New ideas in plant genetics and physiology in Lithuania during the 7th decade

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The 4th and 5th decades of the 20th century could be singled out as the stages of rapid development of biological science. Application of physical and chemical methods and ideas in biology induced its development, resulting in the creation of novel biochemical and molecular methods. Their use in different branches of biological science moved the investigations onto the level of molecular biology. Applying the method of science of science, an evaluation of initial investigations in plant genetics and physiology on the level of molecular and biochemical methods in Lithuania is presented. In the middle of the 1960s, novel methods and ideas were taken to be applied in plant genetics, delivering investigations on mechanisms of mutation process regulation, as well as in physiology investigating the physiological activity of the phytohormone auxin. The estimation of these investigations from the point of view of science of science proves to be of importance for periodization of experimental botany in Lithuania of the 20th century.

Key words: plant genetics, plant physiology, molecular methods, 1960s

INTRODUCTION

Alongside investigations on the level of the organism, the organ, the cell, in the middle of the 20th century investigations on the molecular level are were initiated, applying the methods and ideas of biochemistry and molecular biology in different branches of biology.

Molecular biology is related to the research of vital processes on subcellular and molecular level. In the first part of the 20th century ribonucleic acids (RNA) were supposed to be present only in the cells of plants and microorganisms, while deoxyribonucleic acids (DNA) were ascribed only to animals cells and were called thymus acid. In the middle of the second decade A. Belozerski published some scientific reports proving that thymus acids, *i.e.* DNA, were detected in plant cells, too [1]. In the middle of the 20th century important discoveries were made, which predetermined the further development of molecular biology. In the 5th decade RNA were concluded to be of importance in protein synthesis, while in the middle of the 5th decade it was proved that genetic function in the cell is performed not by protein but by DNA. In the end of the 5th and in the beginning of the 6th decade the key principles of DNA structure were formulated, while in 1953 J. Watson and F. Crick determined the structure of DNA. In the end of the 6th decade the half conservative DNA replication mechanism was proved, DNA polymerase, ribosomes, tRNA, mRNA were isolated, main stages of protein synthesis ascertained [2].

Since the beginning of the 7th decade investigations on gene activity or protein synthesis regulation were undertaken. In 1961 F. Jacob and J. Monod proposed a scheme or operon model of gene activity regulation in procaryotes. It was the basis for the investigations on the regulation of gene activity in eucaryotic cells. It had an influence on the development of different branches of biological science.

Investigations on molecular level in Lithuania were initiated in the middle of the 7th decade. The evaluation of the first works in plant genetics and physiology on molecular, biochemical level from the point of view of the science of science is significant for periodization of experimental botany of the 20th century in Lithuania.

MATERIALS AND METHODS

To study the development of science during a certain period, the methods of science of science are being applied. The development of science can be studied in different ways: considering the influence of historical conditions, the influence of new scientific ideas, etc. Our analysis was based on scientific publications. Considering the development of investigations of phytohormones, mutation processes and

molecular biology, publications prepared in the 7th decade in Lithuania on the regulation of mutation process and of the physiological activity of auxin were analysed. This process was described in review papers by A. Merkys [3, 4], V. Rančelis [5]. The evaluation of these works from the point of view of the science of science is significant for periodization of the experimental botany of the 20th century in Lithuania.

