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Spectral properties of shading screen materials

Skyggegardiners påvirkning af indstrålingens spektralsammensætning

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Summary

The spectral distribution of natural irradiance was measured under different kinds of shading screen materials. White and transparent screens did not affect the spectral distribution in the wavelength range 400-1100 nm. Coloured screens affected the spectral distribution in the photosynthetically active wavelength range (400-700 nm). Some of the coloured screen materials influenced the ratio between R and FR.

Key words: Shading screen materials, spectral distribution, transmission.

Abbreviations: FR: far-red light (725-735 nm), R: red light (655-665 nm).

Resumé

Naturlig indstrålings spektralsammensætning blev målt under forskellige typer af skyggegardiner. Hvide og gennemsigtige gardinmaterialer påvirkede ikke den transmitterede indstrålings spektralsammensætning i bølgelængdeområdet 400-1100 nm. Farvede gardiner påvirkede spektralsammensætningen i det fotosynteseaktive område (400-700 nm). Samtidigt påvirkede nogle af de farvede gardiner forholdet mellem R og FR.

Nøgleord: Skyggegardin, spektralfordeling, transmission.

Forkortelser: FR: langrødt lys (725-735 nm), R: rødt lys (655-665 nm).

Introduction

Leaves have the highest absorbtion in the wavelength range 400-700 nm and have the highest transmission and reflection in the wavelength range 700-2000 nm. At wavelength above 2000 nm the absorbtion is increasing and the reflection is less than 5% and no transmission occurs (5). Approximately 50% of the energy from the sun is in the wavelength range 400-700 nm and 50% in the wavelength range 700-3000 nm where the absorbtion by the atmosphere is high. Shading screens are used for reduction of irradiance in greenhouses. Irradiance in the wavelength range of 700-2000 nm does not influence the leaf temperature directly due to the low absorbtion of the leaf (2). The irradiance heats greenhouse construction, benches, soil etc. which affects the air temperature which influences the leaf temperature. The wavelength range 400-700 nm influences the leaf temperature, and the air temperature is influenced indirectly by the same conditions as mentioned under the wavelength range 700-2000 nm. To overcome increase in air temperature the screen material should have a high reflection of radiation in the wavelength range 700-3000 nm. In the wavelength range 400-700 nm the transmission should be adapted to the plant species grown in the greenhouse, and the surplus reflected.

Changes in spectrál transmission not only influences the energy balance of the plant, but also the photoreceptors. A reduction in transmission in the wavelength range 400-700 nm influences photosynthesis which plays an important role in the growth of plants. A displacement in the ratio between R and FR influences the morphogenesis. Little attention is paid in the literature to the spectral properties of shading screen materials (4,7).

The present work examines the spectral properties of some shading screens made of different materials and with different colours.

Materials and methods

Screen materials from three manufacturers were used (DGT/Volmatic, Farum, Denmark (DGT); Hecotherm (HS), Schiendam, The Netherlands, and Ludvig Svensson (LS), Kinna, Sweden). The screen materials were woven or knitted. The materials were white or coloured and some were also with aluminium strips. The aluminium strips were 5 mm wide independent of the screen material and consisted of a polyethylene base with a top layer of aluminium. The aluminium strips were welded together with the woven screen material (HS670 and HS850). The knitted LS screens consist of 5 mm wide aluminium and polyester bands which are a part of the warp. The colours of the materials were estimated by means of the R.H.S. Colour Chart. The characteristics of the screen materials are described in Table 1.

Table 1. Different properties of the shading screen materials. The nominal shade factor is based on information from the manufacturers.

