Computers and Propagation

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A LITTLE ABOUT OUR COMPANY

Schotte Nurseries is an indoor plant propagation and production nursery. We have approximately 2 acres (8000 m^2) under production in five glasshouses, 1 Hi-Vent house (openable polyhouse) and two shade houses. Indoor foliage is our main production with some flowering lines and "unique living gift" lines. "Growlines" our propagated stock in trays, 5-cm, and 8-cm pots accounts for approximately 25% of the nursery turnover. The nursery has a PRIVA climate control computer operating the climate and water controls which has been in operation since 1981. Control systems in use before the computer were analogue controllers, thermostats, and manual systems.

Commercial Glasshouse manufactures installs and services glasshouses and all manner of related horticultural equipment. PRIVA computers have been sold installed and commissioned since 1981. We have to date installed 65 climate and or water control computers throughout Australia and New Zealand.

In the two businesses at Kellyville we have 19 computers in operation, not including embedded controllers. Propagation nurseries are able to utilise computers in many ways including:

- Bookkeeping (accounts) and business computers
- Data bases and spread sheets for data storage, collection and calculation sheets
- Environment or climate control computers to control heating, ventilation, cooling, humidity, CO_2 monitoring and/or dosing, lighting cyclic or grow, screens for shading, energy saving and blackout, etc.
- Control computers, irrigation, fertilising, substrate, NFT, etc. (fertigation).
- In or on many different types of equipment in the form of embedded computers or PLCs (programmable logic controllers), i.e. printers, fax machines, washing machines etc.

WHY A COMPUTER OR ANY SORT OF AUTOMATIC CONTROL?

Well, it is comforting to know that you can go to church, visit mum, or leave the nursery for any one of a thousand reasons secure in the knowledge that while you are absent your crops will not fry, freeze, wilt, drown, or otherwise succumb to misadventure through neglect. I cannot guarantee that a good controlling computer in the hands of a poor nurseryperson will make him/her an instant success, but a successful nursery operator will definitely benefit from improved computer control.

Business Computers. This is not really part of todays discussion, other than to mention very importantly that sales, orders, and accounts related information are used in production planning, along with past production plans.

Data Bases and Spread Sheets. We use many data base systems for recording, storing, and retrieving in an efficient manner various types of information. For instance, all of our production information is kept in a database. The information kept is the date, product code (with the description from the product file), quantity produced, operators identifier (initials), the source of the material, special treatments (commented on), destination, and time taken to do the whole operation. Similarly, information on spraying, fertilising, and incoming orders is also kept. Most of the databases are cross referenced to other databases where applicable.

Propagation of Cuttings. Cutting propagation relies on promoting root initiation and growth, etc. on the cutting before the energy balance is depleted. All procedures that influence this positively will increase the strike rate and/or yield.

Sunlight, water (H_2O), and carbon dioxide (CO_2) are the main raw materials for plants to produce chemical energy by photosynthesis. Carbohydrate and oxygen (O_2) being the main products of photosynthesis. Respiration is the opposite of photosynthesis where oxygen is combined with carbohydrates to produce energy, with the waste products being carbon dioxide and water.

We use glasshouses with PRIVA computer control to provide us with a well-controlled climate for optimum strike rates and production. The PRIVA control system works with up to 120 settings per climate compartment, and with numerous controlled possibilities that include: misting, irrigation, fertilising, substrate, ebb and flood, and NFT.

Temperature. The primary control parameter to keep effectively in hand is the temperature. This is also one of the easiest parameters to control. If the temperature varies too greatly the humidity will change rapidly and be hard to maintain correctly. The temperature does not need to be, and indeed should not be, flat or the same throughout day and night. However, the temperature should not change quickly. Maximum change rates should be no more than 4 or 5C h^{-1}. The night or low light periods may have a lower temperature. Day to night with a variation of 3 to 5C lower at night is desirable for most crops.

Humidity. With cutting propagation prevention of excessive water loss is the prime objective. Yield is maximised (growth and developed, root initiation) by keeping water moving through the cutting within a temperature range that the plant is "comfortable with" so the cutting is performing at optimal physiological activity. This means not too cold so that some internal systems slow down (i.e., transpiration or photosynthesis) nor so hot that systems go into overload and shutdown (i.e., guard cells close, etc.). If the cutting suffers water stress then its internal systems will also slow, or shutdown, or wilting/death may occur. Therefore, when keeping the temperature up to maintain optimal physiological activity (and therefore yield), sufficient water must also be provided to prevent wilting. These two factors (temperature and water) are in conflict and a balance must be struck to achieve maximum yield (strike rate, continued growth).

