Proefstation voor Bloemisterij en Glasgroente
Vestiging Aalsmeer
Linnaeuslaan 2a, 1431 JV Aalsmeer
Tel. 0297-352525, fax 0297-352270

ISSN 1385 - 3015

PROCEEDINGS ROSE-SEMINAR

(NOVEMBER 2ND 1999)

RESEARCH STATION
FOR FLORICULTURE AND GLASSHOUSE VEGETABLES

J. de Hoog
F. Buwalda
A.J. Dik
J.J. Fransen
N. Marissen
Aalsmeer, november 1999
Rapport 225
Prijs *ƒ* 20,00

Rapport 225 wordt u toegestuurd na storting van *ƒ* 20,00 op banknummer 300 177 976 ten name van Proefstation Aalsmeer onder vermelding van 'Rapport 225, 'Proceedings Rose-Seminar'.

Programme ROSE-seminar

November 2nd, 1999 (during the International Hortifair), Research Station for Floriculture & Glasshouse Vegetables, Linnaeuslaan 2a, 1431 JV Aalsmeer. The Netherlands

9.30 –10.00 a.m.	Registration, coffee	Meeting-room
10.00 a.m.	Welcoming by Dr. Ir. H. van Holsteijn, Director	Auditorium
10.05-10.35 a.m.	Effects of temperature on growth and development of Roses, Dr. F. Buwalda	Auditorium

The effects of day- and night temperature and temperature integration on production and quality of Roses will be reviewed.

10.35-10.55 a.m.	Influence of (supplementary)light and CO_2 on growth and development of Roses, Ing. J. de Hoog	Auditorium

Results of recent research will be presented. In this trial four CO_2 concentrations were combined with 2 light levels.

10.55-11.10 a.m.	Discussion	
11.10-11.30 a.m.	Coffee break	Meeting-room
11.30-12.15 a.m.	Pre- and post-harvest factors influencing post harvest quality of Roses, Dr. N. Marissen	Auditorium

Besides the choice for a certain variety it is important for the Grower to know what to do and what not, to ascertain a maximum vase life and bud opening at the consumers. Effects of pre-harvest climate conditions as well as transport stress, bacteria, *Botrytis* and various pre-treatments are discussed.

12.15-12.30 p.m.	Discussion	
12.30-13.30 p.m.	Lunch	Meeting-room
13.30-14.00 p.m.	Integrated control of powdery mildew and *Botrytis*, Dr. A.J. Dik	Auditorium

The possibilities of integrated control of powdery mildew by variety choice and foliar application of salts solutions, plant extracts and biological control agents will be discussed. Results of research on control of *Botrytis* in the post-harvest stage by salts and biological control agents will be shown.

14.00-14.30 p.m.	Integrated pest management, Dr.Ir. J.J. Fransen	Auditorium

Good control of pests can be carried out by integrating different activities such as scouting, sanitation and instruction of workers, with the application of chemical and biological control. Western Flower Thrips in particular is a global problem and drawbacks and perspectives in control of this pest are discussed in more detail.

14.30-14.45 p.m.	Discussion	
14.45-15.00 p.m.	Coffee / Tea break	Meeting-room
15.00-15.45 p.m.	Influence of harvesting method, planting distance and bending on production and quality of Roses, Ing. J. de Hoog	Auditorium

Production techniques have changed quite rapidly in the last decade. By means of specialised cultivation techniques it appears to be possible to choose for quality or quantity.

15.45-16.00 p.m.	Discussion	
16.00-16.45 p.m.	Visit to experimental greenhouses of the Research station.	
16.45-17.00 p.m.	Conclusions	Auditorium
17.00-18.00 p.m.	Happy hour	Meeting-room

For more information please contact Mr. Ing. J. de Hoog, ph. (+31)297-352310 or fax fax (+31)297-352270 or e-mail: J.de.hoog@pbg.agro.nl.

EFFECTS OF TEMPERATURE ON GROWTH AND DEVELOPMENT OF ROSES

F. Buwalda, PBG Aalsmeer, The Netherlands
f.buwalda@pbg.agro.nl)

A primary target in greenhouse climate control is the achievement of appropriate temperature regimes by means of heating and ventilation. These regimes are generally defined as constant set points, chosen largely on the basis of experience and empirical studies.

There are two distinct motives for studying the effects of temperature on production and quality of rose.

- Firstly, the average temperature level in the greenhouse has effects on biomass production, number of stems and stem quality, and should be chosen to ensure short term and long term efficiency of the production process.
- Secondly, crop tolerance to temporary deviations from the temperature set point can be exploited to increase the resource efficiency (energy, CO_2) of the production process.

With regard to the first point, a brief review of the main effects of average temperature and their interaction with other climate factors (in particular light) is presented. It is concluded that there is no single temperature optimum fore rose production, instead, the best set point depends on marketing strategy and (mainly seasonal) variations in light availability.

With regard to the second point, it is known that many horticultural crops are generally insensitive to temporary deviations from the set point value, as long as the average temperature over a specified period (usually one day) is kept constant. More energy efficient heating strategies take advantage of this tolerance (e.g. Bailey & Seginer, 1989). Efficiency can be gained by delayed ventilation when the greenhouse temperature rises above the desired level, and by allowing the temperature to drop when maintaining the targeted temperature is relatively expensive, e.g. on cold or windy days. In addition, heating can be concentrated in the night period, when the thermal screens are closed.

Optimised temperature control on the basis of daily weather forecasts with a fixed 24 h average temperature was shown to be feasible for rose by (Rijsdijk et al., 1998). Other temperature studies have also concentrated on the 24h time scale (Hendriks et al., 1987; Mortensen and Moe, 1992; Khayat and Zieslin, 1986; Shanks et al., 1986; Van den Berg, 1987). The tolerance of cut rose to temperature fluctuations over several days was investigated under controlled conditions by Buwalda (1997). The results show a tolerance to temperature fluctuations of at least 300 degree*hours in the range from 14-26°C. Thus, the conventional blue print recipe can be extended by defining the parameter for greenhouse air temperature by a range of permissible temperatures and a band of permissible deviations in heat sum accumulation, relative to a standard temperature integral.

