mately rooting in their two or three litre saleable pots. This seems only possible in the warmer months when bottom heat is not necessary.

Algal growth is not a problem with our unit, either on the polythene or paths. However, heavy shading is important to reduce the brightest sun. Having a fairly heavy shade, high temperatures, and high humidity we have encountered few problems of weaning-off cuttings before they are potted, however a good watering-in is important.

Fogging in tunnels is a very adaptable system when using variable amounts of fog throughout the year. We can root our cuttings, callus grafts, and germinate seeds as well as rooting conifers and weaning micropropagated material. We find the equipment easy to manage and problem-free.

THE SPECIFICATIONS FOR NEO PLANTS' NEW PROPAGATION UNIT

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INTRODUCTION

This paper describes how the specification for Neo Plants' new propagating house was drawn up. Decisions have to be influenced by existing circumstances, so while the ideal would be a bare field site and unlimited finances, few small companies would be so fortunate.

Neo Plants needed to expand its facilities in 1983 and bought a typical west Lancashire tomato nursery at Freckleton. It consisted of a 6ha site with a large bungalow, 1ha of venlo glass and two large sheds. Both laboratories and offices were housed in the bungalow and the nursery had good growing facilities which could be adapted into weaning and growing houses.

THE FIRST WEANING UNIT

Four years ago weaning micropropagated plants was a new science, especially for Neo Plants. Initially, only part of the available growing area was needed.

A weaning unit was set up in an existing 1000 sqm house, using three bays of the seven bays. Flexiheat electric underfloor bed heating was installed. Air heating was piped from a small package boiler and a fixed thermal/shade screen of woven polypropylene material and a MacPenny fogging system were installed. The weaning area

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was separated from the rest of the house by a polythene partition.

Various modifications became necessary. The number of fogging nozzles had to be increased. Improved partitions were needed to maintain humidity and to seal up all gaps and holes which seriously affected the weaning of the plants. Doorways also caused a problem.

The remaining four bays of the glasshouse were used as a hardening off/growing area for early production which required heat. The remainder of the nursery was cold houses which could not be used for weaning before April.

EXPANSION

At the beginning of 1986, Neo Plants proposed to increase production from under one million plants per year to three million for the 1987 season. Extra facilities would be needed to accommodate this increase in production. The weaning/fogging area needed to be extended and the cold houses needed frost protection. Additional space was necessary for pricking out, tray filling, compost mixing, etc. and a better method of moving plants around the nursery needed consideration.

Proposal 1: To expand existing house. The weaning unit was set up so it could be expanded by using the whole 1000 sqm of the house. This, however, was discounted for the following reasons:

1. The pipe layout was not suitable, there being no perimeter heating, the main pipes were in trenches, the heating loops too low.
2. The boiler was in an unsuitable position and would have to be moved.
3. The vent system was inadequate, in fact non-existent above the screen because the house was too low.
4. Electric soil heating is too expensive for such a large area.
5. The bed layout resulted in poor use of space, over one-third being non-productive. (1 metre path every 3.2 metre bay)
6. There was no work area available for pricking out, tray filling, etc. within the area.
7. The fog system compressor was too small.
8. The house was on a slope and fog drifted to one end.

Proposal 2: To convert one of the other houses. A specification was drawn up and quotations obtained to convert a neighbouring house into a weaning unit, and build a work area and mixing extension. The cost worked out to be far more than we had anticipated. Also, we would lose a growing house needed for the extra production. The capital cost would be unjustified for what would end up as a compromise at best. We decided to increase the budget to build a new house to our "ideal" specifications based on experiences to date.

Proposal 3: To build a new house. We decided to build on a field at one end of the nursery, adjacent to an existing glasshouse. Here there would be access from the back road; services of water and electricity were available at the old propagation house and oil for heating could be piped easily from the bulk tank. A weaning house here would reverse the whole nursery causing the weaned plants to be nearer the nursery entrance when ready for dispatch.

