginning of March).

Table 9. Additional growth (g fresh weight), light sum (J.cm^{-2} PAR) and calculated efficiency (= additional growth per light quantity) for lit and unlit chrysanthemums per period

period	lit			unlit		
	add. growth	light sum	effic-iency	add. growth	light sum	effic-iency
11/11-06/12	10.4	2331	4.5	5.6	1675	3.3
07/12-27/12	12.7	1378	9.2	6.4	1047	6.1
28/12-17/01	10.4	1396	7.4	6.8	1045	6.5
18/01-07/02	10.1	2000	5.1	9.1	1781	5.1
08/02-22/02	14.0	2375	5.9	12.2	2312	5.3
23/02-06/03	-	-	-	18.2	2362	7.7
11/11-end	57.6	9480	6.1	58.3	10222	5.7

The data collected in the chrysanthemum experiment and in other trials with photosynthetic lighting will be used to develop and/or validate a simulation model.

After harvest both the lit and the unlit chrysanthemums were tested for their keeping quality (vase life). Initially the light distribution over the plants was good but it became worse as the plants gained height. The length, weight and leaf area of the illuminated chrysanthemums increased much more rapidly than of the unlit plants. Only with cv. 'Cappa' this increased longitudinal growth, due to illumination, was less pronounced than with the other cultivars. Apart from that, the lighting and plant density effects on the different cultivars were similar. Five weeks after planting the percentage dry matter of the illuminated plants was considerably higher but dropped again to the level of the unlit plants as soon as extra watering was applied. Since the daylength treatments were aimed at obtaining equal crop height at harvest, the lit chrysanthemums flowered 3 weeks earlier than the unlit ones. Moreover, the quality of the harvested stems was better, due to the higher average stem weight, the greater firmness of the stems and the greater number of flowers per stem. The effect of the lighting on the average stem weight in this experiment corresponded with the effect of an additional 8 plants per m bed. At harvest the lit chrysanthemums had considerably more dead, brown leaves at the bottom of the stems. A small difference in the average number of days of vase life could be observed between the lit and the unlit chrysanthemums, in favour of the lit ones.

Effects of plant density on the productivity, the quality and monetary yield of chrysanthemums (A.P. van der Hoeven)

In combination with illuminance investigations in a winter crop of chrysanthemums on a commercial holding, the impact of plant density on production, quality and monetary yield was studied. Cuttings of cvs 'Cappa Dark', 'Daymark' and 'Cassa' were planted out on 11 November 1987 in densities of 48, 56, 64 and 72 plants per m bed length of 1.25

m wide. At harvest a range of measurements was carried out. On the basis of stem weight the stems were divided into quality classes. For an estimate of the monetary yield the stems were valued as follows: Dfl 1.00 for stems of class 1, Dfl 0.75 for class 2, Dfl 0.50 for class 3 and Dfl 0.25 for class 4. For the cuttings which were planted out in addition to the number needed for plant density 48, Dfl 0.20 was detracted from the calculated yield for costs of plant material, extra labour, etc.

The effect of the plant density was similar for all 3 cultivars. The lower the plant density was, the heavier the stems and leaves were. The stems were firmer, had more flowers and showed less brown leaves at the bottom. With photosynthetic lighting, with an additional 8 plants per m bed length of 1.25 m wide, about the same average stem weight was observed at harvest as without extra illumination. After deduction of the extra cuttings costs at higher plant densities the calculated yields, both with and without artificial lighting, were higher as the plant density was lower. On average the lowest plant density (chessboard system) resulted in the highest calculated yield in this experiment.

Uniformity of cuttings (A.P. van der Hoeven)

In co-operation with the Chrysanthemum Department of the General Netherlands Inspection Service for Ornamental Plants (NAKS), an investigation was carried out of the quality and uniformity of chrysanthemum cuttings. To this purpose the inspectors of the NAKS took samples of 250 cuttings of cv. 'Cassa' of all producers of year-round chrysanthemum cuttings. Fifty cuttings of each sample, selected at random, were assessed for length, weight, stem diameter, number of leaves and leaf area. The remaining 200 samples were rooted and planted out to find out possible differences in growth, diseases and aberrations. There were great differences between cuttings of various sites in average weight and leaf area. With respect to average length, number of leaves and stem diameter, however, the differences were small. With respect to uniformity great variations in weight and leaf area occurred between the samples. There was a close correlation between cutting weight and leaf area in most of the samples. After planting out great variations in vigour, health (virus) and uniformity between the samples were observed. Cuttings producers were informed of the experimental results and they were alerted to the importance of uniform, healthy and qualitatively good cuttings.

Chrysanthemum cultivar trials (A. de Gelder, C. Heidemans and A.P. van der Hoeven)

Every year breeders introduce many new chrysanthemum cultivars. In trials these cultivars are evaluated for characteristics influenced by growing conditions, keeping quality and long day leaf number.

Temperature combined with different daylength treatments influenced spray form, stem length and stem weight of the cultivars. For keeping quality special attention was paid to leaf wilting as a factor of vase life termination. By distinguishing between senescence of the flowers and weakening of leaves the variability of the results was strongly reduced. New promising cultivars were 'Bonita', 'Mundial' and 'Toon

Hermans'.

The second descriptive cultivar list of ornamentals contains a chapter about chrysanthemum.

FREESIA

Winter flowering of freesia (J.C. Doorduin)

In a winter flowering experiment with 2 cultivars the effect of soil temperature until bud initiation and leaf picking on quality and yield was studied. Planting date was 23 July. The target levels of soil temperature up to and including bud initiation were:
a. 15 to 16°C;
b. 18 to 20°C, after 4 weeks 16 to 18°C.
Leaf picking treatments were: none, once and twice. The cultivars used were 'Blue Heaven' and 'Miranda'. At the low soil temperature flowering began after 5.5 months, at the high soil temperature this was 5 weeks later.

At the start of the harvest the soil temperature appeared to have no effect on total fresh plant weight and leaf area. The more often leaf picking was carried out, the lighter the plants were. At the high soil temperature the fresh and dry corm weight at the beginning of harvest was 45 and 70% higher, respectively, than at the low soil temperature at the start of the cropping period.

The stem production of cv. 'Blue Heaven' at the high soil temperature was ca 15% higher than at the low soil temperature, while cv. 'Miranda' showed the opposite. For both cultivars the low soil temperature had an adverse effect on the thumbing of the inflorescence. In view of the results of other experiments, however, the question remains whether this adverse effect should be ascribed directly to the soil temperature or to the moment of bud initiation (plant size) and the subsequent glasshouse climate. The soil temperature did not affect the stem weight. Leaf picking frequencies did not affect flowering time, stem weight or flower head quality. Picking leaves twice was unfavourable for the yield of both cultivars. For 'Blue Heaven' picking leaves once resulted in the highest yield whereas for 'Miranda' this was the case when no leaf picking was carried out. 'Blue Heaven' appeared susceptible to flower bud abortion, while 'Miranda' showed only little susceptibility.

Propagation of freesia (J.C. Doorduin)

This year a long-term experiment was started on the propagation of freesias. To this purpose an aphid-proof gauze house was constructed for the virus-free or nearly virus-free propagation of freesias under aphid-proof circumstances.

In this gauze house the effect of harvesting or not harvesting on the percentage of virus-infected plants of 4 cultivars was studied. The freesia corms were planted out on 11 May after an end-treatment of 3.5 weeks at 13°C. Samples of the 4 cultivars were planted outside the house as control. Furthermore, around the house virus-infected corms were planted to increase the infective pressure and during the cropping period aphids were released among the plants outside the house.

Mid-October plants were serologically tested for virus infection. The average virus infection percentage was 0.4, and, depending on the cultivar, ranged from 0 to 0.9. Harvesting or not harvesting the flowers did not affect the infection rate. In the control samples outside the house the virus percentage varied between 5 and 25.

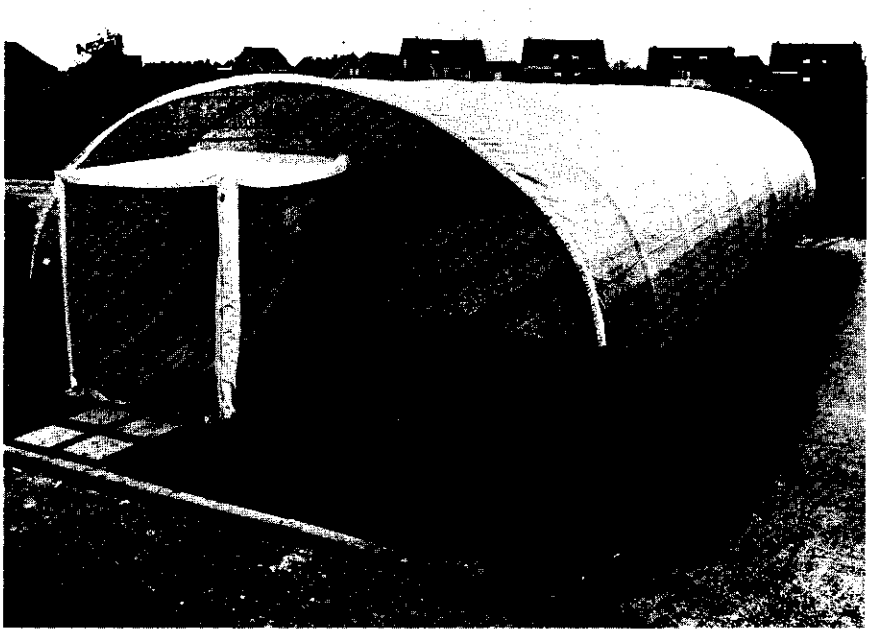


Fig. 6. Aphid-proof gauze house for virus-free propagation of freesia

Freesia cultivar trials (A. de Gelder and C. Heidemans)

A trial was carried out with freesia cultivars flowering in spring. In October 1987 32 cultivars were planted at the Research Station. These cultivars were in research for the first, second or third year combined with standard cultivars. The results of all culttivars are published in a trade press article including the results of cultivars which were in research for the first time. New promising cultivars after 2 years of testing were 'Seagull', 'Ideaal' and 'Cilla'.

AMARYLLIS (HIPPEASTRUM)

Year-round planting of Amaryllis (Hippeastrum) (J.C. Doorduin)

The experimental set-up and part of the results have already been described in the Annual Reports 1986 (p. 65) and 1987 (p. 58-59). For each planting date and growth period bulbs were lifted of both cultivars. After drying and preparation these were again planted out for flowering assessment. Corresponding bulb sizes of both cultivars showed the same or better flower production as the growing period was longer, with the exception of the March plantings which showed more or less diametrically opposed results. A possible explanation is that with the increasing growing period lifting took place in or at the end of the darkest period of the year, so that flowering may have been at the expense of several potentially flowering inflorescences. Furthermore, at the 52 weeks' growing period advanced flowering was observed shortly before lifting.

Bulb cultivation of Amaryllis for early flowering (before Christmas) (J.C. Doorduin)

With the aim to cultivate marketable bulbs which should be capable of flowering well before Christmas, on 23 September 1987 10 Amaryllis cultivars were planted out. Bulb sizes used were mainly 16/18 and 18/20. To obtain more insight into the effect of carbon dioxide on Amaryllis bulbs were grown at 2 treatments, with and without CO_2 enrichment. The bulbs were lifted on 11 and 12 July 1988. The average increase of bulb size without CO_2 enrichment was 11.5 cm and with CO_2 enrichment 15.0 cm. The average bulb weight at lifting was more than 30% higher in the treatment with extra CO_2. After preparation at 13°C the bulbs were again planted out for assessment of flowering time and production. Flowering of all cultivars started in November. Yield data will be presented in the next Annual Report.

CARNATION

Effect of long-day (cyclic lighting) treatment on growth, flowering, yield and quality of carnations (A.P. van der Hoeven)

As a sequel to last season's lighting experiment (see Annual Report 1987, p. 62) the experimental crop was continued, to investigate whether a long-day treatment by means of cyclic lighting also has effect on older crops. In both compartments with the cvs 'White Sim' (standard type) and 'Silvery Pink' (spray type) half the glasshouse area was cyclically illuminated from 25 January to 4 March 1988. Lighting was done from 18.00 to 08.00 h for 10 minutes per half hour with incandescent lamps with a capacity of ca 300 $mW.m^{-2}$ (70 lux).