This extended blueprint recipe was tested under realistic cultivation conditions for 4 rose cultivars. For this purpose, it was used to parameterise a simple control model, which allowed the temperature to vary within specified limits (Tmin, Tmax and maximum deviation from the standard temperature integral). Reference treatment settings were based on the conventional blueprint, and modified according to the advice of a panel of expert growers. Since the control of greenhouse air humidity generally has a large impact on energy requirements for heating, the validation was carried out at two levels of moisture control.

The results demonstrate that an increase in energy efficiency of 15 % could be obtained, without adversely affecting crop production or quality, using a very simple control principle. The 15 % gain was calculated relative to reference treatments, which were chosen to represent, as much as possible, current standard practice. To that aim, growers and crop experts were consulted regularly to determine the best way to translate the conventional recipe into parameter values for the conventional controller. It should even be possible to combine the integrating algorithm with other energy efficient climate control strategies, e.g. optimal use of thermal screens and making use of local weather forecasts (Rijsdijk et al., 1998), and increase their energy saving potential.

More in general, since an integrating controller assigns a lower priority to the instantaneous greenhouse temperature level than a conventional climate controller does, more freedom exists to optimise other factors, such as the use of a heat buffer and CO_2 enrichment.

The integrating temperature controller tested proved to be compatible with the extra heating and ventilation for the purpose of air humidity control, measures which growers generally would be reluctant to abolish.

The average effect of 15% falls within the range of 8 – 18% calculated by Rijsdijk et al. (1998) for a commercial optimising climate controller, which integrates temperature on a 24-h time scale.

Notwithstanding these encouraging results, it should be noted that current knowledge of plant tolerance to temperature fluctuations is largely based on empirical research, and that it is theoretically difficult to define a safe temperature range for integrating controllers. Even the fixed set points used in current horticultural practice form no guarantee against loss of crop quality under adverse climatic conditions (e.g. there is usually a large difference between summer and winter quality). Therefore, large safety margins will be necessary to avoid additional risk arising from the application of temperature integration. The full potential energy saving can only be utilised when the safe ranges for temperature and heat sum deviation can be determined on the basis of information about the underlying physiological mechanisms. In the meantime, the present results indicate that at least 10% efficiency can be gained using existing tools, without any additional risk to the crop. No extensive investments are necessary; all that is required is an update of the software in the climate controller.

References

Bailey B.J. and Seginer I., 1989. Optimum control of greenhouse heating. Acta Hort. 245: 512-518.

Buwalda F., 1997 - Mogelijkheden voor energiebesparing door temperatuurintegratie bij siergewassen - Effecten van lichtniveau, temperatuurniveau en wachttijd op de integratiecapaciteit van Ficus, Kalanchoe, Gerbera en roos. PBG Report 120 (in Dutch).

Hendriks L., Scharpf H.C. and Hackbarth H.J., 1987. Temperaturreaktion von Rosen. Deutscher Gartenbau 5: 272-276.

Khayat E. and Zieslin N., 1986. Effect of different temperature regimes on the assimilation, transport and metabolism of carbon in rose plants. Physiol. Plant. 67: 608-613.

Mortensen L.M. and Moe R., 1992. Effects of CO_2 enrichment and different day/night temperature combinations on growth and flowering of Rosa L. and Kalanchoe blosfeldiana v. Poelln.. Sci. Hort. 51: 145-153.

Rijsdijk A.A., Vogelezang J.V.M., Van Leeuwen G.J.L., Van Noort F.R., Heij G., Mulderij G.E., De Hoog J. and Jasperse H., 1998 - Temperatuurintegratie op etmaalbasis. PBG Report 135 (in Dutch).

Shanks J.B., McArdle A.J., Osnos G.D. and Mityga H.G., 1986. Greenhouse rose production with split night temperatures. J. Am. Soc. Hort. Sci. 111: 387-391.

Van den Berg, G.A., 1987. Influence of temperature on bud break, shoot growth, flower bud atrophy and winter production of glasshouse roses. Dissertation, Wageningen Agricultural University.

EFFECTS OF CO_2 AND ARTIFICIAL LIGHT ON THE PRODUCTION AND QUALITY OF ROSES

Joop de Hoog and Nico van Mourik
j.de.hoog@pbg.agro.nl

Introduction

A plant requires CO_2, the building stone for sugars (carbohydrates) to be able to grow. The process of making these sugars is known as assimilation (or photosynthesis) because light (natural or artificial) is necessary for this process. Only green parts of the plant (chlorophyll) are able to fix CO_2 which starts the complicated set of reactions to form sugars.

The natural level of CO_2 in the air is about 350-360 ppm. This concentration increases with 1-1,5 ppm per year as a result of the industrial activities in the world. CO_2 is also a waste product of burning gas (1 m^3 natural gas provides 1,78 kg CO_2) and this waste product can be used in horticulture to provide CO_2 for crops. A full grown crop has a maximum uptake of 5-8 gram CO_2 per m^2 per hour. Standards for dosage in The Netherlands for cutflowers are 100 kg CO_2 per ha per hour. This of course depends on many factors. This dosage can be realised by burning 40-60 m^3 natural gas per hectare per hour (with a heat storage 40-90 m^3).

For the application of CO_2 growers can use different sources like the heating boiler, warm air blaster, pure CO_2 or CO_2 from the co-generator. Rotting of organic material on the ground can also slightly raise the CO_2 levels. One can use straw in layers on paths. CO_2 dosage can also release other gases into the greenhouse which can damage the crop. Carefull attention should be paid to the effects of nitrogen oxides, ethylene, carbon monoxide and sulphur dioxide.

