# COMPUTERS IN GREENHOUSE CLIMATE CONTROL

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Summary

At the Working Party "Computers in Greenhouse Climate Control" held in Wageningen in June 1979, which was attended by 33 participants from 9 countries, various aspects concerning the use of computers in horticulture under glass were dealt with.
The aim was to assess the "state of the Art" with regard to its application in research and practice, and to examine in which areas of research effort is required to optimise the use of computers.
The contributions can be grouped to the following broad classification:
- general, introductory;
- model explorations;
- set point control;
- set choice and adjustment of the control quantity;
- production strategies;
- survey of computer systems currently in use in research and practice.

This report adheres to the above classification.

## 1. General

Computers are applied in research on the one hand to collect, process and analyse measurement data, on the other hand as instruments for testing control algorithms and to control the climate in an "Experimental Garden under Glass" consisting of several compartments. Often the system is a combination of these functions.

We can say that these systems are powerful aids but that their use demands a careful approach. No measurement data should be collected unless a proper processing and analysing strategy has been set up first. The systems usually constitute a considerable burden on budget and staff, and in this respect, too, the consequences must previously be

considered.

In practice computers are applied as climate control equipment, the other possibilities, such as greater adaptability, recording of the climate, control of various quantities, simple operation, counting as additional sales points.
From an economic point of view the systems used in the Netherlands can compete with analogous equipment, due to which their use has expanded enormously (see paragraph 6).

## 2. Model Explorations

By these we mean computer calculations which can be differentiated according to their respective aims and, consequentily their respective model set-ups.

- models in which the behaviour of the system can be characterized in such a way that it can either be used in a control unit or for testing control algorithms.
  The setup of these models is dynamic and as simple as possible.
- models in which the behaviour of the system can be characterized in such a way that in it the influence of individual physical processes can be distinguished.
  These models enlarge our insight and can have a predictive value. A prerequisite is that the individual physical processes have been adequately quantified.
- models indicating a relation between arbitrary quantities, this connection usually having been determined empirically. These models are usually valid only for the conditions existing at the time of the measurements.

## 3. Set point control

There are various possibilities of improvement. The dynamic behaviour of the control system can generally be described satisfactorily. Also it is possible to determine and record the changes in behaviour occuring under the influence of the weather outside. This is in fact often done in practice, based in that case on a relationship between a change in static behaviour and the weather outside. Is used both in an anlogous and a digital manner.

An other possibility consists in having the system determine the change in dynamic behaviour under the influence of changed outside conditions itself. This can only be done digitally.

## 4. Sensor choice and adjustment of control quantity

When a climatic quantity can be realised by the control system the next question is what value this climate quantity should have for optimal crop growth at a particular moment. At present this choice is based on experience; the way in which crop growth at any particular moment and climatic quantities are interdependent is being studied.

On the one hand the question arises whether there are quantities that can be measured at the plant and provide information concerning crop behaviour (such as e.g. leaf temperature and/or sap flow) and on the other hand how should this measured information be translated into a control action. For direct control it is necessary to first acquire a coherent picture of the crop behaviour into which the quantities measured at the plant fit.

Experiments carried out so far confirm that possibilities exist.

However, the coherent picture into which these experiments fit is still lacking, so that a control strategy based on it is not yet feasible.

## 5. Strategies

Assuming that the return yielded by a crop is time-dependent, earlier production means higher returns. When the relationship between growth and level of light at a specified temperature level is known the planting date can be fixed according to the desired selling data. Average outside conditions determine energy costs.

Total earnings of the market gardener, returns less heating costs, can be optimised by variyng planting date and air temperature.

This optimalisation can be effected by short - as well as long - term strategies. Other strategies, also including labour charges etc., require to be examined in greater detail.

## 6. Existing systems

At a number of research institutes computer systems have been put into operation to study the possibilities of climate control, and,

even more important, to study crop reactions to climate changes. These systems are elaborate and highly advanced as regards control and construction of peripheral equipment.

In the Netherlands more than 1.000 computers have been installed by independent manufacturers for climate control in nurseries.

It is expected that further introduction of such climate control equipment will take place in countries with a comparable situation - greenhouse - heating in winter, continuous production, sufficient level of investment and high cost of labour.

Although the high degree of specialization and the high concentration of horticultural enterprises in the Netherlands has accelerated the application on a practical scale.

## 7. Discussion

### 7.1 Expectations with respect to the use of computers in future

1. Technical possibilities
- proper control
- control of various quantities
- signalling
- easy adaptation
- fuel economy
- recording
- simple operation from a central spot

2. Computer application is simple: There are few hindrances to further use.

3. Market Gardeners should be provide with the additional possibilities which can be realised with a computer.

4. Knowledge of the particular culture in respect of dynamic phenoma will have to be further developed.

5. Computerized climate control equipment will also become attractive to small holdings.

7.2 What specific knowledge is needed to optimize control

All variables influencing greenhouse cultures and their relationships should be reflected in a model (see also item nr. 4).

8. What requirements exist for the transferability of software. What are the current possibilities and how can they be improved.

Adding flow charts to publications or papers seems to be the most effective method.