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CHRONICLE

Fundamental and applied principles of introduction and conservation of phytogenetic diversity of new crops in Ukraine

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Abstract

The Department of Cultural Flora, as a leading scientific center, has achieved significant results in studying the phytodiversity. The research focuses on improving the processes of plant acclimatization and adaptation, creating original phytogenetic resources, and on the conservation, enrichment, and rational use of new, non-traditional, underutilized, introduced, and autochthonous useful plants. From its establishment to the present, the department has passed through three historical periods of development: the first (1945–1968) is associated with Academician Mykola Gryshko and Professor Danylo Lykhvar; the second (1969–2001) with Professor Yuriy Uteush; and the third (2002–present) is defined by the development of modern research directions. During the latest period, 17 major scientific projects were implemented to develop mechanisms for regulating growth, metabolic, and production processes in plants. These studies have unlocked the potential of new crops in Ukraine by leveraging original genetic resources and technological protocols to address critical issues in green energy, food security, organic production, and phytoremediation. Scientific and methodological foundations for the mobilization of new plant resources have been developed, resulting in the creation of gene pool collections of living plants (3,000 accessions) and a seed bank (approx. 10,000 accessions). The Collection Fund of Energy and Aromatic Plants (over 1,800 taxa) is officially recognized as a National Heritage of Ukraine. On this basis, unique genotypes (about 40 new crops) and highly adaptive plant cultivars with specified production parameters (150 original cultivars, nearly 100 of which were developed in the modern period) have been created. Mechanisms have been studied and modern methods developed to increase the resistance of newly introduced regional plant species to abiotic and biotic stressors. A new genotypic base of plants with C_4-type photosynthesis has been established, characterized by significantly higher potential for resilience and accumulation of valuable metabolites. The scientific and practical foundations for the introduction and utilization of new phytogenetic resources as highly efficient sources of protein, lipids, sugars, vitamins, biofuels, food products, feed, and green fertilizers, as well as for the restoration of marginal, eroded, and contaminated lands, have been theoretically substantiated and practically implemented.

Keywords: phytogenetic diversity, plant introduction, acclimatization and adaptation, breeding, gene pool conservation, new crops, bioenergy resources

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Alongside defending its territorial integrity and post-war reconstruction of infrastructure and the economy, Ukraine faces the critical challenge of ensuring its own food, biological, environmental, and energy security. The relevance of the work performed by the Department of Cultural Flora at the M.M. Gryshko National Botanical Garden of the National Academy of Sciences of Ukraine (NBG) is underscored by its alignment with the Law of Ukraine "On Priority Areas for the Development of Science and Technology". This work aims to solve strategically important global and regional problems by developing fundamental principles for the mobilization and rational use of new phytogenetic resources from the world's flora – specifically, economically significant crops essential to the country's recovery and development.

As a leading scientific structural unit of the NBG, the Department of Cultural Flora currently conducts fundamental and applied research in general biology, botany, plant introduction, physiology, biochemistry, genetics, breeding, and plant biotechnology. These efforts are directed toward studying the phytodiversity of Ukraine and the world, enhancing plant acclimatization and adaptation processes, creating original phytogenetic resources, and ensuring the conservation, enrichment, and rational utilization of new, non-traditional, underutilized, introduced, and autochthonous useful plants. The fundamental and applied results achieved by the department have significantly influenced the advancement of science, education, and technology, the popularization of research findings, environmental preservation, and improvements in food security and quality of life.

The historical prototype of the Department of Cultural Flora was the Department of Plant Biology. Founded in September 1945 at the initiative and with the support of Academician Mykola Mykolayovych Gryshko, the department was initially headed by the renowned Ukrainian scientist and breeder, Professor Danylo Fedorovych Lykhvar (Rakhmetov, 2011).

The "Useful Plants" exhibition and collection plot, located in the Zvirynets area of the NBG, was established before World War II. The foundation of the collection consisted of plants transferred from the Kyiv Acclimatization Garden of Academician Mykola Feofanovych Kashchenko. Some of these specimens survived until 1945 and subsequently replenished the department's collection fund (Rakhmetov, 2005).