An area adjacent to the new house, which had been used as a propagation house when the nursery was a market garden, and which had a concrete floor, would be converted into a work area for mixing, tray filling, and pricking out. This would be linked to the new house by a small extension to be used for boilers and controls etc., thus avoiding taking up propagation space with them.

By linking the house in this way we created a unit of nearly 0.75 ha under cover from the new weaning house, boiler house, work area, and four existing growing houses along a central corridor. Access would be via the corridor for pedestrians and by the back roadway for vehicles.

THE HOUSE AND ITS ENVIRONMENT

Up until the time the plants leave the growth rooms, they have been held at temperatures ranging from 18° to 25°C. It is necessary to provide a compatible temperature for the plants when they are pricked out, between 16° and 18°C minimum day temperature. To encourage rooting, base heating would be required at about 20°C. This also would provide the right microclimate at plant level via the moist sand and compost. Electricity would be too expensive to heat such a large area, so a low temperature hot water system beneath sand beds was chosen. The air heating would be provided by 51mm pipes suspended from the trusses and additional pipes around the perimeter.

Two boilers would be required, of 60 per cent total capacity each, to cover for break downs.

Light. The growth rooms have given the plants a regular daylength of 16 to 18 hrs every 24 hrs. It would be necessary to ensure that plants leaving these long days do not suffer when daylength is reduced, so night break lighting would be required.

Shade. Too bright an environment would cause losses from scorch. Shade also prevents the temperature rising too high, so a system of screens would be required. A mobile screen in the roof acts as a shade screen during the bright days and a thermal screen at night. Side screens are primarily for shade but do give added insulation at night. The material chosen was LS15 to give 50 per cent shade.

Humidity. Plants growing in culture are in sealed tubs. The relative humidity inside these tubs is in the range of 95 to 100 per cent. This high humidity causes the stomata in the leaves to be permanently open and they have not started to function normally at this stage. Also the cuticle on the leaves is not formed or is incomplete. *If such a plant was to be pricked-out directly from culture into* a dry atmosphere, it would wilt and scorch. It is, therefore, important to provide a fogging system to maintain a high humidity which reduces the transpiration rate to a minimum during the first few days or weeks of weaning into soilless composts. The fogging system must maintain a satisfactory atmosphere of 85 to 95 per cent RH but at the same time not cause any wet areas under nozzles. The systems considered were MacPenny, D.G.T. and Climatic Controls.

Cooling. During humidification in periods of normal temperatures, 18° to 28°C, the foliage should remain as dry as possible. However, when the temperatures start to rise higher, then a cooling system provided by a very fine jet of water for a few seconds is very useful, so long as the plants do not remain wet for long periods. One such system seen in Holland, manufactured by S.K.V. uses a water pressure of 30 atmospheres and could be controlled from 1 second to 59 second bursts.

Ventilation. Some ventilation would be needed when it becomes too hot. It is limited to the leeward side only, and in most cases that is all that is needed. Automatic vents would be needed on both sides of the ridge. A fixed screen would be required to maintain the humidity in the glasshouse growing area while the vents are open. It should be as light as possible so as not to reduce the light penetration in winter. It was for this reason we chose the polyester cloth L.S.10 which gives a 22 per cent shade and 40 to 45 per cent energy saving.

Insulation. To maintain an even relative humidity throughout the house, it must be well insulated. A cold draught would soon cause plants to wilt and die. This was very noticeable in our existing fog house which was far from perfect due to poor partitions and doorways. Double glazed sides and gables would be required, to reducing draughts in addition to saving energy.

Access. Good access doors are necessary and, once inside, the movement over the house should not be impeded by fixed equipment such as heating pipes. It was, therefore, decided that all heating pipes should be overhead and around the perimeter. No pipes should be in trenches. The mains supplying the base heating should not restrict movement across the house—hence they were to be fed from the far end via mains down each side and not near the header path.

Computer Control. A computer controlled environment, integrating air heating, base heating, humidity, ventilation, screens, and lights would be required and, in addition, a means of recording this information for future reference.