RESULTS AND DISCUSSION

1. Investigations on mutation process regulation

Investigations on plant genetics in Lithuania started in the first half of the 20th century. D. Rudzinskas solved the problems of applied genetics (selection). He was the first investigator of plant genetics sources in Lithuania. In 1922 he established the Plant Selection Station in Dotnuva. M. Natkevičaitė (Chair of Botany of Vytautas Magnus University), applied the method of genetic research to solve the problems of plant systematics. She generalised the obtained results in her doctoral thesis maintained in 1942 [6]. During the postwar period in the Soviet Union and in Lithuania the politically engaged theory of T. Lysenko was declared as the only possible in the science of biology. Genetic science which started to develop in Lithuania in the first part of the 20th century experienced repression. Objective scientific research of genetics as well as its studies at Vilnius State University were interrupted. It was only in the middle of the 7th decade that genetics revived in Lithuania. V. Rančelis and his colleagues at the Chair of Biochemistry, Biophysics and Genetics of the Faculty of Natural Sciences, Vilnius State University undertook investigations on the regulation of mutation process. In the middle of the 20th century I. Rapoport, S. Auerbach and others investigated the influence of chemical substances on mutation process [2]. It was a well-known fact that the process resulting in the occurrence of mutation was multistage: significant are all the processes before mutagen interaction with DNA, mutagen interaction with DNA and appearance or reconstruction of mutation disturbance [7]. It was clear that the efficiency of the effect of mutagenous substance depends on certain regulating endogenous factors, permeability of membranes among them. Ethylenedinitriltetraacetic acid (EDTA), a metal ion binding, and thus membrane permeability increasing, chelate forming substance was used for investigations. In the 7th decade the Chair was investigating the effect of mutagenous EDTA, combined EDTA and the alkylating mutagen ethyleneimine on fodder beans. It was found that the both substances EDTA and ethyleneimine, by different mechanisms of action exert a similar modifying effect that determines leaf colour. It was shown that the modifying action of EDTA is not connected with its chelating properties. There were disscusions on the possibility to utilize the modification to study the mechanisms of mutagen action [8]. In the end of the 7th decade the mechanism of antimutagenic resistance considering EDTA in fodder beans was demonstrated: part of EDTA was inactivated, bound with a certain substance called protector, and after 24 hours EDTA was released. The mechanism of temporal inactivation protects the organism against the harmful effect of a chemical substance [9, 10]. Some time later the mutagen interaction with metal ions, cell metabolites, certain enzymes was investigated; the results of the investigations were summarised in a monograph, and the manual of general genetics for students of universities was prepared [11, 12].

2. Investigations on plant growth physiology

The investigations were initiated in Lithuania in the first half of the 20th century. Investigating the growth processes, J. Dagys considered that apart from phytohormones in growth physiology some bios-substances at present called B vitamins ,are significant [13]. In the middle of the 7th decade investigations on plant growth physiology were proceeded on the molecular level. Since 1957 at the Institute of Biology, later Institute of Botany of the Lithuanian Academy of Sciences, investigations of physiological causes of crop lodging under the guidance of A. Merkys have been started [14, 15]. The following conclusions were made: the vertical growth of plant axial organs depends on the gravitropic reaction and mechanical properties of stem. Thus, in the 7th decade, under the guidance of A. Merkys biophysical and biochemical processes occurring in axial organs of plants belonging to different systematic groups during gravitropic reaction were investigated at the Laboratory of Plant Physiology. The hormonal theory of tropisms (gravitropism, phototropism, etc.) was advanced as far back as the first half of the 20th century [1]. An important part in gravitropic reaction was attributed to the phytohormone auxin; it was not, however, clear enough what forms of it participate in gravitropic reaction and how it acts.

In the middle of the 20th century, considering the data of research into gene activity, hormone function in the organism was evaluated in a novel way. J. Bonner formed a hypothesis that hormones perform an important role in gene regulation: being bound with proteins repressors – histones, they activate repressed genes and thus cause molecular synthesis of mRNA and of corresponding enzymes [16].

