FORESTRY HORTICULTURAL AND AGRICULTURE MANAGEMENT: INTERNATIONAL AND NATIONAL STRATEGIC GUIDELINES OF SUSTAINABLE SPATIAL DEVELOPMENT

According to the scientific edition
Candidate of Economics Sciences,
Professor T.I. Melnyk

RS Global

Warsaw 2024

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Monograph

RS Global
Warsaw, Poland
2024

DOI: 10.31435/rsglobal/059

Recommended for publication by the Academic Council of Sumy National Agrarian University (№.15 from 27. 05. 2024).

Reviewers:
TKACH Lyudmila, PhD of agricultural sciences, associate professor, Ukrainian Order "Badge of Honor" Research Institute of Forestry and Agroforestry named after H. Vysotsky of the State Agency of Forest Resources of Ukraine and the National Academy of Sciences of Ukraine;
SKLYAR Viktoriya, doctor of biological sciences, professor, Sumy National University.
BOYKO Tetyana, PhD of biological sciences, associate professor, Kherson State Agrarian and Economic University.

Authors: Melnyk Andriy, Melnyk Tetyana, Horbas Serhii, Butenko Sergey, Stoyanets Nataliya, Tokman, Trotska Svitlana, Volodymyr, Viunenko Alexsander, Kremenetska Yevheniia, Osmachko Olena, Bakumenko Olha, Borodin Yurii, Karpets Yuriy and others.

FORESTRY, HORTICULTURAL AND AGRICULTURE MANAGEMENT: INTERNATIONAL AND NATIONAL STRATEGIC GUIDELINES OF SUSTAINABLE SPATIAL DEVELOPMENT / scientific ed. T.I. Melnyk. - Warsaw: RS Global Sp. z O.O., 2024. – 246 p.

ISBN 978-83-970624-1-2 (eBook)

The monograph is devoted to the theoretical and practical foundations of international and national strategic guidelines for sustainable spatial development in the field of agriculture, forestry and horticulture, which are shaped by integration and globalization challenges. The influence of environmental determinants on the level of sustainability of the agricultural sector in the short and long term is determined; economic methods of growing planting material of forest and decorative species of the nursery; improvement of existing and development of new technologies for growing planting material of fruit and ornamental crops.

Keywords: for researchers, teachers, graduate students and students, business leaders and governing bodies of different levels, entrepreneurs and anyone interested in agriculture, forestry and horticulture speere.

ISBN 978-83-970624-1-2 (eBook)

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INTRODUCTION

Agriculture is a vital sector of the economy responsible for providing food and raw materials necessary for various industries. Unlike other industries, agriculture's technological processes are closely intertwined with nature, with land serving as the primary means of production. As a result, this sector has a significant impact on the environment compared to other sectors of the economy. Approximately half of the world's economically active population works in agriculture, but this proportion varies across countries based on their level of economic development. Developing countries typically have two-thirds or more of their workforce engaged in agricultural production, while in developed countries, this number is usually less than 10%. In the US and some Western European countries, it can be as low as 2-3%.

In recent decades, Western agribusiness has experienced rapid growth, propelled by large transnational corporations (TNCs) that dominate the production and distribution of food. Among the top 100 agribusiness entities, over 40 are American, while more than 30 are from Western Europe. In the current era, the adoption of new technologies and innovative management methods is crucial for agricultural producers. The sole viable alternative to the existing state of domestic agriculture is seen in innovative advancements. The widespread implementation of scientific and technological breakthroughs represents the most effective and efficient means for ensuring sustainable progress in the industry. The advancement of agricultural production is ultimately determined by the potential for innovative approaches to drive scientific and technological progress.

The content included in various sections of the monograph is closely connected to the establishment of an efficient mechanism to facilitate agricultural advancements in Ukraine across agriculture, forestry, and horticulture. This reflects the researchers' aspiration to align their insights with the evolving standards of labor and governance prevalent in developed nations within the international framework. The findings presented within the monograph are significant and innovative in this context. It is important to note that the authors acknowledge the limitation of their perspectives and judgments, given the ever-changing landscape of challenges in agrarian transformation in Ukraine concerning agriculture, forestry, and horticulture. These challenges continuously influence the theory and implementation of sustainable rural development practices in the country.

The monograph skillfully integrates user-friendly language and scholarly content. It provides focused strategies for enhancing agricultural development in Ukraine within the sectors of agriculture, forestry, and horticulture.

We express our sincere gratitude to the reviewers of this publication G.O. Zhatova, Candidate of Agricultural Plants, Professor of the Department of Ecology and Botany of Sumy National Agrarian University; V.I Trotsenko, doctor of Agricultural Sciences, Professor, Head of the Department of Agrotechnology and Soil Science of Sumy National Agrarian University; S.B. Kovalevsky, doctor of biological sciences, Professor of the Botany, Dendrology and Forest Breeding Department, National University of Life and Enviromental sciences of Ukraine.

PECULIARITIES OF THE FORMATION OF STREET PLANTINGS IN RURAL SETTLEMENTS (SUMY REGION)

Melnyk Tetyana
Candidate of Biological Sciences, Professor
Sumy National Agricultural University, Ukraine
ORCID ID: 0000-0002-3839-6018

Introduction. Provision of urban green space in compact cities is a major problem. Priorities for land allocation in urban green areas are neglected or easily negotiated in countries in transition. Therefore, regardless of the size of cities, it is recommended to include an index of greening in urban planning, and to reserve space for green spaces in the plans.

Unfortunately, during the analysis of urban planning and sanitary-hygienic aspects of the territory planning of the regions of Ukraine, the planning aspects of green areas are not even mentioned. Studies of the ecological condition of small towns of the Sumy region have shown that the beautification of their territory has not been given any importance over the past 50 years, and the problems of greening are clearly outlined here. According to the master plans of small cities, currently too generalized solutions are offered regarding normative indicators and in many cases cannot be a tool for carrying out specific tasks. In modern socio-economic conditions, it is necessary to improve the regulatory and legal framework used to solve the problems of greening of urban areas, a differentiated approach to greening, the introduction of a moratorium on the elimination of green spaces in the central areas of cities, the establishment of norms for new areas where there is practically no greening.

At the current stage, the reform of the branches of the economy of Ukraine is not an exception to urban planning, nature management and territory management. Over the past few years, the legislative framework for the regulation of relations in the field of protection and preservation of green spaces has been updated. New state building regulations (DBN.B.2.2-12:2019), changes to individual legislative acts are increasingly bringing the national legal framework closer to the legislation of the European Union. A lot of work is still being done to improve the regulatory and legal framework for the functioning of the complex green zone of the city, draft Laws of Ukraine are being developed, and other by-laws are being prepared. But, despite such constructive activity of the legislative branch of government in Ukraine, the majority of legal norms regulating relations in the field of urban greening. are outdated and need improvement [2, 4].

In the current national legislation of Ukraine, the issue of green zones of settlements is included in the group of urban planning regulatory acts [6]. Practically none of the laws of the ecological block mentions the preservation, protection and restoration of green areas of cities. This is a significant underdevelopment, since in the countries of the European Community, the issue of green zones is highlighted in most environmental directives.

In Ukraine, special regulatory acts regarding green zones are currently under development, in particular, the draft Laws of Ukraine "On green areas of cities and other settlements", "On the protection of green areas in cities and other settlements" [13, 25-29] etc.

Environmental protection regulations are relevant to the functioning of complex green zones of cities, only in the case of granting protected status to individual objects of the city's green economy. In environmental legislation, in particular in the Forest Code of Ukraine (Article 4), it is stated: "The forest fund of Ukraine does not include: green areas within the boundaries of settlements (parks, gardens, squares, boulevards, etc.) that are not assigned to forests in the established order » [7]. That is, all plantations located within settlements do not belong to the lands of the state forest fund. Thus, a significant part of the complex green zone of the city is legally outside the limits of environmental legislation. In another case, if we consider the functional aspect of the complex green zone of the city, the recreational value is legally located in the ecological plane, since the Land Code of Ukraine (Article 51) states: "Recreational lands include land plots of green zones and green spaces of cities and other settlements..." [12]. Therefore, based on the above-mentioned facts, we can state that the category "complex green zone of the city" from a functional and legal point of view is an ecological concept, and from a territorial and legal point of view - urban planning. Since the legislation of Ukraine, which regulates relations in the functioning of the complex green zone of the city, is more developed in the area of urban planning and improvement of settlements, we will consider the main legal acts that regulate these relations. The main document that defines and details the functioning of the inner part of the complex green zone of the city is the Order of the Ministry of Construction, Architecture and Housing and Communal Affairs of Ukraine No. 105 dated 04.10.2006 "On approval of the Rules for the maintenance of green spaces in populated areas of Ukraine" [4, 8 , 12]. According to this document: "complex green zone of the city (KZZM) is a set of urban and suburban plantings, the boundaries of which are drawn on cartographic materials by architectural authorities (on general plans, schemes and district planning projects), forestry authorities (on plans of forest plantations), local self-government bodies" [27].

In accordance with the Rules for the maintenance of green spaces, the objects of improvement in the field of green management of settlements are: parks, parks-monuments of horticultural art, hydroparks, meadow parks, forest parks, buffer parks, district gardens; dendrological parks, national, memorial and others; parks; urban forests; recreation areas; green plantings in security and sanitary protection zones; coastal green spaces; green plantings of adjacent territories [21, 26].

The nomenclature of the structural elements of the complex green zone of the city, according to Appendix 8 of the Rules for the maintenance of green spaces, includes the built-up areas of the city, the areas outside the built-up areas within the city limits, the areas outside the city limits within the green zone and the so-called undefined areas. Each of these territories is formed by structural and constituent elements.

The structural elements of KZZM include: city-wide landscape and recreation areas, landscape and recreation areas of residential areas, streets, roads, industrial areas, sanitary and protective zones (SZZ), forests and urban forests, highways, green areas of suburban settlements, recreation facilities , tourism and sports, field protection strips, gardens and vineyards, rural land and water bodies. Accordingly, the constituent elements of KZZM are: city gardens and parks, parks and gardens of residential areas, boulevards, squares, alleys, areas of green construction and management of various institutions and territories, forest parks, meadow parks, hydroparks, forest areas within the city, territories of gardens and vineyards, fields, gardens, hayfields, pastures, reservoirs [30]. Taking into account the functional affiliation of agricultural [12] and water lands [19] to the KZZM, especially in the summer season, is a well-founded and scientifically proven fact. Since such objects have not only ecological importance, but also recreational and climate-regulating ones. Agrolandscapes of the urban environment produce oxygen, moisturize and purify the air, increase the level of aesthetics of urban areas and ensure the preservation of agrobiocenoses [8].

According to their functional purpose, the green areas of the inner part of the complex green zone of the city are divided into three groups: general use, limited use and special purpose. Green spaces for public use include suburban forest parks, city parks of culture and recreation, district parks, other specialized parks, city gardens and gardens of residential areas, public squares, boulevards, alleys. Green areas of limited use are green areas of microdistricts, health care facilities, kindergartens, schools, higher educational institutions (HEIs), vocational and technical educational institutions, sports and health and cultural and educational institutions, sanatoriums, private enterprises, warehouse areas etc. Green plantings for special purposes include plantings on city streets and highways, territories of sanitary protection and water protection zones, anti-erosion and wind protection plantings, botanical and zoological gardens, plantings on the territories of nurseries, flower farms, orchards of suburban farms, cemeteries [15].

Rules for the maintenance of green areas regulate the use, maintenance and protection of green areas. Responsible for the maintenance of green spaces in the settlement is the balance keeper of the territory, i.e. the economic entity under whose authority the landscaped plot of land is located. Thus, the greening of the territory of private estates and adjacent territories is the responsibility of their owner, the local self-government bodies are responsible for ownerless territories, and green spaces onin territories where construction is underway - the developer or the owner of the land plot.

The rules for the maintenance of green spaces clearly define: "The general plan for the development of settlements of Ukraine is developed and implemented taking into account the requirements for the protection of green spaces. Urban planning activities in settlements are carried out in compliance with the requirements for the protection of green spaces" [24]. The main document that regulates urban planning activities and defines the main standards for greening of settlements is the State Building Regulations (SRB).

State Building Regulations of Ukraine (DBN.B.2.2-12:2019) "Territory Planning and Development", developed by the State Enterprise Ukrainian State Research Institute of Urban Design "Dipromisto" named after Yu.M. Bilokonya, entered into force in 2020. The current document defines: "Greening of populated areas and suburban areasterritory should be carried out on the basis of the development of a separate "Complex Green Zone" project [9]. However, it is worth noting that in the new document DBN.B.2.2-12:2019 "Planning and development of the territory", in contrast to the previous version of DBN 360-92** "Planning and development of urban and rural settlements", the concept of a complex green zone of the city practically leveled and replaced by landscape and recreational areas and suburban areas, then in the new edition of DBN.B.2.2-12:2019, landscape and recreational areas include a network of landscaped and other open spaces of settlements, suburban and intercity zones [9, 11 , 13]. In the new version of the DBN, it is clarified that landscape and recreational areas, i.e., the complex green zone of the city, include: recreational areas, resorts and medical and recreational areas, objects of cultural heritage and tourist areas, territories of nature reserves and water funds, water protection , field protection, transport and distribution greened lanes and other objects of green economy [20].

As in the Rules for the Maintenance of Green Spaces, as well as in the previous and current editions of the DBN, in the structure of green areas of the city, areas of general use, limited use and special purpose are distinguished. Instead, there are certain discrepancies in the nomenclature of structural elements of the complex green zone of the city. In particular, in DBN.B.2.2-12:2019 "Planning and development of the territory", in addition to the built-up areas of the city, areas outside the limits of development within the city limits, areas outside the city limits within the green zone and undefined areas, extra-urban landscape areas and nature reserve areas. Non-urban landscape areas include landscaped, recreational and health resort areas for public use. Protected natural territories include protected natural territories (national natural parks, regional landscape parks, botanical, dendrological, zoological parks and parks of monuments of horticultural art) and specially protected natural territories (customers, natural monuments, etc.).

Thus, the main provisions of the functioning of the integrated green zone of populated areas are presented in the following normative legal acts: Rules for the maintenance of green spaces in populated areas of Ukraine, Laws of Ukraine "On the improvement of populated areas", "On the regulation of urban planning activities" and State building regulations. The current legislation of Ukraine covers the functioning of only the inner part of the complex green zone of the city. Failure to take into account the role of the suburban green zone of the city and assigning the issues of preservation of green areas to urban planning legislation practically eliminates the ecological component of this problem.

Materials and methods of research. The village of Kosivshchyna is the administrative center of the village council, which includes such villages as Zakumske, Kononenkove, Mali Vilmy, Nadtochieve, Solidarne, Chernetske. It is located three kilometers from the district and regional center, the city of Sumy, on the right bank of the Sumka River (Figure 1).

The first mentions of the village of Kosivshchyna are found in archival documents from the second half of the 18th century. In 1768, the Kosivshchyna farm, with an area of 444 acres of land, belonged to lieutenant Mykola Kosovtsov. There is also another name for the farm - Sukhonosivka. The village was divided into large Kosivshchyna (about 50 yards) and small Kosivshchyna (12 yards, where modern Lesya Ukrainka Street is located).

On the territory of the village of Kosivshchyna, archaeological monuments of the Chernyakhov culture were found, dating back to approximately the 4th century AD. Archaeological excavations were carried out by a group of students of the SDPI named after Makarenko under the leadership of O.I. Zhurk.

According to historical essays that can be found in archival materials, it is mentioned that in the valley of the Vilma River, on lands mostly unsuitable for farming, peasant families of different financial status settled. Their gardens were located above residential buildings. During droughts and crop failures, richer peasants were forced to migrate to the cities of Sumy and the village of Kosivshchyna, while the less well-off moved to the villages of Nadtochieve and Chernetske.

Figure 1. The village of Kosivshchyna on the map of 1770 (archive photo).

At the beginning of the 20th century, these settlements were part of Sumy, Tereshkiv and Stepaniv volosts of Sumy County. According to the information of the newspaper "Sumy Visnyk" dated October 25, 1917, the peasants of the villages of Kosivshchyna and Sukhonosivka arbitrarily plowed 60 acres of land, which was intended for sowing ravines in 1918. They also said that they will distribute other plots of land. Soviet power was established in Kosiv region in January 1918, and in December 1919, rural committees were established in the villages.

In the 1920s, two village councils were formed: Kosivshchynsk and Chernetsko-Vilmivsk. In December 1922, on the territory of the village of Mali Vilma, the land artel "Bzhola" was founded, which united 11 peasant households (48 people), as well as the artel "Selyanin" in the Kononenkove farm with 52 dehiscents of land. The state allocated loans to these artillerymen for the purchase of planters and livestock, guaranteeing the supply of the harvest in 1924. However, the drought and the invasion of the winter weevil prevented small collectives from settling their loans [23].

In 1941, the Second World War began on the territory of Ukraine, and in October of that year the Sumy region came under occupation. The peasants were forced to follow the orders and orders of the occupying rulers. In September 1943, the fascists left the village.

In 1965, the Sumikhimprom plant decided to build a reservoir. In the spring, water began to flood the village and surrounding areas in the city of Sumy. Residents appealed to higher authorities to stop the work, but to no avail. In addition, the project itself turned out to be unsuccessful. In 1966, there was a spring flood, the water level was so high that there was a threat of flooding the village of Kosivshchyna, and therefore the dam was blown up. In 1971, another spring flood occurred, the water breached the dam, and the planned water level was not restored.

In 1966, 800 people lived in the newly built village. New streets of Shkilna, named after Lenina, Pershotravneva, Zhovtneva. In 1967, a new 8-year-old school, a nursery for 40 places, a club for 360 places, a library, and in 1965 a paramedic-midwifery station were built. In the center of the village - a stadium, three shops.

Initially, the collective farm named after Lenina, and in the early 1970s the state farm "Hannivskyi", even later the state farm "Kosivshchynskyi", since November 1999 - the limited liability company "Agrofirma "Kosivshchynska" for a long time specialized in the cultivation of vegetables and dairy production. In the 1960s, sheep were raised. There were several gardens, a berry orchard.

From the beginning of the 1980s to the year 2000, a greenhouse farm with an area of 2 hectares operated. Cucumbers, tomatoes, cabbage, onions, beets, carrots, peppers, eggplants were grown.

As of January 1, 2022, 2516 people live in the village of Kosivshchyna, Sumy district. The scheme of the organization of the village territory is shown in figure 2.

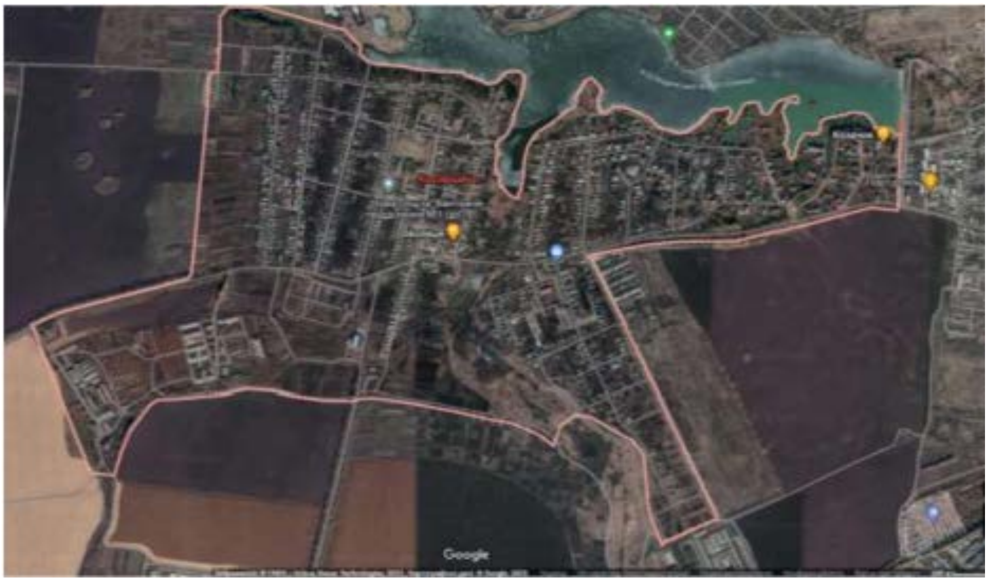

Figure 2. Orthophoto map of the research area.

At the time of the research, the territory of the settlement is adjacent to the red line of the regional center, however, the lands that are used by the Kosiv region settlement council are assigned to the Sumy district.

Therefore, the territory of the village of Kosivshchyna is the land of the settlement community, which territorially borders the regional center, the city of Sumy. The center of the village is located 5 km from the center of Sumy. Transport connection with the largest city of Sumy region is regular and is carried out at the expense of public transport.

Since 2015, the process of deurbanization has significantly intensified due to the outflow of residents of the city of Sumy to nearby villages, in particular Kosivshchyna, to live. During this period, part of the land was taken out of use and given over to the development of low-rise cottage-type houses. Currently, this is the territory of the Tytul housing cooperative. A more in-depth analysis of the planning structure of the research area is provided in Chapter 3 of the qualification work.

The theoretical and methodological principles of research and standardization of the state of green areas of populated areas are highlighted in publications of urban-ecological, economic, legal, geo-ecological, constructive-geographical, architectural-construction and engineering-ecological direction. Within the framework of studies of city ecology, a significant contribution to the development of scientific approaches to the study of the complex green zone of cities was made by V.P. Kucheryavy, F.V. Stolberg, V.V. Vladimirov, V.O. Fesyuk, V.A. Gorokhov, and L. Lunts .B. and other.

The evaluation of the level of spatial organization and the landscape-functional structure of the green zone of the capital city was carried out by O. V. Savytska based on a comparative analysis of the green zones of Kyiv and Berlin. - the functional structure of the urban green zone. In the study of green zones of small and medium-sized cities of the Lviv region, M. Nazaruk and Yu. Zhuk prove that the system of green spaces should correspond to the planning structure of the city. Certain groups of green spaces correspond to each planning unit: microdistrict - microdistrict garden; residential area - residential area garden, boulevard, square; planning district - district park; city - city parks, forests, gardens, specialized parks, hydroparks, forest parks, meadow parks, boulevards, squares, embankments. The structure of the green space system depends on the size of the city [9].

For a small city - the simplest structure, for a medium one - somewhat wider and for a large city - an expanded structure of green spaces. Thus, after summarizing the above, it can be stated that the KZZM is hierarchically divided into macro-level, meso-level and micro-level; the forest park and forestry parts of the KZZM are distinguished by territorial characteristics; according to the functional purpose - green spaces for general use, limited use and special purpose. In the normative legal acts, separately in the structure of the KZZM: built-up areas of the city, areas outside the limits of the built-up area within the city limits, areas outside the city limits within the green zone and undesignated areas are distinguished. Each of these structural units includes specific groups of green spaces or individual landscaped objects that form a complex green area of the city.

Results. In general, the territory of the village of Kosivshchyna can be divided into three zones according to the periods of formation. The first zone (a) is the old village where the central manor of the village council, schools, stadium, and kindergarten are located. In this zone, one-story private estates of 50-60 years of construction of the rural type prevail. The second zone (b) is the zone of the new period, which was formed during the time of independent Ukraine (1992–2000). Private construction of two-story houses prevails in this part. During construction during this period, there were restrictions on the size of plots and the area of houses. It is distinguished by the construction of the post-Soviet type of architecture with a predominance of brick houses made of silicate bricks. The third zone (c) is a modern building. It is also characterized by multi-storey buildings from two to four floors, complex European-style architecture. Visualization of individual sections of different zones is presented in the photo of figure 3.

Figure 3. Zoning of the territory of the village Kosivshchyna depending on the stages of development: red line - old village, blue - buildings of the 90s, green – modern building (2000 years).

The zoning of the territory is shown in the diagram (Figure 4).

The landscape arrangement of rural settlements in the North-Eastern part of the Forest-Steppe of Ukraine has pronounced features of the Ukrainian mentality, which are quite clearly manifested even in modern elite settlements. The most characteristic feature of landscaping is a fence, which reliably separates private property and indicates the owner's wealth (mastery) and secures existing boundaries. Quite often, high fences close from prying eyes not only the private space of the inner courtyard, but also the architectural decoration of the house.

Examples of fences that were discovered during the survey of the streets of the village of Kosivshchyna are presented in figure 5. As you can see from the photo, most fences are about 2 meters high, made of dense materials, mainly bricks of different colors, flat slate and metal profile. The transparency of the fence is 0%.

Green plantations of rural estates consist mainly of fruit plants: apple trees, pears, apricots, plums, walnuts, cherries, hawthorn. Of the bushes, you can most often find lilac, cypress, forsythia, black elder, currant.

Field plantings are functional, in addition to comfort, they provide the owner of the estate with fruits and berries. Recently, it can be observed that the street plantations of fruit species are not used for food purposes and the fruits that fall after ripening pollute the footpaths and the carriageway of the streets. Visualization of street plantings is presented in figure 6.

A

Б

В

Figure 4. Examples of residential construction in different zones.

It has been noted that if until now the greening of the village yard, and not infrequently the streets, was dominated by fruit plants that had a utilitarian purpose and individual decorative bushes, then recently signs of a complex approach to landscape arrangement began to appear. Instead of utilitarian plants, decorative plants are being planted, among which preference is given to conifers, evergreens, and decorative deciduous ones.

Figure 5. Visualization of fence materials and structures of private estates of Kosivshchyna.

You can find regular plantings in the form of living walls and borders, mixed borders, lawns, rose gardens, alpine slides and rocky flower beds. Species of flora not typical for the area begin to predominate in the assortment: western thuja, Canadian spruce, species of juniper, spirea, etc. (Figure 7).

Figure 6. Examples of street landscaping.

Figure 7. Examples of decorative design of the entrance area from the side of the street.

In some areas, you can find colorful landscape compositions of national color with the use of clay, wheels, pots, decorative sculptures in the form of a stork, a mill, etc. Examples of such compositions are presented in figure 8.

Figure 8. Finishing the fence in ethnic style.

Analyzing the material we have collected, we can say that the inhabitants of the villages still have a certain mentality of isolation from the common space. There is no comprehensive approach in the design of the general public space, its colors, beautification and landscaping. These processes are rather spontaneous.

Quite often, behind the beautiful, solid and rich fence of private ownership, public areas are nobody's land and are overgrown with weeds and self-sowing trees and shrubs or are used for storage of building materials, firewood, etc. (Figure 9).

The photos presented in Figure 9 were taken on only one street, on which the construction of new courtyards has long been completed, but construction materials are still stored near the estates, distorting the appearance of the street and making it difficult for pedestrians to move along it.

Complex landscaping and planned greening of streets and public places is episodic and clearly insufficient.

During the Soviet period in Ukraine, the landscape design of villages, in particular public and memorial facilities, was standardized. This was aimed at preserving and enshrining in the landscape the symbols of the new ideals, while destroying and painting sacred places. The development of the so-called model villages, the standardization of the range of decorative plants used for landscaping created equal opportunities for landscaping the yard of most peasants.

Rural parks, squares, landscaping of streets and school grounds in hospitals and preschools did not strive for sophistication and uniqueness, but were implemented according to simplified schemes using available plant material. Thus, the unification of landscape design has become a characteristic feature of most rural settlements. However, thanks to enthusiastic enthusiasts, in some places it was possible to create unique objects of improvement, such as village centers, memorial sites and unusual village parks.

Figure 9. Clogging of public space with construction waste and economic activities of residents.

The use of the principles and experience of landscape architecture of Western countries in Ukraine revealed that blindly following even the best practices of landscape arrangement of territories does not lead to the desired results, if the national characteristics and mentality of our people are not taken into account. The problem lies not only in taking into account the soil and climatic conditions of individual regions of our country, which is especially important for the selection and use of imported plants. Often the key is the mentality of the customer, for whom their own preferences and personal perception of the landscape have more influence than the advice and recommendations of the landscape architect.

Studying the global experience of landscape design of rural settlements and taking into account national traditions and features, in particular mental ones, appears as an urgent task for rational landscape planning.

This involves the use of a functional approach, the involvement of specialists in solving these tasks, the consolidation of the legal status of public areas in the village and the provision of appropriate sources of funding for their maintenance. In particular, systematic work is needed to popularize the best practices at both the global and national level in matters of landscape arrangement of rural areas and private homesteads.

The main differences between ethnic Ukrainian landscapes and Western European landscapes are shown in Table 1.

Table 1. The main distinguishing features of the ethnic landscapes of Ukrainians and Western Europeans (according to D.M. Grodzinsky, 2005).

Ukrainian landscape	**Western European landscape**
One's own yard is arranged as a microcosm, as a model of the world with all the places that provide or symbolize the fullness of being	The composition of places and their configuration within their own estates are minimalist
Fences are a symbol of order, there are many of them in the landscape	Fences are a symbol of the limitations of the individual, there are few of them in the landscape
Public places are seen as nobody's property, they are often unkempt and play a background role in the landscape	Public places are considered as their own, they are neat and make up the central places of the ethnic landscape
The landscape has many unfinished places, places where work is being done; often the landscape resembles a construction site	The landscape has a finished look, with few areas that are being worked on
Multicolored	Monochrome
The complexity and romance of the configuration	The regularity of the configuration, its functionality and pragmatism

Conclusions. The influence of the mental characteristics of Ukrainians is manifested in the characteristic features of the landscape arrangement of rural settlements. The following aspects stand out among the characteristic features of the Ukrainian rural landscape:

1) the use of fences around homesteads, and often within the boundaries of the village yard itself;

2) the preference of fruit plants in the landscaping system, which not only perform utilitarian functions, but also have a decorative purpose;

3) multifunctional and irrational use of homestead territories of public purpose;

4) incompleteness of landscape compositions and constant development and improvement;

5) low level of aesthetics and sometimes neglect of street and public areas, which are considered by residents as undefined;

6) multicolor, complexity and romanticism of landscape compositions, which mainly have an individual character and are far from ideal.

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MODERN METHODS OF OBTAINING AND ADAPTATION OF PINUS SYLVESTRIS L. PLANTING MATERIAL UNDER THE CONDITIONS OF THE BRANCH "SUMY FOREST FARM" STATE ENTERPRISE "FORES OF UKRAINE"

Melnyk Andrii
Doctor of Agricultural Sciences, Professor
ORCID ID: 0000-0001-7318-6262

Dudka Anhelina
Assistant, PhD
Sumy National Agricultural University, Ukraine
ORCID ID: 0000-0001-9444-4339

Introduction. Scots pine (*Pinus sylvestris L.*) is the most common pine found throughout Eurasia. In the EU member states, its share is approximately 20 % of the area of industrial forests and is of great importance as a type of wood, especially in the north of Europe [18]. Scots pine (*Pinus sylvestris L.*) is an important commercial conifer species in many European countries. In Great Britain it accounts for approximately 16 percent of the total conifer stock and up to 30 percent in the north and north-east of Scotland [17]. Thanks to its adaptation to different climatic conditions, it is a fairly common tree species in the world and in Ukraine, because it can grow both in forests and in piles, and it is one of the most commercially important species of wood in Europe. Despite such a wide distribution of the breed in various forest vegetation conditions, it is noted that the best-quality wood of Scots pine is formed mostly in subforests, which occupy about 1,300 thousand hectares of the territory of Ukraine [32]. Scots pine is also capable of forming productive stands in conditions of various edaphotopes, which are characterized by high indicators of stability and durability [29].

Scots pine has a range that covers all of Scandinavia, the northeastern regions of European Russia and Siberia, extending eastward to the Seas of Okhotsk and Japan. In Poland, it is the dominant forest species, covering 66,5 % of the total forest area [39]. In the Caucasus, it is found from sea level to mountain peaks up to about 2,700 m above sea level, in Poland, it is found mainly in lowland areas, reaching a height of 700 m in the Carpathians, although individual trees are found up to 1,100 m above sea level. It is also the most important forest-forming species in Poland with great potential for use in the woodworking industry [14].

Pine wood is valued and widely used not only due to its availability, but also due to its physical and mechanical properties. Its technical properties depend, among other things, on its geographical origin. One of the scientists [20] showed that the properties of pine wood deteriorate in the direction from north to south, and there is no clear trend along the east-west axis. Thus, it is generally believed that pine

A number of factors affect the technical quality of wood. It depends mainly on the geographical location, the type of local growth and the quality of the planting material [15]. Genetics, environment and human factors can determine the dendrometric characteristics of trees, properties and structure of wood. Genotype can affect wood quality. The genome can demonstrate phenotypic features and help determine resistance to internal and external factors [24, 25].

Scots pine is a species with a very wide natural range. Because it grows in different climatic and soil conditions, it shows great variation in the morphology, productivity and quality of its wood.

Scots pine is a medium-sized coniferous tree, reaching 30–35 m in height, only in exceptional cases more than 40 m, and 50–130 cm in diameter. The lifespan of this pine is about 250 years, sometimes up to 400 years. Develops an open crown with spreading branches. The stem is characterized by a reddish-orange bark in the upper part. The leaves are needle-like, blue-green in color, 5–7 cm long, arranged in pairs. Male flowers are numerous, clustered at the base of new shoots and yellow or pink when mature. Female flowers appear at the tips of the shoots and turn pinkish-purple when pollinated. Cones develop the following year after pollination, the size of which reaches 5–8 cm. In autumn, the cones open and throw out winged seeds that are carried by the wind [45].

Scots pine is one of the most commercially important tree species, especially in northern Europe. It is used for the production of pulp and lumber (buildings, structures, furniture, etc.). The wood is easily processed and is one of the strongest conifers. Pine is a pioneer species and grows on poor soils; therefore, it is also planted for reclamation and anti-erosion purposes and as a windbreak [5]. It is often used in dendrochronology, the study of annual tree rings, because it is relatively long-lived and often grows in marginal conditions where small variations in temperature and/or moisture can have a marked effect on its growth and ring size.

In Scandinavia, resin is extracted from Scots pine for the production of "Stockholm resin". This product has traditionally been used as a wood and rope wax to weatherproof, weatherproof, or improve grip (e.g. applied to baseball bat handles or Nordic style skis). Nowadays, this tar has been replaced by synthetic products that are easier to produce industrially. wood from the northern parts is better, having greater density and strength [13].

Products derived from trees have played an important role in driving technological progress throughout human history. A key example of such products is the resin produced by coniferous trees. Pine tar and pitch were used to cover the seams of wooden ships and vessels, etc. For centuries, pine-based products have been widely used in adhesives, soaps, water-repellent surface coatings for ropes, construction, and even art [1].

In the United States, Scots pines are planted to grow as Christmas trees. The Scottish Highlands were once covered with forests consisting mainly of Scots pine. They are cut down mainly for the needs of wood and creating pastures for livestock. Only small patches of ancient pine forests remain in Scotland, covering about 17,000 hectares [37].

Despite various silvicultural alternatives used to guarantee the sustainability of plantations and various aspects of ecosystems [11], growing potentially valuable trees with high-quality trunk wood remains one of the main tasks of traditional forest management. Forest managers use silvicultural techniques to maximize tree growth. At the local and global levels, in the context of climate change, it is important to determine a rational way by which forest plantations will create the maximum possible productivity in the shortest period of time [7].

The efficiency of forest restoration and their productivity in the future depends on the quality of planting material of forest-forming species. Today, about 80 % of forests are artificially created, and therefore foresters and scientists face the issue of production of high-quality planting material, including the common species - Scots pine. Reproduction of forests with the help of high-quality planting material is the basis for a high survival rate, intensive growth and development, good competitiveness of planting material with shrubs and herbaceous vegetation [53].

Of great importance in the creation of high-quality planting material is the use of seeds collected on permanent forest seed bases. The quality of seeds directly affects the productivity of forests in the future. According to the results of genetic testing of selected seeds from 50 % of the best trees, the selection effect of forest seed plantations increases [34, 46]. Seeds collected from forest seed plantations have better seed quality (15–20 %) larger, germination energy and germination) than seeds obtained from normal plantations. For example, the weight of seeds is 10–15 % greater in seeds grown in clonal seed plantations than in conventional forests [27]. Numerous studies also show that the quality indicators of Scots pine seeds (size, germination energy, germination, etc.) are affected by the geographical origin and climatic conditions of growth. For example, seeds collected in the northern regions have higher seed viability, seeds in the western regions lose their germination faster [46].

Also, during the cultivation of planting material, great attention is paid to fertilization, the use of means of protection against weeds, pests, diseases, and the use of auxiliary substances (growth stimulants and microfertilizers) that help plants adapt to adverse conditions of growth and development (drought, frost, etc.) [30, 33]. Scots pine plantations can be restored in three ways: planting, direct seeding, and natural regeneration. In most forestry models, planting material is the most common method. Direct seeding is an old reforestation method that is now rarely used. In Poland in the 1960s and 1970s, 5.3–7.8 percent of clearcuts were restored in this way, compared to 2.6 percent in the 1980s. This method has many advantages. First, reforestation costs are lower than planting costs. Second, direct seeding mimics natural regeneration. Thirdly, forest plantations formed in this way, growing in high density, are characterized by high quality wood. The main reason why direct seeding is now so rare is the risk of failed regeneration due to greater exposure to biotic and abiotic stress factors on the germinating seed than on the established plant. Comparative studies show that when restored by direct seeding or self-seeding, Scots pine and other tree species grow more slowly and have less chance of survival than planted seedlings [12].

Planting of forest crops has some advantages compared to sowing, for example, reduction of seed consumption, uniform placement of seedlings on the area, seedlings are less suppressed by weeds and shrubs, the number of maintenance operations is reduced, etc. [28]. The disadvantages of planting seedlings include their lower resistance to diseases, pests, environmental conditions and frequent damage to the main root, which is intensively formed in the first years [31].

Recently, forest plantations in Ukraine have been restored mainly artificially, and the main type of planting material is usually seedlings. Of particular importance is the creation of highly productive and sustainable forest plantations of the most common forest-forming species, i.e. Scots pine, close to natural stands. This can be achieved precisely with the help of sowing seeds. This method is close to the conditions of natural renewal of pine forests [53].

The use of planting material with a closed root system, as well as with an open root system, has a long history. Scientific works of 1725 have references to the literature that contains information about planting tree plants with a lump of earth, and during the 20th century, there were also methods of planting saplings with a lump of earth during forestry work. They were harvested on well-restored cuttings that are more than 5 years old.

The use of seedlings grown by the closed root system method is the most common method of forest regeneration in many countries, because a good condition of the root system determines the quality of the seedlings used for regeneration, and is also a necessary condition for their successful use in the forest. Outdoors, roots are considered susceptible to overwintering damage, especially if there is no protective snow cover, which impairs seedling quality [40]. And therefore, maintaining the integrity of the root system, which is responsible for the absorption of nutrients and water, during the planting of seedlings is the key that is paid attention to when choosing a method of creating planting material.

The issue of afforestation of areas damaged by forest fires, which arise as a result of climate change, is gaining relevance. These areas have significant or complete loss of forest vegetation and layers of forest litter, which in turn complicates the natural regeneration of Scots pine. Afforestation of such areas with planting material with an open root system is inefficient and is not characterized by survival or death of forest crops [38].

Therefore, as mentioned earlier, the advantages of growing planting material with a closed root system have been repeatedly proven by various scientists, because this approach involves transplanting 1-3 year-old seedlings, which is not traumatic for the plant, effective regulation of nutrition and moisture conditions, effective control of pests of root systems and diseases, obtaining several rotations of planting material suitable for creating forest crops during one growing season, etc. In addition, the issue of further growth and development of planting material in forest crops is not sufficiently studied. One of the disadvantages of creating planting material with a closed root system is its higher cost (by 40 %) compared to seedlings with an open root system [41].

Two methods of growing planting material with a closed root system are common: when seedlings from open ground are moved and pressed into the substrate and in containers. The most popular of these methods is the use of containers made of various materials (paper, plastic, special fabric, etc. that can be placed directly on the landing site). Containers for growing seedlings come in many shapes, sizes and are made from different materials such as polystyrene, polyethylene, rooting agents, fiber or paper. It is convenient to transport the seedlings to the places of silvicultural works, they are used as a shell to give shape to the coma in which the substrate remains, which improves the adaptation of the seedlings and contributes to the mechanization of these works. The primary function of any container is to hold a discrete supply of growing medium, which in turn supplies water, air, mineral nutrients, and physical support for the planting material [50].

The most common container for growing seedlings is black plastic trays. It has been established that the black color absorbs solar radiation and increases the temperature of the substrate. An ideal nursery container should have structural strength and good insulation, the material should not be brittle or decompose quickly, be strong during handling and transportation, and promote a healthy root system. In addition, the container should be light in weight, provide good drainage, be durable and accessible, not pose a danger to customers during planting and ease of disposal (sustainability) of the product. The type of container can significantly affect the root morphology of container-grown plants [10].

The question of selecting the type of substrate, using mineral fertilizers and auxiliary substances, and methods of growing seedlings with a closed root system remains relevant.

Optimal conditions for the growth and development of plants are determined by a whole set of factors, including the reaction of the environment. Scientific studies and practical experience have established that high values of environmental reaction parameters (acidity and alkalinity) negatively affect the growth of root and stem parts of plants. The development of the direction of growing planting material in container seedlings dates back to the 60s of the last century, when almost simultaneously in many countries (Scandinavian countries, Northern Europe, South America, Canada, USA) industrial cultivation and research into the characteristics of growing planting material in in individual and multi-chamber containers of various types and sizes, work on industrial cultivation has begun. Today, many types of insulating materials are known: peat and ceramic pots, briquettes, paper honeycombs, polyethylene bags and others [19, 42].

The substrate must meet the following requirements: be light in weight to facilitate transportation to the landing site; firmly hold cuttings or seedlings in place; maintain a sufficient amount of moisture to avoid the need for frequent watering; be porous enough to allow excess water to drain easily; ensure sufficient root aeration; do not contain seeds, nematodes and diseases; undergo sterilization without changing their properties; have enough nutrients for healthy initial plant development; have enough nutrients for healthy initial plant development; not have a high level of salinity; have an appropriate pH level; be stable, do not swell, do not shrink excessively and do not crust over in the sun;

The growth of seedlings in seedling containers is mainly influenced by the air and water properties of the substrate, as well as its chemical composition.

For the production of seedlings in containers, peat with a high content of sphagnum is used, which has such favorable characteristics as high porosity, moisture-holding capacity, sterility and low mineral content. These properties facilitate regulation of fertilizer application rates and properties (such as low pH, high cation exchange capacity, low natural fertility, proper balance of aeration and water-retaining porosity) and provide reasonable growing conditions in protected soil conditions. However, modification of inadequate physical parameters of the substrate is difficult, especially with too low or too high levels of air capacity, which can be explained by compaction of the substrate [26].

Sand is a common substrate for germinating seeds. Before use, it is sieved to remove small silt particles that lead to the formation of a crust on the surface. For a better result, you can use sand with a size of 0.5–1 mm for germinating seeds and 1–2 mm for rooting cuttings. Sand from a sea beach can contain a high salt content, which must be washed before use. Fine gravel (5 mm) is successfully used for rooting cuttings and as an additive to the soil mixture. Both sand and gravel are heavy (bulk weight 1000–1700 g/l) and make it difficult to transport seedlings to the field. Sand, especially fine sand, should never be used as a potting soil additive because it clogs the pores [49].

The bark of coniferous and deciduous trees is a good alternative to peat with almost the same properties. Bark is a cheap byproduct of many sawmills. It can be used from coniferous (cedar, pine, fir) or deciduous trees; it is also recommended to use the bark of tree ferns. There is only limited information on the suitability of tropical tree species. The bark should be ground with a hammer through a sieve with 2–3 cm holes and then composted for 4-6 months, as fresh bark may contain tannins, phenols, resins or terpenes that are toxic to plants if not broken down. Higher composting temperatures also help reduce insect and pathogen levels. If the bark is not fully composted, plants grown in this environment may suffer from a nitrogen deficiency, as composting bacteria need nitrogen to break down organic matter [36].

Perlite is a siliceous material of volcanic origin, extracted from lava flows. Raw ore is crushed and heated to a temperature of about 760 °C, causing the water contained in it to evaporate and expand the particles like a sponge. It is very light (80–100 g/l), can hold 3–4 times its own weight in water, has an almost neutral pH, and does not contain mineral nutrients. Most useful for increasing aeration in the mixture and in combination with peat moss is a very popular substrate for cuttings in the USA [35].

As additional materials for substrates can also be used: coconut husk, rice husk, sugarcane pulp, coffee husk, old sawdust and other waste can be used similarly to the materials listed above. New materials will undoubtedly be found through ongoing research. Most soilless substrates can be used alone or added to soil to improve its properties.

The analysis of literary sources shows the successful use of substrates from pine trees for growing crops in greenhouses and nurseries, which have caused considerable interest among manufacturers and producers of substrates. Pine tree substrates can be made from pine trees that have been chipped and shredded (with or without bark, limbs, needles, etc.) in a hammer mill or from pure wood shavings (≈40 % pine wood, 50 % bark and 10 % needles) , which is produced from the by-products of the process of harvesting pine trees [3, 8].

Another method that is gaining popularity is growing plants without soil. Cultivation of plants without soil is any method of growing plants without using soil as a medium for rooting [6]. This relatively simple definition covers a variety of plant growth systems, which typically involve the containerization of plant roots in a porous rooting medium known as a "substrate" or "growing medium." Compared to soil cultivation, soilless production can be more cost-effective, providing higher yields and faster harvesting from smaller areas of land. Soilless systems are also generally higher water and nutrient use efficiency. As a result, over the past 50 years, they have become increasingly important worldwide [9].

Warmer and drier conditions associated with climate change are accelerating forest mortality worldwide [22]. In Europe, the frequency and intensity of droughts have increased over the past 30 years [23]. Particularly recent consecutive droughts in 2015–2019 caused large-scale tree deaths in Central European forests [4]. Due to ongoing climate change and accumulation of stress conditions, drought-induced forest loss is expected to increase in many regions [21].

But not only increased drought has a significant impact on forests. Higher temperatures, increased nitrogen deposition in the atmosphere and increased CO_2 concentrations are changing the functioning of forest ecosystems, mainly affecting the productivity and growth of the forest [16].

One of the aids in growing planting material is the use of growth regulators. Plant growth regulators are organic chemical compounds that alter or significantly regulate various physiological processes in a plant when applied in low concentrations. These plant growth regulators have become an integral component of agrotechnical measures for most plants. Research by N. V. Puzrina and G. O. Boyko prove that the use of growth regulators for pre-sowing seed treatment is a good means of increasing the morphometric parameters of woody plants. The use of such growth regulators as trichodermin, nematophagin, fumar, emistim contributed to the increase in the height of one-year-old pine seedlings of the usual seedling height (by 3–14 %), root neck diameter (6–26 %) and root length (by 3–9 %) [44].

In order to prevent the roots from drying out during forestry work (transplantation, storage, transportation of planting material), there are polymer compounds that create a film coating (for example, Akvasorb-3005 KM and Teravet-100). These substances, due to the protection of the roots, are able to increase the percentage of survival of the planting material. Also, these drugs can be used for introduction into the landing gap, which leads to an increase in costs, which is economically unprofitable [43].

The use of mycorrhiza in seedling forest crops is also relevant. Scots pine is an obligate mycotrophic species, that is, its root system can be in symbiosis with fungi. Fungal hyphae penetrate the soil and envelop the roots of a woody plant, increasing their absorption capacity and contributing to the supply of available nutrient compounds (nitrogen, phosphorus and potassium) to the plant, thus increasing the percentage of survival of the planting material [51].

One of the measures to improve the sowing qualities of seeds of woody plants is the use of trace elements for seed treatment. Also, Preparations based on microelements may contain other auxiliary substances in their composition: humic acids, amino acids, macroelements and phytohormones. Although these drugs are more widely used in crops of widely used crops, they are also used in forestry. Thanks to this composition, preparations based on microelements not only provide plants with nutrients, but are also able to increase the resistance of plants to abiotic factors (diseases, pests, effects of high temperatures, late frosts, etc.) [48].

Materials and Methods.

The research was conducted in the conditions of the Northern Forestry Office of the State Enterprise "Forests of Ukraine", which unites the forests of Sumy Oblast and Chernihiv Oblast.

It was organized in 1936 on the basis of the forests of the Ivolzhan, Nikol, Yunakiv, Myropil, Veliko-Vystorop, Lebedyn and Mezhyrich forests, with a total area of 41,000 hectares. The current forest management is carried out according to the 1st category in accordance with the requirements of the current forest management instructions, the decisions of the first forest management meeting and the technical meeting based on the results of field work.

According to forest vegetation zoning, the territory of the forest farm belongs to the zone of the Left Bank forest-steppe. According to the forest typological zoning of Ukraine (according to D. Vorobyov), the territory of the forest farm belongs to the forest typological district of the Dnipro fresh maple-linden thickets [26]. The climate of the area where the forest farm is located is moderate-continental. It is characterized by an optimal amount of precipitation, sufficient for the main forest-forming species.

Of the climatic factors that negatively affect the growth and development of forest plantations, there are late spring and early autumn frosts, strong dry winds. The territory of the forest farm belongs to lowland forests by the nature of the terrain. Its eastern part is strongly cut by valleys of small rivers, streams, ravines and streams. There is a significant variation in altitude above sea level (115-230 m). Along the Psel River there is a floodplain terrace with a width of several hundred meters to several kilometers, which is characterized by specific properties of the soil-forming process.

From the point of view of soil richness, as well as the nature of the soil formation process, the following types of soil are distinguished on the territory of the forest farm:

1. Gray forest (dark gray, gray and light gray).
2. Sod-podzolic soils:
3. Marsh soils:

The main forest types, which are characterized by the richness of the soil and forestry D_2KLD – 67 %; C_2LDS – 17 %; C_3LDS – 4 %; B_2DS – 4 %.

The economic activity of the forest farm is aimed at growing highly productive sustainable plantations, processing wood, and creating conditions for recreation. Forestry occupies a significant place in the economy of the district. The main directions of its development are obtaining marketable wood, while preserving the protective properties of the forest, recreational purposes, as well as protection and reproduction of hunting fauna.

Agricultural land available in the forest fund is used for the needs of forestry workers and feeding of hunting fauna. The value of forest haymakers in the fodder balance of the district is insignificant.

90 % of the felling of the main use was carried out in places designed by forest management. In connection with the change of felling, forest management was additionally included areas for felling of the main use. Now and at the time of the basic forest management in 2007, the forest farm had an approved cut – 22.7 thousand cubic meters of liquid. The yield of commercial wood corresponds to the design.

During felling of the main use, no loss of wood was detected.

In general, main-use fellings improved the state of the forest and exploitation fund, thanks to the revision of the estimated felling of common ash, overgrown plantations, which were already losing their protective functions and the marketability of wood, were included in the felling.

The state of plantations not covered by maintenance fellings is satisfactory for forest management. Accounting for species care felling in the forest farm is generally satisfactory. The quality of maintenance felling and selective sanitary felling is satisfactory. Wood residues were not allowed in the felling areas. The main method of felling maintenance is combined, which combines the principles of bottom and top maintenance.

Wood from care and sanitary felling is sold in round form, and 30 % is used for own needs, including processing – 21 %. The research was carried out in the nursery and forest crops of the Pishchan Forestry. Pishchan Forestry is part of the "Sumy LG" branch of the State Enterprise "Forests of Ukraine" and is located in the forest-steppe zone of Ukraine. Forestry has an area of 8,049.5 hectares and is territorially located in the Sumy district (6,714.0 hectares), Bilopolsky district (217,0 hectares) and the city of Sumy (1,118.5 hectares). It consists of 3 workshops, which in turn are divided into 12 rounds. 16 people work in forestry: a forester, a forester's assistant, 2 logging foremen, 9 foresters, an accountant, 2 tractor drivers.

According to forest vegetation zoning, the territory of forestry belongs to the zone of Livoberezhno-Dnipro Forest Steppe. According to the forest typological zoning of Ukraine (D. V. Vorobyov – 1952), the forestry territory belongs to the forest typological district of the Dnipro fresh maple-linden thickets. According to the forestry zoning of Ukraine (S. A. Gensiruk – 1992), the forestry territory belongs to the northern Poltava plain with oak, linden-maple-oak forests and meadow steppes. The climate of the forestry area is temperate-continental, which is characterized by the amount of precipitation sufficient for the main forest-forming species. A brief description of climatic conditions that are important for forestry is given in the table.

Of the climatic factors that negatively affect the growth and development of forest plantations, there are late spring and early autumn frosts, strong dry winds.

The territory of forestry, according to the nature of the relief, belongs to plain forests. Its eastern part is heavily incised by valleys of small rivers, streams, ravines and gullies with significant variations in altitude above sea level (115–230 m). Along the Psel River there is a floodplain with a width of several hundred meters to several kilometers, which is characterized by specific properties of the soil-forming process.

The western part is a large flat area and only small areas of ravines and streams. The main climatic indicators of the forest farm area are given in the table 1. The main types and types of soils: gray forest (dark gray, gray and light gray), turf-podzolic, turf-podzolic gley, swamp (peat-gley and peat). The main types of forest: D_2KlD – 65,2 %, C_2LDS – 17 %, C_3LDS – 3,6 %, B_2DS – 3,8 %.

Erosion processes in the territory of forestry are poorly developed. In forests, water erosion is hardly noticeable due to the significant moisture content of forest soils and the soil-protective capacity of tree stands. There is no wind erosion. In small forest tracts growing on the slopes of streams, water erosion is more severe, which is facilitated by rains and surface runoff.

According to the degree of moisture, most of the soils are fresh. Forest areas with excessive moisture account for 1,8 % of the area covered by forest vegetation.

In the Pishchan Forestry, today the area of forest crops is 242,8 hectares, of which 35,8 hectares were created this year. Of this total number of forest crops, only 18,1 ha are for conifers (5,8 ha for 2-year, 3-year-old crops), the rest of crops with the main species being oak.

There are 2 forest nurseries with a total area of 1,9 hectares on the territory. Today, oak is grown for its own needs (150,000 pieces of 1-year-old oak are available). This year, 3,050 kg of acorns were collected, of which 1,950 kg were transferred to other branches of the branch, 630 kg were sown in autumn to create forest crops by sowing, and the rest were sown in the nursery for further cultivation of planting material.

Table 1. Climatic indicators.

Name of indicators	Unit of measurement	Value	Date
1	2	3	4
1. Air temperature:			
- average year	degree	+6.0	
- absolute maximum	degree	+31.0	
- absolute minimum	degree	-27.0	
2. Amount of precipitation per year	mm	508	
3. Duration of the growing season	days	197	
4. Late spring frosts			02.06
5. The first autumn frosts			11.09
6. The average date of freezing is a year			16.12
7. Average date of flood onset			24.03
8. Snow cover:			
- thickness	see	12	
- appearance time			12.12
- climbing time in the forest			21.03
9. Depth of freezinggrunt	see	49	

Table 1. Continuation.

10. Direction of prevailing winds by seasons:			
- winter	point	West	
- spring	point	South West	
- summer	point	South West	
- autumn	point	North West	
11. Average speed of prevailing winds by season:			
- winter	m/sec.	5.2	
- spring	m/sec.	4.4	
- summer	m/sec.	3.2	
- autumn	m/sec.	4.2	
12. Relative air humidity	%	6.8	

Spruce nurseries were created for their further sale as planting material and as Christmas trees (available with a height of 0,25–1 m – 500 pcs., up to 0,25–0,5 m – 800 pcs., up to 0,25 m – 1300 pcs.). The purpose of research is the study of the technology of growing the planting material of Scots pine seedlings and determining the features of their growth and development (adaptation) depending on the methods of obtaining and the type of substrate.

Object of study – Scots pine seedlings, the technology of obtaining planting material and its adaptation.

Subject of study – growth and development of Scots pine seedlings with an open and closed root system, type of substrate.

To solve the set goal, we conducted 2 experiments and set the following tasks: to investigate the influence of the substrate on the germination of Scots pine seeds; to determine the viability of Scots pine seedlings (seedlings) depending on the methods of obtaining planting material and the type of substrate (open and closed root system); to establish biometric indicators of Scots pine seedlings (seedlings) depending on the method of obtaining planting material and the type of substrate (height of tree plants, growth height, diameter).

Method conducting research involved the following measurements: Soil similarity was determined according to GSC (ISO 13056.7-93). Height measurements were made with a measuring ruler. The diameter of the root neck is measured with a compass. The mass of raw seedlings was determined on a scale with an accuracy of 0.001 g. Statistical data processing with the Statictica 9.0 program.

Results. Experiment 1. Peculiarities of adaptation of Pinus sylvestris seedlings depending on the method of obtaining.

One of the most important indicators of seed suitability for sowing and determination of its weight norm is seed germination. This indicator is directly related to the growth and development of plants and their future productivity [47].

In the course of the study of the germination of Scots pine seeds (Table 2), it was established that the seeds with the use of "Jiffy" peat tablets had the highest germination – 81,6 %.

Table 2. Similarity of Scots pine seeds depending on the type of substrate, %.

Research option	Similarity, %	Difference compared to control, %
Soil	73,8	–
Peat tablets "Jiffy"	81,6	10,6
Soil + Peat tablets "Jiffy"	75,5	2,3

Seeds sown in a mixture of soil and peat tablets "Jiffy" were characterized by slightly lower germination – 75,5 %.

The lowest similarity was recorded for soil use – 73,8 %. The difference compared to the control (soil) was 10,6 % for substrate based on Jiffy peat tablets, 2.3% for soil and Jiffy peat tablets.

The survival rate of the planting material is a crucial aspect for the productivity of the forest plantations in the future. One of the main parameters that directly affect grafting is the share of root system preservation [52]. Research by scientists has proven that planting material with a closed root system is the least traumatic when planting, due to which it has high survival rates [40].

According to the results of our research (Table 3), it was found that planting material with a closed root system has a higher percentage of survival (76,2–82,3 %) compared to the control variants (seedlings with an open root system) – 60,2 %. Comparing the percentage of survival of planting material depending on the substrate used, it should be noted that seedlings grown on a mixture of soil and peat tablets "Jiffy" have the highest survival rates – 82,3 %, which is 36,7 % more compared to the control. The variants grown using a soil-based substrate were characterized by a slightly lower percentage of survival – 76,2 %, which is 26,8 % more compared to the control.

Table 3. Survival of planting material with a closed and open root system depending on the type of substrate, %.

Research option	Survival rate, %	Difference compared to control, %
Seedlings with an open root system (control)	60,2	–
Seedlings with a closed root system (soil)	76,2	26,8
Seedlings with a closed root system (soil + Jiffy peat tablets)	82,3	36,7

The height of woody plants plays an important role in their survival and competitiveness, especially in dense stands. First of all, this competition concerns light, the lack of which causes plants to stop growing or die. Also, a developed plant trunk is able to better transport nutrients and water absorbed by the root system to other plant organs, which also affects the productivity of plantations in the future.

It was found that the method of obtaining planting material and the type of substrate had a significant effect on the height of one-year-old Scots pine seedlings (Table 4). The smallest height parameters were formed by seedlings with an open root system (control) – 18,7 cm. The highest seedlings were formed by the method of obtaining planting material with a closed root system: on a soil substrate – 24,3 cm; on a substrate made of a mixture of soil and peat tablets "Jiffy" – 23,3 cm, which is 24,6 %, which is 29,9 and 24,6 % higher, respectively, than the control variant. The Duncan test for plant height was equal to 2,5 cm.

The growth of plants in height characterizes the value of the tax indicator and the intensity of growth and development of forest plantations over a certain period of time. This indicator, like the height, to some extent reflects the expediency of carrying out this or that measure during the cultivation of forest plantations.

Table 4. Height of 1-year planting material with a closed and open root system depending on the type of substrate, cm.

Research option	Height, see	Difference compared to control, %
Seedlings with an open root system (control)	18,7	–
Seedlings with a closed root system (soil)	24,3	29,9
Seedlings with a closed root system (soil + Jiffy peat tablets)	23,3	24,6
Duncan test	***2,5***	

The research data obtained by us in 2023 (Table 5) indicate a positive influence of the method of obtaining the Scots pine planting material and the type of substrate (Duncan test = 1,6 cm). The smallest increase in height of one-year-old Scots pine plants was formed by the method of obtaining planting material with an open root system – 10,9 cm. The largest increase was recorded on planting material with a closed root system: on a substrate made of a mixture of soil and peat tablets "Jiffy" – 14,4 cm; on a soil substrate – 15,5 cm, which is 32,1–42,2 % more compared to the parameters of seedlings with an open root system.

Table 5. Growth in height of 1-year-old planting material with a closed and open root system depending on the type of substrate, cm.

Research option	Growth in height, see	Difference compared to control, %
Seedlings with an open root system (control)	10,9	–
Seedlings with a closed root system (soil)	15,5	42,2
Seedlings with a closed root system (soil + Jiffy peat tablets)	14,4	32,1
Duncan test	***1,6***	

The diameter of the stem is the most common indicator used to estimate the thickness of the trunk, which changes dynamically even at the age of one year.

According to the results of research in 2022 (Table 6), it was established that the largest diameter of the root neck in one-year-old Scots pine plants was formed using planting material with a closed root system with a soil-based substrate – 5,06 mm.

The variants of planting material with a closed root system based on soil and peat tablets "Jiffy" had a slightly smaller diameter – 5,02 mm. The smallest diameter values were recorded on the control variants (seedlings with an open root system) – 4,82 mm. The difference between variants with a closed root system under different types of substrates compared to the control was 4,14–4,97 %. Duncan test – 0,11 mm.