From the beginning of January until the beginning of May no significant differences in yield occurred between the lit and the unlit carnations. Subsequently the yield in stems but also in total stem weight of the illuminated carnations increased much more rapidly than of the unlit ones. On 25 May the increase in yield for 'Silvery Pink' amounted to 15 and for 'White Sim' to 30 stems per m^2 bed area. After

25 May the development of the unlit carnations started to catch up on that of the lit ones. The carnations flowering earlier, due to the lighting treatment, had a lower stem weight than the unlit ones. Especially in June this difference was great. On 24 June, when the experiment was terminated the yield in stems was still slightly higher in the illuminated compartments but the total weight per m^2 bed was about the same. Both cultivars produced similar weights but 'Silvery Pink' yielded more stems of a lower average stem weight than 'White Sim'. The commercial application of cyclic lighting increases. Because in commercial practice adjoining plots receive light due to overlap, the illuminance effects in practice are stronger than in the experiments so that it is advisable to apply cyclic lighting for several days less than in the experimental treatments.

Flower development of the main bud of Aster ericoides cv. 'Monte Casino' (W. van Ravestijn)

Between 31 March and 11 May all stages of the formation of the top flower were studied microscopically and recorded photographically. From 1 April onwards the plants were grown under short-day (SD) conditions. After about one week of SD the growing point changes. Between the 10th and the 17th SD the flower primordia (both of the ligulate ray flowers and of the tubular florets) are initiated. The flower bud can be seen with the naked eye after ca 27 SD. After 6 weeks SD the top flowers are in bloom.

GLASSHOUSE CLIMATE CONTROL

Energy saving by shading cloth with an open structure (G.P.A. van Holsteijn)

As a sequel to last year's experiment, in March 1988 during 9 nights measurements were carried out to determine the energy saving of 2 partly aluminised screens with an open structure (LS-14F and LS-15F). On the basis of continuous temperature measurements of heating pipes and air above and below the screen an energy saving could be calculated for LS-15F of 5 to 10% and for LS-14F of 15 to 20%. For both screens this is considerably lower than might theoretically be expected. In all 9 nights the air humidity under both types of screen was lower than in unscreened compartments. Reduction of air humidity by a screen with an open structure was also observed in previous research.

Utility of an accordion screen, aluminised on both sides (G.P.A. van Holsteijn)

On a commercial holding where a completely closed screen, aluminised on both sides, with an accordion folding system was installed, a number of climate observations were carried out. Before the screen was installed a light level of 68% of the outside value was measured in the glasshouse. With an installed, open screen the light level in the glasshouse was 65%. On the basis of temperature measurements above and below the screen a 54% energy saving could be calculated when the

screen was 100% closed. With an opening of ca 0.6% of the screen energy saving still was 38%. It could be concluded from the measurements that small apertures in the screen sufficiently reduce the air humidity without annihilating all energy saving.

It appeared impracticable on this holding, with soil-grown chrysanthemums, to keep the screen free from condensation droplets at the underside, by partly opening it during the night.

Horizontal temperature gradients (G.P.A. van Holsteijn)

The study of the incidence of horizontal temperature gradients was continued during the year under review. The method with small synthetic bottles filled with water (see Annual Report 1987, p. 67) was tested on 8 holdings. A number of significant causes of temperature differences could be added to the list of those already known. The 2 most remarkable were the central rain water drainage in the glasshouse and uninsulated dividing glasshouse walls. On some nurseries it could be demonstrated that the wind direction is only a minor factor in the incidence of horizontal temperature gradients in a glasshouse.

Measuring accuracy of climate computers (G.P.A. van Holsteijn)

On 25 holdings within a radius of 1.5 km the measuring accuracy of climate computers was investigated. All important computer makes (5) were equally represented in this investigation. The measurements indicated that 20% of the computers showed a deviation of more than $0.5^{\circ}C$ from the recorded temperature or a deviation of more than 3% from the relative humidity. At an average CO_2 concentration of 400 ppm 75% of the computers showed an average deviation of more than 25 ppm. Two computers showed an average deviation of more than 120 ppm.

The accuracy of the weather stations was checked by recording hourly momentaneous values for 6 days and calculating the average value for every holding. Considerable deviations were evident for temperature, wind velocity and global radiation.

Transpiration research in the lysimeter glasshouse (R. de Graaf)

In 1988 the adjustment of the lysimeter glasshouse for transpiration research of substrate grown crops was completed. The 9 electronic balances for transpiration experiments and the equipment for setting up a water balance for the 3 separate glasshouse compartments were tested and their correct functioning was checked from January to mid-November. Testing and checking was done during a heated tomato crop. In general the electronic balances, their accessories as well as the equipment for setting up the water balance worked satisfactorily. Several technical adjustments were carried out during the testing period.

The water supply calculation model, developed in 1987, was tested and where necessary adjusted during the year under review. Subsequently this method worked satisfactorily. The water supply calculation model was also used to control the water supply and to measure the amount of drainage water of the plants on the balances, the difference being that for the plants on the balances the transpiration does not have to be calculated but is measured directly.

Description and quantification of the natural ventilation in glasshouses (T. de Jong)

Early in 1988 the ventilation measurements on commercial holdings were terminated. These measurements were carried out in a number of completely detached glasshouses, with the aim to determine whether the ventilation through the glasshouse cover is affected in any way by the presence of outside walls. This was motivated by the consideration that the thrusts and suctions at the walls influence the pressure distribution over the windows and consequently the ventilation characteristic of the glasshouse.

The differences in pressure on the windows, caused by wind, fluctuate due to the strongly varying wind velocities on the glasshouse cover. The air exchange will be driven by the amplitude of the fluctuating pressures over the individual window apertures. However, the presence of pressure fluctuations implies the possibility of momentaneous pressure differences between the various window apertures. The question arose whether the interaction of these momentaneous pressure differences affects the ventilation. In general, this interaction will depend on the number of ventilation windows and their location. In practice, the interaction between the momentaneous pressure differences will be connected to the area of the glasshouse cover.

To determine whether the ventilation characteristic of a glasshouse cover is indeed influenced by the area, following on the measurements on commercial holdings a series of experiments was set up. Care was taken that the wall effect, mentioned above, did not occur.

Pressure differences over the windows may occur as a consequence of wind effects and of temperature differences between glasshouse and outside air. In the latter case pressure differences are caused by differences in density at both sides of the aperture.

In measurements in practice it is virtually impossible to study the effects of the temperature on ventilation separately. In most cases wind effects will always to a large extent be responsible for the pressure differences. To circumvent this problem a construction was erected in a large hall, so that wind effects were almost completely eliminated. In this construction ventilation measurements were carried out; the temperature differences of the air at both sides of the apertures could be kept at constant levels. The measurements were carried out for a series of temperature differences ranging from 1 to 25^{o}C. The ventilation fluxes were measured through openings in a horizontal and a vertical area. The openings differed in length/width ratio, not in area.

The relations found with respect to the natural convection through openings will be converted to the geometry of the ventilation windows.

Photosynthesis measurements (J.G. Vegter)

The photosynthesis research started in 1987 was continued in 1988. Firstly the measurements were analysed of the cucumber crop of autumn 1987. The climate conditions measured (CO_2 concentration, temperature and light intensity) and crop parameters were used to simulate the photosynthesis. The results indicated that the model for (autumn) cucumber works satisfactorily. Various articles were published about

these measurements and simulations in the trade press, Netherlands Journal of Agricultural Science and Acta Horticulturae.

In spring 1988 measurements were carried out on photosynthesis and respiration of sweet pepper and cucumber (2 compartments of each), and in autumn again of the same sweet pepper crop and of a newly planted sweet pepper crop (also 2 compartments of each). Planting date for cucumber (cv. 'Lucinde') was 18 December 1987, for sweet pepper (cvs 'Delphin' and 'Rumba') 24 December 1987 and 13 July 1988, respectively. All measurements were carried out with rockwool grown crops in 4 glasshouse compartments of 192 m^2 each.

The method is based on measurement of the CO_2 balance and simultaneous measurement of the air exchange rate with the aid of the tracer gas N_2O. In 1988 the possibility of keeping the CO_2 concentration of the glasshouse air at a constant level was added to the measuring method.

The measurements of photosynthesis and respiration were conducted during as many days (and nights) as possible. Between 17 May and 1 August the number of measurements was limited. The measurements of the CO_2 and N_2O concentrations were carried out with a time interval of 5 minutes. On the basis of these measurements the crop photosynthesis was calculated over time intervals of 15 minutes. The measuring data together with the accompanying climate data were recorded (CO_2 concentration, temperature and light intensity). Before long these data will be introduced into the simulation model for photosynthesis. Furthermore data were collected for the validation of a growth and production model.

Optimization of the CO_2 enrichment and validation of the model (A.A. Rijsdijk)

During the late summer of 1988 the programme for CO_2 optimization was tested. A previous test of a less complicated version of the programme was carried out in 1986.

Roughly speaking the optimization programme balances momentaneously the costs and benefits of CO_2 enrichment. The costs of CO_2 enrichment up to a certain level are calculated on the basis of uptake by the crop and loss by ventilation, at a previously set cost price. The monetary yield can be calculated on the basis of the CO_2 uptake and the estimated price for the cucumbers. These calculations are carried out for a number of CO_2 concentrations. The optimum CO_2 level is that at which the monetary yield is highest as compared to the costs. In the subsequent minutes this level is maintained as target in the programme. After several minutes a new target value is calculated for the new window aperture, wind velocity, irradiation and glasshouse temperature.

On 3 August cucumbers (cv. 'Ventura') were planted out in the 24 compartments of glasshouse 210. The optimization treatments were compared with the standard CO_2 enrichment procedures in commercial practice. The 8 triplicated treatments were:

1. constant 340 ppm by day;
2. constant 700 ppm by day;
3. 1,000 ppm with closed windows, proportionally decreasing to 340 ppm at 10% window aperture;
4. 1,000 ppm with closed windows, proportionally decreasing to 340 ppm at 60% window aperture;

5. CO_2 optimization at a CO_2 price of Dfl 0.25.kg^{-1};
6. CO_2 optimization at a CO_2 price of Dfl 0.60.kg^{-1};
7. CO_2 optimization at a CO_2 price of Dfl 0.02.kg^{-1} when heat is demanded, and a price of Dfl 0.12.kg^{-1} when no heat is demanded*);
8. Enrichment to 1,000 ppm when heat is demanded*). When no heat is demanded to 600 ppm, until window aperture 4%, proportionally decreasing to 340 ppm in window aperture range between 4 and 20%.

*) It was supposed that heat was demanded if the pipe temperature measured was 10°C higher than the glasshouse temperature.

Processing the data revealed an error in the formula for the calculation of the ventilation rate. This could be compensated for by assuming that the CO_2 values calculated were optima at different CO_2 prices. After correction the initial prices of Dfl 0.25, 0.60, 0.12 and 0.02 were Dfl 0.142, 0.347, 0.068 and 0.01 per kg.

Evaluated economically the results of the optimization programme appeared to be satisfactory. Best results were obtained with optimization at a set price of Dfl 0.25.kg^{-1} (after correction Dfl 0.142). Furthermore the practice treatment (10%340) was also satisfactory. The results of the other 2 optimization treatments were varying. Optimization with a high CO_2 price resulted in lower yield than the practice treatment 3. Optimization with a price dependent on the heat demand (opt12wv2) gave better results than the practice treatment 8 (prakt).

Apart from the observations within the framework of the CO_2 optimization programme, also crop observations were carried out for the validation of a crop model developed by researchers of the Centre for Agrobiological Research (CABO) in Wageningen. Several times plant samples were taken and the fresh and dry weight determined of leaves and stems and the fresh weight of fruits. Moreover, in all compartments and outside the glasshouse climate factors were measured and recorded.

