Optical phenomena produced by the of solar radiation – hop leaf interaction

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Abstract

This paper presents the spectrum of reflectance and transmittance in the case of a hop leaf, as well as the mechanism of light interaction with the hop leaf, accounting for the characteristics of the material (the leaf) and its optical properties.

Key words: light radiation, hop, reflectance, transmittance, absorbance

Introduction

One of the most important issues in the distribution of the solar radiation in the plant cover is that of its interaction with the leaves. At the contact with the leaf, the global radiation suffers a series of physical phenomenon, such as reflection, refraction, transmittance and absorbance. We have considered the hop, due to its vertical growth, which is proper for analyzing the distribution of the solar energy in the canopy, in its interaction with the leaf and depending on the crown canopy.

Material and methods

The biological material under analysis is the hop, respectively the leaf of the hop, being under observation its interaction with the solar radiation, illustrated through reflection, transmittance and absorbance.

The research methods used for this analysis are the laboratory method, of analytical calculation, sustained by techniques of electronic microscopy and spectrometry.

The general issue under analysis is that of radiative balance in a plant cover, which depends on the place where the research is realized, the direction of light conduction, status of polarization, etc. (Bruhat, 1959; Lena and Blanchard, 1990). On particular case, the objective of the research is the leaf of the hop. Considering that the wavelengths of the photosynthesis phenomenon are those from the visible domain and those from the medium infrared, the following hypothesis can be formulated:

- the framework for analysis is that of geometrical optics, because the dimensions of the objects are much bigger than the wavelengths;
- the light is unpolarized, because the radiation emitted by the Sun is unpolarized and the atmospheric radiation is not much polarized. In the plant cover, the light is considered unpolarized (Vandeerbilt *et al*., 1993);
- the phenomenon of phosphorescence and fluorescence are insignificant;
- the plant cover is always found in a thermodynamic equilibrium.

Results and discussion

The laboratory results regarding the reflectance, transmittance and absorbance of solar radiation through a hop leaf are presented in Figure 1.

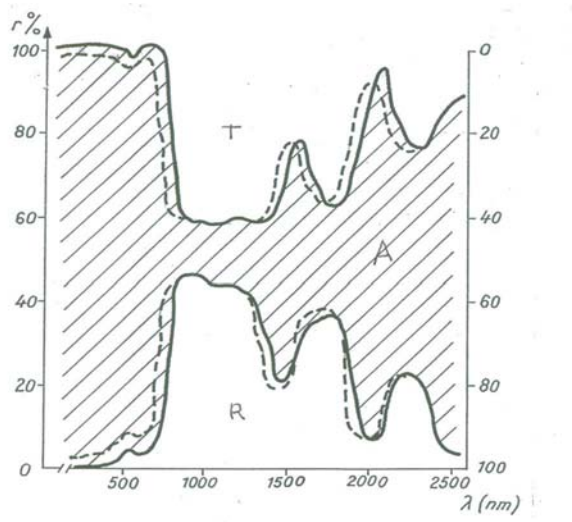

Figure1. Spectrum of reflectance and transmittance in the case of a hop leaf

The division of the spectrum is clear, according to the figure, in three domains dependent on the wavelength:
- the visible domain (400-700 nm), characterized by a small reflectance of about 20% and a present transmittance, but insignificant.

The strong absorbance is the result of the pigments (chlorophyll, carotene, xanthophyll, etc.).

The main pigments, chlorophyll a and b (65% from the pigments) present two absorption bands, one blue and one red, determining a maximum of reflectance, for the yellow-greenish color (λ=550 nm).
- in the adjacent infrared domain (700-1.300 nm). It is remarkable the fact that in this domain, the pigments of the plant and the cellulose from the cell walls are transparent. The absorbance is very small, below 10% and the reflectance of the radiation may be up to 50%. The high value of the reflectance is caused by the relief of the surface of the leaf and the presence of cilia, overlapped on its internal structure.
- in the medium infrared domain (1.300-2.500 nm), appears strong absorbance, for the wavelength of 1.400, 1.900 and 2.450 nm, materialized in two relative maxims, of the water content in the leaf (λ=1.650, 2.250 nm).

