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SYMPOSIUM ON GREENHOUSE CLIMATE AND ITS CONTROL

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An extremely interesting conference, May 19-24, at Wageningen, the Netherlands, attracted individuals from the entire world. Progress since the first Dutch symposium, in 1979, has been phenomenal. Some of the posters are briefly discussed. The proceedings of the conference will be published within the next year.

About 96 people, from as far away as Japan and Australia, met at the principal agricultural research institution in Wageningen, The Netherlands, for a conference on greenhouse control. Contrary to the usual presentation at such conferences of oral reports to other participants, all papers were posters, with a few examples in the accompanying photographs. This allowed one to study each poster and discuss it with the author — a considerable, and successful, departure from the usual situation. Interest was very high as witnessed by the fact that additional hotel accommodations had to be provided to handle the crowd. A few abstracts in the conference publication are outlined below:

1. *Leaf temperatures after withdrawal of thermal screens.* Nielsen and Amsen. Denmark.

   Use of a remote sensing, infrared thermometer, showed typical variation in leaf temperatures during the first 10 minutes after thermal screens retracted. As soon as the leaves of Nephrolepsis, Begonia and Kalanchoe were exposed to the cold glass, there was a steep *rise* (editor's emphasis) of nearly 5.4°F in leaf temperature. Changing the heating system from below to above, or using forced air movement, did not affect the leaf temperature rise. The behavior was not observed in greenhouses covered with double wall PMMA or where slotted benches were employed.

2. *Improved methods of greenhouse evaporative cooling.* Giacomelli, Gininger and Krass. Rutgers University, U.S.A.

   Two techniques of evaporative cooling presently under evaluation. One utilizes low pressure mist above a 55% shade fabric which had a cooling effectiveness of 23 to 38%, highly dependent upon relative humidity. A second method used high pressure nozzles giving temperature reductions of 12.5°F and was less dependent upon relative humidity. The latter was incorporated into a movable boom system.

3. *The influence of thermal screening and moisture ventilation on the transpiration of glasshouse tomatoes at night.* de Graaf. The Netherlands.

   The use of thermal screens results in a large change in glasshouse climate with a corresponding influence on water loss which decreased significantly with thermal screens, with the decrease becoming greater as the crop progressed through the season. The percentage reduction was greater the higher the rate of water loss.

4. *Greenhouse lighting.* Walker and Wood. Penn State Univ., U.S.A.

   The most popular lamp for supplemental irradiation is the high pressure sodium lamp. A fixture with a 1000 watt lamp requires about 1175 watts power, with about 308 watts useful energy in the 400 to 700 nm photosynthetic wavelengths. The remainder is convective heat from lamp and ballast or radiation in the thermal wavelengths. A system is proposed which would collect the waste heat from the lamp by flowing water over the bulb.

5. *Dynamic modeling of heat and mass transfers in greenhouses.* Deltour and de Halleux. Belgium.

   Authors presented a greenhouse climatic model which included heat transfer through 4 soil layers, heat transfer and water transfer between inside and outside air, the cover, the vegetation and the soil, thermal exchange between the cover and the sky, and the solar transfer with a heating input of 500 watts per sq.m. Results are presented for June and December days in Texas, Wageningen and Tokyo.

6. *Condensation effect on heat transfers through greenhouse claddings.* Nijskens and de Halleux. Belgium.

   Condensation causes a higher cover temperature which increases heat loss when it occurs on the greenhouse cladding. Radiation transfer is lower for polyethylene versus glass when condensation occurs. Due to condensation, heat losses increase for glass and decrease for polyethylene.

7. *Greenhouse energy demand comparisons for the Netherlands and Ohio.* U.S.A. Short and Breuer. Ohio and Holland.

   Average winter yields were similar with solar radiation in Ohio being 2.5 times greater versus The Netherlands. In the spring and fall, the average solar radiation for each location was one month out of phase. The Ohio winters were 9°F colder and the summers 9°F higher than the Netherlands. The variation in temperature and radiation was much greater in Ohio. The heat requirement in Ohio was 20 to 30% higher than the Netherlands in the winter and 15 to 40% lower in the spring and fall. The total annual heating requirement, however, was almost the same for both locations.

8. *Growth of young cucumber plants under different diurnal temperature patterns.* Challa and Brouwer. The Netherlands.

   Results strongly suggested that the effect of temperature on plant development depends on the growth rate of the plant. Low night temperature affected growth much less when applied after a dull day than after a bright day. Alternating high and low temperatures within the night resulted in relatively fast growth if the periods were 2 or 4 hours. Growth was reduced with alternating nights of the same temperature differences.

9. *Some speaking plant approach to the synthesis of control system in the greenhouse.* Hashimoto, Morimoto and Fukuyama. Japan.

   The time approach to net CO_2 uptake examined with procedures based upon system theory and control engineering. Authors could identify and estimate any response of net CO_2 uptake as affected by environmental changes. Can synthesize the most effective control system.

10. *Plant growth optimization by photosynthetic monitoring.* Ceulemans and Impens. Belgium.

