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CHRONICLE

Allelopathy Department of the M.M. Gryshko National Botanical Garden of the NAS of Ukraine: scientific directions and prospects

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Abstract

The main periods of scientific research development in the Allelopathy Department of the National Academy of Sciences of Ukraine, from its establishment to the present day, are considered. The significance of allelopathy for modern science and its place among other scientific fields are revealed. The most important achievements of Academician A.M. Grodzinsky, as well as those of his students and followers, are highlighted. The directions of promising research of the Allelopathy Department are shown. The cooperation of scientists of the Allelopathy Department with other Departments of the M.M. Gryshko National Botanical Garden and institutions of the National Academy of Sciences of Ukraine is emphasized. Particular attention is paid to the current direction of restoring soils disturbed by military operations.

Keywords: Academician A.M. Grodzinsky, allelopathy, allelochemicals, microorganisms, silicon-containing mixtures, brassinosteroids, microalgae, phytostimulation

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Since 1965, the allelopathy group, under the leadership of Academician A.M. Grodzinsky, has been working within the Plant Physiology Department. In 1983, on the initiative of A.M. Grodzinsky, the Allelopathy Department was established on the basis of the Department of Plant Physiology, which he headed throughout his scientific activities.

Allelopathy as a scientific discipline emerged at the interface of such fields as plant physiology, geobotany, and ecological biochemistry. Allelopathy studies the physiological and biochemical interactions

and aftereffects of plant organisms in ecosystems, taking into account the influence of microorganisms. Many years of observations in nature and in agricultural and forest plantations have revealed both positive and negative examples of plant coexistence. The above-mentioned mutual influences among plants involve certain physiologically active compounds, mainly secondary metabolites, which can accumulate in the soil, undergo further transformation by microorganisms, and exhibit allelopathic effects (allelochemicals). They enter the soil

as part of plant excretions, products of the destruction of plant residues, and can also be synthesized by microorganisms.

In the 1970s and 1980s, A.M. Grodzinsky, together with colleagues, investigated the phenomenon of allelopathic soil sickness under many agricultural, fruit, flower, and ornamental crops, which made it possible to identify its main causes (primarily the accumulation of phytotoxins of plants and microorganisms) and to conclude that soil is the most important mediator of allelopathy (Grodzinsky, 1973). As a result, A.M. Grodzinsky pointed out the prospects of this direction for decades of further research.

Academician A.M. Grodzinsky, together with other scientists from the Allelopathy Department (i.e., V.Y. Maryushkina, L.D. Yurchak, and V.G. Kozeko), successfully developed the coenotic approach in allelopathy. According to this approach, in allelopathic research, it is necessary to consider the dynamics of population distributions of different plant species to isolate the coenotic component from other environmental factors. This task was solved experimentally using factor analysis. In addition, for understanding biocoenotic processes and managing the composition and productivity of phytocoenoses, an important role was given to microbiological processes of the root environment. Based on this, A.M. Grodzinsky proposed the following definition of allelopathy: “allelopathy is the circulation of physiologically active substances that play the role of a regulator of internal and external relationships, renewal, development, and change of plant cover in biogeocoenosis” (Grodzinsky, 1973: p. 22).

Allelopathic analysis of over 800 plant species allowed A.M. Grodzinsky to formulate the concept of allelopathic activity and tolerance of plants, as well as to divide plant species into active, medium, and low activity (Grodzinsky, 1973).

The scientific legacy of Academician A.M. Grodzinsky is reflected in numerous publications and monographs, among which is “Fundamentals of chemical interaction of plants” (Grodzinsky, 1973). A special place is also occupied by his sci-popular works (e.g., “Among nature and in the laboratory” – Grodzinsky, 1983) addressed to all those interested in the discipline (Davydenko et al., 2012).

In the following years, the Allelopathy Department was headed by Doctor of Biological Sciences, Prof. E.A. Golovko.