J. Bonner supposes that the regulation of gene activation by hormones in eukaryotes causes cell and tissue differentiation. The idea that the phytohormone auxin performs a physiological function by regulating gene activation in one or another way was approved in the 7th decade by some scientists as B. Patterson, J. Key, A. Trewavas [17, 18]. Besides, in Lithuania scientific works that contributed to the supposition that gravitropic reaction is controllable by the regulation of gene activation had appeared earlier, too. While investigating hybrids of the genus *Verbascum*, in 1937 M. Natkevičaitė-Ivanauskienė observed different teratological phenomena in some of them. Stems of thirteen of *Verbascum gnaphal*×*Verbascum thapsus* hybrids proved to be curved, *i.e.* plagiotropic [6]. In this case plagiotropism was shown as a prevailing sign and could serve as an argument that gravitropic reaction may be controlled at the level of genes. These new ideas were significant for the development of plant physiology in Lithuania in the second half of the 20th century.

In the middle of the 7th decade investigations on binding amino acids into proteins during gravitropic reaction were initiated at the Laboratory of Plant Physiology at the Institute of Botany of the Lithuanian Academy of Science. They were carried out by senior research scientist A. Marčiukaitis. Tthe method of labelled atoms allowed to obtain data showing that amino acid binding into proteins becomes more active in intensively growing parts of the axial organs of a gravitropically stimulated plant [18]. Postgraduate student of the laboratory J. Darginavičienė carried out similar investigations. She investigated a correlation between the amount of ribosome RNA and growth process [20]. Other research scientists (A. Putrimas, later M. Madeikytė-Savičienė) worked in this field as well. The accumulated data allowed research scientists of the laboratory of Plant Physiology of the Institute of Botany, guided of A. Merkys, to formulate the hypothesis: auxin performs a physiological function upon binding to a certain protein; this complex acts on the level of genes, forming certain iRNA, in which information required for urgent protein synthesis in cell growth regulation process is coded [21]. These investigations were of significance for further investigations of the physiological activity of auxin.

At present, thirty years later, scientists have no doubts as to the following: auxin performs a physiological function, acting on the DNA–RNA protein level; auxin proves to be physiologically active after binding to certain proteins-receptors. In the end of the 20th century auxin-binding proteins in cytoplasm membrane and cell cytosol were isolated. A great number of scientists from different countries were working in this field: M. Lobler, D. Klamb, S. Shimomura, M. Venis, A. Merkys, J. Darginavičienė, etc. [22–25]. In the beginning of the 21th century the function of phytohormones is being studied on different levels: molecular genetic, physiological, etc. This allows to suppose that in the nearest future the mode of auxin activity regulating plant growth and morphogenesis processes will be clucidated.

Thus, the conclusions are as follows:

1. In the middle of the 20th century novel research methods were developed and mastered, which allowed the research on molecular level.

2. In the middle of the 7th decade in Lithuania specialists of plant genetics and physiology initiated the application of methods of molecular biology.

3. In the middle of the 7th decade investigations on the regulation of mutation process were started.

4. In the middle of the 7th decade the physiological mode of auxin activity was studied on molecular level and a sheme of auxin activity was presented.

5. The above-mentioned information may be estimated as one of the stages in investigating the periodization of experimental botany in Lithuania of the 20th century.

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NAUJOS IDĖJOS AUGALŲ GENETIKOJE IR FIZIOLOGIJOJE, KILUSIOS SEPTINTAJAME DEŠIMTMETYJE LIETUVOJE

S a n t r a u k a

XX a. ketvirtąjį–penktąjį dešimtmetį galima išskirti kaip sparčios biologijos mokslo raidos etapą. Fizikos, chemijos metodų ir idėjų taikymas biologijoje skatino jos raidą, buvo sukurti nauji biochemijos, molekulinės biologijos metodai. Jų taikymas įvairiose biologijos mokslo šakose tyrinėjimus perkėlė į molekulinės biologijos lygį. Straipsnyje, pritaikius mokslotyros tyrimo metodą, įvertinami pirmieji augalų genetikos ir fiziologijos tyrimai molekulinių, biocheminių metodų lygiu Lietuvoje. Šių darbų įverinimas mokslotyros požiūriu yra svarbus eksperimentinės botanikos periodizacijai XX a. Lietuvoje.