The composition of the glasshouse air in a warm air heated lettuce crop (E.M. Nederhoff, A.A. Rijsdijk, R.M. Verkade. H.G. Wolting, E. van Remortel and H. van Poeljen)

In January, February and March 1988 on 3 commercial nurseries measurements were carried out of the composition of the glasshouse air with warm air heated crops. The reason for this was the damage occurring in previous winters during periods of severe frost to air-heated lettuce crops. Increasing concentrations of certain gases (CO_2, NO, NO_2, SO_2 or ethylene) might have been the cause. In 1988 these gases were measured continuously and on-line on 3 nurseries:
1. nursery 1 (with lettuce), with 3 compartments:
   a. with conventional burners (Priva DA-10);
   b. with burners of a new type, which, according to the manufacturer, release less NO_x (Priva LN-10);
   c. as a., but this compartment was equipped with additional pipe heating and a thermal screen.
2. nursery 2 (also with lettuce), corresponding to nursery 1 in terms of cropping method, cultivars and heating regime and with the same burners as compartment a of nursery 1.
3. nursery 3 (with tomatoes) with a much higher heating regime, and

burners of another manufacturer (HH).
On nursery 3 ventilation was done in the morning to dispose of excess of gases.

Table 10. Measured gas concentrations of 2 air heated nurseries (1 and 3) with different types of burners (DA, LN and HH). Measuring period nursery 1: 26 January - 13 February; nursery 2: 23 February - 9 March 1988. Results of nursery 2 similar to those of nursery 1, comp. a.

	n.1, comp.a (DA)			n.1, comp.b (LN)			n.3 (HH)		
	av.	min.	max.	av.	min.	max.	av.	min.	max.
CO_2 (ppm)	1922	259	6469	1864	245	6314	6075	240	11775
NO (ppb)	683	0	1993	74	1	308	1483	100	2480
NO_2 (ppb)	142	5	661	66	4	434	274	0	615
NO_x (ppb)	825	6	2654	141	5	742	1757	95	3095
SO_2 (ppb)	8	3	15	4	2	10	-	-	-

There was hardly any frost during the measuring period (January - March 1988). Consequently, high gas concentrations did not occur, with the exception of nursery 3 (tomatoes). Nonetheless, on all 3 nurseries the concentrations occasionally far exceeded the damage threshold, even for acute effects. However, no damage could be observed (visually). This may be explained by the fact that in NO_x injury many factors play a role, e.g. the stomatal resistance. High NO_x concentrations mainly occur at night, when the stomata are closed. By day the NO_x peaks coincide with CO_2 peaks. At higher CO_2 concentrations (order of magnitude of 1,500 ppm) the stomata are relatively far closed (known from literature) and uptake of gases will be restricted.

The occurrence of 'invisible damage' is probable, in the form of growth inhibition or otherwise suboptimal growth. The injuries observed in previous (far colder) years were probably due to much higher gas concentrations.

The observations indicate that burners with a low NO_x release indeed resulted in a much lower NO_x concentration in the glasshouse. In the compartment with this new type of burners 83% less NO_x was found than in those with the conventional burners. The NO/NO_x ratio, however, had changed, but it is not clear whether this has any consequences.

The ethylene concentration was measured regularly. The highest values were found on the tomato nursery, especially early in the morning, just before ventilation was started. The ethylene content then ranged between 60 and 130 ppb, which, though far above the supposed damage threshold, did not result in any visible symptoms, either.

The conclusion is that damage by ethylene and NO_x is restricted by high CO_2 concentrations. In their turn, these high CO_2 concentrations will have adverse effects as well (suboptimal growth). How circumstances are under real wintry conditions will become apparent from the simulation calculations to be carried out by the Gasunie. Which effects then will occur on (lettuce) plants and which concentrations will not result in damage, will be made clear by subsequent research by the Research Institute for Plant Protection (IPO).

Effects of air pollution under summer conditions (A.A. Rijsdijk, E.M. Nederhoff, H.G. Wolting and E. van Remortel)

From previous observations (e.g. by researchers of the IPO) it had become clear that polluted air entering the glasshouse through the ventilation windows may have adverse effects on crop growth. Gases known to be injurious to crops are NO, NO_2 (together NO_x), SO_2 and O_3. The research was carried out in glasshouse 301, equipped with an artificial ventilation system. This prevents uncontrolled penetration of outside air into the glasshouse. In 3 of the 6 compartments the phytotoxic gases were filtered from the outside air with an active charcoal filter.

On 2 May tomatoes (cv. 'Dombito') were planted in all compartments and examined regularly for visible damage. Furthermore the fresh and dry weight of the removed vegetative parts, and the weight and number of fruits were determined. In all compartments also tobacco (cv. 'Belw3') and plantain (Plantago major) plants were placed as indicator plants, because of their extreme sensitivity to ozone and NO_x. These plants were regularly examined and replaced by fresh ones.

The table below presents the concentrations of the various gases measured in the glasshouse compartments and in the outside air.

Table 11. Average measured gas concentrations (16 May - 16 June 1988)

	filtered			unfiltered			
gas	comp.1	comp.3	comp.5	comp.2	comp.4	comp.6	outside
ozone (ppb)	2	2	3	19	19	17	28
NO_2 (ppb)	7	8	9	17	17	18	17
NO (ppb)	18	11	11	6	6	7	7
SO_2 (ppb)	3	3	3	5	5	5	7
CO_2 (ppm)	366	361	360	363	364	368	362

In the unfiltered compartments a reduced ozone concentration could be observed in comparison with the outside air. The absorption of ozone to all types of material (e.g. the filter installation) might explain this. NO_2 was partly converted to NO on the filter. The NO_x concentrations in the filtered compartments remained about equal to those in the unfiltered compartments. About half of SO_2 was filtered away. The filter did not cause any loss of CO_2.

The tobacco plants showed symptoms in the form of necrotic spots as an effect of ozone. Between plants from the filtered and from the unfiltered compartments clear differences could be observed. The symptoms expected in the plantains (curled leaves and growth reduction) did not occur. The tomato plants showed no visible damage and no significant yield differences could be observed. This may be caused partly by the fact that the climatic conditions were not equal in all compartments (due to the simple analogous control and unequal watering) and that a virus disease occurred. Further processing of the gas measurements will be conducted by the Institute for Phytopathological Research (IPO).

Simulation of the CO_2 consumption in glasshouse horticulture
(G. Houter, E.M. Nederhoff, H. Gijzen and P.C.M. Vermeulen)

In 1987 a project was started to develop a simulation model (CO_2 model) for the calculation of CO_2 consumption, energy consumption and production in glasshouses. The purpose of the model is to use it as a management system, which can be consulted for decisions on investments in CO_2 and heating equipment (see Annual Report 1987, p. 66).

In 1988 the CO_2 model is composed of a crop growth model (from CABO and the Department of Theoretical Production Ecology of the Agricultural University at Wageningen) and a glasshouse model (of the Department of Physics and Meteorology of the Agricultural University). The CO_2 model has options for crop (cucumber or tomato), for CO_2 and heating equipment (CO_2 from burned natural gas or liquid CO_2, or presence of heat storage tank and its size) and for CO_2 control (no CO_2 enrichment, CO_2 enrichment to a fixed concentration independent of outside conditions, CO_2 enrichment to a concentration depending on ventilation rate, or CO_2 enrichment with economical optimization).

A comparison of simulated heat demand (natural gas consumption) and fruit production of cucumber and tomato has been made with data registrated by two growers. This comparison shows that the CO_2 model simulated the reality quite well.

Side-effects of photosynthetic lighting (E.M. Nederhoff)

In recent years the area under photosynthetic lighting has strongly increased, especially in cut flower and pot plant crops. Because lighting is done at such a broad scale, side-effects become evident. In the dark months December 1987 and January 1988 for the first time growth aberrations were observed in cucumber and tomato plants in glasshouses adjacent to glasshouses with high pressure sodium lamps. In the evening and at night these crops were exposed to a certain amount of light from neighbouring glasshouses.

The symptoms in tomato were: shorter plants, retarded growth and development, delayed production, occasionally upright leaves and poorly opening flowers. For cucumber the symptoms were: strongly reduced growth, less and smaller leaves, irregular leaf growth, and delay of the first harvest. Tomato, cucumber and eggplant also showed retarded root development.

Close to the glasshouse wall occasionally light levels of 80 lux were recorded, and in the glasshouse at 30 m distance from the wall 4 lux. Measurements with a spectrophotometer indicated that there was an excess of red light (660 nm) as compared to far-red light (730 nm). The ratio red/far-red was approx. 3, while in the natural daylight this is ca 1.2.

The explanation for the symptoms is to be found probably in the pigment phytochrome. It is known that red light activates the phytochrome. This may stimulate the production of hormones (auxin, gibberellin, cytokinin) and have a direct or indirect effect on many processes, such as cell elongation, longitudinal growth, flowering, development of side-shoots, etc. Probably the problems arise because at night no photosynthesis takes place (light level below the compensation point) whilst the phytochrome is activated, which might cause an

imbalance in the plants.

In the course of 1989 regulations will probably be issued which compel growers who apply artificial lighting to equip their glasshouse walls with a mobile screen.

6. DEPARTMENT OF ECONOMICS AND MANAGEMENT

J.C.J. Ammerlaan

For the quantification of the possibilities and problems on glasshouse holdings a business-economic analysis of the problems in research and practice remains essential. In this framework research was carried out on photosynthetic lighting and substrate cultures. Furthermore the profitability of the main vegetable crops was determined on the basis of yield levels realised in 1988.

Due to the increasing realisation of the importance of ecologically sound business systems, the end of 1988 saw the start of a research programme devoted to the development of such systems. This was done in co-operation with various institutes. As it seems, much of our efforts will be dedicated to this programme in the years to come.

In 1988 the specification of the information model for the glasshouse horticulture was practically rounded off, a project which was managed by the SITU. It is to be expected that in the near future the results of this project may be helpful in the development of management information and advisory systems.

ECONOMIC RESEARCH

Developments in substrate growing of vegetable crops (A.J. de Visser)

Since 1987 the total area of fruit vegetables (tomato, cucumber, sweet pepper and eggplant) stabilizes at a level of ca 2,800 ha. Ninety per cent of the acreage planted before 1 February is grown on rockwool. During the last 2 years this area increases with 200 ha on average per year, and in spring 1989 it will be 2,300 ha. The acreage planted between 1 February and 1 June decreased with an annual 200 ha and is expected to be 500 ha in 1989. It is clear that the rapid decrease of the acreage of late plantings with ca 400 ha in 2 years has great consequences for the glasshouse lettuce area. If on the acreage mentioned lettuce is grown once on average, this change-over from late to early plantings implies a reduction of the lettuce acreage of 20% in 2 years.

Substrate systems (J.K. Nienhuis)

During the year under review various substrate systems, mainly with tomato, were compared from a business-economic point of view. The investments for the different systems (matting, gutters, hose, separate drainage) for tomato range from ca Dfl 4.00 to Dfl 10.00 per square metre. Annual costs range from Dfl 1.30 to almost 3.00 per m^2. One of the main conclusions is that the traditional system, i.e. with sleeved matting, is least expensive. With gutter systems, which include the hose system, the drainage is less than with the traditional system and the system with the separate drainage. Consequently the water and fertilizer consumption is potentially lower than with a gutter system. Depending on the EC and the price of the water this amounts to ca Dfl

0.25 to 1.00 per m^2. Then the hose system appears to be attractive. In all gutter systems, also in the separate drainage system, there is the possibility of recirculation which is not possible in the traditional system. Moreover, in gutter systems an additional 5 to 10% can be saved in fertilizers and water so that the gutter systems appear to be more cost-effective.

Drain water disinfestation (J.K. Nienhuis)

When fertilizers and water are being recirculated in a gutter system it is necessary to disinfect the water because of the risk of spreading diseases. This disinfestation involves investments. Because these depend on the size of the installation, of the materials used and of the disinfestation system, it is difficult to give generally applicable investment figures. In 2 trade journal articles illustrative cases were discussed. These examples indicated that for the greater holdings (exceeding ca 1.5 ha in area) the financial gain (reduced loss of water and nutrients) balances the costs.