The effects of CO_2 dosage in roses interact strongly with large seasonal differences and weather conditions (irradiation, wind speed, rain, outdoor temperature) which means that results can not be reproduced or compared. Other factors can also affect the effect of application of CO_2 :

- technical factors: height of the greenhouse, light transmission of the greenhouse, ventilation, use of artificial light, situation of CO_2 dosage equipment.
- climate conditions which influence the availability of CO_2 : amount of irradiation, temperature and relative humidity, setpoint for ventilation.
- factors which influence the assimilation; daily light sum, light interception (LAI), temperature.
- the crop: differences per variety, behaviour of rootstocks, age of the plants, plant structure, effects of flushes.
- factors which decrease the production: reduced availability of water, nutrition and oxygen in the environment of the roots, diseases, toxic elements.

The interpretation of Dutch and other research results into a recommendation for the present rose culture must take previously mentioned factors into consideration. Greenhouse- and growth models can be a help but it will be a few years before these can be applied in practice.

The application of CO_2 and artificial light in the culture of glasshouse roses is becoming more widespread in The Netherlands. Literature and practical experience indicate a higher yield and a better quality (increased stem length and weight). In general an increase of harvested weight of 4-20% is found for roses. Some results:

- Hendriks and Hackbarth (1985): 'Mercedes', increase of fresh weight and shorter growth cycle.
- Mortensen and Moe (1992): 'Frisco' and 'Kiss', increase of dry weight of the whole plant. Better stem quality (stem diameter). No influence on length of growth cycle.
- Hand and Cockshull (1975): less blind shoots and more bud break.
- Urban and al (1992): shorter growth cycle and a longer stem length.

Although considerable of research has been done in the past on the stimulating effects of CO_2, the precise effects where never comparable.
The economic and practical consequences of CO_2 enrichment in comparison to extra investments in artificial light have not been answered. To investigate this, research was carried out at the Research station in Aalsmeer. At the end of the experiment an economic evaluation will be made. Results of the economic evaluation are not presented today.

Experiment

A greenhouse experiment was carried out from week 39 (1998) until week 35 (1999) using the variety 'Indian Femma!' The combination of the factors CO_2 (no dosage, 350 dpm, 700 dpm and 1400 dpm) and additional artificial light (45 micromol and 85 micromol) was investigated. In the winter vaselife was tested twice.
The effects of CO_2 and light differ per season. In the Dutch winter season it is possible to increase CO_2 and light levels more than in the summer and effects on production and quality (stem weight) increase. Table 1 shows the production until the end of the winter period and the production until the end of the experiment.

Table 1 - Production per m^2 of Indian Femma!, 4 CO_2 levels during the winter period (week 45 1998 - week 21 1999) and the whole year production (week 45 1998-week 35 1999)

	Winter period production	Production until the end of the experiment
0 (control)	115	248
350 ppm	115 (+ 0%)	243 (- 0%)
700 ppm	134 (+ 16%)	275 (+ 10%)
1400 ppm	141 (+ 23%)	290 (+ 17%)

Table 2 shows the effect of artificial light in the experiment. Again the results are presented of the winter period (week 45 1998 - week 21 1999) and till the end of the experiment (week 45 1998 - week 35 1999).

Table 2 - Production per m^2 of Indian Femma!, 2 light levels

	Winter period production	Production until the end of the experiment
3750 lux (45 micromol)	113	243
7100 lux (85 micromol)	139 (+ 23%)	284 (+ 17%)

There is no interaction of the CO_2 and light treatment. A table which presents the interaction of CO_2 and light is still very interesting because it shows that the production

with a low light level/high CO_2 level is comparable with the production with a high light level/low CO_2 level (not presented here). In the summer CO_2 levels can not be increased because the higher temperatures necessitate ventilation.
During the winter period effects of CO_2 and light are observed for the branch weight and stem length. The average branch weight (until the end of the experiment) was for the 4 CO_2 treatments respectively 31,6 gram, 31,9 gram, 33,4 gram and 33,8 gram. In the winter differences were greater between the treatments. The average branch weight of roses grown at the lower light level was 32,5 gram and at the high light level 32,9 gram. Table 3 shows the average branch weight and length of the branches (week 45 1998 – week 35 1999).

Table 3 - Average branch weight (gram / branch) and average length (cm) of Indian Femma!, 4 CO_2 levels, 2 light levels

	3750 lux	7100 lux
0 (control)	31,8 g / 68,3 cm	31,3 g / 67,8 cm
350 ppm	31,2 g / 68,2 cm	32,7 g / 68,8 cm
700 ppm	33,1 g / 69,6 cm	33,7 g / 70,1 cm
1400 ppm	33,8 g / 70,3 cm	33,8 g / 70,4 cm

The vaselife was unaffected by CO_2 concentration or light level. The vaselife was tested twice and about 20 days.

PRE- AND POSTHARVEST FACTORS INFLUENCING POST HARVEST QUALITY OF ROSES

Nollie Marissen
n.marissen@pbg.agro.nl

The length of the vase life and the opening of the flower buds of roses are the most important features to influence the satisfaction of the consumer.
The grower can take many measures to grow a good product, with a long vase life and good bud opening. The first measures even have to be taken before planting the crop. Then, during cultivation there are many things to be taken care of, in order to influence the internal and external quality. Finally, after harvest the treatment of the flowers can be crucial for vase life and bud opening.