From 1958 to 1961, Academician Mykola Mykolayovych Gryshko served as the head of the Department of Cultural Flora, and later, until 1964, as its senior researcher. From 1961 to 1965, the department (then known as the Department of Introduction and Acclimatization of Cultivated Plants) was headed by candidate of agricultural sciences Feofan Gryhorovych Perederiy, who focused on fodder plants and lawn grasses. During this time, the Department included research groups dedicated to fruit-bearing, agricultural, and subtropical plants.

Following a reorganization in 1965, Ivan Myronovych Shaitan became the head of the Department of Introduction of Cultivated Plants. During this period, research continued on new and underutilized food, medicinal, fodder, fruit, and lawn plants.

Subsequently, based on the ideas of Academician Andrii Mykhaylovych Grodzinsky, the Department of New Crops and Implementation was established. Following a competitive selection, candidate of agricultural sciences Yuriy Adoflovych Uteush was appointed as head on October 30, 1968. At that time, the team's primary efforts were focused on studying market demand and implementing the NBG's scientific developments (Rakhmetov, 2005).

The early 1970s marked the beginning of a major reconstruction and the establishment of new collection and exhibition plots for useful plants. In 1971–1972, the collection of aromatic and spice plants was restored, and in 1974, a fodder plant collection was established at a new site.

From 1969 to 1980, a specialized medicinal plant group operated within the Department, focusing on the introduction and use of valuable phytosamples. In 1980, this group became an independent laboratory, and in 1988, it evolved into the Department of Medical Botany. Later, in September 2003, by order of the NBG's director, this department was reorganized and reintegrated into the Department of New Crops as the Laboratory of Medical Botany.

In the early 1980s, the Department of New Crops was reorganized into a laboratory of the same name under the Department of Fruit Plant Acclimatization. Later, in 1984, it was renamed the Department of Fodder and Vegetable Plants, and since 1988, it has been officially known as the Department of New Crops. From 1969 to 1986, Professor Yuriy Adoflovych Uteush served as the head, and from 1986 to 2000, he acted as the interim head of the Department of New Crops.

By the beginning of 2000, the department's total collection fund of useful plants included approximately 300 taxa (Rakhmetov et al., 2003). Professor Yuriy Adoflovych Uteush and his team conducted extensive scientific research on the introduction and breeding of fodder, aromatic, and vegetable plants. During that period, 45 cultivars within these crop groups were developed. Significant scientific progress in the introduction and breeding of crops was achieved through the long-term dedication of scientists, including Professor and Doctor of Sciences Yuriy Adoflovych Uteush, and candidates of sciences: V.P. Hryn, G.M. Rybak, O.O. Abramov, K.M. Kryvytskyi, I.K. Kudrenko, O.A. Korablyova, N.O. Stadnichuk, V.K. Glabets, D.B. Rakhmetov, A.A. Razina, H.H. Ismagilova, and N.M. Smilyanets (Rakhmetov, 2011).

The modern period of the department's development began in 2002 and continues to the present day. During this time, new collection and exposition plots have been established, while existing ones have been reconstructed and expanded; today, their total number has reached ten.

Annually, approximately 3,000 accessions of new, non-traditional, underutilized, forgotten, and socially, economically, and ethnobotanically significant plants are presented across the collection funds, exhibition plots, nurseries, and the mobilization-quarantine area. A significant portion of these – specifically the Collection Fund of Energy and Aromatic Plants – is officially recognized as a scientific object constituting the National Heritage of Ukraine (Order of the Cabinet of Ministers of Ukraine dated January 28, 2015, No. 59-r) (Rakhmetov, 2015; Rakhmetov et al., 2020a; NBG, 2015).