Table 6. Diameter of 1-year planting material with closed and open root system depending on the type of substrate, mm.

Research option	Diameter, mm	Difference compared to control, %
Seedlings with an open root system (control)	4,82	–
Seedlings with a closed root system (soil)	5,06	4,97
Seedlings with a closed root system (soil + Jiffy peat tablets)	5,02	4,14
Duncan test	***0,11***	

Experiment 2. Obtaining and adaptation of Pinus sylvestris planting material depending on age.

According to the results of research carried out in 2022 (Table 7), it was shown that the 1-year and 3-year planting material of Scots pine with a closed root system (with a closed root system) was characterized by better survival compared to planting material with an open root system (with an open root system). One-year-old seedlings with a closed root system had a survival rate of 73,9 %, which is 7 % more than seedlings with an open root system (66,9 %). Three-year-old planting material with a closed root system also had higher survival rates (67,7%), which is 10 % higher than seedlings with an open root system (57,7 %).

Seedlings from with an open root system were characterized by a higher percentage of the death of woody plants within three years after planting.

Table 7. Survival of Scots pine in forest cultures created by planting material with closed and open root systems.

Age of forest crops	Survival rate (%) of planting material with a root system		Difference compared to control, %
	closed	open (to)	
1-year-old	73,9	66,9	10,5
3 years old	67,7	57,7	17,3

Thus, the percentage of survival in seedlings with an open root system decreased by 9,4 % (comparing 1- and 3-year-old planting material), and in seedlings with a closed root system – by 6,2 %, which may indicate a better adaptation of planting material with a closed root system to soil conditions including due to the remaining nutrients from the soil mixture used as a substrate during their cultivation.

The height of plants is an important indicator that indicates the expediency of using this or that measure in growing technology. Light competition is crucial for the survival, growth and reproduction of individuals in dense stands.

The height of 1-year planting material from with a closed root system (Table 8) was 20,2 cm, which is 6,5 cm more compared to planting material with an open root system (13,7 cm). The height of 3-year-old seedlings was also characterized by higher values in planting material with a closed root system – 71,3 cm, which is 16,3 cm higher than in seedlings with an open root system (55,0 cm). The difference compared to the control (seedlings with an open root system) at 1-year age was 47,4 % and at 3-year age – 29,6 %.

Table 8. Scots pine height in forest cultures created by planting material with closed and open root systems.

Age of forest crops	Height (cm) of planting material with a root system		Difference compared to control, %	Duncan test
	closed	open (to)		
1-year-old	20,2	13,7	47,4	6,5
3 years old	71,3	55,0	29,6	14,8

Growth in height, like the height of the plant itself, is of great importance in the development of forest plantations. This indicator characterizes the intensity of growth of woody plants and reflects the impact of certain agrotechnical measures.

According to the results of the analysis of growth indicators by the height of Scots pine seedlings (Table 9), it was established that the largest growth of 1-year-old plants was formed from with a closed root system – 9,2 cm, which is 2,6 cm more compared to planting material with an open root system.

The same trend was observed in 3-year-old plants: growth in height in planting material with a closed root system was 30,2 cm, which is 5 cm more compared to planting material with an open root system. The difference in height growth compared to the control (seedlings with an open root system) at 1-year age was 39,4 % and at 3-year age – 19,8 %.

Stem diameter is one of the most common measurements taken to assess the growth of woody vegetation and the commercial and environmental benefits it provides (e.g. wood or biomass products, carbon sequestration, landscape reclamation).

Table 9. Height growth of Scots pine in forest cultures created by planting material with closed and open root systems.

Age of forest crops	Seedling height growth (cm) of planting material with a root system		Difference compared to control, %	Duncan test
	closed	open		
1-year-old	9,2	6,6	39,4	2,5
3 years old	30,2	25,2	19,8	4,7

According to the results of the research conducted in 2023 (Table 10), it was established that the 1-year-old and 3-year-old planting material grown with a closed root system – 7,67 and 13,15 mm, respectively, which is 1,55–1,79 mm more compared to planting material with an open root system (6,12 and 11,36 mm, respectively).

Table 10. The diameter of the root neck of Scots pine in forest cultures created by planting material with a closed and open root system.

Age of forest crops	Seedling diameter (mm) of planting material with a root system		Difference compared to control, %	Duncan test
	closed	open		
1-year-old	7,67	6,12	25,3	1,5
3 years old	13,15	11,36	15,7	2,1

The difference in the diameter of the root neck of Scots pine compared to the control (seedlings from with an open root system) at the age of 1 year was 25,3 % and at the age of 3 – 15,7%. According to the results of variance analysis, the difference is not significant (Duncan test 1,5 and 2,1 mm), respectively.

CONCLUSIONS. Based on the results of our research in 2023, we can draw the following conclusions for **experiment 1:**

1. The highest seed germination was achieved using "Jiffy" peat tablets - 81.6%. Seeds sown in a mixture of soil and peat tablets "Jiffy" were characterized by slightly lower germination – 75,5 %. The lowest similarity was recorded for soil use – 73,8 %.
2. Seedlings with a closed root system grown on a mixture of soil and peat tablets "Jiffy" have the highest survival rate – 82,3 %, which is 36,7 % more compared to seedlings with an open root system (control) – 60,2 %. The variants grown using a soil-based substrate were characterized by a slightly lower percentage of survival – 76,2 %, which is 26,8 % more compared to the control.
3. The tallest seedlings were formed by the method of obtaining planting material with a closed root system: on a soil substrate – 24,3 cm; on a substrate made of a mixture of soil and peat tablets "Jiffy" – 23,3 cm, which is 24,6 %, which is 29,9 and 24,6 % higher, respectively, than the control variant (18,1 cm).
4. The smallest height parameters were formed by seedlings with an open root system (control) – 18.7 cm. The highest seedlings were formed by the method of obtaining planting material with a closed root system: on a soil substrate – 24,3 cm; on a substrate made of a mixture of soil and peat tablets "Jiffy" – 23,3 cm, which is 24,6 %, which is 29,9 and 24,6 % higher, respectively, than the control variant.
5. The smallest increase in height of one-year-old Scots pine plants was formed by the method of obtaining planting material with an open root system – 10,9 cm. The largest increase was recorded on planting material with a closed root system: on a substrate made of a mixture of soil and peat tablets "Jiffy" – 14,4 cm; on a soil substrate – 15,5 cm, which is 32,1–42,2 % more compared to the parameters of seedlings with an open root system.
6. The largest root neck diameter in one-year Scots pine plants was formed using planting material with a closed root system with a soil-based substrate – 5,06 mm. The variants of planting material with a closed root system based on soil and peat tablets "Jiffy" had a slightly smaller diameter – 5,02 mm. The smallest diameter values were recorded on the control variants (seedlings with an open root system) – 4,82 mm.

Conclusions for experiment 2:

1. 1-year-old and 3-year-old pine seedlings with a closed root system were characterized by better survival compared to seedlings with an open root system. One-year seedlings with a closed root system had a survival rate of 73,9 %, which is 7 % more compared to seedlings with an open root system (66,9 %). Three-year-old planting material with a closed root system also had higher survival rates (67.7 %), which is 10 % higher compared to seedlings with an open root system (57,7 %).
2. Scots pine seedlings grown with a closed root system were taller than seedlings with an open root system. Average in quality of 1-year-old planting material from with a closed root system was 20,2 cm, which is 6,5 cm more compared to planting material with an open root system (13,7 cm). The height of 3-year-old

seedlings was also characterized by higher values in planting material with a closed root system – 71,3 cm, which is 16,3 cm higher than in seedlings with an open root system (55,0 cm). The difference compared to the control (seedlings with an open root system) at 1-year age was 47,4 % and at 3-year age – 29,6 %.

3. It was established that the largest increase was formed by 1-year-old plants with a closed root system – 9,2 cm, which is 2,6 cm more compared to planting material with an open root system. The same trend was observed in 3-year-old plants: the increase in height in planting material with a closed root system was 30,2 cm, which is 5 cm more compared to planting material with an open root system. The difference in height growth compared to the control (seedlings with an open root system) at 1-year age was 39,4 % and at 3-year age – 19,8 %.

4. The 1-year-old and 3-year-old planting material grown from with a closed root system – 7,67 and 13,15 mm, respectively, which is 1,55–1,79 mm more compared to planting material with an open root system (6,12 and 11,36 mm, respectively). The difference in the diameter of the root neck of Scots pine compared to the control (seedlings with an open root system) was 25,3 % at the age of 1 year and 15,7 % at the age of 3 years. According to the results of variance analysis, the difference is not significant (Duncan test 1,5 and 2,1 mm, respectively).

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ANALYSIS OF HUNTING FAUNA IN THE LANDS OF HUNTING FARMS OF THE SUMY REGION

Melnyk Tetyana
Candidate of Biological Sciences, Professor
ORCID ID: 0000-0002-3839-6018

Melnyk Andrii
Doctor of Agricultural Sciences, Professor
ORCID ID: 0000-0001-7318-6262

Tovstukha Alexander
Candidate of Agricultural Sciences, Associate Professor
Sumy National Agricultural University, Ukraine

Hunting is one of the forms of use of natural resources aimed at the exploitation, reproduction and preservation of wild animal populations. In Ukraine today there are problems related to the uncontrolled use of hunting resources, intensive economic activity, deterioration of game conditions, poaching and the lack of a sufficient number of qualified specialists. This situation causes a significant decrease in the population of hunting animals compared to European countries. In the developed countries of North America and Europe, hunting is effective, contributes to the creation of new jobs and brings significant income to the country's budget [41].

Hunting is a way of using the resources of the animal world, in which hunting animals are specially hunted, which are in semi-free conditions or are kept in a state of natural will within the boundaries of hunting grounds. This activity satisfies various needs of citizens, such as material and recreational, and is popular among the population of many European countries. Thus, it is important to study the number of hunters in European countries, the use of hunting resources, the peculiarities of hunting and the management of hunting economy (Table 1) [42].

Table 1. Analysis of the number of hunters in European countries (as of 01.01.2021).

Country	Area, thousand km^2	Number		
		population, million people	hunters	
			persons	%
1	2	3	4	5
Albania	29	3.3	17000	0.5
Austria	84	8.3	118200	1.4
England	244	63.2	800,000	1.3
Belgium	32	10.3	20000	0.2
Belarus	93	9.5	130,000	1.4
Bosnia and Herzegovina	51	4.4	50000	1.1
Bulgaria	111	7.4	95000	1.3
Greece	132	11.3	270,000	2.4

Table 1. Continuation.

1	2	3	4	5
Denmark	43	5.5	165000	3.0
Estonia	45	1.3	15000	1,2
Ireland	70	4.6	350,000	7.6
Iceland	103	0.3	6000	2.0
Spain	505	45	980000	2,2
Italy	301	59	750000	1.3
Cyprus	9	0.8	45000	5,6
Latvia	64	2,3	25000	1.1
Lithuania	65	3,4	25000	0.7
Macedonia	34	2.4	12000	0.5
Moldova	34	3.6	12000	0.3
Netherlands	41	16.4	30500	0.2
Germany	357	81.8	350,000	0.4
Slovenia	20	2.0	22000	1.1
Turkey	783	70.0	300,000	0.4
Hungary	93	10.0	50000	0.5
Ukraine	603	45.4	560000	1,2
Finland	338	5.4	290000	5.3
France	551	65.0	1313000	2.0
Croatia	56	4.3	55000	1.3
Czech Republic	79	10.5	100000	0.9
Switzerland	41	7.6	30000	0.4
Sweden	450	9.3	290000	3.1

France is the leader in the number of registered hunters (more than 1.3 million people). In 1900, the country had 463,000 hunters, in the mid-1950s their number increased to more than 1.5 million, and in 1969 it reached approximately 2 million [8, 13].

In France, *Capreolus capreolus* and *Sus scrofa* are the main objects of hunting among wild animals. Every year in this country hunt more than 450,000 wild animals, of which approximately 50% are roe deer, 45% are wild pigs, and only 4% are *Cervus elaphus*. In one hunting season, the number of deer harvested in France is 15-20 thousand, while the total number of red deer in the forests of Ukraine is about 15 thousand. In addition to hunting for rat animals, hunting for feathered game is popular in the country. At the beginning of the 21st century, more than 6 million pheasants, more than 3 million partridges, about 2 million wild ducks, and more than 1 million grouse were harvested in the hunting grounds.

At the beginning of the 80s of the last century, the number of hunters in Italy was 1.5-2.0 million people, and now their number has decreased to 750 thousand [2, 9]. The area of hunting grounds in Italy is 27 million hectares, and they are home to 70 different species of animals and birds. The country is heavily hunted, including traditional species such as duck and hare, as well as songbirds such as sparrow, lark and finch [6]. In the 70s and 80s of the last century, during autumn and spring migrations, hunters used traps and caught millions of sparrow-like birds. For example, more than 100 million blackbirds alone were harvested, and they are one of the most important hunting objects, along with hare and pheasant [9, 16]. With a large number of hunters comes the problem of securing hunting rights, which is why hunting tourism is popular among French, Italian and Spanish hunters. Italian, French and Spanish hunters enjoy hunting birds such as *Coturnix coturnix* and *Scolopax rusticola*.

During the ten-year period from 2010 to 2020, the hunting-tourism industry of Ukraine received an income of 3,081 thousand dollars from foreign tourists. During this period, from 2010 to 2016, the average annual profit was 152 thousand dollars. However, from 2017 to 2019, thanks to the hunting of Italian and French hunters, the amount of income increased 4.4 times. In total, over 3,000 foreign hunters were hunted in Ukraine during this ten-year period.

However, this number is much smaller compared to other countries such as Poland and Hungary. For example, at the beginning of the 70s of the 20th century, Hungary annually attracted about 8 thousand foreign hunters, and at the beginning of the 21st century, this number increased to more than 25 thousand.

The first exhibition of hunting trophies, which took place in 1871, is considered a stage in the intensive development of trophy hunting. The obtained trophies, even in the situation of high density of animals, are recognized as one of the best in the world and evidence of a high level of hunting economy based on the latest scientific achievements [3, 5].

The successful development of the trophy business was preceded by intensive game breeding. With the onset of the 21st century, this type of hunting has become increasingly popular among hunters. However, attempts to get the best and biggest trophies can negatively affect the gene pool of wild animals, disrupt the age and sex structure of populations and reduce their reproductive capabilities. Aviary maintenance is one of the solutions for optimizing the structure of natural populations and increasing the productivity of hunting grounds. In addition to ducks, partridges and pheasants, wild pigs, mouflons, deer, bison, etc. are also bred in the enclosures.

The hunting industry in Hungary is not only aimed at attracting foreign hunters for tourism purposes, but is also actively engaged in the export of game. Buyers are sent not only the meat of large and small game, but also live hares, partridges and pheasants. During the 80s of the last century, about 90% of produced game was exported [5]. Since the 1960s, Hungarian hunters have achieved the profitability of their hunting industry [18]. This group managed to ensure a rational and effective management of the hunting industry thanks to the implementation of measures that began in the 60s of the last century. Each hunter was allocated more than 7 thousand hectares of hunting grounds. Most of the hunters were over 60 years old, and several of them had no professional education. The order of the Minister of Agriculture established a requirement for the Hungarian Union of Hunters to form a hunting guard with a maximum age of 45 and the mandatory availability of special education [18].

Thanks to the effective organization and observance of ethical standards of hunting, the population of game in the hunting grounds has increased significantly. To ensure the ration of animals, with the exception of wild boar, hunters used exclusively methods of approach or approach. Each hunter was accompanied by a hunter, who at the same time provided transportation. The hunter was allowed to shoot only with the permission of the hunter. For a missed shot or injury to an animal, the hunter was subject to a fine [3]. In general, compared to the 1960s, the number of hunters in Hungary increased 2.6 times and reached 50,000 people at the beginning of the 21st century.

In addition to Italy, a significant number of hunting enthusiasts can be found in Spain (980,000) and Great Britain (800,000). England, which is the most economically developed country in Europe, is marked by a high use of land for hunting - approximately 70% of it is agricultural, and forest land accounts for more than 10%. Despite the exploitation of the territory by economic activity, the number of hunters in this country is increasing. In the middle of the 20th century, their number was 500,000, and by 2000, more than 600,000 were registered. Of the six species of wild animals in hunting grounds, roe deer is the most common. Their number is more than 1 million heads, which is about 49% of the total number. The second place in terms of number is occupied by red deer (more than 35%), followed by *Cervus dama* with approximately 10%. The remaining species include the *Cervus nippon*, *Muntiacus reevesi*, *Hydropotes inermis* and the *Elaphurus davidianus*. Roe deer thus accounts for over 50% of the game taken by English hunters, while red deer accounts for over 30% of the total game hunted.

In the UK, approximately 12% of hunters choose to hunt red deer, but there is a significant number of those who wish to harvest this species. In addition to red deer, hunters also pay attention to three species of hare-like animals in the hunting grounds of Great Britain: wild rabbit (*Oryctolagus cuniculus*), gray hair (*Lepus europaeus*) and white hare (*Lepus timidus*). The number of gray hares in the country is twice as high as the number of white hares. In general, the number of shares is more than 1.2 million, and the population of wild rabbits exceeds them by three times. Wild rabbit hunting is allowed throughout the year. As for game birds, hunters usually hunt pigeons, partridges and wild game. Hunting for game birds is allowed only in summer and only for one species at a time. In the 1970s, English hunters hunted pigeons, and in the 1980s their annual catch was more than 10 million pigeons. Hunting for partridges (*Perdix perdix*, *Lagopus lagopus scoticus, Lagopus mutus*), pheasants (*Phasianus colchicus*) and hunting for foxes (*Vulpes vulpes*) is popular in the country [11].

In the countries of Northern Europe, in particular in Finland, Sweden and Norway, there are traditionally a large number of hunters. A constant number of hunters has been observed for quite a long time. Thus, in the second half of the 20th century, the number of hunters in Norway ranged from 100 to 150 thousand people, and today this number is about 190 thousand. Approximately 7% of men over the age of 16 in the country are engaged in hunting. In general, about 82% of hunters hunt white partridge, 29% - moose (*Alces alces*), 11% - red deer, 10% - roe deer, and 5% - reindeer. It is important to note that the red deer is a rare species in Norway, it is common only in the western part of the country, where the winter is mild and the vegetation provides a better forage base.

Red deer are usually hunted using the herd method, but in rough terrain such as mountains, gorges and others, hunting is not always effective. The use of licenses for hunting these animals does not exceed 40% [14]. Norwegian hunters consider red deer trophies the most valuable. According to literature data, it was established that in 1964, 7 thousand moose, 7 thousand reindeer and 1 thousand red deer were harvested within the country's hunting grounds. After 50 years, the volume of moose hunting increased 5 times, roe deer - 8 times, red deer - 20 times. Reindeer harvesting amounted to about 9,000 heads.

In the second half of the 20th century, the number of wild animals in Norway and other Scandinavian countries increased significantly. Hunters from Scandinavia believed that this increase was the result of a favorable climate, the availability of greater food resources and the absence of natural enemies. Winters in Norway have become warmer, with less snow and milder temperatures. These favorable conditions allowed deer to settle in the northern territories. Logging has led to an increase in the diversity of pastures and food supplies. One of the key factors in the increase in numbers, according to the conclusions of Swedish hunting experts, was the ban on grazing livestock in forest biotopes. Farmers were convinced that keeping large cattle on closed pastures will help increase milk and meat production.

In Sweden, similarly to Norway, moose is one of the main objects of hunting. In order to increase the number of moose in the Scandinavian countries, regulation of the population structure was introduced and various norms for hunting these animals were established. In Sweden, the increase in the moose population began at the beginning of the 20th century. In 1977, their number was half of this figure, and in 1979 it reached 116,000. The prevalence of males that were the object of hunting ranged from 51% to 69%. In 1981, 162,000 animals were sport caught, of which about 54,000 were males, 37,000 were females, and 61,000 were young. At the beginning of 1982, the total number of moose was 300,000, and by 1983 this figure had increased to approximately 450,000. The population density of moose animals in biotopes ranged from 26 to 40 individuals per 1,000 ha.

However, selective hunting has reduced the productivity of the salmon population by increasing the percentage of old females and reducing the average weight of males by 25 kg. Accordingly, a decision was made to conduct a uniform hunt for all age and sex groups of moose. For example, in autumn, they decided to hunt 20% of calves, 20% of individuals aged 1.5 years, 20% of individuals aged 2.5 years and 20% of elderly individuals, with the same number of males and females [4].

According to the mentioned statistics, the optimal number of moose in natural places in Sweden is about 250 thousand individuals. Currently, Swedish hunters conduct more than 100,000 moose hunts. In Sweden, this form of sport is popular among more than 200,000 people who practice it. In total, the number of hunters in Sweden is 290–310 thousand people. In addition, there is an increase in the number of hunters in Finland. In the 50s of the last century, 100,000 to 120,000 hunters were registered there, in the 60s, about 170,000 people, and in the 70s, more than 220,000 people [1, 12, 19, 20]. At the beginning of the 21st century, their number was 290,000.

In Finland, about 200,000 hunting enthusiasts try to take part in hunting at least once during the season. Of this number, more than 30% of hunters remain without prey. About half of hunters are successful in their hunts.

Forest areas cover more than 60% of the country's total area, while agricultural land accounts for only 8%. Moose is the most common game, approximately 38,000 moose are hunted annually. In addition, white-tailed deer and roe deer are hunted, with an annual hunting volume of more than 12,000 deer and more than 90,000 roe deer.

Deer, wild boars and mouflons also participate in hunting, but their numbers are much smaller. The introduction of white-tailed deer in Finland was important. In 1938, emigrants from the USA brought them to the country. During the years of increase in their number, the amount of hunting also increased. During the 1984–1985 season, more than 6,400 white-tailed deer were harvested, including 30% males, 24.8% females, and 45.2% young.

Unlike the Scandinavian countries, in Germany, Austria, Switzerland and other Central European countries, the main object of hunting is roe deer. During the five-year period from 1996 to 2000, about 5.2 million heads of this species were harvested in the hunting grounds of Germany, over 1.0 million heads in Austria. Roe deer hunting statistics in Switzerland at the beginning of the 21st century ranged from 40 to 45 thousand heads every year. In addition to rob deer, red deer, wild boar, and sable (*Rupicapra rupicapra*) are also hunted in these countries. In Germany and Austria, in addition to the previously mentioned species, mouflon and fallow deer are also hunted. Wild pigs are hunted in large numbers in Germany. At the end of the last century, wild boar hunting ranged from 250 to 450,000 heads, and modern hunting is in the range of 450 to 650,000 heads. In other words, such a number of wild pigs are hunted annually in Germany that corresponds to the total number of wild boars in Ukraine.

In the 1990s, the average annual deer harvest in Germany exceeded 50,000 heads; in modern times, this figure is more than 65,000 heads. In Austria, red deer is the second most common prey, with an annual harvest of 35,000 to 45,000 heads. German hunters take doe in roughly the same amount. Mouflon and skelnitsa, in turn, are common mainly in mountainous areas.

In Germany, mass hunting of wild animals is small. The annual catch, using mouflon and sable as an example, is approximately 5.5 thousand heads and 4.5 thousand heads, respectively. In comparison with the German indicator, the catch of glassfish in Austria exceeds it by 5 times, and in Switzerland by 3 times. One of the factors that explains the significant amount of hunting of wild animals in the countries of Central Europe is the absence of poaching. In addition to the mouflon and mountain goat populations, other species such as bears and birds are also actively hunted in Europe. For example, in Austria, the gray hair catch is about 200,000 heads, while in Germany this indicator is lower - 2–2.5 times less. In the case of wild rabbits in Germany, the catch fluctuates widely, but remains significant (from 200 to 450 thousand individuals).

During the 20th century, the number of hunters increased in almost all European countries. For example, in Denmark, the number of hunters in 1922 was 60,000, in 1961 - 110,000, in 1976 - 155,000, which was 8% of the country's male population.

At the beginning of the 21st century, compared to the 1970s, the population increased slightly and reached 165,000 people. Belgium (350 people per 1 km²) and Holland (400 people per 1 km²) have the highest population density in Europe. In Belgium, the area of hunting grounds is 2.8 million hectares, of which 620 thousand hectares are forest lands. In Holland, forests cover only more than 7% of the country's territory (Table 2).

Wild boar and roe deer are most commonly hunted in Poland's hunting grounds. Approximately more than 50% of hunted ungulates are wild boar, about 40% - roe deer, 10% - red deer, and less than 1% - fallow deer and mouflon [22]. The total area of hunting grounds in Poland is about 28.8 million hectares, with agricultural land covering 68% of the country's territory (28% is forest land). The lands of this country have favorable conditions for the existence of the gray hare.

Table 2. Area of forests and forest cover in European countries.

Country	Area, thousand ha			Woodland, %
	general	forests	forests per 1 person	
Finland	33814	21883	4.1	64.7
Sweden	44996	27264	3.0	60.6
Italy	30134	9857	0.2	32.7
Germany	35702	10740	0.1	30.1
Poland	31269	8942	0.2	28.6
France	55169	15156	0.2	27.5
Spain	50596	13509	0.3	26.7
Norway	38515	8710	1.9	22.6
Ukraine	60350	9400	0.2	15.6

In the 1960s, the number of hares was more than 3 million. Since the beginning of the 70s of the 20th century, a decrease in their population was recorded in the country. Annual hare hunting is 15-20 thousand heads, which is 7.8 times less than fox hunting. One of the main reasons for this decrease in the number of hares is the use of oral vaccination against predatory diseases [26]. Foxes had a significant impact not only on the population of field game, such as hares, gray partridge and pheasant, but also on the number of young roe deer [25, 27].

According to the research of Polish scientists, the decrease in the number of hares in Poland has several reasons, in addition to predators such as foxes, stray dogs and cats. One of these reasons is the use of mineral fertilizers and chemical plant protection agents, which negatively affect the environment, including the life of hares. Also, the death of hares can occur during agricultural work, such as plowing and harvesting. These actions often destroy the natural habitats of hares and lead to their death or forced migration. Another reason for the decline in the number of hares is the spread of diseases such as coccidiosis and brucellosis, which can cause great losses in the hare population.

In addition to hares, Polish hunters hunt pheasants and gray partridges. However, the number of pheasants collected (90–100 thousand) in Poland is 2–3 times less than in neighboring Germany, while gray partridge is collected three times more than in German lands. There are significantly fewer hunters in Poland, five times less compared to Ukraine, which may explain the difference in game collection. Nevertheless, the total number of hunters in Poland, as well as in other European countries, has increased compared to the last century. At the end of the 70s of the 20th century, the number of hunters in Poland amounted to 40,000 people, and at the beginning of the 21st century, it increased by 2.7 times and reached more than 100,000 people.

A list of the main types of hunting animals and their occurrence in European countries with the highest level of hunting development is given in Table 3 and Appendix B.

Table 3. List of the main types of hunting animals and their occurrence in European countries.

Hunting animals	Country							
	Finland	Sweden	Italy	Germany	Poland	France	Spain	Norway
Alces alces	*	*		*	*			*
Cervus elaphus		*	*			*	*	*
Cervus nippon			*				*	
Rangifer tarandus	*	*						*
Elaphurus davidianus			*				*	
Hydropotes inermis			*				*	
Odocoileus virginianus	*	*						
Capreolus capreolus	*	*	*	*	*	*	*	*
Dama dama mesopotamica					*	*		
Ovis orientalis gmelini					*	*		
Muntiacus reevesi			*				*	
Rupicapra rupicapra					*	*		
Sus scrofa				*	*		*	
Vulpes vulpes	*	*	*	*	*	*	*	*
Oryctolagus cuniculus	*	*	*	*	*	*	*	*
Lepus europaeus	*	*		*	*			*
Lepus timidus	*	*						*

In Ukraine, only 12% of the territory is covered by forest land, while agricultural land occupies 65%. The population density is 128 people per 1 km². Compared to other European countries, Ukraine ranks eighth in the area of forests. The total area of the forest fund in Ukraine is more than 10 million hectares, of which 9.4 million hectares are covered with forest vegetation. However, the forested area of he country is 15.6%, which is the lowest indicator among the countries of the continent. In neighboring countries, forest coverage is much higher: in Romania - 29%, Slovakia - 40.8%, Poland - 28.6%, Belarus - 42%.

About 560,000 hunters are registered in Ukraine, which is 1.2% of the total population. Approximately 280,000 people hunt every year. During the hunting season in 2021–2012, approximately 13,000 animals were taken, which is 5.3% of the total population. In the period from 2013 to 2022, 166,400 ratnik heads were harvested in the country's hunting grounds. The average annual harvest was only 3.80±0.26% of the total population, which indicates the insignificant productivity of the hunting grounds. The large number of hunters who cannot hunt ungulates forces some of them to resort to illegal hunting. Breeding of hunting animals in enclosures is one of the ways to increase the productivity of hunting grounds and the profitability of the hunting industry. This can provide an opportunity to hunt in large enclosures with a guaranteed harvest for those hunters who do not have access to game licenses or private lands.

Compared to Ukraine, in the neighboring countries of Europe, such as Poland, Slovakia and Belarus, the detection and extraction of ratites is much greater. For example, 350,000 to 400,000 ratnik heads are harvested annually in Poland.

So, in the 21st century, the number of hunters in Europe is significant. After taking into account small countries such as Liechtenstein, Luxembourg, Andorra and others, the total number reaches more than 8 million people. In European countries, the population of hunting animals significantly exceeds the population in Ukraine. In the hunting grounds of European countries, such as Germany, France, Poland, Sweden, Austria and others, the extraction of ungulates is higher than in Ukraine.

Successful hunting in European countries is due to the observance of hunting ethics, the breeding of hunting animals and birds in enclosures, the control of the number of predators and the absence of unsafe hunting for commercial game. Scientific data-driven population management of hunting animals, the development of hunting tourism and other factors also contribute to successful hunting in Europe.

Research materials and methods.

The purpose of research- statistical analysis of the dynamics of the number of ungulate hunting animals depending on the anthropogenic load in the conditions of the North-Eastern Forest-Steppe of Ukraine (Sumy).

Object of study - the number of ungulate hunting animals, in particular, *Bison bonasus* L., *Alces alces* L., *Cervus elaphus* L., *Cervus nippon* n. Temminsk, *Capreolus capreolus* L., *Sus scrofa* L..

Research methods- comparative analysis and mathematical statistics. Materials of statistical reporting and records of the State Statistics Committee, the State Agency of Forest Resources of Ukraine, the Sumy Regional Department of Forestry and Hunting, literary sources, and the results of own research were used for the analysis. Statistical analysis of research results was carried out with the help of variance analysis using Statistica–8.0 computer programs (Ermantraut et al., 2007; Carenko et al., 2000).

Results. Analysis of hunting grounds of the Sumy region.

The hunting grounds of the region are uneven, there are more productive ones, such as forest ones, and there are less productive ones - these are fields and wetlands.

According to the data of the Sumy Regional Department of Forestry and Hunting, the area of hunting grounds provided for use by state enterprises of

SOULMG is 237.8 thousand hectares, which is about 12% of the hunting grounds of the region [50].

11 state forestry enterprises and one state hunting enterprise are engaged in hunting. About 70 specialists are involved in the field of hunting management at management enterprises, of which 13 are state hunting experts. The total costs of running a hunting farm almost double the income from hunting and farming activities.

The state of protection of hunting grounds from poaching is the main restraining factor in the development of the hunting industry. The number of the main species of hunting animals in the hunting grounds of farms has been stable in recent years. In 2021, the number of the main species of hunting animals did not undergo significant changes compared to 2020. The dynamics of the number of the main species of hunting animals (individuals) is shown in the table. 4.

Table 4. Dynamics of the number of the main species of hunting animals (individuals).

Kind of animals	2019 year	2020 is the year	2021 year
Bison bonasus	52	54	64
Alces alces	239	223	228
Cervus elaphus	794	779	777
Cervus nippon	197	203	205
Capreolus capreolus	6117	6296	6333
Sus scrofa	626	965	1233

Hunting was carried out with licenses for ungulates (red deer, spotted deer, roe deer, wild boar) within the approved hunting limit and with shooting cards for fur animals. Of the 58 issued licenses for red deer, 33 were obtained, 1 licenses were not used. 6 were issued for spotted deer, 4 were obtained, 2 were not used. 158 were issued for wild boar, 99 were obtained, 5 were not used. 425 were issued for roe deer, mined - 397, not used - 12. Unfavorable weather conditions, lack of demand for catching animals became the main reasons for not using the limits. In 2021, 399 cases of poaching were detected [35].

In January-December 2021, the State Environmental Inspection in the Sumy Region conducted 39 inspections of compliance with the requirements of environmental legislation regarding hunting and hunting.

A total of 112 protocols on administrative offenses were drawn up, of which 95 were related to poaching. 126 people were brought to administrative responsibility (including one warning) for a total amount of fines of 52,568 thousand hryvnias, of which 42,198 thousand hryvnias were collected (poaching - 109 people were brought to account the amount of 44,098 thousand hryvnias, collected - 37,213 thousand hryvnias).

The total amount of calculated losses was 160 thousand hryvnias (poaching – 32 thousand hryvnias). 2 claims for the amount of UAH 160,000 have been submitted. Materials on 4 facts were handed over to law enforcement agencies, 3 of which have signs of a criminal offense.

Analysis of hunting theriofauna in the hunting grounds of the Sumy region. According to the results of the analysis of the dynamics of the population density of ungulate hunting animals in the lands of the Sumy region, a positive trend towards an increase in numbers was revealed over the last two years (2019–2021) (Table 5).

It should be noted that the total number of representatives of the ungulate hunting theriofauna in 2021 was 8,839 individuals, which corresponds to the level of the "depopulation" years. In general, 2021 was the most numerous in the last three years. Populations of almost all hunting ungulates increased, except for European moose and European red deer. Within species, the dynamics of the number of populations during the period 2019–2021 fluctuated.

Table 5. Dynamics of the number of ungulate hunting animals by species in the Sumy region (2019–2021).

Species name	Years		
	2019	2020	2021
Bison bonasus	52	54	64
Alces alces	239	226	228
Cervus elaphus	793	779	777
Cervus nippon	197	203	204
Capreolus capreolus	3117	6296	6333
Sus scrofa	626	965	1233

As can be seen from the data in figure 1, in 2021, 228 individuals of European moose were found on the hunting grounds of the Sumy OULMG. The largest number (35 individuals) was noted in the lands of the Konotopske LGD. This farm is also the leader in the number of red deer (94 individuals).

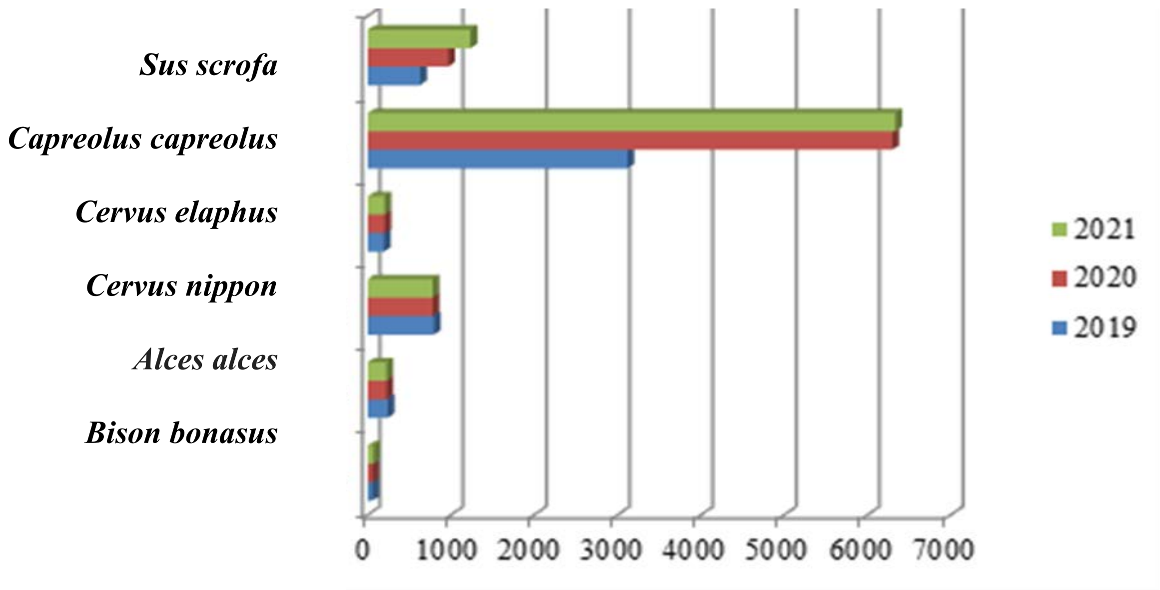

Figure 1. The dynamics of the number of populations of the main hunting species ungulates for 2019–2021.

The analysis of hunting theriofauna of ungulates of the Sumy region showed that the European roe deer population is the most numerous with a positive balance over the last three years. In second place is the wild boar population, which also has progressive dynamics to increase in numbers since 2019.

The European red deer population occupies the third position. The number of individuals has decreased slightly over the past two years, as has the case of the spotted deer.

As for the two red book species of the European moose and the European bison, there is a slight tendency to restore populations with a gradual increase in the number of individuals.

In general, it can be said that the rational organization of hunting management in the hunting grounds of the Sumy region and the growing role of enterprises of other forms of ownership have a positive effect on the development of hunting. However, this indicator is significantly lower than in European countries, which should be taken into account in the priority tasks of the region's forestry management.

Analysis of hunting theriofauna of SMT ‘Lebid’ LLC.

One of the tasks of this qualification work was the analysis of hunting fauna in the lands of the Sumy region, in particular, on the example of SMG ‘Lebid’ LLC.

For this purpose, the data of hunting fauna in the lands of the Department of Ecology, Natural Resources and the Fuel and Energy Complex of the Sumy Regional State Administration were analyzed.

The total area of hunting grounds of SMG ‘Lebid’ LLC is 59.5 thousand ha. The forest fund in the area of activity of the hunting industry is represented by forest massifs, where the main forest-forming species are Scots pine mixed with oak, linden, maple, birch, aspen and alder.

The accounting was carried out by the method of noise running, counting animals by tracks and from observation towers in feeding places. According to the results of the research, the paths of movement of wild animals and 20 feeding grounds located on the territory of Nyizivskyi, V. Vystoropskyi and Byshkinsky forestry were examined.

According to calculations and on the basis of observation materials, field record materials and an analysis of the number of wild animals in accordance with methodological recommendations, the number of animals for the last 5 years is summarized and shown in the table 6.

Table 6. Dynamics of the number of hunting ungulates LLC SMT Lebyd.

Kind of animals	Years			
	2020	2021	2022	2023
Alces alces	8	8	8	8
Cervus elaphus	415	415	420	430
Cervus nippon	128	130	135	140
Capreolus capreolus	512	510	512	520
Sus scrofa	1315	1310	1313	1325

According to the survey results, the list of ungulate hunting animals includes five species, namely: European moose, red deer, spotted deer, European roe deer, and wild boar. The wild boar population is the most numerous. In recent years, the number of pigs has increased to 1,325 from 1,315 heads. In second place is the European roe deer population. The dynamics of population development shows a positive trend. Thus, the number of livestock has remained stable at 510–520 heads for four years.

The third position belongs to the red deer. The population of this species is growing. In 2020, 415 and 430 individuals were discovered in 2023.

The population of spotted deer as a whole is characterized as progressive, as the herd has increased by 15 individuals in four years. One of the unique species of hunting theriofauna is the European moose. Its population is the smallest and is stable at 8 people.

The group of measures to increase the productivity of hunting grounds and increase the population of hunting animals includes: artificial winter feeding of deer; creation of fodder fields and protective sheds; arrangement of biotechnical equipment; control over the number of predators; fight against poaching; veterinary-sanitary measures; reducing the negative impact of care factors; protection of living conditions of red deer.

Biotechnical measures on the territory of the company's hunting grounds.

Biotechnical measures are designed to increase the number of hunting fauna, which is achieved by improving the fodder, nesting and protective properties of the land, feeding animals in difficult periods of the year, reducing the number of predators, eliminating or weakening the harmful effects of human activity, as well as releasing animals and birds for acclimatization. The basis for planning biotechnical measures was the evaluation of farm lands and the ratio of the optimal capacity of lands and the actual number of hunting animals in the farm [2].

These measures will make it possible to determine promising species of hunting animals on the territory of the farm and factors restraining the growth of livestock. To improve the fodder and protective properties of hunting grounds, we plant the following tree and shrub species valuable for game: oak, wild apple, pear, willow, hazel, rowan, blackberry, olive and others.

When creating forest crops, it is necessary to introduce nut and fruit species, olives, dogwoods, rose hips, sea buckthorn and others into their composition.

Table 7. Design of biotechnical facilities of SMG Lebid LLC.

Hunting animals	Canopies and feeders for animals	Places for feeding	Solontsi places	Places for watering hole
Deer	1 in 10 deer	-	1 in 10 deer	1 in 10 deer
Elk	-	-	2 out of 10 moose	-
Chamois	1 in 20 roe deer		1 in 20 roe deer	1 in 20 roe deer
Boar	-	1 in 10 boars	1 in 10 boars	1 in 10 boars

Feeding is a targeted improvement of fodder lands for hunting animals. It should be carried out in winter, when it is most difficult to get food for animals. Winter feeding lasts 100 days. Agricultural organizations must be required to strictly comply with established norms and rules for the use of pesticides and mineral fertilizers. All agricultural machines and units intended for work in the fields must be equipped with devices that would prevent injury and death of game [2, 30].

Harvesting of agricultural crops should be carried out in "overclocking" or in expanding strips. It is necessary to prohibit the circular method of harvesting agricultural crops, as the most harmful for game.

Animals are fed mostly with tree branches and mistletoe branches. At the feeding grounds, feed for animals, sheaves of unthreshed oats, clover, brooms from branches. Places for feeding are set up in a thinned clean forest, preferably near a thickened remze area, in order to protect from the wind and create a hiding place for animals. There should be a good entrance to the sites for the delivery of fodder. Feeders, regardless of their shape and design, should scare animals as little as possible and not stand out against the general background of the area.

There are no special facilities for feeding wild boars on the feeding grounds. Food for them is laid out in designated places. Here, wild boars easily find them and extract them even from under the snow. The best fodder is one-year shoots (together with leaves) from the following species: oak, birch, linden, poplar, ash, apple and pear, hazel, willow, rowan. It is better for animals to eat fodder brooms that have been moistened several times with a solution of 5–6% kitchen salt during drying. For winter feeding of moose and roe deer, it is necessary to cut aspen [1, 2].

On the basis of long-term observations, analysis of the activities of hunting farms, recommendations of candidate of biological sciences V.Ya. Kraynev [28], the average for all forest and hunting regions of feed procurement rates per head for a period of 100 days of feeding were calculated and accepted (Table 8).

Table 8. Table of feed procurement for an individual for the season.

Types of fodder	Unit ex.	Types of hunting fauna		
		deer	roe	boar
Forest hay, vetch, Oatmeal				
	kg	40	10	
Hay (silage)	kg	30	10	40
Bundles of hardwoods	piece	50	20	
Cereal sheaves	piece	50	20	
Grain fodder	kg	20	15	30
Corn on the cob	kg	40	20	80
Root crops	kg	60	30	100
Salt is a lick	kg	5	3	4

The calculation of the necessary amount of fodder is carried out depending on the forest and hunting zoning, the number of wild hunting animals in the lands and the period of the feeding period of wild animals. The timing of the fertilizing period depends on the period of freezing of the upper layer of the soil, the establishment of a significant stable level of snow cover and other factors [30]. Conventionally, the feeding season can be divided into three periods: from November 1 to November 30, the second period: from December 1 to 30, and the third period: from January 1 to February 10 (40 days).

CONCLUSIONS

The following conclusions can be made based on the results of the research of the qualification work:

1. In Ukraine, 12% of the territory is covered by forest land, while agricultural land occupies 65%. The population density is 128 people per 1 km². The total area of the forest fund in Ukraine is more than 10 million hectares, of which 9.4 million hectares are covered with forest vegetation. Forest coverage of the country is 15.6%, which is unsatisfactory.
2. About 560,000 hunters are registered in Ukraine, which is 1.2% of the total population. The average annual hunting of wild game was 3.80±0.26% of the total stock, which indicates the insignificant productivity of hunting grounds.
3. The hunting theriofauna of ungulates in European countries consists of 13 species (elk, red deer, spotted deer, reindeer, David's deer, Chinese water deer, American white-tailed deer, European roe deer, Mesopotamian fallow deer, Armenian mouflon, Chinese muntjac, goat common, wild boar); in Ukraine and the Sumy region - 6 species. The list includes two species included in the Red Book - European moose and European bison, hunting of which is prohibited.

4. The dynamics of populations of hunting ungulates in the Sumy region and their density are in a satisfactory state and have a positive trend towards growth.The number of animals available at the time of the study is insufficient for shooting in order of use, the exception is wild boar, the number of which is higher than optimal for this type of land.

5. The state of biotechnical programs and other adopted and planned measures to increase the number of the main species of hunting fauna in the lands of the SMG Lebid are being carried out at the appropriate level, as evidenced by the results of annual records and the positive dynamics of the growth of indicators.

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CREATION OF AN ORGANIZATIONAL AND ECONOMIC PLAN FOR A PERMANENT DECORATIVE NURSERY OF LEBEDYN FORESTRY

Osmachko Olena
candidate of agricultural sciences, associate professor
ORCID ID: 0000-0003-0591-2650

Bakumenko Olha
candidate of agricultural sciences, associate professor
ORCID ID: 0000-0003-1625-7401

Kriuchko Liudmyla
candidate of agricultural sciences, associate professor
ORCID ID: 0000-0003- 0528-210X

Pivovarova Inna
3rd year student, group SPH 2101-1, «Landscape» specialty
Sumy National Agricultural University, Ukraine

Introduction. The Ukrainian ornamental nursery industry has significant potential, which is highlighted by current trends in the development of the private sector. For private producers, the priority tasks are to expand the area and increase production capacity [1]. To meet the growing demand, it is necessary to implement modern technologies and modernize production to improve its efficiency and competitiveness [2]. Expanding the assortment of cultivated ornamental plants to include new, popular, and exclusive varieties. Production of high-quality planting material with a focus on healthy, resistant, and Ukrainian-climate-adapted plants [3, 4]. Scientific and methodological support for improving knowledge and skills, implementation of innovations and best practices. The implementation of these tasks will contribute to the sustainable development of Ukrainian ornamental plant nurseries, making them competitive on the global market [5].

Despite its significant potential, the ornamental plant nursery industry in Ukraine faces a number of challenges. The government does not provide enough financial support to the ornamental plant nursery industry. An underdeveloped market, a lack of transparency, unregulated pricing, and barriers to export [6, 7].

An analysis of the domestic market for ornamental plants shows that most Ukrainian nurseries lack a clear specialization. They offer a wide range (100-200 items) of varieties and forms, without focusing on specific species or groups [8].

There is a multi-channel system for selling ornamental plants in Ukraine, which gives buyers a wide range of choices [9]. These centers offer a wide range of ornamental plants, as well as related products (fertilizers, soil, tools); Supermarkets are often located in convenient locations, such as near shopping malls or highways. Branded stores are typically represented by major ornamental plant growers. This means that they have a wide selection of high-quality plants to choose from. Specialized small shops have a narrow specialization. This means that they focus on a particular type of ornamental plant, such as indoor plants or fruit tree seedlings. Street trading offers seasonal flowers and seedlings at affordable prices. This is because street vendors do not have the same overhead costs as other sales channels, such as rent and utilities.

Having reviewed the literature, it is clear that the establishment of nurseries in Ukraine has significant potential for development. Thanks to favorable conditions, government support, and the introduction of new technologies, it can become an important sector of the Ukrainian economy.

The purpose of this work is to select information about ornamental nurseries, select a location with a good geographical location and favorable climatic conditions, and develop an organizational and economic plan for a sustainable ornamental nursery.

The climate, terrain, soil, and other natural factors that could affect the growth and development of ornamental plants were studied.

Soil composition: The soil composition on the site where the nursery is planned to be located was determined in order to select the appropriate fertilizers and other agrotechnical measures.

The areas of the sowing, decorative, and mother departments were calculated according to the методичних вказівок [12]. The areas of the production and auxiliary parts of the nursery were calculated (areas of roads, forest belts, economic area, field area, fence, reservoir).

Results. Our work involved the theoretical creation of a nursery based on the State Enterprise "Lebedyn Forestry" and named it "Sakura". It will be located in the Sumy region, Lebedyn district, on the territory of the city of Lebedyn.

The distance to the railway station is 4,2 kilometers, and to the regional center of Sumy city is 42,5 kilometers. This area has a homogeneous relief, which is represented in the form of a wavy plain.

The territory of the Lebedyn district covers an area where two different landscapes meet: the hills of the Central Russian Upland and the flat expanses of the Dnieper Lowland. The Psel River is the main water artery of the Lebedyn district, and its tributaries - Vilshanka and Grun - complement the hydrographic network of the district.

The river system of the Lebedyn district is supplemented by small rivers Budylka, Tashan, Revky, Lozova and Legan, as well as a cascade of ponds, which make the landscape of the district even more picturesque. The Lebedyn district has favorable soil conditions, since fertile chernozems prevail here, as well as soddy-podzolic and gray forest soils.

The nursery will be located in an area with a temperate continental climate. This means that the winters here are cold and the summers are warm. The average annual temperature is 6.5°C, the coldest month is January, the hottest month is July, precipitation: 500-600 mm per year, the maximum amount of precipitation falls in summer, the minimum in winter.

The snow cover lasts from December to February. The wind is mainly from the west. Spring frosts in Lebedyn usually end on April 7, and autumn frosts begin on October 10. The frost-free period is 186 days.

The characteristics of the hydrothermal indicators of the climate of the region where the nursery will be located are shown in Figures 1, 2, and 3.

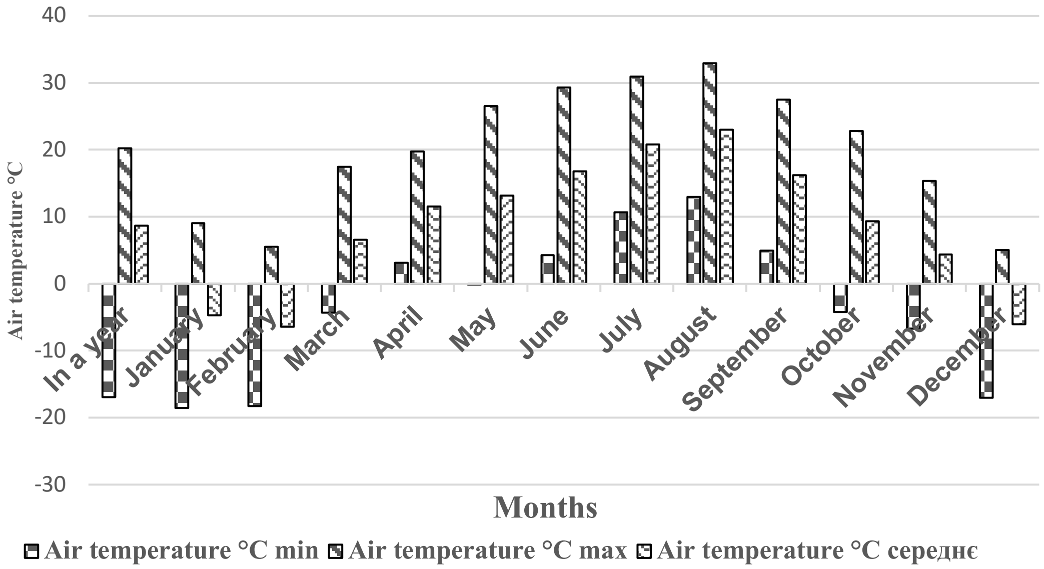

Figure 1. Temperature Indicators, °C.

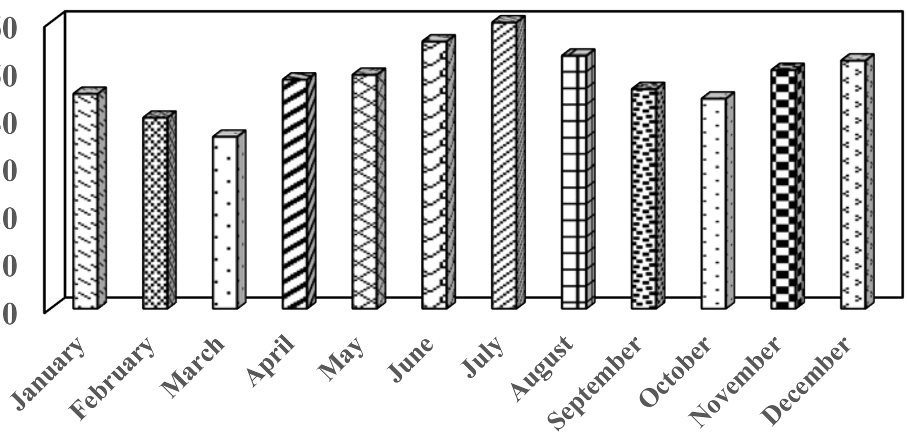

Figure 2. Precipitation Indicators, mm.

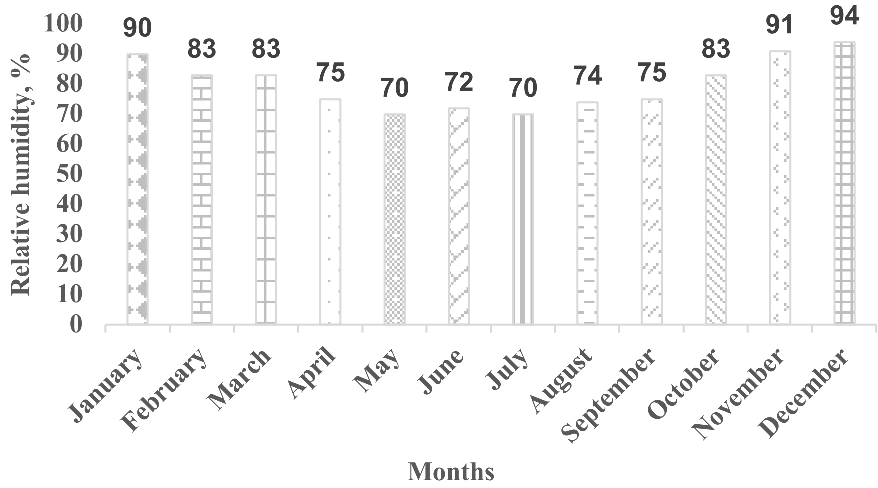

Figure 3. Relative Humidity, %.

The microclimate of this area will have a favorable effect on the nursery, making it an ideal place for growing seedlings of various trees and shrubs.

The economy of the region is constantly developing, which improves the well-being of its residents. The diversity of economic sectors makes the city resilient to external economic shocks, ensuring its stable growth.

Light industry can be called the leader among the sectors of the city's economy, since its share in the total production volume is 46%. Mechanical engineering also plays an important role in the city's economy, accounting for 34.4% of the total production volume. The food industry ranks third in terms of its share in the total production volume, with 27%.

Lebedyn Community can be proud of its forests, which occupy a significant part of its territory - 32.9 thousand hectares, or 21% of its total area. The forestry of the community is conducted at a high level, since it has everything necessary for this - production facilities and qualified workers. The forestry enterprise employs 180 people who take care of the preservation and multiplication of forest resources. Every year, 100 hectares of forest are restored in the community, which indicates a responsible attitude to the environment. Thanks to the work of foresters, the forests of the Lebedyn community not only provide people with timber, but also have important environmental and recreational significance. Forests are a real decoration of the community, a place of rest and a source of inspiration for people. The local authorities are doing everything possible to preserve and multiply forest resources. The forests of the Lebedyn community are our common wealth, which we must preserve and multiply for future generations.

The organizational and economic plan is the basis for the successful functioning of the nursery. It determines the organization, technology and direction of the nursery's activity for a number of years.

The organization of nurseries is based on the principle of separate cultivation of individual species of planting material. This principle has a number of advantages, such as:
1.Better control over growing conditions, different types of seedlings have different needs

for light, moisture, temperature, and soil. Separate cultivation allows you to create optimal conditions for each type, which leads to better growth and development of plants. 2. Reduced risk of spreading diseases and pests, some diseases and pests affect only certain types of plants. Separate cultivation helps to isolate infected plants and prevent the spread of infection to other species. 3. Efficient use of resources, separate cultivation allows for the maximum use of available resources, such as water, fertilizers, and land. 4. Convenience of care, separate cultivation makes it easier to control the quality of planting material. 5. Easy quality control, Separate cultivation makes it easier to control the quality of planting material, since it is immediately visible whether the seedlings meet the specified parameters. 6. Possibility of specialization, nurseries can specialize in the cultivation of certain types of seedlings, which allows them to perfectly master the technologies and obtain high-quality planting material. 7. Preservation of varietal characteristics, cross-pollination can lead to changes in varietal characteristics. 8. Obtaining better planting material: Separate cultivation allows seedlings to become more resistant to adverse conditions, have a better developed root system and crown, which makes them more suitable for planting. 9. Expanding the range of planting material, separate cultivation allows for the cultivation of a wide range of species and varieties, which meets the diverse needs of gardeners.

The division of the nursery area into departments, sections, and nurseries with separate cultivation of planting material is an important condition for obtaining high-quality planting material.

The production part will consist of one sowing department, two nurseries - decorative and fruit (school department) and a mother plantation. The sowing department is planned to grow seedlings of large-leaved lime. The decorative nursery will grow seedlings of oriental thuja, and the fruit nursery will grow seedlings of common pear.

The sowing department is the foundation for growing high-quality planting material and goes through the first stages of its development, associated with the formation of the root system and the formation and development of the above-ground part of plants. The calculation of the sowing department area is shown in Table 1.

Table 1. Area of the Sowing Department.

№	Breed name	Seedling growth period, years	Annual planned seedling release, thousands of pieces	Number of fields in the crop rotation, pieces	Number of fields allocated annually for sowing of a given breed, pieces	Seed sowing pattern	Planned seedling yield per 1 running meter, piece	Area of the sowing department, hectares	
								Total	Size of one field
1	Large-leaved lime	2	990	3	1	30x30x30 x60	25	6,8	2,3

According to the planned task, seedlings of large-leaved linden are planned to be grown for two years. There will be three fields in the crop rotation. Each year, one field will be allocated for sowing of the tree species. The planned yield of seedlings from 1 running meter of the furrow is 25 pieces, taken from the methodological instructions (Surgan O.V., 2019, p. 24). The annual planned release of seedlings according to the planned task was 990 thousand pieces. The number of seedlings grown annually, taking into account the loss, is 1138.5 thousand pieces. According to our calculations, the total area of the sowing department was 6.8 hectares. Accordingly, the area of one field was 2.3 hectares.

One- or two-year-old plants (seedlings, rooted cuttings), less often three-year-old plants, are transplanted to nurseries for further cultivation. In this department, the planting material is grown to commercial condition. The seedlings reach the optimum size and age. The crown is formed with the help of special pruning. The calculations of the area of the school department are located in Table 2.

Table 2. Calculation of the area of the school department.

№	Breed name	Cultivation period, years	Annual seedling release, pieces	Growing period culling, pieces	Number of seedlings to plant, considering expected losses, pieces	Layout plan, m2	Feeding area per seedling, m2	Number of fields in the crop rotation, pieces	Area under the breed in the department, ha	Area of one crop rotation field, ha
Tree nursery (ornamental)										
1	Oriental Arborvitae	2	150 00	225 0	17250	1,0x 0,5	0,5	3	2,58	0,86
Fruit tree nursery										
2	Common Pear	2	170 00	340 0	20400	1,0x 0,5	0,5	3	3,06	1,02
Total			-	-	-	-	-	-	5,64	

To obtain an annual planned harvest of 15,000 Oriental Arborvitae seedlings with a feeding area of 0.5 m², it is necessary to plant 17,250 seedlings. Seedling cultivation is planned for two years. After the calculations, the total area under the breed in the department was obtained - 2.58 hectares. The area of one field will be 0.86 hectares.

According to the calculations, a total area of 3.06 hectares is required for growing Common Pear seedlings. There will be three fields in the crop rotation, so the area of one field will be 1.02 hectares. In total, the area of the nursery department will be 5.64 hectares.

The mother stock department serves for the propagation of woody plants. The quality and diversity of green spaces depend on the work of the mother stock department. The mother stock department has the following functions: 1. Collection of generative material (seeds), for this purpose, mother plants are grown to obtain high-quality seeds with the desired characteristics; 2.Collection of vegetative material (offsets, cuttings), vegetative propagation is used to create new plants that are genetically identical to the mother plant. The area of the mother stock plantation is determined according to calculation table 3.

Table 3. Calculation of the area of the mother stock plantation.

Breed name	Plant spacing, m		Feeding area of one plant, m2	Number of plants per 1 ha, pcs.	Planned cutting yield from		Planned target for cutting collection	Plantation area, ha
	In a row	Between the lines			Per plant, pieces	1 ha, pieces		
Weigela florida	0,5	1	0,5	20000	10	200000	35000	0,175
Total								X

The mother plant department will have one field. The feeding area for one plant is 0,5 m2. The planned yield of cuttings from one plant is 10 pieces, and from one hectare 200,000 pieces. The planned annual cutting production will be 35,000 pieces. According to our calculations, the area of the plantation will be 0,175 ha.

The auxiliary part includes: Roads, Forest strips, Farm yard, Outfield, Fence, Reservoir.

