DESIGN CRITERIA FOR LIGHT ADMISSION

MERVIN EARL DUNN

Valley Orchids Pty. Ltd.
Reynella, South Australia

Plants do not live by light alone. There are other factors which affect their performance, among which are air, water and nutrients. But it is to the intensity of light that the levels of supply of all these other factors must be balanced.

So if the intensity of light which is admitted to the planthouse can be automatically adjusted to the "ideal" intensity at all times, it becomes easier to maintain the levels of supply of the other factors (air, water and nutrients), in balance with the intensity of light and in balance with each other. Rewards measured by the plant's performance will follow accordingly. The intensity of light applied to the plants is, therefore, the prime item for consideration in planthouse design.

To every plant on earth Nature provides an ever-changing intensity of the sun's radiation — light. At any point on earth the sun's radiation is different every second of the day. It is different on every day of the year. It is also different at any two points on earth. Since time began plants have been accustomed to this ever changing intensity of light and, for best results, they still perform best under such conditions. So the first criterion in the design of a planthouse is to provide an ever changing intensity of light admitted to the plants throughout the whole of the day and it should increase or decrease slightly for each day throughout the year. There are no constants in Nature.

Planthouses are built in Adelaide to culture plants which have a genetic makeup accustomed to the relatively constant light (and heat) of the tropics. They are built also to culture plants in their juvenile stage, a time when they require more constant levels of supply of light, air, water and nutrients, than those provided by our climate. So the second criterion for the planthouse design is that it should automatically modify the sun's radiation of our latitudes to be more akin to the relatively constant light of the tropics.

All plants grow their leaves, modified in form within the limits of their genetic makeup, to suit their climate, in particular to suit the intensity of light applied to them at the solstices. They are accustomed to a gradual change between these times and, therefore, do poorly under sudden changes in the cycle, such as when temporary shading is applied or removed. Such practices reduce the plants' yields accordingly. So the third criterion for light admission is that only gradual changes in the intensity of light are to occur between the solstices.

We know that the tropics are always hot and that the polar regions are always cold. We also know that our own winters are cold and dull and our summers hot and bright. The causes of these extremes are the effects of two natural phenomena:

(1) The sun's changing apparent path in the heavens throughout the year.

(2) The light transmission co-efficients of the atmosphere, the transparent barrier which surrounds the earth.

THE SUN'S APPARENT PATH

The sun's apparent path at our Southern Hemisphere winter solstice is over the Tropic of Cancer, 23-1/2° north of the equator. On this day the sun's maximum altitude at noon solar time, when its bearing is true north, is but 31-1/2° above the horizon. The point of apparent sunrise is 28-1/2° north of east and apparent sunset is a corresponding point north of west (See Figure 1).

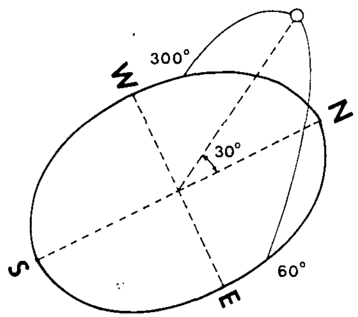

Figure 1. Sun's Apparent Path — winter solstice, Adelaide latitude, −35.030°.

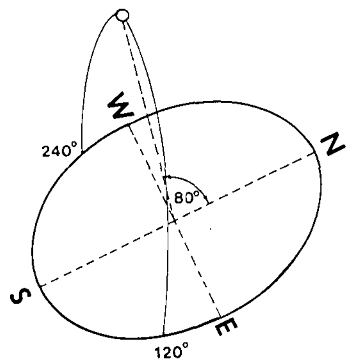

Figure 2. Sun's Apparent Path — summer solstice, Adelaide latitude, −35.030°.

At our summer solstice, the sun's path is over the Tropic of Capricorn, 23-1/2° south of the equator. It has moved 47° from its winter path and its maximum altitude is 78-1/2° with apparent sunrise at 28-1/2° south of east and apparent sunrise at 28-1/2° south of west (See Figure 2).

Note also, by counting the number of days elapsed between the equinoxes when the sun's apparent path is over the equator, that the earth takes but 179 days to travel through its lower apsis compared to 186 days for its higher apsis. Accordingly, the summers of our Southern Hemisphere are hotter, brighter and of shorter duration than are the cooler, milder, longer drawn-out summers of the Northern Hemisphere. Planthouses are therefore considerably more difficult to operate all the year round in the Southern Hemisphere than are similarly constructed planthouses in the Northern Hemisphere.