    A new system is developed that incorporates computer control by monitoring CO_2 uptake. By means of the "speaking plant approach" and the "hill climbing procedure", the main growth factors are optimized through digital computer control. Finding the optimal combination of environmental factors is performed by maximizing the CO_2 exchange rate.

11. *A CO_2 control algorithm based on simulated photosynthesis and ventilation rate.* Bakker. The Netherlands.

    To obtain maximum profit of CO_2 enrichment, large CO_2 fluctuations should be prevented. In this study a "disturbance variable, feed-forward control" method is described based upon simple static ventilation rate and canopy photosynthesis models.

12. *Control of greenhouse air temperature with an adaptive control algorithm.* Hooper and Davis. United Kingdom.

    A distributed computer network has been developed to monitor and control research greenhouses at NIAE. Algorithms which gave similar control in June gave poorer control in October. Also employed an adaptive algorithm which required more ventilator adjustments.

13. *A greenhouse climate simulator for testing greenhouse computers. (1): Operation test of ventilation control.* Koazai et al. Japan.

    A system was developed to provide a means to test greenhouse computers by simulating a greenhouse environment.

14. *Greenhouse parameter estimation by recursive least squares.* Okano et al. China and Cornell University, U.S.A.

    A least-squares method (LSM) for on-line calculations used to estimate greenhouse thermal parameters. A loss function with exponential weighting, a "forgetting factor", was introduced into the LSM to slowly eliminate the influence of old data. This LSM has the advantages of estimating several parameters simultaneously, with little computer memory and having short calculation time requirements.

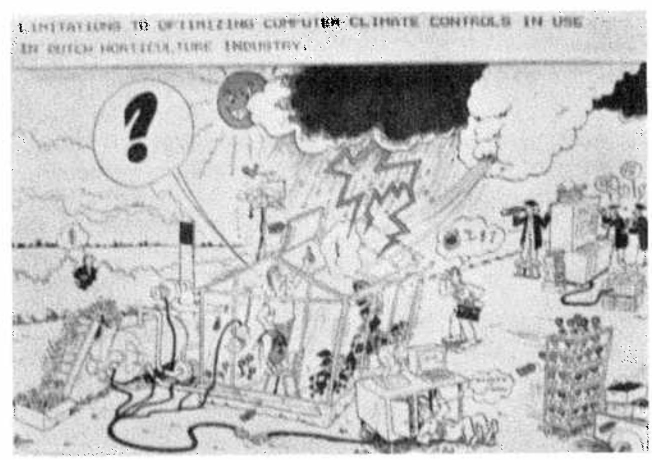
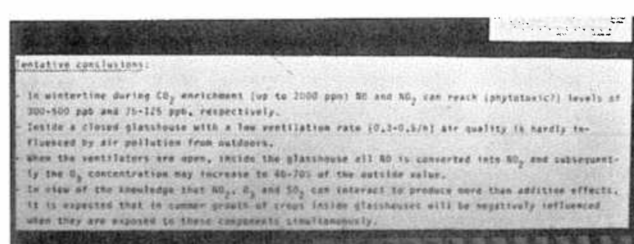


Fig. 1: The Dutch have their problems in this amusing poster by Goeijenbier, The Netherlands. Optimum climate control is hampered by several factors, such as: 1) ability to define "optimum" climate, 2) ability of growers to handle complicated control regimes, and 3) economic factors of cost for the fancy equipment. A remark indicated that some Dutch growers install computers for a tax advantage.



Tentative conclusions:

- In wintertime during CO_2 enrichment (up to 2000 ppm) NO and NO_2 can reach (phytotoxic?) levels of 300-500 ppb and 75-125 ppb, respectively.
- Inside a closed glasshouse with a low ventilation rate (0.3-0.5/h) air quality is hardly influenced by air pollution from outdoors.
- When the ventilators are open, inside the glasshouse all NO is converted into NO_2 and subsequently the O_3 concentration may increase to 40-70% of the outside value.
- In view of the knowledge that NO_2, O_3 and SO_2 can interact to produce more than additive effects, it is expected that in summer growth of crops inside glasshouses will be negatively influenced when they are exposed to these components simultaneously.

Fig. 2: Summation of a poster by Wolting, van Remortel and van Berkel, The Netherlands, dealing with problems of air pollution where combustion is utilized to produce CO_2. If combustion is not complete, NO and NO_2 (nitrous oxide and nitrogen dioxide) increase. This would include possibilities for ethylene. During winter months at Naaldwijk, outside NO concentrations exceeded phytotoxic levels (250 ppb). Ozone may also be high. With several pollutants available, there is likely to be a synergistic (enhancement) effect. Damage from pollution is likely to be greater.