The calculations of the auxiliary area are shown in Table 4.

Roads in the nursery connect different parts: departments, nurseries, fields. They ensure smooth operation and create convenience for people. Three types of roads are planned in our nursery: circular, main and auxiliary.

Main and circular roads should provide the possibility of turning cars and aggregates, so their width within our calculations was 8 meters. For auxiliary roads, a width of 5 meters is taken, and they are cut along the long sides of the fields and are used for the passage of cars and aggregates in one direction. The total area under roads is 2,42 hectares.

Table 4. Calculation of the auxiliary area of the nursery.

№	Auxiliary section name	Size, m2		Area, ha
		Length	Width	
1.	Roads	-	-	2,42
	a) Ring road	1800	8	1,44
	b) Main road	690	8	0,552
	d) Service roads	860	5	0,43
2.	Forest strip	1800	5	0,9
3.	Household plot	-	-	0,5
4.	Field plot	-	-	0,74
5.	Fence:	1800	0,5	0,9
6.	Water body			0,74
Total		-	-	

Shelterbelts are created on the outside of the circular road, and sometimes within them on large nurseries, to protect fields from the harmful effects of winds, especially dry winds. The protective strip is created from fast-growing species of trees in a shade-tree type of mixing with 3-5 rows. The distance between the rows is 1,5-2 m, and the width of the edges is 1,0 m. Our organizational and economic plan also includes a shelterbelt, which will be 5 meters wide and have an area of 0,9 hectares.

A fence (hedge) is planted on the outside of the shelterbelt at a distance of 1,5 m from it with one or two rows of thorny shrubs or trees that tolerate pruning. It serves to protect the nursery from the entry of strangers, domestic and wild animals. The planned width of the fence is 0,5 m, and the area is 0,9 hectares.

An area of 0,5 hectares is allocated for the хозяйственная ділянка, which is divided into two sectors: production and residential. The following facilities are located on the: an office, a building for seed storage and stratification, a garage, a storage facility for inventory and equipment, warehouses and other production facilities. The diagram of the organizational and economic planning scheme is located in Figure 4.

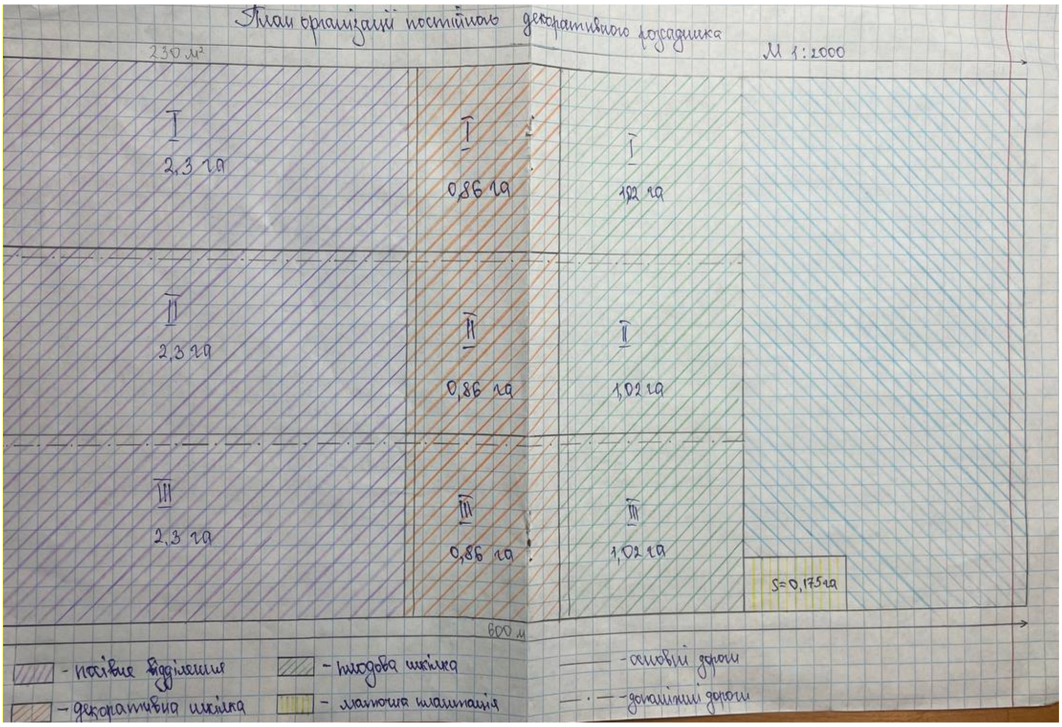

Figure 4. Organizational and Economic Plan of a Permanent Ornamental Nursery State Enterprise «Lebedynskyi Lishoz».

The auxiliary area will also include a 0,74-hectare experimental plot and a 0,74-hectare reservoir.

The land organization plan is drawn to a scale of 1:2000 and is accompanied by appropriate labels and an explication. The production and auxiliary parts of the nursery are first drawn on a sheet of graph paper. Then the dimensions of the auxiliary part are determined on the plan and its area is calculated.

The practice of rotating crops in a specific sequence on the same land over a period of time offers several benefits. Therefore, crop rotation is used to preserve and increase soil fertility, restore its structure, accumulate moisture, and clear fields of weeds, diseases, and pests.

After growing leguminous crops on the area, which enrich the soil with forms of nitrogen available to plants, it is advisable to plant (sow) plants that are demanding on the nitrogen content in the soil in their place. After crops that deplete the soil, it is necessary to place such crops (after fertilization) that contribute to the restoration of fertility.

Crop rotation involves dividing the area of production departments (seedling, school) of the nursery into a certain number of equal-sized fields. In our organizational and economic plan, both departments have a three-field crop rotation, which is presented in tables 5, 6, 7.

Table 5. Crop rotation plan for the seedling department of the Lebedinsky District State Enterprise permanent decorative nursery.

Years of use	**Field No**		
	I	**II**	**III**
2018	**Pair black + herbicides**		
2019	Al	A/C	Al
2020	A/C	Al	YP1
2021	O/f	YP1	YP1+ YP2
2022	YP1	YP2	O/f
2023	YP2	O/f	YP1

Notation: Al – Annual lupin**;** A/c – Agricultural crop; YP1 – young plants of the first year of cultivation; YP2 – young plants of the second year of cultivation; O/f **–** Occupied fallow; YP1+ YP2 – young plants of the second and first years of cultivation.

Table 6. Crop rotation of a permanent ornamental nursery for the ornamental department of the Lebedinsky District State Enterprise.

Years of use	**Field No**		
	I	**II**	**III**
2018	**Pair black + herbicides**		
2019	Al	A/c	Al
2020	A/c	Al	S1
2021	O/f	S1	S2+ S1
2022	S1	S2	Al
2023	S2	Al	A/c

Notation: Al – Annual lupin**;** A/c – Agricultural crop; S1 **–** Seedlings of the first year Seedlings of the first year; S2 – Seedlings of the second year of cultivation; O/f **–** Occupied fallow; S2+ S1– Seedlings of the second and first years of cultivation.

Table 7. Crop rotation of a permanent ornamental nursery for the fruit department of the Lebedinsky District State Enterprise.

Years of use	**Field No**		
	I	**II**	**III**
2018	**Pair black + herbicides**		
2019	Al	A/c	W
2020	A/c	W	B/P1
2021	W	B/P1	B/P2
2022	B/P1	B/P2	Al
2023	B/P2	Al	A/c

Notation: Al – Annual lupin**;** A/c – Agricultural crop; W- wildings; B/P1 – Budded plants of the first year of cultivation**;** B/P2 – Budded plants of the second year of cultivation.

High-quality soil is the foundation for successful cultivation. Favorable conditions for seed germination, loose soil with small lumps allows air and water to pass through well, which allows the roots of seedlings and cuttings to develop freely. Improvement of soil structure: cultivation helps to get rid of weeds, pests and pathogens, and also improves the water permeability and water retention capacity of the soil. Fertilization during cultivation provides seedlings with the essential elements they need for growth and development. Soil cultivation can be divided into two types: primary land development and cultivation measures in fields of accepted crop rotations. Primary land development includes: land preparation for cultivation. Soil cultivation in fields of accepted crop rotations includes primary and pre-sowing (pre-planting) cultivation. Primary soil cultivation includes the following operations: In autumn - stubble disking with simultaneous harrowing, plowing after weeds emerge; In spring - early spring harrowing.

Pre-sowing soil cultivation may include the following techniques: spring plowing, cultivation, harrowing, dragging, rolling, tilling, making ridges.

Conclusions. The city of Lebedin has a significant natural resource potential, which has a positive impact on the development of the national economy, industrial enterprises and agriculture.

A favorable climate, fertile soils and the presence of minerals give this region a significant potential for economic growth. Local residents have the opportunity to use the gifts of nature to improve their well-being and create new jobs.

The large area of forests has made forestry a key sector of the community's economy. Foresters do a variety of work to preserve and increase the community's forest resources.

Their activities include the following main areas: forest restoration – foresters annually plant new forests in the places of clearings, fires and other damaged areas;

increasing forest productivity – Foresters use special measures to improve the growth and quality of trees.

They improve the growth and quality of trees; organization of forest seed production, foresters collect seeds of forest trees, grow seedlings and carry out reforestation work; improving the condition and increasing the productivity of forests.

The activities of the enterprise are not limited to the restoration and care of forests. Foresters also carry out cuttings of different intensity, which contributes to the thinning of the forest stand and the improvement of its sanitary condition. It is important to note that all logging is carried out in accordance with strict environmental standards and regulations. The company also works continuously to protect forests from fires, pests, and diseases.

In view of the above, it is safe to say that the company has all the prerequisites for creating a successful decorative nursery. The successful geographical location and favorable climatic conditions make this place ideal for growing ornamental plants. The company has access to the necessary resources, such as water, land and labor resources. Experience in forestry and knowledge of forestry are a significant advantage. The creation of a decorative nursery can become a new direction of development for the enterprise, which will bring additional profit. A decorative nursery can be a real gem for a community and can attract tourists. The creation of new jobs is also an important factor. Taking into account all these factors, it can be concluded that the creation of a decorative nursery on the basis of the enterprise is advisable and promising. To implement this project, it is necessary to attract the necessary investments, and provided the right approach and competent management, this project will be successful.

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CURRENT TRENDS IN COMPUTER DESIGN OF GARDEN AND PARK FACILITIES

Viunenko Alexsander
PhD in Economic Sciences, Associate Professor
Sumy National Agricultural University, Ukraine
ORCID ID: 0000-0002-8835-0704

Introduction.

The field of landscape architecture is undergoing a significant shift towards the integration of modern computer technology. Computer-aided design, which was once limited to architectural drawings and interior planning, has now expanded to the design of garden and park facilities. The art of landscape design has come a long way. Historically, it was a manual process that relied on the experience and artistic vision of landscape architects. Today, computer-aided design tools have revolutionised the industry, allowing designers to create complex and accurate plans. The evolution of computer-aided design (CAD) systems in the design of gardens and parks is testament to the growing importance of this technology. The use of computer tools for designing open spaces has a rich history dating back to the late 20th century. Initially, CAD systems mainly served as drawing tools, allowing designers to create two-dimensional plans more efficiently. However, over time, CAD software has evolved into sophisticated platforms that are capable of performing 3D modelling and data-driven analysis. Computer-aided design offers numerous benefits to professionals, including increased accuracy, speed and cost-effectiveness. It allows designers to experiment with different concepts, improve their designs, and visualise the end result more effectively.

Modern CAD systems have shifted the focus from 2D drawings to 3D modelling, allowing designers to create more realistic representations of gardens and parks. These models not only improve visualisation, but also aid decision-making and communication with stakeholders. CAD software now also allows for effective analysis of environmental impact, water management and plant selection to create more environmentally friendly and sustainable outdoor spaces. At the same time, augmented reality (AR) has become a valuable tool for designers, giving them the ability to quickly overlay digital models on the physical world. This technology provides real-time visualisation and interaction with proposed projects in their real environment, facilitating better decision-making and public engagement. Modern CAD tools have greatly facilitated public participation in the design process. Virtual tours, online platforms and interactive models allow communities to participate in decision-making and provide valuable feedback.

As urbanisation and environmental concerns continue to grow, the integration of artificial intelligence (AI) into landscape design is becoming increasingly important. In recent years, the use of artificial intelligence in CAD has revolutionised the way we design and create garden and park facilities. Therefore, AI-based generative design has become a powerful tool for landscape architects. It involves the use of algorithms and machine learning to create many design options based on specific input parameters. This method allows designers to explore a wider range of design possibilities and choose the most suitable one. An example of generative design in landscape architecture is the creation of customised urban green spaces that optimise shade, airflow and vegetation placement based on local climate data.

Predictive modelling is another key aspect of integrating artificial intelligence into garden and park design. Machine learning models can predict how different design elements and materials will interact with the environment over time. This helps to select the most durable and sustainable components for garden and park facilities. For example, artificial intelligence can predict the growth patterns of certain plant species over the years, allowing designers to create low-maintenance and self-sustaining gardens.

One of the most prominent current trends in garden design is the emphasis on increasing biodiversity. AI-driven analysis tools can assess the potential impact of design choices on local ecosystems and recommend changes that will promote biodiversity. These recommendations can include the selection of native plant species, water management strategies, and the creation of habitat for local wildlife. AI also plays a crucial role in sustainability assessment. By modelling different environmental scenarios, designers can quickly assess the environmental sustainability of their projects. This can include assessing the energy efficiency of lighting systems, water consumption, and the carbon footprint of materials used in gardening and park facilities.

While there are numerous benefits to integrating AI into garden and park design, there are challenges to overcome, such as data privacy concerns, the need for large data sets, and the potential for over-automation. The integration of artificial intelligence into the design of garden and park facilities is a significant development in the field of landscape architecture. By harnessing the power of artificial intelligence, designers are better able to create aesthetically pleasing, environmentally friendly and sustainable outdoor spaces, which ultimately contributes to a better urban living environment. The future of the field is likely to include continued advances in AI technology and a growing emphasis on interdisciplinary collaboration between landscape architects, data scientists and ecologists.

Computer-aided design has revolutionised the process of creating park facilities, offering designers a range of tools and opportunities to turn their vision into reality. Parks are the main green spaces in urban environments, providing communities with places to relax, unwind and connect with nature. The use of computer-aided design in the creation of park facilities has had a significant impact on the field of landscape architecture, resulting in more efficient, sustainable and visually appealing projects. This essay will examine the multifaceted role of computer-aided design in the creation of park facilities, highlighting its impact on visualisation, accuracy, innovation, collaboration and sustainability.

The role of computer-aided design in the creation of park facilities.

Computer-aided design software has simplified the way designers visualise and conceptualise park facilities. Through three-dimensional modelling and visualisation, designers can create virtual representations that accurately reflect their proposed designs. This virtual visualisation process allows designers and stakeholders to have a clear understanding of the final product, enabling effective decision-making. By translating their ideas into virtual formats, designers can identify shortcomings, iterate on their designs and make necessary adjustments early in the process, minimising costly changes during construction. The ability to visualise park facilities through computer-aided design has changed the way designers communicate their concepts and bring them to life.

Computer-aided design tools provide precise measurements and calculations, ensuring the accuracy and efficiency of park facilities. Designers can enter specific dimensions, functionalities and materials, resulting in objects that fit perfectly into the overall park design. With the help of computer-aided design (CAD) software, designers can manipulate and refine every detail of an object, ensuring the design is accurate and precise. Computer-aided design reduces the likelihood of human error and allows for a simplified process from design to production. In addition, advanced computer algorithms can automate tasks such as creating manufacturing drawings, optimising time and resources while achieving higher levels of accuracy. The use of computer-aided design in the creation of a park facility contributes to more efficient project execution and improves the quality of the final result.

Computer-aided design promotes flexibility and innovation in the creation of park facilities. Designers can experiment with different shapes, colours, materials and textures, allowing them to push the boundaries of traditional design concepts. With the help of computer-aided design software, designers have access to a vast library of design elements and can explore different combinations to create unique and visually exciting park facilities. The flexibility offered by computer-aided design tools encourages designers to think outside the box and apply innovation to their creations. In addition, computer-aided design facilitates the integration of environmental practices, allowing designers to explore environmentally friendly materials, use energy-efficient features, and optimise resource use. The freedom of experimentation and innovation that computer-aided design provides greatly enhances the artistic and functional value of park facilities.

Computer-aided design facilitates effective collaboration between designers, architects, engineers and stakeholders involved in the creation of park facilities. Digital designs can be easily shared, enabling seamless communication and exchange of ideas. Designers can collaborate in real time, making adjustments and taking into account feedback from different stakeholders. Computer-aided design software allows multiple designers to work on the same project at the same time, promoting collaboration and coordination. This collaborative approach ensures that park facilities not only meet visual and functional expectations, but also meet the needs and desires of the community. Through the use of computer-aided design, the creation of park facilities becomes a participatory process that reflects the requirements of all stakeholders.

Implementing sustainable practices in park design is becoming increasingly vital. Computer-aided design tools make a significant contribution to the creation of sustainable park facilities by offering designers the means to assess and optimise environmental impact. Software applications help to model and analyse different design options, providing insight into factors such as material efficiency, energy consumption and carbon footprint. Using these tools, designers can make informed decisions and select materials and elements that improve the overall sustainability of park facilities. Computer-aided design can also facilitate the integration of renewable energy generation systems, such as solar panels, into park facilities. With sustainable design methods implemented through computer-aided design, the creation of park facilities becomes part of a larger commitment to care for the environment.

Computer-aided design is playing a key role in the creation of park facilities, transforming the field of landscape architecture. Thanks to advanced visualisation, accuracy, flexibility, collaboration and sustainability, computer-aided design tools enable designers to bring their creative visions to life. The ability to accurately visualise park facilities, optimise accuracy and efficiency, foster innovation, promote collaboration and embrace sustainability principles ensures the creation of aesthetically pleasing, functional and environmentally friendly park facilities that enhance the overall park experience. As computer-aided design technologies continue to evolve, the possibilities for creating exciting and sustainable park facilities are only expanding, opening up exciting prospects for future generations.

History of industrial garden design in Ukraine.

Garden design in Ukraine has a rich and varied history dating back centuries. From majestic palaces and mansions to small private gardens, the country's landscape is dotted with stunning examples of garden design that demonstrate both artistry and functionality.

One of the oldest influences on garden design in Ukraine can be traced back to the time of the ancient Scythians and their burial mounds. These mounds were often surrounded by elaborate gardens with carefully planned layouts and decorative elements. Archaeological excavations have revealed traces of terraced gardens, water features and ornamental trees and shrubs.

In the medieval period, landscape gardening in Ukraine was heavily influenced by Byzantine and Western European styles. Monastery gardens played a significant role in this period, serving as places for meditation, reflection and the cultivation of medicinal herbs. The Kyiv Pechersk Monastery is an outstanding example of a medieval garden in Ukraine, with its well-preserved layout of terraces, fountains and flower beds.

In the 18th and 19th centuries, landscape art in Ukraine experienced a period of prosperity under the influence of Romanticism. Noblemen commissioned landscape architects to create large park areas around their estates with elements such as artificial lakes, grottoes, pavilions and sculptures. Sofiyivka Park in Uman is a great example of this era, combining natural beauty with architectural grandeur.

At the beginning of the 20th century, modernist influences on garden design appeared in Ukraine. Artists and architects sought to integrate gardens into the urban environment, creating public spaces that combined functionality with aesthetics. The National Botanical Garden in Kyiv is an example of this approach with its collection of rare plants in a carefully designed landscape.

However, during the Soviet era, many traditional Ukrainian gardens were abandoned as industrialisation took over. It was not until the late 20th century that a new interest in garden design emerged, driven by a growing appreciation of Ukrainian cultural heritage. The revival of traditional Ukrainian gardens, such as the Pirogovo Museum of Folk Architecture and Life in Kyiv, has helped to preserve and honour the country's rich history of horticulture.

Today, industrial garden design in Ukraine continues to evolve under the influence of global trends and a growing focus on sustainable practices. Urban gardens are becoming more common, and rooftop gardens and vertical farming are gaining popularity in cities such as Kyiv and Lviv. In addition, garden design is increasingly focusing on the use of local plants and natural materials, reflecting a desire to reconnect with the country's unique natural landscape.

The history of industrial garden design in Ukraine thus reveals a fascinating journey of influence and innovation. From ancient burial mounds to modern urban green spaces, Ukrainian gardens have evolved over time to reflect changing aesthetic preferences and societal values. As the country continues to embrace sustainable practices and honour its cultural heritage, the future of garden design in Ukraine promises to be exciting and environmentally conscious.

The combination of tradition and modernity, manifested in the use of local plants and sustainable practices, will shape the future of industrial garden design in Ukraine.

This not only contributes to the beauty and functionality of these spaces, but also serves as a reminder of the importance of preserving our natural environment.

As Ukraine's gardens continue to flourish, they will undoubtedly inspire and enchant visitors with their unique blend of history, innovation and sustainability. With ongoing efforts to promote sustainable practices and preserve cultural heritage, the Ukrainian garden design industry is poised for an exciting and environmentally conscious future. By seamlessly blending tradition and modern technology, these gardens are not only visually stunning, but also serve as a testament to the urgent need to preserve the environment. Through the use of elements such as rainwater harvesting, native plant species and organic fertilisers, they can serve as educational platforms, raising awareness of the importance of environmental conservation. In addition, these gardens can contribute to the local economy by attracting tourists and providing opportunities for ecotourism initiatives. With their commitment to preserving the past while caring for the future, Ukrainian garden designers are not only creating beautiful spaces, but also laying the foundation for a greener future. By using eco-friendly materials such as recycled wood and environmentally friendly paints in their projects, modern garden designers are setting an example for the entire industry. They are showing that it is possible to create stunning landscapes while minimising the negative impact on the environment.

Garden and park landscape design of residential areas ecological cities based on digital technologies.

In the context of urbanisation and the growing challenges posed by climate change, cities are looking for innovative solutions to effectively manage stormwater. One of these concepts is the development of green cities, which use green infrastructure to absorb and retain rainwater. In these cities, landscape design plays a crucial role in creating sustainable and resilient residential areas. With the advent of digital technology, landscape architects can now harness the power of digital tools to design and optimise garden landscapes in residential areas of such cities.

Modern digital technologies allow for the collection and analysis of data on weather conditions, rainfall and soil moisture in real time. By integrating sensors and data collection systems into the garden landscape, landscape architects can monitor and analyse these parameters. This data-driven approach provides valuable insights into the effectiveness of stormwater management systems, the strengths and weaknesses of the garden landscape design, and helps to make informed decisions for optimisation.

Digital tools allow landscape architects to create accurate modelling and visualisation of water in residential areas of sustainable cities. By modelling the behaviour of rainwater in a garden landscape, designers can identify areas prone to flooding and determine the ideal location for rain gardens, biological ponds and other green infrastructure elements. Visualisation tools help stakeholders to understand the patterns of water flow, the effectiveness of various design measures and contribute to more informed decision-making.

Digital technology also offers huge databases of plant species with information on their adaptability, water requirements and environmental preferences. Landscape architects can use these databases to select suitable plant species for the garden landscape in residential areas of sustainable cities. In addition, digital tools can integrate weather data and soil moisture sensors to optimise irrigation systems. This ensures efficient use of water resources, reduces water loss and contributes to the health and sustainability of green spaces.

Digital technologies can increase citizen engagement by incorporating gamification elements into garden landscape design. By developing interactive apps or platforms, residents can actively participate in monitoring the condition of the garden landscape and contribute to its maintenance. This gamified approach fosters a sense of ownership and encourages greater community involvement, creating a more vibrant and sustainable residential area in ecologically balanced zones.

Digital tools provide landscape architects with the ability to create realistic and immersive visualisations of garden landscapes. Virtual reality (VR) and augmented reality (AR) technologies allow stakeholders to experience and explore future garden landscapes before they are realised. This aspect of visualisation helps residents, local authorities and decision-makers to better understand the design intent, provide feedback and make joint design decisions. It also helps to identify potential design flaws or adjustments before construction begins, saving time and resources.

Digital technologies offer enormous potential for improving the garden landscape design of residential areas in sustainable cities. By using real-time data collection and analysis, water resource modelling, optimised plant selection and irrigation strategies, gamification elements and visualisation tools, landscape architects can create sustainable, resilient and attractive garden landscapes. These digital tools allow landscape architects to make informed decisions, collaborate with stakeholders, and design garden landscapes that manage water resources efficiently. As digital technologies advance, they will play an increasingly important role in creating green, sustainable and livable urban environments.

Using artificial intelligence to optimise park areas.

Artificial intelligence (AI) has proven to be a game-changer in a variety of industries, offering unprecedented opportunities to increase efficiency, improve decision-making and streamline processes. With its potential for data analytics and pattern recognition, AI can play a transformative role in optimising parklands. Parks are not just places for recreation, they are important components of urban infrastructure that contribute to the overall well-being and quality of life of a community.

Artificial intelligence algorithms are excellent at processing large amounts of data and extracting valuable information. This ability can be of significant benefit to park authorities by optimising the allocation of resources within the park. By analysing data on pedestrian flows, visitor behaviour patterns, artificial intelligence can help determine the most appropriate placement of seating, food stalls, and other amenities. This ensures visitor comfort, improves accessibility, and optimises the use of available space in the park.

Parks consume a significant amount of energy for lighting, irrigation, and other utilities. AI can play a crucial role in optimising energy consumption in parks. For example, AI-powered lighting systems can adjust the brightness level depending on the presence of visitors, resulting in significant energy savings. Similarly, intelligent irrigation systems can analyse weather forecasts and soil moisture to optimise water use, reducing waste and contributing to sustainable development.

Traditional waste management systems in parks often suffer from inefficiencies, such as overflowing bins and delays in waste collection. Artificial intelligence can revolutionise this aspect by implementing smart waste management systems. Using sensors, AI can track the level of garbage cans and send alerts to waste management teams when the bins reach their capacity. In addition, AI algorithms can optimise waste collection routes to ensure timely and efficient disposal. With effective waste management, parks can keep their grounds clean, minimise their environmental impact, and improve their aesthetic appearance.

Ensuring the safety of park visitors is also of paramount importance. Video analytics and AI-powered surveillance systems can significantly improve security in park areas. These systems can detect and analyse potentially dangerous situations, such as unauthorised access or suspicious behaviour. By proactively detecting and responding to such incidents, park authorities can reduce risks and create a safe environment for visitors. Facial recognition technology can also be used to detect missing people or potential threats, further enhancing security measures.

Artificial intelligence can improve the level of service in park areas. Virtual assistants or chatbots based on artificial intelligence can provide visitors with real-time information and recommendations about activities, facilities and events in the park. These intelligent systems can answer queries, offer personalised recommendations based on user preferences, and provide updates on weather conditions or park opening hours. By using artificial intelligence to deliver park services, park authorities can improve the visitor experience, engage with visitors, and foster a sense of community.

The use of artificial intelligence to optimise parklands can fundamentally change the way we plan, manage and use public spaces. By leveraging the power of AI to allocate resources, optimise energy consumption, waste management, security and intelligent services, parks can become more efficient, sustainable and visitor-friendly. However, it is very important to strike a balance between technological progress and preserving the natural nature of parks. With the development of artificial intelligence, its use in optimising park areas is expected to grow, offering endless possibilities for creating a greener and more attractive urban environment.

Trends in computer-aided design of garden and park facilities.

Computer-aided design in the context of landscape architecture encompasses a wide range of digital tools and technologies that are revolutionising the way we plan, design and maintain hardscapes. It is crucial for professionals in this field to keep abreast of technological advances, as these innovations play a key role in improving the functionality, aesthetics and sustainability of hardscapes. Digital technologies have had a profound impact on the field of landscape architecture, especially in the field of urban landscape planning and design. These advances have revolutionised the way architects approach the creation of gardens and parks, allowing for more precise and sustainable designs.

One of the most significant advances in digital technology for urban landscape planning and design is the use of 3D modelling. This technology allows architects to create realistic simulations of environmental landscapes, giving them a better understanding of how different elements will interact within a given space.

Using 3D modelling, specialists can:

- create realistic simulations of ecological landscapes;
- visualise the end result of their developments;
- make informed decisions about design components.

This level of precision helps create more sustainable landscapes, optimising resource use and minimising environmental impact. For example, when designing a park, architects can use 3D modelling to simulate how sunlight will interact with trees at different times of the day or year. By analysing this data, they can strategically place trees to provide shade in certain areas or maximise natural light in others. This level of detail ensures that the design of the park is fit for purpose and also takes into account environmental factors.

Practical examples demonstrate the successful application of 3D modelling technology in park design projects. For example, in New York's High Line Park, 3D modelling was used to simulate various planting schemes and determine the optimal plant selection for its elevated park. The result was a vibrant green space that thrives in a complex urban environment.

Virtual reality (VR) and augmented reality (AR) technologies have also become valuable tools in urban landscape planning and design. These immersive technologies enhance the user experience in public spaces by bridging the gap between virtual design concepts and the physical environment.

Putting on a VR headset, users can:

- to be transported into a digital representation of a park or garden;
- explore space and interaction with virtual elements;
- Gain a better understanding of how the final design will look and feel.

This allows architects to gather valuable feedback from stakeholders and make the necessary adjustments before construction begins.

AR takes this immersion one step further:

- allows you to overlay virtual elements on the real world;
- allows users to view the park through their device's camera;
- see virtual objects seamlessly integrated into the physical environment.

This technology allows architects to showcase their projects to clients and the public in an engaging and interactive way. For example, Central Park in New York City has used augmented reality to create an interactive map that provides visitors with real-time information about attractions, upcoming events, and even historical facts.

This enhances the overall user experience by providing valuable information in an accessible and engaging format.

In addition, VR and augmented reality can be used for multisensory interaction in public spaces. For example, virtual reality technology can be used to create soundscapes that mimic different auditory experiences in a park. This allows designers to carefully craft the soundscape to enhance relaxation or create a special atmosphere that matches the theme of the park.

Finally, the development of digital technologies, such as 3D modelling, virtual and augmented reality, has had a significant impact on urban landscape planning and design. These tools provide architects with new ways to visualise and communicate their ideas, resulting in more accurate designs that improve the user experience in public spaces.

The impact of the "digital landscape" on urban construction.

The idea of the 'digital landscape' has transformed the way cities are built, leading to new approaches to design and construction. Here are some important points to understand this concept and its impact on urbanisation:

1. Use of big data analytics. In urban construction, the use of big data analytics has completely changed the way decisions are made and resources are used. By analysing vast amounts of information about urban spaces, designers and architects can gain valuable insights that shape their creative processes. This data-driven method allows for smarter, more efficient and environmentally friendly urban construction projects.

2. The growth of smart parks. Within the concept of the digital landscape, the emergence of "smart parks" has attracted considerable attention. These parks are designed with connectivity, sustainability and adaptability in mind. By combining these key elements, urban green spaces not only look beautiful, but also function as integrated ecosystems that meet the needs of different user groups.

The impact of digital technologies on shaping urban development goes beyond innovation; they are laying the foundation for a more connected, sustainable and flexible urban environment.

In the rapidly evolving field of landscape architecture, interdisciplinary collaboration plays a crucial role in driving innovation and pushing the boundaries of digital landscape research. By bringing together experts from different fields such as ecology, urban planning and computer science, new perspectives and approaches can be explored, leading to revolutionary progress in the integration of technology and landscape design.

One of the most prominent examples of interdisciplinary collaboration in digital landscape research is the emergence of geodesy, which integrates geographic information systems (GIS) with landscape design practice. GIS technologies allow designers to analyse and visualise spatial data, providing valuable insights into land use patterns, environmental factors and community dynamics. By combining these tools with design principles, geodesy allows landscape architects to make informed decisions that optimise both functionality and aesthetics.

Through geodesic design, designers can create more sustainable and resilient landscapes by taking into account factors such as water management, energy efficiency and biodiversity conservation. For example, by using GIS data on hydrology and topography, designers can identify optimal locations for stormwater management systems or green infrastructure elements such as rain gardens. This integration of technology and design expertise can improve the efficiency of decision-making processes that take into account both human needs and environmental considerations.

Collaboration with experts from different disciplines is essential to foster innovation in digital landscape research. By working with ecologists, landscape architects can gain a deeper understanding of ecological processes and incorporate ecological principles into their designs. For example, collaboration with ecologists can help identify native plant species that support local biodiversity or address issues related to the management of invasive species.

Urban planners provide valuable insights into the social and urban context of a project. Their knowledge of zoning regulations, transport networks, and public engagement strategies can be the basis for designing digital landscapes that meet the needs and aspirations of the surrounding community.

Computer scientists and data analysts are important partners in digital landscape research. Their expertise in data processing, algorithm development, and artificial intelligence can extend the capabilities of software tools for landscape architecture. For example, machine learning algorithms can analyse large amounts of data to identify patterns and trends, helping designers make data-driven decisions about land use, vegetation placement, and spatial organisation.

A prominent collaboration between landscape architects, ecologists and computer scientists is the restoration of wetlands using digital tools. Wetlands are complex ecosystems that perform important ecological functions, such as water filtration and habitat for a variety of plant and animal species. However, these habitats are often degraded or lost due to human activities.

Through interdisciplinary collaboration, landscape architects can use digital technologies to assess the ecological condition of wetlands, develop restoration strategies, and monitor the success of restoration efforts over time. For example, remote sensing techniques combined with GIS can be used to map the extent of wetlands and identify areas in need of restoration. By integrating ecological modelling software with landscape design tools, designers can simulate different restoration scenarios and evaluate their potential environmental outcomes.

This collaborative approach ensures that wetland restoration projects are not only visually appealing but also ecologically functional. It provides a holistic understanding of wetland ecosystems and promotes sustainable design that takes into account the long-term health and viability of these valuable habitats.

Finally, interdisciplinary collaboration is key to innovation in digital landscape research. By bringing together experts from fields such as ecology, urban planning, and computer science, landscape architects can leverage diverse perspectives and expertise to create more sustainable, resilient, and aesthetically pleasing landscapes. Collaborative approaches, such as geodesy, allow designers to seamlessly integrate technology into the design process, taking into account environmental principles and social context. Thanks to such collaborations, the field of digital landscape research continues to evolve, pushing the boundaries of what is possible in garden and park design.

Explore the use of key digital tools and techniques in garden and park design.

One of the most prominent examples of the use of digital tools in landscape design is the use of GIS (geographic information systems) software to revitalise abandoned city parks. GIS technology allows landscape architects to analyse and visualise spatial data, enabling them to make informed design decisions based on accurate information. For example, consider an example where an abandoned city park was redeveloped using GIS. The landscape architects used GIS to collect data on the existing features of the park, such as topography, vegetation and infrastructure. By overlaying this data with information about the surrounding area, they were able to identify opportunities for improvement and develop a comprehensive redevelopment plan. In other words, GIS software allows landscape architects to analyse spatial data and make informed design decisions for neglected urban parks.

GIS software also played a crucial role in involving the public in the reconstruction process. Thanks to the interactive maps and visualisations created using GIS, the landscape architects were able to effectively communicate their design proposals to stakeholders and receive feedback. This collaborative approach ensured that the needs and preferences of the community were taken into account in the final design. Digital tools can help transform neglected urban spaces into vibrant, inclusive parks that meet the needs of the community.

Another interesting application of digital tools in landscape design is the integration of classical garden principles with spatial syntax analysis. This approach combines traditional design principles with advanced computational methods to create culturally significant and visually stunning landscapes. For example, Ukrainian classical gardens are known for their harmonious blend of architecture, nature, and symbolism. To preserve and adapt these principles in modern garden design, landscape architects are turning to digital technologies such as spatial syntax analysis.

Spatial syntax analysis is a method that uses computational algorithms to analyse the spatial relationships between different elements of a landscape. By applying this analysis to our classical gardens, landscape architects can gain insight into the underlying design principles and use them as a basis for creating new spaces that honour cultural heritage. For example, by analysing the spatial syntax of a traditional garden, designers can identify key design elements such as axial symmetry, hidden views and water features. They can then incorporate these principles into their digital renderings and physical installations, ensuring that the new design stays true to the essence of classic gardens. By integrating traditional design principles with spatial analysis, landscape architects can create spaces that resonate with both historical significance and contemporary aesthetics.

Finally, these case studies demonstrate the enormous potential of computer-aided design and digital tools in transforming urban spaces and preserving cultural heritage. By applying GIS software, spatial parsing, and other advanced technologies, landscape architects can revitalise neglected parks and create landscapes that reflect a deep understanding of cultural traditions. Using these digital tools and techniques, designers can open up new possibilities in the design of gardens and parks, shaping the future of these public spaces for generations to come.

Exploring new frontiers in computer-aided design for the green environment.

The future of computer-aided design of garden and park facilities is being shaped by new trends that have great potential. With the development of technology, new horizons are opening up, opening up exciting opportunities for landscape architecture. Two key areas that are set to revolutionise the way we design and create green environments are virtual reality (VR) technology and 3D plant modelling.

Virtual reality technology has already made significant strides in improving user experience in various fields, and its application in landscape architecture holds great promise. Using VR, designers can create immersive experiences that allow stakeholders to virtually explore and interact with proposed garden and park designs. Not only does this facilitate better communication and understanding, but it also allows for real-time feedback and adjustments, resulting in more refined and impressive final designs.

Beyond virtual reality, the promising field of 3D plant modelling is poised to revolutionise landscape architecture. The ability to create detailed digital images of plants and vegetation opens up new possibilities for design research and analysis. With 3D plant modelling, designers can simulate how different species will grow and interact in a given space, making more informed decisions about layout, biodiversity and maintenance requirements.

With the advent of 3D printing technology, the lines between digital design concepts and physical green spaces continue to blur. The ability to materialise complex designs with precision and efficiency opens up a world of possibilities for creating unique elements in hardscapes. From bespoke planters to sculptural landscape elements, 3D printing offers a new way to bring digital designs to physical reality, blurring the lines between virtual visualisation and material realisation.

These advances signal an exciting future in which the lines between digital design concepts and physical green spaces continue to blur. As we explore these new frontiers, the potential for innovation in computer-aided green space design is becoming increasingly limitless.

Balancing technology and environmental sensitivity.

In landscape architecture, it is important to find a balance between the use of technology and care for the environment. In this way, we can create sustainable projects that are both innovative and environmentally friendly. Adopting a hybrid approach means finding a delicate balance between using cutting-edge technology and preserving ecological integrity. Sustainable design is at the heart of this approach, which aims to harmonise human-made structures with the natural environment.

One way to achieve this balance is to design with biodiversity in mind. This means using native plants in both digital renderings and on-site installations. By incorporating native flora into our projects, we can support local ecosystems, promote biodiversity and reduce the need for intensive maintenance.

This is how we achieve balance in our landscape architecture practice:

1. Holistic sustainability: We prioritise environmental conservation and efficient use of resources in our projects. This means integrating smart technology with ecological principles to create spaces that are not only visually appealing but also environmentally responsible.
2. Integration of local plants: We aim to use native plants whenever possible. They not only contribute to the overall design aesthetic, but also provide habitat and food for local wildlife.
3. Eco-friendly materials: We carefully select materials that have a minimal impact on the environment. This may include using recycled items or local resources to reduce our carbon footprint.
4. Regenerative design: Our goal is not only to minimise negative impacts, but also to actively restore and improve ecosystems through our projects. We want to create landscapes that return to nature.

By striking a balance between technological innovation and environmental sensitivity, we can create spaces that meet the needs of communities while respecting and enriching the natural world around us.

Through sustainable design and a focus on biodiversity, the hybrid approach ensures that modern advances in computer-aided design are used responsibly in the context of landscape architecture.

The future of hardscapes is closely tied to the development of computer-aided design in landscape architecture. As technology continues to evolve, designers must welcome and adapt to these new tools and techniques to stay ahead. It is important to understand the important role that computer-aided design plays in shaping the landscapes of the future. By harnessing the power of cutting-edge technology, we can effectively shape a future in which garden and park facilities not only reflect environmental sensitivity, but also make full use of computer-aided design to create sustainable, exciting and engaging outdoor spaces.

Improving urban landscape design through information fusion.

Urban landscape design plays a crucial role in creating functional and aesthetically pleasing outdoor spaces. Traditional approaches to urban landscape design often rely on manual data integration, which can be time-consuming and inefficient. However, with the development of computer-aided design and information fusion methods, there is a growing trend towards improving urban landscape design by integrating different data sources.

Limitations of traditional approaches. The traditional model of information fusion commonly used in urban landscape design practice involves manually combining data from various sources, such as topographic surveys, environmental assessments, and user preferences. While this approach is widely used, it has a number of limitations:

1. Low efficiency: Manual data integration can be a time-consuming process involving multiple iterations of data collection and analysis. This can lead to delays in the design process and sub-optimal results.
2. Limited data integration: Traditional approaches often struggle to effectively integrate diverse data sets such as spatial, environmental and social data. Lack of effective integration limits the ability to analyse complex relationships and make informed design decisions.
3. Subjectivity: Manual data integration is subject to human bias and subjectivity. Designers may prioritise certain factors over others based on their personal preferences or experience. This can lead to a lack of objectivity in the design process.
4. Inflexibility: Traditional approaches often lack the flexibility to adapt to changing project requirements or incorporate new data sources. This can hinder the adoption of new technologies or the ability to respond to changing design needs.

To overcome the limitations of traditional approaches, a new modular framework is needed that uses computer-aided design techniques and a genetic backpropagation perspective to improve the accuracy and efficiency of data fusion in urban landscape projects.

This new approach involves breaking down the information fusion process into modular components that can be independently analysed and synthesised. Each module focuses on specific data sources and uses computational methods to integrate and analyse the data. The use of a genetic back-propagation perspective allows for iterative optimisation, increasing the accuracy and efficiency of the fusion process.

By adopting a modular framework for information fusion, urban landscape designers can reap significant benefits:

- Increased efficiency. The modular approach allows for parallel data processing, reducing the time required for data integration and analysis. This increases the overall efficiency of the design process.
- Improved data integration. The modular structure facilitates the integration of diverse data sets, allowing designers to analyse complex relationships and make data-driven design decisions. This leads to more comprehensive and holistic design solutions.
- Objective decision-making. Through the use of computational methods, new frameworks reduce subjectivity in the design process. Designers can rely on objective data analysis to make decisions, leading to more objective and scientifically sound design results.
- Flexibility and adaptability: The modular nature of the frameworks allows the flexibility to incorporate new data sources or modify existing modules to adapt to changing project requirements. This ensures that the design process remains flexible and adaptive.

Thus, improving urban landscape design through information fusion is a promising trend that offers significant advantages over traditional approaches. By adopting a new modular framework that uses computer-aided design methods and the perspective of genetic back propagation, designers can overcome the limitations of manual data integration and create more efficient, integrated and objective urban landscape designs.

In the field of urban landscape design, information fusion plays a crucial role in integrating diverse data sources to inform decision-making. It involves the synthesis and analysis of data from various sensors, databases and expert knowledge to provide actionable insights for designing functional and aesthetically pleasing outdoor spaces. However, traditional approaches to information fusion in landscape design have limitations that hinder their effectiveness and efficiency.

The traditional model of information fusion commonly used in urban landscape design practice often suffers from low efficiency due to its rigid and linear structure. This model usually involves sequential data processing, which can be time-consuming and does not reflect the complexity and interdependencies present in real-world design projects. Furthermore, the traditional model struggles to effectively integrate heterogeneous data types such as images, sensor readings and topographic data, leading to fragmented views and sub-optimal design decisions.

To overcome these limitations, a new modular data fusion model has emerged that uses a genetic backpropagation perspective. This new approach aims to improve the accuracy and efficiency of data fusion in urban landscape projects by introducing principles inspired by genetic algorithms and neural networks.

Key features of the new modular system:

1. Flexible structure. The modular structure moves away from the linear nature of traditional models, adopting a more flexible and adaptive structure.
2. Parallel processing. Allows parallel processing of data streams, enabling simultaneous analysis of several types of data and facilitating the integration of information in real time.
3. Improved speed. The modular approach not only improves the speed of information merging, but also increases the overall consistency and quality of design solutions.

Advantages of the modular system:

- Increased efficiency: by incorporating the principles of genetic backpropagation into the information fusion process, this structure enables iterative learning and optimisation.
- Precision design solutions: uses genetic algorithms to explore a wide range of design possibilities and identify optimal solutions based on predefined goals and constraints.
- Deeper insights: Integrating neural networks enhances pattern recognition capabilities, allowing designers to gain a deeper understanding of complex data sets and make more informed decisions.
- Enhanced collaboration: The benefits of a modular structure go beyond increased efficiency and accuracy. It also facilitates collaboration and interdisciplinary exchange.

Practical examples of the use of modern computer technologies in landscape design.

Sensor image preprocessing plays a crucial role in obtaining an accurate representation of the terrain for designing gardens and parks. By producing high quality data, it enables the creation of accurate digital elevation models (DEMs), which are essential for landscape visualisation software.

An effective approach to preprocessing sensor images is to use the ordered number sequence method. This method provides a seamless integration with the overall design workflow, facilitating the creation of detailed and realistic images of terrain features.

The use of advanced computer technology, such as sensor image preprocessing, has revolutionised the way landscape designers approach terrain representation, offering unprecedented accuracy and detail in digital terrain models. This technological advancement has greatly increased the accuracy and visual fidelity of 3D garden landscapes, allowing designers to create immersive and realistic virtual environments that accurately reflect real landscapes.

The use of sensor image preprocessing is an example of the successful integration of artificial parallax assistance mechanisms that allow designers to achieve an enhanced sense of depth and perspective in digital images of garden landscapes. Through careful data collection and processing, this advanced technology contributes to the creation of compelling and engaging visual experiences, enhancing the overall quality of landscape design projects.

By using advanced computer technology and sensor image pre-processing to accurately map the terrain, landscape architects can overcome traditional limitations and open up new possibilities for creating exciting and realistic garden and park facilities.

Another area is the use of computational intelligence for optimal design solutions. In the field of landscape architecture, the use of computational intelligence is becoming increasingly important to facilitate informed decision-making and optimise design solutions. Two key aspects that contribute to this are neural networks and parallel data processing mechanisms. By using these technologies, landscape architects can improve their pattern recognition capabilities, interpret data more efficiently, and process large volumes of heterogeneous data during the design analysis phase.

Neural networks are computational models inspired by the neural structure of the human brain. They consist of interconnected nodes (or neurons) that process and transmit information. When applied to landscape architecture, neural networks can significantly improve pattern recognition and data interpretation capabilities, enabling landscape architects to make more informed decisions.

For example, in the context of information fusion in landscape architecture projects, neural networks can be used to solve the following tasks:

1. Analysing and interpreting complex data sets such as sensor data, climate conditions, or user preferences.

2. Identify patterns and relationships in data that may not be obvious to human designers.
3. Recognising specific features or characteristics that contribute to a successful design outcome.

Neural networks also have the ability to adapt and learn from new data. This means that as landscape architects input more information into the neural network, its performance improves over time. This adaptive nature makes neural networks a powerful tool for continuously improving design decisions based on real-time feedback and changing project requirements.

In addition to neural networks, parallel processing mechanisms play a crucial role in processing large volumes of heterogeneous data during the design analysis phase. Parallel processing refers to the simultaneous execution of multiple tasks or instructions on multiple processors or computing cores.

Landscape architecture projects involve a huge amount of data that needs to be processed efficiently. This includes geospatial data, environmental data, topographic data, etc. Parallel processing allows landscape architects to:

- Split these data sets into smaller subsets and process them simultaneously.
- Significantly reduce the time required for data analysis and increase the overall efficiency of the design process.
- Strengthen cooperation between interdisciplinary teams working on a landscape architecture project.

By distributing tasks across multiple processors or computing cores, different team members can work on different aspects of a project simultaneously. This parallelisation of tasks allows for faster decision-making, increases productivity, and ensures that all the necessary data is taken into account in the design process.

Another powerful computational tool for optimising design solutions in landscape architecture is the genetic algorithm for encoding real numbers. This algorithm uses genetic algorithms that are inspired by natural selection and evolutionary processes.

The genetic algorithm for coding real numbers optimises the configuration of modular elements in garden landscapes. It uses a combination of real numbers and genetic operators (such as mutation and crossover) to iteratively generate new solutions. By evaluating these solutions based on predefined matching criteria (e.g., functional efficiency and aesthetic consistency), the algorithm gradually approaches the optimal design solution.

This approach allows landscape architects to do just that:

1. Create responsive and flexible designs that can respond to changing user needs and site conditions.
2. Consider a wider range of design possibilities and systematically explore the design space.
3. To find innovative solutions that combine functionality, aesthetics and environmental friendliness.

Hence, the use of computational intelligence through neural networks, parallel processing mechanisms and genetic algorithms enables landscape architects to make more informed decisions, efficiently process large amounts of data and optimise design solutions. These technologies enhance the ability to recognise patterns, interpret complex data sets, facilitate collaboration between multidisciplinary teams, and enable adaptive design. By using these computational tools responsibly and integrating them with ecological principles and human-centred design strategies, landscape architects can create truly successful garden and park spaces that enrich the lives of users and contribute to the well-being of the environment.

As we look to the future of landscape design, it is clear that the use of the latest technologies will play a key role in shaping the landscape architecture industry. The integration of computer-aided design tools, virtual reality platforms and information technology is set to fundamentally change the way we conceptualise, plan and implement landscape architecture.

Key trends for the future.

1. Integration of virtual reality. The seamless integration of virtual reality technology into the landscape design process will allow you to create multidimensional compositions of spaces, creating an immersive experience for both users and designers.

2. Real-time design modification. With the use of advanced computer-aided design tools, real-time modelling and interactive features, designers will be able to change and improve design schemes on the go, allowing for greater creativity and flexibility.

3. Sustainable design solutions. New technologies will facilitate the introduction of sustainable design practices, such as rainwater harvesting systems and environmentally friendly soil solutions, which will contribute to the environmentally conscious design of gardens and parks.

The prospects for computer-aided design in landscape architecture are endless. By using these technological advances responsibly, landscape architects can create innovative, sustainable and visually appealing outdoor spaces that blend harmoniously with their natural surroundings. As we move forward, a balanced approach that combines computational tools with ecological principles and human-centred design strategies will be crucial to creating hardscapes that enrich lives and make a positive contribution to the environment.

One of the key takeaways is the importance of staying at the forefront of technological progress. By using these tools responsibly, landscape architects can create sustainable and innovative design solutions. However, it is crucial to maintain a balanced approach that combines computational tools with ecological principles and human-centred design strategies.

Advantages of computer-aided design in gardening.

There are many advantages to using computer-aided design in landscape gardening:

1. Accurate data integration. Data fusion models improve the accuracy and efficiency of design projects.

2. High-quality data collection. Advanced computer technology enables designers to collect high-quality data and make informed decisions during the design process.

3. Optimisation of modular elements. The power of computational intelligence allows designers to optimise modular elements for optimal design solutions, ensuring both functional efficiency and aesthetic coherence in the overall composition.

Looking to the future, it is clear that new technologies will continue to shape the field of landscape architecture:

- Virtual reality technology that provides an immersive experience by integrating sight, hearing and touch into virtual landscapes.
- A computer rendering technology that allows you to create realistic visual effects and improves communication between owners and designers.

By using computer-aided design trends in garden and park facilities, landscape architects can create spaces that not only enrich the lives of users but also contribute to the well-being of the environment. Continuous study and application of these technologies will pave the way for sustainable and innovative design solutions in landscape architecture. With the development of virtual reality, landscape architects can now create immersive experiences for clients, allowing them to walk through future gardens and parks before construction even begins. This not only helps to accurately visualise the design, but also enables clients to provide feedback and make informed decisions during the design phase.

The future of computer-aided design for gardens and parks.

Computer-aided design (CAD) has redefined the way architects and designers create and visualise structures. From buildings to green spaces, CAD has become an integral part of the design process. However, its potential in the field of gardens and parks remains largely untapped. As society becomes more urbanised, the need for well-designed green spaces has never been greater.

CAD software enables designers to create accurate and faithful representations of garden and park plans. It allows you to measure and manipulate space, ensuring that every detail is well thought out and optimised. Designers can experiment with different layouts, paths and elements, refining their vision before construction begins. This level of precision in spatial planning ultimately results in well-organised and efficient gardening projects.

CAD allows designers to create stunning visual representations of garden and park designs, demonstrating the potential of a space before any physical work is done. Through the use of 3D modelling and rendering techniques, CAD software brings designs to life, allowing stakeholders to visualise the end result. This visualisation aspect is invaluable in communicating the design intent to clients, community members and decision makers, gaining support and ensuring that everyone is on the same page.

Given the vast number of plant species, selecting and placing plants in a garden or park can be a daunting task. CAD software can simplify this process by providing databases of plant species with their growth characteristics, care needs and aesthetic qualities. By simulating the growth and interaction of different plant species in a virtual environment, designers can make informed decisions about the most appropriate plants for a given space, ensuring optimal biodiversity and aesthetic appeal.

In an era of climate change and growing environmental awareness, it is essential to design sustainable and resilient gardens and parks. CAD software can incorporate climate data and simulation models to analyse the effects of solar radiation, wind patterns and water runoff. This allows designers to optimise the placement of trees, structures and water features to maximise shade, minimise water use and reduce the urban heat island effect. By integrating sustainability considerations into the design process, CAD greatly contributes to the creation of environmentally conscious green spaces.

CAD facilitates an iterative design process, allowing designers to improve garden and park designs through successive iterations. With CAD, designers can easily modify and experiment with different design elements, materials and layouts. In addition, CAD platforms support collaboration between designers, landscape architects and other stakeholders by providing a centralised platform for sharing and reviewing design iterations. This collaborative approach improves communication, speeds up decision-making and leads to more cohesive and successful garden and park projects.

The future of computer-aided garden and park design has the potential to revolutionise the way we create and use green spaces in urban environments. With precise spatial planning, visualisation capabilities, optimised plant selection and placement, climate consideration and collaborative design, CAD software enables designers to create sustainable, vibrant and functional gardens and parks. As technology advances, we can expect CAD to become an indispensable tool in the hands of landscape architects, helping to create and preserve well-designed green spaces for future generations.

Evolution of garden landscape design methods.

The design of gardens and park facilities has changed significantly over the years thanks to technology. Limitations of traditional 3D simulation methods:

- Lack of realism: Handmade models and handwritten plans often did not accurately show what the gardens would look like in real life. They could not convey details such as textures, lighting effects and spatial relationships between elements.
- Limited interaction: With traditional 3D simulation methods, designers could not easily explore different design options or make changes in real time. This made it difficult to assess how design choices would affect the overall composition and functionality of the garden spaces.

Due to these limitations, there was a need for better tools that would provide a more immersive and interactive design experience.

Virtual simulation technology has changed the rules in garden landscape design. With the use of digital technology, multimedia, virtual reality and networking, designers have been able to create more realistic and dynamic project models.

With the use of virtual simulation technology, designers can:

- Create detailed and realistic representations of garden landscapes.
- Use specialised software such as AutoCAD to accurately analyse the site and estimate flow rates.
- Present your projects with multimedia presentations and virtual reality simulations.

With the help of virtual simulation technology, designers can overcome the limitations of traditional 3D simulation methods and improve their ability to create functional and beautiful outdoor spaces.

This shift from traditional 3D simulation to virtual simulation technology has opened up new possibilities for garden landscape design. Virtual simulation technology has significantly changed the landscape architecture industry, offering innovative solutions to traditional design methods.

Innovative tools for park design.

In modern garden and park design, a variety of digital tools and technologies are changing the way we plan, visualise and create outdoor spaces. These tools help landscape architects to be more creative, efficient and collaborative in their work. The following are the key technologies that will shape the future of garden and park design:

Multimedia presentations. Multimedia presentations are an essential element in explaining design concepts to clients, stakeholders and the public. By combining different types of media, such as images, video and interactive elements, designers can create engaging presentations that effectively communicate their vision for a garden or park space.

Virtual reality simulations. Virtual reality (VR) simulations have become an inexhaustible source of realistic experience for clients and designers before any construction project. With VR technology, stakeholders can explore and interact with virtual environments, gaining a better understanding of how the space will look and feel.

Network communication technology. The ability to easily exchange information and ideas is made possible by network communication technology. This allows landscape architects to collaborate with teams from different industries, share real-time design options and receive feedback from experts from anywhere in the world. This connectivity improves collaboration and fosters innovation.

Scientific tools. By using scientific tools such as geographic information systems (GIS), environmental modelling software and climate analysis platforms, designers can make informed decisions about factors such as site suitability, environmental impact and sustainable resource management. These tools help create environmentally conscious projects.

Technological tools. Advanced software for parametric modelling, 3D rendering and digital sculpting allows you to accurately visualise complex shapes, organic structures and detailed landscape elements.

The use of tools in garden design:

- Semi-regular textures - these textures provide a structured basis for displaying the dynamics of flow in a garden space. By integrating semi-regular textures, designers can visualise the interaction of elements such as paths, water features and plants with the natural flow of the space.

- Deformation matrices - the use of deformation matrices allows for the manipulation and transformation of visual elements in garden design. This innovative approach allows designers to experiment with different configurations and evaluate their impact on the overall flow and aesthetics of the landscape.

Advantages of flow visualization:

- Enhanced spatial understanding - Flow visualisation allows designers to gain a deeper understanding of the spatial relationships in the garden environment. By visualising how elements interact and influence each other, designers can make informed decisions that optimise both functionality and aesthetics.
- Real-time analysis - the dynamic nature of flow visualisation allows for real-time design analysis. Designers can quickly evaluate different scenarios and improve their designs based on instant feedback, leading to more efficient decision-making processes.

With the help of advanced techniques such as flow visualisation, landscape architects can improve the quality of their design process, resulting in the creation of thoughtful and engaging spatial experiences in garden and park facilities. This is defining an exciting shift towards more dynamic and responsive approaches to garden design, where technology is becoming a means of fostering creativity and innovation. By continually pushing the boundaries of what is possible with computer-aided landscape architecture, these trends will undoubtedly shape the future of gardens and public parks, providing new opportunities to create sustainable and engaging environments.

The integration of advanced drawing techniques into landscape animation has opened up new possibilities for designers. They can now create immersive animations that provide clients with a realistic preview of their future garden or park. These animations can showcase a variety of design elements, such as paths, water features, plant arrangements and lighting effects. All of these design elements can be presented in visually appealing images, thanks to advanced drawing techniques.

In addition, the use of advanced rendering technologies can greatly enhance the realism of these animations. For example, realistic lighting effects can be simulated to reflect how a garden or park will look at different times of day and in different weather conditions. Textures and materials can also be applied to objects to create a more painterly representation of the final design.

Advanced drawing techniques have transformed landscape animation, allowing designers to create more dynamic and expressive images of gardens and parks. The integration of technologies such as OpenGL and contour line generation has improved the realism and visual appeal of these animations. The ability to showcase complex details, simulate lighting effects and depict changes in elevation allows landscape animations to provide clients with a compelling preview of their future outdoor space.

Virtual simulation technology has proven to be indispensable in optimising the installation and maintenance of garden lighting systems, especially in situations where medium voltage operation is required without power outages. This application of virtual simulation demonstrates the clear benefits of integrating advanced technology into outdoor design.

Also in the field of garden landscape design, various methods of rational judgement play a significant role in guiding the decision-making process. The main methods of rational judgement in garden landscape design include:

1. Judgement method based on weighted average theory. This approach involves assigning weights to different criteria based on their relative importance, which allows for a comprehensive evaluation of design elements. By calculating a weighted average of these criteria, designers can make informed decisions that address both aesthetic and functional aspects.
2. The network projection method of judgement. Using the network projection judgement method involves analysing the complex relationships in a garden landscape design. This method takes into account the complex relationships between different elements, such as vegetation, paths and focal points, to assess the overall coherence and visual harmony of the outdoor space.
3. Deep Learning Judgement Method. Deep Learning Judgement explores advanced computational technologies to predict and evaluate the long-term impact of design choices on sustainability and ecological balance. Using deep learning models and data from analytics, designers can assess the environmental impact of their decisions, ensuring responsible and sustainable development.

The use of these rational judgement techniques not only improves the accuracy of computer-aided garden design, but also highlights the importance of the human mind in creating outdoor spaces that harmoniously combine technological innovation with practicality and sustainability.

Integration of digital tools for integrated design solutions.

The integration of Autocad with other digital tools allows landscape architects to create integrated solutions that take into account various aspects of public park design. The most famous examples of these tools include:

- 3D modelling software that allows you to visualise proposed projects and conduct virtual walks.
- Geographic information systems (GIS) for spatial mapping and analysis of environmental factors.
- Rendering software that allows you to create realistic images and videos of the proposed park design.

By combining the strengths of each tool, designers can improve the efficiency and accuracy of the design process while enriching their understanding of the potential of a place. This integrated approach also fosters collaboration between the multidisciplinary teams involved in public space renewal projects, such as architects, engineers and urban planners.

Through the use of Autocad and other advanced design technologies, landscape architects can bring public spaces to life with the help of:

- careful planning that takes into account the unique characteristics and needs of the local community;

- resource management practices aimed at preserving nature and minimising environmental impact;
- attractive outdoor environments that promote physical activity, social interaction and contact with nature.

In general, this comprehensive approach to the design of public parks is aimed at creating inclusive spaces that contribute to the well-being and quality of life of residents of all ages and social strata of society.

Future directions of expanding the boundaries of computer support for the design of gardens and parks.

