OPTICAL FEATURES OF LEAVES OF NEPETA CATARIA VAR. CITRIODORA BECK. CONNECTED WITH THE WATER REGIME OF PLANTS

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The purpose of the present work was to study the opportunities of using characteristics of reflection and absorption of the intact leaves of plants in order to assess water status of plants by means of laser spectrophotometer with simultaneous registration of a leaf plate thickness. Investigations of the optical features of Nepeta cataria var. citriodora Beck. plants` leaves in the near infrared radiation (970nm) in the connection with the water regime changes have been carried out.

High correlation between optical features of the plant`s leaves and its water regime has been determined. To characterize the water regime in N. cataria the method based on the dependence of the leaves` optical features and leaf plate thickness on the water content has been used. Coefficient of absorption and leaf thickness changes in N. cataria has been determined. There is a linear dependence of absorption and high correlation of the leaves` parameters with the leaf plate thickness. Absorption of the near infrared radiation emanation (970 nm wave) depends not only on the leaf water content but also on its tissue structure peculiarities and pigments content.

There exists a basic opportunity to use methods of parallel control of optical characteristics of leaves in the near infrared radiation and water status of plants as an instrument for assessment of the ecological-physiological characteristics. Methods can also be used as an element of precise agricultural technology for the control of the water regime in sowings.

Keywords: Nepeta cataria var. citriodora Beck., optical properties of leafs, leaf plate thickness, water regime.

Conference participants

Introduction

Researches of the plants leaves optical properties in a visible part of the spectrum are usually connected with the conditions of pigmentary system and leaves structure (Brandt, Tageeva, 1967; Penuelas et al., 1993; Penuelas et al., 1997; Surin, 1997; Radchenko et al., 1998; Dallon, 2005). The study of the plants water status is usually carried out in the waves more than 1000 nanometers. For the definition of water stress in plants by analysis of reflection measurements on the several key lengths of the waves called "strips of water" laser spectrophotometer was used. The most known "strips of water" are 1400 and 1900 nanometers. It has been shown that reflection on these lengths of waves corresponds to the maintenance of water in fabrics of plants (Penuelas et al., 1993; Penuelas et al., 1997). Besides, it is difficult to measure water stress on these lengths of waves on a distance because of a high level of absorption by the water fume of a terrestrial atmosphere.

Today there are some inexpensive spectrophotometers on silicon diodes, suitable for exact measurements of waves` lengths up to 1000 nanometers, including remote measurements. The strip of 970 nanometers historically was considered too small for exact measurement of water stress, however it has been shown (Penuelas et al., 1997), that it can be used for indication of water stress of the close crops where the index of a leave surface doesn`t vary too much.

We tried to use characteristics of leaves` reflection and absorption for estimation of the plant water status with the help of laser spectrophotometer with simultaneous registration of leaf plate thickness.

Objects and methods

Objects of our investigation were the plants of *Nepeta cataria var. citriodora* Beck., family *Lamiaceae. N. cataria* is a perennial herbaceous plant. In nature it spreads from the west of the USA to Canada, in the Eastern Asia, Central and Eastern China, Japan, the Far East and the Middle Asia. As a cultural plant it is known in the Eastern Asia – places of its natural growth. Used of selection varieties of NBS-NSC N. cataria - sort Pobeditel – 3.

We studied the water mode of *N. cataria* plants by the measurement of leaves optical properties (Lisker, 1998) with laser spectrophotometer "Perfot-93" (the working of St.-Petersburg optic-mechanical association, Russia) and measurements of the leaves thickness with the device "Turgoromer-1" (Kushnirenko, 1975). "Perfot-93" allows registering simultaneously values of integrated factors of radiation reflection, absorption and passage and it was used for discrete measurements. Changes of the leaves optical characteristics were compared with the condition of the water mode of intact plants – increase of water deficiency, reaction on having been watered. The thickness of leaves in all experiments was used as a characteristic of the water concentration level.

In practice the procedure of leaf optical parameters measurement consists in registration of the falling, reflected and passing radiation, and the absorption factor is calculated according to the formula:

$$A = 100 - (T + R), \quad (1)$$

where A – absorption (factor of absorption, %);

T – passing, %;

R – reflection, %.