The light transmission co-efficients of the atmosphere are such that, at Adelaide, for the month of July, the daily amount of solar radiation which reaches ground level is expressed as 7.22 megajoules per square metre. For the month of January, the daily amount is 26.2 megajoules/m^2. That means there is almost four times greater solar radiation daily near the summer solstice than there is daily near the winter solstice (See Table 1).

Table 1. Mean solar radiation at ground level in Adelaide, Australia, for the years 1959 to 1975.

MONTH	MEGAJOULES M^2/Day	INCREASE July = 1.0
January	26.92	3.8
February	24.02	3.0
March	19.03	2.7
April	12.93	1.8
May	8.71	1.2
June	7.42	1.0
July	7.22	1.0
August	10.34	1.4
September	14.65	2.0
October	19.65	2.7
November	23.71	3.0
December	26.04	3.8

Fortunately, all transparent barriers have somewhat similar light transmission co-efficients. Sheet glass transmits 90% of the sun's light (the maximum transmission) when the radiation is normal to the surface of the glass. As the angle increases from normal to normal + 45° the percentage transmission remains constant at 90% but then falls off rapidly as the angle increases further from Normal to be nil at normal + 90° (See Figure 3).

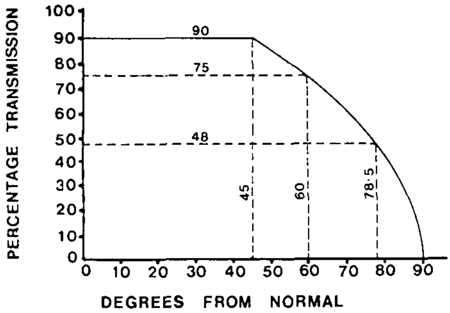

Figure 3. Light transmission of window glass.

Calculating from the light transmission co-efficients of glass it is noted that the transmission through glass fixed horizontal (normal + 90°) is:

- at noon day winter solstice = 75%
- at noon day summer solstice = 90%

And for glass fixed in the sides of a 30° pitch gable roof with the gable ends facing north and south (normal − 60°, facing east and normal + 60°, facing west) averages over the total floor for all day are:

- at the winter solstice = 75%
- at the summer solstice = 90%

This is the complete reverse to that which is required. But for glass fixed normal facing true north, the light transmission at Adelaide (−35.030° Latitude) is:

- at the winter solstice = 90% almost all day
- at the summer solstice = 48% at noon (See Table 2).

Table 2. Solar radiation transmission for glass fixed normal and facing true north.

SOLAR TIME HOURS	PERCENT TRANSMISSION Winter Solstice	Summer Solstice
0800	84	00
0900	87	11
1000	90	32
1100	90	45
1200 (noon)	90	48
1300	90	45
1400	90	32
1500	87	11
1600	84	00

Fixing glass normal, facing true north, gives nearer the desired relatively constant light admission to the planthouse throughout the whole year but it is still excessive at and near the summer solstice. To overcome this some additional shade can be incorporated in the building. An arrangement of east-west rows of glass fixed Normal facing north, joined with an opaque material fixed at 31-1/2° to the horizontal (the maximum altitude of the sun at the winter solstice), gives the desired effect (See Figure 4).

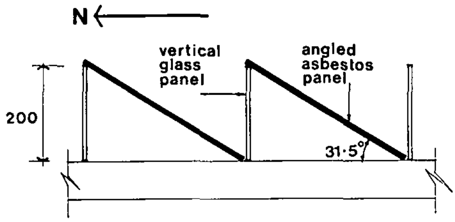

Figure 4. Horizontal roof — glass and asbestos.

So far we have planned only the roof of the planthouse. The walls of the planthouse for practical and economic purposes in building should be vertical. But from the table of the light transmission co-efficients of glass we note that vertical glass without additional shade transmits too much light in summer. What is needed is glass fixed normal minus a number of degrees but not so many degrees as to interfere with the winter radiation.

In practice it has been found that glass fixed normal −15° is adequate to offset the excessive radiation of summer. Fixed in such manner it will admit all the winter solar radiation as the effective angle between the sun and the glass is almost within the bounds of normal +45° (See Figure 5).

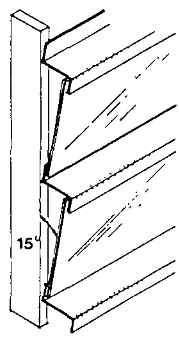

Figure 5. Vertical wall, glass and metal glazing bars.