1. Before planting a crop.....

The decision to grow a certain variety is the first and a very important factor determining the vase life of the crop. There are clear (genetical) differences in potential vase life between varieties:

Variety	Vase life	Seasonal variation	*Botrytis* susceptibility
Tineke	11.5	10.5 to 13.0	**
First Red	12.5	8.5 to 15.0	**
Kiss	16.0		
Noblesse	16.0		
Sacha	16.0		
Mercedes	17.0	12.0 to 21.0	*
Escimo	17.5		*
Frisco	20.0		*
Vivaldi	20.0		**
Prophyta	22.0		**

The same can be said for the susceptibility for *Botrytis*, which can be a severe threat for the vase life of roses. Of the above mentioned varieties Mercedes, Escimo and Frisco have a significant lower susceptibility (*) than some others (**). There are also differences in susceptibility for bacterial plugging. Although the way of testing it is still not perfect, it has become clear that some varieties will always suffer from bent neck as soon as there is a minor contamination of the water. others will keep a positive water balance, even in water with a considerable amount of vessel-plugging substance.

2. During cultivation.....

For the external quality (stem length, stem diameter, bud size) there is sufficient knowledge available to grow the desired quality. However, until recently, there was little fact material to support which decisions to make when one is aiming for improvement of the internal quality (vase life, bud opening, transport tolerance).

For a long time, there has been the presumption that a rose with good external quality also will have a good internal quality. During the post-harvest research performed at this institute it has been shown that the above-mentioned presumption often is not true. An illustration for this is the effect of continuous lighting during growth: it yields superb looking roses, but during vase life, the leaves will wilt and dry in a few days, and bent-neck will occur. Obviously a dark period of at least four hours each night is necessairy to overcome these problems in the water balance of cut roses.
This example shows that there is a need for knowledge about which factors influence post-harvest quality. Especially now, when growers join quality-labels, or have buyers who want a vase-life guarantee, it is important to know which factors during growth and handling influence the post-harvest quality.

Supplemental lighting
Effects of supplemental lighting or temperature on carbohydrate level and vase life. Three levels of supplemental lighting were applied: 0, 4250 and 8500 lux (= 0, 50 and 100 $umol.m^{-2}.s^{-1}$ or 0, 8 and 16 $Watt/m^2$). During one winter season (1996-1997) six rose varieties were tested for their vase life and their sugar- and starch content at the start of the vase life. It was clear that the higher the level of supplemental lighting, the heavier the stems were, and the higher the amount of carbohydrates found in the leaves and the flower bud. However, for most of the varieties there was no difference in vase life. Only 'First Red' showed a slight improvement in vase life and bud opening when more light was applied.

Growth temperature
The next winter (1997-1998), the light levels were equal (4250 lux), and three different growth temperatures were set: 16, 18 and 20 °C. Again, vase life and carbohydrates were measured. There were only minor differences in carbohydrate contents, but vase life was better at 20 °C than at the lower temperatures.

	Temperature		
Variety	16 °C	18 °C	20 °C
Charmila	12.6	12.7	12.8
First Red	12.7	13.2	13.8
Sacha	16.6	18.7	20.9
Frisco	22.8	23.7	24.0

These experiments give insight in which single factors can influence vase life and bud opening. Also, they have proven that the amount of carbohydrates at the beginning of the vase life is no indication for the length of vase life. But it was still unclear how these factors influence vase life if there is an interaction with each other, and when other factors (relative humidity, CO_2 , nutrition etc) are also involved. This asks for a different sort of research.

A nursery comparison for vase life of roses
In this research 35 rose nurseries having 'First Red' were involved. In Oktober the climate (relative hunidity, temperature, CO_2, PAR-light) at crop level was recorded. Also several features of the crop (growth rate of the stems, number of developing shoots per m^2), were registred. After a period of 6 weeks registration, data were analysed with multivariate techniques and the factors that influenced vase life could be described.

One of the most important factors influencing vase life was the relative humidity during cultivation. The higher the humidity, the shorter the vase life. For 'First Red' in the winter season this means that every % higher RH caused a decrease of 0.1 to 0.25 days vase life.
Another factor which correlated with vase life was the number of young shoots in the crop at the moment of harvest. The more shoots, the longer the vase life. Although this is not a factor on which the grower has much influence, it is good to know, especially when a crop developes in flushes: at the end of a flush there are more small developing shoots than at the beginning of a flush.

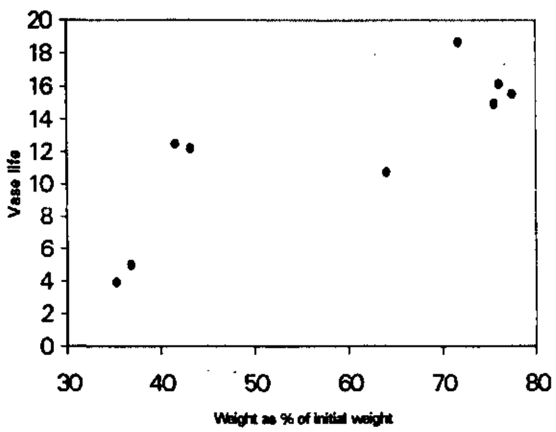
	Mean value per group			
Vase life	9.8	10.6	10.7	11.3
Bud opening	3.9	3.6	3.5	3.7
Mean RH	85.3	81.8	80.1	75.5
Mean temp	18.3	19.1	19.2	19.9

For flower bud opening the ripeness of the bud at the moment of harvest was the most important factor. The riper cut, the better the opening. But there were other factors that were of influence: the temperature, age of the crop and the level of supplemental lighting.

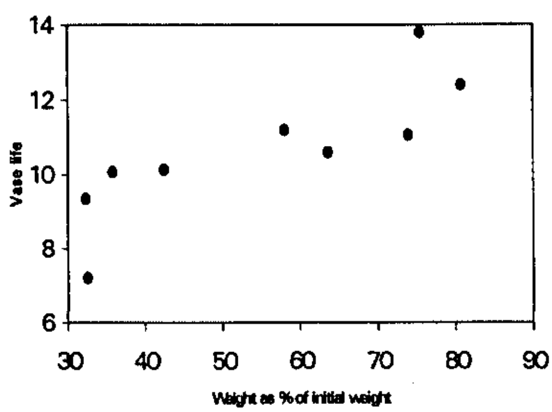
	Mean value per group			
Vase life	10.6	10.9	11.2	10.8
Bud opening	2.9	3.3	3.5	4.0
Bud stage (harvest)	1.7	1.8	2.2	2.6

Relative humidity
There is also proof from research from Norway that a high relative humidity influences vase life. We have found that there are certain varieties that suffer from leaf wilting and 'crispy leaves' during vase life, although the dark period per day was at least 4 hours. Other varieties seem less susceptible. A way of checking whether there is a risk for leaf drying, is to measure the speed of weight loss of isolated leaves. A larger weight loss during the first two hours correlated with a shorter vase life.