Screen type	Nominal shade factor (%)	Process of manufacture	Colour	R.H.S. Colour Chart	R/FR ratio
DGT4b		woven	white		1.0
DGT8b		woven	white		1.0
HS850	50	woven with aluminium strips	white		1.0
LS56 b2		woven	white		1.0
LS15 Opal	60	knitted with aluminium strips	white		1.0
HS670	55	woven with aluminium strips	blue	111D	0.6
LS56 b14195		woven	blue	106D	0.7
LS56 b14227		woven	blue	102A	0.1
LS56 b1966		woven	grey		0.2
LS56 b1699		woven	orange	28A	1.0
LS56 b16119		woven	yellow	20C	1.0
LS56 b15181		woven	green	123D	0.7
LS10	22	knitted	transparent		1.0

A piece of each screen material (0.1 × 0.1 m) was placed directly on the cosine receptor of an LI-1800 portable spectroradiometer (LiCor, Lincoln, Nebraska, USA). The screen material was fixed with a rubber band preventing the screen material from fluttering. Measurements were made from 300-1100 nm at 1 nm intervals. Approximately 75% of the solar energy comprises of this wavelength range.

The measurements were made in the open air at the Research Centre for Horticulture, Årslev, Denmark (latitude 55° 18' N, longitude 10° 26' E).

The measurements were made under a clear blue sky on 19 August 1990 and repeated on 27 August 1990. The measurements were made between 11.00 a.m. and 1.00 p.m. There was approximately one minute between the transmitted and incident scans, but this delay had no measurable influence on the values obtained.

The transmission as a function of wavelength is calculated by dividing transmitted scan with incident scan. The shade factor cannot be estimated from the measurements due to the different pattern of the screen material. In the calculation of the ratio between R and FR, the wavelength range defined by *Holmes* and *Smith* (1) was used.

Results

In the wavelength range 700-1100 nm the screen materials do not affect the spectral distribution (Fig. 1, 2, and 3). Coloured screen materials affects the spectral distribution in the wavelength range 400-700 nm (Fig. 2 and 3). White and transparent screen materials have only a small effect on the spectral distribution, and only in the photosynthetic wavelength range 400-425 nm. Only the spectral distribution of the screen material HS850 shows a slight decreasing trend from 400-750 nm, after which it is flattened (Fig. 1).

LS15 Opal consist of aluminium strips and white polyester strips. Using white polyester strips the transmitted light becomes more diffuse than using transparent polyester.

The blue screen materials differ widely (Fig. 2). The dark blue material (LS56 bl4227) has a very low transmission in the wavelength range 400-700 nm. The two light blue materials (HS670 and LS56 bl4195) has a decrease in transmission in the wavelength range 475-680 and 425-610 nm respectively. LS56 bl4195 has a very low transmission in the wavelength range 300-400 nm followed by a steep increase in transmission. The blue screen materials and especially LS56 bl4227 affect the ratio between R and FR, due to their low transmission in the wavelength range 610-680 nm.

The grey shading screen material (LS56 b1966) has a very low transmission in the wavelength range 300-650 and strongly effects the ratio between R and FR (Fig. 3).

The orange shading screen material (LS56 b1699) has a very low transmission in the wavelength range 300-600 nm, but only slightly affects the ratio between R and FR. The yellow shading screen material (LS56 bl6119) has a stepwise increase in the transmission from 300 to 600 nm where it flattens (Fig. 3).

The light green shading screen material (LS56 b15181) has maximum transmission at 500 nm in the wavelength range 400-625 and also affects the ratio between R and FR (Fig. 3).

LS10 is a transparent material. It is the same material used in combination with aluminium strips in transparent screens from Ludvig Svensson. The material is a polyester which has a high transmission and has no influence on the spectral distribution in the wavelength range 425-1100 nm (Fig. 3).

Discussion

In the present experiment absorption and reflection is not measured. The absorption and reflection depends on the chemical composition of the material. Some manufacturers (Ludvig Svensson and Hecotherm) are using aluminium for increasing reflection. The use of aluminium strips are not affecting the spectral distribution of the screen material because the strips are opaque.

White screens reduce irradiance equally over the wavelenght range of 400-1100 nm. Coloured screens are only used in greenhouses in garden centres and not for the production of plants. The coloured screens are used to reduce direct sunlight and improve the internal environment for the visitors.

The displacement in the ratio between R and FR influences the phytochrome balance and promote the production of P_r (the inactive form of phytochrome). A change in transmission of R and FR to a ratio lower than 1 is considered to be a disadvantage of the screen material because it will promote elongation of the stem and petiole (3,6).