The Collection Fund of Energy and Aromatic Plants (1,826 accessions) consists of eight collection and exhibition plots. This fund has been meticulously developed by NBG's scientists over an extensive period – the aromatic plant collection for approximately 80 years and the energy plant collection for over 30 years. It stands as the largest foundational collection of these plant groups in Ukraine (Rakhmetov, 2019; Rakhmetov et al., 2024a).

The collection fund represents flora from various botanical and geographical regions of the world. It includes annual, biennial, and perennial, as well as monocarpic and polycarpic plants. In terms of life forms, the majority of the accessions are herbaceous plants, while the woody group includes trees, shrubs, and subshrubs. The collection features diverse groups of plants categorized by their requirements for light, moisture, temperature, soil acidity, salinity, trophism, and other environmental factors. Generally, these plants have undergone long-term introduction trials, are well-adapted to conditions in Ukraine, demonstrate high production potential, and are capable of reproduction, with some species showing a capacity for naturalization.

In terms of quantitative and qualitative composition, the NBG collection of energy and aromatic plants is unparalleled in Ukraine and ranks among the best in Eastern Europe. It serves as a vital source for the conservation and *ex situ* reproduction of the rare phytogene pool of relevant plant groups from the flora of Ukraine and other countries. The collection fund gathers plants of immense scientific, economic, social, educational, and cognitive-ethnobotanical significance. This collection is particularly valuable for the preservation of plant diversity *ex situ*, providing an essential genetic fund for breeding and the creation of new forms and varieties with enhanced economically valuable traits, as well as for the production of new raw phytomaterials based on the most productive bioenergy, spice, essential oil, and medicinal crops.

For many decades, the collection fund has served as the foundation for creating targeted collections in various botanical gardens, specialized research institutions, and higher or secondary vocational educational institutions. The most promising representatives of the collection are continually involved in research addressing fundamental and applied problems in plant introduction, acclimatization, breeding, and biotechnology, led by research centers in Ukraine (including institutions of

the National Academy of Sciences of Ukraine, National Academy of Agrarian Sciences of Ukraine, and the Ministry of Education and Science of Ukraine) and other countries. The collection serves as a benchmark in the field of state cultivars testing.

In recent years, research results have been synthesized on the development of biological-ecological, physiological-biochemical, and breeding-genetic foundations for the introduction and acclimatization of new promising energy, aromatic-medicinal, spice, and essential oil plants. These represent the most valuable components of the collection fund, which constitutes an Object of National Heritage (Rakhmetov et al., 2024b).

Currently, the Department's primary research is conducted within the priority area of science and technology development: "Fundamental scientific research on the most important problems of developing scientific and technical potential to ensure Ukraine's competitiveness in the world and the sustainable development of society and the state". The priority thematic area of the Department's scientific research and technical developments is "Fundamental principles of plant functioning and adaptation under the influence of various external factors".

Over the recent period, through the execution of departmental (2), competitive (12), and contractual (3) research topics, as well as tasks within the framework of National Heritage support, the Department has achieved significant scientific and practical results of high social, economic, and environmental importance.

Based on these studies, the fundamental principles for introducing new useful plants have been developed, and original phytogenetic resources for economically important crops have been created to improve Ukraine's biological and food security in the context of climate change. A significant contribution has been made to the development of theoretical interdisciplinary scientific fields. Fundamental results have been obtained regarding the mobilization and effective utilization of resources from introduced and autochthonous plants with a complex of beneficial traits.

Biological-ecological, breeding-genetic, biotechnological, physiological-biochemical, and phytocenotic foundations have been developed to enhance the efficiency of plant introduction, acclimatization, and adaptation. These efforts focus on preserving and enriching phytogenetic diversity, increasing plant resistance and immunity, and improving the productivity and qualitative and quantitative characteristics of new cultures and genotypes. These achievements aim to strengthen Ukraine's food, energy, and environmental security during the state of war and in post-war reconstruction (Rakhmetov et al., 2020b, 2024c).