Propagation. There are three main areas we place our cuttings.

Dry Bench. Cuttings that can readily control their evaporation in a glasshouse with stable temperature and humidity may be propagated in the normal growing area. In our production facilities this is applicable with 25% of the plants grown, such as with *Peperomia, Draceana, Begonia* Rex, St. Paulia, and *Pedilanthus.*

Mist. Mist is used for plants where maintaining a light layer of water on the foliage is sufficient to prevent excessive moisture loss from the cutting. We use California type mist nozzles with mains (town) water controlled with the PRIVA computer and electrical water solenoid valves. The control parameters the computer uses are misting between start time and stop time with the times shifted astronomically as the day length varies and using accumulated light count (light sum). Light measurement in mWatt/cm^2 is multiplied by time providing a light sum accumulator, J/cm^2. Should the light sum accumulate to the amount set the mist cycle will operate. Should the weather be very dull the maximum rest time may also instigate a mist cycle. On a hot summers day our misting would operate 8 to 12 cycles per day and on dull summer days 5 to 6 times per day. The valves operate for 10 sec each. Mist benches are filled with newly propagated plants and the mist is turned off when the majority of cuttings have rooted (80% to 90%).

The aim of our misting system is to keep a layer of water on the foliage without appreciably wetting the soil. This has the effect of maintaining reasonably good transpiration rates (production) without wilting and without water logging. We do have a little loss of turgidity with some softer cuttings initially which usually recovers in 24 to 48 h. This is more of a problem on particularly hot days. Some hand held hose watering is still required on the mist benches. Liquid fertilising takes place regularly in the glasshouse except in the first 2 weeks after propagation. We use this system for approximately 40% of our cutting grown plants, such as *Pilea, Fitonia, Coleus, Poinsettia,* and others.

Enclosed Tent. This system, tents over the benches, relies on trapping within the confines of the tent the evaporation from the soil, etc. and some transpiration of the cuttings with the intent of keeping the humidity high (usually above 90%). The principle being that if the surrounding air is fully saturated there can be no further evaporation, consequently the cuttings do not wilt or dry out. In reality there will be condensation on the surfaces of the tent and foliage as temperatures change outside and within the tent, this causes the humidity to fluctuate between 80 and 100%. This system relies on having slow changing temperatures and good control of the surrounding environment. Temperature within the tents on summer days may reach 35C or more.

The majority of our seed germinated lines are in seed trays on bottom heat benches. Some types are covered with glass. For a warmer environment. The majority of our tray, tube, pot and hanger lines are grown from cuttings and are propagated directly into the finished pot.

Heating System. With all of the above propagation systems we use bottom heating with 25 mm NB hot water pipes making up most of the support for the bench tops. There are 12 benches to each heating system. Each heating system is fitted with a three-way modulation valve, circulation water pump, and water temperature sensor. These systems are connected to two boilers.

The water temperature sensor measures the water temperature in the heating pipe after the pump. The computer, taking into account the settings programmed and other influences, calculates the water temperature required in the heating pipes should heating be required. The computer drives the three-way valve to a position that mixes the correct amounts of return water from the heating system and from the boiler to provide the wanted heating water temperature to an accuracy of 1C.

The control principles the computer uses is Pre Control and PID control, (Proportional, Integral and Derivative). The Pre Control works on the basis of outside temperature, wind speed, and wind chill factor setting the base heating water temperature and proportional band, i.e. the lower the outside temperature, the higher the basic minimum water temperature will be and along with a higher wind speed would increase the basic water temperature. There are also a number of settings in the computer to set the glass house characteristics in the computer, most of which are set by the installer, ie. the size, effectiveness, driving speed, running time, compass direction, wind side or single side vents, hysterisis, and many others.

Proportional control calculates an offset temperature relative to the temperature difference to outside. The integral control calculates the step size that is required to move the mixing valve to the correct position. The integral component calculates the time dependent variations for the P and I control components to have the temperature as accurately as possible follow the calculated heating temperature. This type of heating control calculates a desired water temperature in the heating pipes to equalise the energy losses from the glasshouse very closely.

Research has shown that for the average glasshouse if the temperature is approximately 2.5C higher than it should be whilst heating then double the energy is being consumed. At 5C too warm, energy usage will be approximately four times higher. The computer control system we use keeps the house or the bench temperature within 1C of the desired calculated heating temperature.

The ventilation is controlled in a similar manner with the computer calculating the required vent position. Shading systems for shade and energy saving usage have a more specific control system, operating between start and end times with light, temperature, humidity, heat loss, and many other factors. Effective shading control is one of the more complicated systems.