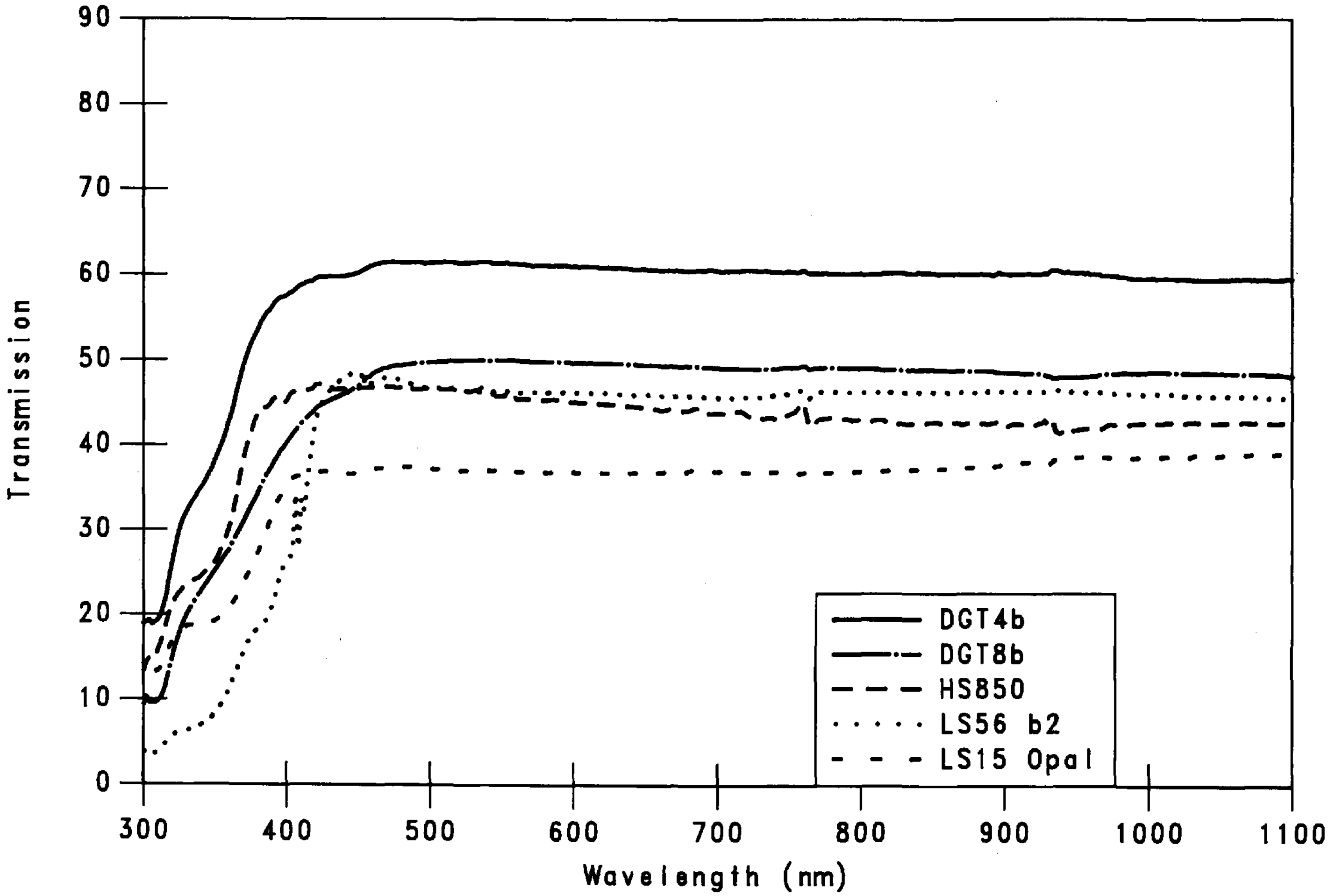

Fig. 1. Transmission as a function of wavelength of white screen materials.