The phenotypic and genotypic variability of specific traits in plants under the influence of climatic and orographic factors has been established. Furthermore, changes in the rhythm of seasonal development under new growing conditions have been identified, and the reaction norms to abiotic factors have been determined.

Fundamental principles for enriching phytodiversity have been developed to unlock the potential of approximately 60 valuable crops new to Ukraine. Based on these principles, more than 140 cultivars have been created (including about 30 during the most recent period), all of which are included in the State Register of Plant Cultivars of Ukraine (MEU, 2025).

Mechanisms for regulating plant production processes have been developed using new genetic resources and original technological discoveries. A correlation has been established between the quantitative and qualitative parameters of specific substances and the degree of adaptive responses of plant organisms to stress factors. The positive role of new crops has been proven in phytoremediation of radionuclide- and heavy-metal-contaminated soils, in the restoration of marginal lands, in organic production, and as niche crops that serve as the foundation for a new direction in bioeconomics.

New genetic models of economically valuable crops have been created to enhance plant immunity and resistance to biotic and abiotic stresses. The physiological and biochemical characteristics of highly adaptive plant genotypes have been established. Furthermore, the most promising sources of proteins, lipids, sugars, and biologically active compounds for Ukraine have been identified through the evaluation and selection of the most valuable genotypes with superior quantitative and qualitative

raw material indicators. These results are intended for practical introduction and use in the agricultural, energy, and pharmaceutical industries, as well as in ornamental gardening.

The mechanisms underlying energy accumulation in plants (including those with the C_4 photosynthetic pathway) have been revealed, and evaluation criteria have been established, depending on taxonomic affiliation, genotypic differences, and seasonal development. This has enabled the development of fundamental and applied frameworks for creating new bioresources for the bioenergy sector (Blum et al., 2010, 2014; Rakhmetov et al., 2015, 2020b).

For the first time, the high efficiency of new crops of various life forms in CO_2 sequestration has been demonstrated, correlating with species-specific and genotypic characteristics. The most adaptive producers for organic carbon sequestration have been selected. Technologies have been developed for utilizing original cultivars of annual and perennial drought-, cold-, and frost-resistant plants for decarbonization. These cultivars are characterized by high levels of valuable organic matter accumulation and soil nutrient enrichment, facilitating the structural and functional optimization of crop rotations.

Based on theoretical generalizations and experimental research, promising phytoresources for Ukraine from three botanical genera (*Cicer* L., *Lepidium* L., and *Mentha* L.) have been mobilized. As a result of introduction and breeding work, a valuable gene pool (ca. 40 accessions) has been created, with 22 genotypes serving as subjects for comprehensive studies.

The impact of stressful introduction conditions on the morphological, biological, biochemical, and photosynthetic characteristics of plants was studied, along with production processes and the dynamics of secondary metabolite accumulation, including proteins with prion-like properties. Based on these findings, the most adaptive genotypes within each species were identified and integrated into the breeding process, resulting in the development of high-yielding cultivars.

Plants were identified in which an active transition of proteins from the alpha-state to beta-structures is observed in various tissues, depending on the influence of stress factors related to climatic and introduction conditions (representatives of the genera *Parrotia* C.A.Mey., *Mentha*, and *Cicer*). High-yielding cultivars have been created, including garden cress (*Lepidium sativum* L.) cultivar 'Talyshskyi', and horse mint (*Mentha longifolia* L.) cultivar 'Lerikska', which have been included in the State Register of Plant Cultivars (Rakhmetov et al., 2021a, 2023; Rashydov et al., 2022; MEU, 2025).

An introduction and breeding evaluation of new economically important oilseed crops has been conducted to enhance food and biological security. A gene pool collection of oilseed plants (camelina, mustard, and rapeseed – approximately 85 accessions) was established, serving as the scientific basis for the evaluation and selection of high-yielding breeding lines using biological-morphological, biochemical, and breeding-genetic markers. For the first time in Ukraine, the scientific and methodological foundations were developed for the introduction of a new oilseed plant, Ethiopian mustard (*Brassica carinata* A. Braun), into cultivation.