Computer. Some of the settings applicable for a controlled growing area such as a glasshouse or greenhouse are: heating temperature day, heating temperature night, ventilation temperature day, ventilation temperature night, light increase/decrease heating, light increase/decrease ventilation, relative humidity day, relative humidity night, heating limits, and ventilation position limits. There are many more settings.

For the new "Integro" range the 24 h period is able to be divided into periods denoted by a start time. Up to four periods are possible.

THE NITTY GRITTY

Climate and Hydro Control Computers.

1) From the simplest, doing it manually. Opening a vent or turning on/off a heater. Usually done when the person doing it remembers, and this is usually too late. Sometimes forgotten. Capital expenditure almost zero. Running expenses extremely high, 7 days a week with penalty rates etc. without even taking into account the loss of production. Results—fair at the very best.

2) A simple on/off thermostat. (Actually a binary switch). Works 24 h a day. Has the problem of a differential (i.e. turns on at different temperature than it turns off heating on at say 16 off at 20); a differential of 2C is better than a larger one. Over and under shoot

may also be a problem. When the heating turns on there is a delay before the heating actually catches up, during which time the temperature continues to fall. A similar condition happens at the turn off end. This may cause temperature cycling of more than 4C, i.e. 2.5C overshoot for say 25% of the heating period, adds approximately 25% to the heating costs. The problem being accentuated when heating loads are small. Time switches do not have the differential and over/under shoot problems. Capital expenditure moderate, thermostats of good quality approximately $75, timers approx. $50 to $150 plus installation costs. Running expenses much improved. Thermostats with day/night capabilities have more improved running expenses. Results—fair to good.

3) Simple controllers computerised or analogue. Usually operate a single controllable item, i.e. a heating system or a ventilation system. Proportional or PID control is the usual method. Sometimes fitted with day/night switching. Capital expenditure for the control system, sensor/s and actuators is usually more than $2000 per controlled parameter. Running expenses on a well designed system would be 5% to 15% less than thermostat. Some quick calculations on the running expenses (energy usage, etc.) will show if this type of option is economical. Results are usually very good.

   All of the above systems usually work on a single unit of control, i.e. one heating system or one vent. There is also no interconnection between parameters. With larger amounts of controlled parameters having them set correctly relative to one another may also be problematic.

4) Computers of the PLC types. There are a number of growers tackling the control of their environments with PLCs. With the Omron or Hitachi types the capital expense is usually much lower than purpose built horticultural computers. The software development of these systems with simple control is usually quite extensive while full, Pre and PID control across the many parameters is rarely achieved. Controller costs per house depending on input and output parameters would be $600 to $2500. Software and debugging costs vary depending on the programmer. Nil for the home developer to an almost endless cost for consultant development. The running costs of the controlled environment vary between thermostat type control to the best possible.

   A further possibility is the use of PCs (personal computers) fitted with input and output capabilities. The programmability is somewhat easier than PLCs. The software development is similar to PLCs. The ability of the equipment to keep running reliably day after day for many years is still a serious question (without needing resets or reloading of programs). The capital equipment costs vary depending on system development from $4000 to prices similar to specifically designed computers.

5) Computers of the type specifically designed for horticultural use. Usually have the programs in Firmware, i.e. in EPROMs or similar, with simple and dedicated user interfaces. Will have been designed with extreme reliability in mind (in amongst rural mains voltage supply variations, lightning, and a myriad of other consequences.) The main consideration being that a grower's livelihood and ability to make profits relies heavily on effective control of all of the parameters of the growing climate and water regimes. The software development has been extremely well worked out with R&D and grower feedback continuing. Capital costs depend on the size, compartments, and hydro requirements. A nursery with say three compartments climate control would be approximately $20,000. A hydro controller irrigation and fertilising for say three controllers and 100 valves would be about $19,000. For a hydroponics installation NFT, one system about $14,000. These include installation, commissioning, and grower training. The gains in running costs are high, i.e. for a heating system a minimum 15% in energy savings. Increases in productivity are always noted. Growers using this type of equipment have distinct market advantages with the ability to control the climate and consequently cropping. With the above the equipment to be controlled, i.e. mixing valves screens or vents, etc. are not included.

This is by no means an exhaustive study of computer control in nurseries and propagation facilities. There is a publication available in Europe that discusses, climate control in glass and greenhouses. "Computerised Environmental Control in Greenhouses" a step by step approach. The author is P.G.H. Kamp/G.J. Timmerman. The publication is in English.

Acknowledgments. I wish to thank my wife for her help and patience in compiling these notes, and also the staff of our company for their contribution.