TRENDS IN GREENHOUSE CONSTRUCTION

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Like all other sections of primary industry, pressures are being applied to the greenhouse producer, particularly from increased costs. To meet these pressures, all aspects of the industry have to be looked at critically. The capital cost of the structures and equipment to be used in the business and the running and maintenance of the business form a large part of the costs, and these costs are all interrelated. There is not much point to attempting to use old greenhouses, or to use low cost houses, if these incur a large penalty in operation costs, e.g. labour and fuel. Protected cropping requires a good deal of capital, particularly in automatic environmental control and watering equipment. Thus, there should be considerable care taken in selecting the type of house to be used.

There are three basic types of greenhouse — narrow span or venlo, medium span, and widespan. A low cost alternative is to use plastic film over a simple framework of wood or pipes; these will be discussed later.

Widespan houses, 60 to 90 feet wide, are no longer economic. They may cost 50% more than the equivalent area of medium or narrow span house and maintenance is much more difficult. The tendency today is to build medium span houses about 7 metres wide, or venlo type houses 3.2 metres wide. Actually venlo houses can be built on a truss to give a clear internal span of 6.4 or 9.6 metres, so that the essential differences between the two types is: (1) method of construction of the roof, and (2) the glass size. Each slope of the roof of the venlo consists of a single sheet of glass, with 60 cm glazing bars, while a modern aluminum-framed medium span house has glass measuring 80 x 100 cm.

Whichever type of house is selected, it should have plenty of headroom to allow good air circulation. This is particularly important under Australian conditions, where a height under the gutters of some nine feet is desirable. When a new house is being built, make sure that the house is as large as possible, to reduce the outside surface area through which heat can be lost. For example, three houses, each 60 feet by 20 feet, have a total sidewall area twice that of a single house 60 feet by 60 feet. On the other hand, the larger the house the more difficult it is to ensure adequate ventilation in the centre. If a venlo type house is selected, the system of roof vents supplied with these houses will allow adequate ventilation in the centre of quite large blocks.

It has been shown at the Institute of Horticultural Research, Wageningen, Holland, that in a comparison between different types of houses, the medium span house produced the largest and best quality vegetable crop. However, the venlo house gave the best return in relation to capital and running costs.

Venlo type houses have other advantages. The edge of each pane of glass can be sealed into the glazing bars or frame, so that the whole house is comparatively airtight, and allows better retention of CO_2 if enrichment is practised. In a similar wind the venlo will have less air change then a medium span house, thus saving heat.

Both narrow span and medium span houses can be built of a variety of materials. The most popular combination, at the present time, seems to be a steel frame, preferably galvanised, aluminum glazing bars in the roof and wooden glazing bars in the sidewalls. However, the use of pressure-treated timber for the framework should not be overlooked. Factory made trusses from pressure-treated wood can give a saving of 40% in the framework of the house, and will last as long as steel. A timber framework does have the disadvantage that the members have a greater cross-sectional area than steel or aluminum, but if a plastic covering is used a wider spacing of the trusses may be permissible, thus overcoming this disadvantage.

In the UK there is an increasing use of structures covered with plastic film, though rigid plastics are not common. The film-covered structures are based on pipe-framed tunnels which may be single or multispan, but in Canada these are timber-framed single span structures, with a few examples of aluminum-framed tunnels.

In the UK the general opinion was that single tunnels are uneconomic to heat, but are cheaper than multispans to build. In 1973, single span tunnels were available, in kit form, at about $4,500 per acre, while multispans cost about $6,000.

It is estimated that replacement of the plastic film would cost about $600 per acre every second year and this is comparable to a cost of $200 per acre for cleaning glass. In some cases the plastic film will last 3 years.

Shelters clad with rigid plastic are not widely used in England or the Netherlands. Work in Yorkshire has indicated that GRP clad shelters are slightly better in winter than film covered structures, but have no advantage at other times and cost twice as much (as the film-covered structures). On the other hand, rigid plastic is widely used in Canada, particularly GRP coated with acrylic. This material is guaranteed to last 20 years, and has been used on some large tunnel shelters in Adelaide. Rigid PVC (polyvinylchloride) is not satifactory as it darkens too quickly. Ac-

rylic is used on post-entry quarantine greenhouses that have been built in various parts of Australia.