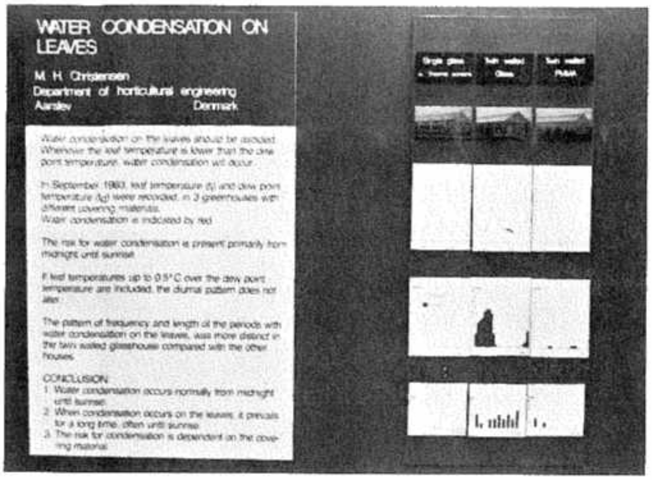


Fig. 3: Poster by M.H. Christensen shows that condensation in glass covered greenhouses in Denmark usually occurs between midnight and sunrise. Long risk periods were more frequent in twin-walled acrylic greenhouses compared to single layer glass with thermal screen, or twin-walled glass.

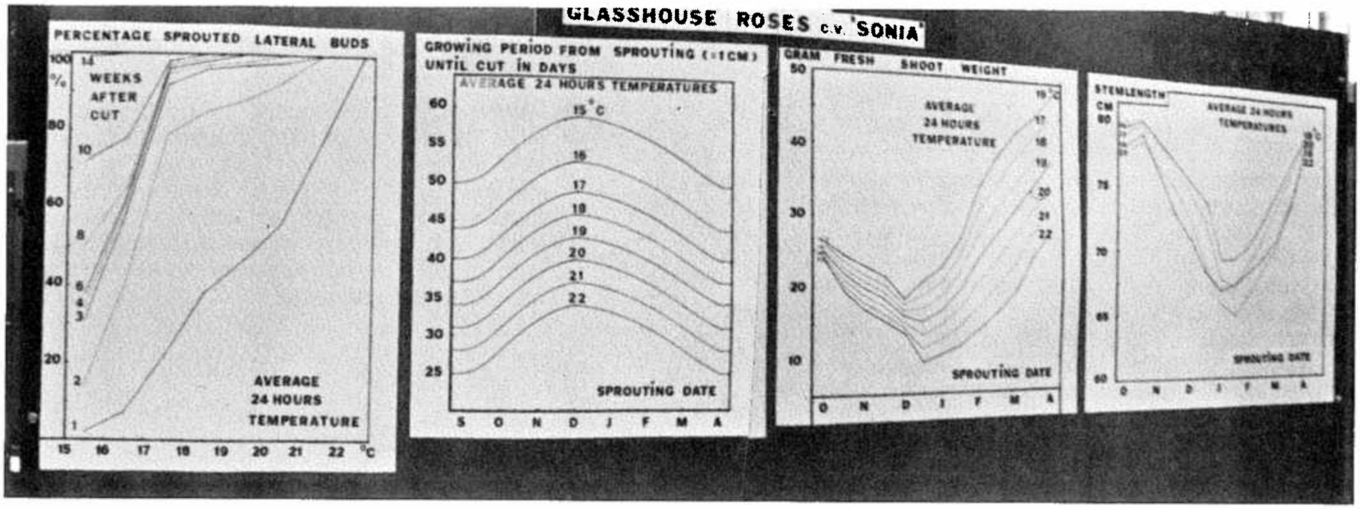


Fig. 4: Interesting poster on the effect of average daily temperature on budbreak, development, fresh weight and shootlength of 'Sonia' by G.A. van den Berg, Aalsmeer. The night and day temperatures over 24 hour periods were averaged from October to April.

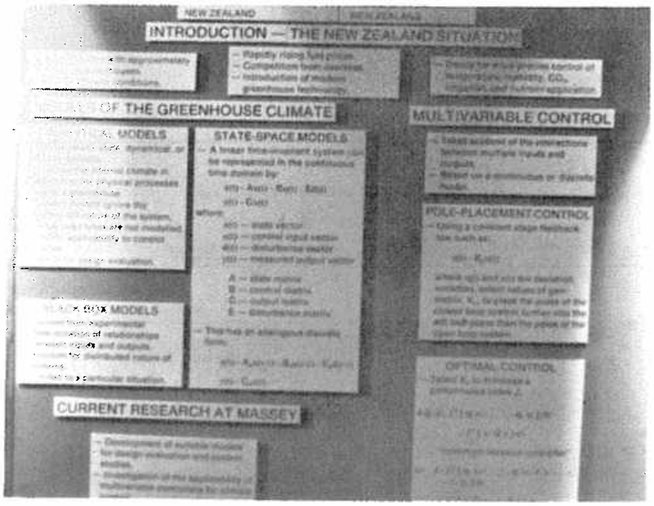


Fig. 5: The poor photograph of a poster by Wells et al., New Zealand, suggests the increasing complexity of climate control in greenhouses. There are several approaches, control methods, and models being examined, which means a grower will have considerable difficulty in choosing systems that may be touted by a salesperson.