Determination of the yield level and the profitability of glasshouse vegetables on the basis of registration of yield data by growers' study groups (P.C.M. Vermeulen)

At the end of 1987 and the beginning of 1988 a programme was developed to process the data which were made available by the NTS business comparison groups. During the year under review for 8 different crops production and yield data were recorded. These groups were put together on the basis of equal sowing period (ca 2 weeks). At the end of the cropping period a subsequent calculation was made on the basis of these data for the net business result (loss or profit). The results are presented in Table 12.

Table 12. Averages per group for production, monetary yield, net business result and profitability at the end of the cropping period

Crop	Production	mon. yield	net result	profitability
cucumber	56.2 kg	Dfl 63.67	-Dfl 7.60	89%
lettuce/tomato	26.9 kg	51.10	-Dfl 4.30	92%
eggplant	28.7 kg	71.01	Dfl 2.95	104%
sw.pepper red/green	18.9 kg	80.78	Dfl 12.04	118%
sw.pepper yellow	17.0 kg	69.95	Dfl 1.64	102%
tomato high wire	41.3 kg	73.32	Dfl 2.53	104%
tomato interplanted	39.0 kg	68.97	-Dfl 4.63	94%
beefsteak tomato	42.6 kg	75.04	Dfl 7.49	111%

The differences between the results of the individual holdings are large also within this group. The production in kg and the monetary yield of the holding with the lowest result are 60 to 65% of the holding with the highest result. The average for the whole group is ca 85 to 90% of the holdings with the highest results.

Photosynthetic lighting (P.C.M. Vermeulen)

In co-operation with the Agricultural Economics Research Institute (LEI) and the Research Station for Floriculture (PBN) the economic aspects of photosynthetic lighting were investigated. In spring a calculation model was drawn up with which the annual costs of photosynthetic lighting could be calculated if the lighting duration and intensity were known. For electricity supply a choice could be made between the electric mains and a total energy installation.

In the course of the research it became evident that opinions diverge on the technical starting points of a photosynthetic lighting equipment. Points of discussion were the conversion factor, the reflection of the fittings and the percentage growth light. There is a difference in light production between most favourable and the most unfavourable starting points, and consequently between the number of lamps required for a desired light quantity of over 30%.

Table 13. Annual costs for different electricity prices and light intensities at a lighting duration of 2,800 h per year.

KWh price	Dfl 0.10	Dfl 0.15	Dfl 0.20	Dfl 0.25	Dfl 0.30
costs per m^2 at ... lux (Dfl)					
1500	14.20	17.30	20.30	23.40	26.40
2000	19.00	23.00	27.10	31.20	35.30
2500	23.70	28.80	33.90	38.90	44.00
3000	28.40	34.50	40.60	46.70	52.80
3500	33.10	40.30	47.40	54.50	61.60
4000	37.90	46.00	54.10	62.30	70.40

Depending on the electricity price 50 to 65% of these costs are electricity costs. The most important determining factors are the electricity price, the desired light intensity and consequently the number of lamps per square metre and the number of hours of lighting per year.

It became apparent during the experiment that the expectations of the production increase due to application of artificial lighting are not sufficiently accurate. Yield data will have to point this out. Several realistic options, however, were calculated for tomato, chrysanthemum and freesia, in consultation with crop specialists. In all cases the costs considerably exceed the profits.

Possibilities of flexible substrate systems for leafy vegetables, especially butterhead lettuce (J.C.J. Ammerlaan)

In a working group the technical and cropping aspects of year-round growing of leafy vegetables in a flexible substrate system consisting of gutters were studied. Systems with a concrete floor (ebb-flow), rockwool matting and mobile benches are not economically justified for

the year-round crop of leafy vegetables. The aim of the working group was to quantify the technical and business-organizational consequences of year-round cropping of leafy vegetables, in particular butterhead lettuce, in a flexible substrate system consisting of gutters.
The following procedure was chosen:
1. Conducting literature study of the possibilities of (flexible) substrate systems for butterhead lettuce;
2. Setting up technical and cropping preconditions for the equipment of a holding with year-round production in a flexible substrate system (gutters);
3. Inventory and estimate of the technical and business-organizational consequences of year-round cropping of butterhead lettuce as pilot crop in a flexible substrate system;
4. Evaluation of the information obtained and making recommendations for further research.
The results of the research of the working group will be laid down in a final report at the beginning of 1989. On the basis of this report decisions can be made with respect to the research aimed at the realisation of a flexible system.

MANAGEMENT RESEARCH

Development of an information model for the glasshouse horticulture
(A.A. van der Maas, M.N.A. Ruijs, J.K. Nienhuis and A.T.M. Hendrix)

The Information Model for Glasshouse Horticulture is a systematic description of all activities on an individual glasshouse holding, from the point of view of information supply. Activities, with required and resulting data, are described in a process model. In the data model the data are described in full and their interrelationships are indicated.

The main aims of the information model are:
- uniformizing calculation rules and concepts;
- tuning and integrating existing applications and systems.

In 1986 a global information model was drafted, being the first stage in its development (see Annual Report 1986, p. 77). To achieve the above aims it is necessary to make broadly-based arrangements. These arrangements should be made in the second stage, the so-called specification stage, which was started in 1987 and further elaborated in 1988.

The global model is split up into several parts or clusters, which are worked out separately. For each cluster a working group is formed consisting of experts and an executive team. The latter translates the information obtained from the experts in terms of the model. Apart from the working group each cluster also has a sounding board group consisting of representatives of research, advisory service and industry. Its task is to evaluate the generated results as regards content, including the taking of decisions.

Business management can be divided into planning (tactical and strategic), operational management and control (reporting and evaluation). Operational management includes the production process and the necessary means of production. In 1987 the clusters 'Execution', 'Standards for operational use' and 'Climate control' were worked out. In the course of 1988 the specification of the following clusters was

carried out:
- Inventory/co-ordination. This cluster consists of determination of the cultivational activities and the planning of the space and labour required. Together with the clusters 'Execution' and 'Operational standards' this cluster rounds off the specification of the production process.
- Strategic and tactical planning. This cluster focuses on setting up strategic and tactical plans and employs strategic and tactical standards. This and the above cluster were adjusted to one another so that a connection between the tactical and operational level could be established.
- Personnel management. Organisation of labour on a holding is at the centre of this cluster, in today's terms this is the problem of the staffing in glasshouse horticulture. The information model does not supply direct solutions to this problem, but the results indicate what kind of things enter into proper personnel management. This cluster is part of the means of production.
- Finances. In a project of the Agricultural Economics Research Institute (LEI) and the Association of Accountants and Tax Consultants (VBL) a so-called Branch Transecting Model (TakDoorsnijdend Model, TDM) is being developed which concerns the financial aspects of the business management. This cluster consists of this aspect insomuch as it specifically concerns glasshouse horticulture. Furthermore the management of current means of production is part of this cluster.
- Starting material. This cluster focuses on short-term decisions concerning the acquisition of starting material. In this decision process a purchase plan from the tactical planning is elaborated and, if necessary, modified. The result is a bilateral agreement with a supplier about the delivery of seedlings, etc.

Within the framework of the project 'Information Model Glasshouse Horticulture' 2 students of the Agricultural University in Wageningen conducted a research with the aim to set up a holding characterization and to indicate for each type of holding the need for support by means of (automated) systems. On the basis of the research results priorities for the development of systems can be indicated. Because of the scope of this assignment only a preliminary investigation was carried out.

The specification stage of the 'Information Model Glasshouse Horticulture' will be rounded off in January 1989. The main investigation of the demand for (automated) support of the information supply will be carried out early in 1989.

Development of analytical methods for the processing of business comparison data (J.K. Nienhuis)

The aim of this investigation was to develop simple presentation methods for the analytical results of business comparison data in order to bring discussions, especially among growers during study tours, on a higher level.

In co-operation with the Vegetables Division of the General Advisory Service, and the Department of Horticulture and Glasshouse Climate the project was started early in 1988. All relationships to be investigated were described in consultation with study group supervisors and with representatives of the national business comparison committee. The

periods over which these relationships will be investigated and the requirements the data should meet were also established.

The crop investigated during the year under review was beefsteak tomato. The data analysed produced only a few reliable relationships.

In 1989 the analytical results of the 1988/1989 cropping season will be compared to those of the 1987/1988 season and subsequently the project will be evaluated.

Development of an automated business economic advisory system (BEAG) (M.N.A. Ruijs and P.C.M. Vermeulen)

In the (state) advisory service the development of a business economic advice with the aid of a spreadsheet programme has been given high priority. This resulted in a project plan for a spreadsheet business economic advice for the glasshouse horticulture (BEAG), started in the middle of 1988. This project is managed and co-ordinated by the General Advisory Services for the glasshouse horticulture, and our Department assisted in developing and building the system.

Development of a management advisory system ('Management Advice') (J.K. Nienhuis and M.N.A. Ruijs)

Several years ago the results of the investigations of the Working Group Management Development were applied in a manual advisory system, 'Management Advice', to be used by advisory officers. Due to a number of problems at that time, 'Management Advice' could not be developed further. An automated advisory system might contribute to fulfilling the need for management recommendations.

To investigate the possibilities of an automated system with which an advisory officer could recommend an individual grower how to improve his management, during the year under review a preliminary study was conducted in co-operation with the Agricultural Economics Research Institute (LEI) and a firm specialised in the development of information systems (Pandata). The feasibility of such an automated system was investigated, focusing on functional, organisational, technical and economic aspects. The conclusion was that an automated management advisory system is practicable from technical, organisational and economic points of view. This resulted in a project proposal for a follow-up stage in which the intended system will take shape.

In the follow-up stage in 1989 a number of advisory meetings will be held for the authorities directly involved in advising individual glasshouse growers. During these meetings these authorities will be informed and they will be asked whether a sequel is feasible and whether further realisation will receive support.

ORGANISATION AND WORK STUDIES

Labour research in the beefsteak tomato crop (A.T.M. Hendrix)

Labour data collected during experiments were stored in 'Werkbank', an automated system for data storage. By means of a programme connected to this task times can be calculated with data from the databank. The

storage of the data posed serious problems so that there was no time left for the calculation of task times with the task times programme.

Assessment system for incapacity for work (A.T.M. Hendrix)

For all branches involved (glasshouse vegetables, glasshouse cut flowers, pot plants, flower bulbs and bulb flowers) working method profiles were set up. These are descriptions of how a certain activity is carried out, where it takes place, which appliances are used, which forces should be exerted, which weights are to be lifted, how often and for what length of time the activity should be repeated, etc. On the basis of these descriptions pressure profiles were set up for vegetables, cut flowers and pot plants, indicating the weight of the labour in 38 different aspects.

System development for substrate growing (A.T.M. Hendrix)

In order to be able to compare different substrate systems, mattings, gutters and hoses, in autumn 1988 data were collected of the labour requirement of the termination of the old and the preparations for the new crop in gutters and in hoses. The data have not been processed yet. The impression is, however, that these substrate systems require more labour in the change-over than the crop on rockwool matting.

Workloads on the human locomotor system (A.T.M. Hendrix)

On the basis of an inquiry and the workload profiles a list was composed of the most burdensome activities in the cultivation of low, soil-grown glasshouse vegetable crops with a once-over harvest, such as lettuce and radish. This group of crops was selected on the basis of the impression, which was confirmed by the inquiry, that they involve quite a number of heavy activities. From these activities ca 20 working methods and postures were selected which involve a heavy load on certain parts of the body (back, knees, hands).

After this inventory possible solutions were investigated, in which 4 categories of improvements were involved: change activity, modify working method, improve tools, organisational changes. This stage was not completed by the end of 1988.