Methods for increasing the resistance of oilseed plants and improving their physiological processes have been developed. The qualitative and quantitative composition of lipids and other nutrients (56 samples) was assessed, and the content of 22 macro- and microelements in the raw phytomaterial was determined. The economic and technological properties of the plants, along with the quantitative and qualitative characteristics of the oil and by-products, were established, leading to the development of practical recommendations for the use of the raw phytomaterial.

Comparative analysis across different research periods revealed that all forms of *Camelina sativa* (L.) Crantz are characterized by high contents of linolenic (31.4–35.6 %), linoleic (19.8 –24.6 %), oleic (11.9–18.5 %), gondoic (11-eicosenoic) (9.5–12.9 %), and palmitic (9.5–11.4 %) fatty acids. It was found that *Brassica carinata* oil is characterized by a high content of erucic acid (36.0–45.0 %), linoleic acid (15.0–18.8 %), linolenic acid (11.0–13.0 %), and oleic acid (7.0–9.6 %). It was determined that the phytomass (3,444–3,994 kcal/kg) and seeds (5,830–6,331 kcal/kg) of these new oilseed plants possess high energy value.

High-yielding cultivars of *Camelina sativa* ('Ranok' and 'Runo' – spring forms, and 'Lider' – winter form) and a cultivar 'Novynka' of *Brassica carinata* were created using genetic markers. Original technologies for the utilization and processing of seeds and by-products have been developed for the production of edible and industrial oils, bakery products, and functional foods. Utility model patents UA157654 and UA157655 were obtained, and a Technological Instruction was developed alongside the "Methodology for determining the compliance of *B. carinata* cultivars with the criteria of distinctness, uniformity, and stability" (Rakhmetov et al., 2025).

Fundamental principles of plant introduction, acclimatization, breeding, and biotechnology have been established regarding the mobilization and creation of new phytogenetic resources. Modern technologies have been developed to conserve, enrich, and efficiently utilize the global potential of food and energy plants amid environmental changes (Zaimenko & Rakhmetov, 2022).

Biological-ecological, morpho-anatomical, physiological-biochemical, breeding-genetic, and phytocenotic criteria have been identified to enhance the adaptive capacity, resilience, productivity, and qualitative and quantitative characteristics of valuable introduced species. These criteria are essential for forecasting and preventing the negative impacts of climate change. Correlation-regression dependencies between morphological-biometric and biochemical indicators of plants have been established. The dynamics and accumulation levels of critical organic compounds in plants were determined, demonstrating the relationship between the quantitative-qualitative parameters of specific substances and the degree of adaptive response and resilience of plant organisms to stress factors under changing climatic conditions (Rakhmetov, 2017; Rakhmetov & Zaimenko, 2022).

Significant scientific and practical results have been achieved within the Department, providing the fundamental and applied frameworks for utilizing original phytoresources in the bioenergy sector. A comprehensive collection of bioenergy crops has been established, comprising approximately 714 taxa and 35 original cultivars bred by the NBG, supported by five utility model patents (AgrobioNet, 2018; Rakhmetov et al., 2020a, 2024a, 2024b, 2024c; Kalenska et al., 2021, 2022).

Research within the Biofuel Resources and Bioenergy framework led to the creation of a genotype collection of sweet sorghum (*Sorghum saccharatum* (L.) Moench). This collection, based on original and mobilized global cultivars' potential (approximately 100 accessions), aims to identify high-yielding plant forms as sources of biofuel. The biological and technological properties of the biomass have been established as second-generation energy raw materials for the continuous production of alternative liquid fuels. Using modern introduction, breeding, and biotechnological methods, highly adaptive sweet sorghum genotypes with superior qualitative and quantitative raw phytomaterial characteristics (14 accessions) were selected. Highly adaptive cultivars with increased sugar content have been developed, namely 'Garant', 'Botanichnyi', and 'Sorgodar'. An energy assessment of the plant's potential and resulting biofuel was conducted, along with a quantitative and qualitative evaluation of productivity indicators for the selected genotypes based on yields of primary and secondary products (Rakhmetov et al., 2024f).

