From Genetics to Agro-Industrial Programs: The Role of Agrobiological Knowledge in Ukrainian Agriculture in the Second Half of the Twentieth Century

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Abstract.
Relevance. In the second half of the twentieth century, agrobiological knowledge became a key factor in the modernization of Ukrainian agriculture, combining the achievements of genetics, breeding, and agrotechnology with state food programs. Studying them allows us to better understand the interaction between science and agricultural policy and to evaluate the experience that is important for the current challenges of food security.
Results. The peculiarities of the functioning of the agricultural sector of the Ukrainian SSR as a key region of the Union are summarized: construction of agro-industrial facilities, development of infrastructure, introduction of technical resources and strengthening of the role of collective farms. It is shown that the use of biological science achievements - the creation of new varieties and hybrids of plants, animal breeds, and strains of microorganisms capable of functioning effectively in artificially created production conditions – was crucial for increasing the productivity and sustainability of agrocenoses. The article focuses on the scientific activities of Academician O. Sozinov, who played a key role in the development of agrobiological science and agricultural policy of Ukraine, and his scientific work has become a theoretical and methodological toolkit of modern agricultural science in Ukraine. The scientist emphasized the importance of combining genetics, breeding, and physical and chemical biology in the formation of new approaches to agrobiological food security.
Conclusions. In the second half of the twentieth century, agrobiological knowledge became a key tool for the renewal of Ukrainian agriculture: it determined scientific priorities, ensured the introduction of new varieties and technologies, and formed the basis of food programs, including the USSR Food Program of 1982, contributing to food security. The experience of this period demonstrates that the integration of science and production is the key to food security and agricultural sector development.
Keywords: agrobiology, food program, Ukrainian SSR, O. Sozinov, genetics and breeding, agricultural science

Від генетики до агропромислових програм: роль агробіологічних знань у сільському господарстві України другої половини XX ст.

Нижник Світлана
Національна наукова сільськогосподарська бібліотека Національної академії аграрних наук України (Київ, Україна)

Анотація.
Актуальність. У другій половині XX ст. агробіологічні знання стали ключовим чинником модернізації українського сільського господарства, поєднавши досягнення генетики, селекції та агротехнологій із державними продовольчими програмами. Їхнє вивчення дає змогу глибше зрозуміти взаємодію науки й аграрної політики та оцінити досвід, важливий для сучасних викликів продовольчої безпеки.
Результати. Узагальнено особливості функціонування аграрного сектору Української РСР як ключового регіону Союзу: будівництво агропромислових об'єктів, розвиток інфраструктури, впровадження технічних ресурсів та зміцнення ролі колективних господарств. Показано, що вирішальне значення для підвищення продуктивності та стійкості агроценозів мало використання досягнень біологічної науки – створення нових сортів і гібридів рослин, порід тварин, штамів мікроорганізмів, здатних ефективно функціонувати у штучно створених умовах виробництва. Акцентовано увагу на науковій діяльності академіка О. Созінова, який відіграв ключову роль у розвитку агробіологічної науки та аграрної політики України, а його науковий доробок став теоретико-методологічним інструментарієм сучасної аграрної науки в Україні. Вчений наголошував на важливості поєднання генетики й селекції у формуванні нових підходів до агробіологічного забезпечення продовольчої безпеки. Висвітлено розвиток таких напрямів, як генетика імунітету та стійкості, культура клітин і тканин in vitro, молекулярна генетика й генетична інженерія, що заклали підґрунтя для якісно нового етапу у сільськогосподарській науці.
Висновки. Агробіологічні знання у другій половині XX ст. стали ключовим інструментом оновлення українського сільського господарства: визначали наукові пріоритети, забезпечували впровадження нових сортів і технологій та лягли в основу продовольчих програм, зокрема Продовольчої програми СРСР 1982 р., сприяючи формуванню продовольчої безпеки. Досвід цього періоду демонструє, що інтеграція науки й виробництва є ключем до продовольчої безпеки та розвитку аграрного сектору.
Ключові слова: агробіологія, продовольча програма, Українська РСР, О. Созінов, генетика і селекція, аграрна наука, сільське господарство

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Introduction.