Vase life and weight loss of 'Orange Unique'



Vase life and weight loss of 'Diva'



Apart from effects on vase life, the relative humidity also has influence on the occurrence of *Botrytis* spores in the greenhouse, and thus on the number of infected flowers. In Holland, August, September and October are the months with te highest *Botrytis* risk. Besides a high relative humidity in the greenhouse, this is also caused by a decrease in global radiation outside the greenhouse, which coincides with low spore counts. An additional measure to take against *Botrytis* infection is to remove dead plant matter from the greenhouse.

Mineral nutrition
In the past there have been several researches on the effects of mineral nutrition on growth and development of a rose crop. Often samples of the different treatments have been tested for vase life. Mostly there was no difference in vase life between the treatments. Later, a research about the effects of Calcium and Borium on the susceptibility to infection with *Botrytis* showed that the higher the Calcium concentration in the flower petals, the less susceptible the flower to *Botrytis.* Also there was a small positive effect of higher Ca nutrition on the vase life of 'Mercedes' and 'First Red'.

3. After harvest.....

'A fresh product is a guarantee for a good vase life' is a saying that seems all too true. However, keeping the transport chain as short as possible is not the only prerequisite for long-lasting roses.
After harvest, especially in the warmer climates, the stems have to be placed in water as soon as possible. A very important thing to take care of, is the contamination of the water with bacteria and other plugging substances. Using a bactericide helps to keep the bacterial counts low. Although there is no simple linear correlation between the number of bacteria and the vase life of roses, it is unevitable that water uptake is blocked when the vessels arre plugged. Especially when the temperature of the water is high, multiplication of the microörganisms will be fast, since there is enough nutrition for them to grow on.
Keeping the water in the harvest container at a low temperature thus not only slows down the growth of bacteria, but it also improves water uptake, as shown in research on water temperatures. For roses, rehydration is faster in water of 0 °C than in water of 20 or 40 °C.
There are all sorts of commercial pretreatment solutions. All of these contain a bactericide, and some may provide a small amount of sugars, which can be used as a substrate for respiration during storage.
Keeping the air temperature low during storage is important for the water balance, but also to slow down the respiratory process. A low storage temperature, however, can cause problems too: when flowers are taken from the cooler, and brought to a much warmer and more humid room, there will be condensation on the flower buds. This will cause *Botrytis* spores to germinate, forming a lesion, which in itself will cause loss of ornamental value, but when growth of the fungus continues, this inevitably will lead to deterioration of the flower.

Concluding....

There is a lot of knowledge available now which can be of good use for the growers. Good growers will already be using al lot of this knowledge, maybe even in a quality management system. However, there are still many questions to be solved. Especially when quality guarantee and closed transport chains are becoming more common, the grower will need to know how he can grow a crop with a well defined post harvest quality.

This lecture is based on research of Rob Baas, Jan Benninga, Anita Hazendonk, Albert Kerssies, Casper Slootweg and myself. Thanks to all supporting technicians and staff.

INTEGRATED CONTROL OF POWDERY MILDEW AND *BOTRYTIS CINEREA* IN ROSES

A.J. Dik, A. Kerssies and J. Wubben
a.j.dik@pbg.agro.nl.

Introduction

Powdery mildew and *Botrytis cinerea* are two important diseases in greenhouse-grown roses. For several years, research at the PBG has focussed on integrated control of these diseases. Powdery mildew is a big problem in the greenhouse, whereas *Botrytis* is mostly a post-harvest problem. The main objectives of the research are to gain insight in the epidemiology of both diseases and to develop biological and integrated control methods. This will reduce the input of chemical fungicides and will also reduce the dependence of growers on these fungicides.

Powdery mildew

Powdery mildew, caused by *Sphaerotheca pannosa*, is one of the main problems in roses grown in protected cultivation. The damage threshold was estimated to be between 5 and 10 infected leaflets per m^2 (Kerssies and Pieters, unpublished results). In less susceptible cultivars, supervised control using this threshold leads to reduced input of fungicides.

The cultivar choice is an important tool in integrated control. Several cultivars are highly resistant and almost no fungicides need to be used against this disease. However, in commercial practice, the choice of cultivar is only rarely based on disease resistance.

Scientific literature mentions phosphates, bicarbonates and sulphates as control agents of powdery mildew diseases in several crops, but the reported results are not always consistent. Besides these salts, several so-called biorational products are commercially available. Most of these products contain extracts from plants or algae or are based on silicon. The mode of action is often claimed to be induced resistance, but some products also seem to have a direct effect on the fungus. In order to compare several of these compounds, four plant extracts and five salts have been tested in a series of experiments for their efficacy against rose powdery mildew. These compounds were applied weekly and compared to an untreated control. Some salts and several products containing plant extracts or silicon had a distinct effect on powdery mildew, whereas others were not effective at all. The effect of these compounds was dependent on the cultivar (Fig. 1). At higher infection levels, the efficacy decreased. Under the Dutch law, these compounds need registration and the names of effective but unregistered products can not be published.

