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SOME ACTUAL TASKS OF ECOLOGICAL PHYSIOLOGY OF PLANTS

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ABSTRACT
Even prior to the development of agriculture, people paid attention to the influence of climate on the growth characteristics of plants. Development of agriculture and, in particular, the great geographical discoveries accelerated studying of the botanical characteristics of plants. This work gives a brief review of the history of development of eco-physiological trend in physiology and ecology of plants. Possibilities of the use of the planned multiple-factor experiment in adjustable environmental conditions with the regression analysis of the obtained results for the definition of the ecological characteristic of ecotype on the set phase of its development are considered.

KEY WORDS
Ecological physiology; Plants; Ecology; Light-temperature characteristics; Ecotype; System approach; Planned multiple-factor experiment; CO_2-gas exchange; Regression analysis; Adjustable conditions; Environment.

Data on the processes determining growth, development and formation of plants have been accumulating in the process of botany development, in the interior of which in the 17th–18th centuries physiology of plants originated. However, only in 1800 Zh. Senebye in the five-volume treatise «Physiology vegetable» suggested to use the term «physiology of plants" for the designation of an independent branch of knowledge. He generalized available literary data, formulated the primary objectives and described methods of the researches [10].

The process of genesis and formation of new branches of sciences in the process of their development is continuously in progress. Formation of interdisciplinary sciences and development of new methods of research of biological materials on their basis led to active development of a number of essentially important trends in modern phytophysiology such as the biochemical, biophysical, evolutionary and ecological ones. As a matter of course, these trends are interconnected and complement each other. Some subdisciplines of physiology of plants developed into independent scientific disciplines: virology (1902), agrochemistry (1910), chemistry of herbicides and stimulators (1925), biochemistry (1930) and microbiology (1930).

At the end of the 19th century, owing to the works of the Danish botanist E. Varming (1842–1924) plant ecology became an independent scientific discipline that gained official recognition on the third World botanical congress in 1910 in Brussels as a part of two sections: auto- (species ecology) and syn-(ecology of a community, population). At that time it was considered that the autoecology is the basis for synecology [1]. However, further researchers came to a conclusion that autoecology depends on the whole complex of both abiotic, and biotic factors of environment.

Fundamental processes of activity of plants are so far widely studied. They are: hotosynthesis and breath which are carrying out transformation of a matter and energy; mineral nutrition of plants which is a scientific basis of the doctrine about the use of fertilizers in agriculture. Ability of legumes and some other plants to symbiosis with nitrogen-fixing organisms is shown. The main mechanisms and regularities of a water exchange of plants, their adaptation to environmental conditions, role of phytohormones etc. are found out. The powerful contribution to the solution of problems of intensification of agriculture is made by

physiologists of the ecological profile. The ecological orientation of phytophysiological researches arose at the turn of the 20th century. N. A. Maksimov is one of its founders in our country [11]. His classical researches on freezing and drought resistance of plants nominated domestic physiology to the leading positions in the world science. In 1952 V. Billing drew attention of the physiologists to the “plant-environment” system studying and for the first time used the term «ecological physiology» which was widely adopted in subsequent years.

The goal of the ecological physiology of plants is studying of regularities and mechanisms of the influence of environmental conditions on a complete organism and its life-determining processes, such as: efficiency formation, growth, development, CO_2-gas exchange, resistance to extreme influences etc. Solving of those problems, along with the general-biological problems, has an important practical value for rural and forest farms. For a long time the limiting factors in the development of this trend of physiology of plants were weakness of the experimental base, including possibility of creation of adjustable environmental conditions, and lack of setting up and processing technique of multiple-factor experiments. Considering interaction of physiological processes in a plant and influence of multiple-factor environmental conditions on them, such researches can be conducted generally only on the basis of a system approach.

Specifics of the system approach are defined not by the complication of methods of the analysis, but by the promotion of the new principles of approach to the object of studying – creation of the theory of planning of multiple-factor experiments [12]. In the most general terms this approach is the construction of the entire image of object. Formation of the system approach, based on a natural-science basis, was promoted by the penetration of cybernetics ideas into biology. However system approach gained the status of special and internally uniform research position only in the second half of the 20th century [14]. Development of computer engineering and phytotroniks gave an opportunity of performing of the system researches in biology by the introduction of the active multiple-factor planned experiments (AMFPE). It allowed the ecological trend to pass from studying of qualitative characteristic to their quantifications. It includes determination of power of influence of a factor on a biological process and characteristics of the conditions providing set intensity to it, size of a potential maximum etc., i.e. ecophysiological characteristics of species, ecotypes, genotypes and varieties [8].

Widespread in physiology molecular and biochemical approach presents the composition and structure of an object, but it can't answer questions concerning interaction regularities of internal parts of an organism, its structural arrangement. These questions can be answered only on the basis of the system approach [13], so far as organizing role concerning the interconnected elements is primary for a biosystem – properties of the elements are, to a great extent, determined by their inclusion into the system. Elements don't play an unambiguous role in the biosystem functioning: different elements can participate in the same functions and vice versa, the same elements can exercise various functions [3, 5].

The analytical method allows estimating the structure of a live object. The system approach shows how functioning of a live object is organized, abstracting from the idea of its structure. Therefore when studying questions of ecological physiology of plants the use of the system approach and on its basis performing multiple-factor planned experiments with the subsequent creation of influence models of the environment conditions on these or those biological processes gain a special role [7].