The relevance of the topic is driven by growing global challenges related to food security, climate change, soil degradation, biodiversity loss and population growth. In the second half of the twentieth century, Ukraine, as one of the key agricultural republics of the USSR, played an important role in implementing food programmes aimed at providing the country's population with food. The success or failure of these programmes largely depended on the level of development of agrobiological knowledge – a set of scientific knowledge about soils, crops, agricultural techniques, breeding, genetics, biological plant protection products, etc.

Given the global challenges such as pandemics, environmental disasters, geopolitical crises and shrinking arable land, agrobiology is becoming a key tool in ensuring food independence and developing sustainable agricultural systems. The use of scientific achievements of both past and present scientists allows not only to increase the effectiveness of food programmes, but also to minimise the negative impact of the agricultural sector on the environment.

Ukraine plays a key role in ensuring global food security. Thanks to its fertile soils, favourable climate and developed agricultural sector, the country is one of the largest exporters of grains and oilseeds in the world. The Russian-Ukrainian war has had a significant impact on all areas of life, including the agricultural sector. The blockade of ports, the destruction of infrastructure, the mining of fields and the lack of resources have made agricultural production difficult. In this context, genetics and breeding are of particular importance, as they help to increase the resilience of crops and animals to stress factors, reduce the need for resources and ensure production sustainability.

Analysis of research and publications. The theoretical and practical foundations of food supply are thoroughly covered in the works of foreign scientists: M. Izraelov, J. Silber (Izraelov & Silber, 2019), J. Cadillo-Benalcazar, A. Renner, M. Giampietro (Cadillo-Benalcazar, Renner & Giampietro, 2020), J. Fanzo, N. Covic, A. Dobermann, S. Henson, M. Herrero, P. Pingali, S. Staal (Fanzo. 2020).

Ukrainian scientists have made a significant contribution to solving food security problems: D. Krylov (2023), V. Zalizniuk (2018), L. Kuchechuk (2022), O. Shevchenko (2021), V. Franchuk, M. Kopytko & S. Melnyk (2022), A. Maryna, Ya. Yankovska (2023).

L. Shynkaruk, K. Alekseeva, V. Bykhovchenko, T. Vlasenko (2022) study the essence of food security, the main principles of its formation in Ukraine, and consider the problem of food sovereignty as the main approach to food security. The authors analyze food security in the context of association with the EU, issues of food safety regulation, and the implementation of the European model of food safety control.

Paying tribute to the achievements of these authors in this area, it should be noted that agrobiological knowledge in the formation and implementation of food programmes in Ukraine in the second half of the twentieth century has not been studied in depth.

The purpose of the article is to analyze the role of agrobiological knowledge in the implementation of food programs in Ukraine in the second half of the twentieth century, to find out their impact on increasing the productivity of agroecosystems, the formation of highly productive varieties and hybrids, and to show the importance of scientific achievements, in particular of Academician O. Sozinov, in ensuring food security and the development of modern agricultural science.

Outline of the main material of the study. Food security is one of the key challenges of the modern world. It encompasses the availability, quality and sustainability of food systems that provide the population with the necessary food. Today, Ukraine's food security is facing a number of threats that may complicate food supply both in certain regions of the country and globally. These include climate change, armed conflicts and political instability, shortage of natural resources, economic crises and inflation, and dependence on global supply chains.

The development of agricultural science in the USA and Europe had a significant impact on the emergence of agricultural experimentation in Ukraine. At the end of the 19th and the beginning of the 20th century, research institutions established on Ukrainian territory received equipment and scientific literature from European countries, seed materials from the USA and Canada, and talented youth, upon completing university education, were sent abroad to eepen their knowledg and enrich their experience (Vergunov & Shchebetiuk, 2024, p. 85).

After the end of the Second World War, Ukrainian agriculture found itself in an extremely difficult situation. The war caused huge material and human losses. Fields were mined and some areas were devastated, making it impossible to conduct normal agricultural production. Nevertheless, a gradual process of agricultural recovery began in the second half of the 1940s and early 1950s. However, despite some recovery of economic potential, agriculture remained unproductive. Peasants were not motivated to work, as wages were low and the state seized the lion's share of the harvest. Yields remained low, and food supplies were unstable. Despite some successes in restoring the economy, the overall situation remained a crisis for many years.