Furthermore, research on new bioenergy resources and the improvement of primary raw materials for biofuel production led to the mobilization and breeding of new genotypes of fast-growing trees (poplar, willow, paulownia – 36 accessions) and perennial herbaceous plants (*Silphium* L. species – 35 accessions), promising for the biofuel industry. A comprehensive evaluation of the bio-ecological, adaptive, yield, biochemical, and productive potential of new stress-resistant plant genotypes was performed to develop first- and second-generation alternative biofuel sources. The technological properties, qualitative parameters of the plants, and the potential yield of biofuel, biogas, and bioethanol from the raw phytomaterial were assessed. The heat capacity of the biofuel and the energy and economic value of the promising genotypes were determined. Additionally, potential enhancements to the quality of phytomass pellets were evaluated. The impact of moisture deficit and salinity on the biological, morphological, molecular,

genetic, and physiological parameters of several poplar and willow clones was established (Rakhmetov et al., 2024d).

Based on our scientific justification, a new hybridogenic species, *Rumex kioviensis* Rakhmetov, A.S.Mosyakin & Mosyakin (*R. patientia* L. × *R. tianschanicus* Losinsk.) was described (Rakhmetov et al., 2024e). A new crop – hybrid 'Shavnat' was developed, leading to the creation of five cultivars now included in the State Register of Plant Cultivars of Ukraine (MEU, 2025).

As a result of the Department's scientific activities, a comprehensive methodological framework, including DUS (Distinctness, Uniformity, and Stability) methodologies for 46 crops, has been developed to introduce plant species new to Ukraine into both industrial and amateur cultivation (MEU, 2025). For approximately 40 plant species, the Department acts as the leading introduction and breeding center for new crops, holding a prominent or primary position in Ukraine.

The Department has developed over 20 modern phytotechnologies to improve the quality of life in Ukraine. Significant work has been carried out to prepare and publish 17 of the Department's scientific and innovative developments, which were included in the series of the reference publications "Promising Scientific and Technical Developments of the NAS of Ukraine". This series comprises three volumes: "Agro-industrial Complex and Ornamental Gardening", "Fuel and Lubricant Materials and Technologies", and "Food Industry" (Malchevskyi & Bespalova, 2017a, 2017b, 2017c).

The department's innovations – including cultivars and cultivation technologies for multi-purpose phytomass – are being implemented both within Ukraine and abroad. These include innovative technologies for the cultivation, processing, and utilization of high-value useful plants as efficient sources of biofuels, new food products, medicinal agents, and phytofertilizers. The highly adaptive cultivars developed by the department are well known internationally. They are successfully used as alternatives to traditional crops in agricultural production, the energy sector, organic farming, and as high-value niche crops.

The implementation of the department's horticulture and agricultural production initiatives ensures employment, enhances landscape quality, and expands the range of available phytomaterials. The social and practical significance of this work lies in increasing the biotic diversity of cultural phytocoenoses by enriching the assortment of high-yielding crops, developing bio-ecological methods for soil fertility enhancement and health restoration, reducing protein deficits, utilizing promising biofuel sources, and improving public access to high-vitamin food products and medicinal raw materials with elevated concentrations of bioactive compounds.

The Department's collection fund has served as the foundational base for the preparation and successful defense of one doctoral dissertation (Ludmyla Anatoliivna Kotyuk) and a series of Candidate of Sciences and PhD dissertations (including works by V.I. Solonenko, S.D. Kryklyva, O.M. Vergun, O.L. Andrushchenko, V.H. Mykolaichuk, L.V. Todorova, O.V. Shkura, O.M. Kozlenko, S.M. Kovtun-Vodyanytska, N.Y. Levchyk, V.O. Derkach, A.S. Polyakova, O.P. Bondarchuk, V.P. Voloshchuk, O.V. Sokol, O.V. Shymanska, and I.V. Tsaruk). Currently, doctoral candidates I.V. Ivashchenko and A.M. Gnatyuk, along with postgraduate students N.V. Nikishova, S.T. Osmanov, O.M. Gavrylyuk, D. Ilienko, and researcher O.M. Melnychuk, are actively working on their dissertations under the scientific consultation and supervision of D.B. Rakhmetov.