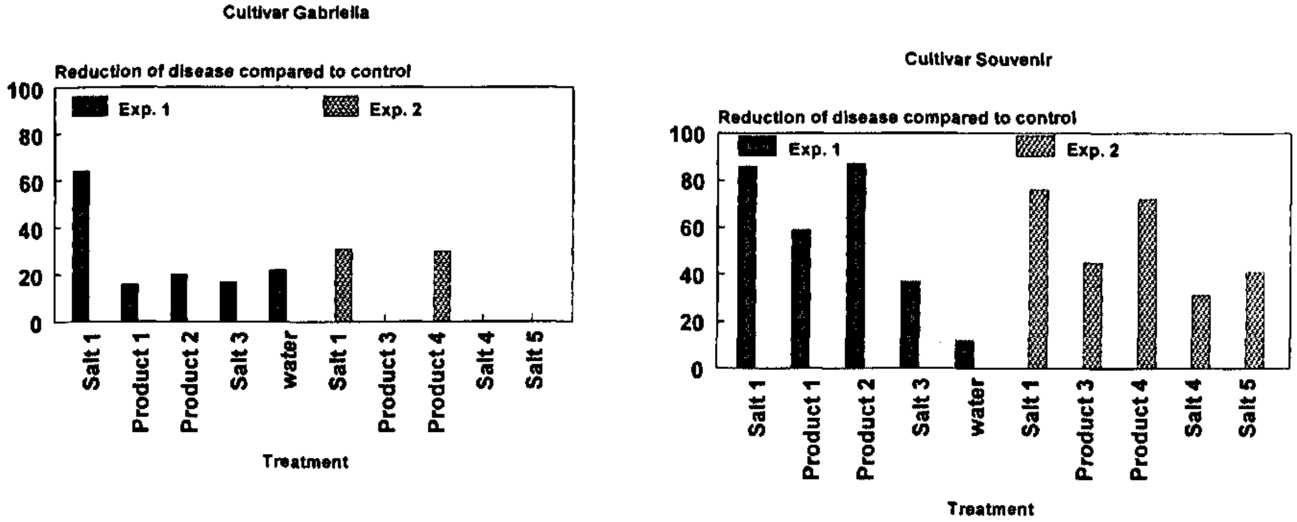


Fig. 1 - Efficacy of several compounds against powdery mildew in rose cultivars Gabriella and Souvenir

Apart from the plant extracts and salts, the efficacy of microbial biocontrol agents has been tested. One biological control agent gave good control of powdery mildew when applied weekly or in alternation with a chemical fungicide. This fungus has been developed into a commercial product for which a request for registration will be filed within the next few months.

Botrytis cinerea

B. cinerea spores are always present in the greenhouse but their numbers fluctuate with the production system, amount of senescing plant material on the ground and periods with the windows open for ventilation. Usually, *B. cinerea* spores do not germinate on the flowers in the greenhouse, because the relative humidity is too low.

Temperature influences susceptibility of the flowers to *B. cinerea*, but the infectivity of the spores is influenced by temperature as well as relative humidity (RH) and radiation. There is no clear relation between season and susceptibility of the flowers. A warning system was developed against *B. cinerea* in the post-harvest stage. If daily mean RH in the greenhouse for days 6, 7 and 8 before flower harvest exceeds 70% and the mean daily global radiation outside for days 1, 2 and 3 is below 1500 J cm^{-2} day^{-1}, there is great risk of *B. cinerea*. More research is needed to test the applicability in practice.

After the flowers have been picked they are stored and transported at low temperatures. During this post-harvest phase the temperature and humidity fluctuate and conditions can easily become conducive for germination of the spores and infection of the flowers. This results in small necrotic lesions or spreading lesions at a later stage. Recently, research in PBG has focussed on biological control of *B. cinerea* in the post-harvest stage with micro-organisms. In collaboration with the Volcani Center in Israel, several isolates of yeasts and bacteria were compared under a range of climatic conditions. Two yeast strains were found to be effective under low temperature conditions in combination with both high and low relative humidity. Integration of the yeasts with several salts was tested, but the results showed that the efficacy of the yeasts was not improved by the addition of the salts. Currently, research is done on the mass production and formulation of the yeasts. After that, the yeasts can be filed for registration as biological control agents of *B. cinerea*.

Conclusions

All in all, several options for integrated control of powdery mildew in roses are available. The research focuses on optimisation of these methods and implementation in practice. Most of the compounds that are effective need registration. Biological control of *B. cinerea* in the post-harvest stage will be possible in the future, once the effective biocontrol agents have been developed into commercial products.

In the future, the input of chemical fungicides against foliar diseases can strongly be reduced. Biological and integrated control systems will be most effective when they are combined with other methods such as cultivar choice and cultural practices.

INTEGRATED PEST MANAGEMENT IN ROSES

Joanne J. Fransen
j.fransen@pbg.agro.nl

In integrated pest management (IPM) the attention is focussed on different methods for prevention and control of pests and diseases, such as:

- insect exclusion screening of greenhouse openings,
- sanitation,
- use of insect-resistant/tolerant varieties,
- cultural methods (climate, nutrition, light, plant density, artificial substrate, arching method (bent cane))
- biological control
- chemical control

The most important aspect of IPM is knowledge about what is going on in the crop. To achieve this, one has to monitor the crop for damage and presence of pests and diseases on a regular base. In a rose crop the monitoring can be integrated with other activities such as harvesting, and accounts of visual damage or presence of insects on plants should be noted down and displayed on a map of the greenhouse. In addition also sticky color traps, light traps or pheromone traps can be used to monitor flying insects. As a consequence of collecting this information on presence of pests and their infestation level one may decide to take control measures.
Education of the grower and his personell to recognize pests and damage is essential when integrating different control methods.Time for visual inspection should be incorporated in the tasks of educated workers, as well as time for registration of all control activities in the crop. As such one can evaluate the success rate of different control activities and learn from one's mistakes.