In the 1950s and 1960s, there was no single approach to solving the food problem. However, global and agricultural policies focused on stimulating the production of key crops, primarily wheat and rice. It was believed that this was the only way to achieve ‘freedom from want’ and ‘freedom from hunger’ at the global level. Therefore, the global dynamics of grain production and stocks served as an important indicator of the implementation of these concepts. At the national level, developed countries sought to ensure food independence

and reduce food imports. At the same time, there was a gradual realisation that food aid not only contributed to the improvement of the situation in recipient countries but could also undermine their ability to be self-sufficient in the medium term. As a result, it only worsened the food security of the population. This point of view was reflected in numerous publications and influenced the activities of the World Food Programme (Pylypenko, 2013, p. 48).

In the mid-twentieth century, Ukraine made a transition to industrial food production. An agro-industrial complex (AIC) was formed, which accounted for more than 40% of national income (Sozinov, 1982, p. 3-8). Under these conditions, a new approach to the development of agriculture as a key component of the agricultural production chain was needed.,

The USSR Food Programme of 1982 was a large-scale government initiative launched to overcome the food crisis and ensure a stable supply of food to the population of the Soviet Union, including the Ukrainian SSR. Ukraine, as one of the main agricultural regions of the USSR, played a key role in the implementation of the programme.

Implementation features: massive construction of agro-industrial facilities (elevators, meat processing plants, dairies); increased supply of machinery to villages (tractors, combines, trucks); opening of specialized enterprises for storage and processing of products; strengthening the role of collective and state farms (the state stimulated 'labour competitions', introduced bonuses for 'overfulfilment of the plan'); investments in rural infrastructure (roads, housing, schools, clubs, but in very limited amounts).

In the new environment, the nature and role of agricultural science has changed: a systematic approach, comprehensive research and evaluation of the effectiveness of scientific developments based on the final results have come to the fore.

Since the main means of production in the food industry are living organisms - plants and animals – biological science played a key role in the implementation of this programme. One of the main ways in which biology influences this process is through the creation and introduction of new varieties and hybrids of crops, as well as animal breeds and hybrids.

To ensure high and stable yields, it was necessary to form artificial agrobiocenoses, whose productivity was maintained through significant fossil energy consumption for tillage, land reclamation, fertilizers, pesticides, etc. The main feature of such biocenoses was the limited number of components, as in most agricultural regions, the sown areas were used to grow 5-6 main crops. As a rule, the same crops returned to the same field every 3–4 years, and due to the saturation of crop rotations with cereals, they were often grown in the same place for 2-3 years in a row. This made it difficult to comply with the phytosanitary regime and created difficulties in providing plants with the necessary mineral elements. In addition, the fields differed significantly in terms of soil fertility, erosion, topography and slope exposure. Therefore, in order to obtain high and stable yields, O. Sozinov stressed that it is important to use several varieties or hybrids of major crops in each region and farm, which differ in terms of fertility requirements, length of the growing season and genetic resistance (Sozinov, 1982, p. 5). As a result, the optimal placement of different varieties and hybrids, taking into account their adaptation to specific growing conditions, has significantly increased the productivity and sustainability of agrocenosis without additional fossil energy consumption.

It should be noted that among the cohort of scientists, O. Sozinov (1930–2018) stands out for his broad scientific outlook – a geneticist, breeder, biotechnologist, agroecologist, organiser of genetic and breeding and agricultural science, education and agricultural policy in Ukraine, academician of the Ukrainian Agrarian Academy of Sciences of Ukraine (now the National Academy of Agrarian Sciences of Ukraine), the National Academy of Sciences of Ukraine and 16 other academies of the world (Nyzhnyk, 2024, p. 32).

By the end of the twentieth century, agrobiological science had made significant progress in creating new varieties and hybrids of plants, animal breeds and strains of microorganisms that can effectively use artificially created conditions to produce valuable biomass. On the one hand, huge investments are being made in improving tillage technologies, fertiliser and pesticide production, and on the other hand, in improving the hereditary characteristics of cultivated plants, which is done by relatively small groups of breeders. Obviously, these factors are interconnected: without the right growing conditions, new varieties will not be able to reach their genetic potential. However, if, under the same conditions, a new winter wheat variety produces 10–15 centners more grain per hectare than the old one, the enormous potential of breeding work becomes apparent.