Recently, the department's scientific staff has been strengthened by a senior researcher and Dr. Agric. Sci. N.V. Leshchuk, senior researcher and Cand. Biol. Sci. A.S. Mosyakin, and a senior researcher and Cand. Biol. Sci. N.S. Shuvalova. The engineering staff provides crucial scientific and practical support for collection maintenance and laboratory research under the guidance of research directors: M.O. Gaznyuk, N.V. Nikishova, N.P. Ovsyannikova, O.V. Chepurna, D.K. Zdrylyuk, and O.M. Gavrylyuk.

In recent years, fundamental and applied research utilizing the Department's phytogenetic resources has resulted in the publication of approximately 20 monographs, three textbooks, and over 60 articles indexed in Scopus and Web of Science, as well as more than 40 articles in specialized Ukrainian scientific journals. Furthermore, approximately

20 plant cultivar patents and ten utility model and invention patents have been obtained. Three methodologies for the DUS examination of new crop cultivars were published, and two Technical Specifications were prepared and approved.

The department holds a leading position in popular science and environmental education. It has organized and hosted ten international scientific conferences and seminars, as well as over 30 events aimed at popularizing scientific developments. The proceedings of these scientific events have been published. They are available through official platforms, including the Ministry of Education and Science, the National Academy of Sciences of Ukraine, and regional educational portals (MESU, 2024; Dity v Misti, 2024; NASU, 2024).

The department's scientific results have been comprehensively integrated into the higher education process. A specialized educational and methodological complex has been developed for postgraduate students within the NBG educational programs: "Plant Introduction, Acclimatization, and Breeding" and "Scientific Foundations of Biodiversity Conservation, Enrichment, and Utilization" (NBG, 2023).

Furthermore, an educational and methodological complex for master's students has been developed for the disciplines "Energy Plant Resources" and "Phytoenergetics" at the National University of Life and Environmental Sciences of Ukraine (NULES, 2022a, 2022b). Through our active participation, three textbooks have been published (AgrobioNet, 2018; Rakhmetov & Kovtun-Vodianytska, 2021; Kalenska et al., 2021, 2022).

Approximately 100 students from biological, medical, biotechnological, and agricultural backgrounds complete their practical internships at the Department each year. These internships cover key areas such as biology, crop production, medical botany, bioenergetics, and plant introduction and acclimatization.

In conclusion, the Department's activities have yielded significant scientific and practical results. The fundamental and applied frameworks for the introduction, acclimatization, adaptation, and breeding of useful plants have been established to ensure the conservation and enrichment of genetic resources for economically valuable species. Scientific and methodological foundations for the mobilization of new plant resources and the creation of funds for collection, breeding, and exhibition have been developed. Furthermore, the department's collection funds have been fully digitized for accounting and management.

The cultigenic range of valuable introduced species in Ukraine has been modeled, providing a comprehensive assessment of the success and prospects of plant introduction, acclimatization, and breeding. Environmental and geographical trials of new crops and newly created cultivars have been conducted across various regions.

The mechanisms have been studied, and modern methods have been developed to increase the adaptive capacity and resilience of plant species new to the region, depending on abiotic and biotic stress factors. The specific characteristics of seasonal growth and development rhythms have been identified. Macro- and microscopic studies of various plant forms and hybrids were performed to identify diagnostic features and structural changes under the influence of biotic and abiotic factors. Scientific principles have been established for the creation of highly adaptive forms, plant cultivars, and hybridogenic crops with specified production parameters.