7. DEPARTMENT OF PESTS AND DISEASES

N.A.M. van Steekelenburg

VIRUS DISEASES

Pepper yellow vein in sweet pepper (A.T.B. Rast and C.C.M.M. van Veen-Stijger)

The host range of the Olpidium-transmitted disease agent, causing pepper yellow vein (PYV), was further investigated. Inoculations of test plants were done either with resting spores, contained in dried infected root material, or with zoospores from fresh roots of infected sweet pepper plants.

Vegetatively grown freesia and crocus plants did not become infected since the O. brassicae isolate from pepper failed to colonize their roots.

Lettuce proved to be a good host for this O. brassicae isolate and apparently also for the PYV agent. Roots of lettuce, previously inoculated with zoospores from PYV-infected pepper, were used to back-inoculate 26 pepper seedlings with zoospores. All of the inoculated seedlings developed yellow vein symptoms. Similar symptoms appeared in all of the 18 pepper seedlings after they were planted in the soil, in which the lettuce had been grown.

Rooted cuttings grown from the infected lettuce plants after shooting were inoculated with a pepper isolate of O. brassicae, free from virus or any viruslike agent. An experiment to investigate the possible transmission of PYV from the lettuce cuttings to pepper seedlings is in progress. Three O. brassicae isolates of different origin, cultured in the roots of PYV-infected pepper cuttings (see Annual Report 1987, p. 82), were each used to inoculate lettuce seedlings. Although the lettuce roots were profusely colonized by O. brassicae, no symptoms were observed in the leaves.

Sweet pepper seedlings were used to attract O. brassicae in soil samples infected with either the freesia leaf necrosis agent (FLNA) or the lettuce big vein virus (LBVV). An O. brassicae was obtained from each soil sample.

Spread of Olpidium brassicae infected with pepper yellow vein, via the drainage water (W.T. Runia)

In a sweet pepper crop (cv. 'Rumba', planting date 13 July), one of the 4 replicates per treatment was infected with O. brassicae, infected with PYV, by placing one infected sweet pepper plant at the top of the gutter and one halfway down the gutter which contained a total of 12 plants. Symptoms were visible during the entire cropping period until the end of November. In the end 50% of the artificially infected plants showed symptoms of pepper yellow vein. The other plants in all replicates remained symptomless. Microscopic analysis indicated that in all replicates of the treatments resting spores of the fungus were present as well as in the plants outside the experiment. Both the irrigation water and the plant material should be considered as source of infection.

Virus diseases in freesia (C.C.M.M. van Veen-Stijger and A.T.B. Rast)

The search for an intermediate host for Olpidium brassicae, the supposed vector of freesia leaf necrosis, was continued. The O. brassicae found in crocus last year (see Annual Report 1987, p. 81) failed to reinfect freesia. A further search will be conducted among other members of the Iridaceae family.

Tobacco mosaic virus in eggplant (A.T.B. Rast and C.C.M.M. van Veen-Stijger)

Among 100 Solanum melongena accessions of the U.S. plant germplasm collection no resistance was found to the eggplant strain A1 of tobacco mosaic virus.

Tomato spotted wilt virus in tomato (C.C.M.M. van Veen-Stijger)

In an autumn crop of tomato, hitherto unknown virus symptoms were observed. Symptoms were transmitted by sap inoculation to tomato and other test plants.

Electron-microscopical examination revealed isometric virus particles, which were found singly or confined in vesicles and sometimes showed tail-like extrusions. This, together with characteristic lesions developing in mechanically inoculated, detached leaves of Petunia hybrida, enabled identification of the virus with tomato spotted wilt virus.

FUNGAL DISEASES

Epidemiology and biological control of pathogens in substrate crops (N.A.M. van Steekelenburg and M. van der Sar)

This project, started last year (see Annual Report 1987, p. 82-83) with a tomato crop and the fungus Fusarium oxysporum f.sp. radicis-lycopersici as model, was continued. Both in a spring crop and in an autumn crop the pattern of the infection in a drainage rockwool system was compared with that in a closed system in which the nutrient solution was recirculated.

Epidemiology. The plants of the spring crop were inoculated with the pathogen 3 weeks after sowing in rockwool cubes (4 days after potting in rockwool blocks). In the propagation stage no wilting occurred. Five weeks after inoculation, however, the length of the shoot was 13% smaller and the fresh weight 28% lower than of the untreated plants. In the drainage rockwool crop the first wilting occurred 8 weeks after inoculation. Four weeks later all plants were wilted. At that time only 5% of the inoculated plants in the recirculation system was wilted and no subsequent increase occurred. However, inoculated plants showed a growth reduction of ca 10%.

Recirculating the nutrient solution resulted in a spread of the disease. The vascular bundles in the stem base of all non-inoculated plants showed a brown colouring when the experiment was terminated; on all occasions the pathogen could be isolated from them.

In the autumn experiment which was carried out in a similar way, the disease showed a more rapid development. In this experiment also more plants wilted in the recirculation system; 65% of the plants was wilted 12 weeks after inoculation.

In the recirculation water the presence of conidia of Fusarium oxysporum f.sp. radicis-lycopersici could be demonstrated. To this purpose water samples were plated out on a selective agar medium; subsequently the pathogenicity of the Fusarium colonies was tested.

Biological control. In co-operation with the Phytopathological Laboratory in Baarn the effect of the iron chelates DTPA and EDDHA and the application of Pseudomonas bacteria on the development of the disease was studied. The iron chelate was applied in the standard nutrient solution in a concentration of 10 umol Fe per litre. Pseudomonas was applied the first time one week before the Fusarium inoculation and then with intervals of 4 weeks.

In the spring crop no effect was observed of the iron chelate on the Fusarium infection in the drainage rockwool system. The application of Pseudomonas retarded the incidence of wilting with only one week. Eventually the infection was just as serious as in the control treatment.

Likewise in the autumn the iron chelate and the Pseudomonas applications had no effect on the Fusarium infection in the drainage rockwool system. In the recirculation system Pseudomonas reduced the number of wilted plants 12 weeks after inoculation with 37%. Application of EDDHA instead of DTPA had the same result. Additional effects of the iron chelate and Pseudomonas on the infection were not observed.

Powdery mildew (Oidium sp.) on tomato (S.J. Paternotte)

Powdery mildew conidia and dried tomato leaves with powdery mildew were stored for 14 days at 17°C. They were subsequently used to inoculate tomato plants. Simultaneously plants were inoculated by spraying conidia which came directly from infected plant material. Inoculation was done in 2 glasshouses. In one glasshouse water was sprayed in such a way that the plants were wet for most of the time. Assessment after 10 days pointed out that mildew infection was only observed on plants which were sprayed with conidia directly coming from plant material. In the sprayed glasshouse the infection was on average 62 spots per plant, in the other, non-sprayed glasshouse there were on average 38 spots per plant.

In climate cabinets tomato plants were inoculated with mildew by a. spraying a conidial suspension, and b. pressing leaves with mildew infection lightly on healthy leaves. After 5 days mildew infection was observed on plants inoculated according to method b., 3 days later on plants inoculated according to method a.

Effectuating powdery mildew infection on tomato with mildew from various other crops appeared to be impossible.

Fig. 7. Powdery mildew spots on tomato leaves

Botrytis in eggplant (S.J. Paternotte)

In an experiment with eggplant grown on rockwool at different nutrition levels serious Botrytis infection occurred in March in glasshouse compartments with high air humidity levels by day and by night. On average 30% of all young fruits was infected. The nutrition levels in the experiment were 5 K, Ca, and Mg levels of 3.4 to 9.8, 9.0 to 1.5 and 2.3 to 6.6 $mmol.l^{-1}$, respectively, 4 NO_3/SO_4 levels of 25 to 4 and 0.5 to 11 $mmol_1l^{-1}$, respectively, and 3 NO_3/NH_4 levels of 20 to 17 and 0 to 3 $mmol.l^{-1}$, respectively. No effect of the nutrition on the infection could be observed. In compartments with low air humidity during day and night no Botrytis infection could be observed on the fruits.

Phytophthora capsici resistance in hot pepper (S.J. Paternotte)

Three hot pepper cultivars were tested for their resistance against Phytophthora capsici. Six-week old plants were inoculated with 2 isolates of P. capsici. The Capsicum annuum lines CM331 and CM334 were used as resistant control, and the sweet pepper cultivar 'Delphin' as

susceptible control. One pepper cultivar was resistant for 97.5%, one cultivar for ca 50% while one cultivar was susceptible to these 2 isolates.

Control of Botrytis and Rhizoctonia (M. van der Staaij)

Lettuce. The control of Botrytis and Rhizoctonia was carried out with the new chemical compounds mepronil, SchAA 4220, and the biocontrol agents Mycostop (Streptomyces sp.) and MTR-35 (Trichoderma sp.), singly or in combination with thiram and/or iprodione and/or tolclofos-methyl. All treatments were carried out 10 days after planting out. Mycostop and MTR-35 were also applied before planting out as a soil treatment. Before planting no soil disinfestation was carried out so that the infection pressure of the fungus was high. The cropping periods were from December 1987 to March 1988 and from mid-April to mid-May 1988.

In both cropping periods best results were obtained with the standard treatments iprodione 0.2 g a.i. m^{-2} + thiram 0.8 g a.i. m^{-2}, and iprodione 0.2 g a.i. m^{-2} + thiram 0.8 g a.i. m^{-2} + tolclofos-methyl 0.4 g a.i. m^{-2}. Mepronil is effective only against Rhizoctonia and will always have to be combined with agents against Botrytis (iprodione and/or thiram). In both cropping periods the treatments with mepronil 0.3 g a.i. m^{-2} combined with iprodione 0.2 g a.i. m^{-2} + thiram 0.8 g a.i. m^{-2} were just as effective as the standard treatment with tolclofos-methyl. The combinations of mepronil with thiram or with iprodione gave good results but less satisfactory than the standard treatments.

The results with SchAA 4220, a compound effective against Botrytis strains which are less susceptible or resistant to benzimidazoles, in a concentration of 0.25 g a.i. m^{-2} were varying. In winter a small effect of this agent against the fungal complex was observed but in spring this was lost. The combinations of SchAA 4220 with iprodione, with thiram + tolclofos-methyl and with iprodione + tolclofos-methyl showed reasonable to good results, probably caused by the effects of iprodione, thiram and tolclofos-methyl on the infection.

The agents Mycostop and MTR-35 had a small effect in winter but no effect at all in spring. The results were comparable to those with SchAA 4220 alone. The experimental plots with the best control effects also had the highest yields at harvest.

Leafy vegetables. The fungal complex Botrytis/Rhizoctonia was controlled with iprodione, thiram, and tolclofos-methyl, and with combinations of these compounds, in the following leafy vegetable crops: curly endive, lollo rosso, oakleaf lettuce, pakchoy, corn salad, chinese cabbage, with butterhead and iceberg lettuce as control crops. One week after planting out the first treatments were carried out with standard and 50% of the concentrations normally used in commercial lettuce crops. For iprodione this was 0.2 and 0.1 g a.i. m^{-2}, for thiram 0.8 and 0.4 g a.i. m^{-2}, and for tolclofos-methyl 0.2 and 0.1 g a.i. m^{-2}. Two weeks later the 50% concentration was applied for the second time and 3 weeks after planting out the standard concentration was applied for the second time. Half the concentration was applied for the third time 4 weeks after planting out. A single spraying with the standard concentrations one week after planting out appeared to result in a satisfactory protection against the infection in oakleaf lettuce,

lollo rosso, corn salad and curly endive. The results were comparable to those with lettuce. For leafy vegetables with a longer cultivation period such as pakchoy and chinese cabbage repetition of the treatment was necessary.

No clear differences in crop yield were observed between the various treatments. Compared to untreated all treatments resulted in a higher yield. This experiment was joined with residue research experiments, the results of which are recorded below.

Control of Olpidium brassicae in butterhead and iceberg lettuce (M. van der Staaij)

The aim of this experiment was to study the possibilities to control Olpidium brassicae in the roots of lettuce with systemic fungicides to prevent the occurrence of virus problems in butterhead and iceberg lettuce. O. brassicae is the supposed vector of lettuce big vein and ring necrosis in butterhead and iceberg lettuce.