The field of computer-aided design for gardens and public parks is constantly evolving, driven by advances in technology and the need for more efficient and sustainable solutions. Looking to the future, we can identify some interesting trends and innovations that are likely to shape the way we design and experience open spaces:

- AI-assisted plant selection algorithms: With the help of artificial intelligence, designers can quickly and accurately select plants that are well suited to specific environmental conditions. These algorithms can take into account factors such as soil type, sunlight exposure, and climate data to create optimal plant palettes that thrive in their environment.
- By combining technological innovation with sustainable design practices, we can create garden and park structures that are not only visually appealing, but also environmentally sound and socially relevant. These advances have the potential to revolutionise the way we design and experience outdoor spaces, providing us with more efficient, engaging and sustainable landscapes.

- As this industry continues to evolve, it is important for designers and landscape architects to keep up to date with the latest trends in computer-aided design for garden and park facilities. By introducing new technologies and experimenting with innovative approaches, we can push the boundaries of what is possible in landscape architecture and create outdoor spaces that inspire and delight.

As we move forward, it's important for designers and enthusiasts to stay up to date with the latest advances in computer-aided design for gardens and parks. By experimenting with new technologies, we can push the boundaries of creativity and create truly immersive experiences for users. However, in the midst of all the technological innovation, it is important to keep in mind the timeless aspects of nature-inspired aesthetics and community needs. While technology can enhance our design processes, it should not obscure the basic principles of sustainable design and environmental conservation. We should use technology as a powerful tool that can enhance our creativity and efficiency. By staying informed about trends in computer-aided garden and park design, we can make informed decisions about how to incorporate technology into our projects. Nature has always been the greatest source of inspiration for designers throughout history, and it continues to provide valuable lessons in aesthetics, functionality and sustainability.

The success of any landscape design project depends on its ability to coexist harmoniously with nature and the environment. Technology can be a powerful tool in achieving this harmony, but it must be used wisely and with respect for nature. It is important to preserve what makes our world unique and wonderful and work with it, not against it.

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CONDITIONS FOR THE ESTABLISHMENT OF LODGEPOLE PINE CULTURES IN THE TERRITORY OF THE NORTHEASTERN FOREST-STEPPE OF UKRAINE

Sergii Butenko
Doctor Phd, Lecturer of the Department
Sumy National Agricultural University, Ukraine
ORCID ID: 0000-0002-9925-3029

The biosphere, often referred to as the lungs of the Earth, is heavily dependent on forests, which cover approximately one-third of the planet's surface. Forests play a crucial role in converting carbon dioxide into oxygen through the process of synthesis. In addition, forests are a valuable source of timber and other products for the population, and play an important role in water conservation and soil protection.

It is difficult to overestimate the importance of tireless and often unnoticed work for Ukraine, its people and land. Many people don't know that half of Ukraine's forests were created by the purposeful activity of humans, planted, tended and protected by generations of foresters.

The impact of human activity on forestry has undoubtedly been devastating: the destruction caused by wars, revolutions, and man-made disasters has reached unprecedented proportions. However, it is difficult to identify any other area of natural resource management where the positive impact of human intervention is as tangible and significant.

The importance of this is undeniable, as it is not only a quiet refuge for countless people or a valuable resource for the woodworking and food sectors.

The value of forest work to humanity goes beyond the common statement that "forests are the lungs of the planet." There are many other factors that contribute to the exceptional value of forests.

Combating deforestation plays a crucial role in preserving rivers, controlling soil erosion, and preventing droughts and catastrophic natural events.

It is well known that the current challenges we face in Zakarpattia, which lead to significant losses of resources, could have been avoided if more care had been taken to preserve the Carpathian forests more carefully in recent years.

Protecting and expanding our forests, in particular in Donbas, Crimea, Kherson, Mykolaiv and the Carpathians, is not just a desire but a necessity.

Forest plantations are a major factor in maintaining oxygen balance at the global level.

The national economy relies on forests as a valuable source of raw materials, including wood. Wood provides more than 20,000 different materials, including food and other raw materials. Demand for wood has grown significantly along with advances in the chemical industry. The chemical processing of wood raw materials produces many essential products and technical materials, such as pulp, paper, fabric, alcohol, and medicines.

The forests are a valuable source of food, rich in a variety of nuts, mushrooms, and various types of berries: blueberries, cranberries, cranberries, raspberries, and blackberries. In addition, these forested areas provide a range of medicinal resources with a collection of approximately 12,000 types of raw materials. In addition, the forested areas are used for honey harvesting.

The presence of forests plays an important role in the social and recreational aspects of people's lives, contributing significantly to their aesthetic development and leisure.

Due to the growing demand for timber, there is a need to increase the volume of harvesting of forest materials. However, this has led to negative consequences, prompting the search for methods to increase and expand forest areas through artificial tree cultivation. Natural regeneration of forests is a slow process, hence the implementation of artificial reforestation, which involves planting seedlings, saplings, cuttings or sowing seeds to create plantations. This approach not only focuses on reforestation of areas that have been cleared of forests, but also includes reforestation of areas that have never had forests or have been deprived of them for a significant period of time, leading to soil degradation. Afforestation is also carried out in unsuitable agricultural lands to create protective forests and in wetlands. Numerous forest plantations have been created in such areas, so it is extremely important for the entire forestry complex to demonstrate a highly professional and organized capacity, from seed collection to sowing and planting, as well as ongoing care.

HISTORICAL ASPECTS OF INCREASING FOREST PRODUCTIVITY.

In the postwar years, the problem of increasing forest productivity and quality became increasingly important. By the end of the 1950s and early 1960s, various works on this issue appeared. Among them, it is worth noting the fourth edition of "Problems of increasing forest productivity" (1959-1961), as well as monographs by P.V. Voropanov, O.O. Molchanov (1971), V.V. Smirnov (1971), D.F. Sokolov, E.F. Ivanitskaya (1971), N.A. Moiseenko (1972), V.K. Myakushka (1978), V.G. Atrokhin (1980), S.A. Gensiruk (1980), and others. In addition, numerous publications on this topic were presented in scientific journals, for example, by V.V. Protopopov (1970), A.I. Utkin (1970, 1975), A.I. Pitikin (1974), V.S. Shumakov (1975), V.P. Grigoriev, V.K. Hvozdev (1978), V.G. Atrokhin, E.Y. Afonin (1984), and others.

Based on research conducted by S.A. Gensiruk in 1980, it was found that approximately 40% of the plantations in the State Forestry Fund of Ukraine had a specific gravity of 0.6 to 0.5. In addition, the coefficient of utilization of the potential productivity of forest land did not exceed 0.7.

Foresters considered the primary goal to be to increase forest productivity due to the fact that more than a quarter of Ukraine's forested areas are low-density forests, despite some improvements by the end of the second millennium.

The publications of Artemenko, Tyukov, Yarmolskaya (1960), Georgievsky (1960), Melekhov (1962), Loginov (1965) and other respected scientists present a number of exceptional methods for increasing forest productivity. These publications particularly focus on various aspects, such as reforestation of both forest and non-forest lands, revitalization of low-value plantations, and drainage of swampy forests. It should be noted that these measures are tailored to the specifics of Ukraine. M.P. Georgievsky, in particular, proposed a comprehensive set of strategies applicable to forests throughout Ukraine. These strategies included reforestation of non-forested areas, seed production and selection, plantation reconstruction, forest drainage, replacement of mature plantations with seed plantations, use of pre-regeneration, introduction of understory and secondary growth, improvement of soil fertility, timely maintenance felling, and sustainable use of wood, among others.

Melekhov linked productivity measures to deforestation practices. These measures include protecting and caring for young trees during harvesting, as well as initiatives to optimize the use of wood and maximize its potential. In addition, full utilization of harvested trees is emphasized, along with efforts to improve soil conditions through controlled fires and the introduction of special materials. Other strategies mentioned include improving the composition of young plants through lightening and clearing, as well as implementing drainage reclamation projects.

The proposals put forward by B.Y. Logginov primarily concerned Ukraine and covered various problem areas. These included, in particular, a significant improvement in the forest vegetation condition by draining excessively wet lands, protecting forests from diseases and pests, strengthening forest protection from fires, improving artificial reforestation techniques, raising the level of forest management in collective farm forests, implementing a rational approach to the use of the logging fund, and maximizing the use of logging waste.

Back in 1956, academician A. B. Zhukov divided strategies aimed at increasing forest productivity into the following classifications:

Those that increase efficiency by significantly changing environmental conditions.

The goal is to maximize the use of soil fertility by the trees on the territory.

Those that increase the caliber of already established forests and accelerate forest development.

The goal is to eliminate the factors that lead to a decrease in forest productivity. Maximum utilization of the logging stock.

A comprehensive study of the issue of increasing forest productivity was conducted by A.B. Zhukov and A.S. Buzikin, who identified a complex network of interrelated abiotic and biotic factors operating at four different levels: climatic, edaphic, biocenotic, and physiological and biochemical.

Two key factors influence the expansion of forests and the growth of plant biomass in them: the radiation balance of the earth's surface and precipitation. In addition, soil nutrition, as well as the availability of water, heat, and air, play a crucial role in determining the overall health and development of forest ecosystems.

Relationships between and within species in forest ecosystems, known as biotic interactions, play a crucial role in maintaining the balance of trophic relationships. These interactions can be influenced and controlled through a variety of forestry practices, such as logging and fertilizer use.

Vital processes, such as photosynthesis and transpiration, are based on the physiological and biochemical level. In this hierarchical structure, each higher level influences the one below it and at the same time serves as the basis for the level above.

According to Prof. Nesterov, increasing forest productivity requires the introduction of advanced forestry technologies, in particular, focusing on the strategic placement of trees based on specific forest vegetation conditions. In addition, it is crucial to improve these conditions in accordance with the specific requirements of different tree species.

WAYS TO IMPROVE FOREST MANAGEMENT.

Increasing tree productivity depends not only on natural factors but also on the organizational and economic conditions of forestry. Professor Gorshenin recognized this and developed a comprehensive set of measures to optimize productivity. These measures include organizational strategies, interventions aimed at the stand, and measures to improve the condition of forest vegetation.

Activities carried out by the organization: proper use of wood at the stages of supply, transportation and processing of production waste,

reforestation of land unsuitable for agriculture,

protection from pests and diseases, fire prevention, mitigation of damage caused by natural phenomena such as storms and hurricanes, icebreakers, etc. Creating a system of long trails through forests and along waterways. Taking into account the biology of the forest, mechanization of forestry operations is being introduced. The organization of forestry activities is gradually being improved and structured. The main focus is on the development of works that cyclically cover the entire territory of the forestry.

Actions affecting the stand position: selection of appropriate methods of harvesting for main use, taking into account the forest type. practice of preserving soil, undergrowth and trees intact during harvesting. reconfiguration of disturbed low-density and inadequately formed forest formations, selection and cultivation of tree species for seed, selection of species and mixing methods taking into account existing forest vegetation conditions, planting the required number of fast-growing tree seedlings taking into account specific forest vegetation conditions, creation of plots and specialized farms in close proximity to consumers using fast-growing species.

Implementation of a systematic approach to thinning, focusing on maintaining high quality, involving the highest forms and ecotypes in mass selection for many generations, choosing the right methods for cleaning up areas where trees have been cut down, and stimulating natural regrowth, taking into account the specific characteristics of the forest.

Changes affecting the condition of forest vegetation: regulating the water regime of drained forests on both sides, applying mineral fertilizers, controlling runoff and preventing soil erosion;

By creating diverse plantations and carefully managing the density, composition and structure of forest stands, we can effectively maintain and improve soil fertility.

Soil fertility can be improved by adding undergrowth and supplementing the secondary rock layer, if the soil is damaged by fire or mechanical impact;

The process of restoring sandy soils by planting lupine and other legumes.

The priority of artificial reforestation is the uniqueness of natural plantations, which cover most of Ukraine's forests.

Artificial reforestation involves growing trees on carefully prepared soil. Before planting seedlings, the soil is loosened and existing grasses are removed. As the trees mature, selective pruning is done to promote the growth of the main tree species and related varieties, giving preference to those that offer the greatest economic benefit. These strategic actions help to ensure the survival of trees even in difficult environmental conditions and in the presence of various threats.

Artificial plantations, which are all of the same age, have a unique feature. The ability to pre-design and organize the composition of these plantations, along with the possibility of including introductions, greatly simplifies reforestation efforts.

The investment required to create artificial plantations is repaid through significant growth of stem wood within a short period of one to two years, as demonstrated by both medieval and modern plantations.

When it comes to reforestation, both natural and artificial methods have their own unique characteristics. In all types of forested areas, it is important to prioritize the creation of forest crops

The focus of the project is to substantiate the characteristics associated with the establishment of forest crops. These characteristics include different densities, composition and mixing patterns, as well as the way of establishment within a subgroup and subgroup conditions within. In addition, the project aims to study the impact of these characteristics on the productivity of future plantations.

ECONOMIC AND TECHNOLOGICAL STATE OF REFORESTATION.

They are shaped by various environmental factors such as light, heat, humidity, soil properties and biotic interactions. When engaging in artificial reforestation, it is important to consider the growth characteristics of tree species, which can vary depending on the cultivation method and technology used in different environments. These conditions may include unfamiliar practices for the plants, including tillage methods, mixing methods, density, and maintenance. These considerations are important for successful reforestation.

As mentioned earlier, Scots pine is the main species responsible for forest formation in the forestry areas. However, the natural regeneration of this valuable conifer is insufficient due to variations in growing conditions in different climatic zones.

The scientific literature of V.V. Ogievsky (1949) and V.V. Mironov (1977) provides guidance on the creation of pine plantations by sowing or planting methods.

To create sustainable pine plantations in forestry, it is extremely important to understand the various aspects of grafting, pine cultivation, agronomic and silvicultural care. An important role in the successful reproduction of pine plantations is played by the correct choice and application of planting methods.

The conclusions of our study, set out below, to some extent reflect the information gathered from the review of existing literature.

In total, over the past 5 years, the primary enterprise has required 3 thousand kg of seeds for forestry needs. This includes 150 kg of coniferous seeds, 2850 kg of deciduous seeds, 2500 kg of oak seeds and 350 kg of other seeds. To meet this demand, 176.0 hectares of temporary forest-seed plots and 4 permanent forest-seed plots of 45 hectares were allocated for the collection of forest-seed raw materials. In addition, 10 Scots pine trees were officially registered.

The demand for forest seed is largely met by the large number of available forest seed plots and surplus trees in harvest years. However, some seeds are still harvested.

Scots pine cones are processed by the Capera-Gogolitsyn cone dryer located on the company's premises. The cone dryer is adjacent to the seed storage facility, which is used to store seeds.

Growing planting material is a common practice among forestry enterprises. The total area of nurseries is 7.3 hectares. The forestry operates two temporary nurseries with a total area of 0.95 hectares. These nurseries are created specifically on recently cleared areas and remain in operation for 2-3 years. One of these nurseries covers 0.40 hectares and is located in section 23, while the other nursery covers 0.45 hectares and is located in section 60, both with 8 and 14 seedlings respectively.

The main species grown in these temporary nurseries include scots pine, common oak, spruce, black alder and hazel, with an annual production of approximately 100-120 thousand pines and 10-15 thousand spruces.

The cultivation of planting material using agricultural technology is a simple process that involves plowing the soil to a depth of 22-25 cm, followed by manual spring row sowing with row spacing of 30-35 cm. Throughout the growing season, the crop needs regular care, which includes loosening the soil with a hoe about 6-7 times. In this particular method, crop rotation is not implemented, and only peat is used as a fertilizer. Consequently, the harvest mainly consists of class II seedlings, which indicates the need for further improvement of the agricultural technology of growing planting material.

The company's forests are located in the Polissya region, which is dominated by wet and humid subsoil and conglomerates. As noted earlier, the prevailing forest conditions in this area necessitate artificial reforestation. The main reason for this is the insufficient natural regeneration of primary tree species, in particular Scots pine, due to its destruction during mechanized logging. Secondary species, primarily birch, quickly colonize freshly cut areas, which further emphasizes the need to reintroduce the main species. In addition, the remnants of the yellow azalea undergrowth prevent natural regeneration in the logged areas.

In the pre-war era, forestry crops were established in the forestry sector; however, there are no existing records detailing the agricultural methods used to establish them. From the postwar period until the 1960s, small-scale forestry operations were carried out annually, usually covering an area of 10-15 hectares and relying heavily on manual labor. The technology of creating forest crops consisted of preparing narrow strips 0.30.5 m wide with a hoe, located at intervals of 1.5-2 m.

Then, in the spring, annual pine seedlings were planted with the Kolesov sword and hand-cared for for 3-4 years. Initially, the planting density was 11-13 thousand per hectare. In some cases, the crowding of plantations led to the formation of pine monocultures, which is considered a negative phenomenon.

Previously, there were large areas of uncultivated meadows with yellow bindweed undergrowth, which were either overgrown with birch and aspen or remained untouched. But after the consolidation of forestry, timber industry, and chemical forestry enterprises into forestry enterprises, the volume of forestry work increased to 30-45 hectares per year. To eliminate old, cluttered clearings, a mechanized clearing technique was introduced, using a D-210A snagging machine to create 1.5-2 m wide strips every 4-6 m. Mechanized sowing methods were also introduced, using DKLN-6/8 or KLB-1.7 disk cultivators for maintenance. In ten years, all old clearings were successfully restored. From the 1970s to the present, an average of 15-20 hectares of silvicultural work has been carried out annually.

At that time, the process of creating forest crops using agrotechnical methods included mechanized soil cultivation with PKL-70 plows by plowing to a depth of 1012 cm or clearing stumps into defined strips every 3-5 meters. In the first approach, the planting sites were located at intervals of 2.0-3.0 x 0.5-0.75 m with a density of 6.7-4.8 thousand plants per hectare. In the latter approach, planting sites were placed 3-5 x 0.50.7 m with a density of 3-5 thousand plants per hectare.

The main species planted are annual seedlings of Scots pine, Scots oak, northern oak, as well as two-year-old seedlings of hanging birch and black alder.

In freshly cleared areas, predominantly pure pine stands are created, and alder is found in more natural habitats. Over time, birch begins to regenerate, although oak is less common. The introduction of birch into secondary forests is not recommended, as it naturally regenerates well and eventually becomes a strong competitor to pine. If maintenance felling is not carried out in time, birch can overtake pine and become the dominant species. In general, oak regeneration does not threaten pine forests; within 1015 years, oak reaches only half the height of pine. However, the presence of oak in forest plantations has several positive effects, including increased productivity, soil improvement, and increased resistance to disease and fire.

In wet subsoils, oak-pine crops are created using a technology similar to subsoils. In wet soils, black alder cultures are practiced, and in transitional edatopes from wet to wet, oak-alder cultures are created.

In our opinion, the technology of creating forest crops has both positive aspects and disadvantages. On the positive side, we should note the refusal to introduce hanging birch into the crops on clearings, as it successfully regenerates naturally in these conditions. Crop density is mostly environmentally sound. Soil cultivation operations are mechanized, including partial maintenance.

As disadvantages, we should note the relatively poor assortment of species, and the acclimatization of highly productive introductions, such as Japanese larch, is not practiced, as recommended by I.Y. Oliynyk (1990). Furrow tillage is not justified in wet and even damp forest conditions, which leads to waterlogging, slow growth, and even crop death. There is no deep loosening of the soil in the furrows, no return of the chips to the bottom of the furrow, and mechanized planting is rarely practiced. The use of disk cultivators for maintenance in the planting rows leads to cutting of root systems. In relatively poor forest vegetation conditions, it is advisable to apply biological reclamation (sowing perennial lupine), as recommended for these conditions by Melnik (1982).

Both state and district authorities prioritize optimizing forest regeneration and cultivation, as well as improving wood quality. A method of increasing the efficiency of reforestation is the creation of plantations using closed root system (CRS) planting material. This method has been used for about five decades in Europe, the United States, and Canada.

These technologies were developed in countries that have favorable climatic conditions for forest cultivation, with significant precipitation (over 1000 mm per year). However, these methods cannot be universally applied in all natural zones of Ukraine. Another disadvantage is the limited size of containers, block cells and tablets, which makes them unsuitable for use to produce larger quantities of standard planting materials that meet the requirements for tree and shrub seedlings, resulting in the lack of standardized survival rates of planted seedlings provided on the forestry area. Promote scientific and best practices in the production of planting materials of SFAS and use them to create forest crops for various purposes, study the growth and development of forest crops and artificial forests, and develop agricultural technologies, as their planting will help solve and improve methods of forest reproduction Many tasks related to technology. SCA planting material is relevant for use during forest fires and other unfavorable growing conditions.

These recommendations describe the technique of growing planting material in boxes

In accordance with the "Rules for Forest Reproduction", "Instructions for Design, Technical Acceptance, Accounting and Evaluation" and "Rules for Forest Reproduction", the data for the "Recommendations for the use of box -type planting materials with a closed root system for plantations" were developed. "The "Forest Crops by Forest Vegetation Zones" compiled in accordance with the current Forest Law of Ukraine are mandatory for all permanent forest users who plant box-type planting material.

Among the methods of forest reproduction (natural, artificial or combined), artificiality (creation of forest culture) continues to prevail. In the current structure of the forest fund of the left-bank forest-steppe, artificial pine plantations account for approximately 95% of the total area of pine forests. This trend will continue in the future, due to the specifics of pine forestry in the region. Scientists estimate that within 20-40 years, the area of reforestation will tend to increase dramatically as large plantations created in the postwar period, especially within the left-bank forest-steppe, reach maturity.

The upcoming increase in forest restoration efforts will require the vigorous development of the latest technologies for growing planting material that will ensure the efficient creation and cultivation of high-quality forest crops for various purposes.

This will involve the wider use of planting material with the introduction of a closed root system (CRS), which is an important technique in the processes of reforestation and reproduction.

Growing planting material with a closed root system offers numerous advantages that surpass those of an open root system. This method allows for economical application of fertilizers, plant growth regulators and other targeted substances and preparations for each seedling. It also makes it possible to use improved seeds efficiently and to manage the growth of seedlings in a targeted manner, optimizing the ratio of their aboveground and underground parts. Using the CCA method, 2-3 rounds of high-quality planting material can be produced in one growing season, while the planting period for forest crops can be extended throughout the growing season. In addition, large-sized planting material can be used to protect the root system as efficiently as possible, reducing the need for fertilization of forest crops due to the high viability of the planting material. In general, the method of SFM increases the efficiency of forest crop production.

Today, when the climate is becoming increasingly dry, the technology of growing seedlings of WSC deserves special attention. There is no comprehensive study on the impact of different methods of cultivating forest tree species on the overall health and further development of seedlings in the forest environment. As a rule, studies of the effectiveness of planting materials using CSA are limited to the first one or two years after planting in forest regions.

REPRODUCTION OF PINE PLANTATIONS.

To create productive and environmentally sustainable plantations, it is important to make good use of environmental conditions. To achieve this, the complex interplay between environmental factors and the plantation itself must be carefully considered.

In the process of both artificial reforestation and afforestation, it is imperative to take into account the unique growth patterns of the forest community. This involves taking into account various land preparation techniques and technologies, migration patterns, and the ideal density of forest crops in different environmental conditions. Additional considerations include proper care and maintenance of the crops, as well as other important factors.

The growth, development and general condition of forest crops are significantly influenced by a variety of environmental factors. These include, but are not limited to: the quantity and quality of light, temperature, physical and agrochemical characteristics of the soil, the degree of frost and moisture, and the interaction between different biological groups.

In the northeastern forest-steppe of Ukraine, pine is the main tree species for planting, but due to various environmental and economic factors, its natural regeneration capacity is weak or unsatisfactory.

Many scientists have pointed out and convincingly proved that the artificial creation of forest cultures of lodgepole pine should be given priority in reforestation on different areas of forestry.

The main factors in the creation of scots pine forest culture are the choice of the method of its creation, the method of selection and mixing of tree species, taking into account interspecies relationships. It is recognized that planting mixed forests is the basis for increasing the productivity of plantations.

When selecting varieties of trees and shrubs in mixed plantations, it is necessary to take into account biological and economic aspects, the interaction between which fully corresponds to the conditions of forest vegetation.

There are also scientists who note that the choice of sowing or planting method for creating forest crops is closely related to local growing and climatic conditions. Scientists have concluded that with the help of modern agrotechnical methods, loblolly pine can be successfully grown on fresh, moist clay, sandy and loamy soils with sufficient moisture.

Given the requirements for wood quality, foresters in the late nineteenth century began to focus on planting density. According to V. G. Nestorova, G. F. Morozov and others, intensive culture closes earlier and at lower costs. In addition, with intensive cultivation, the effect of branch cleaning is better, the trunk is flat, and the quality of hardwood is high.

Mr. Georgievsky believes that planting density plays an important role in the cultivation of loblolly pine crops. He draws attention to the fact that low-density plantations provide a greater supply of timber during major felling, but produce low-quality wood. Z. S. Holovyanko argued that the adjacency of closed crops can be reduced by pruning the cuts.

M.M. Padiy noted that the reduction in crown closure affected the number of red pine trunks in which bark beetles live, and the number of stem trees increased. From the monitoring of publications, it can be concluded that most researchers share the views expressed by T.F. Morozov. In fact, the key conclusion is that as the quality of soil for crop growth decreases, it is necessary to increase the initial density of forest crops. This idea is especially relevant for regions such as Polissya and the Forest-Steppe, where the hydrological soil moisture coefficient is equal to or exceeds a certain threshold.

Martynov wrote that reducing the density of pine crops should be treated with great caution, as lodgepole pine plantations in seedlings form clumps, poor clearing of trunks and branches, and poor growth at an early age due to soil erosion.

FEATURES OF CREATING CULTURES OF LODGEPOLE PINE.

An important issue is also determining the optimal density of the main types of crops and subsequent changes in the number of trees to ensure maximum accumulation of plantation biomass. Some scientists believe that well-treated soil, uniform planting sites, the use of high-quality planting material, timely and regular crop care contribute to accelerated plantation growth, and this should be taken into account when developing methods for growing forest crops involving loblolly pine and other species.

Many years of experience in reforestation of Scots pine and other tree species on fresh logs with 1-2 year old seedlings shows that such crops require careful maintenance. Pysarenko pointed out that the resistance of loblolly pine forest crops to natural regenerative shading of herbaceous vegetation and deciduous tree species can be increased by planting large-scale planting material with a height of more than 25 cm.

When reforesting in Polissya, the type of log should be taken into account. When establishing pine plantations on newly harvested pine logs, it is important to give preference to forest crops of Scots pine, which are partially cultivated in mineralized areas and ditches.

The success of reforestation and afforestation largely depends on forestry maintenance, which should be related to the natural and climatic zone, the type of forest vegetation conditions, and the harmfulness of grass vegetation. The negative effects of preparing land for growing forest crops can be remedied by high-quality care.

Practice has proven that the primary requirement of the surface layer preparation structure is to control grass vegetation, among which the roots are the first to absorb water and nutrients, especially cereal weeds.

Gordienko M. I. The biggest competitors of scots pine for moisture and nutrients are other species, in particular, ground marten and creeping heather. Their destruction increases the content of moisture and nutrients - nitrogen, phosphorus and potassium - in the upper soil layer.

AGRICULTURAL TECHNOLOGY FOR CREATING CULTURES OF LODGEPOLE PINE.

When carrying out mechanized care in the third and fourth years, make sure to cut off 51-68% of the damaged root system. In drought conditions, the cut roots cannot recover, as a result of which young loblolly pine trees weaken and slow down in development, even if they recover, their number will decrease by 5 -7 times compared to before the damage.

There is limited information on the use of traditional methods of growth enhancement, coatings that form films of polymers and contain fungicides, insecticides and herbicides, in the cultivation of pine crops. However, the use of the above-mentioned preparations in forestry production allows to protect seeds and roots of seedlings and seedling systems from root rot, to protect the roots of red pine seeds from May rust.

The vigor and efficiency of growth of loblolly pine seedlings in the first years of planting in a permanent place depends on the preparation of the internal seedling. Soil-anchored cultivation of forest crops should be carried out in dry growing conditions in all soil and climatic zones, preferably in fresh cultivation conditions with unstable and insufficient moisture. As an exception, fresh log cabins with a continuous layer of litter can be used to plant Scots pine without soil preparation.

In areas with sparse forests and forest fires, the cost of complete land preparation for forest crops is high. In addition, it is recommended to use natural regeneration of target species in the stands to form future plantations, so in such forests it is recommended to partially prepare the soil for pine crops by conventional felling. The shape of the tape or groove. Many publications by M.I. Gordienko describe the convenience of this method of soil preparation for pine crops.

In the Ukrainian Polissya, most of the territory is covered by sands and poor soils where pine and birch can grow. In the very dry pine conditions of the northern Polissia and forest-steppe regions, the introduction of Banks pine and loblolly pine is recommended, as loblolly pine has high biological resistance in the first decades and grows faster. Banks pine should be introduced into forestry crops in clean rows after one or two rows of loblolly pine.

There are different opinions about the impact of hanging birch on the growth of lodgepole pine, since the roots of lodgepole pine in a mixed forest of pine and birch deviate from the roots of hanging birch, and the mass of pine roots is reduced by 4.5 times. times. The cleaner the stands.

According to Rakhtienko, it is known that the roots of lodgepole pine penetrate deep into the roots of birch, taking advantage of the increased fertility of their rhizosphere. The addition of several hanging birches in the immediate vicinity can also increase photosynthesis in lodgepole pine trees. However, studies conducted on 15-year old lodgepole pine plantations did not reveal any significant differences in tree growth rates in pure plantations compared to those mixed with birch. Mr. Georgievsky noted that birch trees can negatively affect the health and growth of young larch trees.

Compared to the poor forest soil, the subspecies soil is richer and is a sandy loam with a layer of loam and clay deep beyond the reach of its roots.

Therefore, the best mixture for loblolly pine in fresh and moist forest conditions is petiole oak, which increases soil fertility with the onset of autumn and absorbs nitrogen and nitrogen with the same intensity, and less during certain periods of growth. This positive effect on the soil contributes to an increase in the growth rate of scots pine trees, as evidenced by organic precipitation.

When growing loblolly pine, it is better to introduce oak into a clean row every 3 - 5 rows of loblolly pine. During the main harvesting of 9-10-year-old oak pine, the stock of dry oak wood material is 40-50 cubic meters per hectare.

The introduction of the common spruce was proposed by Polystyrol Pogrebnyak, who saw its advantages mainly in its beneficial effect on the subgenus of the common oak. According to Pogrebnyak, the roots of the common oak do not compete with the common spruce, as the oak forms a deep root system, while the spruce has a shallow one [38].

G. F. Morozov noticed that in depleted sandy soil, Scots spruce tends to remain under the cover of the main layer of the plantation. This is because the main layer of the plantation is in much less competition for nutrients. Nevertheless, it is important to note that this phenomenon will inevitably lead to a decrease in the growth rate of Scots pine in the vicinity.

BIOLOGICAL AND ECOLOGICAL FEATURES OF SCOTS PINE.

Ukraine's forest cover is gradually expanding; however, the problem of providing the national economy with timber remains unresolved. To solve this problem, one solution is to grow fast-growing tree species in plantations with a shorter harvesting period. In the northern forest-steppe of Sumy region, this includes Scots pine. In the process of establishing loblolly pine plantations, questions arise about the optimal initial density for crops and the appropriate thinning intensity during thinning operations. Many scientists have tried to solve these issues.

It has been established that the taxation indicators of plantations depend on their initial completeness, which is established during the formation of pine cultures. In addition, it depends on the density that was maintained during thinning of plantations during felling of forest maintenance.

In the late 1970s, researchers conducted a study of loblolly pine plantations that had different initial densities ranging from 1000 to 4000 units per hectare. Their conclusions showed that the ideal density for creating such plantations, according to the data obtained, is approximately 2000 trees per hectare.

According to the research of O.P. Ryabokon on experimental stands of pine of different completeness, it is necessary to carry out timely thinning in densely populated crops (10-20 thousand pieces-ha-1). This is due to the fact that, compared to thinned crops (2.5-5 thousand units ha-1), the average diameter is reduced by 42%, and the volume of trunks - by 106% [10].

Having studied the growth of pine plantations of different densities, Klymenko found that in dense crops, the supply gradually decreases over 50 years. This is in contrast to crops with sparse planting, which show a difference of 27%. The study is documented.

Scots pine *(Pinus sylvestris) is a* tree species that grows in temperate climates and has a wide distribution area. In the Polissia region of Ukraine, Scots pine is the main forest formation type. This tree can grow in both mixed and pure stands, and is common in the northern Forest-Steppe, and occasionally on sandy lands in the Steppe. According to sources, about 35% of the state forest fund of Ukraine is made up of Scots pine.

As a rule, Scots pine grows in the primary forest layer and can reach a height of 20 to 50 meters with a diameter of 1.0-1.5 meters. These measurements differ significantly from other types of forest vegetation. Its crown usually has the shape of a pyramid or cone and ring-shaped branching. When young, the shoots of loblolly pine are greenish, but turn yellow with age. In addition, two conifers 4.5-7 cm long grow on the yellow shoots. The upper shoots are dark green and convex.

Scots pine is not very special when it comes to the fertility of the soil it grows on or the ambient temperature. It can thrive in a variety of trophic and hygrophic conditions, each with a different degree of productivity. Although it prefers sunlight and can tolerate direct exposure, this species does not tolerate shade, especially in the early stages of development. Loblolly pine is also known for its rapid growth rate, with the most significant growth periods occurring between the ages of 20 and 40 years, as documented in the sources.

Despite the difficulties, Scots pine is a tree species that thrives in dry hygrothermal forests and undergrowth due to its xerophytic nature. Loblolly pine is able to adapt to temperature fluctuations and has exceptional frost resistance, which allows it to withstand unfavorable temperature conditions.

The development of the root system of Scots pine depends on the environment in which it grows. As a rule, in areas with moist and fresh soil, a primary root system with accompanying lateral roots is created. Conversely, in dry areas, the root system consists of a weak taproot and strong lateral roots. In areas with excessive moisture, a shallow root system develops instead. The adaptability of the root system to the environment is what makes loblolly pine a valuable tree species that can thrive in a variety of growing conditions, regardless of moisture levels or soil quality. This information is confirmed by sources.

CREATING PINE CULTURES IN FRESH FORESTS.

In the 1800s, the first attempts were made to grow loblolly pine forest crops. Since then, many scientists, including prominent foresters such as Arnold, Shelgunov, Alekseev, and Gordienko, have devoted a significant amount of research to this topic. Their work has been studied and expanded in order to accumulate knowledge in forestry.

In the forested areas of Polissya and Forest-Steppe, where pine plantations grow, boron conditions prevail. These conditions are mainly located in areas that are dry, fresh and moist, but infertile. This is confirmed by sources.

Currently, the main approach to reforestation in newly created forests is to create artificial forest plantations. This approach is justified by the fact that under unfavorable soil and climatic conditions, natural regeneration of loblolly pine is impossible.

Enterprises in Ukraine engaged in intensive forestry tend to favor artificial reforestation over other methods. This is because artificial reforestation offers a number of advantages, including the ability to select specific species for plantations and to plan the number of planting sites on a forestry plot, which leads to faster movement of forest crops into the forest zone. In addition, the costs associated with artificial reforestation are paid off by increasing the timber supply over several years of the existence of the medieval plantations, as evidenced by sources.

When creating forest cultures of loblolly pine in fresh forests, it is recommended to use annual seedlings for planting. The best time for planting is early spring, in dry conditions and on granular soils. In the case of autumn planting, this can also be done on these soils. When creating pine plantations in these conditions, it is advantageous to introduce hanging birch with two-year-old seedlings with strong upper shoulder straps. In addition, the root system should be well developed and branched, with lateral roots.

Seedlings are inspected shortly before planting, and damaged ones are rejected. To prevent the roots from becoming entangled during planting, the root system is cut to a uniform length. Before planting, the roots of the seedlings are dipped in a pot of liquid clay humus, which increases the chances of survival. Additionally, growth stimulants are added to the pot to further promote their survival.

To increase the survival rate and stimulate the growth of loblolly pine seedlings, the introduction of mycorrhizal fungi into the soil has proven to be effective. These fungi are present in large quantities in the topsoil and organic matter found in thriving lodgepole pine habitats.

Scots pine is grown both by hand and with the help of machinery, under the influence of the Kolesov method.

When working with pine environments, it is not recommended to plant loblolly pine seeds. This is due to the correlation between seeds and insufficient soil fertility and moisture content, which are important for seedling growth and maturation.

If there is sufficient moisture, partial sowing is recommended.

In the rich pine environment of Polissia, it is possible to grow both pure and mixed pine plantations. Although pure pine plantations are easier to establish, maintain and develop, they have certain disadvantages. These include lower productivity and biological susceptibility to pests and diseases. On the other hand, mixed plantations have the advantage of being more resistant to such problems.

The impact of pure pine forests on the soil is unidirectional. These plantations accumulate a significant amount of coniferous debris, which is poorly mineralized and leads to soil acidification. As a result, the availability of minerals is limited.

feeding.

The coexistence of deciduous trees with mixed pine plantations has a positive effect on the mineralization of the litter and the accumulation of organic compounds that contribute to soil fertility. Taxation indicators in mixed pine plantations at the age of eight years exceed those of pure ten-year-old plantations. In addition, mixed pine plantations have a higher degree of biological stability, as evidenced by the literature.

Hanging birch and lodgepole pine are often found together in forested areas. However, it is impractical to introduce the common oak into such an environment, as it lacks the necessary nutrition and moisture to survive for more than a year. An exception is red oak, which can be grown in fresh forests as a soil improvement. It is recommended that red oak be no more than one component of a pine plantation. Undergrowth is not typical for pine forests, although rowan and juniper are sometimes found.

There are conflicting opinions among established scientists about the impact of birch on pine growth. A study has shown that if more than thirty percent of birch trees grow next to a pine plantation, it can hinder the growth and progression of lodgepole pine.

According to some scientists, the growth rate of lodgepole pine trees mixed with hanging birch is noticeably slower, and it takes thirty years longer to mature compared to pure crops of the same species.

Until the age of 60, the growth of pine and birch plantations is sufficient to compensate for the losses. However, after the age of 60, the productivity of these plantations is accelerating and exceeding the productivity of pure Scots pine plantations.

When creating new forest areas, experts suggest introducing a variety of forest crops, including:

For fresh felling, a mixture of 75% lodgepole pine and 25% shrubs such as gray alder, juniper and red elder in lowland areas is used. The composition is known as a pine-shrub mix and is achieved by mixing three rows of lodgepole pine followed by one row of shrubs.

The initial composition of pine and birch with shrubs consists of half pine, a quarter of hanging birch and a quarter of shrubs. To mix this composition, plant four rows of scots pine, then one row of shrubs, two rows of hanging birch and another row of shrubs. This type of composition is recommended for use on old farmland and old log cabins. When planting under these conditions, it is recommended to use two-year-old seedlings for hanging birch.

The pine-birch forest type lends itself to a variety of crop combinations, with mixing schemes being viable options in different forestry areas. These mixing schemes have been investigated and documented in the literature.

The density of plantations during their establishment is crucial for the formation of thriving and biologically balanced ecosystems. With increased planting density, movement into the forest is faster and the negative impact of herbaceous vegetation is minimized. In addition, dense plantations experience fewer complications with removing knots during harvesting. However, it should be noted that the maintenance of such crops requires considerable effort, as evidenced by the sources.

To achieve maximum density when planting fresh pine, certain layout schemes are used. These schemes include row spacing of 1.5-2 meters with a planting distance of 0.75-0.5 meters. However, in the case of pine trees, it is important to note that widening the rows may extend the time required for the forested area to be populated by the main species. This information is confirmed by the source.

For optimal reforestation of Scots pine in arid conditions and on grassy lands, it is recommended to carry out continuous tillage as a priority.

The use of continuous tillage contributes to the full mechanization of sowing and crop care. However, this method is more costly and can only be carried out in advance on non-forest lands, wastelands, meadows, clearings, abandoned agricultural lands and forest clearings after uprooting affected by root rot. In such cases, it is recommended to pre-plant hardwoods and shrubs in a mixture. You can also sow perennial lupine in the aisles. To increase fertility, it is necessary to implement a side pairing system with gill treatment elements. To prevent the root fungus from damaging the plantings, it is necessary to destroy the "plow sole" with the RX-60 tools. This will lead to the formation of a taproot system of medieval plantations.

In forests with soaked fresh logs, you can limit yourself to tillage using platforms or strips with the application of PBN-1, PL-1.2 with simultaneous surface loosening.

When constructing new dry log cabins, the process of preparing the soil for forest crops involves the use of loosening equipment. Strip tilling is not recommended in this scenario, as the humus accumulation horizon has limited capacity.

To achieve the best results, it is recommended to use disk harrows (BDNT-2.2, BDT-2.0) to lay strips on the wet ground around the log cabins after removing the stumps. The next step is to cut furrows with the PKL-70 plow and then use the KLB-1.7 cultivator to return the layer to the bottom of the furrow.

In cases where furrow cultivation is impractical, forest crops are grown on platforms. This method of cultivation is commonly used in agricultural regions, as well as during the rehabilitation of low-value plantations and on clearcuts where undergrowth already exists.

In the first years after planting forest crops, agronomic care is of great importance. This care helps to eliminate weeds, which are direct competitors of forest crops, as well as to promote the decomposition of organic residues and generally improve the water and physical properties of the soil.

In early spring and early summer, an excessive amount of weeds may appear, which impede the growth of young loblolly pine trees. The success of their growth and development in the early years depends on the correct implementation of agrotechnical measures.

Frequent application of agronomic practices can damage the root system of Scots pine trees, leading to a discrepancy between the aerial part and the roots. To prevent this from happening in forestry, Polissia recommends 5 -6 agronomic measures, taking into account the condition of the forestry territory and weather conditions. Agronomic care should be carried out within the first three years after planting forest crops. In the first years, a mechanized regime of care is applied using a KLB-1.7 row cultivator, and manual weeding with a shovel in the row. In subsequent years, mechanized cultivation is carried out in the inter-rows with a KLB-1.7 cultivator with an increase in the protective zone to prevent damage to the root system of Scots pine trees.

It is recommended to apply fertilizers in the spring together with agronomic care to enhance the growth of forest vegetation communities.

PROGRAM AND METHODOLOGY OF FIELDWORK.

Materials and methods of the study**. Scots** pine seedlings were grown in 2022 at the selection and seed complex of the State Enterprise "Tomashivske Forestry" from pre-prepared improved seeds: seedlings were grown in open ground using recognized technology, seedlings were placed in boxes for growing in closed ground.

Figure 1. View of the container with seedlings.

Container dimensions: height - 25 cm, diameter - 6 cm, volume - 707 cubic centimeters. The composition of the substrate for filling the container is a mixture of dark gray medium loams and sandy loams with good humus in a 1:1 ratio, transitional peat and humus in a volume ratio of 3:1:0.25. Crops are planted manually: seedlings with ZKS are planted under an electric drill, and seedlings with VKS are planted under the Kolesov sword.

Figure 2.View of seedling plots.

The soil cultivation process involved creating 60 cm wide furrows using a combined forest plow (PCL-70).

In order to study the peculiarities of growing Scots pine in the Romny Forestry, located in the southeastern region of the Left Bank Forest-Steppe, a 0.10 ha experimental plantation was created in 2022-2023. The growth of forest crops obtained from both and seedlings was studied. In the closed environment of individual containers, pine seedlings were grown and in the open ground, various intensification techniques will be used to test their survival and further growth, crop growth, and the possibility of summer planting. Seedlings of SCC and comparison with the growth rates of VCC seedlings.

The location of the planting sites is as follows: seedlings with VCS are placed at intervals of 2.5x0.7 meters, and seedlings with ZCS - 2.5x1.0 meters.

The viability of one- to two-year-old pine seedlings was assessed at the end of the growing season as the ratio of the number of live seedlings to the number of seedlings planted in the experiment, expressed as a percentage. The value M±m represents the mean value of the recorded value together with its standard deviation, expressed as a percentage. This percentage indicates how much the measured value exceeds the control.

Biometric parameters of the pine harvest (average height, diameter and height growth) were determined annually for two years by direct measurements and subsequently recorded in field experiments. At least 150 to 200 seedlings per variant (VCS and WCS) are tested annually.

The visual assessment of the studied crops included an assessment of their hygienic condition. This assessment took into account any observed damage to branches, trunks, roots (both whole and their individual parts), as well as any changes in the shape of the crown. A numerical code [8] was assigned to each type of damage observed. The degree of damage to forest crops was assessed by the condition index (Ic). Ic is calculated according to the following system:

$$Ic = \frac{1}{N}\sum_{j=1}^{N} K_j \cdot n_j ,$$

Where: Is is the condition index; Kj is the j-th condition category (from I to VI); nj is the number of pine seedlings of the j-th condition category, pcs.

THE RESULTS OF EXPERIMENT 1.

One of the main advantages of planting material grown in closed ground instead of seedlings grown with an open root system is that it eliminates the need for temporary digging on the territory of the forestry. This approach also minimizes plant injuries during transportation and transplanting into crops. In addition, it makes it possible to extend the period of planting forest crops and applying fertilizers, moisture accumulators and other substances at the required rates for each plant. These advantages were emphasized in the studies of Savich (1979), Zhigunov (2000) and Vedmid (2007).

In the basic nursery of the Hlynske forestry, the survival rate of Scots pine seedlings was assessed, comparing the conditions of open and closed ground. Biometric measurements of the grown seedlings were carried out in the fall. The average biometric parameters, which included the height of the aboveground part, growth and diameter of the root collar, fluctuated in the samples of Scots pine at the end of the growing season.

By analyzing the data, it was confirmed that there is a marked predominance of average biometric measurements in plants grown from seedlings, as opposed to those obtained from VKS seedlings. This statistical analysis was performed to determine the differences between the two groups.

Measurements of biometric and qualitative parameters of the grown seedlings were carried out in the fall. The average values of biometric parameters (height, growth, and diameter at the level of the root collar) of scots pine planting material grown in containers and in closed ground after the growing season differed significantly.

At the end of the initial season of forest crops growth, the results of the research showed that the survival rate of crops grown from WCC seedlings (96%) was significantly higher than that of crops grown from HCC seedlings (80%). Large plant losses (LPL) are associated with damage to the root system by beetles due to possible planting in spring.

As of 2022 (crop age - 1 year), forest crops grown from VCS seedlings were 15 cm high, as opposed to plants with ZCS - 23.9 cm, respectively. In 2023, this figure was 40.6 cm for seedlings with VCS and 50.8 cm for seedlings with ZCS, respectively (Another important biometric indicator is the diameter of the root collar,

which is shown in Table 3.3 - in 2022, it was 6.8 mm in the established cultures of scots pine from seedlings with VCS and 8.5 mm.

The data obtained statistically confirmed the predominance of average biometric parameters of plants in crops created from seedlings compared to crops created from VKS seedlings: 50% higher height, 38% higher growth in height, 25% higher growth and larger diameter of the root collar. This trend is confirmed in forest crops grown from VKS and ZKS seedlings - 78 cm, 15 mm and 33 cm, respectively.

The data obtained statistically confirmed the dominance of average plant biometric parameters in crops created from ZKS seedlings compared to crops created from VKS seedlings: 30% higher height, 17% larger root collar diameter, and 22% higher height growth. It should also be noted that the SCC seedlings produced crops with better storage stability and sanitary conditions - 91 vs. 75%. In general, forest crops grown from SCA seedlings developed successfully due to better survival and growth time of the crop both during the year and within two years.

The comparison found that forest crops grown using closed-root seedlings have a more developed root system at two years of age, including a stronger taproot and lateral roots, compared to crops grown from open-root seedlings. These characteristics generally contribute to improved survival rates and more successful growth for established forest crops. The results of the research are significant and should be taken into account when developing or improving existing regulations for forestry in pine forests.

RESULTS OF EXPERIMENT 2.

The greenhouse soil was sown manually with Scots pine seeds in 2 cm wide strips with a distance of 15 cm between each strip. The optimal biological and economic density for growing annual pine seedlings is considered to be 950-1000 pcs/m^2, which is achieved by sowing 230-260 germinating seeds per linear meter. However, forestry enterprises usually sow 300 germinating seeds per linear meter. This often leads to overcrowding, which results in lower quality seedlings and fewer standard seedlings. To test this, three seeding rates were used simultaneously in the experiment: 200, 250 and 300 seeds per 1 m^2 , or 1.8, 2.4 and 3.0 g, respectively.

Before planting, the greenhouse substrate is prepared. The substrate consisted of alder soil with an acidity level of pH = 5.0. The soil was sifted and laid down with a layer of 30-40 cm, on top of which 5-10 cm of sand was added and dug up by hand. Under the cord, two small ridges 0.8-0.9 m wide with 0.3 m paths were constructed. These ridges were then placed along the greenhouse.

For sowing, we used ordinary first-class pine seeds obtained from the forestry. Before planting, the sowing tapes were applied with Bordeaux liquid at the rate of 0.5 liters per 1 meter. The seeds were planted manually according to the experimental plot layout. The remaining area in the greenhouse corresponded to the standard seeding rate of 3.0 g (300 seeds) per 1 meter. After planting, we installed an irrigation system and started drip irrigation.

During the embryonic stage of ontogenesis, which is related to dry seeds, the main problem is the availability of excess nutrients to support the survival of the embryo until optimal germination conditions are reached. The most favorable conditions for germination are an air temperature of 14-16°C and air and soil humidity of 75-80%. In greenhouse conditions, these factors were regulated, which led to the emergence of healthy sprouts in 10-15 days. It was observed that the density of seed sowing had no effect on seed germination (Table 4).

Table 4. Germination of Scots pine seeds depending on the seeding rate.

Seeding rate, pcs./m	Number of plants, pcs./m	Germination rate, %.
200	184	92
250	235	94
300	273	91

The point at which roots emerge from a seed is the beginning of the germinal stage of ontogeny. In the life of woody plants, the embryonic stage of ontogeny (which covers the period of seed germination and sprouting) is the most important. During the juvenile stage, the development of seedlings can be divided into several phases: emergence of seedlings, formation of true needles, appearance of the apical bud and the beginning of branching. Vegetation observations were conducted, in which the following periods were distinguished: the first period - from sowing to the emergence of mass shoots, the second period - from mass shoots to their complete rooting (in anthers - to the formation of true conifers), and the third period - characterized by intensive growth and formation of shoots.

The seeding rate did not affect the time from sowing seeds to emergence. In all experimental groups, seedlings germinated in 7-8 days. In addition, the formation of conifers after mass germination in all groups took approximately 35-36 days. The simultaneous growth of seedlings with different densities can be explained by their small size during initial development, which allowed them to thrive regardless of the feeding area (Table 2.2).

In the course of further experiments, it was found that a decrease in the feeding area at a higher seeding rate significantly affected the developmental stages of pine plants. At a seeding rate of 200 seeds per meter of furrow, it took 144 days for coniferous plants to form and reach standard seedling sizes. However, with an increase in the seeding rate, the plant nutrition area decreased, and, as a result, this period was reduced. For example, the duration was reduced to 125 days for a seeding rate of 250 seeds per meter and to 105 days for a seeding rate of 300 seeds per meter. The vegetation period for seedlings was also reduced accordingly, namely to 180 days for 200 seeds per meter, 160-250 seeds per meter and 140 days for 300 seeds per meter by the end of the growing season in 2014. Therefore, the denser sowing resulted in faster seedling growth and achievement of the standard height.

Table 5. Development of loblolly pine plants depending on the seed rate.

Seeding rate, pcs./m	Duration of the period, day			
	From sowing to massive shoots	From mass shoots to needle formation	From the formation of needles to the seedlings reaching standard sizes	Growing season, total
200	7	36	144	180
250	7	35	125	160
300	7	35	105	140

The biometric parameters of loblolly pine seedlings, such as their height, root collar diameter and root system length, play a significant role in determining the quality and viability of the planting material during planting. These parameters must meet the standard requirements for optimal results. According to the standard, pine seedlings of the first grade should have a height of at least 15 cm, a root collar thickness of at least 3 mm, and a root system length of at least 20 cm. Pine seedlings of the second grade should have a height of at least 10 cm, a root collar thickness of 2-3 mm and a root system length of 15-20 cm.

The highest values for all biometric parameters, including seedling height, were shown by seedlings grown at a minimum density of 200 pcs/m.

According to Table 3, the diameter of the root neck is 19.2 cm, the length of the root system is 22.5 cm, and the length is 2.8 mm. Seedlings grown at a sowing rate of 250 pcs./m had slightly smaller sizes, but still met the required standards, with a diameter of 16.7 cm and a length of 2.4 mm.

Table 6. Linear performance of loblolly pine seedlings depending on the seeding rate.

Seeding rate, pcs./m	Seedling height, cm	Root neck diameter, mm	Root system length, cm
200	19,2	2,8	22,5
250	16,7	2,4	19,3
300	15,4	1,3	17,2
NIR05	1,1	0,2	1,3

According to Table 3, the measurements for seedlings grown at a seeding rate of 300 per meter gave the lowest biometric parameters with a height of 15.4 cm and 17.2 cm, and a thickness of 1.3 millimeters. The diameter of the root neck did not meet the standard when sowing at maximum capacity. The corresponding length of the seedlings was 19.3 cm.

The optimum density for growing annual pine seedlings in a greenhouse from both a biological and economic point of view is considered to be a density of 950 to 1000 per square meter. During the experiment, 184, 230, and 260 Scots pine seedlings per linear meter were obtained, resulting in 920, 1150, and 1300 seedlings per square meter, respectively (see Table 4). It was observed that the highest number of seedlings was obtained at the maximum density, while the lowest number was obtained at the minimum density. However, not all seedlings reached the required standard size with a root collar diameter of at least 2 mm. Thus, the maximum yield of standard planting material per 1 square meter is achieved at a seeding rate of 250 to 904 seedlings per square meter. At the minimum seeding rate, the yield is somewhat lower - 823 seedlings per square meter, and at the maximum - the lowest - 421 seedlings per square meter.

Table 7. Yield of standard lodgepole pine seedlings depending on the seeding rate.

Seeding rate, pcs./m	Total yield of seedlings, pcs./m^2	The output of the machine	of seedlings
		pcs./m^2	%
200	920	823	89,5
250	1150	904	78,6
300	1300	421	32,4
NIR05	-	29,2	-

The yield of standard seedlings as a percentage of the total number of seedlings is higher than the minimum seeding rate - 89.5%. On the other hand, the average rate gives a slightly lower yield of 78.9%, while the highest rate gives the lowest yield of 32.4%. Optimal yields of standard pine planting material were obtained at seeding rates of 200 and 250 pcs/m. With an increase in the seeding rate, the plant nutrition area decreased, resulting in a shorter growing season for seedlings, which, in turn, allowed them to reach the standard height faster. At the initial stages of development, the seeding rate did not significantly affect the growth rate of plants. Plant density did not affect seed germination, but did affect linear parameters. The minimum density gave the highest values of linear parameters, followed by the average seeding rate, while the maximum seeding rate gave the lowest values.

After conducting research on different seeding rates, it was found that the largest amount of standard planting material was obtained at a seeding rate of 250 seeds per meter. A slight decrease in productivity was observed when the seeding rate was the minimum - 200 pieces per meter, while the lowest yield was recorded when the maximum seeding rate of 300 pieces per meter was used. In addition, the share of standard seedlings in the total number was highest at the minimum seeding rate, lower at the average, and lowest at the maximum.

CONCLUSION.

In the Left-Bank Forest-Steppe of Ukraine, there is a lack of information on the growth characteristics of forest crops, including Scots pine (Pinus sylvestris L.), in different planting environments, such as seedlings with open and closed root systems.

Nowadays, the question of what type of planting material is used in the creation of forest crops is very relevant, since the productivity of future plantations directly depends on it. A study was conducted to compare the growth of scots pine forest crops using seedlings with an open or closed root system over a five-year growing period in the southeastern zone of the Left Bank Forest-Steppe of Ukraine. In the fall of 2022, the experimental crops were planted with annual loblolly pine seedlings that had a closed root system and were grown in open ground conditions. In the spring of 2023, the experimental crops were planted with annual scots pine seedlings that had an open root system and were grown in closed ground conditions.

The creation of facilities that facilitate forest restoration is based on various actions, such as researching areas where deforestation is planned, transferring land for protective plantations, using forest survey data, and utilizing scientific knowledge and successful precedents.

The rules and regulations for the use of forest reproduction technology are established by the SAFR through the development and approval of regulations in accordance with the established procedure. Forest reproduction is carried out with the help of state programs and projects, the priority of which is the use of effective technologies for the creation of highly productive forests consisting of economically valuable trees and shrubs within the established timeframe.

In regions with favorable environmental and soil conditions, the focus is on natural forest regeneration. This approach allows for the creation of highly productive and environmentally sustainable forests in a short period of time while minimizing costs. Permanent forest users and forest owners develop a project for the establishment of forest crops for each plot after a thorough survey conducted at least one year before afforestation. The method of soil cultivation used should provide optimal conditions for the growth and survival of trees. Before planting or sowing, seedlings and seed material can be treated with substances that increase resistance to desiccation, pests and diseases, as well as to increase growth and survival.

To ensure optimal survival and preservation of forest crops, they are planted in certain periods. In the studied range of seeding rates, the highest yield of standard planting material was obtained at a seeding rate of 250 pcs/m. At the minimum rate of 200 pcs./m, the yield is slightly lower, and the lowest is at the maximum seeding rate of 300 pcs./m. At the same time, the yield of standard seedlings as a percentage of the total number is higher at the minimum seeding rate, it is lower at the average rate, and the lowest at the maximum rate.

The planting scheme for seedlings with an open root system is 2.5*0.7 meters, and for seedlings with a closed root system - 2.5*1.0 meters. The study used methods of silviculture, forestry, and forest crops. The data obtained show that the biometric parameters of seedlings, including average height, diameter and height growth, are significantly higher in pine cultures created from seedlings with a closed root system compared to their counterparts grown from an open root system.

When creating pine crops through seedlings with an open root system at the age of two, the growth indicators were as follows: height - 40.6 cm, root collar diameter - 8.6 mm, height growth - 19.5 cm. Instead, the seedlings with a closed root system had a height of 50.8 cm, a root neck diameter of 10.2 mm, and a height increase of 22.2 cm. The difference in relative values between them is 7% in height, 15% in diameter and 4% in height growth.

In addition, it was observed that forest crops grown using closed-root seedlings showed a more advanced root system after two years of growth compared to crops established using open-root seedlings. This advanced system included a strong taproot and lateral roots, which resulted in increased survival and successful growth of the established forest crops. It is important to consider the results of this study when developing or refining existing regulations for forestry in pine forests.

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CULTIVATION OF *LAVANDULA* PLANTING MATERIAL IN THE CONDITIONS OF THE EDUCATIONAL LABORATORY OF HORTICULTURE AND VITICULTURE OF THE SUMY NAU

Horbas Serhii Mykolaiovych
Candidate of Agricultural Sciences
Associate Professor of the Department of Garden Design and Forestry
Head of the Educational Laboratory of Horticulture and Viticulture
ORCID ID: 0000-0003-3768-8833

Kytaihora Anton Vasylovych
Master of Industrial Training of the Educational Laboratory of Horticulture and Viticulture
assistant PhD
ORCID ID: 0009-0008-0459-3508

Prokofiev Dmytro Serhiyovych
assistant PhD
Sumy National Agricultural University, Ukraine
ORCID ID: 0009-0009-3190-5607

Lavender is a leading crop for obtaining essential oil, which is in great demand both in Ukraine and around the world. Natural essential oil and essential oil raw materials are used in numerous branches of domestic industry and medicine. Lavender is also known for its value as a honey plant and a popular decorative element.

Many aspects of cultivation and biological features of plants of the genus *Lavandula* have been studied by scientists both in Ukraine (A.P. Merkuryev, T.M. Latushkina, I.V. Belova, O.P. Yunosheva, L.A. Kotyuk, V.D. Rabotyagov , D. B. Rakhmetov, L. V. Svidenko, L. D. Yurchak, O. I. Popova), and abroad.

Since the main areas under cultivation of lavender were located mainly in the Crimea and in the south of Ukraine, scientific research on this culture was carried out in accordance with the growing conditions in these regions. However, global changes in climate, such as an increase in temperature and a decrease in precipitation, open the possibility for the cultivation of lavender in the conditions of the forest-steppe zone. Despite this, scientific information on the specifics of lavender cultivation in this area, its reproduction and cultivation, is quite limited.

In order to further expand the area of industrial cultivation of lavender in Ukraine, scientific research is needed, which will allow to develop effective cultivation technologies with obtaining high-quality essential oil products. Thus, there is a need to conduct research in areas that were previously not typical for growing lavender, including the Forest Steppe of Ukraine. Until now, many aspects of this problem remained insufficiently researched, and these questions became the object of our research.

The purpose of the study: Studying the possibilities and optimization of the process of growing planting material of the *Lavandula* plant in the conditions of the northeastern forest-steppe of Ukraine.

Objectives of the study:

1. Analyze the history of lavender culture and the main conditions for its introduction;
2. To analyze the main morphological and biological features of *Lavandula* planting material, the practical value of *Lavandula*;
3. Investigate the location of the research object, soil and climatic conditions of the area, materials and methods of research;
4. Investigate the effect of stimulants on the rhizogenesis of lavender cuttings (*Lavandula*);
5. To characterize the features of the development of lavender plants when rooted by cuttings;

Object of research: The process of growing planting material of the *Lavandula* plant.