The Glasshouse. Taking all these factors into consideration, glasshouse manufacturers were contacted to see what types of glasshouses were available. The standard Venlo, double and triple Venlo, and the single span houses of 6 to 8m wide were considered. A house which would provide as clear a floor area as possible, with the minimum number of paths, would be ideal. It would be essential to make use of as much of the heated floor as possible but at the same time to leave access for plant movement. The standard 3.2m wide Venlo was far too restricted. Our existing fogging house of this type had 45 per cent of its floor area unproductive due to pathways down each bay and header paths at each end.

The triple venlo was also dropped because the area chosen for the new house was only wide enough for eight standard 3.2m bays and nine would be required to accommodate three triple bays.

Quotations for double Venlo houses of 6.4m and the single span houses of between 6 and 7m were sought.

DRAWING OF A SPECIFICATION

Advice was sought from various glasshouse manufacturers and other interested parties. Visits were made to other nurseries to look at their houses and equipment and the owners were asked if they were satisfied with their installations. If they had had more than one make of house, or more than one contractor to install the heating, etc., why did they change? Trips were made abroad to Dutch glasshouse manufacturers, irrigation companies, and nurseries.

One of the major difficulties was that there were very few glasshouses with fogging systems, especially a single unit in the region of 1000 sqm. In addition, most growers did not use their unit for weaning micropropagated material and so they ran the system in a different manner to the way we would need to use it.

By July 1986 a specification was drawn up to cover the glasshouse, heating, screens, and fogging required. This was sent to 10 companies. We gave plenty of detail of our requirements, under main headings such as Dimensions, Heights, Vents, Doors, Paths, Storm bracing, etc. followed by short descriptions or measurements required. The more detail given at this stage the less likelihood of any errors or misunderstandings by the contractors.

EVALUATION OF THE QUOTATION

Seven quotations were received, five from manufacturers of the double Venlo (Bridge, Wilco, HOK, Simpsons and DACE), and two for single span houses (Cambridge and Robinson). To give complete flexibility, we also received quotations from:

Climatic Controls for their fogging system, screens, and computer; MacPenny for the fogging system; Victor Automation Systems for their computer; Van Vliet for their computer; Southern Heat and Controls for the heating, fogging, and computer.

When all the quotations were received, a master sheet was drawn up to compare one company with another. Most quotations gave a breakdown of the cost for each section or part of the quote, so aiding comparisons. In comparing prices, care must be taken to ensure that all requirements have been covered.

Glasshouse comparisons. The single span houses were more expensive than the double Venlo. They were more or less the same size so it was felt for this factor alone they gave no advantage.

Both Robinsons and Cambridge houses have good continuous rack and pinion vent systems and the higher ridge would provide a large buffer of air above the screen which can be an advantage to equalise extremes in temperature below the screen at plant level, especially important during very hot days and very cold nights.

The installation of screens in single span houses is not quite as straightforward as in the double Venlo where it is fitted horizontally to the roof truss. The truss in the single span houses have side braces which would protrude below the screen or involve a more complicated screen support system which, in our view, did not look as good as the horizontal screen fitted to the lattice truss of the double Venlo.

Comparison of heating systems. The construction of the heated sand beds differed widely among companies. All companies used buried PE plastic tube but the major variation was in the spacing of the tubes from 0.8m apart for Wilco and DACE, 0.6m for HOK and 0.2 m for Bridge, Simpson, and Southern Heat.

The first three companies were using pipe spacing that is popular in continental Europe for under soil heating where the pipes are buried to a depth of about 0.4 to 0.5 m, unsuitable for a sand propagation bed. Also the companies with wider spacing did not want to construct the sand beds. They would leave the plastic pipe etc. for us to lay and connect up when the beds were complete.

Southern Heat and Controls Ltd covered the whole aspect of sand bed construction in their quotation, from 50mm depth of pea gravel on the base for drainage followed by 25mm polystyrene sheets covered with polythene. On top of this the PE pipes are laid and pegged down at 200mm spacing followed by the 100mm sharp sand cover.

