Shading of Plants

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INTRODUCTION

The use of shading screens in the greenhouse not only influences the irradiance but also the greenhouse climate, e.g., relative humidity and air temperature (Andersson, 1991; Andersson and Skov, 1991). The aim of shading plants is first and foremost to reduce the energy load and to create the right level of light for the plant species which are grown in the greenhouse. A shading screen also influences the natural ventilation of the greenhouse (Andersson, 1991a; Andersson, 1992) and thus the air temperature and humidity. It is possible to take advantage of the reduced ventilation rates when rooted cuttings become acclimatized after propagation.

ENERGY LOAD

One of the aims of shading plants is to reduce the energy load. For rooted cuttings, shading results in a greater ability to maintain the water balance because of a smaller energy load. A rooted cutting has a greater leaf area than the root system can adequately supply with water. Even though the cutting has only a few leaves, all the leaves are fully exposed to radiation because the leaves do not shade each other. If rooted cuttings are exposed to high radiation, the water balance will be upset, cooling by transpiration will stop, and the risk of leaf damage will increase. The best way of reducing the energy load is by reflecting the irradiance. It can be achieved by using a highly reflective shading material. White shading screen materials or materials containing aluminum stripes have a high reflection. By mounting the shading screen parallel to the greenhouse covering material the highest possible reflection and the lowest energy load will be obtained.

AIR-CHANGE RATE

The rise of air temperature on a sunny day is mitigated by natural ventilation of the greenhouse. If a rise in air temperature is to be avoided, natural ventilation should be high. One of the problems in shading is to have a high level of shade and at the same time be able to keep the air-change rate up. A shade screen material with a high shade factor very often has a low air change rate which restricts the natural ventilation of the greenhouse. This results in increased air temperature.

The problem with ventilation of the greenhouse can be solved by the way the shading screen system is mounted. In many Danish greenhouses which are orientated east-west, the shading screen system is divided into two separate parts, one facing the southern side and one facing the northern side of the greenhouse (Gammelgaard et al., 1993). The two parts of the shading screen system are individually controlled. This increases natural ventilation because the northern part of the shading-screen system is closed only a few hours a day—even on bright

days. This kind of shading screen system is probably not the most suitable for a propagation greenhouse. Instead, a shading screen system consisting of two shading screen materials with different shade factors is used. On the southern side a shading screen material with high shade factor and reflection is used and on the northern side a shading screen with low shade factor and an open weave for increasing the change of air is used.

AIR HUMIDITY AND TRANSPIRATION

Transpiration can be divided into two types—transpiration dependent upon aerodynamic conditions and transpiration dependent upon radiation. The term radiation depended transpiration is used even if it is the increase in tissue temperature of the leaves which influences the rate of transpiration. The term is used because the irradiance is measured, whereas the canopy temperature only occasionally is measured.

Transpiration rate depends on the water vapor pressure gradient between the intercellular spaces of the leaf and the surrounding air (Andersson, 1991b). At low irradiance the transpiration rate depends on the aerodynamic conditions because the energy load is small and the water vapor gradient is the limiting factor.

During acclimation of rooted cuttings, climatic control is difficult, because both low air temperature and irradiance are wanted. Low air temperature is established by a high shade factor and a high rate of ventilation. High air humidity is established by a low air-change rate, but an increase in air temperature is unavoidable due to reduced ventilation. A high air humidity during acclimation decreases the transpiration rate and the cutting does not develop a negative water balance. At a high irradiance level, the energy load is high and temperature increases. The actual water pressure of the air has little influence on the transpiration because the water vapor pressure in the intercellular spaces is high. By using a very high level of shade, transpiration depends only on the water vapor pressure, but very often the shade-screen material with a high shade factor reduces natural ventilation. The necessity of ventilation is reduced when the shading material has high reflectivity. Under such conditions the air humidity increases and the transpiration rate is lowered. The growth of the cuttings is promoted because the water balance is stable, damage to the leaves is avoided, and a maximum growth rate of the root system is obtained.

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