Besides the noted leaves optical features peculiarities there is one more. Leman (Leman, 1961) has noticed that in the visible part of the spectrum absorption depends of the factor either emanation falls on the upper (adaxial) or lower (abaxial) leaf surface. If the emanation falls on the upper surface its absorption will be about 10% higher than on the lower surface. First of all it may be explained by the fact that in most of plants color of the low surface is lighter than of the upper one. That`s why reflection of the radiant energy is 10-12% higher. Emanation passing also depends of leaf anatomy peculiarities; particularly what tissues get the radiant energy first. When the leaf is lightened on the upper surface on the way of the radiant energy there is palisade parenchyma first, and than spongy parenchyma and amount of the passed through energy will be 2-3% less then under the lightning of the lower surface.

The formula (1) is not fully befits for investigations of the connection between absorption and leaf structure as the result of absorption estimation depends on reflection. The method of emanation absorption determination with the help of some solution has

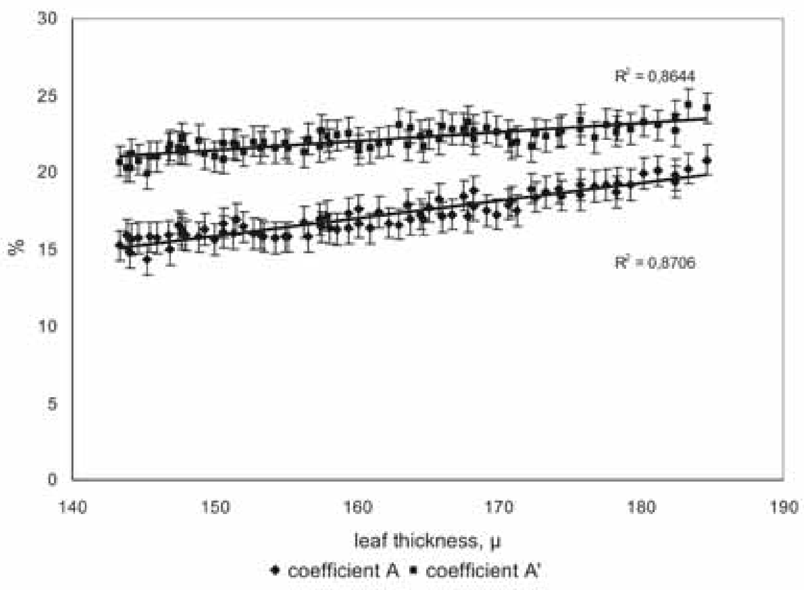

Fig. 1. Dependence of the near infrared radiation emanation absorption from *N. cataria* leaves` thickness.
A – coefficient of absorption; A' = A /(A+T)

been brought to botanical and plant physiology researches from physics. Probably, during the study of the optical peculiarities of hard objects there wasn`t a problem of differences in reflection properties of upper and low surfaces though it isn`t obvious. In physiological studies characteristics of reflection are mostly connected with the amount of some leaf component. If according to some reasons reflection R has increased that means decreasing of A+T part and it may lead to the wrong conclusion that absorption has decreased because of the inner leaf tissues changes, but in fact there hasn`t been such changes and their absorption peculiarities hasn`t changed. As the main characteristic of leaves, which has been studied in the infrared range, is their water content emanation absorption of leaf should be determined by its thickness, structure and humidity but not with its reflection abilities. These reasons concern the visible part of spectrum during the discussion of emanation absorption connection with the pigments content in leaves. That`s why it may be possible to exclude the influence of reflection range during the estimation of absorption and radiant energy passing peculiarities in solutions absorb properties analyses.

To exclude the influence of differences in the reflection properties of upper and lower leaf surfaces we propose to use the formula:

$$A' = A/(A+T) \qquad (2)$$

A' – coefficient of absorption permeated in a leaf (specific absorption).

So we calculated the absorption not as a part of falling emanation but as a part of emanation permeated in a leaf. Hadn`t been canonized term "specific absorption" is the result of the division of the average absorption on the average leaf thickness and it characterizes the lines slope for A and A` trends. This dependence has a simple look:

$$A = C + Kd, \qquad (3)$$

Where C – a constant, d - thickness of a leaf, K = A/d - specific absorption which in fact is the index of incstinction for linear dependence of near infrared radiation emanation absorption from the plants` leaves thickness in the unites %/μ

Statistical analysis

Mathematical treatment of the data was made using the program Statistitsa.