The glasshouse soil was artificially infected with Olpidium brassicae. During the cropping periods 1, 2 or 3 treatments with benomyl, thiophanate-methyl or carbendazim were carried out, in which the agents were watered to the plants. Until now no virus symptoms could be observed, but resting spores were found generally in large numbers in the roots of the plants, irrespective of the treatments.

RESIDUE ANALYSES

Carbendazim in a recirculation system with artificial substrate (W.T. Runia)

The benzimidazole fungicide carbendazim was watered on 6 June to the stem base of eggplants (cv. 'Madonna', planting date 21 March). To each plant 0.03 ml a.i. was applied in 40 ml of nutrient solution. Until 4 weeks after application the harvestable fruits were analysed for residue of this agent. No residue could be found during this period.

Residue research (M. van der Staaij)

Lettuce. The residue pattern of propamocarb was studied in a lettuce crop from December 1987 until March 1988. After planting out fortnightly sprayings with propamocarb (1.5 $l.ha^{-1}$ Previcur N) were carried out for a period of 10 weeks (in this case this was 5 days before harvest). Nine weeks after planting out part of the treatments were sprayed for a second time with propamocarb (1.5 $l.ha^{-1}$ Previcur N). Depending on the growth rate, once per fortnight or once a week a sample of 5 heads was taken from all sprayed plots, the first sample always immediately after spraying as soon as the crop had dried. Results of this experiment will be used to effectuate an allowance of propamocarb in lettuce.

In the same crop a number of treatments with fosetyl-al were carried out. Ten, eleven and twelve weeks after planting out 3 $kg.ha^{-1}$ Aliette was sprayed in ca 2,000 l water per ha. Weekly samples of 5 heads were collected, the first directly after treatment. From the plot sprayed 12 weeks after planting out, daily samples were taken until

harvest. In the samples taken immediately after spraying, residues of fosetyl-al could be measured. After 24 h almost all traces of the compound had disappeared. Fosetyl-al is one of the few fungicides of which the active ingredient cannot be demonstrated anymore after such a short period.

Leafy vegetables. The experiment was carried out with 3 fungicides controlling the fungal complex in butterhead and iceberg lettuce, viz. iprodione, thiram and tolclofos-methyl. These compounds were applied in various concentrations and at different moments during the cropping period. At harvest samples were taken from all plots. The results indicated that in all single treatments the residues found were below the tolerance levels, valid for butterhead and iceberg letuce. In all other treatments the concentrations exceeded these levels.

All residue analyses were carried out by the Central Institute for Nutrition Research (TNO) in Zeist.

PESTS

Thrips (P.M.J. Ramakers and M.H. Cools)

On full-grown cucumbers Western Flower Thrips, Frankliniella occidentalis, was controlled by introduction of the predatory mite Amblyseius barkeri (called A. mckenziei in previous reports). After stabilisation of both populations in July, the average numbers per leaf were found to be: 2.7 thrips adults, 5.2 thrips larvae and 8.1 predators (including 3.1 predator egg). The highest number on one leaf was 31 for the thrips and 50 (including 21 eggs) for the predator. Among some 200 thrips larvae present on the leaves, only 1 was found in the prepupal and 2 in the pupal stage.

All instars of spider mite as well as thrips larvae were accepted as prey by both A. barkeri and A. cucumeris. If offered simultaneously, L_1 of thrips was killed more often than adult spider mites, whereas L_2 of thrips was killed less often than eggs, larvae or protonymphs of spider mite. With the remaining host combinations no clear preference was found.

Large scale introductions of Amblyseius spp. for thrips control were continued on sweet pepper (over 200 ha) and started on cucumber (over 300 ha). Since problems were expected on cucumber, some 2,000 leaf samples were collected from this crop during the season to monitor predator and pest. The intended introduction programme (see Annual Report 1987, pp. 88-89) could not be fulfilled, because a serious outbreak of a microsporidian disease nearly wiped out the massrearing of predators. Therefore a final evaluation of this cucumber project is not possible yet. The monitoring indicated that usually the predators established, but that numbers were lower than desirable. From May onwards higher densities were observed, but often in combination with an already unacceptable thrips attack. Many growers, on the other hand, did not need additional chemical control, especially in those areas where the native Thrips tabaci rather than F. occidentalis is the predominant pest species.

Whitefly (P.M.J. Ramakers and A. van der Linden)

In order to avoid the difficulty of chemical control of WFT (see under 'Thrips'), more than 300 cucumber growers attempted biocontrol of 3 main pests (spider mite, thrips and whitefly) simultaneously. Introduction of Encarsia formosa against whitefly was started preventively and continued until sufficient black scales were found on the plants. In the present circumstances (low initial density of whiteflies, availability of selective chemicals) biocontrol of whitefly was found very dependable.

Aphids (P.M.J. Ramakers)

Cocoons of the aphid predator Aphidoletes aphidimyza were introduced to control Aphis gossypii on cucumber. Additionally, cyanid gas was used once when most predators of the first generation had left the plants for pupation. The predator completed several generations and reached a high density, but could not prevent destruction of the plants by the aphids.

Spider mite (A. van der Linden)

Control of spider mite, Tetranychus urticae, on tomato tends to become more difficult. Since the predatory mite Phytoseiulus persimilis is not well adapted to this crop, interest in other mite predators, such as the Coccinellid Stethorus punctillum and the Cecidomyiid Therodiplosis persicae, is reviving. The predatory thrips Scolothrips longicornis was obtained from Prof. Segonca in Bonn. The predator was reared on Phaseolus lunatus with spider mites, but failed to establish on tomatoes with the same host.

Leafminers (A. van der Linden)

Parasitized pupae of leafminers were stored at 5 - 7^{o}C. After 6 months the Eulophid Chrysocharis oscinidis (called C. parksi in previous reports) hatched in similar rates as from fresh pupae, and a part of the population even survived 76 weeks of storage. The Braconid Opius pallipes hatched in varying numbers after 6 months, and none survived a storage period of more than 40 weeks.

Control of spider mite (M. van der Staaij)

In semi-laboratory trials the effect of PH 70-23 on larvae and eggs of spider mite (Tetranychus urticae/cinnabarinus) was studied. On both the eggs and the larvae 7 concentrations (ranging from 0.16% to 0.0025% formulated compound) were sprayed. After 4 and 7 days the condition of the larvae and after 11 days that of the eggs was evaluated.

The results were satisfactory. With all concentrations the mortality of the larvae was more than 90% whilst with untreated it was 3.5%. The percentage of unhatched (dead) eggs and dead larvae of the sprayed eggs was also higher than 90%, except with the lowest concentration where it was 86.8% (untreated 1.1% mortality)

Control of whitefly (M. van der Staaij)

Four insecticides were tested for their effectivity against various stages of whitefly larvae and pupae (Trialeurodes vaporariorum). Each compound was sprayed on the 1st, 2nd, 3rd and 4th larval stage and the pupal stage. The assessment of the results was carried out at the moment that nearly all pupae on the untreated plants were hatched. In the assessment all unhatched and hatched pupae and dead larvae were counted. Teflubenzuron (150 mg a.i. l^{-1}) was only effective in the 1st and 2nd larval stage. On the bigger stages and the pupae no effect at all could be observed. EI 3324 (150 mg a.i. l^{-1}) was very effective on all larval stages. Even on the pupae this agent had a reasonable to good effect. SBO 86120 (125 mg a.i. l^{-1}) was very effective on the young larval stages but had no effect at all on the 4th stage and the pupae. The effectiveness of SBO 8670 (50 mg a.i. l^{-1}) on the 1st and 2nd larval stage was reasonable, there was also some effect against the 3rd stage but no effect at all against the 4th larval stage and the pupae.

The susceptibility of predatory mites to pesticides (M. van der Staaij)

Phytoseiulus persimilis. In a semi-laboratory experiment PH 70-23 was tested for possible side-effects on Phytoseiulus persimilis. A mixed population of mature mites, larvae and eggs was sprayed with 7 concentrations (ranging from 0.04% to 0.000625% formulated compound). Two days after the treatment the first assessment took place, 4 days later the second. In this experiment no adverse effects of PH 70-23 on P. persimilis could be observed.

Amblyseius species. In semi-laboratory trials the insecticide heptenophos and the fungicide imazalil were tested for possible side-effects on Amblyseius mckenziei (barkeri). Both compounds were sprayed in 7 concentrations and compared to an untreated control. Imazalil had no adverse effects on A. mckenziei. This was also the case with heptenophos but this compound had an extremely adverse effect on A. cucumeris. The concentration of heptenophos applied in commercial practice is 250 mg a.i. l^{-1}, the LD50 for A. mckenziei is at ca 1,000 mg a.i. l^{-1}, and for A. cucumeris at ca 8 mg a.i. l^{-1}.

In semi-laboratory trials the possible vapour effect of Thripstick and cypermethrin, sprayed on plastic film, on Amblyseius cucumeris was studied. In none of the experiments an adverse effect on the predatory mites could be observed. Even with high concentrations of cypermethrin the mortality was the same as in the untreated control. These results correspond with those of the experiment with Phytoseiulus persimilis carried out in 1987. The results obtained warrant the conclusion that when no Thripstick with cypermethrin is observed on the plants, problems with the predatory mites Amblyseius cucumeris and Phytoseiulus persimilis are not to be expected, because cypermethrin sprayed on the plants had very harmful consequences for these mites.

Disinfestation of the drainage water in recirculating substrate systems (W.T. Runia)

Ozone. A water treatment machine producing 6 g $O_3.h^{-1}$ was tested for

its disinfecting capacity. The ozone was created by leading air oxygen through a high voltage electrical discharge. In a closed tank with 900 l nutrient solution an unpurified suspension of the cucumber green mottle mosaic virus was added in a 1:1,000 dilution. After 80 minutes of ozone treatment the virus had lost its infectivity. Fe-EDTA was lightly broken down by ozone and Mn moderately. The other elements were not oxidized by ozone.

Ultrafiltration. Three types of hollow-fibre membranes (PM10, PM50, GM80) were tested for their dividing/separating capacity. All membranes filtered purified tobacco mosaic virus, present in a 1:1,000 dilution, out of the nutrient solution.

Behaviour and emission of pesticides in a recirculating and in a non-recirculating substrate system (W.T. Runia)

This experiment was carried out as a joint project with the Institute for Pesticide Research in Wageningen. In a tomato crop (cv. 'Dombito', planting date 23 March) on rockwool slabs ca 10 ppm oxamyl was added to the nutrient solution in the storage tank on 18 April and 5 September. In the non-recirculation system the nutrient solution draining from the rockwool slabs was drained off after sampling and volume determination; in the recirculation system it was poured back into the storage tank. The experiment resulted in the following conclusions:
- oxamyl is not broken down in the storage tank at a pH of 5-6;
- in a non-recirculation system oxamyl can leach out;
- in a recirculation system oxamyl remains demonstrable longer than in a non-recirculation system;
- the concentration of oxamyl in the rockwool slabs may be higher than the concentration applied because the roots can take up only part of the oxamyl from the nutrient solution due to the polarity of this compound;
- some adsorption of oxamyl takes place in the rockwool slab, none on the polythene film.