The department’s employees continued their research into the features of the allelopathic regime: in orchards – V.P. Grakhov; in aromatic and medicinal plants – L.D. Yurchak, G.A. Pobirchenko, S.P. Mashkovska, and T.O. Shcherbakova; in agrophytocoenoses, artificial substrates and steppe phytocoenoses – E.A. Golovko, N.N. Dzyubenko, S.O. Gorobets, L.I. Krupa, V.A. Derevyanko, and A.A. Blum; in ornamental plants – O.I. Dziuba, L.S. Akhov, and N.A. Pavliuchenko; in weeds – N.P. Didyk (Yurchak, 2005, 2006).

The studies on the microbiocenosis of soils in natural and artificial biogeocoenoses were of extreme importance. Thus, E.A. Golovko, O.Y. Kostroma, T.S. Shrol, N.E. Ellanska, O.P. Yunosheva, and I.G. Khokhlova studied the role of microorganisms in the processes of formation of steppe and agrophytocoenoses. Employees of the Allelopathy Department studied the composition of microbial groups in the soil of monocultures (agricultural and fruit crops, ornamental, aromatic, and medicinal plants, etc.), which allowed them to identify indicator microorganisms under conditions of allelopathic soil sickness.

Since 2006, the Allelopathy Department has been operating under the leadership of the Director of the M.M. Gryshko National Botanical Garden (NBG), Doctor of Biological Sciences, Corresponding Member of the NAS of Ukraine, N.V. Zaimenko.

At the current stage, the Allelopathy Department conducts a comprehensive analysis of plants and the soil environment using agrochemical and agrophysical (N.V. Zaimenko, I.P. Kharytonova, and T.Y. Bedernichuk), microbiological (N.E. Ellanska and O.P. Yunosheva), physiological-biochemical, and allelopathic research methods (N.P. Didyk, N.A. Pavliuchenko, O.I. Dziuba, O.V. Zakrasov, A.V. Viter, and others).

One of the priority areas of allelopathy is the search for highly effective, safe means of restoring disturbed and degraded soils, particularly due to acidification and salinization, as well as increasing the adaptive resistance of plants to drought and damage by phytopathogens. In this regard, the employees of the Allelopathy Department have proposed and implemented the use of silicon-containing

mixtures, exometabolites of micromycetes, as well as phytoameliorants to improve the condition of the root environment and increase the resistance of plants to the above-mentioned stress factors (Zaimenko et al., 2016a, 2016b, 2018a, 2018b, 2022).

The result of fruitful cooperation between scientists from the Allelopathy Department, Landscape Construction Department, Dendrology Department, Natural Flora Department, Cultural Flora Department, Acclimatization of Fruit Plants Department, Department of Tropical and Subtropical Plants and Flower-Ornamental Plants Department is microbiological, allelopathic, and agrochemical monitoring of the root environment of phytocoenoses of botanical and geographical areas, as well as research into the allelopathic properties of valuable introduced species, in particular non-traditional fruit and sideral plants, to regulate the allelopathic regime under conditions of long-term cultivation and create stable mixed agrophytocoenoses (Zaimenko et al., 2017, 2020, 2024c, 2025; Pavliuchenko & Dovhaliuk, 2019; Pavliuchenko et al., 2019).

One of the interesting areas of research in the Allelopathy Department is the modeling of energy and information processes operating in ecosystems, as well as ideas about the energetics of soil formation, allelopathy as a phenomenon of information exchange, and the development of approaches to analyzing the phenomenon of metabolism in ecosystems (Bedernichek & Hamkalo, 2014; Viter, 2016).

One of the important areas of work of the Allelopathy Department is the study of the role of biogenic elements in the induction of brassinosteroid synthesis to increase plant resistance to stress factors (Zaimenko et al., 2024b; Likhanov et al., 2024).