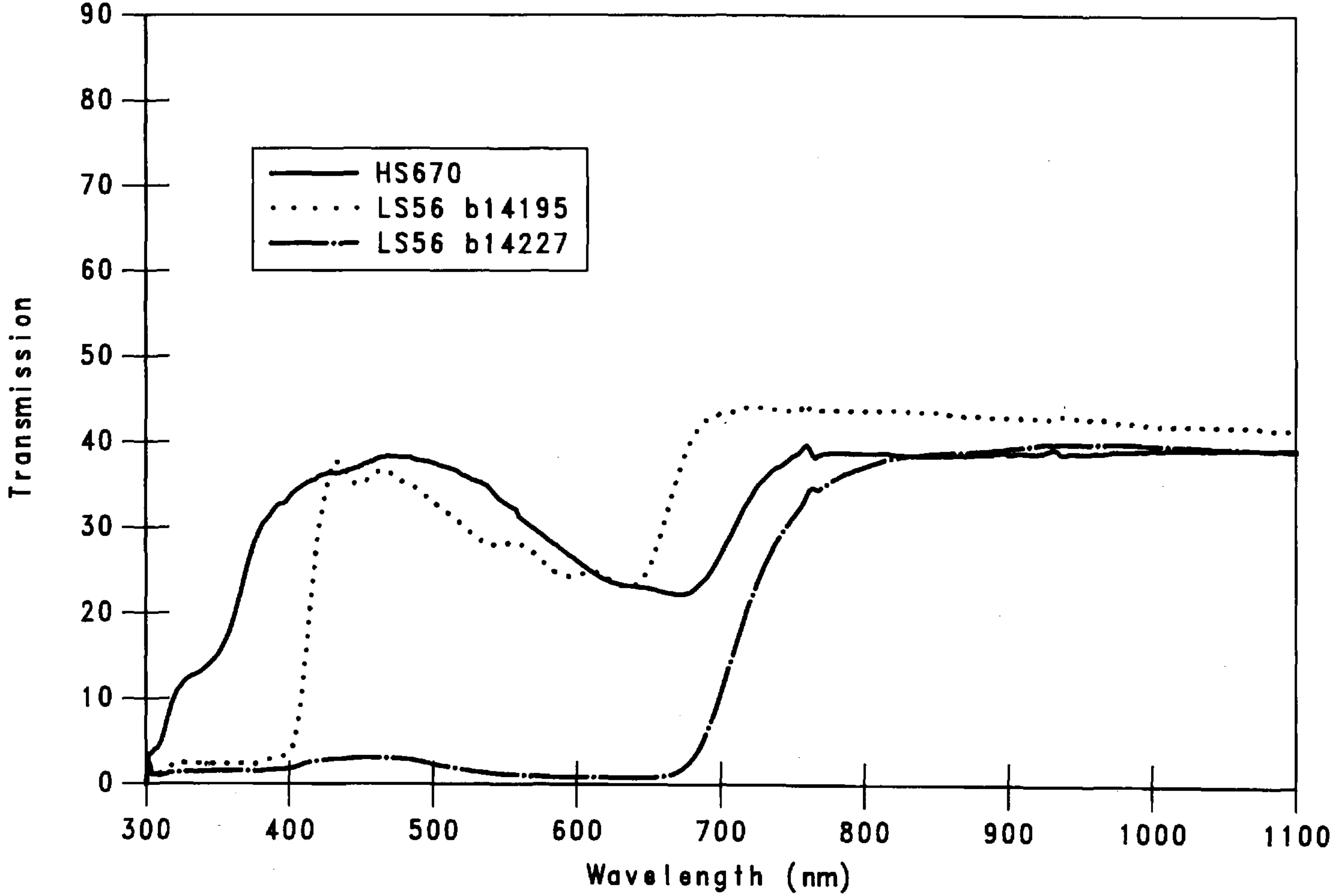

Fig. 2. Transmission as a function of wavelength of blue screen materials.