Results

Researches have shown, the maximal leaves thickness is observed in the morning (at 6–7 a.m.), and minimal – at 2-3 p.m. The thickness of *N. cataria* leaves plate varies under the influence of the natural factors in the borders from 143 to 185 μ. Coefficient of absorption for the leaf plate is 7-15%. Changes of *N. cataria* leaf thickness for 46 μ, that is 22,7% from the whole leaf thickness, lead to the changes of absorption coefficient in a range from 15 to 21%. A'= 20-24% (fig. 1). Coefficient of reflection is 27-40% (fig. 2).

Discussion. The results of laser testing of the plants` water status together with monitoring of the leaves thickness showed high correlation of these two characteristics and high enough sensitivity.

Besides leaves` thickening in the posses of growth the reasons of their thickness changes are the water content

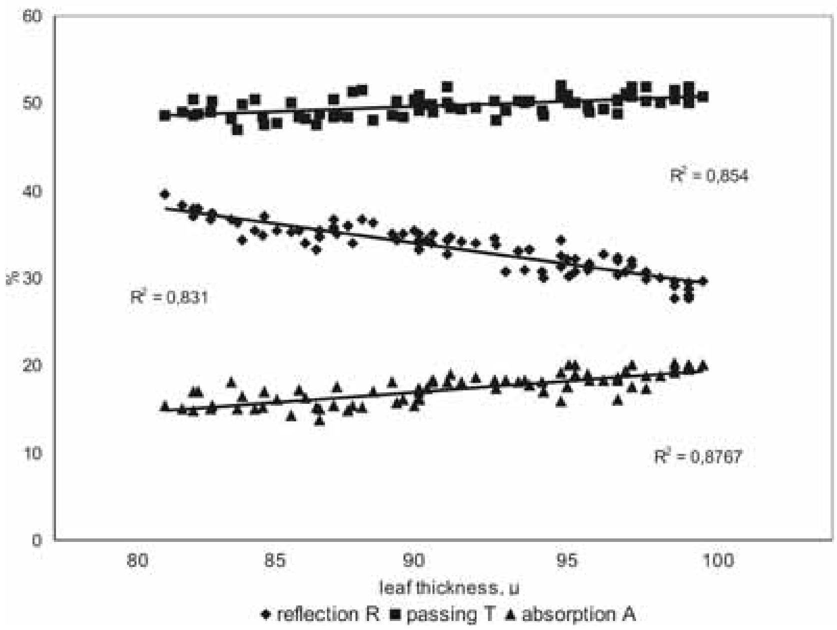

Fig. 2. Leaf optical parameters under the different water content in *N. cataria*

changes which are affected by the natural daily regime under the influence of water deficiency or watering. Convertible changes of the living leaves` plates may reach up to 1/3 or even a half of the maximal size (Radchenko et al., 1998; Lisker I. S. et al., 1999). It is certainly influences the value of the near infrared radiation emanation absorption.

Some variations of measurements' points along the trend line may be partially explained with leaves` anatomy peculiarities, that`s why measurements on the leaf veins and between them can differ (fig. 1).

By reduce of the water content in the leaves tissues of the species reflection of the near infrared radiation emanation increases and its absorption reduces. Coefficient of reflection is under the influence of leaves anatomy peculiarities particularly glands density on the leaf surface. Absorption of the near infrared radiation emanation is influenced by the leaf structure, pigments and carotenoids content. The higher content is the higher coefficient of absorption is.

The character of emanation passing is less determined. Scale of the changes is not high. Some decreasing of the index has been fixed and it may be explained by the more rapid water loss during the same period of time (fig. 2).

Probably the structural peculiarities of leaves in different species are the reason of high dispersion among the experimental points. Decision of this question is waiting of the investigations.

The study of leaves optical properties and their light absorption is a perspective branch of investigations which have a great significance for understanding of the common principles of the sun energy assimilation, physiological status and adaptive processes in plants.

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