THE FINAL CONTRACT

The ideal quotation to accept would be from a single contractor who can do all the work from the glasshouse construction to the final electrical connections. This simplifies matters considerably because if there is a delay in one part of a contract then there is a knock-on effect which upsets the plans of the other contractor if the contract is split. On the other hand, one should not only look at full contracts but leave options open, contacting companies supplying the computer control, fogging systems, heating and screens separately. In the end we decided to split.

One of the visits made earlier had been to Findons Nurseries at Stratford Upon Avon where we were shown an installation nearing completion by Roger Saint of Southern Heat and Control Ltd. This was a propagation house built by Bridge and heated by Southern Heat. It consisted of perimeter and overhead heating pipes and a heated floor similar to the one we required except that it was concreted after the pipes had been laid. We were also shown the D G T fogging system in another house.

It was very impressive and certainly appeared to provide the correct atmosphere. There was no fall-out onto the plants, which was a problem with some systems we had seen. The cost was also considerably less. Therefore we offered the contract for heating, both piped and soil, the sand bed construction, the boilers and related equipment, together with the computer and controls to Southern Heat and Control of Spalding.

We considered that this company would provide the best system to suit our needs and they were used to the construction of heated sand beds. They had also worked closely with the D G T fogging system and computer control, which we considered would give us the best fogging system we had seen, linked with a very good computer.

The glasshouse was to be from one of the double Venlo companies and we had a short list of four—Bridge, DACE, HOK, and Wilco. The house we were to build was on an exposed site and was to be higher than our existing houses, so it was felt that the construction must comply with Dutch building standards. A cheaper quotation was therefore dropped as it was too weak, the double venlo steel specification being identical to the single. There was not a lot to choose among the others, they all seemed to provide what was wanted, with slight variations. Bridge's quotation, together with Southern Heat, satisfied our requirements but they could not guarantee completion by the end of the year due to their other commitments.

The final decision was made more by the need to start than anything else. We wanted completion by the end of December. The decision was made to have the Van Der Hoeven house supplied by DACE through Mr. P. Bishop of Commercial Greenhouse Sales, who is now acting as agent for Van Der Hoeven direct. They were also to supply the thermal screen.

IMPROVEMENTS AND ALTERATIONS

Although we have the best structure and equipment circumstances allowed at the time, after nine month's use, the need for some modifications and improvements has become apparent, which could be considered in any future expansion:

1. The possibility of a further 0.5m in height to ensure adequate

space for the equipment in the roof-fogging, heating, screens, and lights.

2. A slightly thicker mobile screen material of LS16 to give a 60 per cent shade. This is most important to keep the house cool in very hot weather.

3. The possibility of roll-up side screens, rather than one which moves with the roof, to give more flexibility.

4. The inclusion of a secondary cooling system in addition to the fogging system for use when temperatures reach 30°C. This would take the form of very high pressure spray lines in the region of 30 atmospheres. This was considered for our present house but was dropped because of cost.

5. Control of the water and air temperature used in the fogging system is non-existent. A means of cooling these in summer would be a great advantage in keeping the temperature down.

CONCLUSIONS

Allow plenty of time for building. Ensure that the site is levelled well in advance of the starting date, to give time for the land to settle and give a reasonable working surface from which to build. Failure to do this may, in a wet season, result in a mud bath. The removal of between 150 to 200 tons of mud from inside a glasshouse, with shovels and dumper truck, for two weeks in December, is something I am not likely to forget.

ULTRASONIC FOGGING SYSTEM—SONICORE NOZZLES

J. DONOVAN

Lucas Dawe Ultrasonics Ltd.
London W3 OSD

To obtain best results from a fogging system each water droplet must be of the correct size. The smaller the droplet the larger the number present from a given volume of water. It is the greater number of very small water droplets that gives optimum coverage and distribution of the fog.

Fog works because the small droplets, with very little mass, stay in suspension drifting with any air movement until they evaporate. Large water droplets must not be formed as these will fall in the immediate area of the nozzle causing overwetting.

Sonicore atomising nozzles can produce much smaller droplets than conventional nozzles. The nozzles are air-driven "acoustic