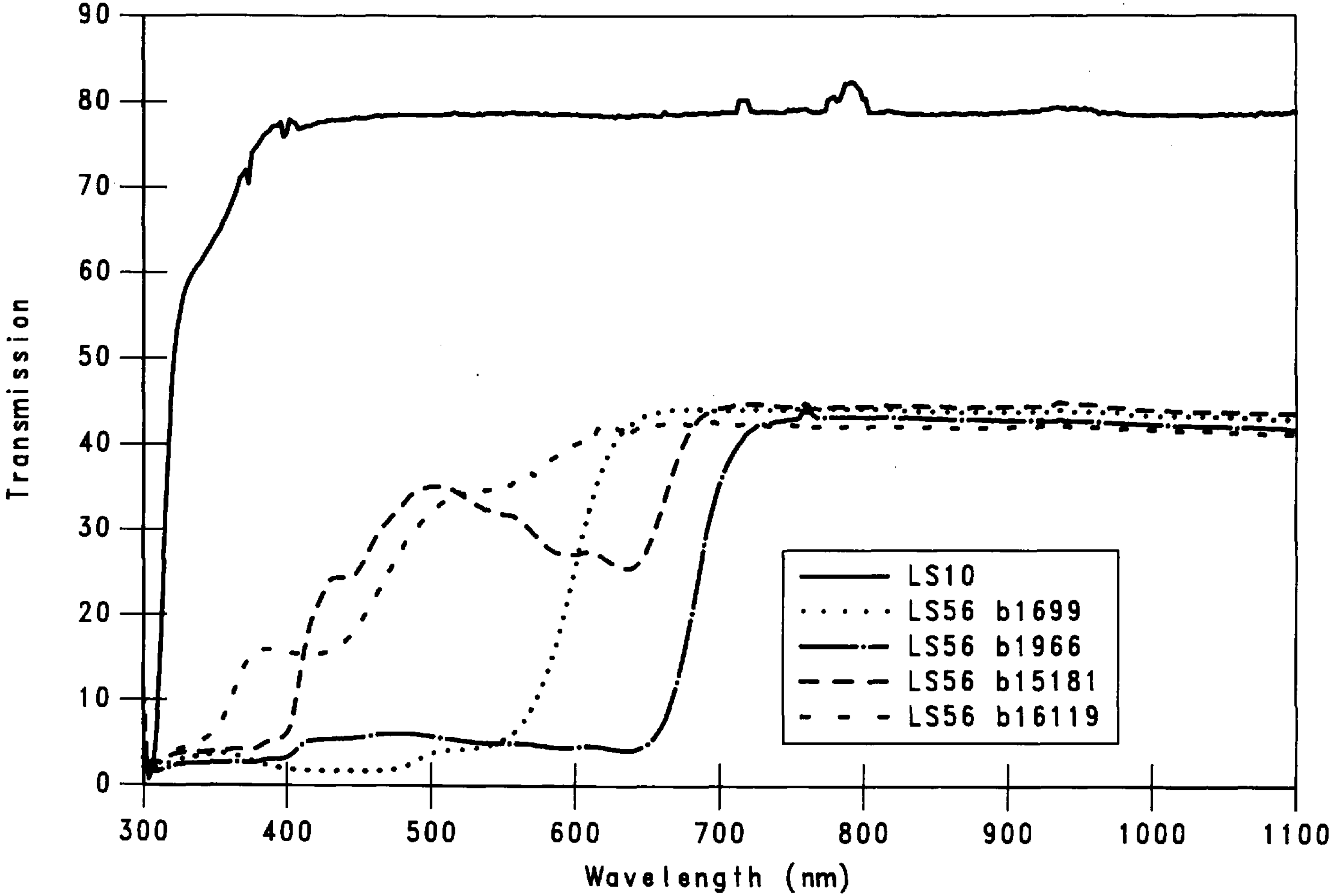

Fig. 3. Transmission as a function of wavelength of screen materials with different colours. Transparent (LS10), green (LS56 b15181), grey (LS56 b1966), orange (LS56 b1699) and yellow (LS56 b16119).

A ratio between R and FR of 1 for the screen material will not displace the natural ratio when the screens are used during the day where the natural ratio between R and FR light is 1.3. The low transmission of grey and orange screens may cause a reduction in quality and shelf life.

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