Regularities in the progression of production processes and the accumulation of secondary metabolites in plants have been established. Methods to increase photosynthetic efficiency have been developed by selecting new, high-performance producers. Significant results have been obtained regarding the potential use of new crops in phytoremediation to enhance soil fertility and restoration.

Modern phytotechnologies have been developed to reproduce and rationally utilize new phytogenetic resources of economically valuable crops, specifically tailored for operation under martial law and for the post-war recovery of Ukraine. Promising plant sources of bioactive compounds, nutrients, various types of biofuels, medicinal phytoagents, and balanced food products have been successfully introduced into production.

As a leading scientific center, the Department of Cultural Flora plans to continue

its fundamental and applied research aimed at studying plant diversity and at preserving, restoring, and utilizing the potential of the original phytogene pool of both newly introduced and autochthonous useful plants. These efforts are dedicated to strengthening Ukraine's food and energy security and advancing the bioeconomy.

In the long term, the scientific team's primary focus will be on deepening research into ecological-biological, physiological-biochemical, genetic-breeding, and biotechnological mechanisms to optimize the processes of plant introduction, adaptation, and the development of resistance and immunity to abiotic and biotic stressors. A key priority will be the implementation of modern IT technologies for the inventory and management of phytoresources. Special attention will be devoted to the environmental aspects of studying new crops, particularly leveraging their potential in carbon farming and phytoremediation.

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Фундаментальні та прикладні засади інтродукції та збереження фітогенетичного різноманіття нових культур в Україні

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Відділ культурної флори як провідний науковий центр досяг вагомих результатів з вивчення фіторізноманіття, поліпшення процесу акліматизації, адаптації рослин, створення оригінальних фітогенетичних ресурсів, збереження, збагачення і раціональне використання нових, нетрадиційних, малопоширених інтродукованих та автохтонних корисних рослин. Від початку заснування до сьогодення відділ пройшов три історичні періоди становлення та розвитку: перший період охоплює 1945-1968 рр. і пов'язаний з ім'ям академіка М.М. Гришка та професора Д.Ф. Лихваря; другий – 1969-2001 рр. – з ім'ям професора Ю.А. Утеуша; третій період – з 2002 до теперішнього часу, який пов'язаний з розвитком сучасних напрямів досліджень. За останній період у відділі здійснено низка вагомих наукових проєктів (17), спрямованих на розробку механізмів регуляції ростових, метаболічних, продукційних процесів у рослин і відкриття потенціалу нових для України культур з використанням оригінальних генетичних ресурсів та технологічних регламентів для вирішення важливих проблем у галузі зеленої енергетики, продовольчої безпеки, а також у органічному виробництві та фіторемедіації. Розроблено науково-методичні основи мобілізації нових рослинних ресурсів та створено генофондові колекції живих рослин (3,0 тис. зразків) та насінний фонд (близько 10 тис. зразків). Колекційний фонд енергетичних та ароматичних рослин (понад 1800 таксонів) визнано державою як Національне надбання України. На цій основі розроблено унікальні генотипи (близько 40 нових культур) та створено високоадаптивні сорти рослин із заданими продуктивними параметрами (150 оригінальних сортів, майже 100 з яких за сучасний період). Вивчено механізми та розроблено сучасні методи підвищення стійкості нових для регіону видів рослин залежно від абіотичних та біотичних стрес-чинників. Створено нову генотипову базу рослин з C_4 типом фотосинтезу, які відзначаються суттєво вищим потенціалом стійкості та накопичення цінних метаболітів. Теоретично обґрунтовано та практично реалізовано науково-практичні основи введення у культуру і використання нових фітогенетичних ресурсів як високоефективних джерел білку, ліпідів, цукрів, вітамінів, фітопалива, харчових продуктів, кормів, фітодобрив та для відтворення маргінальних, еродованих, забруднених земель.

Ключові слова: фітогенетичне різноманіття, інтродукція рослин, акліматизація та адаптація, збереження генофонду, нові культури, біоенергетичні ресурси