Research subject: Optimizing the conditions and parameters of growing *Lavandula* planting material in the conditions of the northeastern forest-steppe of Ukraine.

Used scientific methods and research methods: In the course of this study, both general scientific and special research methods were used. General scientific methods included such stages as formulating a hypothesis, conducting an experiment, systematic observations and analysis of the results of the obtained data. These methods allowed us to approach the solution of the investigated tasks in a structured and scientific manner.

Among the special methods that were used, it is worth noting the following: Laboratory method for determining the agrochemical parameters of the soil and the quality of the essential oil. Yield by calculation-weight method for determining yield. Determination of the content of inorganic elements in bio-raw materials and oil. Field method for determining the influence of biotic and abiotic factors of the environment on the growth, development and biometric parameters of plants. A statistical method for conducting dispersion and correlation analysis, which allowed us to objectively evaluate the results of the study. Calculation and comparative method for establishing the economic efficiency of the application of technological measures of lavender cultivation.

The collection of lavender has been known since the 12th century in the Provence region of France. The first attempts to create lavender plantations for oil production were known in the Duchy of Burgundy from the 14th century. The principles of lavender cultivation have been passed down from generation to generation and developed over the centuries [4] .

In the Middle Ages, lavender also became famous in the British Isles. From the beginning of the 13th century, the plant was included in the list of medicinal products, and already in 1568, its active cultivation began in England. From the end of the 16th century, lavender began to be cultivated in many botanical gardens of Western Europe, as well as on a small scale for apothecary and amateur needs [8] .

Due to the popularity and demand for essential oil and lavender flowers, by the middle of the 19th century, most of the raw materials were exported outside of Southern

Europe. However, the demand for lavender raw materials for the light and food industry exceeded the capabilities of wild plants, and therefore, from 1890, the first industrial lavender plantations began to be created in France.

The spread of lavender cultivation on a large scale took place in the 20s of the last century and spread to various countries, including Italy, Spain, Yugoslavia, Germany, Hungary, Bulgaria, the Czech Republic, Romania, the United States of America and some Asian countries.

These attempts to introduce and cultivate lavender testify to the interest in this plant and its importance in the pharmaceutical and decorative spheres in past centuries.

Initial attempts to create production lavender plantations were made in 1929 in the Crimea, especially in the vicinity of Gurzuf. Seed plantations were also established. From 1930 to 1932, the cultivation of lavender on an industrial level spread to the Crimea, the Kuban, and later to the southern regions of Ukraine, Kyrgyzstan, Tajikistan, and Georgia. Since 1946, lavender has been actively cultivated in Moldova [8].

Research was also carried out in Kyiv and in the north-west of Ukraine, where lavender plants kept their vital form, tolerated the winter well without shelter and bloomed annually. However, the seeds were formed in small quantities and not annually.

During this period, lavender selection was carried out abroad in various countries, such as France, Bulgaria, Czechoslovakia, Japan, Hungary, Austria, Romania, and Yugoslavia. For example, in France, seed populations of lavender are mainly researched and cultivated. High-yielding clonal varieties such as Blanket, Bled Alp, Blanche, La Carle Mayet, Materone, Barem were created there. Clonal varieties such as Kazanlik, Vinets, Aroma, Freshness, Karlovo, Hemus, which have a compact bush shape, are also grown in Bulgaria.

Lavender is a popular plant for landscaping. In foreign selection, there are many decorative varieties of lavender, which differ in various colors of the corolla. These include Dwarf Blue, Hidcote Blue, Munstead (with dark purple corolla), Hidcote Giant (with bright purple corolla), Atropurpurea, Twickel Purple (with dark purple), 10 Dutch (with blue), Nana Alba (with white), Loddon Pink, Rosea (with a purple-pink corolla) [3].

In recent decades, the cultivation of lavender has expanded significantly thanks to the introduction of machine technology. The yield reaches 6.5–7.0 centners per hectare, which makes this type of economic activity profitable. Mechanization simplified the most labor-intensive processes, such as growing seedlings in greenhouses and harvesting inflorescences with lavender harvesters, which replaced the cutting of seedlings with sickles. Also, the use of herbicides reduced manual weeding.

In the care of fruitful lavender plantations, it is recommended to take the following measures:

1. Treatment with herbicides in early spring.
2. One weeding in the rows and three inter-row treatments with a cultivator before harvesting.
3. One treatment with a cultivator after harvest.

4. In the autumn, at the beginning of the relative rest of the plants, carry out deep loosening with the simultaneous application of mineral fertilizers.

It is recommended to start picking flowers for essential oil in July when they are in full bloom, approximately 10-14 days after the beginning of flowering.

The productivity of cultivated lavender plantations depends on their care, the age of the plants, the lavender variety and meteorological conditions. It is important to note that lavender is a plant of a temperate climate, resistant to droughts and frosts. However, it has critical temperature limits that should not exceed -25...30 °C and below. In the presence of snow cover, the lavender plantation can tolerate lower temperatures. Late spring frosts, especially in mountainous areas, can damage plants.

If the shoots freeze, it is necessary to prune dry shoots, as well as "rejuvenate" the plants.

The analysis of long-term observations showed that lavender plantations, which are older than 5 years and do not have snow cover, can freeze partially or completely at an air temperature of -21...22 °C. If there is a snow cover of up to 10 cm, this critical temperature can be 5...7 °C lower. On the other hand, young lavender bushes (1–4 years old) survive the winter better in the same conditions [8] .

It is also important to note that the lavender crop begins to form in the summer of the previous year before harvesting. After the inflorescences are cut, buds formed on annual shoots can produce new growth and new inflorescences in the same year, provided there is sufficient moisture. This process of formation of flower-bearing shoots takes place without the need for low temperatures during a period of relative rest, which distinguishes lavender from some other plants, such as the ethereal rose.

The awakening of lavender in areas of industrial cultivation occurs in March–April, when the average daily air temperature consistently exceeds 8...10 °C in the Crimea and the Krasnodar region, or 10...14 °C in Moldova. In May, peduncles form, and in mid-June lavender plants enter the phase of the beginning of flowering [17] .

The beginning of flowering of varieties B-34 and Stepova occurs when the sum of average daily air temperatures is above 10 °C, which is equal to 1050 °C (on average by zone).

Regarding moisture circulation, there are three critical periods in the annual cycle of lavender development:

1. July-September, when the summer-autumn growth of shoots is formed.
2. March-April, when the maximum number of buds germinate.
3. May-June, when peduncles and flower whorls on them are formed [17] .

These critical periods can be defined by the need for moisture, and it is important to ensure adequate moisture levels during these times. How moisture-intensive a crop like lavender is requires a lot of moisture, and many other factors, including climate and cultivar. In general, the best lavender yields are obtained in wet years and in wet areas. It is also important to avoid excess moisture, as this can lead to diseases such as rot or wilt.

Places of natural growth of lavender are mainly located at an altitude of 700 to 1100 meters above sea level. These plants are usually found in mountainous regions where the climate is temperate and drier. Today, the industrial range of lavender is quite extensive and includes regions from the African coast and the islands of the Mediterranean Sea, Asia Minor and India to Great Britain and Norway.

It is noted that the best area for growing "thin" lavender is located in the French Alps. It is important to consider that lavender is a plant that has an influence of climate and environment on its production and quality. Displacing it from natural conditions can affect the characteristics of the plant and its essential oil. Therefore, when growing lavender outside its natural range, it is important to create optimal conditions for its growth and development, which are close to those that exist in the natural places of its growth.

The experience of growing lavender in different countries, including ours, confirms the possibility of obtaining high-quality essential oil that meets the needs of industry. This is possible not only in mountainous regions. In the past, for example, in the USSR, the best essential oil was obtained from plantations on the southern slopes of the Crimean Mountains, in particular in the Chatyr-Daga and Demerji areas, where there was also great confidence in the safe wintering of plants.

However, these regions are not the only possible areas for the expansion or establishment of lavender plantations. According to many researchers [63–65], there are new areas in different zones of Ukraine where it is possible to develop this culture. In Central Asia already in the 1930s, studies were conducted that confirmed the possibility of growing lavender, and this region, according to S. N. Kudryashov [66], can be the "second homeland" for this plant. According to the conclusions of E.V. Wulf and V.I. Nilov [17], there is also no reason to reject areas such as the Right Bank Forest-Steppe of Ukraine on limestone soils or even areas of Polissia.

Indeed, the territory of agricultural regions of our country, generally speaking, meets the requirements for the heat necessary for lavender to bloom. This process begins at an average daily temperature of more than 10 °C, which is equivalent to 1050...3060 °C. Accumulation of this amount of heat in the areas of developed agriculture is possible, but the limitations for the spread of lavender are the conditions of its winter overwintering and the suitability of the soil [8].

Areas for the introduction of lavender are limited by climatic and soil conditions, and they require regular rejuvenation of plantations every 4-5 years. Lavender is frost-resistant, provided this agrotechnical measure is carried out. This makes it possible to grow lavender even in the northeastern regions of the country.

In the territory north of this line, the average absolute minimum air temperatures are -30 °C, often falling to -28 °C, and here the snow cover can reach 40-50 cm, especially in the northwestern regions of the country, and in the southeast it is usually does not exceed 20 cm. The winter hardiness of lavender is determined by the height of the snow cover, since without it the shoots of the plant can freeze.

In the area south of the isoline of average absolute minimum temperatures, equal to -21 °C, lavender can grow and develop at any age, even without frequent rejuvenation every 4-5 years. This includes the southern regions of Ukraine, including the Crimea, with the exception of areas with desert soils, salt marshes and areas with excess moisture in the soil [8].

The geographical distribution of yield and oil content of lavender inflorescences is determined by agro-climatic conditions, and its main feature can be described as close to mountainous and foothill areas, which have high humidity. These regions are the most favorable for growing this culture.

Interestingly, in some mountainous areas with a dry climate, characteristic of subtropical zones, where other crops require irrigation to grow, lavender can grow successfully. Under these conditions, yields may be lower, but lavender oiliness may be higher due to hot and dry weather.

Lavender plants are also effective anti-erosion agents and can be used to conserve soils. Lavender plantations can be placed on slopes and on soils that are not suitable for growing other crops.

Lavender essential oil is most concentrated in glands located on flower calyxes. There is little oil in the flower corollas, but they are of the highest quality. The formation of essential oil in lavender plants is a protective response to drought. Therefore, the highest content of essential oil is observed in lavender inflorescences during hot daytime hours. The highest content of essential oil occurs 10-14 days after the beginning of flowering.

Researchers confirm that a decrease in temperature and an increase in air humidity beyond the specified parameters lead to a decrease in the content of essential oil in lavender plants. At low temperatures, dry air does not contribute to the formation of oil. According to the data of V. L. Zatuchnoi and M. Kh. Kigelman, dry sunny weather with high temperature contributes both to the strengthening of the process of oil formation and the accumulation of ethers.

Since lavender is mainly grown in southern Ukraine and Crimea, existing cultivation technologies were developed for these southern regions. Lavender is planted as a perennial plant outside crop rotation. For its planting, select areas that receive enough sun, have protection from north and north-east winds, and have a slight slope in the direction of south and south-west exposure.

The preparation of plots for lavender plantations takes place taking into account the technology and requires advance and thorough preparation. Special attention is paid to cleaning the field from weeds and tilling the soil to a certain depth.

If a lavender plantation is created after the cultivation of grain crops, grain-legume mixtures, then after harvesting these crops, the soil is treated, usually peeling, after 10-15 days the soil is treated with an amine salt-based herbicide to rid the soil of annual and biennial weeds, as well as thistles pink and yellow, the plants of which can grow quickly. After 10-20 days, peeling is repeated using a plow peeler.

In the southern regions of Ukraine, lavender plants are fed with mineral fertilizers (N100-120P100-120K40-60) and organic fertilizers (40-50 tons per hectare). Plantation plowing is carried out to a depth of 45-50 cm. After autumn plowing, the soil is leveled and left for the winter, and in the spring and summer of the following year it is kept in a state of black steam. At the end of September - at the beginning of October, lavender fields are cultivated with a chisel-cultivator to a depth of 20-25 cm [2,3].

Before planting lavender seedlings, a certain system of passages is created on the site. Longitudinal passages are made every 400-600 meters and transverse passages every 200-300 meters.

Lavender can be propagated both by seeds and vegetatively, using cuttings, division of the bush and branching (side shoots). Industrial conditions provide mainly a vegetative method of reproduction. Cuttings 8-10 cm long are cut in September-October from one-year semi-lignified shoots from 4-5-year-old mother bushes and planted in greenhouses. After the cuttings take root, seedlings grow from them.

The optimal time for planting lavender seedlings on the plantation is the second half of October and November. However, planting is also possible during the thaw in winter, as well as in early spring. Lavender is planted with the help of lavender ponds or by hand according to the scheme of 1.2 x 0.5 meters. When planting, the root neck of the seedlings is buried 5-6 cm below the soil surface, watered and covered with a layer of soil 3-5 cm thick.

Caring for young lavender plantations includes several important aspects [8] :

1. Protection against weeds: In early spring, before the start of lavender growth, soil herbicides such as simazine and promethrin are used at a dose of 2 kg/ha of the active substance. This helps rid the soil of weeds and ensure a healthy start for lavender.
2. Loosening the soil between the rows: Regular loosening of the soil between the rows of lavender helps to keep the soil in a relaxed state, facilitates the access of air and water to the roots of the plants.
3. Lavender planting: Timely planting of new plants in place of the dead helps to maintain the full area of the lavender plantation.

After entering the fruiting phase, lavender should be regularly fed with mineral fertilizers. In the second year of life, plants are recommended to be fed with nitrogen fertilizers at a dose of 50-60 kg/ha of the active substance in the spring.

Between the work of keeping the soil in a loose state and clean of weeds, it is also important to regularly trim the bushes. This includes removing dry and damaged branches. The next step is the rejuvenation of the bushes, which consists in pruning them by 1/2 of the annual growth. After rejuvenation, plants are fed with mineral fertilizers with the appropriate ratio of nitrogen and phosphorus (N60P60).

Plantation rejuvenation is recommended every 5-6 years of industrial operation.

The following measures can be used to control the main pests of lavender, such as the gamma bollworm, the head nematode, and the meadow butterfly, as well as to prevent root rot:

- Agricultural measures: Ensuring proper plant care, including adequate watering, fertilization, pruning, and removal of diseased or damaged plant parts. Regular inspection of the plantation can help detect pests and diseases in the early stages.
- Pesticide treatment: Use of pesticides or other chemicals as necessary to control pests and diseases. It is recommended to follow the manufacturer's instructions and take into account the recommendations regarding processing times and methods.

Regarding the collection of lavender, technical ripeness occurs in the flowering phase, when 50% of the flowers on the bushes open. The collection is carried out by cutting the flower stalks to a length of 10-12 cm. For collection, you can use a special lavender harvesting machine "Crimea", which simplifies the collection process.

Lavender seeds are small, about 2.1–2.8 mm long, 0.9–1.3 mm wide, and 0.5–0.8 mm thick. They have an oblong-elliptical shape and can be light brown to dark brown or even black in color. The seeds are smooth and glossy. Each seed has a scar, which has the shape of a sickle-shaped scar of white color, without a ridge.

Lavender (Lavandula) is a perennial evergreen semi-shrub that grows to a height of about 60 cm. This species of the genus Lavender grows naturally on the dry southern slopes of southern France, eastern Spain and North Africa. The main characteristics of this plant include [8]:

1. Root: The lavender root is woody and can penetrate deep into the soil. In the upper part, the root is usually thick and densely wet.
2. Leaves: Lavender leaves grow opposite each other, without a petiole (sessile). They can have a different color from dark to light green, sometimes gray-green. The leaves are usually lanceolate or linear, pubescent, narrowed at both ends, with slightly curved downward edges. These leaves remain on the plant throughout the year.
3. Shoots: A lavender bush can be spherical in shape and consist of an average of 400-500 semi-woody branched shoots, but this number can vary from 300 to 1000 per plant.
4. Lifespan: The average lifespan of lavender bushes is 20-25 years. After a certain period (usually 5–6 or 8–12 years), old shoots begin to dry out, and new replacement shoots are formed from buds on the root neck or on the lower parts of the branches.

Lavender is a prized species for its fragrant flowers, from which lavender oil is extracted, which has numerous uses in perfumery, aromatherapy and beauty products, as well as in cooking and for the creation of scented sachets and sachets.

Each main shoot of the plant ends with an inflorescence, which can have a spike-shaped or cylindrical shape and consists of separate multi-flowered pseudo coils. These pseudo spindles consist of two oppositely located half-spindles, each of which includes several flowers.

Lavender flowers have a cylindrical cup shape with five teeth and on the surface contain eight-cell glands, which are the main places for the accumulation of essential oil. The number of these spikes can indicate the amount of essential oil in the flowers.

This detailed information about the structure of lavender flowers is important for understanding how essential oil is formed and stored in these plants (Figure 1.1).

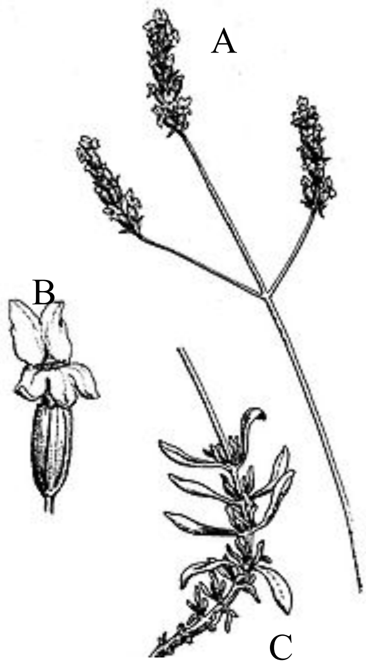

Figure 1.1. Micromorphology of lavandula flowers [18].

a - The top of the inflorescence during budding, with pronounced ribbing of the cups.

b - Dry cup with small light ethereal glands (original).

c - Magnified view of calyx surface with hairy epidermal cells (pubescence) and globular ether oil glands.

These images and details of their structure demonstrate the features of the sepals of lavender flowers.

The lavender flower has a top, which during budding is formed as a two-lipped corolla with fused petals. It also has four stamens and one pistil. The nectaries are located near the base of the flower tube and are protected from rain by a ring of hairs. The ovary is upper and four-lobed. The fruit is dry and consists of four dark, smooth nuts.

Until now, there is uncertainty about the total number of chromosomes in the lavender diploid set. Various sources indicate that this number can vary from 2n = 36 to 75. It is generally accepted that the base ploidy level of lavender and broadleaf is 2n = 50. But recent studies also mention that the diploid chromosome set of lavender can be 2n = 48 [8].

Varieties of lavender differ in a variety of morphological features, including the height of plants and the shape of the bush, the size of the leaf blade, their color and degree of pubescence, the color of flowers and the structure of the inflorescence. In the 1930s, H.K. Gunko, who was a pioneer of lavender breeding in the USSR, published the first intraspecific classification of morphological types of lavender. He singled out three types based on the shape of the bush: spherical, with radially branched flower-bearing shoots; cone-shaped or dome-shaped; and thyroid, in which flowering shoots grow vertically, and inflorescences are located horizontally [17].

Forms with thyroid bushes, 30 to 65 cm high, which are best adapted to mechanized methods of growing and harvesting, have the most economic value. Regarding the type of inflorescence, there are two main types within the lavender species: spike-shaped, where the number of flowers in whorls decreases towards the top, and cylindrical, where the number of flowers in whorls remains the same from the base to the top of the inflorescence. According to the number of flowers in the inflorescences, three groups are distinguished: few-flowered (3-5 flowers in whorls), intermediate (6-12 flowers in whorls) and multi-flowered (13 or more flowers in whorls) [16].

Lavender is characterized by significant intraspecific diversity in the color of flower cups and corollas. Usually, the colors of corollas and calyxes match and can belong to one of three main color groups: dark purple, pink and white. It is important to note that the dominant dark purple coloration is the most common, and the white flowers are recessive and are observed mainly within the natural range of this species.

Regarding the type of flower cups, H.K. Hunko singled out elongated, cylindrical, oval; with pronounced ribbing and smooth; with pressed and distant pubescence; strongly and weakly pubescent (hairy) [14].

Lavender is an allogamous (cross-pollinated) entomophilous plant that relies on bees of various species for pollination. Bees are attracted by the smell of nectar, so most of the ancient varieties of lavender are hybrids. In this regard, when propagated by seed, lavender shows great variability in biotypes and has a wide range of properties, such as yield and essential oil content.

Lavender shows adaptations not only to cross-pollination, but also to self-pollination. However, when self-pollinating lavender using individual insulators, only 3–13% of flowers can form fruits. This is because lavender pollen is fine, sticky and loose, measuring around 37-42 μm. Opening of anthers and maturation of pollen occurs even in young, closed buds. The stigma of the queen is also ready for fertilization during this period. However, at the beginning of flowering, when the pistil receptacle emerges from the pistil tube, the probability of self-pollination decreases to a minimum [21, 22].

Lavender can also be propagated vegetatively using stem cuttings and roots. Propagation by stem cuttings is the most common growing method, as it allows preserving the biological and economic properties of varieties. However, even with vegetative reproduction, bud mutations and deviations from high-yield varieties in biological and biochemical characteristics can occur.

Clonal propagation of lavender is a high value, but expensive method. To make lavender production cheaper, it is possible to create stable self-pollinating lines of plants, from which annual sowing would give interline hybrids. This would allow using the effect of heterosis. In nature, you can find lavender plants that have female flowers equipped with sterile anthers and a fertile pistil. This usually refers to the seed progeny of an artificially pollinated clone. After several generations of inbreeding, the number of sterile plants in the offspring increases.

Lavender essential oil is considered high-quality and is widely used in high-end perfumery and cosmetics. It is a component of many perfumes, colognes and eau de toilettes, especially those produced by extraction of volatile solvents. Lavender essential oil contains components such as linalool and linalyl acetate, which give it its characteristic aroma. [14].

Linalool is a lily-of-the-valley-scented liquid that is used directly in perfumery and as a raw material for the production of other aromatic compounds. Linalyl acetate is also a liquid with a pleasant fruity aroma. Linalool can be used to obtain citral, and one of the practically important derivatives of citral is ionone, which has a violet aroma. In addition, lavender oil is structurally similar to the carotene pigment, which may also be important for the synthesis of valuable compounds [36].

Therefore, lavender essential oil is a valuable source of aromatic compounds and has important applications in the perfumery and cosmetic industry.

Lavender oil is an ideal agent for flavoring toilet soaps, as it has a high resistance to the alkalinity of soaps. This allows you to preserve the wonderful aroma in products with lavender oil. Fragrant lavender flowers are also used to purify the air in rooms, to scent linen and clothes, and to repel moths. In the fight against mosquitoes, special candles are created using lavender [36, 37].

Lavender also has significant medicinal uses. Lavender inflorescences collected during flowering, as well as essential oil from them, are used in medicine. It is used to treat various diseases, including migraines, neurasthenia, rheumatism, cardiovascular diseases, urolithiasis and pyelonephritis. Lavender is also used for therapeutic baths for inflammation of the joints, dislocations, as well as a wound healing agent and for skin diseases.

In various countries and traditional medical practices, lavender is also used to treat diseases of the stomach and intestines, inflammation of the middle ear, bronchitis, laryngitis, and as a diuretic. Thus, lavender has important medical and aromatic applications [18–20].

Preparations made from lavender flowers have numerous beneficial properties. In particular, they have a diuretic, anticonvulsant and sedative effect, improve cerebral blood circulation. A solution of lavender essential oil can stimulate wound healing, especially with chemical burns, and promotes complete regeneration of the epidermis. Lavender oil is also part of drugs that have neurotropic and myotropic activity, and are used for inhalation as a preventive measure against influenza infections. Moreover, lavender oil can lower cranial blood pressure, relieve bronchospasm, increase intestinal tone, increase the acidity of gastric juice, and improve appetite [51, 52] .

In domestic medicine, lavender oil is also used to treat purulent wounds and gangrene. Bulgarian doctors recommend lavender flowers as a mild sedative and antispasmodic agent for migraines, nervous palpitations, neurasthenia, as well as a choleretic agent and for gastrointestinal colic. Essential oil dissolved in alcohol can be used for rubbing against rheumatic pains. In addition, lavender oil is used in dentistry and for inhalation treatment in rhinitis, laryngitis, and pneumonia [13, 14].

Studies of the phytoncide activity of lavender essential oil have confirmed its ability to reduce the content of bacteria in the air, such as staphylococci and streptococci. The use of lavender essential oil vapors in workplaces has resulted in a normalized heart rate, reduced fatigue and headaches after a day's work, increased vitality and a general improvement in well-being. The course of preventive aerophytotherapy also increased the general resistance of the body, which was manifested in the reduction of morbidity.

These results indicate the possibility of using lavender essential oil for indoor air sanitation and as a therapeutic and preventive agent for acute respiratory diseases. This is especially relevant in the context of increased attention to the health and hygiene of the indoor air environment, especially during periods of epidemics and pandemics.

Lavender does have a variety of important uses. Its honey and essential oil, which are used in many fields, are especially valuable.

Lavender honey has a wonderful aroma and healing properties. It is a tasty and useful product that can be used to improve general health and treat various diseases [7–9].

Lavender essential oil also has a wide range of uses. This oil is used in perfumery, cosmetics and aromatherapy. It has a number of useful properties, including soothing, anti-inflammatory and wound-healing effects.

Lavender plants are often used in gastronomy to flavor dishes and drinks, as well as as a spice ingredient [13] .

Decorative lavender is used for landscaping and decorating gardens, flower beds and gazebos. It adds beauty and fragrance to landscape design.

Lavender plants can be useful in combating soil erosion because their roots help hold the soil in place and prevent it from weathering.

In summary, lavender is a multi-functional plant that is important in agriculture, medicine and perfume industries, as well as in decorative and landscape design.

The northeastern forest-steppe of Ukraine, located in the Sumy region, is known for its rich natural diversity and favorable conditions for the development of agriculture and agricultural products. In this context, the cultivation of planting material Lavandula, or lavender, acquires special importance. In this subsection, we will consider in detail the aspects of growing Lavandula planting material in the conditions of the north-eastern forest-steppe of Ukraine.

Due to its physical and geographical conditions, the territory of the Sumy district is one of the most developed territories of the Dnieper region. The antiquity of development left a significant mark on the current state of natural resources. This is especially clear on the example of land resources - in connection with the practically one-sided agrarian direction of the district's economic complex, the long-term use of extensive land use methods, its agricultural potential has significantly decreased. This was reflected in the decrease in the amount of humus in the soil (as a result of erosion and other unfavorable processes); in increasing the content of ballast substances; in violation of the soil structure.

Sumy district is located in the southern part of Sumy region, in the forest-steppe zone. It stretches 49 kilometers from south to north, and 57 kilometers from west to east. The climate is continental.

The thermal regime is determined on the basis of the average monthly air temperature. The lowest average temperatures are recorded in the coldest month - January, when they are approximately -6.1°C. From April, an active process of increasing the air temperature begins, and from April to April the temperature can vary from +5 to +16°C. The highest average monthly temperature is observed in July, when it reaches a maximum value of +20.7°C (detailed data are given in Table 1.1) [16].

Table 1.1 Air temperature indicators at the Lebedyn weather station, °S.

Meteorological indicators	I	I	II	V	V	VI	VII	VIII	IX	X	XI	XII	Annual
Absolute min temperature	-36	-33	-28	-14	-6	+2	+5	+2	-6	-9	-22	-33	-36
Absolute max temperature	+7	+6	+17	+26	+32	+34	+36	+38	+34	+26	+19	+10	+38
Average monthly and annual temperatures	-6.1	-6.7	-1.7	+6.7	+14.7	+17.6	+20.7	+18.3	+13.3	+7.1	-0.3	-4.9	+7.4

The climatic regime of this area can be characterized as continental. Maximum temperatures are observed in summer and can reach +36...+38°C. The lowest absolute temperature values were recorded at approximately -36°C. Severe frosts are most commonly observed in January and February. The annual amplitude between extreme temperatures is approximately 74°C, and the average monthly amplitude is about 27°C.

The mode of moistening of the region depends on the annual amount of precipitation, which is 500 mm in the Lebedyn district. Summer precipitation makes up 70% of the total annual precipitation, this is due to the arrival of moist air masses from the west and northwest. The maximum amount of precipitation per month is observed in July (63 mm), and the minimum - in February (26 mm) (see table 1.2) [1 6].

In May, the amount of precipitation increases, which leads to the strengthening of erosion processes. Showers during this period can be very intense. Often in the summer months, along with the rain, hail falls, which causes significant damage to agriculture. During the cold period of the year, precipitation in the form of snow falls on the territory of the district. The snow cover lasts an average of 90 days. The depth of the snow cover is approximately 15-18 cm, with a peak in February. The increase in the thickness of the snow cover in February is primarily related to the accumulation of snow during the cold season, and not to a large amount of precipitation during this period. The maximum depth of soil freezing reaches 162 cm, the minimum is 30 cm, and the average is 67 cm.

The soil cover of the Lebedyn district is quite complex and is determined by various factors, such as relief, geological composition of soil-forming rocks, moisture conditions and the influence of natural vegetation, as well as the relationship between forest and steppe. The main territory of the district (70.2%) is dominated by chernozems, which were formed on watersheds covered with forest rocks and under grassy meadow-steppe vegetation. These soils are among the most fertile and widespread in Ukraine.

Also, in the area under the oak forests, which cover or used to cover large areas of the watershed slopes and banks of streams, you can find gray forest soils, silted and regraded chernozems. This indicates the influence of the forest component on the formation of soil cover. So, the watershed lands of the Sumy district are mainly covered by three groups of soils: typical chernozems, which include typical, podzolized, and regraded chernozems. These soils may be washed to some extent on slopes. River valleys and stream bottoms are covered with a complex complex of hydromorphic soils, which include meadow chernozems, meadow, meadow-swamp, and swamp soils. These soils often have salinity and brackishness.

Table 1.2 Humidity indicators at the Lebedyn weather station.

Meteorological Indexes	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XI	Annual
Absolute air humidity (mb)	3.5	3.5	4.8	7.2	10.5	13.9	15.7	13.9	10.7	8.8	5.9	4.0	8.5
Relative humidity air (%)	88	87	85	74	68	70	71	67	75	79	85	89	78
mid-month, amount of precipitation (mm)	34	26	29	39	51	59	63	47	44	40	34	34	500
Maximum amount precipitation (mm)	100	63	82	103	132	199	157	185	93	118	129	113	930
Minimum amount precipitation (mm)	6	10	1	1	3	12	23	8	0	0	8	6	374

The research program on the topic of the thesis provides for the study of opportunities and optimization of the process of growing Lavandula planting material in the conditions of the northeastern forest-steppe of Ukraine (Vegetative propagation using plant growth stimulants and their effect on the adaptive potential of lavender (2020 - 2021).

The study took into account three main factors: A - varieties of lavender (Orion control, Feuerfogel, Livadia, Vostok, Kenning Gumberg, Maestro, Veseli notki, Richard Walls, Mriya), B - plant growth stimulants used and C - different concentrations of these stimulants (see Table 1.4).

In an experiment with vegetative reproduction, the influence of stimulants on the rhizogenesis of lavender cuttings was studied in order to determine how effective these stimulants are and what their influence is on the rooting process. The study also included optimizing the concentrations of stimulant solutions in order to obtain the maximum number of healthy, rooted lavender cuttings that would have a well-developed root system. This will contribute to the further development of an efficient and rapid method of propagation of this plant culture in the Forest-Steppe Zone for its decorative use.

The following biologically active substances were used to treat lavender cuttings: 3-indolylbutyric acid (IMK, $C_{12}H_{13}NO_2$) and succinic acid ($C_4H_6O_4$) in different concentrations of the aqueous solution: 140, 280, and 420 mg/l. The duration of exposure was 16 hours. Cuttings that were simply soaked in water for a day at a temperature of 20-22°C were used as a control. Stimulant-treated cuttings were pruned in the second half of May.

Table 1.4 Scheme of the experiment.

Factor A	Factor B	Factor C
Sort	Stimulants growth	Concentration, mg/l
Orion, Feuerfogel control Livadia East Canning Humberg Maestro Funny notes Richard Walls Dream	3-indolylbutyric acid (IMK, $C_{12}H_{13}NO_2$) succinic acid ($C_4H_6O_4$)	140 280 420

In the experiment, a mixture of peat (with a pH level of 6.9) and river sand in a ratio of 3:2 was used as a substrate for rooting cuttings. The air temperature in the rooting zone was maintained in the range of 30-35°C, the temperature of the substrate - 20-25°C, and the relative humidity was in the range of 80-90%. The cuttings were placed on a scheme of 5 x 5 cm, and their planting depth was 3-4 cm.

Cuttings were watered by an automatic fogging system. During the first 25-30 days, fine-dispersed water was sprayed for 30 seconds at five-minute intervals. After the formation of roots, the interval between irrigations was increased.

Method Z was used to determine the duration of rooting. I. Ivanova (1982). Agrotechnics of cultivation, grafting and study of regeneration ability were determined according to the Methodology of the State Varietal Testing of Agricultural Crops (1989).

To assess the differences, homogeneity and stability of lavender varieties, the methodology of the Ukrainian Institute of Plant Varieties Expertise, developed for lavender, was used.

Phenological observations and calculations of the phases of growth and development of plants were carried out in accordance with the Methodology for the qualification examination of flower-decorative, essential oil, medicinal and forest plant varieties for suitability for distribution in Ukraine.

Varieties of lavender were subject to a detailed morphological description and comparative assessment of their decorativeness, biological, ecological and economic characteristics during the growing season. These actions were performed in accordance with the methodology developed by the State Variety Test for lavender (Lavandula) varieties to determine their difference, uniformity and stability in 2006 [19].

The introduction of decorative forms of lavender in gardens and other areas of production is limited by the complexity of its reproduction [17]. The generative method of reproduction, despite the high yield of planting material and the possibility of saving resources and costs, is not optimal in selection and seed production. The vegetative method of reproduction ensures full preservation of all valuable characteristics of the mother plant [29].

There are various methods of vegetative propagation, including in vitro culture of plant cells, tissues and organs, widely used in breeding and seed production, as well as traditional methods such as separation of rooted shoots from mother plants, division of bushes, grafting with green and annual lignified shoots . The last method is the most effective [24].

One of the factors that increase the effectiveness of decorative gardening is the use of high-quality planting material and growing technology, which includes the use of biologically active substances to support the rooting of cuttings. It is important to emphasize that each culture requires experimental determination of optimal concentrations of growth stimulants, as plants may have their own individual limitations regarding their perception.

Some researchers describe the phenomenon when plants react to the concentration of well-known growth stimulants even unlike the stimulating effect at certain concentrations. On the contrary, it can cause inhibition of growth processes, contrary to the expected result [24].

Today, five main groups of phytohormones are known, which are common not only among higher plants, but also among lower multicellular organisms. These groups include auxins, gibberellins, cytokinins, abscisins, and ethylene. The action of each of these groups of phytohormones is characterized for plants of different species. In addition to these five "classical" phytohormones, plants also have other endogenous substances that, under certain conditions, can affect plant growth, similarly to phytohormones. They are collectively called "natural plant growth regulators" [22].

Regarding the method of growing planting material, cassettes for seedlings are now the most advanced modern method. Despite the limited volume of each cassette cell, the plants grown in them are more viable. Based on cassettes can reach 99%. This is almost 30% more than when growing plants using traditional methods [23, 24].

In addition, the use of cassettes allows efficient use of the area of the complex and their reuse during the season. In decorative horticulture, together with sprinkler irrigation systems, this helps to increase the amount of planting material that can be obtained from a unit of area. The use of growth promoters such as indolylbutyric acid (IBA) and succinic acid to improve rooting over three years of research showed a positive result in the form of an increase in the number of rooted lavender plants (see Tables 1.5 and 1.6).

As can be seen from the table, the effect of the BMI stimulator on the rooting process of green lavender cuttings was quite pronounced compared to the control, reaching more than 20% in some variants. However, in variants with different concentrations of the stimulator, the differences in the rooting of the cuttings were insignificant, ranging from 1.2% to 3.3%. On average, over three years of research, the optimal concentration of the BMI stimulator turned out to be 280 mg/l, which contributed to the rooting of green lavender cuttings at the level of 97.6%.

Table 1.5 The effect of the BMI stimulator of different concentrations on the rooting of green cuttings of lavender varieties (%), average for 2020–2021.

Sort	Concentration stimulant, mg/l			
	Without processing (CONTROL)	140	280	420
Orion (CONTROL)	71	94	98	95
Feuerfogel	78	96	98	97
Livadia	77	92	99	99
East	76	93	96	96
Canning Humberg	75	95	97	95
Maestro	79	96	99	98
Merry notes	77	96	97	95
Richard Walls	76	92	97	96
Dream	73	95	97	95
Average	76.1	94.3	97.6	96.4
V, %	3.3	1.8	1.0	1.5
NIR 05	3	2	1	2

The variety Maestro showed the highest yield of rooted cuttings, usually reaching a level of 99.0% on average over three years of studies. While the varieties

"Vostok" and "Richard Walls" showed the lowest yield of rooted cuttings, at the levels of 96.0% and 97.0%, respectively. These high indicators indicate that the stimulator was correctly selected to promote high rooting of green cuttings. In particular, all varieties that participated in the study showed high suitability for rooting cuttings (see Table 3.2).

During the years of cultivation, no influence on the effectiveness of rooting of green lavender cuttings was found. Even in 2021, when the difference between the lowest (Kening Gumberg variety) and the highest (Maestro variety) rooting rates was 3.3%, in the following year 2021 this difference decreased to 2.7% (Orion and "Feuerfogel").

Table 1.6 Effect of succinic acid concentration on rooting of green cuttings of lavender varieties (%), 2020–2021.

Sort	Concentration stimulant, mg/l			
	without processing (CONTROL)	140	280	420
Orion (CONTROL)	71	74	78	75
Feuerfogel	78	86	88	87
Livadia	77	82	89	85
East	76	73	76	86
Canning Humberg	75	85	87	85
Maestro	79	85	85	86
Merry notes	77	86	86	85
Richard Walls	76	87	87	86
Dream	77	83	86	85
Average	76.1	82.3	84.5	84.4
V, %	3.0	6.4	5.3	4.3
NIR 05	2	6	5	4

From the results of research over the years, it can be concluded that there is no significant dependence of the rooting of green lavender cuttings on the variety. However, plants respond positively to the concentration of the stimulator indolylbutyric acid (IBA). In all years of research, the percentage of rooted cuttings was higher when using a stimulator with a concentration of 280 mg/l.

The results of the analysis of the rooting of cuttings using succinic acid also showed a positive effect of this stimulator on the process of root formation in plants of varieties that participated in the study. However, compared with indolylbutyric acid, rooting rates were lower but higher than in the control group. The influence of the variety factor was also smaller compared to indolylbutyric acid. For example, Feuerfogel and Richard Walls cuttings, which showed the highest rooting rates compared to the control, increased the rates by 9.0% and 10.7%, respectively, which is half the rate of using indolylbutyric acid. The variety "Orion" was less sensitive to succinic acid, and the difference between the varieties with the highest rooting rates was more than 11%.

Feuerfogel and Richard Walls showed the highest rooting results of lavender cuttings during the years of research when the succinic acid stimulant was applied. On average during this period, the variety "Feuerfogel" had rooting at the level of 87.3%, and the variety "Richard Walls" - 88.7%.

The optimal concentrations of succinic acid for rooting of green lavender cuttings turned out to be 280 mg/l and 420 mg/l in all years of research.

The analysis of rooting processes using the succinic acid stimulator confirmed its positive effect on the formation of roots in the cuttings of the varieties that participated in the study. Compared to the control, the rooting rate was higher by 8.4% and 8.3% in variants with concentrations of 280 mg/l and 420 mg/l, respectively, and at the level of 6.2% when using the lowest concentration of stimulant.

Varietal planting material was used to propagate lavender through rooted cuttings. Growing such plant material for production purposes is extremely expensive and requires significant capital investment in the process of creating plantations. However, it is worth considering that lavender can be grown in one place for up to 20-25 years, while ensuring a high yield. It is known from literary sources that two methods are the most promising for propagating lavender plants: the use of green cuttings and one-year lignified cuttings.

One of the key stages of growing lavender seedlings is the organization of the nursery. The indicators of the rooting of cuttings, the number of seedlings obtained, their cost price and the profitability of the production of planting material depend on the correct agricultural technology in the nursery. It is important to note that the ability of cuttings to form additional roots largely depends on the area where the mother plants are located, their age and growing conditions. According to F.Ya. Polikarpova, the rate of production of planting material largely depends on the productivity of mother plants.

The tasks of the research were as follows:

1. To determine the possibility of using full-fledged queens of lavender seedlings obtained from green cuttings for planting, and to compare this method with the classical method of laying queens with seedlings obtained from one-year lignified cuttings.
2. Set the optimal load on the mother bush during the collection of cuttings.
3. Determine the number of seedlings obtained in each option for choosing the most optimal conditions and terms of operation of lavender queens, taking into account the biological features of these plants.
4. To clarify the optimal conditions for growing lavender queens, which ensure a high level of rooting of cuttings, and to determine the rational terms of their exploitation.
5. To study the relationship between the time of grafting and the age of the mother plant and its effect on the rooting of lavender cuttings.

Studies have shown that the maximum number of lavender seedlings of the "Veseli Notki" variety per unit area in the nursery, which can be obtained by one-time harvesting of one-year lignified cuttings, is reached in the fourth year of vegetation and amounts to 84,660 pieces. In the case of planting a mother plant with seedlings obtained from green cuttings, in the fifth year of vegetation, the yield of seedlings from 100 m2 is 69.96 thousand pieces, if two-time harvesting of green cuttings is carried out. It should be noted that the productivity of queen cells increases with age, reaching a peak in the fourth year of plant vegetation.

The results of research on the rooting of cuttings of the variety "Richard Walls" are shown in table 1.7. The obtained data indicate that the rooting of green cuttings, namely the yield of conditioned seedlings, starting from the third year of vegetation, was high and amounted to 59%. During the following growing year, this indicator increased by 10%, but in the fifth growing year (in 2018), it decreased by 12% compared to previous years.

Table 1.7 The influence of the intensity of cuttings harvesting and the age of the lavender mother plant of the Veseli notki variety planted with rooted one-year lignified cuttings on the yield of seedlings, thousands of pieces, S = 100 m ^{2}.

Version research (factor IN)	Year vegetation (factor AND)					Average on factor IN
	2017	2018	2019	2020	2021	
1. One-time preparation one-year woody cuttings	1.97	14.47	25.92	26.00	29.96	19.66
2. One-time preparationgreen cuttings	2.05	1.80	45,37	50.29	18.83	23.67
3. Double provisiongreen cuttings	4.19	7.96	40.34	57.35	23.65	26.70
4. One-time preparationgreen and one-year woody cuttings	4.28	15.75	28,25	43.66	16.59	21.70
5. Double provisiongreen and disposable cuttings one-year woody cuttings	9,16	21.66	49.65	64.20	29,32	34.80
Average by factor AND	4.33	12.33	37.90	48.30	23.67	
V, %	67.4	61.9	27.6	30.3	25.4	23.3

Also, it was found that the maximum annual growth of vegetative shoots in 2-10-year-old plants was recorded for the species U. laevis and was 144.2 cm, as well as for the weeping form of U. g. 'Pendula' and was 151.1 cm. On the other hand, the lowest maximum growth of annual shoots was observed in decorative forms, in particular U. g. 'Crispa Pyramidalis' (19.2 cm) and U. g. 'Albovariegata' (25.2 cm). A minimal increase was found in the decorative forms of U. g. 'Crispa Pyramidalis' (5.5 cm) and U. g. 'Albovariegata' (7.9 cm), and was significantly different from the indicators of the weeping form of U. g. 'Pendula'.

CONCLUSIONS

Based on the assigned tasks, we reached the following conclusions:

1. In the master's thesis, a detailed review of the literature related to the cultivation of *Lavandula* planting material (lavender) in the conditions of the northeastern forest-steppe of Ukraine was carried out. The review included research and practical aspects related to the cultivation of this crop in this region.

Based on the results of the review, the following conclusions can be drawn: Growing lavender in the northeastern forest-steppe of Ukraine is a relevant and promising branch of agriculture. This culture can have great decorative and economic potential. To successfully grow lavender in a given region, it is important to choose varieties that match the local climate and soil conditions. Agrotechnical aspects such as substrate selection, temperature control, humidity and other parameters are of great importance to achieve the best results in cultivation. The use of growth stimulants and optimization of solution concentrations can have a positive effect on lavender rhizogenesis and rooting. An important aspect is the study of phenological and morphological features of lavender, which allows you to effectively control its development and growth. In order to increase the quality and quantity of lavender planting material, it is important to observe variety testing and evaluation of different varieties for their decorativeness and economic value. The peculiarities of the climate and soils of the northeastern forest-steppe of Ukraine are of great importance in the cultivation of lavender, and they should be taken into account in the planning and agricultural techniques of cultivation.

2. In the master's thesis, the natural conditions and research methods for growing Lavandula planting material (lavender) in the conditions of the northeastern forest-steppe of Ukraine were carefully considered. The natural conditions and methods were chosen taking into account the specifics of this region and the features of the lavender culture.

3. The results of research over several years indicate the absence of a significant influence of varieties on the rooting of green lavender cuttings. However, a positive effect of changing the concentration of the BMI stimulator was found. In all years of the experiment, rooting rates were the highest when using a concentration of 280 mg/l. According to research results, the best rooting results of green lavender cuttings were shown by Feuerfogel (87.3%) and Richard Walls (88.7%) varieties. The optimal concentrations of succinic acid for rooting were in the range of 280-420 mg/l.

Studies have shown that the highest yield of lavender saplings of the Veseli notki variety per unit area in the nursery, where green cuttings were used, can be obtained using a one-time harvest of one-year-old wooden cuttings. The productivity of queen cells increases over the years and reaches its peak in the fourth year of plant growth.

The low level of damage to cambium tissues of three-year-old wood under the influence of low temperatures indicates the possibility of recovery of lavender plants after harsh winters. Taking into account the correct selection of varieties and the appropriate cultivation technology, lavender can be successfully introduced in the forest-steppe zone of Ukraine.

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FORMATION OF SOLANUM TUBEROSUM YIELD WITH REGULATED NUTRITION LEVEL AND APPLICATION OF GROWTH REGULATORS

Tokman Volodymyr
candidate of agricultural sciences, Associate Professor
Sumy National Agrarian University, Ukraine
ORCID ID: 0000-0002-1237-4611

Solanum tuberosum are one of the leading and most valuable food, industrial and feed crops. European cuisine knows more than 200 potato dishes. Processing tubers into food products and semi-finished products opens up great opportunities for their use. They are of particular value for solving the problem of nutrition and it is not for occasional that people call them “the second bread”.

Physiological standards of the Institute of Nutrition of the Academy of Medical Sciences provide for the average annual consumption of 110 kg of potatoes per person. The average per capita consumption of potato tubers in our country is 104 kg per year (Fomicheva L. A. et al., 1989).

Existing potato varieties have a biological yield potential of 400 c/ha or more (Pisarev B. A., 1990). According to N. D. Goncharov et al. (1987), the coefficient of realization of their genetic capabilities ranges from 0.9 to 0.7, but in production conditions it is much lower.

K. A. Timiryazev (1957) notes that the main task of science is to determine optimal conditions, facts that contribute to the best development of plants and to satisfy the needs of plants in these conditions profitably for humanity.

The bulk of the organic matter of a plant - 90-95% or more, is formed during the process of photosynthesis due to carbon dioxide, water and light energy, and only a small part of it is created due to mineral elements (Vecher A. S. et al., 1973; Mokronosov A. T., 1981).

Potato plants use solar energy most effectively when the assimilation surface of the leaves is at least 5-40 thousand m2/ha (Mokronosov A. T., 1990). The energy utilization coefficient of the photosynthetically active part of the solar spectrum is usually 1.0-1.5% (Nichiporovich A. A., 1976) with a theoretically possible range of 4 to 6% (Nichiporovich A. A. et al., 1965). The accumulation of 2-3% of photosynthetically active radiation by cultivated plants on a planetary scale will increase the production of plant products by 4-6 times (Shatilov I. S., 1979).

Many people strive to increase potato yields by applying high rates of fertilizers - especially nitrogen, as well as when cultivating potatoes on soils rich in organic matter, but under conditions of sufficient moisture, rapid growth of above-ground mass is observed, which leads to a delay in tuberization and the accumulation of nitrates in tubers above the maximum permissible concentration (more than 250 mg per 1 kg of raw tubers), and such tubers become unsuitable for food purposes.

The yield level is determined not only by the provision of plants with available forms of macroelements, but also by the content of mobile microelements in the soil (Khachataryan B. S., 1975; Vlasenko N. E., 1987). In conditions of a lack of macroelements, plants produce low and insufficient quality of yields (Stoilov P. P., 1965; Peive Ya. V., 1968).

Although a plant organism is capable of independently synthesizing the biologically active compounds it needs in its tissues, under certain circumstances there is a shortage of these substances and an additional supply of them can have a significant positive effect on the most important physiological and biochemical processes and plant yield (Maksimov N. A., 1946).

In connection with the above facts, there is a special need to study the possibility of controlling the growth and development of potato plants, ensuring a high yield of tubers with good nutritional properties.

Place, methodology and design of research. Experiments to study the characteristics of potato crop formation were carried out in 2005-2007. on the experimental fields of the Department of Plant Growing in the educational and experimental farm of the Timiryazevsk Agricultural Academy (TSHA), Mikhailovskoye, Podolsk district, Moscow region.

The research was carried out in two experiments: in the first one, crop formation was studied at a controlled level of mineral nutrition, and in the second one, crop formation was studied under conditions of the use of physiologically active compounds, copper sulfate and a low-frequency electromagnetic field.

In the first experiment, potatoes were planted after winter wheat in a field crop rotation: fallow (vetch – and - oat mixture), winter wheat, potatoes, barley + perennial grasses, grasses of the first year of use, grasses of the second year of use, oats. Crop rotation is deployed in time and space on poorly, medium and well-cultivated soil.

The soils of the first experimental plot are soddy-podzolic, medium loamy, with a topsoil depth of 20-25 cm. The level of its fertility was characterized by the following indicators (Table 1).

The arrangement of options in the first experiment is as follows: on moderately cultivated soil - 1 - without fertilizers (control); 2 – calculated fertilizer rate for potato yield of 250 c/ha, or absorption of 2% PAR; 3 – calculated fertilizer rates for a yield of 350 c/ha or absorption of 3% PAR; 4 – recommended fertilizer rate for the Moscow region. On well-cultivated soil, the 2nd corresponds to the 3rd, and the 3rd – to the 4th option, on moderately cultivated soil.

The size of the plot on poorly cultivated soil is 360 m^2, repeated 3 times. On medium- and well-cultivated soil, the plot size is 180 and 100 m^2, respectively, and the repetition is 4-fold.

In the second experiment, potatoes were planted outside the crop rotation and its predecessor in 2005 and 2007 was corn for silage, and in 2006 - winter wheat. The soil of the experimental plot is soddy-podzolic, medium loamy, with an arable layer depth of 25 cm. It was characterized by the following agrochemical indicators: pH - 6.0, humus content according to Tyurin - 2.0, easily mobile P_2O_5 and K_2O - 16-18 mg per 100 g of soil.

The scheme of the second experiment included 17 options: 1- control; 2- simarp, 1 mg/l; 3 - krezacin, 40 mg/l; 4 - control (water); 5 - furolan, 30 mg/l: 6 - furolan, 50 mg/l; 7 - furolan, 70 mg/l; 8 - furolan, 10 mg/l; 9 - furolan, 30 mg/l; 10 - furolan, 50 mg/l;

11 - furolan, 60 mg/l; 12 - furolan, 80 mg/l; 13 - furolan, 100 mg/l; 14 – copper sulfate bloom, 500 mg/l; 15 – copper sulfate (budding), 500 mg/l; 16 – copper sulfate (budding), 500 mg/l + (blooming), 500 mg/l; 17– EM. Options 2, 5, 6, 7 and 17 – processing of seed material, and the remaining options – spraying of plants before the budding phase. The size of the survey plot was 75 m^2, the replication was 4 times.

Agrochemical characteristics of experimental plots

Soil	Option	pH			Content								
					humus			mobile P_2O_5			mobile K_2O		
		2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
Well-cultivated	1	6,0	6,0	5,6	2,47	2,44	2,02	13,1	13,0	15,5	16,8	14,8	10,5
	2	6,4	6,0	5,7	2,86	2,78	2,36	25,2	22,6	25,8	25,5	20,4	26,0
	3	6,2	6,0	5,8	2,64	2,76	2,38	22,3	21,6	27,6	20,8	17,3	17,2
Medium cultivated	1	6,0	6,0	5,9	2,19	1,79	1,81	13,4	10,3	11,2	13,9	5,7	5,2
	2	6,6	6,2	6,0	2,45	2,25	2,34	18,5	13,7	18,4	24,0	14,9	16,7
	3	6,6	6,5	5,9	2,40	2,63	2,46	18,0	16,2	21,8	25,5	16,1	23,5
	4	6,4	6,4	6,0	2,28	2,73	2,16	18,1	16,3	21,4	17,5	9,0	13,0
Pour cultivated		4,6	4,7	4,3	1,80	1,84	1,27	2,6	2,4	2,9	6,3	5,6	5,1

Note: humus content according to Tyurin, %;
mobile P_2O_5 and K_2O – mg/100 g of soil.

The object of study was the medium variety Nevsky, released since 1990, which is distinguished by good ecological plasticity and the ability to accumulate high yields on different types of soil and in different soil and climatic conditions, which is very important for the weather conditions of the Moscow region.

Following the harvesting of winter wheat, peeling was carried out in 2 tracks with a disk huller (LDG - 5) to a depth of 6-8 cm, and after corn for silage - with a disc harrow (BDT - 7) in 2 tracks to a depth of 10-12 cm. In September, autumn plowing was made to a depth of 20-25 cm.

In the experiments, organic and phosphorus-potassium fertilizers were applied in fall under the fall plowing, and nitrogen fertilizers were applied during the growing season (½ on days 10-12 after germination and ½ during the flowering phase) with simultaneous incorporation into the soil. The rates of applied mineral fertilizers are shown in Table 2. Organic fertilizers in the first experiment were applied at the rate of 35 t/ha of manure, except for poorly cultivated soil, where organic and mineral fertilizers and protection products have not been applied for 25 years.

2. Norms for applying mineral fertilizers, kg/ha.

Soil	Option	2005	2006	2007
Wellcultivated soil	2	$N_{120}P_{45}K_{247}$	$N_{110}P_{45}K_{234}$	$N_{110}P_{45}K_{177}$
	3	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$
Medium cultivated soil	2	$N_{90}P_{45}K_{155}$	$N_{90}P_{61}K_{165}$	$N_{90}P_{45}K_{148}$
	3	$N_{120}P_{78}K_{74}$	$N_{120}P_{111}K_{178}$	$N_{170}P_{45}K_{209}$
	4	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$

Experiments were carried out according to research methods on a potato culture (Andryushina N.A. et al., 1977), testing regulators of plant growth and development in an open and protected ground (Kazakova V.N. et al., 1990).

The treatment of the planting material with simarp (1 mg/l) and furolan (30-50-70 mg) was carried out the day before planting at the rate of 30 l/t of tubers. The seed material was exposed two days before planting. Before budding, potato plants were sprayed with water, krezacin (40 mg/l), furolan (10-30-50-60-80-100 mg/l) using a backpack sprayer at the rate of 400 l/ha of aqueous solution. Plants were treated with a solution of copper sulfate before budding (500 mg/l) and during flowering, both separately in the indicated phases and together at a consumption of an aqueous solution of 400 l/ha.

During the growing season, the following phenological phases of plants were noted: germination, budding, flowering, harvesting. The beginning of the phase was taken to be the time when this sign was observed in 10% of plants, and the full onset of the phase was taken to be 75% of plants.

The accumulation of raw and absolutely dry mass was studied in dynamics, with the first three determinations coinciding with the phases of germination, budding, flowering, and then after flowering on the 15th, 30th and 45th day. The accumulation of raw matter both in the above-ground part and in the underground part was determined in a sample composed of 10 plants (bushes). The dry matter content in the above-ground mass, roots and tubers was found by drying crushed samples (3-5 times repeated in each sample) in an oven at a temperature of 105°C.

The leaf area was calculated by the "cutting" method during sampling for the accumulation of raw and absolutely dry matter (Nichiporovich A.A., 1955). The photosynthetic potential of the leaf surface of potato plantings was calculated according to the generally accepted method (Nichiporovich A. A., 1955). The net productivity of photosynthesis was determined using the formula proposed by Kidds, West and Briggs (Nichiporovich A. A., 1961).

$$Fnpp = B_2 - B_1 / \tfrac{1}{2} (L_1 + L_2)\, T, \text{ where}$$

Fnpp – net productivity of photosynthesis;
B_1 and B_2 – dry mass at the beginning and end of the accounting period;
½ (L_1+L_2) – average working leaf area for this period of time;
T – number of days in the accounting period.

Soil moisture during the growing season was determined monthly by taking soil samples with a drill in the middle of the ridge from a layer of 0-10 cm, every 10 cm with two repetitions, in two repetitions for each soil layer and drying them at the temperature of 105 ° C to constant weight in a dryer closet.

The soil temperature during the period of tuberization of potato plants was determined in the ridge at three depths (5-10-20 cm) from 5 to 14 measurements per day.

The infection of plants by viruses (X, Y, S, M, L) was determined in the leaves of the middle tier at the beginning of the flowering phase in 10-15 fold repetitions using the enzyme immunoassay method (Instructions, 1990).

The content of nitrates in tubers was determined using an ion-selective electrode on a universal ionometer (EV - 74), starch - on a sugarimeter (SU-4), according to the Everes method (Methodology for research on potato culture, 1967); vitamin C content - according to Murri (Peterburgsky A. V., 1968); reducing sugars - according to the Schorl method, total sugars - according to the Felushin method, protein - by the biuret method in the Jennings modification on a photoelectric concentration colorimeter (KFK - 2) (Vinogradova A. A. et al., 1991).

The influence of physiologically active compounds on late blight resistance of potato tubers was assessed by the content of the antifungal substance - rishitin, formed in tubers after infection with an incompatible race of late blight pathogen, as well as after treatment of untreated tubers with growth regulators. The content of rishitin was determined by the colorimetric method (Ozeretskovskaya O. L. et al., 1975).

The content of available phosphorus in the soil was determined according to A. G. Kirsanov, available potassium - according to A. L. Maslova and E. V. Chernisheva (Arinushkina E. V., 1980).

Doses of mineral fertilizers in variants with calculated doses were calculated taking into account affective fertility, removal of the main elements of mineral nutrition with the planned harvest and coefficients of use of nutrients from the soil and applied fertilizers (Zamaraev A. G. et al., 1979).

The yield properties of tubers from the studied variants of the second experiment were studied in a separate experiment, repeated 4 times, where N_{90} P_{60} K_{60} was added. The size of the plots is 30 m^2.

Meteorological conditions during the years of the experiments varied both in the amount of precipitation and air temperature.

The growing season of 2005, in terms of temperature conditions and precipitation distribution, was relatively favorable for the growth and development of potatoes. The average daily air temperature in May was 1.3°C below normal, and the amount of precipitation was approximately at the level of the long-term indicator. During the month of July, the air temperature was 1.1°C below the long-term average, and the amount of precipitation was within the normal range, although in the first ten days it fell almost twice as much as normal. In July, the average daily temperature was slightly below normal. July is characterized by uneven precipitation. In the first ten days of July it was almost absent, but in the third ten days 77.3 mm fell, which is 49.3 mm more than normal. Large amounts of precipitation at the end of the month caused rapid development of late blight. In general, during this month precipitation fell 23.9 mm more than normal. In August, the same pattern of precipitation was observed as in July. In general, during the month precipitation fell 25.5 mm above normal. During the growing season of 2005, the air temperature was 0.7°C below the long-term average, and the amount of precipitation was 43.7 mm more than normal.

The growing season of 2006 was characterized by higher air temperatures and less precipitation compared to 2005. During the month of May, precipitation fell 28.8 mm more than normal and the air temperature was 1.1°C higher. June and July turned out to be drier and warmer compared to the long-term average. During the month of August, the air temperature was at normal levels. As for precipitation, it fell at the end of August by 31.9 mm more than normal.

The growing season of 2007 turned out to be unfavorable for the growth and development of potatoes. It is characterized by: high daytime soil and air temperatures, low precipitation. During the month of May, precipitation fell 19.9 mm less than normal, and its precipitation was characterized by unevenness. During the month, 22.7 mm of precipitation fell, which is 3 times below normal. The average daily air temperature was 1.0°C below the long-term indicator. In July and August, precipitation fell significantly below normal. So, in July it fell 52.8 mm less than normal, and in August by 39.5 mm. The air temperature in August was 2.2°C above normal. In general, during the growing season, precipitation fell 157.5 mm less than the long-term average, and the air temperature was 0.9°C above normal.

Research results.

A number of factors have a significant impact on the growth and development of potato plants: weather conditions, quality of planting material, fertilizer, soil fertility, etc.

The results of phenological observations are presented in table. 3. Potato shoots in 2005 appeared only after 40 days and this was the result of reduced quality of seed material and unfavorable weather conditions (low soil temperature). In 2006, the planting material was of slightly better quality and the soil temperature was more favorable; seedlings appeared 12 days earlier than in 2005.