Together with scientists from the M.G. Kholodny Institute of Botany of the NAS of Ukraine, the synecological role of microalgae in the adaptation of biogeocoenoses to the increasing impact of anthropogenic load and climate change was studied. By joint efforts of the NBG, Biosphere Reserve "Askania-Nova", and Carpathian Biosphere Reserve, the soil-forming role of microalgae in soils with different agrophysical, agrochemical, and biological characteristics under anthropogenic load was determined. The effect of soil microalgae on the distribution of greenhouse gas pools and flows was analyzed.

The species-specific allelopathic activity of the studied microalgae in relation to various higher plant species was established. This feature allows the studied algae to be used not only to increase the productivity of certain crops, but also to control specific weed species in crops. It was established that the growth-stimulating effect of organosilicon fertilizer and microalgae culture fluid was enhanced when applied jointly before sowing (Zaimenko et al., 2023). It is shown that soil characteristics affect the allelopathic properties of microalgae. In particular, deficiencies in mineral nutrients can increase competition between higher plants and microalgae, negatively affecting growth processes. A significant effect of experimental strains of soil microalgae on the microbiocoenosis, agrophysical, and agrochemical characteristics of the soil has been established. The synecological role of microalgae in forming the pool of macro- and microelements in soil has been proven. A methodology for using microalgae for bioindication of soil pollution has been proposed. A technology for producing biological preparations from blue-green algae and natural silicon-containing minerals to increase plant resistance to abiotic and biotic factors has been developed.

A relevant area of scientific research at the present stage is the restoration of soils damaged by hostilities under conditions of russian aggression (Zaimenko et al., 2024a). In this regard, the Allelopathy Department, together with scientists from the Cultural Flora Department, the Acclimatization of Fruit Plants Department, and the Flower-Ornamental Plants Department, has launched a large-scale study to clarify the roles of microorganisms and allelochemicals in the purification and optimization of the biological state of soils contaminated as a result of hostilities. To reduce the negative impact of mixed contamination with explosives, it is planned to use phytostimulation to intensify microbial activity due to plant root exudates, which are capable, on the one hand, of using a source of nitrogen and carbon for rapid development, and, on the other, of decomposing, transforming, and removing pollutants from the soil.

The scientific achievements of the staff of the Allelopathy Department have been published in numerous foreign and domestic publications, including monographs, patents,



Figure 1. Principal monographs of the Allelopathy Department.

and a methodological manual, which is the result of a generalization of classical and modern methodological developments of both the staff of the department and world-famous scientists (Figs. 1 & 2).

The Allelopathy Department has trained five doctors and over 50 science candidates, who continue the work of Academician A.M. Grodzinsky. The global recognition of the achievements of the Ukrainian allelopathic school is evidenced by the International Allelopathic Society's establishment of the A.M. Grodzinsky Prize for the best published works in this field, which unites specialists from almost 50 countries worldwide.

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Figure 2. The Allelopathy Department patents received in recent years.

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Відділ алелопатії Національного ботанічного саду імені М.М. Гришка НАН України: наукові напрямки та перспективи

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Розглянуто основні періоди розвитку наукових досліджень у відділі алелопатії Національного ботанічного саду імені М.М. Гришка НАН України від його створення до сьогодення. Розкрито значення алелопатії для сучасної науки та її місце серед інших наукових галузей. Висвітлено найважливіші досягнення академіка А.М. Гродзинського, а також його учнів та послідовників. Показано напрямки перспективних досліджень відділу алелопатії. Підкреслено співпрацю науковців відділу алелопатії з іншими відділами Національного ботанічного саду імені М.М. Гришка НАН України та іншими установами Національної академії наук України. Особливу увагу приділено актуальному на сучасному етапі напрямку відновлення порушених ґрунтів за умов військових дій.

Ключові слова: академік А.М. Гродзинський, алелопатія, алелопатично активні сполуки, мікроорганізми, кремнієвімісні суміші, брасиностероїди, мікроводорості, фітостимуляція