The amount of used pesticides differs between growers. This is related to differences found in greenhouse facilities and growing conditions such as climate control, amount of water, nutrients, substrate, lights, etc. Also, one year there can be a high infestation level of aphids, the other year of thrips. Therefore, a general recipe for insect control cannot be given, but the decision about what kind of control, and when, has to be adjusted to the greenhouse conditions and the attitude of the grower himself.
Even in the Netherlands a more than three-times difference was noticed in amount of pesticides used in one year by different rose growers.
Also, seasonal influences affect the use of chemicals, for instance in the Netherlands use of insecticides in a month time in winter (December- Januari) amounts to 0.5 to 1.0 kg active ingredient per ha, whereas in summer (August- September) this ranges between 2.0 and 3.0 kg active ingredient per ha (Vernooij en Ploeger, 1999).

A whole range of different insects and mites may develop into a pest in a rose crop, but generally thrips species such as Western Flower Thrips, *Frankliniella occidentalis*, mite species such as twospotted spider mite, *Tetranychus urticae*, and several aphid species such as *Macrosiphum euphorbiae*, *Myzus persicae* and *Aphis gossypii* are the most common. In addition caterpillars, leafrollers, whitefly and occasionally mealybugs can occur.
In the Netherlands in fruit vegetables integrated pest management including biological control has been applied for over 25 years and in ornamentals the number of growers

using IPM with biological control is expanding rapidly. IPM has many advantages, only to mention that growers notice an improvement of crop quality as a delay in growth, fytotoxicity and residues have decreased when reducing the amount of pesticides. The introduction of natural enemies is often user friendly as one does not need warm protective clothing used when applying chemical pesticides.

A whole range of natural enemies is presently on the market (about 30 different species) and still others are under investigation. The main bottleneck for biological control in roses is western flower thrips. Only mixtures of different natural enemies can suppress this pest, but often, especially in late summer and early autumn, chemicals have to be applied. Lack of a selective chemical for control of thrips makes it difficult to integrate biological control against other pests.

Table 1 - Some natural enemies against aphids, thrips and spider mites

Natural enemy commercial and in research	Pest
Predatory mites	
Amblyseius cucumeris	Thrips
Hypoaspis spp.	
Phytoseiulus persimilis	Spider mites
Amblyseius californicus	
Predatory bugs	
Orius spp.	Thrips, aphids
Macrolophus spp.	Whitefly
Coccinelids	**Aphids, whitefly,**
Predatory thrips	
Franklinothrips spp.	Thrips
Parasitoids	
Ceranisus spp.	Thrips
Aphidius spp.	**Aphids**
Aphelinus spp.	
Encarsia spp.	**Whitefly**
Eretmocerus spp.	
Entomopathogenic fungi	
Beauveria bassiana	**Whitefly, thrips, aphids,**
Verticillium lecanii	**Aphids, whitefly, thrips**
Metarhizium anisopliae	**Thrips**
Entomophthorales	**Thrips, aphids**

Control measures for plant diseases have to be compatible with the use of biological control. Exposure to sulphur (powdery mildew control) can counteract the activity of certain natural enemies. However, the use of sulphur for restricted periods at night in a lower density or the use of a fungicide schedule for a certain time period, can be integrated. Several selective chemicals are available against aphids, spider mites, whitefly and caterpillars and these can be used in a corrective way, together with natural enemies. Although plant breeding for insect resistence is difficult in roses apparent variation in susceptibility for plant pathogens as well as insects has been observed in rose cultivars. A trend has set and biological control agents, host plant resistence, selective chemicals and cultural methods will, hopefully, all contribute to an environmentally safe crop protection.

EFFECTS OF PLANT DENSITY, HARVEST METHODS AND BENDING OF BRANCHES ON THE PRODUCTION AND QUALITY OF ROSES

Joop de Hoog, Mary Warmenhoven, Barbara Eveleens-Clark and Nico van Mourik
j.de.hoog@pbg.agro.nl

Introduction

The production of roses is influenced by many interrelated factors. The higher production achieved during the last decade has mainly been realised through *improvement in the control of environmental factors (light, temperature, carbon-dioxide,* relative humidity, substrates, nutrition etc.) and the optimisation of technical equipment. These improvements require large investments which increase production costs. At the same time less attention has been paid to other factors (like plant building, method of harvesting, plant spacing) to control the growth of the plant and the production and quality of the stems.
Modern rose growers in The Netherlands are increasingly using 'heightened systems'. Using this system a crop is formed without the familiar plant form that the grower was used to. When (bottom-)breaks are harvested near the base of the plant (on the first scale) or even very near to the base (arching-method or knuckle-cut), the shape of the rose bush remains rather small. In the cropping systems used here, branches are regularly bent. The bending enlarges the light-interception of the plant.
A few weeks after planting a grower can bend the primary shoot to promote the formation of bottom breaks. In practice the primary shoot is bent when the first side-shoots of the primary shoot have a 10 mm flower bud. During the crop bending can be used to establish the leaf area and a good stem quality. Shoots can be bent just above an axillary bud (development of the axillary bud) or under an axillary bud (an adventious shoot has to develop).
Two experiments were carried out at the Research Station for Floriculture and Glasshouse Vegetables in Aalsmeer to investigate the influence of bending branches (experiment A) and of harvest methods and plant density (experiment B) on the production and quality of roses.

Influence of bending on production and quality

Experiment A started in week 16 (1997). Four different methods of bending which caused a difference in the number and age of the leaves were combined with two varieties ('First Red' and 'Frisco'). The four methods of bending were:

1. only the primary shoots were bent
2. primary shoot and the first flush of bottom breaks are bent + lateral shoots
3. primary shoot and bottom breaks of inferior quality are bent. Stems of inferior quality are bent
4. primary shoot, bottom breaks of inferior quality are bent. One per 3-4 branches (First Red) or 5-6 branches (Frisco) is bent at the end of a flush.

