The influence of plant photosynthetic indices on the effectiveness of PRI use

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To achieve success in agriculture, large expenditures are required for irrigation, fertilizing, pest control, etc. However, these costs are not always justified, since plants growing in different parts of the field can differ significantly in terms of water and fertilizer availability, in terms of the intensity of the abiotic stress factors, in the degree of damage caused by diseases and pests, etc.

In the framework of the actively developing practice of "precision farming," Lobachevsky University researchers are working to develop and introduce methods for spatially heterogeneous treatment of plants that minimize costs and improve the ecological quality of the crops, due to the less intensive use of chemical compounds.

A necessary stage in precision farming is fast, remote analysis of the state of plants in the fields, which allows spatial heterogeneities in this state to be revealed. For this purpose, scientists use optical methods based on the registration of light reflected by plants, since such methods are relatively cheap and are potentially highly informative.

However, the use of the spectra themselves is ineffective, therefore scientists often analyze indices calculated on the basis of the intensity of light reflection at two or more wavelengths. These indices reflect changes in a variety of plant physiological parameters, including the volume of green biomass, the content of photosynthetic pigments, the water status of the plant, etc.

One of important indices is the photochemical reflectance index (PRI), which is associated with changes in the activity of redox processes in the xanthophyll cycle. In turn, the xanthophyll cycle plays a key role in protecting the plant photosynthetic chain from damage caused by the action of a wide range of stressors (excessive illumination, elevated temperature, drought, and many others).

"It follows from numerous studies that changes in the photochemical reflectance index can be a promising indicator of photosynthetic stress in plants. Thus, the task of identifying the conditions under which PRI measurement is the most effective tool for assessing the photosynthetic processes in a plant is of a significant fundamental and practical importance," says Vladimir Sukhov, head of the Plant Electrophysiology Laboratory at the UNN Institute of Biology and Biomedicine.

A meta-analysis of literature data (a quantitative research of a large body of results obtained and published by other authors) undertaken by Ekaterina Sukhova, a graduate student of the UNN Department of Biophysics, under the guidance of Dr. Sukhov has proved to be an effective method for solving this problem. This research was supported by the Russian Science Foundation and was published in *Remote Sensing*, one of the leading scientific journals in the field of remote monitoring.

The method of meta-analysis is quite effective in revealing the general regularities of the effect being studied, since it allows one to abstract from various experimental conditions and to reveal the most general features of the effect.

In the course of the meta-analysis, Ekaterina Sukhova analyzed literature data on the relationship between the photochemical reflection index and the quantum yield of photosystem II (showing the efficiency of photosystem II), non-photochemical quenching of chlorophyll fluorescence (which shows the development of stress in the

photosynthetic chain of plants) and light use efficiency in the process of photosynthetic assimilation of carbon dioxide.

The meta-analysis used in the study showed that the efficiency of using the photochemical reflection index for estimating the quantum yield of photosystem II and non-photochemical quenching depends significantly on the distribution of these parameters in the study group.

In particular, the effectiveness of using the method was higher when there were plants in the group with a low level of photosynthetic stress and when the level of such stress among plants in the study group varied significantly.

Studies have shown that this effect disappeared in the conditions that were optimal for PRI measurement (studying the canopy surface, measurements under artificial lighting), since a good correlation of the photochemical reflectance index with the quantum yield of photosystem II and non-photochemical quenching was regularly observed under such conditions.

"On the other hand, in the less favourable conditions for measuring the photochemical reflection index (measurement from the leaf surface, studies in sunlight), the significance of the distribution of photosynthetic parameters in plants for the effectiveness of PRI use increased considerably," Ekaterina Sukhova points out.

This research has confirmed the important fact that the effect of the distribution of photosynthetic indices among the plants in the study group had no effect on the efficiency of using the photochemical reflectance index to evaluate the efficiency of using light energy in the process of photosynthetic assimilation of carbon dioxide. It means that the regularities revealed do not apply to all photosynthetic indices.

"On the whole, the obtained results are of great practical importance, since they help to understand the conditions under which the use of the photochemical reflectance index measurement for monitoring photosynthetic indices in plants (and hence their production process and stress) will be most effective," concludes Ekaterina Sukhova.

More information: Ekaterina Sukhova et al, Connection of the Photochemical Reflectance Index (PRI) with the Photosystem II Quantum Yield and Nonphotochemical Quenching Can Be Dependent on Variations of Photosynthetic Parameters among Investigated Plants: A Meta-Analysis, *Remote Sensing* (2018). DOI: 10.3390/rs10050771

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