At the present time the assessment of condition of plant resources of natural and artificial cenoses is most often based on morphological and cytogenetic criteria. Physiological indicators are used less often. However physiological plasticity in many respects predetermines prospects of survival and productivity of an individual. Therefore the eco-physiological characteristic of a genotype is especially significant when determining donors of valuable and economically useful features and resistance to extreme conditions of the environment, including anthropogenous, and also when studying an intraspecific variety, in the introduction of plants and forecasting of influence of climate changes on the boundary displacement of the area of species and their ecotypes.

The main indicator of productivity of a cenosis or a separate plant is either biomass, or an economically valuable crop. In active multiple-factor planned experiments crop

assessment is practically excluded owing to the need of registration of «response» (reaction) of one or group of plants at very short expositions of stages of the plan – a permutation of combinations of levels of environment factors. Therefore in the active multiple-factor planned experiment (AMFPE) it is desirable to use the integrated indicators connected with the life-determining processes, control for which can be exercised continuously and remotely. One of such indicators of activity of plants, meeting these requirements, sensitively reacting to the changes of the environmental conditions and controlled to a high precision, is the CO_2-gas exchange of intact plants finally defining biological and economical crops [8]. However when studying physiological processes in a plant it is necessary to remember interrelation of all its parts. Therefore the most real information can be obtained only when determining gas exchange of an intact (whole) plant, instead of its separate part, especially in extreme ecological conditions when the organism will mobilize all the resources for its survival [9].

The total link of these researches is obtaining of the ecophysiological characteristic of plants expressed in the form of mathematical model of dependence of biological processes from factors of environment and allowing to define potentially possible level and conditions of the environment, providing its manifestation, and also other parameters: optimum, compensation conditions etc., characterizing plasticity of an organism. The specified characteristic can be received in laboratory experiment or, partially, with a great degree of error, by mathematical processing of results of mass measurements of intensity of physiological processes and environment parameters in habitats (cultivation areas) of plants.

The functional characteristic of plants can be used together with the biochemical and anatomo-morphological one for studying of physiological processes, explanation of behavior of genotypes, their dispersal and viability, relationship in the cenoses, adaptation to extreme conditions of the environment and etc. The considered characteristics are a link of the physiological researches with phytopathology, genetics and selection. Studying of potential opportunities of a genotype depending on environmental conditions has special value for rural and forestry as these data can be used in selection work, variety testing, introduction of plants, zone and intraeconomic placement of cultures and development of agrotechnology of their cultivation.

The regression models secured from the planned active (in the adjustable conditions of the environment) and passive (in the unregulated conditions of the environment) experiments, allow to define not only optimum conditions of formation of efficiency of plants, but also possibility of compensation of the limiting uncontrollable factors of the environment by the controllable ones. Partial change of factors of environment is possible not only in the protected area where practically all its main indicators, proceeding from economic reasons, are regulated, but also when developing agrotechnology of cultivation of field crops.

In this regard the problem of providing the constantly growing population of the Earth with food continues to be relevant. The area of arable land per one person was reduced to 0,35 hectares and tends to decrease. The important reserve of the solution of this problem in the visible prospect is the increase of efficiency of the arable land. It can be achieved either by increase of productivity of cultivated crops, or by the introduction of new more intensive species. During the development of agriculture people introduced about 5 thousand species of plants. However over 90% of food are provided by means of cultivation of only 15-20 species, that to a significant extent can be explained by insufficient knowledge of potential opportunities of both specific and intraspecific species diversity of natural plant resources.

Even now considerable capital investments in melioration are being made, and the system of agriculture is being improved. Thus improvement of cultivation conditions of agricultural and forest cultures at the expense of the increase of capital investments, is beneficial only at the equivalent increase of their efficiency. However it can be realized only on the basis of fuller use of potential opportunities of cultivated cultures according to their eco-physiological characteristics, selection of the new grades and introduction of highly productive ecotypes and species.

The ecophysiological characteristic of plants has to be considered when carrying out a variety testing, especially for the cultures of the protected area, in adjustable conditions of the environment. A variety has to be chosen not by testing on an equal footing, as it is done nowadays, but according to the eco-physiological characteristic, creating environment parameters which are the most optimum for the growth and development of concrete ecotype-variety. Forestry passing to an intensive way of development with cultivation of

saplings in the protected areas and plantation cultivation of the wood also raises topical questions for the ecological physiology. Optimization of these processes is possible only on the basis of knowledge of the environmental conditions providing an optimum for the growth and development of a certain crop.

In reference with the above, at the present time the ecophysiology is faced by a number of actual tasks:

– learning and further development of a technique of setting up of planned multiple-factor experiments on the basis of system approach;

– studying of regularities and mechanisms of influence of the leading factors of environment taking into account their zone influence on the biological processes in various phases of development of plants;

– constructing statistical, and at a later stage, dynamic models and quantification of the influence of both biotic, and abiotic factors on plants, and on the ecological characteristic of studied ecotype – variety.

Considering the importance of value of the ecophysiological characteristic of plants in selection and introduction work, at variety testing, geographical and intraeconomic placement of cultures, its definition at the specific and varietal levels, especially for the economically valuable and perspective for introduction species and varieties of plants becomes efficient.

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