8. PUBLICATIONS

TRADE PRESS ARTICLES

All articles are in Dutch. An English translation of the title is given between brackets

- Bakker, J.C., and J. Janse, 1988. Lage etmaaltemperatuur geeft meer kans op zwelscheuren bij tomaat (Low 24-h temperature increases the risk of swelling cracks in tomato). Groenten en Fruit 43 (34) : 30-31

- Bakker, J.C., 1988. Ventilatie beter te regelen door ventilatievoud (Improvement of ventilation control by air exchange rate). Vakblad voor de Bloemisterij 43 (10) : 48-49

- Bakker, J.C., 1988. Onderzoek luchtvochtigheid bij aubergine : gematigd niveau optimaal voor produktie en kwaliteit (Air humidity experiments with eggplant : moderate level optimum for yield and quality). Tuinderij 69 (24) : 16-17

- Bakker, J.C., 1988. Verbeterde temperatuurregeling kan energiebesparing opleveren (Improved temperature control may result in energy saving). Groenten en Fruit 44 (22) : 34-35

- Bayense, B., I. Smeets, K. Buitelaar and R. Maaswinkel, 1988. Nieuwe produkten bieden consument meer variatie (New vegetable crops provide consumers with a more diversified supply). Groenten en Fruit 44 (26) : 52-55

- Bos, A.C. van den, 1988. Meer inzicht in vochtverloop substraat door pF-curve (pF curve improves insight into the moisture pattern of substrate). Vakblad voor de Bloemisterij 43 (4) : 149

- Buitelaar, K., 1988. Effect van voedingstoestand op produktie en kwaliteit van cherry-tomaten (How the nutrient condition affects yield and quality of cherry tomatoes). Groenten en Fruit 43 (26) : 22-23

- Buitelaar, K., 1988. Is stamtrillen een volwaardig alternatief voor trostrillen ? (Is stem vibration a satisfactory alternative to truss vibration ?). Groenten en Fruit 43 (27) : 35-36

- Buitelaar, K., 1988. Plantafstanden bij Ogenmeloen. Nauwer planten niet gauw rendabel (Planting distance experiments with Ogen melon indicate that higher plant density is not easily profitable). Tuinderij 68 (5) : 20-21

- Buitelaar, K., 1988. Suikergehalte meloen : zon is niet de enige smaakmaker (Sugar content of muskmelon : sun is not the only determinant factor for flavour). Tuinderij 68 (16) : 14-15

- Buitelaar, K., 1988. Onderzoek cherrytomaten. Rassen en plantafstanden bepalen opbrengst (Experiments with cherry tomatoes :

cultivars and plant distance determine yield). Tuinderij 68 (20) : 53

- Buitelaar, K., 1988. Tomaat : Fusarium voetziekte door enten de baas blijven (Keeping Fusarium foot rot in tomato under control by grafting). Groenten en Fruit 44 (18) : 41

- Buitelaar, K., 1988. Chinese kool : datum uitplanten bepaalt aantal stuks per m^2 (Chinese cabbage : planting date determines yield per m^2). Groenten en Fruit 44 (23) : 37

- Buitelaar, K., 1988. Rassenonderzoek Charentais meloen : vroege vrucht met weinig smaak (Cultivar trials with Charentais muskmelon : early fruits with little flavour). Tuinderij 69 (25) : 31

- Burg, A. van der, and R. Bergsma, 1988. Waterafgifte druppelaars zelf meten : resultaat geeft inzicht in vervuiling (Measure water release of drippers yourself : the result gives insight into clogging). Tuinderij 68 (22) : 18-19

- Burg, A. van der, and C. Sonneveld, 1988. Vochtigheid van steenwolmat : gebruikte matten blijven droger (Humidity of rockwool slabs : used matting remains drier). Tuinderij 68 (20) : 19

- Burg, A.M.M. van der, 1988. Drogere steenwolmat door tijdelijk geen water toe te dienen (Drier rockwool slab by temporarily interrupting water supply). Vakblad voor de Bloemisterij 43 (39) : 31

- Burg, A. van der, 1988. Wat zijn acceptabele natrium- en chloorgehalten bij paprika? (Which sodium and chloride levels are acceptable in the sweet pepper crop). Groenten en Fruit 43 (28) : 36-37

- Burg, A.M.M. van der, 1988. Druppelaars blijven gevoelig voor verstopt raken (Drippers remain susceptible to blockage). Vakblad voor de Bloemisterij 43 (29) : 52-53

- Burg, A.M.M. van der, 1988. Capillair meest gevoelig voor verstopping (Dripper 'Capillair' most susceptible to blockage). Groenten en Fruit 44 (4) : 26-27

- Cools, M.H., 1988. Andijvierassen winterteelt. Breedblad Volhart Winter favoriet (Endive cultivars for the winter crop : Breedblad Volhart Winter gives best results). Groenten en Fruit 44 (7) : 36-37

- Cools, M.H., 1988. Vicky en Carlos voor winterteelt sla een welkome uitbreiding (Vicky and Carlos welcome addition to winter lettuce cultivars). Groenten en Fruit 44 (7) : 42-43

- Cools, M.H., and A.B. Jansen, 1988. Nieuwe komkommerrassen voor de hetelucht- en koude teelt (New cucumber cultivars for the warm air and cold crop). Tuinderij 68 (3) : 44-45

- Cools, M.H., and A.B. Jansen, 1988. Drie nieuwe rassen voor koude tomatenteelt (Three new cultivars for the cold tomato crop). Groenten en Fruit 43 (33) : 34-35

- Cools, M.H., and A.B. Jansen, 1988. Grote keus bij tomatenrassen voor tussenplanting (A wide range of tomato cultivars for interplanting). Groenten en Fruit 43 (34) : 28-29

- Cools, M.H., and A.B. Jansen, 1988. Komkommerrassen hetelucht- en koude teelt: enkele nieuwe rassen bieden perspectief (Cucumber cultivars for the warm-air heated and cold crop: several new cultivars offer perspective). Groenten en Fruit 43 (29) : 52-53

- Cools, M.H., 1988. Nieuwe gele paprika dient zich aan (New yellow sweet pepper introduces itself). Groenten en Fruit 43 (41) : 35

- Cools, M.H., 1988. Rassen vroege herfstteelt : Concurrentie voor Sitonia (Lettuce cultivars for the early autumn crop : competition for Sitonia). Tuinderij 68 (15) : 20

- Cools, M.H., 1988. Slarassen herfstteelt : Ruime keus als resistentie tegen witfysio 15 niet vereist is (Lettuce cultivars for the autumn crop : ample choice if resistance to powdery mildew race 15 is not required). Groenten en Fruit 44 (6) : 32-33

- Cools, M.H., 1988. Andijvierassen herfstteelt : 'Nummer Vijf' is niet nummer één (Endive cultivars for the autumn crop : 'Nummer Vijf' is not number one). Groenten en Fruit 44 (4) : 28-29

- Dorst, H.J.M. van, 1988. Herkennen en bestrijden van virussen en viroide bij komkommer (Recognition and control of viruses and viroids in cucumber). Tuinderij 68 (7) : 27-29

- Gelder, A. de, and A.P. van der Hoeven, 1988. Gebruikswaarde-onderzoek chrysant. Rassen anders bekeken (Utility value research of chrysanthemum. A different view of cultivars). Vakblad voor de Bloemisterij 43 (32) : 33

- Gelder, A. de, and C. Heidemans, 1988. Verbanden tussen lengte, gewicht, aantal bladeren en bladoppervlakte (Relationships between length, weight, number of leaves and leaf area of chrysanthemum). Vakblad voor de Bloemisterij 43 (32) : 40-41

- Gelder, A. de, C. Heidemans and M.G. Hoogeveen, 1988. Resultaten gebruikswaarde-onderzoek : grote verschillen in houdbaarheid nieuwe freesia-rassen (Results of utility value research : great differences in keeping quality of new freesia cultivars). Vakblad voor de Bloemisterij 43 (46) : 41-45

- Gelder, A. de, and M.G. Hoogeveen, 1988. Gebruikswaarde-onderzoek chrysant. Houdbaarheid sterk afhankelijk van behandeling (Utility value research of chrysanthemum: keeping quality strongly dependent on handling). Vakblad voor de Bloemisterij 43 (32) : 39

- Goor, B.J. van, 1988. Complexvorming beinvloedt opname voedingselementen (Complex formation influences uptake of nutrient elements). Vakblad voor de Bloemisterij 43 (28) : 41

- Goor, B.J. van, 1988. Organische stoffen hebben invloed op opname voedingselementen (Organic compounds influence the uptake of nutrient elements). Groenten en Fruit 44 (4) : 30

- Goor, B.J. van, 1988. Gebreksverschijnselen in planten : transport van voedingsstoffen geeft doorslag (Deficiency symptoms in plants: transport of nutrients is decisive). Tuinderij 69 (25) : 16-17

- Graaf, R. de, 1988. Watergeefrekenmodel en continue niveaumeting (Water supply calculation model and continuous level measurement). Tuinderij 67 (2) : 42-44

- Graaf, R. de, 1988. Niveaumeting en watergeefrekenmodel. Automatisering watergift vindt steeds meer opgang (Level measurement and water supply calculation model: automation of the water supply is on the increase). Vakblad voor de Bloemisterij 43 (29)

- Graaf, R. de, and A.J. Arendzen, 1988. Silometer : nieuwe methode om hoeveelheid drainwater te meten (Silometer : a new method to measure the amount of drainage water). Groenten en Fruit 43 (35) : 37

- Heidemans, C., and A. de Gelder, 1988. Onderzoek herfstbloeiende Freesia : vijftien rassen positief bevonden (Experiments with autumn flowering freesia : fifteen cultivars showed positive results). Vakblad voor de Bloemisterij 43 (27) : 42-45

- Heidemans, C., A.P. van der Hoeven and A. de Gelder, 1988. Temperatuur- en onderbrekingsproef toont rasverschillen (Temperature and interruption experiment showed differences in chrysanthemum cultivars). Vakblad voor de Bloemisterij 43 (32) : 34-37

- Heij, G., 1988. Radijs en substraat : een overenigbare combinatie? (Radish and artificial substrate : an impossible combination?). Groenten en Fruit 44 (9) : 36-37

- Heij, G., 1988. Radijs : kwaliteit beinvloeden tijdens de teelt (Influence the quality of radish during the cropping period). Groenten en Fruit 44 (20) : 44

- Heij, G., 1988. Fotosynthese bij radijs : CO_2 doseren levert vervroeging op (Photosynthesis of radish : CO_2 enrichment results in advancement). Tuinderij 69 (24) : 18-19

- Hendrix, A.T.M., 1988. Mentale belasting in de glastuinbouw valt mee (Mental stress in glasshouse horticulture not so bad as expected). De Landbode 43 (5) : 29

- Hendrix, A.T.M., 1988. Transport- en handlingskosten drukken : vollere stapelwagens vragen aangepaste werkwijze (Reducing transportation and handling costs : fuller stacking carts require

adjusted working method). Vakblad voor de Bloemisterij 43 (8) : 58-59

- Hendrix, A.T.M., 1988. Arbeidsomstandigheden komkommerteelt voor verbetering vatbaar (Labour conditions in cucumber crop can be improved). Groenten en Fruit 43 (35) : 30-31

- Hendrix, A.T.M., 1987. Bedrijfskundige aspecten van teelt- en transportsystemen bij komkommers (Management aspects of cropping and transportation systems for cucumber). Wageningen, Institute for Agricultural Engineering, Publication 220

- Hendrix, A.T.M., 1988. Arbeidsomstandigheden voor verbetering vatbaar : betere werkhouding geeft meer arbeidsvreugde (Labour conditions can be improved : a better working posture increases job satisfaction). Tuinderij 68 (22) : 26-28

- Hendrix, A.T.M., 1988. Medische Dienst doet meer dan vaststellen arbeidsongeschiktheid (Medical Service involves more than just diagnosing incapacity for work). Groenten en Fruit 44 (18) : 50-51

- Hendrix, A.T.M., 1988. Belastingprofielen veelzijdig toepasbaar : arbeidsongeschiktheid afhankelijk van afname verdiencapaciteit (Stress profiles have a wide range of applications : incapacity for work depends on reduction of earning capacity). Vakblad voor de Bloemisterij 43 (48) : 68-69

- Hoeven, A.P. van der, 1988. Mogelijkheden chrysantenteelt op voedingsfilm opnieuw in onderzoek (Renewed research of growing chrysanthemums on nutrient film). Vakblad voor de Bloemisterij 43 (13) : 48-49

- Hoeven, A.P. van der, and E. Nederhoff, 1988. Assimilatiebelichting : snellere groei en steviger tak bij belichte chrysant (Artificial lighting : more rapid growth and firmer stem in lit chrysanthemum). Vakblad voor de Bloemisterij 43 (40) : 43