3. Phenological observations.

	Planting	Shoots	Budding	Blooming	Harvesting	Planting - harvesting
2005						
Date	9.05	18.06	7.07	16.7	10-18.09	
Duration of the interphase period (days)		40	19	9	56-64	124-132
Date	17.05	14.06	1.07	8.07	3-5.09	
Duration of the interphase period (days)		28	17	7	57-59	109-111

The onset of all phenological phases of growth and development of potato plants in 2006 occurred earlier than in 2005 due to more favorable weather conditions during the growing season.

The rains of September 2005 caused a postponement of the harvesting date and, due to significant soil moisture, the harvesting period was extended.

Potatoes, like all green plants, are an autotrophic organism that performs all its vital functions using organic matter created from elements of inanimate nature and the energy of sunlight.

The bulk (85% or more) of organic matter created by a plant is formed during the process of photosynthesis due to carbon dioxide, water and light energy (Vecher A. S. et al., 1973; Makhanko L. A., 1985).

The main organ of photosynthesis is the leaf (Mokronosov A.T., 1981) and the accumulation of organic matter yield is highly dependent on the growth rate and size of the photosynthetic organs. We obtain high productivity of photosynthesis under the condition that the leaf area increases, very quickly reaching the optimal level, and then remains active at this level for a long time and partially or completely dies at the end of the growing season (Nichiporovich A. A. et al., 1958; Mäetadu H. I. et al., 1984).

Most researchers (Stroganova L. E., 1959; Nichiporovich A. A., 1963) believe that in the conditions of the Non-Chernozem Zone, a leaf surface index of 3.5-4.0 m^2/m^2 is optimal. With irrigation and abundant fertilization, an increase in yield can be associated with an increase in leaf area to 50 thousand m^2/ha (Pisarev B. A., 1990).

As A. A. Nichiporovich et al. (1965) point out, at low light intensities, maximum photosynthesis intensity is observed with a relative leaf area of about 4-6 m^2/m^2, and with crop illumination of 100*103 erg/cm^2 sec, the optimal leaf area is about 8-9 m^2/m^2.

The intensity and magnitude of the increase in the assimilation surface depend on soil moisture, the provision of available nutrients and other factors. In our experiments, the size of the leaf surface of potato plantings varied greatly from year to year and depended on the prevailing weather conditions, soil fertility, and rates of application of organic and mineral fertilizers (Table 4, Figure 1-2).

The progress of leaf surface formation is represented by a single-peak curve with a maximum on the 15th day after flowering. Although in 2006, on option 2 in medium- and well-cultivated soil, the maximum leaf area was on the 30th day after flowering.

4. Leaf area, thousands m^2/ha.

Option	Shoots	Budding	Blooming	After flowering on		Harvesting
				day 15	day 30	
Moderately cultivated soil						
1	1,1 / 2,9	7,1 / 3,1	12,3 / 4,2	23,8 / 5,5	22,0 / 3,0	- / 0,9
2	2,2 / 3,0	7,2 / 5,2	19,5 / 7,5	31,4 / 16,4	22,2 / 17,4	- / 9,1
3	2,2 / 3,2	9,0 / 5,6	27,2 / 8,7	46,5 / 19,6	38,6 / 18,5	- / 10,9
4	1,6 / 3,1	10,1 / 4,3	21,3 / 9,0	28,7 / 15,2	26,3 / 11,2	- / 3,8
Well-cultivated soil						
1	1,7 / 3.1	6,7 / 3,7	9,7 / 4,4	20,9 / 7,6	8,5 / 5,0	- / 1,6
2	2,5 / 4,0	9,2 / 7,7	21,8 / 12,4	28,4 / 21,3	20,5 / 22,7	- / 12,8
3	2,3 / 3,9	10,8 / 6,0	22,0 / 10,0	36,3 / 18,1	22,7 / 17,8	- / 10,1
Poorly cultivated soil						
	1,5 / 1,2	2,5 / 1,4	3,7 / 3,2	4,8 / 4,8	3,6 / 3,7	- / 0,5

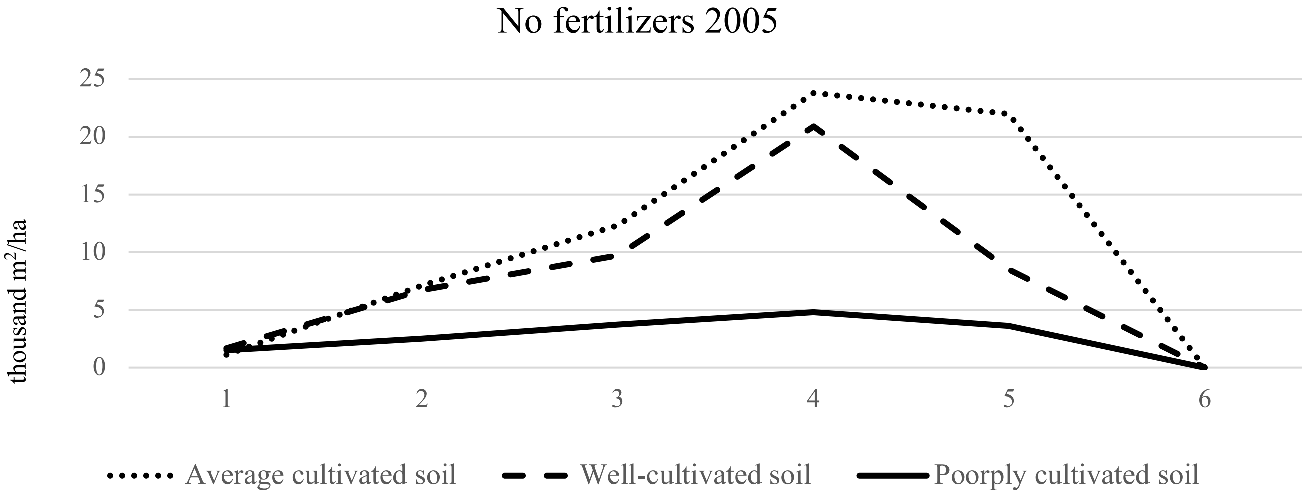
Note: numerator – 2005; denominator – 2006.

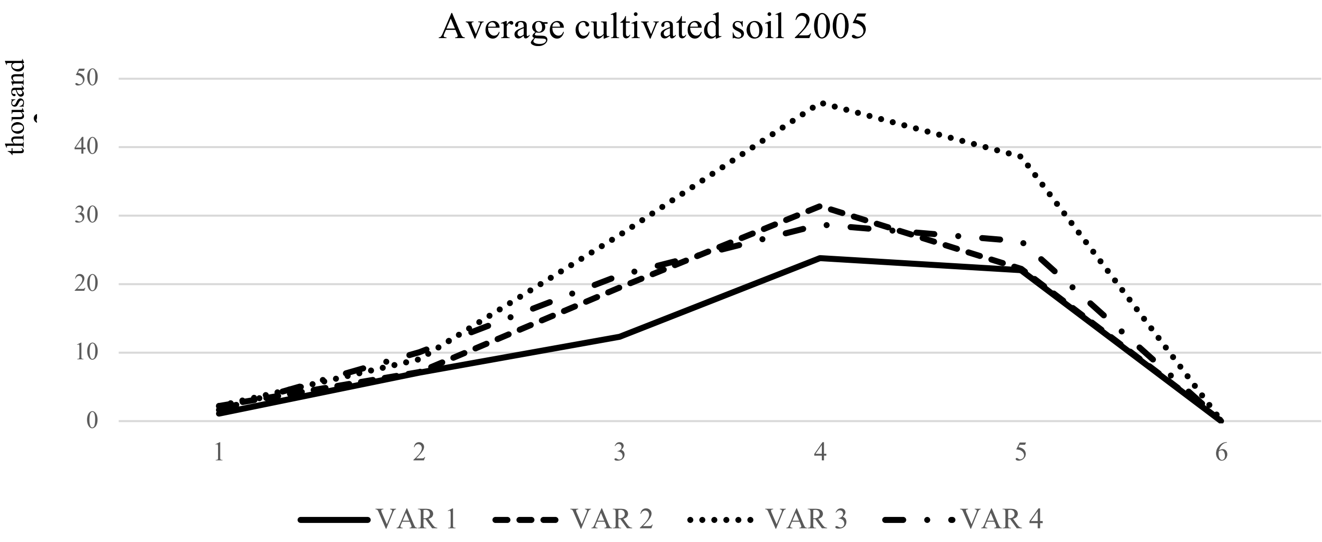
Soil fertility had a positive effect on leaf area. In the variant without fertilizers on well-cultivated soil it was 435 and 158% more, and on moderately cultivated soil it was 496 and 115% more than on poorly cultivated soil in 2005 and 2006 on the 15th day after flowering.

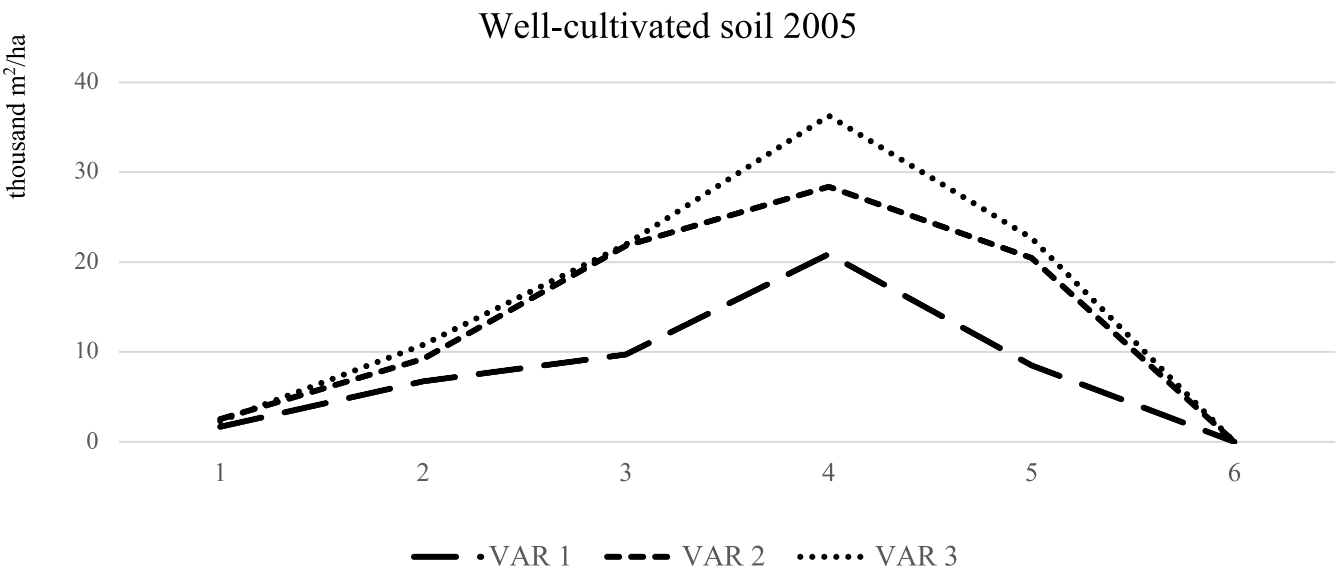
The largest leaf area was observed in 2006 on medium- and well-cultivated soil in the variants where the calculated rates of fertilizers were applied to absorb 3% PAR, and in 2005 on well-cultivated soil the maximum leaf area of 36.3 thousand m^2/ha was observed in the variant with the recommended fertilizer standards, and on a medium-cultivated one - 46.5 thousand m^2/ha in the option for absorbing 3% PAR at 4.8 thousand m^2/ha on a poorly cultivated one.

The maximum increase in leaf surface was in 2005 on medium-cultivated soil of option 3 during the interphase flowering period - day 15 - 19.3 thousand m^2/ha. 20 days after flowering, leaves died off in all variants.

In 2005, this process accelerated due to the development of late blight and by the time of harvesting there were practically no green leaves on all variants, and in 2006 their area was - on poorly cultivated soil from 0.5 thousand m^2/ha to 12.8 thousand m^2/ ha on well-cultivated soil of option 2.

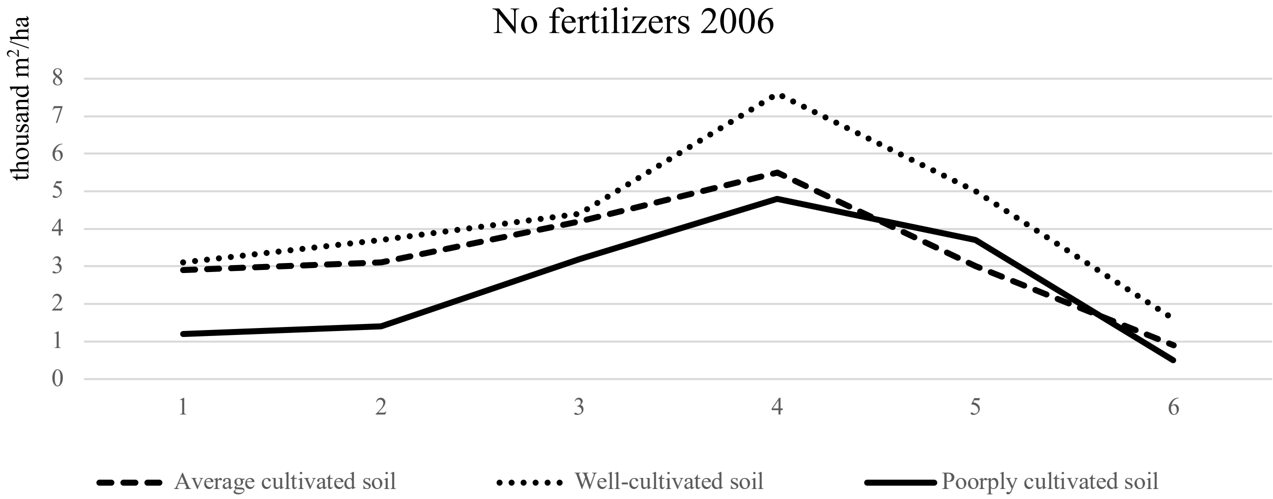




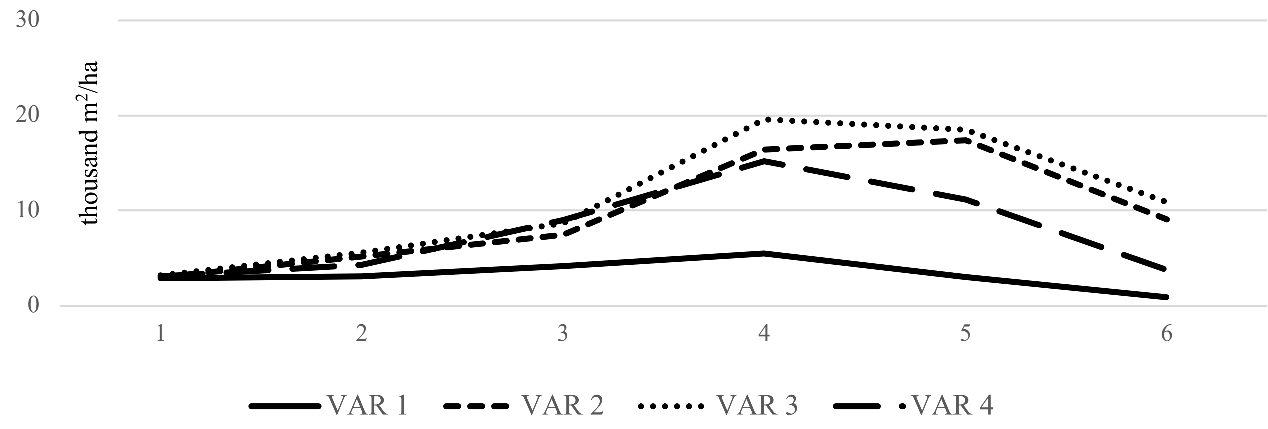


Dynamics of increase in leaf area

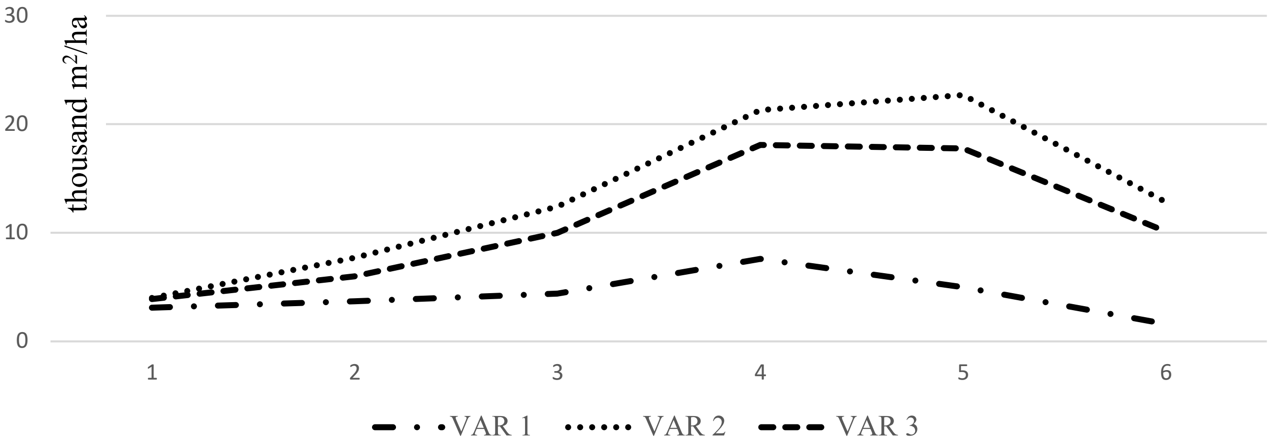
Note: I – shoots; II – budding; III – flowering; IV and V – on the 15th and 30th days after flowering; VI –harvesting.



Average cultivated soil 2006



Well-cultivated soil 2006



Dynamics of increase in leaf area.

Note: I – shoots; II – budding; III – flowering; IV and V – on the 15th and 30th days after flowering; VI –harvesting.

The highest productivity of a potato plant, 362 c/ha, was formed on medium-cultivated soil of option 3 with the following course of leaf surface growth: shoots – 2.2; budding – 9.0; flowering – 27.2; on the 15th and 30th days after flowering - 46.5 and 38.6 thousand m^2 ha.

In our studies, intensive growth of leaf surface in variants with calculated and recommended doses of fertilizers occurred due to a rapid growth, more intensive development of plants and the formation of larger leaf shares.

In order to truly reflect in our minds the picture of yield formation by potato plants, it is necessary to study the process of tuberization in dynamics. One of the main indicators characterizing this process is a daily growth.

Yield accumulation and a daily increase in raw weight of potato tubers are presented in table. 5-6. Weather conditions had a significant impact on the dynamics of these indicators. For example, planting tubers in a slightly heated soil in 2005 caused the tubers to grow, which subsequently affected the daily growth and accumulation of raw weight by potato tubers.

5. Accumulation of raw weight by potato tubers, c/ha.

Option	Deadlines for determination					
	1	2	3	4	5	6
Moderately cultivated soil						
1	4,5 -	28,8 2,1	44,7 19,8	91,4 47,4	235,5 86,9	220,6 146,0
2	6,7 -	25,0 5,0	75,1 35,0	172,7 97,5	315,5 262,5	375,4 286,7
3	4,4 -	26,2 5,6	96,7 36,0	186,3 106,5	386,0 305,0	448,4 390,1
4	7,5 -	32,8 3,9	57,0 33,6	145,0 102,5	371,2 208,5	390,3 274,7
Well-cultivated soil						
1	8,6 -	21,2 1,5	47,5 25,1	120,0 55,6	186,2 103,1	202,2 161,5
2	7,4 -	34,5 5,8	80,0 42,6	125,5 131,0	283,0 287,5	272,3 379,5
3	4,2 -	28,6 5,2	84,2 40,1	155,0 108,0	270,7 210,0	307,1 267,3
Poorly cultivated soil						
	2,7 -	17,4 1,0	34,8 13,6	67,2 43,0	99,8 77,8	77,3 87,9

The use of recommended and calculated doses of fertilizers increased daily growth. Thus, in option 2 of well-cultivated soil on the 30th day after flowering in 2006, it was 9.2 c/ha, which is 3.3 times more than the control option.

Soil fertility had a significant impact on the accumulation process and daily increase in raw mass. For example, on poorly cultivated soil these indicators were lower than the unfertilized variants of medium- and well-cultivated soil.

The bulk of the potato tuber harvest is formed by plants during the flowering period - the 30th day after it. All efforts when cultivating potatoes should be aimed at creating conditions for the optimal progress of crop formation during this period.

6. Daily increase in raw weight of potato tubers, c/ha.

Option	Phases of growth and development					
	Shoots	Budding	Blooming	After flowering on		
				day 15	day 30	day 45
Moderately cultivated soil						
1	0,5 / -	1,9 / 0,3	2,0 / 1,8	3,6 / 2,0	9,0 / 2,3	-1,1 / 4,2
2	0,67 / -	1,4 / 0,7	6,3 / 3,0	7,5 / 4,5	8,9 / 9,7	4,3 / 1,7
3	0,44 / -	1,7 / 0,8	8,8 / 3,0	6,9 / 5,0	12,5 / 11,7	4,5 / 6,1
4	0,75 / -	1,9 / 0,6	3,0 / 3,0	6,8 / 4,9	14,1 / 6,2	1,4 / 4,7
Well-cultivated soil						
1	0,86 / -	1,0 / 0,2	3,3 / 2,4	5,6 / 2,2	4,2 / 2,8	1,1 / 4,2
2	0,74 / -	2,1 / 0,8	5,7 / 3,7	3,5 / 6,3	9,8 / 9,2	-0,8 / 6,6
3	0,42 / -	1,9 / 0,7	7,0 / 3,5	5,4 / 4,9	7,2 / 6,0	2,6 / 4,1
Poorly cultivated soil						
	0,27 / -	1,1 / 0,1	2,2 / 1,3	2,5 / 2,1	2,0 / 2,0	-1,6 / 0,7

The most important indicator of the plant production process is the dynamics of dry matter accumulation.

The progress of dry matter formation by potato plants is presented in Table 7-8 and figure 3-5. From the first phases of plant growth and development until the period of 15-30 days after flowering, depending on the weather conditions of the year, there was an increase in the dry matter of the above-ground part, and then it began to decrease due to the aging of leaves (their fall), the decrease is associated not only with abscission, but also weakening of the arrival of PAR, reducing on this basis the photosynthetic activity of assimilating organs.

The accumulation of dry matter by tubers by the flowering phase in 2005 on well-cultivated soil of options 1 and 2 exceeded its accumulation by the aboveground part, although the maximum accumulation of matter by the tops was observed on the 15th day after flowering, which is very important for obtaining a high potato yield. On poorly cultivated soil this year, the amount of dry matter accumulation by tubers already at the budding phase exceeded the tops by 1.67 times. The above mentioned fact was not observed this year on moderately cultivated soil. In 2006, in the 1st variant of well- and moderately cultivated soil, an early intersection of the curves of dry matter accumulation by tubers and tops was noted.

7. Accumulation of dry mass by potato plants, c/ha. (2005).

Option	Deadlines for determination					
	I	II	III	IV	V	VI
Moderately cultivated soil						
1	1,52 / 0,64	4,84 / 4,32	6,93 / 6,03	12,39 / 11,97	15,11 / 40,51	4,48 / 42,0
2	1,82 / 0,92	4,88 / 3,28	11,88 / 9,84	19,03 / 21,93	11,33 / 53,0	5,45 / 57,81
3	1,53 / 0,62	6,17 / 3,64	16,45 / 12,67	26,16 / 24,22	19,72 / 64,08	5,69 / 63,67
4	1,14 / 0,4	7,24 / 4,36	12,16 / 7,41	16,32 / 18,27	15,68 / 62,36	3,49 / 59,72
Well-cultivated soil						
1	0,97 / 1,29	4,63 / 3,14	4,96 / 7,08	13,53 / 14,64	5,96 / 35,57	2,28 / 36,6
2	1,72 / 1,06	5,72 / 4.73-	9,63 / 9,84	18,87 / 14,68	13,29 / 47,54	3,32 / 45,49
3	1.46 / 0,62	6,57 / 4,0	12,43 / 10,61	23,77 / 17,67	14,31 / 45,75	2,21 / 43,61
Poorly cultivated soil						
	1,3 / 0,4	1,8 / 3,01	2,77 / 6,16	5,63 / 10,82	3,14 / 20,96	0,58 / 20,82

Note: in the numerator – the above-ground part; the denominator is tubers;
I – sprout; II – budding; III – flowering; IV and V – on the 15th and 30th day after flowering;
VI –harvesting.

8. Accumulation of dry mass by potato plants, c/ha. (2006).

Option	Deadlines for determination					
	I	II	III	IV	V	VI
Moderately cultivated soil						
1	1,0 / -	2,0 / 0,2	2,7 / 2,9	3,6 / 7,3	4,3 / 17,5	1,7 / 29,2
2	1,1 / -	3,1 / 0,6	6,5 / 4,8	8,1 / 13,3	15,6 / 51,5	9,0 / 57,6
3	1,3 / -	3,4 / 0,6	6,4 / 4,9	10,7 / 14,5	13,4 / 60,4	11,2 / 78,4
4	1,1 / -	2,6 / 0,4	6,4 / 4,5	8,1 / 14,2	9,5 / 40,7	5,7 / 54,9
Well-cultivated soil						
1	1,1 / -	2,7 / 0,2	3,9 / 3,9	4,1 / 8,9	2,2 / 22,4	1,1 / 35,5
2	1,7 / -	4,4 / 0,6	9,6 / 6,4	10,8 / 17,6	16,2 / 56,1	12,2 / 82,4
3	1,2 / -	3,7 / 0,6	7,4 / 6,1	9,0 / 16,2	10,1 / 41,0	9,2 / 57,5
Poorly cultivated soil						
	0,8 / -	1,1 / 0,1	2,7 / 2,1	3,8 / 7,7	1,7 / 17,3	0,8 / 21,0

Note: in the numerator – the above-ground part; the denominator is tubers;
I – sprout; II – budding; III – flowering; IV and V – on the 15th and 30th day after flowering;
VI –harvesting.

Based on the data on the accumulation of dry matter by plants (Tables 7 and 8), we can conclude that the application of fertilizers causes a later suppression of the dry matter accumulation curves by tubers and tops. The most intensive accumulation of dry matter by tubers occurs from the flowering phase until the 30th day after it, and then the rate of dry matter accumulation decreases somewhat.

The maximum accumulation of dry matter by potato plants in 2005 was on the 30th day after flowering, and in 2006 - during the harvesting period, which is associated with different weather conditions.

The dynamics and magnitude of dry matter accumulation by plants was influenced by soil fertility in both years of research. Thus, on well-cultivated soil in the variant without fertilizers in all phases of plant growth and development, the intensity of accumulation was higher than on poorly cultivated soil and at harvest it amounted to 36.6 and 21.8 c/ha in 2006.

Over the course of two years of research, we noted a certain pattern in the process of accumulation of dry matter mass in potatoes. In the early stages of potato growth until the flowering phase, the increase in dry matter was slow. Starting from the budding phase, the effect of fertilizers on the increase in dry matter began to appear. The highest rate of dry matter accumulation was observed in 2006 on well - and moderately cultivated soil using calculated doses of fertilizers to absorb 3% PAR than using recommended doses. Thus, in 2006, on well-cultivated soil in option 2, the accumulation of dry matter was 94.6 c/ha, and in option 3 – 66.7 c/ha. The application of fertilizers caused more intensive accumulation of dry matter by plants. On medium cultivated soil in option 3 in the flowering phase it was 11.3 c/ha and at harvest - 89.6 c/ha, and in the option without fertilizers it was 5.6 and 30.9 c/ha, respectively.

Photosynthetic potential is one of the decisive factors determining the size of the crop, as it gives an idea of what photosynthetic area and for what time worked to form the crop.

A. Nichiporovich (1965) and A. T. Mokronosov (1990) believe that a good crop should have a photosynthetic potential of 2.0-2.5 million m^2. days/ha, days calculated for every 100 days of actual growing season. However, creating an optimal leaf surface or tops mass per 1 ha and achieving high values of photosynthetic potential by plantings does not guarantee high yields of potato tubers. As can be seen from our studies (Table 9), the photosynthetic area of plantings depended both on the year of research, soil fertility, and the amount of fertilizer applied. The most favorable conditions for the development of photosynthetic potential occurred in 2005. On a medium cultivated soil in the variant with calculated fertilizer rates for the absorption of 3% PAR (photosynthetically active radiation), it amounted to 1658.7 thousand m^2/ha days, while on poorly cultivated soil it reached only 206.0 thousand m^2/ha days.

The highest value of photosynthetic potential, regardless of the weather conditions of the growing season, reached the 5th period of determination (15 days after flowering) and corresponded to the period of formation of the largest leaf surface by plants.

For example, on moderately cultivated soil in 2005, by the 5th period of determining the PP (Photosynthetic potential) in the option of absorbing 3% PAR was 680.8 thousand m^2/ha days, and on poorly cultivated soil - 67.2 thousand m^2/ha days.

9. Photosynthetic potential of potatoes (thousand m^2/ha days), 2005 – 2006.

Option	Deadlines for determination						During the growing season
	1	2	3	4	5	6	
Moderately cultivated soil							
1	5,5 16,0	53,3 21,0	77,6 36,5	234,7 67,9	366,4 72,3	154,0 27,3	891,5 241,0
2	11,0 16,5	61,1 28,7	106,8 63,5	330,9 167,3	428,8 287,3	155,4 185,5	1094,0 748,8
3	11,0 17,6	72,8 30,8	144,8 71,5	749,1 198,1	680,8 323,9	270,2 205,8	1658,7 847,7
4	8,0 17,1	76,1 25,9	125,6 66,5	325,0 169,4	440,0 224,4	184,1 105,0	1158,8 608,3
Well-cultivated soil							
1	8,5 17,1	54,6 23,8	65,6 40,5	198,9 84,0	235,2 107,1	59,5 46,2	622,3 318,7
2	12,5 22,0	76,1 41,0	124,0 100,5	326,3 235,9	391,2 374,0	143,5 248,5	1073,6 1021,9
3	11,5 21,5	85,2 34,7	131,2 80,0	379,2 196,7	472,0 305,2	158,9 195,3	1237,8 833,4
Poorly cultivated soil							
	7,5 6,6	26,0 9,1	24,8 23,0	55,3 56,0	67,2 72,3	25,2 29,4	206,0 196,4

Note: numerator – 2005; denominator – 2006.
1 – shoots; 2 – budding; 3 – flowering; 4 and 5 – on the 15th and 30th days after flowering; 6 – harvesting.

The formation of PP by potato plants was greatly influenced by soil fertility, so in 2006 the total photosynthetic potential on well-cultivated soil was 318.7 thousand m^2/ha days, and on poorly cultivated - 196.4 thousand m^2/ha days, although in 2005 on well-cultivated soil it was slightly lower compared to averagely cultivated soil.

For all experimental variants, the amount of applied fertilizer had a significant effect on the value of photosynthetic potential. Thus, in the most favorable year of 2005, the photosynthetic potential in the variant with calculated doses of fertilizers to absorb 3% PAR was 1.43 times higher than in the variant with recommended doses on moderately cultivated soil, and on well-cultivated soil 1.73 times higher than in the variant without fertilizers and slightly lower compared to the variant where the recommended doses were used. It should be especially noted that on poorly cultivated soil, the photosynthetic potential in all years of research was lower than on the control variants of moderately and well-cultivated soil.

Photosynthesis is the main source of the creation of organic matter by plants, and the most important role in this process is played by leaves. But as it was said earlier, creating an optimal leaf surface per 1 hectare does not guarantee high yields of potato tubers. Of great importance in determining the intensity of accumulation of organic mass is the value of net productivity of photosynthesis (the amount of dry matter accumulated per day per 1 m^2 of leaves), which can greatly change under the influence of external factors.

The net productivity of photosynthesis is determined by the gross productivity of photosynthesis minus the cost of organic matter for respiration and all kinds of losses due to root secretions into the soil, dying and falling of leaves.

10. Net productivity of potato photosynthesis (g/m^2 day), 2005 – 2006.

Option	Deadlines for determination						Average for the growing season
	1	2	3	4	5	6	
Moderately cultivated soil							
1	39,3 / 6,3	13,1 / 5,7	4,9 / 9,3	4,9 / 7,8	8,5 / 15,1	-5,9 / 33,3	5,2 / 12,8
2	24,9 / 6,1	8,9 / 9,4	12,7 / 12,0	5,8 / 6,0	5,5 / 15,2	-0,7 / 0,8	5,8 / 8,9
3	19,5 / 7,4	10,5 / 8,8	13,3 / 10,2	4,4 / 7,0	4,9 / 15,0	-5,3 / 7,7	4,2 / 10,6
4	27,3 / 6,4	12,4 / 7,3	6,3 / 11,9	4,6 / 6,7	9,9 / 12,4	-8,1 / 9,9	5,5 / 10,0
Well-cultivated soil							
1	26,6 / 6,4	10,1 / 7,6	6,5 / 12,1	8,1 / 6,2	5,7 / 10,8	-4,3 / 26,0	6,3 / 11,5
2	22,2 / 7,7	10,1 / 8,0	7,3 / 10,9	4,3 / 5,3	7,0 / 11,7	-8,4 / 9,0	4,5 / 9,3
3	18,1 / 5,6	10,0 / 8,9	9,5 / 11,5	4,9 / 5,9	3,9 / 8,5	-9,0 / 8,0	3,7 / 8,0
Poorly cultivated soil							
	22,7 / 12,1	12,0 / 4,4	16,6 / 15,7	13,6 / 12,0	11,4 / 10,4	-10,6 / 9,5	10,4 / 11,1

Note: numerator – 2005; denominator – 2006.
1 – shoots; 2 – budding; 3 – flowering; 4 and 5 – on the 15th and 30th days after flowering; 6 – harvesting.

Our research, presented in Table 10 show that the indicators of net productivity of photosynthesis change throughout the entire growing season depending on the area of the leaf surface, the rate of its formation, the duration of active leaf growth, meteorological factors, and soil fertility. In the first periods of tops formation and growth, the assimilation apparatus is represented by the most efficient young leaves and therefore during this period its productivity is the highest. In our experiments, it fluctuated during this period from 5.5 in 2006 to 39.3 g/m^2 per day in 2005. This is probably due to weather conditions during the period of germination and the beginning of the formation of the leaf surface.

The productivity of photosynthesis is inversely proportional to the growth of leaf area; as a result, the net productivity of photosynthesis on unfertilized variants was higher than on variants with calculated and recommended doses of fertilizers.

The productivity of the potato leaf surface and the economic efficiency coefficient are the most important indicators of the photosynthetic activity of potato plantings.

In our experiments, as well as in the works of I. S. Shatilov (1971, 1975) with colleagues, Yu. I. Pashin (1989) and A. M. Dzeitov (1974), the productivity of leaves depends on weather conditions, soil fertility and doses of fertilizers (Table 11-12). Each thousand units of photosynthetic potential synthesized from 20.8 to 29.7 kg of tubers in 2005, and from 29.6 to 45.5 kg of tubers in 2006.

11. Leaf surface productivity (kg of dry matter and tubers per 1 thousand PP units), 2005.

Option	Shoots	Budding	Blooming	After flowering on		Harvesting	Account for tubers	Khoz
				Day 15	Day 30			
Moderately cultivated soil								
1	39,3	15,6	9,5	6,6	7,5	5,2	23,0	0,90
2	24,9	11,3	12,1	8,0	6,9	5,8	26,2	0,91
3	19,5	11,7	12,7	7,1	6,0	4,2	21,8	0,92
4	27,3	13,8	9,3	6,5	8,0	5,6	29,7	0,94
Well-cultivated soil								
1	26,6	12,3	9,4	8,6	7,4	6,3	24,6	0,94
2	22,2	11,8	9,2	6,2	6,5	4,6	21,1	0,93
3	18,1	10,9	10,1	6,8	5,6	3,7	20,8	0,95
Poorly cultivated soil								
	22,7	14,4	15,3	14,5	13,3	10,4	27,7	0,97

12. Leaf surface productivity (kg of dry matter and tubers per 1 thousand PP units), 2006.

Option	Shoots	Budding	Blooming	After flowering on		Harvesting	Account for tubers	Khoz
				Day 15	Day 30			
Moderately cultivated soil								
1	6,3	5,9	7,6	7,7	10,2	12,8	43,7	0,94
2	6,1	8,2	10,4	7,8	11,6	8,9	34,0	0,87
3	7,4	8,3	9,4	7,9	11,5	10,6	41,9	0,88
4	6,4	7,0	10,0	8,0	10,0	10,0	37,4	0,91
Well-cultivated soil								
1	6,4	7,1	9,6	7,9	9,0	11,5	45,5	0,97
2	7,7	7,9	9,8	7,1	9,3	9,3	34,9	0,87
3	5,6	7,7	9,9	7,6	8,0	8,0	29,6	0,86
Poorly cultivated soil								
	12,1	7,6	12,4	12,1	11,4	11,1	39,5	0,96

The applied fertilizers, regardless of the level of natural soil fertility, reduced the productive work of the leaves. Thus, in 2005, every thousand units of photosynthetic potential in option 1 of well-cultivated soil synthesized 6.3 kg of dry matter, and in options 2 and 3 only 4.6 and 3.7 kg. In 2006, exactly the same picture was observed as in 2005, but there was already more than 1 kg of dry matter for every thousand units of leaf surface. This decrease was due to, but not proportional to, an increase in leaf area. Therefore, fertilizers ultimately contributed to greater dry matter and tuber yields.

Soil fertility levels significantly affected leaf productivity only in 2005. For example, on poorly cultivated soil, for every thousand units of photosynthetic potential there were 10.4 kg of dry matter, and on medium- and well-cultivated soil, 5.2 and 6.3 kg, respectively.

One of the main characteristics of the photosynthetic activity of potato plantings is the indicator of the economic value of the crop (Kkhoz), equal to the ratio of the dry mass of tubers to the total yield of dry matter.

According to A. T. Mokronosov (1971), in potatoes it can vary widely: from 0.87-0.89 under conditions favorable for tuber formation and up to 0.4-0.5 with one-sided nitrogen nutrition and abundant water supply. For the conditions of the Moscow region, this figure is 0.92 (Vecher A. S. et al., 1973).

In our studies (Table 12), fertilizers reduced this indicator only in 2006. Thus, on poorly cultivated soil it was 0.96, and on medium and well-cultivated soil in the variants with the use of fertilizers it changed from 0.86 to 0.88.

The economic efficiency coefficient, as well as the productivity of the assimilation apparatus in our studies, varied depending on weather conditions. In the wettest of the years studied, 2005, according to the options, it ranged from 0.90 to 0.97 on poorly cultivated soil.

Productivity is an integral indicator determined by the complex interaction of external and internal factors (Velyaminova-Zernova L.D., 1982).

Cultivation of potatoes under various conditions of mineral nutrition with favorable moisture had a noticeable effect on its productivity (Table 14). On average, over 2 years on moderately cultivated soil, when applying calculated doses of fertilizers for tuber yields of 250 c/ha, 271 were obtained, and when calculating 350 - 359 c/ha. The increase to the control was 116 and 204 c/ha or 74.8-131.6%. The calculated dose of fertilizers to produce 350 centners had an advantage in yield formation over the recommended doses on average for 2 years.

On well-cultivated soil, the variant with calculated doses of fertilizers received an average of 292 centners over 2 years, which is 143 centners higher than the control. There was a clear predominance of calculated doses over recommended ones in 2006.

Significant impact on potato productivity in 2005-2006 had soil fertility. The yield of potato tubers on well- and moderately cultivated soil without the use of fertilizers on average over 2 years was significantly higher than on poorly cultivated soil by 81-87 c/ha.

The difference in the yield of tubers grown on well- and moderately cultivated soil without the use of fertilizers in 2005-2006 research was significant, but on average over 2 years it was not significant.

The dry summer and high air temperature of 2007 negatively affected the tuberization process. On some days the air temperature rose to almost 32°C.

F. I. Bobryshev (1977) points out that at air temperatures above 22-23°C, the assimilation of carbon dioxide by plants decreases sharply, and at higher temperatures, complete inhibition of the synthesis of organic matter is observed.

According to O. I. Volovik (1990), an increase in air temperature from 15 to 28°C leads to a significant – 27-30% – reduction in the accumulation of organic matter.

Potato productivity for all options in 2007, with the exception of poorly cultivated soil, was significantly lower than in previous years.

The use of calculated and recommended doses ensured an increase in yield on medium and well-cultivated soil. The calculated dose of fertilizers to produce 350 centners of tubers provided an increase in yield over the control of 112 centners/ha on medium cultivated soil.

The yield of potato tubers consists of the yield of individual fractions used for various purposes. The use of calculated and recommended doses of fertilizers on average over 2 years contributed to a significant increase in the proportion of the coarse fraction due to a decrease in the small and seed fractions (Table 13).

Soil fertility had a certain influence on the structure of the crop. On poorly cultivated soil, more seed and small tubers were formed than on control variants of well- and moderately cultivated soil.

13. Structure of the potato harvest (in %, tubers).

Option	2005			2006			Average for 2005-2006			2007		
	<30 g	30-80 g	>80 g	<30 g	30-80 g	>80 g	<30 g	30-80 g	>80 g	<30 g	30-80 g	>80 g
Moderately cultivated soil												
1	20,5	25,7	53,8	11,1	48,1	40,8	15,8	36,9	47,3	17,8	56,8	25,4
2	8,0	14,9	77,1	1,9	14,5	83,6	5,0	14,7	80,3	14,1	29,2	56,7
3	5,3	14,2	80,5	3,1	14,3	82,6	4,2	14,3	81,5	22,4	31,2	46,4
4	9,0	12,2	78,8	1,8	19,3	78,9	5,4	15,8	78,8	11,2	19,1	69,7
Well-cultivated soil												
1	8,9	32,4	58,7	5,6	36,0	58,4	7,	34,2	58,5	14,0	58,0	28,0
2	9,6	13,3	77,1	4,3	12,0	83,7	7,0	12,6	80,4	24,7	29,9	45,4
3	11,6	20,7	67,7	7,1	32,2	60,7	9,4	26,4	64,2	14,0	35,9	50,1
Poorly cultivated soil												
	27,3	50,4	22,3	11,7	42,3	46,0	19,5	46,4	34,1	55,9	44,1	-

In the dry year of 2007, the share of the coarse fraction noticeably decreased due to an increase in the small and seed fraction. On poorly cultivated soil, there were no tubers >80 g. The recommended dose of fertilizers on moderately cultivated soil increased the proportion of large tubers due to a decrease in the seed fraction compared to the calculated doses.

14. Potato yield (by fractions) at different levels of mineral nutrition (2005-2007).

Option	Year	Tuber yield, c/ha	Tubers obtained (per 1 ha)		
			small	seed	coarse
			<30 g, c/ha	30-80 g, c/ha	>80 g, c/ha
1	2	3	4	5	6
Moderately cultivated soil					
1	2005	205	42,0	52,7	110,3
	2006	105	11,7	50,5	42,8
	cp.	155	24,5	57,2	73,3
	2007	78	13,9	44,3	19,8
2	2005	287	23,0	42,8	221,2
	2006	255	4,8	37,0	213,2
	cp.	271	13,6	39,8	217,6
	2007	155	21,9	45,3	87,8
3	2005	361	19,1	51,3	290,6
	2006	356	11,0	50,9	294,1
	cp.	359	15,1	51,3	292,6
	2007	190	42,6	59,3	88,1
4	2005	344	31,0	42,0	271,0
	2006	228	4,1	44,0	179,0
	cp.	286	15,4	45,2	225,4
	2007	161	18,0	30,8	115,2
Well-cultivated soil					
1	2005	153	13,6	49,6	89,8
	2006	145	8,1	52,2	84,7
	cp.	149	10,9	51,0	87,1
	2007	112	15,7	65,0	31,3
2	2005	226	21,7	30,1	174,2
	2006	357	15,4	42,8	298,8
	cp.	292	20,4	36,8	234,8
	2007	190	46,9	56,8	86,3
3	2005	258	29,9	53,4	174,7
	2006	247	17,5	79,5	150,0
	cp.	253	23,8	66,8	162,4
	2007	169	23,7	60,7	84,6
Poorly cultivated soil					
	2005	57	15,6	28,7	12,7
	2006	78	9,1	33,0	35,9
	cp.	68	13,3	31,6	23,1
	2007	57	31,9	25,1	-

Significant increase in yield in 2005-2006 occurred due to greater collection of the large fraction. On poorly cultivated soil, the collection of all fractions was significantly lower than on more fertile soil (Table 14).

Part of the solar energy used by plants for the process of photosynthesis is called a photosynthetically active radiation and it makes up 48% of the total radiation (Klimov A. A. et al., 1971).

The arrival of a photosynthetically active radiation according to the phases of development of potato plants and during the growing season as a whole varies from year to year (Table 15). Thus, in 2006, it was received during the flowering-harvesting period 1.7 times more than in 1990.

15. PAR arrival by phases of development of potato plants, million kcal/ha.

Year	Planting - shoots	Shoots - budding	Budding - flowering	Flowering - harvesting	Посадка - уборка
2005	867,0	444,2	200,1	906,6	2417,9
2006	781,8	491,9	223,0	1545,8	3042,5

Indicators of the efficiency of solar energy absorption is the coefficient of the use of photosynthetically active radiation for the process of photosynthesis and the formation of phytomass. It depends on many factors: meteorological conditions, leaf surface area, level of mineral nutrition, biological and genetic characteristics of the variety, etc.

In our studies, the amount of solar energy absorption (PAR) by potato plants changed over the years (Table 16). Thus, in the wet year of 2005 it was higher than in the less wet year of 1991, except for the variant with calculated doses of fertilizers for a yield of 350 centners of tubers in well-cultivated soil and the variant of poorly cultivated soil.

16. Utilization of solar energy by potato plants, % of incoming PAR.

Option	Aligned from the field	Enters the soil					PAR utilization factor	PAR utilization rate on average over 2 years
	tubers	Total	tubers	tops	litter	roots		
Moderately cultivated soil								
1	0,65/0,31	0,49/0,15	0,05/0,02	0,08/0,02	0,13/0,03	0,23/0,08	1,14/0,46	0,80
2	0,80/0,75	0,86/0,41	0,25/0,02	0,10/0,13	0,22/0,06	0,29/0,20	1,66/1,16	1,41
3	0,93/1,05	0,86/0,45	0,23/0,02	0,10/0,16	0,23/0,03	0,30/0,24	1,79/1,50	1,65
4	0,96/0,67	0,70/0,31	0,14/0,01	0,06/0,08	0,21/0,05	0,29/0,17	1,66/0,98	1,32
Well-cultivated soil								
1	0,50/0,43	0,61/0,18	0,16/0,01	0,04/0,02	0,18/0,04	0,23/0,11	1,11/0,61	0,86
2	0,61/1,05	0,69/0,49	0,13/0,01	0,06/0,18	0,26/0,05	0,24/0,25	1,30/1,54	1,42
3	0,67/0,73	0,61/0,36	0,13/0,01	0,04/0,13	0,20/0,03	0,24/0,18	1,28/1,09	1,19
Poorly cultivated soil								
	0,16/0,23	0,19/0,13	0,03/0,02	0,01/0,01	0,08/0,03	0,07/0,07	0,35/0,36	0,36

Note: the numerator is 2005, the denominator is 2006.

The use of calculated and recommended doses of fertilizers increased the efficiency of using photosynthetically active radiation compared to control options.

In variants with calculated doses of fertilizers for a tuber yield of 350 centners, the coefficient of PAR utilization was higher than in variants with recommended doses. So, on average over 2 years on medium and well-cultivated soil it was 1.65 and 1.42%, and at recommended doses 1.32 and 1.19%.

The coefficient of solar energy use on unfertilized variants of medium- and well-cultivated soil on average over 2 years was 2.2-2.4 times higher compared to poorly cultivated soil.

The size of the phytomass has a significant influence on the consumption of physiologically active radiation by potato plants; the greater the accumulation of phytomass (Table 17), the higher the coefficient of solar energy use (Table 16).

17. Balance of potato phytomass, c/ha.

Option	Phytomass, total	Aligned from the field	Enters the soil					Phytomass average for 2 years
			Total	tubers	tops	litter	roots	
Moderately cultivated soil								
1	63,8 33,2	35,9 21,6	27,9 11,6	2,7 1,3	4,5 1,7	7,9 2,6	12,8 6,0	48,5
2	92,8 81,5	44,1 52,2	48,7 29,3	13,6 1,7	5,5 9,0	13,5 4,6	16,1 14,0	87,2
3	100,4 104,8	51,3 72,9	49,1 31,9	12,4 1,5	5,7 11,2	14,0 2,2	17,0 17,0	102,6
4	92,5 68,5	52,6 46,6	39,9 21,9	7,1 0,4	3,5 5,7	12,8 3,8	16,5 12,0	80,5
Well-cultivated soil								
1	62,5 42,4	27,7 29,7	34,8 12,5	8,9 0,4	2,4 1,1	11,1 3,0	12,4 8,0	52,4
2	73,1 108,0	33,7 73,1	39,4 34,9	6,9 0,7	3,3 12,2	15,6 40,	13,6 18,0	90,6
3	71,4 76,2	36,6 50,6	34,8 25,6	7,0 1,4	2,2 9,2	12,1 2,0	13,5 13,0	73,8
Poorly cultivated soil								
	20,0 25,8	8,8 15,9	11,2 9,9	1,6 1,4	0,6 1,0	5,0 2,5	4,0 5,0	22,9

Note: numerator – 2005; denominator – 2006

In our studies, the energy productivity of plants changed over the years (Table 18). Thus, in 2005, on medium and well-cultivated soil in options without the use of fertilizers, it was 1.9-1.5 times greater compared to 2006.

The use of recommended and calculated doses of fertilizers for a yield of 250 and 350 centners of tubers significantly increased the calorie content of the phytomass. For example, on average cultivated soil in option 2 (calculated doses of fertilizers for a tuber harvest of 350 c), the energy productivity of the agrophytocenosis on average over 2 years amounted to 44.65 million kcal/ha, which is 2.1 times higher than the indicator for the option without fertilizers.

18. Energy productivity of potatoes, million kcal/ha.

Option	Aligned from the field	Enters the soil					Coefficient of PAR utilization for tubers	Coefficient of PAR utilization on average for 2 years
	Tubers	Total	Tubers	Tops	Tubers	Total		
Moderately cultivated soil								
1	15,8 9,5	11,83 4,89	1,19 0,53	1,98 0,74	3,16 1,04	5,50 2,58	27,63 14,39	21,01
2	19,45 22,96	20,73 12,56	5,98 0,74	2,42 3,96	5,40 1,84	6,93 6,02	40,18 35,52	37,85
3	22,57 32,07	20,88 13,77	5,46 0,66	2,51 4,92	5,60 0,88	7,31 7,31	43,45 45,84	44,65
4	23,14 20,5	16,88 9,35	3,12 0,17	1,54 2,5	5,12 1,52	7,10 5,16	40,02 29,85	34,94
Well-cultivated soil								
1	12,19 13,06	14,74 5,29	3,92 0,17	1,06 0,48	4,44 1,20	5,32 3,44	26,93 18,35	22,64
2	14,83 32,16	16,57 15,00	3,04 0,30	1,45 5,36	6,24 1,60	5,84 7,74	31,40 47,16	39,28
3	16,10 22,26	14,7 11,04	3,08 0,61	0,97 4,04	4,84 0,80	5,81 5,59	30,80 33,30	32,05
Poorly cultivated soil								
	3,87 6,99	4,69 4,20	0,70 0,61	0,26 0,44	2,0 1,00	1,73 2,15	8,56 11,19	9,88

Note: numerator – 2005; denominator – 2006.

The calorie content of the potato harvest on poorly cultivated soil on average over 2 years was 2.1-2.3 times less than the calorie content of the yield of variants without fertilizers in medium- and well-cultivated soil.

As a result of harvesting potatoes, the solar energy accumulated by the agrophytocenosis is divided: part of it is alienated from the field by humans, and part of it enters the soil, replenishing the reserves of organic matter. In the humid year of 2005, from 42.2 to 54.8% of the stored solar energy entered the soil with unharvested tubers (losses), tops, litter and root system of plants, and in the less humid year of 2006 it entered from 30.0 to 37.5 %.

Productivity is the product of photosynthetic activity of green leaves. The formation of the yield of potato plants is significantly influenced by a number of factors: weather conditions, soil fertility, level of agricultural technology, quality of planting material and others.

The research results showed that physiologically active substances and low-frequency electromagnetic fields influence the realization of the potential capabilities of potato plants to varying degrees. The control yield on average over 2 years was 284.5 c/ha (Table 19).

19. Productivity of potato tubers, c/ha.

Option	2005	2006	Average for 2005-2006	Average increase		2007
				c/ha	%	
Control	276,0	293,0	284,5	-	-	206,0
Simarp, 1 mg/l	330,0	290,0	310,0	25,5	9,0	209,0
Krezacin, 40 mg/l	374,0	366,0	370,0	85,5	30,1	218,0
Water	294,0	287,0	290,5	6,0	2,1	-
Furolan, 30 mg/l	316,0	317,0	316,5	32,0	11,2	-
Furolan, 50 mg/l	331,0	324,0	327,5	43,0	15,1	-
Furolan, 70 mg/l	331,0	330,0	330,5	46,0	16,2	216,0
Furolan, 10 mg/l	270,0	304,0	287,0	2,5	0,9	-
Furolan, 30 mg/l	318,0	309,0	313,0	29,0	10,2	-
Furolan, 50 mg/l	315,0	317,0	316,0	31,5	11,1	-
Furolan, 60 mg/l	317,0	345,0	331,0	46,5	16,3	224,0
Furolan, 80 mg/l	323,0	361,0	342,0	57,5	20,2	230,0
Furolan, 100 mg/l	340,0	340,0	340,0	55,5	19,5	221,0
Copper sulfate bloom, 500 mg/l	344,0	332,0	338,0	53,5	18,8	-
Copper sulfate budding, 500 mg/l	317,0	344,0	330,5	46,0	16,2	223,0
Copper sulfate budding, 500 mg/l + flowering, 500 mg/l	326,0	342,0	334,0	49,5	17,4	-
EM	281,0	298,0	289,5	5,0	1,8	-
NSR_{05} c/ha	17,8	23,7				23,0

Krezacin turned out to be the most effective in influencing plant productivity. Spraying plants with the drug caused an increase in yield to 370 c/ha, which is 30.1% higher than the control.

The use of simarp in different years had a different impact on the realization of the genetic capabilities of plants.

A more stable increase in potato productivity compared to simarp was caused by spraying seed material with furolan at a drug concentration of 70 mg/l, where the yield on average over 2 years was 16.2% higher.

The use of furolan during the growing season ensured an increase in productivity. With an increase in the concentration of the drug, there was an increase in yield from 287 c/ha at the minimum (10 mg/l) to 342 at 80 mg/l.

Copper sulfate increased potato yields, but this effect was slightly lower compared to krezacin. The yield over 2 years of research for the three options where the drug was used was approximately the same and varied from 330.5 to 338 c/ha.

The low-frequency electromagnetic field did not have a significant effect on yield. In this option, over 2 years, the average tuber harvest was 289.5 c/ha.

Due to the dry summer of 2007, the differences between the options in terms of yield were insignificant. It varied from 206.0 c/ha in the control to 230.0 c/ha in the variant with the use of furolan (80 mg/l) during the growing season.

A prerequisite for active photosynthetic activity of plants is optimal moisture supply. A decrease in soil moisture primarily affects the formation of tubers (Buzover F. Ya., 1957, 1963).

The soil temperature during the period of tuber formation on some days rose to almost 27˚C at a depth of 5 cm and more than 20˚C at a depth of 20 cm, which negatively affected the process of their formation and accumulation of organic matter.

According to P. I. Alsmik et al. (1979), at soil temperatures above 20°C, tuber formation is sharply inhibited, and at 29°C it stops. Normal tuberization in potatoes occurs at temperatures no higher than 18-19°C.

Physiologically active substances influenced the structure of the crop (Table 20). In 2005, potato tops were attacked by late blight at the end of flowering, and as a result, the proportion of the coarse fraction decreased. In all variants, except for the treatment of tubers with furolan, compared to the control, the proportion of the large fraction (>80 g) was higher due to a decrease in the proportion of the seed fraction (30-80 g).

20. Structure of potato harvest, in%.

Option	2005			2006			Average for 2005-2006			1992		
	<30	30-80	>80	<30	30-80	>80	<30	30-80	>80	<30	30-80	>80
Control	9,1	44,9	46,0	6,5	21,0	72,5	7,8	33,0	59,2	11,5	75,1	13,4
Simarp, 1 mg/l	7,8	27,4	64,8	5,5	29,0	65,5	6,7	28,2	65,1	11,4	84,3	4,3
Krezacin, 40 mg/l	9,3	32,7	58,0	1,5	14,5	84,0	5,4	23,6	71,0	14,8	30,3	54,9
Furolan, 70 mg/l	10,2	44,5	45,3	3,5	20,0	76,5	6,9	32,2	60,9	15,2	71,9	12,9
Furolan, 80 mg/l	12,2	21,5	66,3	2,0	16,0	82,0	7,1	18,8	74,1	10,2	61,1	28,7
Copper sulfate budding, 500 mg/l	7,8	25,0	67,2	2,0	5,0	93,0	4,9	15,0	80,1	11,9	57,9	30,2

The use of krezacin, furolan during the growing season and copper sulfate in 2006 contributed to an increase in the proportion of large fractions by reducing the proportion of small (<30 g) and seed (30-80 g) ones. On average, over two years of research, the proportion of tubers >80 g in the above-mentioned variants was significantly higher than in the control.

21. Potato yield (by fractions) under the influence of growth regulators (2005-2007)

Option	Year	Tuber yield, c/ha	Tubers obtained (per 1 ha)		
			small	seed	coarse
			<30 g, c/ha	30-80 g, c/ha	>80 g, c/ha
Control	2005	276,0	25,1	123,9	127,0
	2006	293,0	19,1	61,5	212,4
	av	284,5	22,2	93,9	168,4
	2007	206,0	23,7	154,7	27,6
Simarp, 1 mg/l	2005	330,0	25,7	90,4	213,9
	2006	290,0	16,0	84,0	190,0
	av	310,0	20,8	87,4	20,8
	2007	209,0	23,8	176,2	9,0
Krezacin, 40 mg/l	2005	374,0	34,8	122,3	216,9
	2006	366,0	5,5	53,1	307,4
	av	370,0	20,0	87,3	262,7
	2007	218,0	32,3	66,1	119,6
Furolan, 70 mg/l	2005	331,0	33,8	147,3	149,9
	2006	330,0	11,6	66,0	252,4
	av	330,5	22,8	106,4	201,3
	2007	216,0	32,8	155,3	27,9
Furolan, 80 mg/l	2005	323,0	39,4	69,5	214,1
	2006	361,0	7,2	57,8	296,0
	av	342,0	24,3	64,3	253,4
	2007	230,0	23,5	140,5	66,0
Copper sulfate budding, 500 mg/l	2005	317,0	24,7	79,3	213,0
	2006	344,0	6,9	17,2	319,9
	av	330,5	16,2	49,6	264,7
	2007	223,0	26,5	129,1	67,4

Yield growth in 2005-2006 occurred due to a greater collection of the large fraction (>80 g) in all options (Table 21). In 2007, which was atypical for weather conditions, there was a difference in the harvest structure among the variants. The use of simarp caused an increase in the proportion of the seed fraction (30-80 g) due to a decrease in the proportion of the coarse fraction (>80 g). Krezacin, copper sulfate and furolan during the growing season influenced the share of the large fraction (>80 g).

Taking into account the dependence of the yield on the quality of the seed material, during 2006 and 2007 we studied the influence of physiologically active substances, copper sulfate and low-frequency electromagnetic field on the yield of tubers in the offspring. Tubers after winter storage were planted on the same agricultural background with the application of $N_{90}P_{60}K_{60}$ and 35 tons of organic fertilizers.

22. Seed properties of tubers under conditions of use of physiologically active substances.

Option	2006	Average increase		2007	Average increase	
		c/ha	%		c/ha	c/ha
Control	361,0	-	-	269,0	-	-
Krezacin, 40 mg/l	366,0	+5,0	+1,4	283,0	+14,0	+5,2
Furolan, 70 mg/l	488,0	+127,0	+35,2	251,0	-18,0	-6,7
Furolan, 80 mg/l	466,0	+105,0	+29,1	291,0	+22,0	+8,2
Copper sulfate budding, 500 mg/l	-	-	-	248,0	-21,0	-7,8
EM	405,0	+44,0	+12,2	249,0	+20,0	-7,4
NSR_{05} c/ha	32,4			29,1		

The experimental results (Table 22) clearly show that some growth regulators affect the seed properties of tubers. Thus, the use of furolan for pre-planting treatment of tubers caused an increase in productivity in the offspring by 35.2%, while the use of krezacin had no effect. In 2007, due to drought, there were no significant differences between the options.