O. Sozinov, being a global expert on grain quality, paid special attention to the quality of the crop. After all, if we evaluate production by the end product, the efficiency of agricultural activities largely depends on the quality of grain, oilseeds, sugar beet roots, etc. Despite technological changes, biological objects – plants, animals and microorganisms – continue to play a key role in food production. To increase yields, intensive tillage, fertilisation and pesticides, the use of modern machinery, and measures to improve soil fertility are used. At the same time, the effectiveness of increasing food production depends to a large extent on the hereditary and genetic characteristics of valuable agricultural organisms.

O. Sozinov identified the establishment of integration between research at the molecular genetic level and genetic analysis of traits and properties of organisms as a priority task of agrobiological science. Particular attention was paid to establishing relationships between

genome structure, functional activity of genes and phenotypic manifestations of organisms. He obtained new data on the mechanisms of functioning of the genetic apparatus of eukaryotic and prokaryotic cells, deciphered the nucleotide sequences of DNA and RNA of numerous plasmids, bacterial chromosomes and individual genes. The peculiarities of molecular chaperones, which ensure the correct folding of proteins, and DNA repair mechanisms, which play a key role in the preservation of genetic information, were elucidated.

The discovery of introns and transposons was a significant achievement, which expanded the understanding of genome variability and its evolutionary development. A major breakthrough was the synthesis of functionally active genes, including the interferon gene, which can be integrated into the chromosomal or plasmid machinery of bacterial and yeast cells. These achievements laid the foundation for the development of genetic engineering and biotechnology, which opened up new opportunities in medicine, pharmacology and agriculture.

We can say that there have been qualitative changes in the breeding process. Already then, it was possible to put on the agenda the development of biotechnologies for the construction of genotypes with a set of necessary traits and properties, which should have led to a significant increase in the efficiency of breeding and a significant increase in its impact on the implementation of the country's food programme.

Effective use of breeding achievements was closely linked to the development of the biological basis of seed production and breeding. In order to obtain high-quality seeds, it was necessary to study more deeply the physiology and biochemistry of the processes of seed formation, accumulation of reserve and physiologically active substances, and to develop methods to stimulate the initial processes of plant development.

The effectiveness of breeding achievements was determined by the development of the biological basis of seed production and breeding. Research on the physiology and biochemistry of seed formation and plant growth regulation contributed to the creation and use of physiologically active substances (gibberellins, retardants, herbicides), which increased yields and product quality while reducing energy costs. The study of photosynthesis, resistance to stress factors and environmental conditions has led to an increase in agricultural productivity.

At the same time, the concentration of crops has led to the spread of diseases and pests, which has led to the massive use of pesticides. Agricultural science has improved the methods of their application, reducing toxicity and application rates. To prevent pest resistance, we introduced the alternation of pesticides. In particular, this approach in cotton farming has reduced treatments and costs, increasing yields.

In the second half of the twentieth century, biological methods of plant protection were developed significantly: trichogramma, entomophages, entomopathogenic bacteria, fungi, viruses, and nematodes were used; microbiological preparations (in particular, based on Bacillus thuringiensis) and the nuclear polyhedrosis virus against the cabbage scoop were created. This helped reduce crop losses. The Ukrainian microbiological industry was formed on the basis of the use of microorganisms, which ensured the production of feed protein, amino acids, antibiotics and biologically active substances. The main areas of biotechnology were the production of amino acids, vitamins, medicines, and the development of technologies based on plant cell culture.

The study of the structure and functions of biological membranes has become important in the development of new effective biotechnologies. The significance of these studies was evidenced by the Resolution of the Central Committee of the CPSU and the Council of Ministers of the USSR ‘On Further Development of Physical and Chemical Biology and Biotechnology and the Use of Their Achievements in Medicine, Agriculture and Industry’, adopted on 26 August 1985, number 807. This document defined the strategic directions for the development of biological sciences and biotechnology in the USSR, in particular in the fields of medicine, agriculture and industry. The Resolution provided for the intensification of research in molecular biology, genetics, and biochemistry and the implementation of their results in practice. It also focused on the creation of new biotechnological drugs, the development of genetic engineering, and the use of scientific achievements to improve the efficiency of the national economy. It should be noted that the CPSU Central Committee and the Council of Ministers of the USSR considered further expansion and deepening of fundamental research in the field of physical and chemical bases of life phenomena to be one of the most important tasks of Soviet science. On this basis, it was planned to ensure the prevention and effective treatment of human diseases, as well as the production of medicines, food and feed substances using new methods.