The experiment finished in week 37 (1998). Production, quality of the harvested product, LAI (leaf area index) of the bent branches and the photosynthesis of the leaves on the bent stems are measured. Plants were grown in coconut fibre (buckets), 6 plants/m^2 . Artificial light 4000 lux (= 50 micromol/m^2).

More and regular bending of branches gives a lower production of branches but a higher average branch weight, although there are differences per variety (Table 1).

Table 1 - Production per m^2 (average branch weight (gram)) of Frisco and First Red, 4 methods of bending (week 23 1997-week 37 1998)

	Meth. 1	Meth. 2	Meth. 3	Meth. 4
Frisco	386 (22,7)	390 (22,7)	320 (24,9)	297 (26,1)
First Red	142 (44)	129 (44,7)	121 (48,8)	113 (51,3)

The production in kg/m^2 differs per variety but the influence of bending is only visible by Frisco (Table 2).

Table 2 - Harvested weight (kg/m^2) of Frisco and First Red, 4 methods of bending (week 23 1997-week 37 1998)

	Meth. 1	Meth. 2	Meth. 3	Meth. 4
Frisco	8,7	8,9	7,9	7,7
First Red	6,3	5,8	5,9	5,8

The LAI can vary per plant and per season and is not always influenced by bending. At the beginning of the experiment the LAI developed to 4-5 m^2 (Frisco) or about 6 m^2 leaves per m^2 ground surface. In winter as the amount of light decreases the LAI also decreases (bending continued through the winter period). The LAI seems to regulate itself and is influenced by the light level. For this reason more and more growers in The Netherlands do not bend branches during winter anymore !
More or less bending seems to influence production and quality (branch weight). One can choose either for a higher production with a lower average branch weight or for a lower production with a higher branch weight. There are differences per variety and other climate conditions (e.g. a higher temperature) can influence bud break for example.

Influence of plant density and harvest method on production and quality

Experiment B started in week 7 (1996) and the combination of the factors harvest method (first-scale and knuckle-cut), variety ('Bianca','First Red','Frisco' and 'Mercedes') and plant density (10, 7.5 and 5 plants per m^2) is investigated. The experiment finished in week 3 (1998). Production and quality of the harvested roses are measured. The roses were grown on a heightened two row system. Artificial light in the first winter about 3000 lux (= 36 micromol) and in the second winter 4500 lux (54 micromol).
In general the number and quality of the first bottom breaks is not influenced by the plant density. For cutflowers it is general knowledge that a higher plant density gives a decrease in branch weight and diameter of the harvested flowers.
In the experiment carried out at the Research station in Aalsmeer a higher plant density gives a higher production, but production levels differ per variety (Table 3). The production of branches per plant is higher with a lower plant density.

Table 3 - Yield (branches/ gross m^2) / branches per plant / % compared to 10 pl/m^2 (week 3 1996- week 3 1998) of 4 varieties grown at 3 plant densities

	10 pl/m^2	7,5 pl/m^2	5 pl/m^2
First Red	235 / 23,5 / 100	208 / 27,7 / 88	168 / 33,6 / 71
Bianca	329 / 32,9 / 100	325 / 43,3 / 99	281 / 56,2 / 85
Mercedes	371 / 37,1 / 100	342 / 45,6 / 92	280 / 56,0 / 75
Frisco	561 / 56,1 / 100	495 / 66,0 / 88	432 / 86,4 / 77

Average branch weight is higher with a lower plant density (Table 4).

Table 4 - Average branch weight (gram) (week 13 1996 – week 3 1998) of 4 varieties grown at 3 plant densities

	10 pl/m^2	7,5 pl/m^2	5 pl/m^2
First Red	48,5	52,4	55,4
Bianca	46,6	47,5	49,9
Mercedes	26,7	28,2	30,5
Frisco	24,2	25,5	26,8

An interaction between plant density and harvest method is observed for the harvested weight. A very small difference in harvested weight is found between the plant density when the roses are cut on the first scale (table 5). The amount of harvested kilograms depends on the variety; Bianca 14,7 kg, Frisco 12,4 kg, First Red 10,5 kg, Mercedes 9,3 kg.

Table 5 - Harvested weight (kg/ gross m^2) (week 13 1996-week 3 1998)

	10 pl/m^2	7,5 pl/m^2	5 pl/m^2
Knuckle-cut	12,2	11,4	10,4
First scale	12,7	12,6	11,1

The production is higher when roses are constantly harvested on the first scale. The knuckle-cut method gives a higher branch weight (results differ per variety) (Table 6 and 7).

Table 6 - Yield (branches/ gross m^2) / % compared to first scale (week 13 1996-week 3 1998)

	Knuckle-cut	First scale
First Red	189 / 86	219 / 100
Bianca	271 / 77	353 / 100
Mercedes	296 / 81	366 / 100
Frisco	439 / 79	553 / 100

Table 7 - Average branch weight (gram) of 4 varieties, 2 harvest methods (week 13 1996-week 3 1998)

	Knuckle-cut	First scale
First Red	54,8	49,4
Bianca	51,9	44,2
Mercedes	30,8	26,1
Frisco	27,8	23,2

Plant density and harvest method can be used to influence the production level and quality of roses. Growers in The Netherlands are generally planting about 7 plants/ gross m^2. With hybrid tea varieties the plant density is sometimes lower (around 6) to enable the long branches to be bent in the right way. Sweet hearts are sometimes planted at a higher plant density. With a 2- row system the plant distance in the row is small. Systems with 3 or 4 rows of plants per bed are becoming more popular because the plants can be better spaced over the whole bed.
It is hard to find a grower who constantly uses the knuckle-cut method for harvesting. Growers develop their own strategy. On the heightened systems mixtures are found of the knuckle-cut and first scale method. Growers with an older crop sometimes establish their crop at a certain height and then use the new harvest methods. The choice of a harvest method depends on the time of the year (in the winter with lower light levels -> less branches m^2), the variety (how is the bud break ?) and the price for a certain quality (depends per variety).