23. Structure of the potato harvest, in%, 2007.

Option	fractions		
	<30 g	30-80 g	>80 g
Control	10,4	28,1	61,5
Krezacin, 40 mg/l	8,5	27,3	64
Furolan, 70 mg/l	13,6	49,0	37,4
Furolan, 80 mg/l	8,6	39,9	51,5
Copper sulfate budding, 500 mg/l	11,8	45,2	43,0
EM	10,1	33,0	56,9

The use of physiologically active substances when growing potatoes caused a change in the structure of the yield in the offspring (Table 23). Furolan and copper sulfate ensure an increase in the proportion of the seed fraction by reducing the coarse fraction.

The area occupied by potatoes, other things being equal, produces almost three times more dry matter than bread (D. P. Pryanishnikov, 1965).

The dry matter of tubers contains a number of compounds that characterize the taste and culinary qualities of potatoes. One of the main nutritional indicators of potato tubers is the starch content. The starch content in tubers depends on many factors: weather conditions, characteristics of the variety, agricultural technology, level of mineral nutrition, etc.

The use of physiologically active substances in the experiments influenced the process of starch accumulation (Table 24). Spraying seed material with furolan only in 2005 ensured an increase in its content by 1.5%. The use of krezacin in 2007 contributed to an increase in its content by 0.9%. On average, over three years there were no significant differences among the options in terms of starch content in the tubers.

In our studies, the process of the starch accumulation was influenced by weather conditions. Thus, in the dry year of 2007, the tubers were characterized by a higher starch content than in the wet year of 2005.

24. Content of starch, nitrates, sugar and protein in potato tubers.

Option	Processing time	Year	Starch, %	Nitrates, mg/kg	Ascorbic acid, mg%	Sugars reducing, %	Sugars total, %	Protein, %
Control		2005 2006 2007 av	17,9 18,6 19,1 18,5	55,0 140,0 - 97,5	0,25	1,79	4,69	1,28
Simarp, 1 mg/l	1	2005 2006 2007 av	17,8 18,4 19,3 18,5	50,0 150,0 - 100,0	0,40	1,78	2,50	1,10
Krezacin, 40 mg/l	2	2005 2006 2007 av.	18,1 18,4 20,0 18,8	61,0 71,7 - 66,4	0,31	1,77	3,93	1,03
Furolan, 70 mg/l	1	2005 2006 2007 av.	19,4 18,6 19,1 19,0	47,0 71,7 - 59,4	0,33	1,47	2,20	1,18
Furolan, 80 mg/l	2	2005 2006 2007 av	18,1 18,7 19,2 18,7	56,0 70,1 - 63,1	0,31	1,62	3,50	1,09
Copper sulfate budding, 500 mg/l	2	2005 2006 2007 av	18,2 18,5 19,2 18,6	40,0 128,0 - 84,0	0,42	2,0	3,95	1,22

Note: 1 – processing of planting material; 2 – spraying plants.

An essential indicator of the quality of tubers is the nitrate content. The process of accumulation of nitrates in tubers is influenced by many factors: meteorological conditions, fertilizer, variety and others.

The use of physiologically active substances in our studies had different effects on the nitrate content in tubers (Table 24). In the humid year of 2005, growth regulators did not have a noticeable effect on the process of nitrate accumulation by tubers, and this year, according to all options, their content was 4-6 times lower than the MPC. In the less humid year of 2006, in the control variant, their content was 140 mg/kg, which is 1.7 times lower than the norm. From the above it follows that weather conditions can have a significant impact on the process of accumulation of nitrates by tubers. The use of physiologically active substances (krezacin and furolan) in 2006 provided a significant reduction in nitrates. For example, spraying potato plants with furolan caused a decrease in nitrates by almost 2 times.

The most important indicators of the quality of potato tubers include: the content of ascorbic acid, protein and sugars. Spraying plants with copper sulfate increased the vitamin C content by 68%, and with simarp - by 60%. Physiologically active substances and copper sulfate did not have a significant effect on the content of reducing sugars and protein in the tubers. In the variants using simarp and furolan before planting tubers, the content of total sugars was lower than the control variant. The low content of ascorbic acid and high content of sugars can probably be explained by the fact that the analyses were carried out 3 months after harvesting.

Growth regulators ensured an increase in starch yield per unit area (Table 25), but this was largely due to a higher yield than to its relative content. Krezacin ensured an increase in starch collection on average for 2005-2007 by 29.8%.

25. Starch collection, c/ha.

Option	Processing method	2005	2006	Average for 2005-2006	Average increase		2007
					c/ha	%	
Control		49,4	54,5	52,0	-	-	39,3
Simarp, 1 mg/l	1	58,7	53,4	56,1	4,1	7,9	40,3
Krezacin, 40 mg/l	2	67,7	67,3	67,5	15,5	29,8	43,6
Water	2	54,1	52,2	53,2	1,2	2,3	-
Furolan, 30 mg/l	1	56,9	58,3	57,6	5,6	10,8	-
Furolan, 50 mg/l	1	59,9	59,9	59,9	7,9	15,2	-
Furolan, 70 mg/l	1	64,2	61,4	62,8	10,8	20,8	41,3
Furolan, 10 mg/l	2	50,0	55,9	53,0	1,0	1,9	-
Furolan, 30 mg/l	2	56,9	55,9	56,4	4,4	8,5	-
Furolan, 50 mg/l	2	58,3	59,0	58,7	6,7	12,9	-
Furolan, 60 mg/l	2	58,0	64,5	61,3	9,3	17,9	43,2
Furolan, 80 mg/l	2	58,5	67,5	63,0	11,0	21,2	44,2
Furolan, 100 mg/l	2	62,6	62,2	62,4	10,4	20,0	42,9
Copper sulfate bloom, 500 mg/l	3	63,0	62,4	62,7	10,7	20,6	-
Copper sulfate budding, 500 mg/l	2	57,7	63,6	60,7	8,7	16,7	42,8
Si. 500 mg/l + 500 mg/l	2-3	58,7	62,9	60,8	8,8	16,9	-
EM	1	51,7	55,7	53,7	1,7	3,3	-

Note: 1 – processing of planting material; 2 – spraying plants.

A viral infection significantly changes almost all plant parameters at all levels - from the state and functional activity of the photosynthetic apparatus, the activity of enzyme systems, the consumption and accumulation of mineral elements, the intensity of transpiration, the area of vascular bundles (Ambrosov A.L. et al., 1979, Leontyeva Yu A. et al., 1974).

Tsoglin L. N. et al. (1990) found out that the total photosynthesis during the entire growing season in healthy plants is almost 40% higher than in infected ones, and they are characterized by faster growth of the leaf surface.

Plants freed from viruses have an increased physiological activity compared to conventional seed material, which determines a higher level of tuber yield (Batsanov N. S. et al., 1974).

N. I. Adamov et al. (1985) indicate that the degree of plant damage by viruses is reflected in the potato yield, but it depends on the potato variety, its resistance to viruses and the growing area.

The most harmful to potato plants is the leaf curl virus (L), which can cause a reduction in yield up to 77%, loss of starch - up to 12.6% and vitamin C - up to 12.1% (Azbukina E. M., 1980).

In the experiments of V. I. Igontov (1990), the overall infection of potatoes with viruses and mycoplasma diseases of the Volzhanin and Volzhsky varieties changed slightly under the influence of growth regulators, but there was a tendency towards an increase in infection. Physiologically active substances (ethrel, alar and camposan) contributed to a decrease in potato infection by certain viruses in the Volzhanin variety, but no clear pattern was identified.

The results of our research show that the use of physiologically active compounds has an impact on the spread of viral infection. In 2005, in variants using the growth stimulants, there were no plants infected with virus Y, and in 2006, their use caused a decrease in the infection of potato plants with virus X.

In response to infection, plant tissues are capable of producing substances that are practically absent in intact tissues and have nonspecific fungitoxic effects. Plants oppose pathogens of infectious diseases, phytoalexins, which are a special class of phytoncides (Metlitsky L. V. et al., 1985; Metlitsky L. V., 1982; Ozeretskovskaya O. L., 1990).

Phytoalexins are formed not only in damaged plant tissue, but also in response to treatment with a number of chemical agents and physical stress, and in this regard they are sometimes called stress metabolites (Stoessl A. et al., 1976).

In cells infected with a race of late blight (*Phytophthora infestans*) incompatible with the potato variety under study, mainly two phytoalexins are formed - rishitin and lyubimin (Metlitsky L.V. et al., 1980).

As indicated by L. V. Metlitsky et al. (1971), fungicides containing copper have the greatest inducing activity against phytoalexins.

26. The influence of physiologically active substances and copper sulfate on the induction of rishitin.

Option	Rishitin content, mcg/5 ml
Control	0,00
Cu O_4*7H_2O (500 mg/l)	7,89
Krezacin, 40 mg/l	0,00
Simarp, 1 mg/l	0,00
Furolan, 70 mg/l	0,0

The results of our studies (Table 26) show that treatment of tubers only with a solution of copper sulfate ($CuSO_4$ * $7H_2O$) caused the biosynthesis of rishitin in the cells and its content was 7.89 µg per 5 ml of extract.

When cells interact incompatibly with an infection, they quickly react to it and become necrotic, resulting in the rapid release of oligosaccharins responsible for phytoalexin formation. Phytoalexins accumulate in necrotic cells where the parasite is localized and have a negative effect on it. In some cases, phytoalexins kill pathogen cells, and in others they inhibit their growth, in other words, they have both biocidal and biostatic effects. Having killed the parasite, they are metabolized by the tissue and disappear from the necrotic zone (Metlitsky L. V. et al., 1971).

Treatment of seed material with BIF-2 (3-benzimidazolidophosphate) in tubers of a new crop causes an increase in the biosynthesis of phytoalexins when they are infected with the virulent late blight mildew (Tyutchev S. L. et al., 1984).

The use of physiologically active substances for processing seed material and during the growing season of plants had an after-effect when tubers were infected with an incompatible race of the late blight fungus (*Phytophthorosa infestans* (Mont.) de Bazy) on the biosynthesis of rishitin (Table 27).

27. Content of rishitin in potato tubers when they are affected by an incompatible race of late blight, mcg/5 ml.

Option	Rishitin content, mcg/5 ml			
	48 hours after infection	% to control	72 hours after infection	% to control
Control	4,68	-	44,60	-
Simarp, 1 mg/l	20,32	434,2	46,53	104,3
Krezacin, 40 mg/l	11,85	253,2	60,24	135,1
Furolan, 70 mg/l	4,92	105,1	44,11	98,9
Furolan, 80 mg/l	4,60	98,3	36,05	80,8
Cu O_4*7H_2O (500 mg/l)	11,45	244,7	37,02	83,0

The tubers where simarp was used had the greatest activity in the formation of rishitin 48 hours after infection, and its content exceeded the control variant by 434.2%. Spraying potato plants with krezacin and copper sulfate also had an effect on the induction of rishitin, where it was 2.53 and 2.45 times higher than the control variant.

The use of furolan (70 mg/l) for processing seed material and furolan (80 mg/l) for spraying plants did not affect the biosynthesis of rishitin.

72 hours after infection of the tubers, the rishitin content increased in all variants compared to the first recording period (48 hours). The maximum amount of rishitin was contained in tubers obtained from plants sprayed with krezacin, where it was 35.1% more than in the control variant. In other variants, the phytoalexin content was at the control level or slightly lower than it. The most intensive process of induction of rishitin occurred in the control variant compared to the first recording period (after 48 hours) and its amount increased by 9.53 times in 24 hours. The rate of rishitin biosynthesis in the cells of other variants was lower.

Krezacin and simarn, not being direct inducers of phytoalexin (rishitin) and not having an antifungal effect in the concentrations we tested, are able to enhance the biosynthesis of rishitin induced by the fungus, and thus increase the stability of tubers during storage. Copper sulfate is the cause of bioinduction of rishitin, has an antifungal effect and is able to enhance its synthesis. The use of furolan for processing seed tubers and during the growing season does not have a significant effect on the content of rishitin.

CONCLUSIONS AND PROPOSAL TO PRODUCTION

1. An increase in the leaf surface area of the Nevsky potato variety is observed until 15 days after flowering, and then due to the natural aging of leaves and the development of late blight, it decreases.

2. Potato plants reach the maximum accumulation of dry matter on the 30th day after flowering or before harvesting, depending on weather conditions. The application of mineral fertilizers, especially nitrogen, causes a later intersection of the dry matter accumulation curves of tops and tubers.

3. Due to the use of physiologically active substances in 1990, there were no plants affected by the virus on potato plantings, and in 1991 they helped to reduce the incidence of the virus on plants.

4. Application of calculated doses of fertilizers taking into account the absorption of 2% and 3% PAR on well- and moderately cultivated soil ensures the production of 271 - 359 c/ha of tubers, and the increase in yield occurs due to a greater collection of the coarse fraction.

5. The accumulation of harvest by potato plants is greatly influenced by: soil fertility, the level of mineral nutrition, the phase of plant development and others. The bulk of the tuber harvest is formed during the flowering period - the 30th day after it, and during this period the daily increase can reach 14.1 c/ha.

6. Spraying seed material and potato plants with physiologically active substances and copper sulfate ensures an increase in yield up to 85.5 c/ha, and the increase in yield occurs due to an increase in the proportion of the coarse fraction (> 80 g).

7. The use of a low-frequency electromagnetic field, furolan for processing planting material and spraying plants improves the yield properties of seed tubers. The productivity of potato plants increases by 12.2 - 35.2% compared to the control (1991).

8. Physiologically active substances and copper sulfate, used for processing seed material and during the growing season of plants, have an aftereffect when tubers are infected by an incompatible race of late blight fungus on the biosynthesis of rishitin. The tubers where simarp was used had the greatest activity in the formation of rishitin 48 hours after infection and its content exceeded the control variant by 434.2%, and after 72 hours the tubers obtained from plants sprayed with krezacin.

9. Calculated doses of fertilizers ensure an increase in the coefficient of PAR use on medium and well-cultivated soil from 1.41 to 1.65%. The higher the accumulated phytomass, the higher is the solar energy utilization rate.

10. Wet and cool weather during harvest formation helps to reduce the nitrate content, while dry and warm weather increases their content. The use of krezacin and furolan in warm and less humid growing seasons reduced the nitrate content by almost 2 times.

11. The starch content is influenced by weather conditions. Hot and dry weather increases its content. The use of furolan before planting provided an increase in the starch content by 1.5% in 1990, and krezacin in 1992 by 0.9%. Physiologically active substances increase starch collection, but this increase occurs largely at the expense of tuber yield.

In the conditions of the Moscow region, when cultivating potatoes for food purposes, it is necessary to use calculated doses of fertilizers that ensure the accumulation of 2-3% of photosynthetically active radiation by plants, as well as to use physiologically active substances and copper sulfate on commercial and seed plantings in order to increase plant productivity and improve seed properties of tubers.

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RESEARCH OF THE HYDROLOGICAL CYCLE IN FOREST ECOSYSTEMS UNDER CLIMATE CHANGE: CONCEPTS, SIGNIFICANCE, METHODS

Trotska Svitlana
PhD, Sumy National Agricultural University, Ukraine
ORCID ID: 0000-0003-2089-5780

This article attempts to cover the important issues of today. In this article, an attempt is made to cover the important issues of today's science. The article examines the issue of the meaning and importance of forest ecosystems. It is emphasized how climate change affects forest ecosystems. This article is devoted to the analysis of the current state and the historical aspect of the study of the hydrological cycle in forest ecosystems under conditions of climate change. Different methods of research of these processes are considered. Important importance is given to the issue of plant adaptation mechanisms in response to climate changes.

Forest ecosystems, their significance and the importance of research. A forest ecosystem is a complex biotic system consisting of trees and other plants, animals, microorganisms, and abiotic environment that interact with each other in a specific spatial and temporal context [16, 6, 53].

The importance of studying forest ecosystems is unquestionable, as noted by many authors and researchers [38, 57, 54, etc.]. Scientists highlight several key aspects closely related to the significance and importance of forest ecosystems: biodiversity, climate regulation, air and water purification, socioeconomic value, protection against natural disasters, recreational opportunities, and others.

Forests are habitats for a large number of diverse plant, animal, and microbial species. Forest ecosystems provide a unique environment for many living organisms and preserve the genetic diversity of our planet. Forests are a source of various products such as timber, food, medicine, water, and other resources that are crucial for human life and the economy. Forests serve as places for relaxation and the replenishment of human resources. Forests absorb carbon dioxide, release oxygen, and influence the hydrological cycle of forest ecosystems and the planet as a whole. Forests filter the air by absorbing pollutants and dust, and they modify the quality and slow down the runoff of water, filtering contaminants through the soil. Forests are important for preserving climate balance and mitigating the impact of climate change. Forests can reduce the risk of floods, earthquakes, and other natural disasters.

The concept of climate change and its implications on forest ecosystems. Climate change denotes substantial alterations in Earth's overall living conditions, occurring gradually over an extended period. This phenomenon encompasses fluctuations in temperature, precipitation, wind patterns, and various elements comprising the climate. It is worth noting that these changes can stem from both natural factors and human activities [26].

Presently, considerable attention is being directed toward discerning the significance and mechanisms underlying the impact of climate change on forests. Forest ecosystems are already experiencing substantial repercussions as a result of climate change. The magnitude of this influence is diverse, encompassing shifts in precipitation patterns, an upsurge in the occurrence of natural wildfires, modifications in the geographical distribution of various species, heightened susceptibility to diseases and pest infestations, among others.

Climate variability results in an imbalanced distribution of precipitation, consequently giving rise to instances of both droughts and floods on varying scales [11, 10, 7, etc.]. In light of the evolving climate, forest fires are increasingly prevalent, posing a significant risk to the destruction and disruption of entire forest ecosystems. As temperature patterns shift and precipitation redistributes, certain tree species may lose their natural habitats, leading to detrimental effects on their overall distribution and biodiversity [32, 27, 1, etc.]. Climate fluctuations can contribute to the proliferation of diseases and pests, thereby jeopardizing forest ecosystems and causing widespread tree mortality [47, 44, 17]. The changes in climate can provoke alterations in the growth, development, and phenology of plants [4, 35, 58]. These impacts can give rise to severe repercussions for the essential ecosystem services that forests offer, encompassing the conservation of biodiversity, purification of air and water, regulation of climate, and other critical functions. Consequently, climate change emerges as a formidable threat to forest ecosystems, necessitating prompt attention and decisive action to ensure the preservation of their stability and sustainability.

Numerous researchers worldwide have conducted extensive investigations concerning the influence of climate change on forest ecosystems. These scholars diligently analyze the repercussions of climate change by considering various factors such as alterations in temperature, precipitation patterns, occurrences of fires, and shifts in species distribution. Additionally, they present compelling evidence regarding the correlation between climate change and the escalation of fires, prevalence of pests, and outbreak of diseases within forests. It is crucial to acknowledge that these circumstances can profoundly jeopardize the long-term viability and persistence of these ecosystems [59, 43].

Water cycle in forest ecosystems: concept, significance. The investigation into the effects of climate change on the water cycle within forest ecosystems holds significant significance. Exploring the impact of climate change on the water cycle in forest ecosystems is crucial in order to uphold sustainable management of forest resources, safeguard biodiversity and ecosystem resilience, and ensure accessibility to water resources for both humans and other life forms. The importance of studying this matter stems from its direct relation to the preservation of biodiversity, the influence it has on water resources and climate change, and the characteristic aspects of land use. The water cycle, also known as the hydrological cycle, can be comprehended from various perspectives, such as on an individual tree level or within the broader ecosystem.

What is water exchange at the level of a forest ecosystem? Water exchange in forest ecosystems is the transfer of water between various components of the forest and its surrounding environment. This intricate process operates across multiple levels. Plant transpiration, for instance, denotes the mechanism through which water absorbed by roots from the soil evaporates via leaves or other plant organs into the atmosphere.

This represents the primary means by which forest plants lose water. The soil's capacity to absorb water and maintain moisture availability is a critically important characteristic. Within forest ecosystems, the soil possesses the capability to store and furnish water for plants. Simultaneously, evaporation from the soil surface assumes a significant role in the water cycle within forest ecosystems. Following rainfall, other forms of precipitation or irrigation, water may directly evaporate from the soil surface. Consequently, the phenomenon of surface water runoff should not be disregarded. The presence of rivers, streams, and other water sources profoundly impacts the water balance of the forest, providing a vital water supply for both plants and animals.

Water exchange in forest ecosystems constitutes a pivotal process for the sustenance of plant vitality and the preservation of water equilibrium within the environment. Its influence extends to biodiversity, water balance, climate, and various other aspects defining forest ecosystems.

What is tree-level water exchange? Tree-level water exchange refers to the process by which water is transported within trees and other plants, moving from the root system to the above-ground portions such as leaves, stems, and shoots. This water is then released into the atmosphere through the stomata, which are small openings on the surface of leaves, in the form of water vapor. The plant's transport system plays a crucial role in facilitating this process.

The primary stages of water exchange in woody plants involve the absorption of water from the soil, transportation of water to the upper parts of the plants, evaporation of water, and stomatal regulation.

During the absorption stage, plants utilize their root system to absorb water from the soil. Groundwater contains essential minerals that are vital for the plant's survival. The upward transport of water occurs through the stem and branches, aided by the xylem tissue. The xylem is responsible for the transport of water and mineral salts, and the upward movement is facilitated by capillary rise and transpiration flow. As water reaches the leaves, it undergoes evaporation, whereby it transforms into water vapor. This evaporation process takes place through the stomata or stoma on the leaf surface. Stomatal regulation plays a crucial role in controlling water and gas exchange. When the stomata are open, water evaporates more easily, but there is also an increased risk of water loss. Conversely, when the stomata are closed, evaporation is reduced, conserving water but potentially limiting oxygen access to the leaves. This water exchange process in trees is vital for sustaining plant life, as water plays a fundamental role in nutrient transport and plant structure maintenance.

The study of water exchange in forest ecosystems holds great significance from *multiple perspectives*. It enhances our understanding of the hydrological cycle, which encompasses processes such as evaporation, transpiration, condensation, and precipitation. This knowledge aids in predicting water movement within ecosystems and its impact on biodiversity. Water exchange within forests also influences climate regulation through its effects on humidity and heat exchange in the atmosphere. By comprehending these processes, scientists can better anticipate climate change and its consequences. Understanding water exchange in forest ecosystems is crucial for effective management of water resources such as rivers, streams, and groundwater, which significantly impact both human life and ecosystem health.

Moreover, water exchange affects the distribution and diversity of plants and animals. Forests play a pivotal role in conserving rivers, lakes, and water supplies, which are invaluable natural resources. Studying water exchange helps preserve these resources and utilize them efficiently.

Therefore, the study of water exchange in forest ecosystems is essential for the preservation of natural resources, maintenance of biodiversity, sustainable management of water resources, and climate regulation. Numerous scientists have made noteworthy contributions to the research of water exchange in forest ecosystems and other types of ecosystems. Hans-Jörg Vogel [18, 55] conducted studies on forests' influence on the hydrological cycle and soil water exchange. Keith Loague [31, 5] focused on hydrological processes within forest ecosystems, particularly the impact of trees and plants on the water balance. Frederick Swanson's research [50, 51] revolved around water dynamics and the influence of forest ecosystems on the hydrological cycle. Jan F. Adamowski has authored several articles exploring water exchange and hydrological processes in forests and forest ecosystems [60]. These works delve into the interconnections between climate changes, vegetation, and hydrological processes. They aim to understand these relationships and assess water exchange processes and utilization within forest ecosystems.

Historical aspect of the study of the water cycle in forest ecosystems. The initial investigations on the water cycle within forest ecosystems took place during the mid-20th century, focusing on comprehending and analyzing various facets of this intricate process. Among the earliest noteworthy inquiries was the recognition of forests' pivotal role in shaping the water cycle and water patterns in regions with extensive forest coverage. An example of such investigation is the Amazon Hydrological Cycle Experiment (ABLE), which delved into the study of hydrological processes in the Amazon forests. Initiated in the 1960s and 1970s, this project aimed to examine the impact of Amazon forests on the water cycle. The findings indicated that the Amazon forests exert a substantial influence on precipitation, evaporation, and water flow within the region [48, 46].

Experimental studies examining water balance in the horizontal soil profile, also known as Soil Water Balance Studies, have garnered considerable attention [45, 14, 56]. These studies have been conducted across various ecosystems, including forests, with a focus on investigating soil water balance components such as precipitation, infiltration, evaporation, and transpiration.

These early investigations serve as crucial milestones in developing our comprehension of how forest ecosystems influence the water cycle and water dynamics in different regions around the world. They have laid the foundation for subsequent research endeavors in this field, revealing the substantial impact of forests on water resources and climatic conditions.

Presently, there is a multitude of scientists actively engaged in studying the repercussions of climate change on forest ecosystems. Their efforts bear significant importance in advancing scientific knowledge and enhancing our understanding of these intricate processes. Among these accomplished researchers, notable individuals include Richard J. Norby, Nate McDowell, Jonathan A. Foley, Camille Parmesan, and many others.

Richard J. Norby has garnered recognition for his extensive research on carbon cycling within forest ecosystems and their intricate interplay with climate change. His body of work serves as a valuable source of information regarding the influence of climate change on forests [37, 36]. Nate McDowell has conducted significant research on the effects of stressors such as drought and fire on forest ecosystems. His active endeavors aim to unravel the mechanisms behind tree adaptation to climate change [33, 34]. Jonathan A. Foley's expertise lies in exploring the connections between climate change, biodiversity loss, and the adaptive capacity of forest ecosystems to evolving conditions [15]. Camille Parmesan is renowned for her investigations into the impact of climate change on species distribution and biodiversity, with a particular emphasis on forest ecosystems [39, 40]. These esteemed scientists have made noteworthy contributions to the scientific investigation of climate change's influence on forest ecosystems. Their research plays a pivotal role in expanding our understanding of these intricate processes and identifying strategies for the adaptation and conservation of forests in the face of a changing climate.

The investigation of water absorption by deep tree roots holds significant importance in comprehending the water balance within ecosystems. This becomes particularly crucial within the context of climate change. The study conducted by M. Yang, X. Gao, S. Wang, X. Zhao (2022) titled "Quantifying the importance of deep root water uptake for apple trees' hydrological and physiological performance in drylands" [61] delves into the impact of deep water absorption roots on the hydrological and physiological efficiency of apple trees in arid conditions. It sheds light on how deep roots aid in the adaptation of trees to limited water resources. In their publication titled "Determining deep root water uptake patterns with tree age in the Chinese loess area" [52], Z. Tao, E. Neil, B. Si (2021) examine how deep root water uptake patterns change with tree age. These researchers represent merely a fraction of the numerous scientists actively engaged in studying water uptake by deep tree roots and its ramifications on forest ecosystems. Their research is integral to comprehending the role of tree roots in the water cycle and ecological functioning of forests. It underscores the significance of deep root systems in facilitating water provision to trees across diverse environmental conditions.

Various countries worldwide are conducting research on the impact of climate change on the water cycle within forest ecosystems, recognizing its pivotal role in biodiversity preservation and ecosystem stability. The journal "Forests" elucidates the effect of climate change on the water cycle in forest ecosystems through reviews and publications. Specifically, it explores how alterations in temperature and precipitation can influence plant evaporation, transpiration, as well as the hydrological regime of rivers and streams flowing through forests. Additionally, it unravels the impact of climate change on water resources in different forest regions. Within the scientific community, concerns regarding the heightened risk of forest desiccation and altered precipitation patterns, which can influence tree nutrition and ecological functions, are raised. These studies underscore the importance of comprehending the influence of climate change on the water cycle within forest ecosystems and the necessity of devising adaptation strategies to preserve these intricate ecosystems.

Tools and methods used by scientists to understand the hydrological cycle in forest ecosystems. The significance and indispensable nature of investigating hydrological processes in forest ecosystems are beyond dispute. However, a pertinent query arises as to the tools, means, and methods employed in the examination of the water cycle within such ecosystems. Given that these processes occur on various levels, diverse approaches are consequently warranted. The study of the water cycle within forest ecosystems can encompass a range of methods and approaches, which may be employed singly or in conjunction with one another, facilitating a comprehensive comprehension of this intricate phenomenon.

Hydrological measurements encompass a range of crucial variables, including precipitation, evaporation, surface water runoff, and groundwater collection and analysis. These measurements have a pivotal role in establishing the water balance within forest ecosystems and assessing the status of water resources.

To assess plant transpiration, one method involves quantifying the water vapor emitted from leaves and other plant components. Diverse techniques, such as line photometry or monitoring changes in plant weight during evaporation, can be employed for this measurement.

Modern geographic information systems (GIS) facilitate the analysis of spatial transformations in water resources within forest ecosystems by utilizing measurements, satellite imagery, and other relevant data sources.

Computer models play a crucial role in predicting the water cycle within forest ecosystems under varying climatic conditions and different climate change scenarios.

Extensive studies conducted within designated forest plots, where specific parameters are controlled, provide valuable insights into the impact of these factors on the water cycle within forest ecosystems. It is through this kind of comprehensive research, in conjunction with other methodologies, that a thorough understanding of hydrological processes prevailing in forest communities can be achieved.

The examination of water absorption by deep tree roots involves the utilization of diverse methodologies. For instance, isotopic labeling of water allows for tracking its movement in the ecosystem using either radioactive or stable isotopes. These isotopes can be directly introduced into the soil or water, enabling subsequent measurement of their concentrations in different parts of the forest, including outflows. This method helps elucidate the routes and rates of water movement.

Another approach in studying water uptake by deep roots involves the use of radioisotopes. By leveraging radioactive probes or similar techniques, researchers can gain valuable insights into this process.

Use of radioisotopes: Radioactive isotopes can be utilized in the investigation of water uptake by deep roots, similar to isotopic labeling of water. Employing radioactive probes or other techniques enables the tracking of water movement through the roots, facilitating the determination of the specific segment of the root system that actively absorbs water from deep sources. Non-destructive methods: In certain cases, researchers employ alternative approaches to study the root system without causing damage. For instance, geophysical methods such as ground-penetrating radar or seismic tomography can be employed to visualize the root system of a tree, enabling the determination of its size and the extent to which it penetrates the soil. These methods can be utilized individually or combined to acquire a more comprehensive comprehension of the process of water absorption by deep tree roots and its impact on the functioning of the forest ecosystem. Numerous publications in contemporary scientific literature cover various methodologies employed to investigate the water cycle in forest ecosystems. Researchers persist in their efforts to explore and elucidate hydrologic processes in bioecosystems.

The examination of the water cycle in forest ecosystems necessitates the utilization of diverse tools for both data collection and analysis. For instance, hydrological stations function as data collection points for precipitation, evaporation, groundwater level, surface water runoff, and other relevant parameters. Typically, these stations are equipped with an array of devices that facilitate automatic long-term measurement of said parameters. Transects are employed to gauge soil and water characteristics, including soil moisture, by conducting selective measurements along forest transects or lines traversing various forest types and hydrological conditions. Weather stations are instrumental in capturing atmospheric parameters such as temperature, humidity, wind speed, and other variables that can significantly impact the water cycle within the forest.

Geoinformation technologies are employed extensively for collecting, analyzing, and visually representing geographic data pertaining to the hydrological traits of forest ecosystems. Contemporary measurement techniques may encompass the utilization of stable isotopes for quantifying plant transpiration, radio systems for measuring water flow, infrared thermal cameras for assessing evaporation, and similar approaches. These advancements in technology empower scientists to acquire comprehensive insights into the water cycle within forest ecosystems and its intricate interplay with diverse environmental factors.

The study of the water cycle in trees necessitates the utilization of specialized tools. For instance, dendrometric instruments are employed to gauge tree dimensions such as trunk diameter, height, and volume. These measurements serve to complement data for water balance and water exchange calculations. A tool known as a gradient dendrometer permits the monitoring of variations in tree trunk diameter over time, thereby aiding in the estimation of water intake across different sections of the tree and transpiration. Thermal sensors, used to assess the temperature on the surface of the tree trunk, can be correlated with evaporation and transpiration intensity. Isotope sensors gauge water content using stable isotopes, contributing to the evaluation of water sources for trees and their efficacy of utilization. Spectroscopic sensors are utilized to measure light characteristics that may be associated with photosynthesis and transpiration.

These aforementioned tools enable researchers to acquire comprehensive insights into the water cycle in trees and their respective activities. Such knowledge plays a vital role in comprehending the significance of trees in hydrological processes and the water equilibrium of forest ecosystems.

Climate change stress factor for plants and mechanisms of adaptation to it. Plants experience stress when subjected to unfavorable external conditions that have a detrimental impact on their growth, development, reproduction, or survival. These adverse circumstances can encompass abiotic factors like extreme temperatures, drought, soil salinity, mechanical damage, heavy metals, and pollutants, as well as biotic stresses such as infections, pests, and competition from other species. In response to stress, plants employ various physiological mechanisms that enable them to adapt to challenging environments. Dedicated scientists diligently investigate the stress-inducing factors in plants and the corresponding adaptive mechanisms, employing a range of methodologies suited to different levels of analysis. These methodologies encompass genetics, molecular biology, ecological studies, and field investigations [3, 62]. Such a comprehensive approach facilitates a more profound comprehension of how plants navigate and adjust to demanding living conditions. Given that climate change is a reality and its impact is already being felt, it becomes imperative to extensively study the adaptation of forest ecosystem components to these transformations.

Forest plants are employing various strategies to adapt to the impacts of climate change, enabling their survival, growth, and reproduction amidst changing conditions. Notably, there have been noticeable alterations in the phenological rhythms and characteristics associated with these processes. Such changes may manifest as earlier emergence from winter dormancy or a delay in the onset of autumn in November.

One adaptive mechanism observed is the potential for plant species to undergo "migration," wherein they alter their distribution and inhabit habitats that continue to provide favorable conditions for their existence. Numerous publications have documented the outcomes of research on the ways in which forest plants modify their ranges in response to the challenges posed by stressful conditions and climate change. HilleRisLambers, J., Harsch, M.A., and their colleagues explored this topic in their 2013 work [23], examining how biotic interactions can impact the shifting of species ranges in response to climate change. Another research by Hirata, A., Kominami, Y., Ohashi, H., Tsuyama, I., et al. (2022) [24] emphasized the assessment of stress indices and crucial climatic factors influencing the range shifts of forest plants. Additionally, there are publications that investigate the influence of wildfires on the displacement of tree ranges as a response to climate change in the western United States [22]. These publications emphasize the crucial significance of comprehending the effects of climate change on the habitats of forest plants, as well as the essential role played by biotic interactions in these processes.

Certain plants have the ability to undergo alterations in their morphological parameters as a direct response to fluctuations in the climate. Notably, trees exhibit morphological changes that facilitate their survival in dynamic environmental conditions [2, 19, 25]. In order to adapt to variations in humidity and temperature, trees have the capacity to modify the dimensions of their leaves. In arid settings, certain species may develop smaller leaves as a means to minimize evaporation, whereas in more humid environments, leaves may increase in size. Additionally, trees possess the capability to adjust the shape of their canopies in order to optimize their access to available light. As a defensive measure against the heightened occurrence of wildfires, certain trees may exhibit the growth of thicker and more resilient bark.

Another notable adaptation is the development of deeper root systems, which allow trees to access water located in deeper soil layers during periods of drought. These morphological changes serve as vital adaptation mechanisms that enable trees and forests to persist and fulfill their ecological functions amidst varying conditions. Plants can also harbor mechanisms to tolerate extreme environmental conditions, including heat, aridity, soil salinity, and so forth. These mechanisms may involve physiological changes, such as an augmented production of antioxidants. In terms of adaptation, plants are capable of modifying their interactions with other species.

For instance, they can strengthen symbiotic relationships with mycorrhizal fungi, thereby enhancing their capacity to absorb essential nutrients or water. Through such adaptations, forest ecosystems as a whole are able to maintain their functionality in the face of climate change.

The examination of mechanisms pertaining to the tolerance of trees to extreme conditions holds a prominent position within the realms of plant ecology and biology. These studies are instrumental in elucidating the adaptive strategies employed by trees to contend with stressful circumstances, including but not limited to extreme temperatures, droughts, high soil salt levels, and pollution. Here, we present several notable examples of such studies.

Researchers investigating the mechanisms of plant tolerance to adverse conditions frequently concentrate their efforts on adaptations pertaining to drought, fluctuations in temperature, and various other stress factors. A case in point is the research conducted by Dai A. and Trenberth K.E. in their scholarly article titled "Projected changes in drought occurrence under future global warming from multi-model, multi-scenario IPCC AR4 simulations," which was published in the esteemed Journal of Hydrometeorology back in 2004. Their study delved into investigating the extent to which climate change would influence the frequency of drought occurrences.

In their study titled "Understanding the Global Hydrological Cycle under Global Warming," Cook B.I. and his colleagues delve into the examination of the influence exerted by global warming on the hydrological cycle. This research holds significant value in terms of comprehending the adaptability of plants to alterations in water supply conditions [12, 7].

In the research article titled "The global spectrum of plant form and function" [13], a comprehensive investigation was undertaken to examine the breadth of plant characteristics found throughout the world. This study highlights the six most significant attributes that impact the growth, survival, and reproductive capabilities of plants. By analyzing diverse physiological and morphological traits, the researchers aimed to discern the association between these features and a plant's ability to thrive in conditions where certain factors are limited. Employing an extensive global database, the authors successfully uncovered a wide array of survival strategies employed by plants. Several noteworthy studies and scientists have dedicated their efforts to exploring how trees adapt to the ever-changing environmental conditions.

"Adaptation of forest trees to rapidly changing climate" authored by J. Kijowska-Oberc, A.M. Staszak, and J. Kamiński (2020) [28] provides a comprehensive analysis of the imperative need for tree species to acclimate to new climate conditions in order to ensure their survival. The paper places a strong emphasis on elucidating the various adaptation mechanisms employed by tree species to mitigate the effects of shifting climate conditions. In "Response of forest trees to global environmental changes," penned by J.L. Hamrick (2004) [21], valuable insights are presented regarding the responses exhibited by tree populations in the face of evolving environmental circumstances. The author achieves this by examining and contrasting recruitment patterns observed in central locations versus those found in ecologically marginal sites.

“Forests and trees for social adaptation to climate variability and change” by E. Pramova, B. Locatelli, H. Djoudi, and others (2012) [42] discusses the importance of tree species in ecosystem-based adaptation projects, focusing on site characteristics and ecosystem service prioritization under specific climatic conditions. “Modern strategies to assess and breed forest tree adaptation to changing climate” by A.J. Cortés and others (2020) [9] highlights the importance of understanding tree adaptation for conservation and improvement efforts, emphasizing the need for strategies to assess trees' successful adaptation to global climate change. “Forest tree species adaptation to climate across biomes: Building on the legacy of ecological genetics to anticipate responses to climate change” by L. Leites and M. Benito Garzón (2023) [30] builds on the foundation of ecological genetics to anticipate how forest tree species will respond to climate change across different biomes. “Putting the landscape into the genomics of trees: approaches for understanding local adaptation and population responses to changing climate” by V.L. Sork, S.N. Aitken, R.J. Dyer, A.J. Eckert, and others (2013) [49] explores how genomic approaches can help understand tree populations' adaptation to new climatic conditions and guide conservation efforts.

These research cover a range of methods and strategies for understanding and enhancing tree adaptation to changing environmental conditions, from genetic analysis to conservation and breeding strategies [21, 41, 30].

Conclusions. Based on the aforementioned observations, it can be inferred that extensive research is currently underway to investigate the mutual influence of climate change and forest ecosystems. However, it is important to note that this process is still ongoing, and in the foreseeable future, both scientists and humanity as a whole will be confronted with the immensely crucial task of devising solutions to address all contemporary challenges. This intricate issue possesses an interdisciplinary nature, thereby rendering the harmonization and implementation of various research findings a daunting undertaking. Consequently, there is a pressing need to formulate a standardized approach towards data and establish universally accepted methods of analysis. Furthermore, the development of prognostic models capable of predicting the impact of climate change on forest ecosystems across different spatial and temporal scales assumes paramount significance. Such models can prove instrumental in the formulation of adaptive strategies and the preservation of forest biodiversity.

Moreover, certain aspects remain relatively understudied and demand further exploration, such as the consequences of climate change on the microbiological composition of soil, animal migration patterns, and the response of different forest types to climate variations. Consequently, a comprehensive investigation into these areas can significantly contribute to a more comprehensive understanding of the ramifications of climate change on forest ecosystems.

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CERTIFICATION OF THE FOREST MANAGEMENT SYSTEM AND THE SUPPLY CHAIN (IN TERMS OF REQUIREMENTS FOR NON-TIMBER FOREST PRODUCTS) IN THE CONDITIONS OF UKRAINE

Kremenetska Yevheniia
Candidate of Agricultural Sciences, Associate Professor
Sumy National Agrarian University, Ukraine
ORCID ID: 0000-0001-5581-7868

Holub Mykhailo
An expert of Non-Entrepreneurial Society "Forest Certification Society in Ukraine"
Kyiv, Ukraine

Forest certification is considered to be an activity during which a duly recognized body (in Ukraine - a certification body) certifies the compliance of the forestry management system with the established ecological, economic and social requirements.

Forest Stewardship Council (FSC®) [1] is an international, non-governmental, non-profit organization created in 1993 to promote environmentally responsible, socially beneficial and economically viable forest management in the world.

The institutional formation of FSC Ukraine is directly related to the development of voluntary forest certification [2] and the development of national standards with subsequent placement on the website of the National FSC Representative Office in Ukraine [3] based on the Principles and Criteria of the Forest Stewardship Council [1].

An important prerequisite for this study is the study of the current national legislation, as well as taking into account those provisions that are required at the international level - in accordance with the FSC principles and criteria.

Forest certification can be considered as a tool of ecological marketing of forestry enterprises [4].

Currently, the main types of FSC certificates in Ukraine relate to wood harvesting: certification of the forestry management system ("FM"); certification of the supply chain (wood processing - "SoC"); supply chain certification at the same time as the Controlled Wood ("CW") code.

The relevance of for non-timber forest products (NTFPs) certification in Ukraine is related to: significant resources of various types of NTFPs (mushrooms, berries, tree juices, etc.); sufficient production capacities of forestry enterprises for the processing of various types of natural resources; the increased level of interest of foreign buyers in the purchase of fresh and canned NTFPs.

The reasons for carrying out research on NTFPs' certification in Ukraine can be considered: the lack of experience in NTFP certification in Eastern European countries and the need to adapt the international requirements of forest certification (according to the FSC scheme) in the part of NTFPs to the conditions of Ukraine.

The purpose of the work is to develop the institutional basis for the certification of the forestry management system and the supply chain in terms of the requirements for NTFPs in the conditions of Ukraine.

Field of application - forestry, forest certification according to the FSC scheme.

The purpose of the work is to develop the institutional basis for certification of the forestry management system and the supply chain in terms of requirements for NTFPs in the conditions of Ukraine. The object of the study is the process of certification of harvesting of NTFPs in accordance with the standards of forest certification according to the FSC scheme in the conditions of Ukraine. The subject of the study is methodical approaches to the analysis of the content of the current FSC standards regarding the certification of the forestry management system and the supply chain in terms of the formation of matrices of requirements for NTFPs in the conditions of Ukraine. Research methods: monographic, analytical, field evaluation method. The results and their novelty – for the first time, the institutional basis for the certification of the forestry management system and the supply chain in terms of the requirements for NTFPs were developed for the conditions of Ukraine. The degree of implementation – the developed institutional foundations and methodical approaches were included in the "Guide to the practical implementation of the FSC® national standard of the forestry management system for Ukraine" [5].

The conducted research made it possible to successfully prepare state enterprise "Manevytske Forestry" (Volyn region) for the certification of the forestry management system and the supply chain in terms of requirements for NTFPs. The results of the work are recommended to be used when choosing a list of written procedures, preparing documentation and carrying out field testing in accordance with the requirements of the standards under the FSC scheme.

This study is interconnected with the standards of forest certification under the FSC scheme: "NEPCon Interim Standards for Assessing Forest Management in Ukraine" [6] and "Annex on Certification of Non-Timber Forest Products" [7], "FSC Directive on Supply Chain Certification" [8], "Supply chain certification" [9]; "FSC product classification" [10], "National risk assessment of controlled wood for Ukraine" [11], "Requirements for the supply of FSC® controlled wood" [12], Requirements for the use of FSC® trademarks by certificate holders [13], "FSC national standard of forestry management system for Ukraine" [14].

Approbation of the latest developments was carried out in production conditions - SE "Manevytske Forestry" (Volyn region) was prepared for the audit of the certification of the forestry management system and the supply chain in terms of requirements for NTFPs.

National legislation of Ukraine and FSC requirements regarding NTFPs. Forests of Ukraine perform functions such as water protection, protection, sanitation, health care and other functions, depending on the purpose and location, and also satisfy the needs of society in terms of resources [15]. The legislation of Ukraine defines the necessary tools for ensuring tireless and rational use of natural resources, avoiding damage to the environment and preserving the functions of forests [16]. Certain developments regarding the management of forest resources deserve attention [17].

Providing the population with high-quality NTFPs, as well as supporting and improving the well-being of local communities are urgent issues.

Ukrainian foresters-scientists studied the biological features of mushrooms, berries, and medicinal plants that grow in the forests of Ukraine, and methods of their accounting were also proposed [18-20].

At the same time, the use of NTFPs can increase income for forestry enterprises. Improving management approaches in this area requires: formation of a strategy for the use of NTFPs (at the state level); provision of economic incentives for the use of NTFPs (preferential lending; reduction of the tax burden); ensuring effective regulation and control of use; interests of local self-government bodies; development of FSC certification of NTFPs. The latter will help ensure access to environmentally sensitive product markets and increase the competitiveness of Ukrainian forestry enterprises at the national and international levels [16].

"FSC National Forest Management System Standard for Ukraine" [14] includes 10 principles that contain the latest approaches and strategies for effective forestry management. Solving the ecological problems of the environment to a greater extent relate to principle 6, principle 8 and principle 9 [21].

In the future, appropriate approaches should be developed for the preservation of NTFPs in forest ecosystems (estimation of the forest stock to identify NTFPs; identification of existing threats; monitoring to detect changes; management strategies, etc.) by analogy with those approaches that were used when considering the practical implementation of FSC strategies on preserving biodiversity in forest ecosystems and maintaining the integrity of natural landscapes in the conditions of Ukraine [22].

Certification of the supply chain (wood processing - "SoC") [8; 9] provides for certification of wood processing enterprises, including processing shops of forestry enterprises.

If the forest farm is not certified according to the forest management standard, then its wood cannot have FSC status, the possibility is "FM/SoC".

Supply chain certification in conjunction with the Controlled Wood ("CW") code [12] is in demand among wood processing companies wishing to exclude from the procurement system that wood that is not eligible for FSC wood [23; 24].

The defining normative legal acts regarding the use of NTFPs (in the framework of planning, organization and control of use) include: "Forest Code of Ukraine" [25], "Tax Code of Ukraine" [26], "Procedure for special use of forest resources" [27], "Procedure for the harvesting of secondary forest materials and secondary forest uses in the forests of Ukraine" [28], "Rules for harvesting resin in the forests of Ukraine" [29], "Rules for the use of beneficial properties of forests" [30]. They are mandatory for all permanent and temporary forest users. They provide for the rational use of secondary forest materials, tireless implementation of secondary forest uses to meet the needs of the population and production in forest resources.

According to the "Forest Code of Ukraine" (Article 6) [25], forest resources include not only timber, but also technical, medicinal and other forest products that are used to meet the needs of the population and production and are reproduced in the process of forming forest natural complexes, and also useful properties of forests.

The use of NTFPs is carried out during secondary forest uses and the use of secondary forest materials. The legislation of Ukraine defines the possibility of general and special use of forest resources.

General use of forest resources is carried out by citizens for their own consumption. The maximum norms of the free fee take into account the restrictions provided by local state executive bodies and local self-government bodies.

The "Procedure for special use of forest resources" [27] defines the conditions and mechanism of special use of forest resources - harvesting of wood during felling for main use, secondary forest materials, secondary forest uses and use of beneficial properties of forests. Special use is carried out for the needs of production activities, subject to the availability of a forest ticket (as a special permit for the use of forest resources) in accordance with the limits of the use of forest resources and the specified terms of harvesting forest resources on the plots that were allocated for the harvesting of forest resources, taking into account the rate of rent.

In the "Procedure for the harvesting of secondary forest materials and the implementation of secondary forest uses in the forests of Ukraine" [28], the requirements for the harvesting of NTFPs are given: tree stumps (for the purpose of obtaining osmol and firewood); forehead; bark of tree species (bark of oak, buckthorn, guelder rose, spruce, etc. - as medicinal and technical raw materials); raw materials for the production of tar; tree greens (for animal feed, for technical and other needs); wild fruits, nuts, mushrooms, berries, medicinal plants; tree juices; placement of beehives; harvesting hay and grazing livestock; collection of forest litter and harvesting of reeds.

According to the "Rules for the collection of resin in coniferous plantations of Ukraine" [29], issues related to the raw material base of saplings, diversion and transfer of plantations for sapling, terms and procedures for conducting pine sapling, as well as sapling in other coniferous plantations, monitoring of compliance with the rules of resin harvesting and responsibility are regulated for their violation.

"Rules for the use of beneficial properties of forests" [30] establish norms and requirements for the use of beneficial properties of forests for cultural, recreational, sports, tourist, educational and educational purposes and conducting scientific research. These rules define the approaches to the allocation of forest areas for the use of useful properties of forests, the assessment of the recreational suitability of forests, the goals, directions and conditions of the use of useful properties of forests, as well as the limitation and termination of their use.

NTFP certification according to the NEPCon standard. In the process of certification of a forest management system ("FM") [14], In the process of certification of a forest management system ("FM") [14], holders of this type of certificate certify a forest management system, while the level of forest management must comply with the 10 Principles of FSC.

NEPCon is a recognized certification body. The NEPCon forestry management system standard has an appendix that deals with the certification of non-timber forest products [7]. This Annex consists of 10 principles, 29 criteria and 43 indicators. Two criteria (5.3 and 8.3) and 2 indicators (5.3.1 and 8.3.1) relate to the processing of NTFPs.

Taking into account the requirements that are given in the principles, criteria and indicators of the NEPCon application for the certification of NTFPs (in accordance with the Forest Management System Standard), it is possible to formulate the following requirements (in terms of each of the principles).

In accordance with the requirements within the framework of principle 1 of the implementation of the applicable legislation regarding the use of non-timber forest resources (collection and cultivation of NTFPs, timely payment of necessary fees, deductions, payments); compliance with the requirements of international agreements regarding the preservation of biodiversity; declaration of cooperation with third parties regard ing the collection of non-timber forest resources, as well as control over the activities of third parties.

Principle 2 envisages cooperation with local communities to determine their participation in the field of marketing of natural resources, use of local knowledge; providing information to interested parties, as well as parties affected by the enterprise's economic activity.

It should be noted that principle 3 is not applied in Ukraine due to the absence of indigenous peoples.

Within the framework of principle 4, the following actions should be followed: priority provision of jobs to representatives of local communities; compliance of wages and other benefits with the requirements of Ukrainian legislation; compliance with safety rules by employees at the procurement of natural resources; planning of areas and volumes in relation to the harvesting of natural resources, the number of harvesters; assessment of the social impact taking into account the opinion of the participants in the procurement process of NTFPs.

Principle 5 takes into account the promotion of long-term forestry management and strategies to maximize self-sufficiency and control. The use of advanced technology for collecting and processing natural resources under the condition of monitoring the viability of populations of natural resources species. Taking into account the impact of harvesting on the diversity of forests. NTFPs procurement indicators should not exceed sustainability levels.

Principle 6 requires conducting an environmental impact assessment and paying attention to the following measures. Studying the situation regarding the presence of plant and animal species included in any local and / or international list of endangered species or species that are in danger of extinction. Minimization of the impact of economic and management activities on the regulation of forestry activities (forest harvesting, forest crops) and harvesting of natural resources in order to limit the impact on the composition of forests and their structure, as well as on the condition of soils, water resources and forest infrastructure. Maintaining the natural composition and structure of populations of target species of NTFPs, properties especially valuable for high conservation value forest (HCV forest). Preservation of NTFPs resources for local communities. Ensuring the protection of forests.

In accordance with principle 7, a forestry management plan is developed. Informing, training, and monitoring of procurers regarding issues related to the procurement NTFPs.

Principle 8 provides for the monitoring of changes in the conditions associated with the populations of NTFPs, any significant environmental changes from management aimed at NTFPs, affecting flora, fauna, soil and water resources; socio-economic aspects of the use and procurement of natural resources.

Principle 9 regulates the holding of consultations with the aim of determining the status of HCV forest, in which NTFPs' species grow, with granting them the status of socially important forests for local communities.

Assessment of the impact of NTFPs' plantations, planting or cultivation of NTFPs' undergrowth in natural forests on resources or rights of local communities or local population, reduction of values of ecological, social and economic functions in natural forests should be carried out in accordance with principle 10 [31].

Contradictions between the national legislation of Ukraine and FSC principles and criteria (reflected in the appendix to the NEPCON standard in terms of requirements for NDLP) were identified for indicators 2.2. (NTFP.1) and Indicator 5.1 (NTFP.1). Indicator 2.2 (NTFP. 1) "Local communities must receive fair and adequate benefits for any use of their name or image in the field of marketing of NTFPs" is not applicable to the conditions of Ukraine. Indicator 5.1 (NTFP. 1) “Where NTFPs are currently harvested on a commercial scale by third parties, compensation to the Forest Management Organization (FMO) in cash, services or products should be at or above the norm and should to be perceived as an incentive to encourage long-term forestry" is inapplicable to the conditions of Ukraine.

Exceedings between the national legislation of Ukraine and FSC principles and criteria (reflected in the annex to the NEPCON standard in terms of requirements for NTFPs) occur for indicators: 2.2 (NTFP. 2), 4.1 (NTFP. 1), 4.4 (NTFP. 1), 5.2 NTFP. 2), 5.6 (NTFP. 2), 6.3 (NTFP. 2), 9.1 (NTFP. 1).

According to the content of indicator 2.2 (NTFP. 2) "When local knowledge is the basis for a patent related to NTFPs, informed consent should be obtained from the community whose interests are affected, and the community should receive fair and adequate benefits" in order to avoid excess, it is necessary to establish contractual relations between the enterprise administration and representatives of the local community in the matter of using local knowledge.

Indicator 4.1. (NTFP. 1) it is assumed that "Local communities should be given priority over third parties regarding resources of NTFP in the territory of forestry." Based on this, in order to avoid excess, there is a need to provide jobs for representatives of local communities as a priority.

In order to fulfill the indicator 4.4. (NTFP.1) "The social consequences of the harvesting and commercialization of NTFP by assessment of forestry management or third parties for local communities should be considered and included in the planning process of forestry management, with special attention to ensuring the minimum level of livelihood of users of NTFPs" the need for involvement in the management planning process was noted of forestry data on the area and volume of natural resource harvesting.

Analysis of the market and potential buyers should suggest which of the certification systems should be applied in addition to FSC certification - according to indicator 5.2 (NTFP. 2) "When possible and acceptable, the assessment of forestry management should apply several certification systems (for example, FSC, organic, fair trade (fairtrade)) for NTFPs' resources".

Examining the situation regarding the appropriateness of methods of collection of NTFPs' resources will allow to fulfill the requirement of indicator 5.6 (NTFP. 2) regarding the maintenance of viable populations of NTFPs: "Intensity of harvesting NTFPs, cultural methods and approaches to harvesting should be suitable for the specific part of the plant that is used (exudate, fruits and seeds, vegetative structures), farming activities must support viable populations of targeted natural resources.

It is necessary to take into account the ecological role and needs of the target species of NTFPs and other species that are related to them in the process of harvesting and managing resources of NTFPs - this is provided for by indicator 6.3 (NTFP. 2) "The harvesting and management of NTFPs must take into account the ecological role and needs of the target NTFPs and other related species, for example, food for fruit-eating birds and mammals, seed dispersal by animals, maintenance of specific ecological interdependencies, etc.

In order to avoid excess, there is a need to conduct consultations to determine the status of HCV forest, which include NTFPs - socially important forests for local communities - in accordance with the content of indicator 9.1 (NTFP. 1) "Consultations to determine the status of HCV forest should specifically include NTFP as an element of the section a social analysis that covers the importance of forests to local communities (as specified in the definition "d" of the HCV forest, which was provided by the FSC) [32].

Forest management system standard requirements matrix, procedures and documentation. In the Matrix, in the column in the requirement of the standard, the criteria and indicators of the NEPCon Annex, which relate to the certification of NTFPs, were listed [7].

It was indicated whether a certain requirement of the NEPCon Annex complies with, exceeds, or contradicts the national legislation of Ukraine.

The key component of the requirement was formulated in order to adapt to a certain indicator from the NEPCon Appendix, for the practical implementation of the forestry management system in terms of harvesting non-timber forest products (organization, planning and control) in the conditions of Ukraine.

Verifiers were offered taking into account: the principles, criteria and indicators of the NEPCon Appendix; verifiers "FSC national standard of forestry management system for Ukraine" [14]; the results of the field test at the State Enterprise "Manevytske Forestry"; own experience in conducting certification works. The list of persons who are responsible for the implementation of FSC procedures was formed by the administration of SE "Manevitske Forestry".

According to the requirements of the standard of the NEPCon Appendix, for the practical implementation of the forest management system in the part of harvesting NTFPs (organization, planning and control) in the conditions of Ukraine, it is necessary to develop and introduce certain procedures, forms and documentation.

Analyzing the requirements of the forestry management system standard, the following procedures can be attributed to the typical procedures for the certification of the forestry management system (in the part of NTFPs harvesting): "Assessment of the social impact of economic activity", "Assessment of the impact of NTFPs harvesting on the surrounding natural environment", "Harvest planning of NTFPs", "Training", "Monitoring".

The procedure "Planning the harvesting of NTFPs" consists of the following parts: "Business plan (short)", "Enterprise’s management plan for NTFPs harvesting ", "Forestry development program for the enterprise" (annually), "Placing berry gardens and mushroom groves on the territory of the enterprise", "Job instructions for the procurer of products and raw materials", "Instructions for the procurement of biological species of NTFPs and honey".

The "Training" procedure can be ensured by developing certain documentation: "Plan for training enterprise’s employees on non-timber forest product certification (according to the FSC scheme)" (annually), "Journal on training enterprise employees on the presence of types of natural resources, international and local list of endangered or threatened species", "Protocol on checking the awareness of enterprise employees regarding the presence of species of non-timber forest products that are included in the local and international list of endangered or threatened species", "Training protocol regarding the knowledge of the requirements of the forest certification system (in the part of non-timber forest products in accordance with the NEPCon Appendix) and the supply chain standard of the company's employees."

The "Monitoring" procedure may include indicative documentation: "Scientific basis of monitoring plant populations", "Questionnaire of phenological monitoring of wild berry plants", "Questionnaire for accounting of the areas of probable mushroom deposits at the enterprise", "Summary of the location of berry plants at the enterprise and forecasted harvest volumes of berries" (annually).

Typical forms for certification of the forestry management system (in the part of NTFPs harvesting) can be: "Act of inspection of felling sites (with indication of the state of the place of growth of non-timber forest products)", "Act of inspection of the place of harvesting of non-wood forest products", "List of interested parties, "List of parties whose interests are affected by the economic activity of the enterprise".

Supply chain standard requirements. The generalized list of requirements of the supply chain standard [9] includes: documentation of procedures; maintaining up-to-date records and documentation regarding FSC procedures; control over the labor protection system; safety techniques and occupational hygiene at production sites; development of "Enterprise Policy"; establishing a system for filing complaints and resolving conflict situations and disputes; control over inappropriate non-wood forest raw materials / products; verification of transactions; compliance with the FSC control scheme for NTFPs statements; control of the production of FSC non-timber forest products; FSC labeling of non-timber forest products; use of FSC trademarks.

Documentation of procedures covering the requirements of NTFPs certification, maintenance of their effectiveness should be carried out by the person who is responsible for FSC NTFPs certification, as well as key personnel who are responsible for the implementation procedure of the supply chain of non-timber forest products in production.

An important step is to determine whether the processing shop belongs to the type of NTFPs supply chain certification (individual, multi-location or group). Cooperation with the certification body of International Accreditation Service regarding access to FSC transaction data is mandatory. It is necessary to maintain up-to-date information on NTFPs suppliers and control the validity and scope of NTFPs groups in the certificate (if there are FSC-certified suppliers). A procedure for checking purchase agreements and accompanying documents of the supplier of non-wood forest products is also being introduced. FSC product groups are defined and an up-to-date list of product groups is maintained.

Attention is drawn to maintaining up-to-date records of non-timber forest raw materials and products that are within the scope of the FSC certificate. Additional information is provided for invoices issued for other related services. FSC labeling of non-timber forest products must comply with the FSC statement on sales contracts, except in the case of retail sales of finished and labeled products to end consumers. FSC-certified non-timber forest products must meet the requirements of applicable legislation. Attention is drawn to determining the period of applications or orders for the production of those non-timber forest products for which a single FSC application must be made. Use of FSC trademarks must be done accordingly.

Written recommendations and/or procedures (documentation) for certification of the supply chain are set out in the document "Instructions for the implementation of the NTFPs supply chain system in accordance with FSC standards in the SE "Manevytske Forestry".

This Instruction defines the mandatory requirements for the supply chain of products from NTFPs in SE "Manevytske Forestry" (hereinafter - the company), starting from the verification of the sources of origin of raw materials to the sale of the company's products as certified.

The main tasks regarding the implementation of the supply chain control system are: fulfilling the requirements of the standards, which are indicated below; establishment of movement control and accounting of FSC-certified NTFPs in the canning workshop of the enterprise; ensuring the supply of products to the consumer with an appropriate FSC statement and logo.