Research on the genetics of immunity and resistance to adverse environmental conditions played a crucial role in the Food Programme. The in vitro cultivation of cells and tissues was of particular importance in solving this key problem. At that time, in addition to the already mentioned uses of in vitro culture, the production of somaclonal variations became widespread. The genetic nature of this phenomenon was not fully understood, but under certain conditions, real mutational "explosions" occurred in the cultured callus, covering numerous loci (Kimura, 1979).

In the second half of the twentieth century, significant progress was made in genetics: introns and transposons were discovered, and their role in gene regulation and evolution was clarified. Molecular genetics and genetic engineering of plants were actively developed, and gene cloning was introduced. This led to the use of molecular

biology methods in the creation of new forms of plants and animals. At the same time, the effectiveness of these approaches depended on the development of classical genetics and physicochemical biology, in particular methods of DNA cloning, in situ hybridization, and protein and DNA sequencing.

O. Sozinov noted that a qualitatively new stage in the development of genetics and breeding had begun. In his opinion, provided that genetic research is developed at the appropriate intensity in close cooperation with breeding centres and research teams working in the field of physical and chemical biology, the role of genetics and breeding in solving the problem of providing the country's population with diverse and high-quality food could increase immeasurably (Sozinov, 1987, p. 13).

To increase the productivity of the land, the rhythms of seasonal plant development were used to form compacted crops and agrocenoses with similar growing and ripening periods. This allowed for 2–3 harvests per field during the warm season, which significantly increased the efficiency of land use. The USSR Food Program in the second half of the twentieth century also envisaged the creation of complex biogeocenoses of terrestrial and aquatic organisms linked by ecological interconnections.

The urgency of the problem was exacerbated by the fact that agricultural technologies and other forms of natural resource management were focused on cultivating large homogeneous areas, which contributed to increased risks of erosion, the spread of diseases and pests, and disruption of natural ecosystem regulation mechanisms.

O. Sozinov prepared a number of fundamental works in which he consistently substantiated the importance of genetic and breeding research for the modernization of agricultural production. Among them are his works «Genetics and Breeding in the Implementation of the Food Program» (1987), «Scientific Support of the Agricultural Industry» (1988), «Agricultural Science and the Food Problem» (1990) (Sozinov, 1987; 1988; 1990) and others. In his publications, the scientist focused on the integration of agrobiology achievements into agricultural practice, justified the need to strengthen interdisciplinary research and introduce the latest breeding methods to increase crop productivity and the stability of the country's food supply. His works became the conceptual basis for the formation of agro-industrial programs of the second half of the twentieth century, combining theoretical achievements of genetics with the actual needs of state agricultural policy.

Conclusions.

A study of the role of agrobiological knowledge in the implementation of food programmes in Ukraine in the second half of the twentieth century has shown that it played a key role in the transformation of the agricultural sector in the Soviet period. Agribiology – including genetics, breeding, biotechnology and agroecology – became one of the main tools for ensuring food security and increasing the productivity of agroecosystems within a centrally planned economy.

The importance of scientific research in the creation of highly productive plant varieties, animal breeds and strains of microorganisms adapted to the natural and climatic conditions of Ukraine was identified. The development of agrobiological science has contributed to the rational use of natural resources and the reduction of energy costs in production processes.

Despite administrative and command restrictions and ideological pressure, Ukrainian scientists, including O. Sozinov, made a significant contribution to the modernization of the agricultural sector. The experience of this period convincingly proved that an effective food policy is possible only if it is based on scientifically sound approaches and close integration of scientific knowledge into agricultural production practices.

The introduction of agrobiological knowledge into the implementation of national food programmes has contributed to increasing the efficiency of agricultural production, preserving natural resources, adapting to climate change, and providing the population with quality and safe food. The prospects for the development of agrobiology in Ukraine remain significant, and its further integration into agricultural practice is a key to the sustainable development of the industry and the achievement of global food security goals.

Thus, agrobiological knowledge in the second half of the twentieth century played not only an applied but also a strategic role in shaping the food policy of the USSR. The experience gained during this period became the methodological basis for the further development of innovative approaches in the agricultural sector of independent Ukraine.

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