The mechanism of the interaction of the light with the leaf, the phenomenon of reflectance, transmittance and absorbance, in the leaf, depend on the optical characteristics of the layers (Figure 2.a,b)

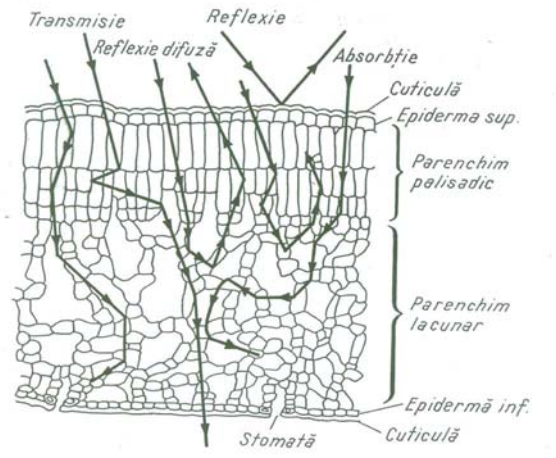

Figure 2a. The structure of a hop leaf and the interaction with the solar radiation

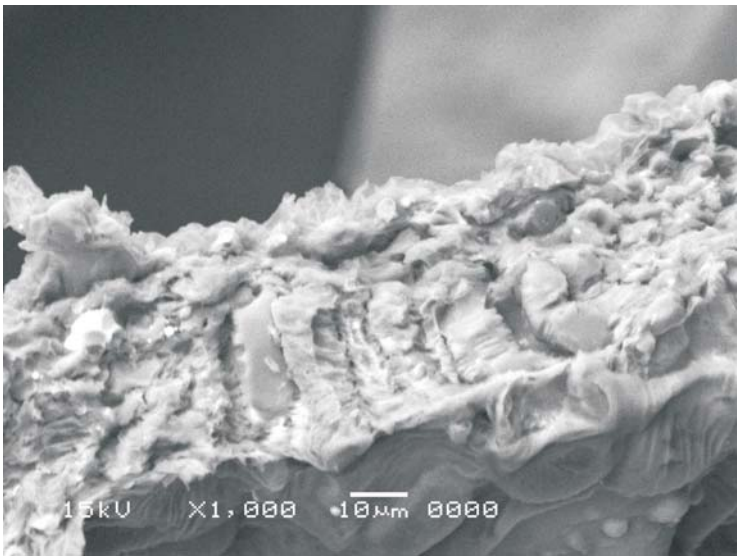

Figure 2b. The image through electronic microscopy in the section of a hop leaf

It is observable the fact that the strongest diffusion is occurring in the lacunar parenchyma, due to the random orientation of the cell walls and of the numerous interfaces gas-cell walls.

In the palisadic parenchyma situated under the superior epidermis, no reflection is occurring, neither diffusion, but only a small absorbance.

In the adjacent infrared, the reflectance of the leaves depends on the number of the cell layers, on the cell dimensions and on the relative density of the lacunar parenchyma.

On the superior surface of the leaf, (Figure 3.) due to the big irregularity and to the presence of the cilia a strong reflection is produced, especially in the visible domain.

Figure 3. The image through electronic microscopy of the surface of hop.

The laboratory experiences realized on leaves of different ages have emphasized the modifications of the reflectance. The disappearance of the chlorophyll pigments and their replacement with brown pigments produce a strong growth of the reflectance for the yellow-greenish and red wavelengths.

The water contain of the leaf is in inverse proportionality, especially, in the medium infrared domain, comparing with the adjacent infrared and visible domains.

Conclusions

- the measurements of reflectance, transmittance and absorbance are significant for the biological growth of the plants, the phytosanitary status and the forecast of the harvests;
- the main contribution in the reflectance produced by a plant is the plant surface and mass, the other organs having a small qualitative and quantitative influence.

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