Similar light admission effects as achieved with glass can be had with fibreglass reinforced plastic sheets having clear vertical surfaces and screened adjoining sloping surfaces. The sloping sections are fixed at 31-1/2° to the horizontal, the maximum altitude of the sun at the winter Solstice, so that the sloping sections offer no shade at this time of the year. The percentage screen of these sloping or adjoining surfaces can be varied to give other than relatively constant light admitted to the plant-house throughout the year (See Figure 6).

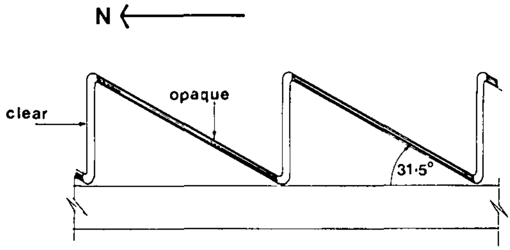

Figure 6. Horizontal roof — translucent formed sheets.

Used as cladding for the vertical walls of a planthouse, translucent sheets should have the screened surfaces fixed in a horizontal plane and the adjoining, sloping, clear sections will be normal, minus the number of degrees calculated to admit the desired proportion of the solar radiation (See Figure 7).

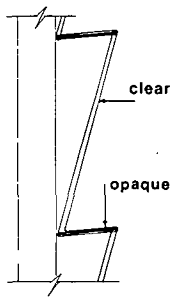

Figure 7. Vertical wall, translucent formed sheets.

Over 200 planthouses using glass and asbestos cement sheets to these designs have been built in Adelaide, Australia. They are used to culture orchids, indoor plants, tropical plants, juvenile plants, vegetables and flowers out of season and many plants which produce annual crops of flowers, seeds or fruit. They are in use on every day of the annual cycle without additional shading required (See Figure 8).

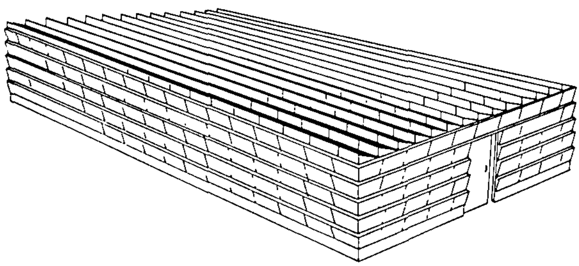

Figure 8. Controlled light admission planthouse.

REFERENCES

Anon. "Climatological Summary 1925-75", *Waite Agric. Research Inst.* Biennial Report, 1974-75 University of Adelaide.

Waldron, P.J. 1936. Light transmission coefficients of window glass. *Journ. Royal Inst. British Architects* 17.

GREENHOUSE COVERING — WHAT CAN BE USED?

ALAN J. NEWPORT

Dundas Nursery Supply Co. Pty. Ltd.
Dundas, New South Wales

The number of greenhouse covers are almost as varied as the crops grown within. Some of the covers are polythene (polyethylene), both ultraviolet inhibited and, for short term crops, non-treated material, clear polyvinyl chloride, Mylar (Dupont), certain nylon reinforced polythene and vinyl sheets (e.g. polyscrim).

In the rigid sheet we have polyvinyl chloride (e.g. Vinlon Tuflite), acrylic and, of course, fibreglass, either with or without tedlar (Dupont) coating. There are, of course, variations of these and other materials. Finally there is glass.

The following more common materials being used will be discussed, namely glass, fibreglass, rigid P.V.C., and polythene. In these we have a range of coverings that will meet the needs of growers over the whole of the climatic regions of the continent and the horticultural crops they grow. They also represent the materials currently most widely used.

Glass. The oldest covering used in horticulture and, in Australia, still one of the most popular. Glass has the advantage over all other materials in having a known life expectancy; the structure will give out long before the glass wears too thin. Light transmission is high and suitable for all crop growth. It is easy to paint and comparatively easy to clean. It is not flammable and, in Australia, is reasonably priced.

There are, however, some disadvantages, namely the design limitations and the need for structures to carry the weight. To ensure a tight house the structure has to be well designed, usually using extruded aluminum and featuring large glass sizes and plastic mastics to give a good seal to the glass and ridge and side vents. These houses are not made in Australia. Imported models, however, are available and represent excellent structures. The locally available houses are constructed to the size of the glass sheets available — ranging in size from 16″ × 14″ to 24″ × 24″, the largest. The glass is carried in rafters, usually galvanized steel, and a simple glass clip is used to support