Acrylic sheeting, used as a greenhouse covering in preference to glass or other plastics, has possibilities in giving substantial financial benefits. To obtain full benefit from its properties, transmission can be increased by improved greenhouse profile and corrugation of the material to the optimum profile; the corrugation is made so that the crests and troughs since have an included angle of 100^0 and allows the material to be self-supporting. There is an increase in surface area, allowing a greater dissipation of heat; this disadvantage may be outweighed by the increase in light transmission due to the deletion of the glazing bars.

In a plastic film-covered structure the actual structural details have been well developed. The Lee Valley Horticultural Research Station at Hoddesdon, just north of London has finalised designs for single, double or multispan tunnels with frames made of one inch galvanised iron pipe.

This Station has also constructed a single tunnel covered with a double film of 500 gauge plastic with air blown between the layers by a small electric fan. The main object was to reduce the heat loss, which it did by about 20%, but there was a corresponding loss in light transmission of between 7 and 10% and it was felt that this would outweigh the benefits of the insulation. This may not be applicable in Australia with its higher light intensities.

Adequate ventilation is most important, and despite the cost, a combination of vents and fans will give the best result. Fans are essential to ensure air movement when there is little wind, but vents will give adequate results on many occasions as well as offering a "fail-safe" capability in the event of power failure. Vents can be opened by hand if necessary, even though it may be difficult.

The design and installation of both heating and cooling systems is an integral part of the overall design of the greenhouse structure, whether it be clad with glass, plastic film or rigid plastic. In the larger blocks of venlos, mechanically-operated roof vents are the only method of getting fresh air to the centre of the house. In the smaller blocks, particularly in England, fans are mounted in the sidewalls, with opening vents in the opposite side of the house. These vents may or may not be fitted with pads.

Plastic film tunnels cannot be made with roof vents, so they rely on exhaust fans mounted in the ends, or simply have removeable end walls. Work is being done at Lee Valley E.H.S. with inflatable ducting as a means of closing vent openings along side and end walls.

Recent developments in cooling use the production of mist or spray directly in the air in the house as a means of cooling the

plants. It has been shown that damping down of plants, together with a minimum of ventilation, can result in leaf temperatures as low as those produced by any other commercial system. The mist or spray can be produced by mechanically operated spinning units or as a coarser spray by various simple nozzles. These can also be used to water the crop. It is reported in England that a side benefit to the use of damping down is a reduction in attack by mildew in tomato crops.

In the past it was considered that piped heating systems were far more efficient than blown air systems, as heating engineers maintained that the latter type of heating was inefficient and created different heat levels throughout the house. This is quite correct when free blowing heaters are used, but a well designed ducted warm air system can be as efficient as a piped hot water, and have a lower capital cost. The type of system is not so important as the efficiency of each part. The burner unit (and boiler) are most affected by the quality of the maintenance. It is suggested that before the heating unit is selected you should look closely at that section of the market where there is most demand and volume of sales. It is here that competition and development is most intense, and that best value for money can be obtained. Today this section covers the domestic area, and many of the units developed for domestic use can be adapted to greenhouse use.

The choice of fuel is dependent on many factors, but primarily cost per therm (100,000 BTUs).

There are two particular aspects of greenhouse construction with which I have been associated. The first concerns the transmission of light through glazing materials with shaped surfaces, and the second is with the development of a greenhouse for post-entry quarantine.

The work done with glazing materials parallels work done by Professor Nisen in Belgium. When the angle of the lower surface, to the plane upper surface of the glazing material exceeds the critical angle for internal reflection within the glazing material, the effect is to reduce the percentage transmission at low angles of incidence, but to have relatively less effect at angles of incidence greater than about 25°. This effect can be used to reduce transmission in the height of summer, but to allow nearly the same transmission as a smooth material in winter.

The greenhouse developed for post-entry quarantine has a number of unique features. It is clad with a pyramidally embossed diffusing acrylic, has a curved roof and is adaptable to different climates and uses. In the form as constructed for quarantine this house is relatively expensive, but many of the features could be used in a commercial house.

The house is engineered to withstand 100 mph winds, but be-

cause of the light weight and integral strength of the acrylic has an extremely light frame and thus allows maximum light penetration. A steel frame would have an even smaller cross-sectional area. Because of its tight construction, this house requires a minimum heat input, but at the same time can be opened to allow maximum ventilation in summer. As a final point, the strength of the acrylic makes the house quite resistant to hail damage.

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Ed. Note: The article by Prof. M.G. Mullins, University of Sydney, "Propagation of Virus-Symptomless Material," which appeared in the Australian Section of Vol. 23 (1973) was prepared from a transcription of a tape recording. Due to a misunderstanding, the article went to press without the author having seen the galley proofs.