- Holsteijn, G.P.A. van, 1988. Schermen in de zomer : bij zonnig weer koelere vruchten en minder verdamping (Screening in the summer period: in sunny weather cooler fruits and less transpiration). Groenten en Fruit 43 (40) : 28-29

- Holsteijn, G.P.A. van, 1988. Lichtdoorlatendheid belangrijk criterium bij keuze scherm (Light transmissivity is an important criterion when selecting a thermal screen). Vakblad voor de Bloemisterij 43 (48) : 50-51

- Holsteijn, G.P.A. van, and C.P.G. Zuidgeest, 1988. Meetnauwkeurigheid moet en kan beter (Measuring accuracy can and must be improved). Groenten en Fruit 44 (24) : 30-31

- Janse, J., 1988. Teeltmaatregelen en kwaliteit bij tomaat : het mag niet alleen om produktie draaien (Cropping measures and the keeping quality of tomato : yield should not be the be-all and end-all). Tuinderij 68 (1) : 22-23

- Janse, J., 1988. In de winter scherper smakende radijs gewenst (In winter a spicier taste of radish is called for). Groenten en Fruit 43 (28) : 29-30

- Janse, J., 1988. Teeltmaatregelen en kwaliteit bij komkommers : Grotere instraling werkt gunstig op kwaliteit (Cropping measures and the quality of cucumber: positive effect of irradiation on quality). Tuinderij 68 (3) : 30-32

- Janse, J., 1988. Teeltmaatregelen en kwaliteit bij paprika's : tegengestelde reacties vragen om weloverwogen instellingen (Cropping measures and the quality of sweet pepper: contrasting responses require well-balanced setpoints). Tuinderij 68 (4) : 22-23

- Janse, J., 1988. Maatregelen en kwaliteit bij sla : teeltgericht ingrijpen beperkt rot in handelskanaal (Cropping measures and the quality of lettuce: taking measures in time reduces rot in trade channel). Tuinderij 68 (5) : 18-19

- Janse, J., 1988. Kleine gewassen : teeltmaatregelen en kwaliteit : werken aan verdere verbetering (Cropping measures and the quality of minor crops: working on further improvement). Tuinderij 68 (7) : 18-20

- Janse, J., 1988. Goudspikkels bij tomaat : een oplosbaar probleem (Gold specks in tomato : a solvable problem). Groenten en Fruit 43 (39) : 30-31

- Janse, J., 1988. Schermen in de zomer : tomaten minder bont en langer houdbaar (Screening in the summer results in less variegation and improved keeping quality of tomatoes). Groenten en Fruit 43 (40) : 36-36

- Klapwijk, D., 1988. Proeven met Anthurium andreanum. Meer licht geeft hele jaar snellere produktie (Experiments with Anthurium andreanum: more light results in earlier production throughout the year). Vakblad voor de Bloemisterij 43 (1) : 54-55

- Klapwijk, D., 1988. Een kas kan niet te dicht zijn! (A glasshouse cannot be airtight enough!) Tuinderij 67 (2) : 24-25

- Klapwijk, D., 1988. Plantgrootte paprika beinvloedt vroege produktie, maar manier van telen is belangrijker (Plant size affects early yield of sweet pepper, but cropping method is more important). Groenten en Fruit 43 (48) : 30-31

- Klapwijk, D., 1988. Sterke wisselingen in wekelijkse produktie paprika (Strong fluctuations in weekly production of sweet pepper). Groenten en Fruit 43 (48) : 32-33

- Klapwijk, D., 1988. Alternatieven voor steenwol (Alternatives for rockwool). Vakblad voor de Bloemisterij 43 (28) : 58-59

- Klapwijk, D., 1988. Substraatteelt evalueert. Eindfase nog niet

bereikt (Evolutions in substrate growing: end stage not reached yet). Groenten en Fruit 44 (12) : 58-59

- Klapwijk, D., 1988. Wortelgroei en produktie : geen heldere relatie (Root growth and production : no unambiguous relationship). Groenten en Fruit 44 (16) : 46-47

- Klapwijk, D., and F. Wubben, 1988. Wortelonderzoek tomaat : verwachte groeistimulans door wortelsnoei blijft uit (Root research of tomato : expected growth impulse by root pruning fails to materialize). Groenten en Fruit 44 (16) : 48-49

- Klapwijk, D., 1988. De software van tomaat : ontwikkeling bloem blijft boeiend (The software of tomato : flower development remains fascinating). Tuinderij 68 (22) : 44-47

- Klapwijk, D., 1988. De software van tomaat : sturing van het groeipunt (The software of tomato : control of the growing point). Tuinderij 68 (23) ; 14-17

- Koning, A.N.M. de, 1988. Groei en plantbelasting bij tomaat (Growth and plant load of tomato). Groenten en Fruit 43 (27) : 32-33

- Koning, A.N.M. de, 1988. Schermen in de zomer : 'een procent minder licht kost een procent produktie' gaat niet altijd op (Screening in summer : 'one percent less light costs one percent yield' does not always work). Groenten en Fruit 43 (40) : 32-33

- Maas, A.A. van der, and G.R.N.M. Selman, 1988. Goed management steunt op juiste en relevante bedrijfsgegevens (Good management is based on correct and relevant business data). Vakblad voor de Bloemisterij 43 (46) : 60-61

- Maaswinkel, R.H.M., and H.G.M. Sonneveld-van Buchem, 1988. Kelkverdroging bij aubergine voorlopig nog met scherm tot minimum beperken (For the time being calyx browning can be restricted to the minimum by screening). Groenten en Fruit 43 (28) : 35

- Maaswinkel, R.H.M., 1988. Krulandijvie heeft mogelijkheden, maar dan vooral in het voorjaar (Curly endive offers perspectives, but mainly in spring). Groenten en Fruit 44 (6) : 30-31

- Maaswinkel, R.H.M., 1988. Slaplanten koelen kan onder bepaalde voorwaarden (Under certain conditions, cooling lettuce plants is possible). Groenten en Fruit 44 (6) : 24

- Maaswinkel, R.H.M., 1988. Rand beteugelen met kalksalpeter : lage concentratie heeft voorkeur (Restricting tipburn with calcium nitrate: low concentration is preferred). Tuinderij 68 (17) : 27

- Maaswinkel, R.H.M., 1988. Bolrot in ijsbergsla : streef naar hoge EC en kleine verschillen in temperatuur (Headrot in iceberg lettuce: aim at high EC and small temperature differences). Tuinderij 68 (19): 41

- Maaswinkel, R.H.M., 1988. Effect van licht op roodkleuring lollo rosso. Gewenste kleur kost wel erg veel geld (Effect of light on red colouring of lollo rosso: desired colour costs a lot of money). Tuinderij 68 (19) : 38-39

- Maaswinkel, R.H.M., 1988. Aubergine : geringe verdamping beperkt kans op kelkverdroging (Eggplant : low transpiration reduces the risk of calyx browning). Groenten en Fruit 44 (22) : 39

- Nederhoff, E.M., and Th. Roelofs, 1988. Problemen door assimilatiebelichting bij buurman (Problems with neighbour's photosynthetic lighting). Groenten en Fruit 43 (34) : 39-40

- Nederhoff, E.M., 1988. Oorzaak negatief effect van assimilatiebelichting op naburig gewas (The cause of the adverse effect of photosynthetic lighting on neighbouring crop). Groenten en Fruit 43 (34) : 41

- Nederhoff, E.M., 1988. Schermen sluit schade belichting buurman buiten (Screening excludes damage by artificial lighting of neighbour). Vakblad voor de Bloemisterij 43 (10) : 54-57

- Nederhoff, E.M., 1988. Assimilatiebelichting (1). Hoeveel extra licht op het gewas? (Photosynthetic lighting (1): how much extra light on the crop?). Groenten en Fruit 44 (6) : 26-27

- Nederhoff, E.M., and H. Gijzen, 1988. Assimilatiebelichting (2). Bijdrage belichten aan versnellen groei en hogere produktie (Photosynthetic lighting (2): Contribution of lighting to accelerated growth and higher yield). Groenten en Fruit 44 (6) : 28-31

- Nederhoff, E.M., 1988. Grootheden en begrippen. Voor lichtbehoefte natuurlijk en kunstmatig licht vergelijken (Quantities and concepts: For light requirement compare natural and artificial light). Vakblad voor de Bloemisterij 43 (40) : 30-33

- Nederhoff, E.M., and H. Gijzen, 1988. Groeistimulans in donkere periode. Met simulatiemodel bijdrage kunstlicht berekend (Growth impulse in dark period: simulation model calculates the contribution of artificial light). Vakblad voor de Bloemisterij 43 (40) : 34-37

- Nienhuis, J.K., and A. Ammerlaan, 1988. Het voortbestaan van heteluchtbedrijven (The survival of warm-air heated nurseries). Tuinderij 67 (2) : 34-36

- Nienhuis, J.K., 1988. Wat levert ontsmetten drainwater op? (The profitability of drainwater disinfestation). Groenten en Fruit 43 (51) : 28-29

- Nienhuis, J.K., 1988. Knelpunten bedrijfsvergelijking. Niet alle deelnemers op een lijn (Bottlenecks in business comparison: not all participants on the same wavelength). Groenten en Fruit 44 (13) : 33

- Nienhuis, J.K., 1988. Kosten van substraatsystemen. Schoner milieu

gaat ons geld kosten (Costs of substrate systems: cleaner environment will cost us money). Tuinderij 68 (20) : 50-51

- Nienhuis, J.K., 1988. Thermisch ontsmetten drainwater alleen voor grote bedrijven voordelig (Thermal disinfestation of drainwater profitable only for large holdings). Vakblad voor de Bloemisterij 43 (39) : 38-39

- Nienhuis, J.K., 1988. Eisen aan bedrijfsregistratie : gegevens moeten betrouwbaar en vergelijkbaar zijn (Business registration requirements: data should be reliable and comparable). Vakblad voor de Bloemisterij 43 (49) : 65

- Ramakers, P., and A. van der Linden, 1988. Biologische bestrijding bij de drie hoofdgewassen (Biocontrol in the three main crops). Tuinderij 67 (2) : 56-58

- Ravestijn, W. van, and L. Nederpel, 1988. Trostrillers in Belgie aan de kant : hommels doen het werk (Truss vibrators in Belgium can be put aside : bumblebees do the job). Groenten en Fruit 43 (32) : 38-41

- Ravestijn, W. van, 1988. Ethrel kan bonte vruchten aan einde teelt rood kleuren (Ethrel may improve red colouring of variegated fruits at the end of the cropping period). Groenten en Fruit 44 (13) : 32

- Ravestijn, W. van, 1988. Bloemaanleg en vruchtzetting bij paprika : echt verbeteren van zetting valt niet mee (Flower initiation and fruit set of sweet pepper: obstacles for real improvement). Tuinderij 69 (24) : 28-31

- Runia, W.Th., 1988. Steenwol matten in goot of volvelds stomen : denk om stoomduur (Steaming of rockwool slabs in gutter or directly on soil: keep length of steaming period in mind). Groenten en Fruit 43 (50) : 33

- Runia, W. Th., 1988. Ontsmetting drainwater in recirculerende systemen : milieubewust en economisch verantwoord omspringen met water (Disinfestation of drainwater in recirculation systems: handling water from economic and environmentally justified point of view). Tuinderij 68 (22) : 38-39

- Runia, W.Th., 1988. Verhitten ultrafiltratie en ozonisatie. Methoden ontsmetten drainwater voor hergebruik getest (Heating, ultrafiltration and ozonisation: different methods of drainwater disinfestation for re-use tested). Vakblad voor de Bloemisterij 43 (51/52) : 116-117

- Selman, G.R.N.M., A. van der Maas and E. van Rijssel, 1988. Hoe geregistreerde gegevens verwerken en gebruiken? (How to process and use recorded data?) Groenten en Fruit 43 (31) : 22-23

- Simonse, M.P., and J.A.M. van Uffelen, 1988. Komkommer : dichloorvos tijdens opkweek : kiezen voor minst kwade oplossing

(Dichlorvos during cucumber raising : select the least evil solution). Groenten en Fruit 44 (18) : 45

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