The instruction was developed for the enterprise based on the following FSC standards: "FSC supply chain certification standard" [9]; "FSC product classification" [10]; "Requirements for the use of FSC® trademarks by certificate holders" [13].

The list of typical forms for the certification of the NTFPs supply chain can be recommended: "Matrix of the distribution of responsibility for the implementation and support of the FSC supply chain system", "Logbook of training of employees on issues of certification of the supply chain of FSC products", "FSC groups of non-timber forest products", "Accounting FSC products", "List of types of non-timber forest products that are processed at the cannery", "List of certified suppliers of NTFPs".

The procedure for implementing FSC statements. "Certification of the supply chain" [9] in the context of its application in relation to the certification of the supply chain of NTFPs provides for the following components: supply chain management system, supply of materials, handling of materials, records of FSC materials and products, trade, compliance with legislation on the legality of wood, formation of groups products for the purpose of control of FSC statements, requirements for FSC labeling.

The procedures covering the certification requirements (regarding the supply chain management system and compliance with the legislation on the legality of wood or other forest raw materials) must be documented and effective, there must be: a list of persons who are responsible for the implementation of FSC supply chain procedures in the enterprise; list of certified suppliers of raw materials); training of the company's employees on the requirements of the supply chain standard (director's order; training program, journal and protocol); "Occupational safety and safety equipment in the processing plant of natural resources (instructions, briefings and logs of their registration); "Complaint handling procedure"; "Policy of the enterprise regarding the purchase of raw materials and its processing"; "Procedure regarding the use of uncertified forest raw materials."

Regarding confirmation of other components of the NTFPs supply chain certification (supply of materials; handling of materials; records of FSC materials and products; trade; formation of product groups for the purpose of control of FSC claims; requirements for FSC labeling) must be available: "Summary list of sites where procurement of NTFPs will be planned"; "Register of issuance of forest tickets for the harvesting of NTFPs ", goods and transport invoices for the transportation of incoming raw materials and finished certified products; information "List of groups of FSC non-timber forest products" and "Accounting of FSC products"; the list of biological species of raw materials that are processed; invoices for the sale of FSC-certified products; sales contracts (physical or electronic) for NTFPs sold with FSC claims; contract number ("On the purchase and sale of NTFPs "; "On the sale of NTFPs "); code and number of the FSC certificate of the supply chain; sales agreement from small or communal forest producers; additional documents to invoices issued for other related services.

Supply Chain Standard Requirements Matrix. For the certification of the supply chain of NTFPs, it is necessary to determine the indicators and form the Matrix in accordance with the requirements of the FSC-STD-40-004 V3-1 UKR Supply chain certification [9]. The matrix consists of sections that group indicators according to the requirements of FSC-STD-40-004 V3-1 as applied to the FSC supply chain: "Supply chain management system", "Supply of FSC", "Handling of FSC", "FSC records materials and products", "Trade", "Compliance with legislation on the legality of non-timber forest products", "Formation of product groups for the purpose of control of FSC applications", "Acceptance and storage of NTFPs", "Requirements for FSC labeling of NTFPs".

In the Matrix, the requirements of the standard include indicators that were formed taking into account the requirements of the certification of the wood supply chain. Among them, those indicators are selected that are relevant for the certification of NTFPs supply chain. The key component of the requirement is formulated in order to adapt the requirement of FSC-STD-40-004 V3-1 [9] for the practical implementation of the process of certification of NTFPs supply chain in the conditions of Ukraine.

Verifiers are selected taking into account the requirements of FSC-STD-40-004 V3-1 UKR Supply chain certification [9]; verifiers "FSC national standard of forestry management system for Ukraine" [14]; the results of the field test at the SE "Manevytske Forestry"; own experience of conducting certification works.

The list of persons responsible for the implementation of FSC procedures is compiled by the enterprise administration.

The introduction of requirements for the certification of NTFPs procurement took place in the conditions of the SE "Manevytske Forestry".

Conclusions. Certification of the compliance of the forestry management system with respect to the established environmental, economic and social requirements was carried out by studying the current national legislation, as well as taking into account those provisions required at the international level - in accordance with the FSC principles and criteria.

The process of certification of the harvesting of non-wood forest products in accordance with the standards of forest certification under the FSC scheme in the conditions of Ukraine involves the development of certain methodical approaches to the analysis of the content of the current FSC standards regarding the certification of the forestry management system and the supply chain in terms of the formation of matrices of requirements for NTFPs.

For the practical implementation of the forest management system in the part of NTFPs harvesting (organization, planning and control) in the conditions of Ukraine, it is necessary to develop and introduce certain procedures, forms and documentation. Typical procedures include the following: "Assessment of the social impact of economic activity", "Assessment of the impact of harvesting of natural resources on the environment", "Planning of harvesting of NTFPs", "Conducting training", "Monitoring".

In the context of the application of the "FSC Supply Chain Certification Standard" (FSC-STD-40-004 V3-1) in relation to the certification of the supply chain of non-timber forest products, the following components should be taken into account: the supply chain management system; supply of materials; handling of materials; records of FSC materials and products; trade; formation of product groups for the purpose of control of FSC claims; FSC labeling requirements.

Implementation of the supply chain system of non-timber forest products involves the development of Instructions to organize: distribution of areas of responsibility and personnel training; documentation and accounting; definition of FSC product groups; tracking raw material sources; reception and storage of materials; production control; sales and supply; control systems; labor protection and safety equipment; labeling; installation of inappropriate products; compliance with trade and customs legislation; information about the annual FSC audit and complaint handling, etc.

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ORGANIZATION AND PLANNING OF GARDEN AND PARK FACILITIES TAKING INTO ACCOUNT MODERN TRENDS

Nataliya Stoyanets
Doctor of Economic Sciences, Professor
professor of the department of horticulture and forestry
Sumy National Agricultural University, Ukraine
ORCID ID: 0000-0002-7526-6570

The task of the forestry and horticulture industry of Ukraine is to create and grow highly productive, long-lasting and biologically stable forest, field protection, horticulture and other types of artificial plantations from economically valuable tree plants, as well as the cultivation and sale of decorative planting material.

Planting material can be sold both in nurseries and in garden centers created for this purpose. In garden centers, the assortment of decorative plants can be relatively poorer, since the types that are presented should have the greatest demand in a specific locality. Unlike nurseries, garden centers offer, in addition to planting material, other types of services related to design, landscaping and beautification works, plant care).

Nurseries in Ukraine have significant potential, as evidenced by the current trends in the development of private nurseries. For producers, the increase of areas, the mastery of modern technologies, the expansion of the assortment of cultivated plants, the specialization of nurseries for the purpose of producing high-quality planting material, as well as scientific, methodological and professional production support were and remain relevant for producers.

The current state of production of decorative planting material and its provision of landscaping needs in Ukraine is, to a large extent, determined by the latest history of flower and decorative nursery, which covers the period from the moment Ukraine gained independence to the present day. This story has its roots, its characteristic features and features unique to it, and its knowledge probability to predict the future of domestic nurseries. The characteristic features of modern domestic flower and decorative nurseries are: significant expansion of the range of cultivated breeds and types of products; active mastering of modern technologies for growing new types of planting material; a certain spontaneity in the formation of individual nursery elements due to the diversity of producers, the absence of a consolidating center and a scientifically based concept of its development; not always sufficient attention and assistance to producers of floral and decorative products from the state, etc.

Table 1. Stages of planning garden and park activities.

1. Defining Objectives:	- Identify the purpose of garden and park activities (e.g., recreational, educational, community engagement). - Determine the target audience or participants for the activities. - Establish specific goals and outcomes to be achieved during the events.
2. Research and Information Gathering:	- Utilize search engine capabilities to gather information on different types of garden and park activities. - Explore various ideas, trends, and best practices in designing engaging activities. - Collect data on user preferences, interests, and needs through surveys or feedback channels.
3. Selection of Activities:	- Based on the inputs gathered from and research, curate a diverse range of activities. - Ensure activities align with the objectives and target audience's interests. - Consider the practicality of implementing selected activities within the available garden or park infrastructure.
4. Framing the Schedule:	- Create a detailed schedule for each activity, considering time slots, duration, and participant flow. - Factor in the time required for setup, breakdown, and any necessary transitions between activities. - Allocate ample time for breaks, refreshments, and relaxation.
5. Resource Management:	- Identify the resources required for each activity, such as equipment, materials, and personnel. - Collaborate with relevant departments or vendors to source and manage these resources effectively. - Consider budgetary constraints and explore cost-effective options.
6. Safety and Accessibility:	- Prioritize the safety and accessibility of garden and park activities. - Ensure compliance with local regulations and guidelines for public gatherings. - Provide clear instructions, signage, and support to enhance participants' safety and experience.
7. Promotion and Outreach:	- Leverage capabilities to develop engaging promotional content. - Utilize social media platforms, local communities, and relevant organizations to reach the target audience. - Empower to answer frequently asked questions and provide event-specific information.
8. Evaluation and Improvements:	- Gather feedback from participants through surveys or interactive features. - Analyze the data to identify areas for improvement and success stories.

The history of garden and park art has hundreds of years of development and evolution. It encompasses styles and techniques that are the result of the interaction of different cultures, traditions and aesthetic views of different eras.

The oldest known example of horticultural art is found in Egypt, where the gardens of Ife, which were decorated with temples and water features, existed already around 2800 BC. In Greece and Rome, gardens were also popular, they were decorated with architectural elements and sculptures.

In the Middle Ages, the development of gardens was connected with the introduction of ancient culture in Europe. French gardens, with their symmetrical avenues and geometric patterns, became popular in the 17th century. In Italy, large Byzantine gardens were created with fountains, sculptures and plants.

During the Baroque era, the gardens became more hidden and natural. An example of this style is the English landscape gardens that appeared in the 18th century. They transformed landscapes by using natural beauty and creating the illusion of vast space.

As technology and architecture developed, it became possible to create innovative garden and park elements. Modern gardens and parks use not only plants, but also sculptures, water effects, lighting and other architectural features.

The history of garden and park art continues to develop and evolve. Today we see a variety of styles and techniques in gardens and parks around the world, from classical forms to ecologically oriented concepts. Work on the improvement of garden and park art keeps pace with the growing demands of society and the development of new technologies.

For more than 22 years of Ukraine's independence, domestic ornamental nurseries have passed the initial stage of modern development, which has its own national features and characteristic patterns. It is time to sum up the first results not only for the generalization of the development experience, but also for the purpose of identifying existing problems, tasks for the future and finding ways to improve it. This determines the relevance of the conducted research, the scientific results of which complement the theory of nursery farming and are of considerable interest for its modern practice and further development. At the same time, it should be remembered that the appearance of Ukraine as a European country depends to a large extent on the state of domestic decorative nurseries and that it has unique conditions, much better than other European countries, for highly efficient production of planting material.

In the history of the country's modern decorative nurseries, there are many achievements and unsolved problems [3, 6,]. The positive aspects of its development include, first of all, the formation of an extensive network of nurseries under private ownership [5, 9, 10], a significant expansion of the assortment of tree cultivars and the assortment of products at state and communal enterprises [5], the mastery of new technologies for propagation and cultivation of planting material , in particular, an increase in the specific weight of container culture [8, 9], the start of production of accompanying materials (universal and specialized substrates, containers, fertilizers, etc.) and, in general, an increase in the specific weight of domestic products on the market of Ukraine and abroad [2].

The shortcomings and problems inherent in the Ukrainian segment of the production of decorative planting material include:

- lack of a state strategy and national policy for the development of domestic ornamental nurseries [6, 11];

- imperfection, and in some cases also insufficiency of legislative and regulatory and instructional support, lack of production regulations and requirements for products harmonized with European ones, etc. [8];

- the spontaneity of development due to the lack of effective monitoring of nursery development and production volumes [4] and the possibility, as a result, of forecasting and purposeful, harmonious development of various areas of its activity;

- unequal attention to nurseries of different forms of ownership from the central authorities and rare open lobbying of the interests of state and communal enterprises or, on the contrary, ignoring the proposals and wishes of private ones [5].

In the context of the latter, the results of the assessment of the current state of domestic decorative nurseries and the attitude to its problems and possible ways of development of national producers of planting material for landscaping of various forms of ownership are of particular interest, which was the subject of our research.

The solution to the problem of providing ever-growing domestic needs for high-quality planting material for landscaping, mainly at the expense of imports from European countries, is not only inexpedient due to the need to take into account the national interests and protection of the Ukrainian commodity producer, and unjustified due to certain ecological and biological differences of imported planting material, which significantly affect its viability and decorativeness under local conditions. However, the problem of improving supply concerns not only the increase in the production of decorative planting material, but also the expansion of its range and assortment and a significant increase in its quality.

Analysis of the modern assortment of ornamental woody plants, which grown in nurseries in Europe and actively imported into Ukraine, shows that in Western European nurseries, about 6 thousand species, subspecies, varieties, cultivars (varieties) are grown, while the majority of domestic producers - 25-200 names. Taking into account the fact that "Assortion of trees, bushes and vines for landscaping in Ukraine" (2022) includes 90 taxa of gymnosperms and more than 500 angiosperm woody plants and a significant number of taxa suitable for green construction in the collections of botanical institutions of Ukraine (over 3600).

The achievements and achievements of modern decorative nurseries include see Figure 1.

· formation of a network of manufacturers of decorative products nurseries and, as a result, the relative decrease in import growth rates in the last 2-3 years;

· significant improvement of existing and introduction of European, modern technologies of reproduction and production of new types of planting material of woody plants (with a closed root system, plant regenerants);

· the appearance of powerful, industrially oriented methods of reproduction and cultivation of planting material manufacturers (in Kyiv, Lviv and other cities);

revival at a new qualitative level of decorative nurseries in state nurseries of various departments;

· introduction of new productions focused on the production of related and auxiliary nursery products (substrate, fertilizers, containers, tools, machines, etc.);

· the adoption of the Laws of Ukraine "On Seeds and Planting Material" and "On Protection of Rights to Plant Varieties", the implementation of which will largely depend on the civilized development of nurseries and its prospects.

The achievements and achievements of modern decorative nurseries

Figure 1. The achievements of modern decorative nurseries.

One of the main problems that inhibits the development of flower and decorative plant nurseries in modern conditions is the diversity of planting material producers, which not only complicates the exchange of best practices between them, but also does not allow, to a sufficient extent, to lobby the interests of entrepreneurs and protect their rights before the central authorities legislative and executive power and more fully provide for the urgent needs of the production of decorative planting material on the part of the state.

From the point of view of a professional forecast regarding the possible volumes of production of decorative planting material in domestic nurseries, an important place belongs to the assessment of the modern base of nurseries.

The segment of state nurseries of Ukraine is mainly represented by permanent forest nurseries, most of which produce a fairly limited range of ornamental plants. The state sector includes nurseries of botanical gardens and arboretums, the assortment of which is much larger, primarily due to the introduction of the most suitable introducers for landscaping needs.

A significant share of planting material of woody ornamental plants for landscaping is produced by communal nurseries - enterprises that are concentrated in green construction farms. The main purpose of their operation is to meet the needs of settlements in decorative seedlings for large-scale landscaping works as much as possible.

Recent years have been characterized by a sharp increase in the number of private nurseries and garden centers, which, along with growing their own, devote a significant amount of time to growing imported planting material.

The problems of the market of ornamental plants, namely, representatives of nurseries name the following problems that they face in their work

1. Lack of personnel needed for nursery work. Almost all interviewees, representatives of nurseries, faced this problem. This is due to the fact that the borders have opened and a lot of personnel of various levels are moving to other countries, in particular to Poland, where salaries are higher. In addition, agricultural universities do not train agronomists for the cultivation of ornamental plants, the focus is more on agricultural crops.

A separate problem that hinders the development of the ornamental plant market is the insufficient number of gardeners who could take care of the planted plants. The lack of gardeners leads to the fact that due to lack of proper care, planted plants die or get sick, they are planted incorrectly. Clients of nurseries can lose significant funds on planting material, which then dies due to unprofessional care. Because of this, the client then does not buy new plants.

2. The problem of selling grown products: representatives of nurseries admit that it is difficult for them to guess the assortment of plants according to the tastes of buyers, since there are no marketing specialists who can predict changes in demand for certain categories of plants. Often the plants are not sold according to plan.

Municipalities have little interest in urban greening, which significantly reduces the demand for decorative plants.

There is no culture of gardening in the population, there are no legal norms that would oblige to green the territory adjacent to the house. Low purchasing power of the population, which does not allow spending money on decorative plants, and accordingly reduces the profit of nurseries.

3. Lack of a developed infrastructure that would allow quick and easy access to all consumables needed for growing plants, for example: the pesticide market specifically for nurseries is not developed. Fertilizers and containers are not so easy to find. Finding them at the best price and quality requires more effort, compared to how it happens in the Netherlands, according to Cornelis nursery representatives. The latter, in turn, have experience working in nurseries in the Netherlands, and are currently doing business in Ukraine, that is, they have something to compare with. The main reasons for the low development of infrastructure: a small number of nurseries and, accordingly, a young market, so the related institutions did not have time to develop

4. Difficulties associated with updating the fleet of equipment necessary for nursery maintenance: lack of funds for the purchase of equipment, inflated prices including customs clearance, unfavorable conditions for renting equipment or lack of service for nurseries, lack of assistance from the state.

5. Potential risks when selling plants grown in nurseries, as most of the crops grown there are not included in the State Register of plant varieties suitable for distribution in Ukraine. So far, there have been no cases when plants have been banned from sale, but such an option is potentially possible, and it causes concern among nursery owners.

6. Lack of loans with low interest, banks currently have no offers for nurseries that would take into account their capabilities and an important feature in their work - seasonality of profits. Because of this, nurseries do not have the opportunity to update and buy additional machinery and equipment.

7. The problem of maintenance of specialized equipment: service centers are either difficult to access or do not exist at all. Manufacturers and distributors of equipment are not interested in organizing the service, since the number of nurseries is not large, accordingly, there are not many potential customers. If there are problems with the equipment, nurseries are forced to call specialists from abroad, which is very expensive.

8. Difficulties that arise when crossing the border, especially during customs clearance. Among the difficulties, some representatives of nurseries called the long time for which the products are delayed at customs, difficulties with the processing of documents as a reason for demanding bribes.

9. Difficulties associated with climate and weather conditions that may cause plant losses.

Despite the significant expansion of the assortment of decorative planting material grown in domestic ornamental nurseries over the years of independence, its diversity is significantly inferior to the average similar indicators of most European countries. Therefore, in the process of development and expansion of one's own decorative material, the constant, scientifically based expansion of the assortment of woody plants is important. In recent years, there has been a tendency in Ukraine to increase the demand in the green economy for planting material of ornamental plants that are unique and unusual for local conditions.

The main ways of expanding the range of ornamental plants in nurseries and landscaping are introduction, own selection and the use of new forms of plants of foreign selection in landscaping. The main material for green construction is trees and shrubs. The species composition, or assortment, of woody and shrubby plants determines the architectural qualities of plantations, their sanitary and hygienic properties, durability and economic efficiency of use on various landscaping objects.

Planting material is divided into basic, additional and limited assortment according to the sum of characteristics (stability and longevity of the species in the given natural conditions and conditions of a specific object) and according to the decorative qualities of the species grown for landscaping [10].

The main assortment includes species of trees and shrubs that have been grown in urban plantations for a long time and do not lose their decorative qualities. To include them in the main assortment, it is necessary to have reliable queens for harvesting seeds or cuttings. These species are mainly of local origin. They usually make up the bulk of the plantations, but their diversity is relatively small.

The additional assortment includes species that are characterized by high decorative qualities, but are less biologically durable or stable under these environmental conditions. Most often these are introduced breeds, but there may also be aboriginal species. The additional assortment is much more diverse than the main one and includes most decorative species, which are often difficult to reproduce by seed [3].

The range of limited use is intended mainly for collector landings. The limited assortment includes breeds that require additional care and protection from adverse conditions.

The formation of an assortment of plants in a garden and park object is not always based on the durability, stability and decorativeness of plants. Quite often, the composition of tree species depends on the available planting material in local nurseries, where mainly the most technologically convenient species are grown. The consequence of such work is the impoverishment of landscape compositions, as well as the irrational ratio of breeds of the main and additional assortment.

The choice of high-quality planting material is one of the most important conditions for creating long-lasting plantations. Many production problems that may arise in the future are directly related to the use of plants that were grown with a violation of technology, affected by diseases and pests.

Planting material sold on the Ukrainian market is classified into two categories according to the state of the root system: with an open and closed root system. Plants that have a closed root system are characterized by a higher level of survival after transplantation, are less sick and more resistant to adverse weather conditions.

Seedlings grown in containers should have a symmetrical, well-developed healthy crown, characteristic of this botanical species, a straight trunk, and a root system formed in the volume of the container. There should be no mechanical damage on the seedlings, as well as external signs of damage by pests and diseases.

Certified planting material is grown from virus-indexed mother material of the basic and initial categories. For planting material, a full package of accompanying documents is provided, in particular:

Certificate certifying the varietal quality of the planting material

A certificate certifying the marketable quality of planting material

The planting material meets the requirements of the Technical Conditions of TC U 01.3-40375245-001:2018, which were developed by the "Ukrsadprom" Association

These Technical Conditions apply to seedlings (planting material) of berry crops, which are intended for the establishment of commercial plantations for the purpose of growing fruit and berry products, as well as for sale to the public for the purposes of amateur gardening.

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Planting material, like seeds, is characterized by certain quality indicators that determine its grade or category. The category of seeds and planting material is the belonging of seeds and planting material to a certain stage of reproduction of the variety and phytosanitary status.

The initial planting material of perennial plants is virus-free plants or plant parts of varieties, clones, created as a result of selection work for further propagation. The basic planting material of perennial plants is virus-free plants or plant parts of varieties, clones, obtained from the successive reproduction of the original planting material and intended for the creation of mother plants.

Certified planting material of perennial plants - virus-free plants of varieties, clones, obtained from the propagation of basic planting material and intended for planting industrial plantations.

Varietal qualities of seeds and planting material are a set of morphological features that determine whether the plant belongs to the corresponding variety. Commercial qualities of planting material - a set of biometric indicators of planting material, established by regulatory documents, according to which the sorting and determination of economic suitability of planting material is carried out. Planting material marking is a label indicating the details of the producer, culture, variety, rootstock, age, category and product quality of the plants. Perennial plants are plants whose development takes place over two growing seasons. Ornamental plants - flowers, lawn grasses, bulbs, bulbs, seedlings and saplings, cuttings, micro-cuttings and regenerating plants used for decorative purposes.

State management in the field of nursery production is carried out by the Cabinet of Ministers of Ukraine, the central body of executive power that ensures the formation and implementation of state agrarian policy, the central body of executive power that implements state policy in the field of state supervision (control) in the field of seed production and nursery production

One of the main elements of this industry is state control in the field of seed and nursery production - the activity of authorized state supervision (control) bodies within their powers to detect and prevent violations of legislation.

Mandatory are the Register of Plant Varieties of Ukraine (Register of Varieties)

– the State Register of Plant Varieties Suitable for Distribution in Ukraine and the State Register of Seed and Planting Material Producers – the list of seed and nursery entities that are granted the right to produce and sell seeds or planting material .

The procedure for seed and planting material certification has been improved in accordance with EU requirements.

By Resolution No. 1274 dated November 11, the Cabinet of Ministers of Ukraine amended the Procedure for Certification, Issuance and Cancellation of Certificates for Seeds and/or Planting Material [7-8].

These changes were implemented within the framework defined by the Action Plan for the Implementation of the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their member states, on the other, and relate to trade in planting material of perennial fruit, berry, and nut trees , rare and grape varieties and ensuring the improvement of the efficiency of nursery management of fruit, berry, nut-bearing crops and grapes, the output of domestic producers of planting material to the modern level in terms of quality and phytosanitary status.

The document establishes: the procedure for determining the varietal qualities of planting material by means of field evaluation of plantings to check for the presence of regulated harmful organisms, establishing the compliance of the variety with the morphological features determined during its state registration, and, if necessary, laboratory varietal control by molecular and genetic methods; deadlines for submitting an application for determining the varietal qualities of planting material; the validity period of the certificate certifying the marketable quality of the planting material; the mechanism of re-certification of imported planting material or during growing, re-skilling in the new growing season (season); the grounds for cancellation of certificates certifying the sowing and commercial qualities of seeds and planting material, in particular based on the results of the arbitration (expert) determination of seed sowing qualities and the commercial qualities of planting material and/or violation of the requirements of their certification procedure.

We expect that the improvement of the Order will have a positive effect on increasing the efficiency of fruit, berry, nut and grape nursery operations and improving the quality of domestic planting material in terms of quality and phytosanitary status, and at the same time will contribute to meeting export demand and opening new markets.

The set of control measures at all stages of seed and planting material reproduction, aimed at determining their varietal and sowing qualities, is called seed and planting material certification. It is carried out in accordance with a separate procedure according to the legislation. The form and content of the certificate for seeds or planting material are approved by the Cabinet of Ministers of Ukraine. Only certified planting material is put into circulation.

Planting material is considered certified if it: meets the requirements of normative legal acts in terms of varietal purity and seed quality; belongs to the variety entered in the Register of Plant Varieties of Ukraine or the Register of Plant Varieties of the Organization for Economic Cooperation and Development.

To create highly decorative green plantings in settlements, it is recommended to expand the existing species range of woody plants. In order to improve the greening of populated areas, it is recommended to optimize the species composition of green spaces based on the introduction of new fast-growing, decorative, tolerant to anthropogenic influences species and cultivars of tree plants, taking into account the correspondence of their biological and ecological properties to the specific conditions of local growth.

Taking into account the practical experience and the generalization of scientific data, the dominance of the negative impact on plants of atmospheric pollution over soil pollution has been proven, it is recommended to give preference to smoke- and gas-resistant taxa in the selection of plants for landscaping urban landscapes. The resistance of plants to adverse environmental factors is increased by observing the necessary agrotechnical measures during planting and plant care. This will greatly improve the condition and decorativeness of green spaces in the future.

When creating urban green spaces, it is worth using high-quality planting material with a formed and intact root system, which is a guarantee of good plant survival.

The taxa most adapted to the specific climatic conditions in a specific geographical area are characterized by higher resistance to air pollution. It is advisable to give preference to planting material of local reproduction (grown in nurseries near the place of planned plantings). This will ensure the maximum degree of adaptation of the plant to the new place of growth, and therefore - minimize the amount of losses.

To strengthen the phytomelioration role of street greenery, it is advisable to plant more bushes, especially in the lane between the sidewalk and the roadway. Green street plantings of the city require regular sanitary and health measures, improvement of agricultural techniques for the creation of plantings and their care, taking into account the peculiarities of the conditions of local growth on the streets of the city. Simultaneously with the implementation of measures to expand the diversity of ornamental plants in green areas, it is recommended to foresee measures to monitor the species composition in the urbanized environment.

Ecological design of horticulture - Ecological design of horticulture involves the use of sustainable and environmentally friendly practices in growing and caring for plants. It is aimed at minimizing the negative impact on the environment while maximizing productivity, that is, it is an approach to the organization of space taking into account the ecological principles of nature conservation and creating a favorable environment for plants, animals and people.

It is appropriate to highlight the basic principles of ecological design in horticulture:

1. Biodiversity - modern horticultural practices should promote and enhance biodiversity by creating diverse ecosystems, this can be achieved by combining different plant species, conserving native plant varieties and creating habitats for beneficial insects and wildlife.

2. Organic and regenerative methods, namely avoiding the use of synthetic pesticides, herbicides and fertilizers, are important in ecological gardening. Instead, organic practices such as composting, crop rotation and biological pest control should

be used, and regenerative practices such as the use of organic mulches and cover crops to improve soil health and fertility should also be considered.

3. Saving water, that is, gardening should be aimed at minimizing water use. Water-efficient irrigation systems should be implemented, such as drip irrigation, rainwater harvesting and wastewater treatment can also be used to reduce dependence on fresh water sources.

4. Soil health: Maintaining healthy soil is critical to sustainable gardening. Practices such as composting, vermiculture (using worms to break down organic matter) and avoiding over-tilling help improve soil structure, nutrient availability and retention. water

5. Integrated pest management involves the use of a combination of cultural, biological and chemical methods of pest and disease control, this approach minimizes the use of synthetic pesticides and instead focuses on prevention, monitoring and targeted intervention.

6. Energy efficiency requires efforts to reduce energy consumption in horticulture, which may include using renewable energy sources to heat and cool greenhouses, implementing energy-efficient technologies, and maximizing the use of natural light for plant growth.

7. Habitat preservation, i.e. creating habitats for pollinators and beneficial insects, is an integral part of ecological gardening. This includes providing flowering plants, shelter and water sources to support the ecosystem.

Implementing these principles, ecological design in horticulture aims to create sustainable agricultural systems that are ecologically clean, conserve resources and support biodiversity and contribute to the preservation of human health and well-being.

Therefore, the prospects of garden and park ecological design are important nowadays, as ecological sustainability involves ecologically clean design from the creation of gardens and parks that harmonize with nature and minimize the negative impact on the environment, as they will be designed taking into account ecological principles that benefit both people and and the environment. These include improved air quality, reduced soil erosion, water filtration, climate regulation, and enhanced pollination and pest control by beneficial insects. They have benefits for health, physical and mental well-being as visiting nature is associated with reduced stress, improved mood, increased physical activity and stabilized cognitive functions, meaning these spaces can also provide opportunities for community engagement, socialization and education. In fact, by imitating natural landscapes and using a diverse plant palette, these spaces can create a visually pleasing and culturally meaningful environment that increases their value and appeal to visitors. By using plants that are adapted to local climate conditions, implementing water management strategies and implementing elements of green infrastructure, these spaces can better withstand extreme weather events such as heat waves and heavy rainfall. Gardens and parks designed with ecological principles in mind can serve as outdoor classrooms, providing hands-on learning experiences for people of all ages. They can be used to teach about environmental conservation, sustainable development, gardening techniques and the importance of biodiversity.

Overall, the prospects for sustainable garden and park design are promising as they offer a balance between human needs and environmental conservation, leading to sustainable and vibrant open spaces that benefit both people and the environment.

In the conditions of growing urbanization, it is becoming extremely important to implement technologies in the landscaping of urban spaces that contribute to the creation of ecologically clean and cozy areas for the urban population. One of the key innovations is the use of green technologies to strengthen the shores of water bodies.

Fortification of shores. The use of modern technologies of shore fortification allows not only to ensure the resistance of coastal areas to erosion, but also to create aesthetically pleasing and functional areas for recreation. Green fortification systems, which include the use of vegetation and geotextiles, help conserve water resources and balance the ecosystem.

Digging a trench for the foundation. Another innovative technology in the landscaping of urban spaces is the use of methods of digging trenches under the foundation to create optimal conditions for plant growth. This approach allows you to develop green spaces from the very roots, providing them with convenient access to water and nutrients.

Greening of urban spaces is becoming an increasingly important component of sustainable urban development. The variety of technologies in the landscaping of urban spaces reflects the enormous progress in this direction. Here are some types of technology used in urban landscaping: Automated irrigation systems: Modern sensor-controlled automatic irrigation systems are used that adapt to plant needs depending on soil moisture and weather conditions.

Hydroponics and aeroponics: techniques for growing plants without the use of soil, instead using aqueous solutions of nutrients or air to deliver nutrients to plant roots. Smart management systems: use of the Internet of Things (IoT) and sensors to monitor the condition of plants, soil and atmospheric conditions, allowing automatic adjustment of parameters for optimal plant growth. Vertical gardening: the use of vertical gardens and horizontal planters on the walls of buildings to make efficient use of urban space and improve air quality. Water management technologies: rainwater collection and use systems for irrigation and the development of drainage systems that help avoid flooding and water pollution. The use of ecological materials: the introduction of biodegradable materials for the arrangement of lawns and alleys, which allows to reduce the environmental impact and preserve natural resources. Solar Power Systems: Using solar panels to power lighting and other systems in city parks and squares, providing an environmentally friendly source of energy. Green walls and roofs: using technologies to create living walls and roofs that improve the energy efficiency of buildings and improve air quality.

All these technologies are aimed at creating a healthier and ecologically clean urban environment, ensuring a balance between development and environmental protection measures.

Conclusions. To the problems of the formation of the latest floral and decorative nurseries in Ukraine should also be attributed to the lack of consulting and design institutions in the country that could provide producers of planting material with the necessary consulting services and develop scientifically based projects of organizational and economic plans decorative nurseries, marketing of their products and special management. Such institutions would certainly contribute to increasing the profitability of production and would save individual entrepreneurs from making mistakes when making professional decisions on certain problems. In this list, it is necessary to single out modern problems related to the production of planting material with a closed root system, the main of which are: search for modern, environmentally friendly, reusable containers for plant containers; improvement of the quality and specialization of the substrate for the container house cultures of individual types and stages of production; development of new ways and methods of optimizing the mineral level plant nutrition in container culture; improvement of water quality and development of new, more rational ones ways of irrigating container culture.

The problems caused by implementation become especially acute provisions of the aforementioned Laws of Ukraine "On Seeds and Planting Material" and "On Protection of Rights to Plant Varieties". This is also the preparation of by-laws, the necessary normative and regulatory materials, which would be state-based in essence and would maximally take into account the interests of all producers and users of nursery products of various forms of ownership.

In the future, taking into account existing production trends and market of nursery products in the country, it is necessary to be ready for problems arising as a result of intensifying competition, both between domestic producers and related to competition with foreign firms. In this regard, with great probability, it is possible to predict the specialization of nurseries already in the near future. From the experience of foreign countries, we should expect the emergence of nurseries with the following specializations: nurseries for growing planting material of certain breeds (lilac, roses, rhododendrons, other species) with a wide range of varieties and forms plants; nurseries with an emphasis on certain types of activities: reproduction and production of small-sized planting material, growing planting material with a closed root system, enterprises for growing and forming large-sized trees, hedges, certain forms of trees and shrubs, etc.; expert - breeding; the Internet - nurseries and a number of others.

We cannot ignore the problems associated with the certification of producers of nursery products and the use of plant varieties by individual producers, the solution of which should contribute to the formation of civilized relations between the state and nursery subjects. In connection with the latter, again based on the experience of foreign countries, it is not difficult to predict the future intensification of work on expanding the assortment of cultivated breeds, especially at the expense of own selection, with the subsequent entry of them into the state register and obtaining the right to their reproduction and use.

It is extremely important for the successful development of the domestic flower and decorative nursery industry to find and develop its own ways of its formation and improvement, which would maximally take into account the soil and climatic features of Ukraine, its supply of natural and energy resources, national historical traditions, and spiritual values and the mentality of the Ukrainian people.

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PROSPECTS OF BEEKEEPING DEVELOPMENT IN THE TRANSCARPATHIAN REGION

Borodin Yurii
Ph.D. in Agricultural Sciences, Senior Teacher. State Biotechnological University, Kharkiv, Ukraine
ORCID ID: 0000-0001-7385-9383

Kovalov Oleksandr
Head of the Information and Computing Center State Biotechnological University, Kharkiv, Ukraine
ORCID ID: 0009-0008-5567-4551

Chalyi Oleksandr
Ph.D. in Agricultural Sciences, Associate Professor State Biotechnological University, Kharkiv, Ukraine
ORCID ID: 0000-0001-6159-9908

Kiymenko Igor
Ph.D. in Agricultural Sciences Yuriev Plant Production Institute of the National Academy of Agrarian Sciences of Ukraine
ORCID ID: 0000-0002-3014-1694

Degtiarova Kateryna
Senior Teacher
ORCID ID: 0000-0002-7772-5195

Abstract. *The article presents the prospects for the development of beekeeping in various directions in the Transcarpathian region. It is known that beekeeping has healing properties when resting in an apiary, and not only beekeeping products or bee venom can be used for health purposes, but also the healing energy of the bee colony (sleeping on the hives), and successful examples of such use are already known and attract consumers. Therefore, the modern realities of the man-made environment dictate the urgent need to restore the physical and spiritual strength of a person, which he loses in the process of work and everyday life. It is recreation as an activity aimed at the realization of recreational needs, restoration and development of physical and spiritual forces, and its intellectual improvement, which is the most dynamically developing segment of the hospitality industry in the world today.*

One of the directions in beekeeping is apitourism as a type of tourism, which aims to taste, consume, and buy beekeeping products (honey, wax, propolis, royal jelly, bee venom, bee podmor, perga, zabrus, homogenate from drone larvae) directly on the spot at the manufacturer, which significantly reduces the cost of production and is convenient for consumers, because by visiting the apiary and getting acquainted with the production technology, the buyer can be sure of the quality of the product.

Research and practice of advanced farms have proven that pollination by bees increases yields of sunflower, buckwheat, mustard, safflower seeds, alfalfa, clover, apple, cherry, cherry, and other fruit trees and fruit crops by 25-30 percent or more.

Pollination by bees also improves the quality of the seeds, increases the size, juiciness and taste of the fruits. The benefit that bees give when pollinating agricultural crops is 10-15 times greater than the direct income from beekeeping.

Thus, beekeeping has not only honey, but also pollination, which is a fairly developed branch of agriculture.

Key words: *beekeeping, recreational areas, apitourism, apitherapy, beekeeping products, apiaries, honey, queen, drone, bees, beehives, honey plants*.

The study of beekeeping as a branch of agriculture is quite important, since beekeeping is a special and extremely valuable branch of agriculture. It is based on the breeding of honey bees, which are *Apismelliferamellifera* – a kind of biological unit.

The economic value of beekeeping is also complemented by the fact that bees are used for pollination of crops; beekeeping also plays a very important role in increasing the yield of many entomophilous crops (Zhulynskyi et al., 2028, Bilym et al., 2018, 2019, Bukovsky et al., 2007, Ganych et al., 2018, Danchenko et al., 2020, Senkiv et al., 2020, Omelchenko et al., 2022).

As we know, it has long been known that beekeeping has the healing properties of resting at the apiary; and the modern realities of the technogenic environment make it urgently necessary to restore physical and spiritual strength that a person loses in the course of work and everyday communication. It is recreation as an activity aimed at fulfilling recreational needs, restoring and developing physical and spiritual strength; its intellectual improvement that is the fastest growing segment of the hospitality industry in the world today.

In many countries, recreational areas are emerging in new areas of world exploration, so apiaries are becoming a tourist attraction. There are examples of successful cooperation between travel agencies and bee apiary owners in Slovenia (considered the world`s leader in apiculture), Austria, Ukraine, Poland, the USA, and Israel.

Apiculture (honey tourism, bee tourism) is a type of tourism that involves tasting, consuming, and buying bee products (honey, wax, propolis, royal jelly, bee venom, bee submor, parchment, zabrus, drone larvae homogenate) directly from the producer.

This gives humanity an insight into one of the oldest cultures – the culture of beekeeping. The biology, physiology and "sociology" of the bee family, the mystery of honey creation, modern advances in beekeeping technology – all this can be not only interesting but also entertaining. And living in an apiary and working with bees gives people wisdom and brings them closer to harmony with the world around them – few other types of recreation can surprise them with this.

True connoisseurs of honey and other bee products will welcome the opportunity to taste and buy them right at the place of production, where, among other things, they will be able to verify the compliance with technology and the high quality of the apiary`s products. And tourists will be especially attracted to products that they have personally helped to produce.

It should be noted that medical tourism can become a powerful component of apiculture. Not only bee products or bee venom can be used for health purposes, but also the healing energy of a bee family (sleeping on hives), and successful examples of such use are already known and attract consumers (Zhulynskyi et al., 2008, Bilym et al., 2019, Tourist resources of health tourism, 2018, Resources of health tourism in the Kherson region Varna, 2018, Bilym et al., 2018, Law of Ukraine "On Beekeeping" 2000, Kalinichenko et al., 2021, Klyap et al., 2011, Omelchenko et al., 2022, Omelchenko et al., 2021).

It is known that tourists are very convenient buyers of beekeeping products, because they come themselves and buy products directly at the apiary, which significantly reduces the cost. This is also convenient for consumers, as when they visit an apiary and learn about the production technology, the buyer can be sure of the quality of the product.

Therefore, by all accounts, apitourism is a sustainable type of tourism that does not deplete resources but contributes to their enrichment. Its development contributes to the socio-economic revival of rural areas, ensures the diversification of agricultural production, and creates new jobs (Zhulynskyi et al., 2008, Mamenko 2012, Senkiv et al., 2020, Omelchenko et al., 2021, Omelchenko et al., 2022, Pylypenko et al., 2019, Polischuk et al., 2008, Polevyi et al., 2011, Polevyi et al., 2012).

The purpose and objectives of the study are to reveal the potential of beekeeping as an important element of forestry and hunting, parks, squares, to ensure sustainable development of both industries and preservation of natural resources: park and recreation areas, forest areas, meadows, etc.

The main promising areas for the development of beekeeping in the Zakarpattia region are identified. The variety of forest crops and adjacent parks, squares that affect the quality and quantity of honey production, as well as the development of bee colonies, additional bee products and their properties are analysed; the current development of a new direction (apiculture and apiary houses as a type of promising tourism) is studied.

Research results. The main task is to identify the main problems of beekeeping development, to find out the peculiarities of distribution and promising directions of development of this industry, to analyse the most optimal measures to improve the current level of beekeeping development, as well as to identify ways to popularise new directions in beekeeping in Transcarpathia.

In the current conditions of Ukraine, with its developed intensive agriculture and horticulture, bees are an important factor in increasing the yield of many grain, industrial, vegetable, fruit and berry crops. Thus, beekeeping has not only honey but also mainly pollinating activities and is a fairly developed branch of agriculture (Bilym et al., 2019, Ganych et al., 2018, Danchenko et al., 2020, Guidelines for the use of the complex probiotic preparation "Baikal" EM-1U – 2001, Omelchenko et al., 2022, Koshkalda et al., 2022, Sedoi et al., 2012, Factors influencing the development of tourist attractiveness of the region, 2018, Hamid et al., 2020).

Research by scientific institutions and the practice of advanced farms has shown that bee pollination increases yields of sunflower, buckwheat, mustard, sainfoin, alfalfa, clover, apple, cherry, sweet cherry and other fruit trees and fruit and berry crops by 25-30% or more. Bee pollination also improves seed quality, increases the size, juiciness and taste of fruits. The benefits provided by bees when pollinating crops are 10-15 times higher than the direct income from beekeeping.

It should be noted that the development of the industry is facilitated by the presence of large forestry and hunting farms with various different age groups of honey-bearing trees and shrubs, such as raspberries, blackberries, linden, acacia, wild pears, and apple trees. Over the past 20 years, bees of the Ukrainian Carpathian breed have been intensively sold by Transcarpathian beekeepers to various countries: Hungary, the Czech Republic, Slovakia, Romania, Moldova, Poland, which have a combination of interesting breed qualities under the influence of abiotic and biotic factors. Moreover, the selected Carpathian bees are already successfully used in China, Korea, and Cyprus, and have shown great interest in Canada.

Today, 70,000 bee families are kept in the Zakarpattia region, of which approximately 65,000 are kept in private households and about 2,000 in agricultural enterprises.

To analyse the registered beekeepers` associations for the reproduction of special breed qualities of bee breeds in the Zakarpattia region, we analysed the percentage of the total population of the districts and the number of registered bee farms, and identified the main areas of their distribution.

Analysing this location, we can say that among the registered associations of beekeepers and bee farms, the largest percentage is observed in Mukachevo district (0.007%), namely: Association of Beekeepers of Zakarpattia, SE "Bdzhilka", SE Mukachevo Research Breeding Bee Farm, Society of Amateur Beekeepers, PE Gaidar E.V. and others.

In terms of percentage, it is possible to observe that Khust (0.004%) and Svalyava (0.003%) districts stand out among others. The following beekeepers` unions are concentrated here: Beekeepers` Union "Narcissus", PE Pap V.V. and Svalyava District Beekeepers` Association, respectively.

Irshava, Tyachiv and Rakhiv districts are next in terms of number, with 0.001% of registered bee farms. They are: The Union of Beekeepers of Tyachiv district, the Society of Beekeepers and Honey Lovers of Irshava district and the private enterprise "Soima V.G." of Rakhiv district.

In other districts (Berehove, Velykyi Bereznyi, Vynohradiv, Volovets, Mizhhirya, Perechyn and Uzhhorod) there are no registered beekeepers` unions or bee farms.

It can be concluded that beekeeping in Zakarpattia is mainly carried out by amateurs. And the main areas of concentration of bee farms can be observed in lowland and foothill regions. The reasons for this are:

- a wide variety of honey plants;
- large areas covered by the necessary vegetation;
- small temperature differences.

In our opinion, the main task for the future is to improve the quality of bee colonies.

Accelerating scientific and technological progress in beekeeping should start with the comprehensive implementation of domestic and foreign scientific achievements and best practices. One of the most important prerequisites for accelerated STP in beekeeping is to improve the quality and productivity of bee colonies. This can be achieved under the following conditions:

- improving the pollination qualities of bees;
- application of advanced beekeeping methods;
- providing apiaries with platforms, mobile pavilions, which will allow more frequent roaming, directly to the honey plantations,
- increase the range and quality of products;
- organisation of a market for beekeeping products, development of modern methods for determining honey falsification;
- search for rational ways to combat diseases and pests;
- introducing mechanisation of the main production processes in beekeeping, which will increase labour productivity and profitability of apiaries;
- guaranteeing the safety of bee colonies in winter (Bilym et al., 2017, Bukovsky et al., 2007, Kalinichenko et al., 2021).

The urgent problems that need to be addressed in the beekeeping sector include:

- preserving and strengthening the training of highly professional young personnel;
- intensifying control over changes in biodiversity and the quality of the feed base;
- ensuring the production of high-quality and safe products that meet international requirements using the latest modern technologies;
- improving the regulatory framework; market development and development of marketing strategies;
- improving the efficiency of the industry by adding new revenue streams.

It is known that in addition to the main product of beekeeping – honey – beeswax, propolis, pergue, pollen, brassicas, royal jelly, bee venom, bee submor, homogenate, bee packages, queen cells, and rebuilt honeycombs (sushi) are also extracted from apiaries.

According to its origin, honey is divided into monofloral and polyfloral flower honey, plant and animal honey, and mixed honey. According to the technological characteristics, honey is divided into centrifugal, pressed, and honeycomb (Bilym et al., 2017, Bukovsky et al., 2007, Ganych et al., 2018).

Currently, many beekeepers use beehive therapy in their apiaries, i.e. a medical house is placed directly on the apiary, with 3 bee colonies below and a bed above them. Immersed in an aura of calm and honey aroma, a person lies quietly, and the micro-vibrations from the bees` movement heal the entire body. The success of the treatment depends on several elements, namely:

- ➢ micro-vibration arising from the work of bees in the hive;
- ➢ powerful insect biofield and phytoncides from bee products;

➢ the temperature of the nest, as bees maintain it in hives or in their natural habitats within 36-37 degrees, which is the same as the temperature of the human body.

Apitherapy is a very popular trend that is gaining momentum in the country. Apitherapy is the medical and preventive use of bee products. The products used are honey, beehive, wax, propolis, royal jelly, bee venom, bee submor, wax moth, and drone homogenate. According to the current legislation of Ukraine, apitherapy is defined as "the treatment and prevention of diseases with the help of bee products" (Zhulynskyi et al., 2008, Bilym et al., 2019, Tourist resources of health tourism – 2018, Resources of health tourism in the Kherson region – 2018, Bilym et al., 2018, Bilym et al., 2017, Bukovsky et al., 2007, Ganych et al., 2018). It is popularised as an exotic form of ecotourism – apiculture.

Apitourism involves tasting (testing and/or evaluating the quality of food products by tasting bee products) directly from the producer, consuming and buying bee products at the place of residence or apiary location, and the medical use of bee products in the treatment and prevention of diseases.

Medical tourism can become a powerful component of apiculture. Not only bee products or bee venom can be used for health purposes, but also the healing energy of a bee colony, and successful examples of such use are already known and attract consumers. Honey tourism can solve a number of problems, one of which is the disorder of the mental stress of the human condition, health improvement and rehabilitation through the impact of natural physiological and environmental factors on human health.

The popularity of apitourism as a type of recreation is due to the fact that it best meets the physiological and recreational needs of people living in an urbanised environment, in areas with a difficult environmental situation and constant nervous stress.

It should be noted that the main goal of apitourism development is to develop a national tourism product that can meet the needs of both our citizens and foreigners to the fullest extent possible. In order for this to gradually come into effect, it is necessary to:

➢ ensure the preservation and restoration of the natural environment and historical and cultural heritage;

➢ promote sustainable growth by ensuring the integrated development of recreational areas and tourist centres, taking into account the socio-economic interests of their population (Naboka et al., 2020, Lysenko et al., 2007, Rudenko et al 2000, Polischuk et al., 2001, Kalinichenko et al., 2022, Senkiv et al., 2020, Tertyshnyi et al., 2004, Shandova et al., 2019).

Conclusions: So, we have examples and experience of apitourism in the world, and Ukraine also has unique opportunities for the development of this area. In addition, apitourism is a sustainable type of tourism that does not deplete resources but contributes to their enrichment. Its development contributes to the socio-economic revival of rural areas, ensures the diversification of agricultural production, increases the profitability of beekeeping and creates new jobs.

Ukraine has a great potential for apiculture development, but it requires a favourable regulatory framework and the creation of regional beekeeping development programmes. It is necessary to ban the cutting down of honey-bearing trees (acacia, linden, etc.) and protect bees from pesticides. Ukrainian apitourism can become a hallmark of our country`s development in the international tourism market and will help to increase respect for Ukrainian culture, especially in the Zakarpattia region.

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FORMATION OF NONSPECIFIC RESISTANCE AND INCREASE OF BIOPRODUCTIVITY OF SCOTS PINE SEEDLINGS UNDER TREATMENT WITH SEDAXANE

Karpets Yuriy
Doctor of Biologycal Sciences, Professor, State Biotechnological University Kharkiv, Ukraine
ORCID ID: 0000-0002-1888-2334

Suska Anastasiya
Doctor of Economic Sciences, Professor

Bila Yuliya
Ph.D. in Agricultural Sciences, Associate Professor

Taraban Dmytro
Assistant

Introduction. The full-scale military invasion of Russia on the territory of Ukraine brought great environmental and economic losses to forestry. Significant areas of forest plantations were affected by forest fires, damage of trees by bullets and shrapnel as a result of military operations in a large area along the entire line of combat clashes. In addition, a large number of forests were uncontrollably cut down for the needs of warfare - the construction of military defense constructions, bridges and water crossings, heating of military premises and shelters. Also, a large area of forests was destroyed in the Kherson and Mykolaiv regions as a result of Russian terrorist actions from blowing up the dam of Kakhovka Reservoir. Currently, it is impossible to calculate the damage in the forests of Ukraine until the end of the war. But in the first few years in the post-war period, the need for high-quality planting material to restore destroyed forest plantations will increase many times over in short period of time. Also, partially damaged plantations will require reforestation in the coming decade. Therefore, the question of effective cultivation of planting material with the use of the modern drugs to protect young seedlings of woody plants from various negative factors for further successful forest restoration in the post-war period is acutely facing the forest science and forestry production of Ukraine.

It is well known that millions of young plants die every year on forestry sites due to infectious diseases, which leads to significant losses. The most common and dangerous diseases of conifers in the nurseries of Ukraine is infectious root rot disease caused by fungi of the genera *Fusarium* spp., *Alternaria* spp., *Rhizoctonia* spp., *Verticillium* spp., *Botrytis* spp. etc (Karpets et al., 2014; Damszel et al., 2021; Gomdola et al., 2022). 30-45% of plants can die under the significant infectious damage, and in some cases – 85-100% (Elvira-Recuenco et al., 2019; Luo, Yu, 2020; Gomdola et al., 2022; Li et al., 2023). Also, the impact of adverse climatic factors, in particular drought, causes significant losses when growing coniferous seedlings, including pine (Steckel et al., 2020; Brown et al., 2020). Despite the relative tolerance of pine to drought, its sensitivity to this factor in the early stages of development is quite high (Steckel et al., 2020).

One of the effective techniques for protecting young seedlings of woody plants from biotic and abiotic factors can be the use of drugs based on Sedaxane as an active substance (Brown et al., 2020; Tong et al., 2022). Sedaxane (a mixture of *trans*- and *cis*-isomers of N-[2-(1,1'-bicyclopropyl)-2-ylphenyl]-3-(difluoromethyl)-1-methyl-1-H-pyrazole-4-carboxamide) – artificial a synthesized substance with pronounced fungicidal properties of contact action (Ebbinghaus et al., 2010; Jeschke, 2016; Dal Cortivo et al., 2017). The first information about the possibility of its use as a fungicide appeared about 10 years ago (Walter et al., 2015; Sharma et al., 2021). Currently, Sedaxane is used as one of the active substances in the disinfectants of Vibrance group produced by Syngenta (Lamberth, Dinges, 2016; Polson et al., 2020). It is believed that the main mechanism of action of Sedaxane is related to highly specific inhibition of succinate dehydrogenase of fungi and blocking of energy metabolism (Jeschke, 2016; Tong et al., 2022). Although this substance is positioned as a fungicide of contact action, there is information about its systemic effect due to the possibility of absorption by some plant organs and transport through conductive tissues to other organs (Lamberth, Dinges, 2016; Kolupaev et al., 2017; Steckel et al., 2020). It was established that Sedaxane is capable to inhibit plant succinate dehydrogenase, which has a certain structural homology to the identical fungal enzyme (Kolupaev et al., 2017; Shkliarevskyi et al., 2019; Sharma et al., 2021).

Currently, Sedaxane is considered as a physiologically active substance that can positively affect the resistance of agricultural plants to biotic and abiotic stressors (Dal Cortivo et al., 2017; Kolupaev et al., 2017; Shkliarevskyi et al., 2019). However, the physiological effects of Sedaxane on woody plants, including conifers, have not been investigated so far. Preparations based on it are recommended for use in Ukraine only for agricultural plants (State …, 2024).

In connection with the above, the aim of the work was to study the effect of pre-sowing treatment with Sedaxane on the resistance of Scots pine (*Pinus sylvestris* L.) seedlings to biotic (infectious root rot disease) and abiotic (artificial drought) stressors in laboratory soil culture.

Material and methods. Scots pine seeds were sown 300 seeds each in plastic cuvettes with sandy forest soil. Seedlings were grown at a temperature of 20±2°C, relative air humidity of 60±10%, illumination of 6 klk (photoperiod of 14 h) with moderate daily watering to maintain the relative humidity of the substrate at the level of 70-80% of the full moisture capacity (Karpets et al., 2014; Karpets et al., 2017).

Pre-sowing treatment with Sedaxane was carried out by immersing the seeds in appropriate solutions in the concentration range of 0.001-10 g/l for 1 h, followed by drying on filter paper before sowing (Shkliarevskyi et al., 2019).

The number of seedlings unaffected by the causative agent of the infectious root rot disease was found by continuous counting in each biological replication. The height was calculated as the arithmetic mean value of the measurements of 30 seedlings or, if the remainder is smaller, all the seedlings of biological replication. The number of unaffected seedlings and their height were determined starting from the 20th day after sowing the seeds in the soil with an interval of 10 days until the 60th day of observation, after which, as a rule, infectious root rot disease stops due to the beginning of intensive lignification of pine seedling tissues (Karpets et al., 2014).

An artificial drought was created for 10 days, starting from the 20th day after sowing the seeds, by reducing the intensity of watering with the gradual decrease in the relative humidity of soil to 25-30% of the full moisture capacity (Karpets et al., 2017).

When determining the wet and dry mass of the above-ground part of plants and water balance indicators, 50 seedlings were selected from each biological replication. To determine the water deficit, the plant material was placed in cuvettes with distilled water for 2 h without the access of light to completely saturate the tissues with water (Karpets et al., 2017).

Experiments were completed independently twice with four biological replicates each. Figures show mean values and their standard errors. The significance of the differences was assessed by Student's t-test. A difference at $P \leq 0.05$ was considered significant, a difference at the level of trends – at $P \leq 0.1$.

Results. *Growth effects of Sedaxan.* Seed treatment with Sedaxane in concentrations ranging from 0.001 to 1 g/l increased soil fertility, which was assessed on the 10th day after sowing (Figure 1). A concentration of 10 g/l significantly inhibited seed germination.

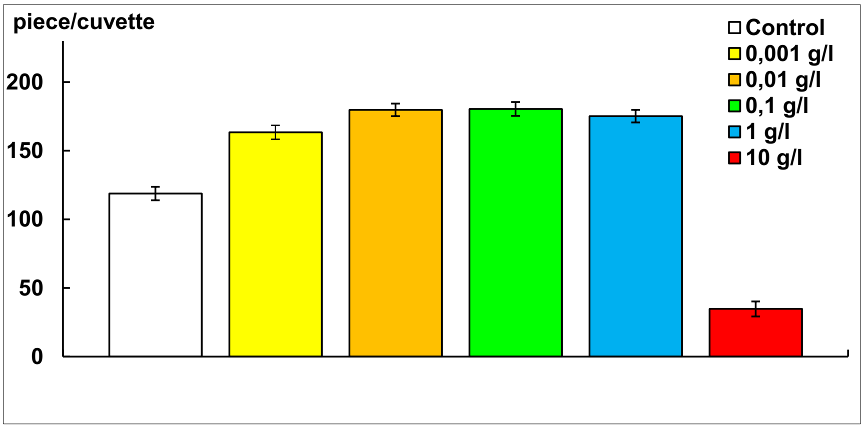


Figure 1. The effect of Sedaxane on the soil germination of Scots pine on the 10th day after sowing.

Under the influence of Sedaxane in concentrations from 0.001 to 1 g/l, the growth of pine seedlings increased in height (Figure 2). The difference between the experimental and control variants was especially noticeable at the beginning of the experiment, then this effect decreased somewhat, but remained significant. The concentration of 10 g/l of Sedaxane had a negative effect on seedling growth throughout the experiment (Figure 2).

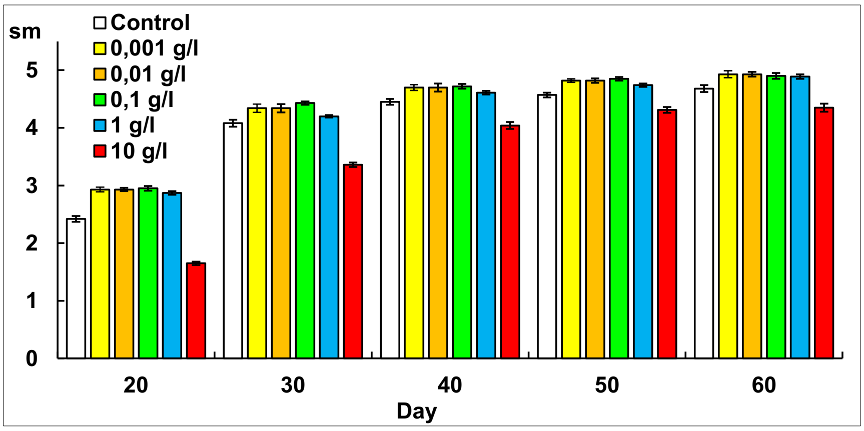


Figure 2. The effect of Sedaxane on the height growth of Scots pine seedlings.

In variants with seed treatment with Sedaxane in non-toxic concentrations, a tendency to increase the fresh weight of seedlings was noted, while a significant positive effect of Sedaxane in variants with concentrations of 0.01, 0.1 and 1 g/l on the accumulation of dry biomass was established (Figure 3).

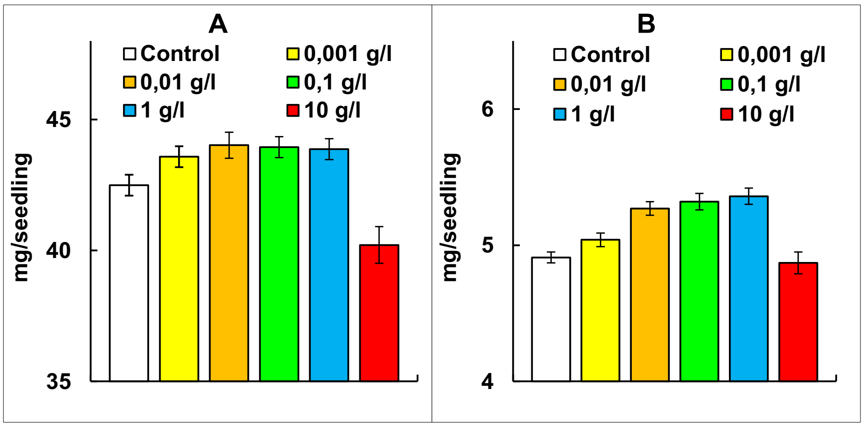


Figure 3. The effect of Sedaxane on the accumulation of fresh (A) and dry (B) mass of Scots pine seedlings.

Effect of Sedaxane on resistance of seedlings against infectious root rot disease. A significant increase in resistance against infectious root rot disease compared to the control was found in variants with Sedaxane in concentrations of 0.01, 0.1 and 1 g/l (Figure 4). The concentration of 0.001 g/l had a relatively small positive effect, and 10 g/l showed the greatest protective effect against fungal lesions, although against the background of suppression of seed germination and growth of seedlings in height (Figs. 1-3). At optimal concentrations of Sedaxane (0.01, 0.1, and 1 g/l), which did not suppress seed germination and seedling growth, their preservation in the end of experiment was 6-7 times higher compared to the control (Figs. 4, 5).

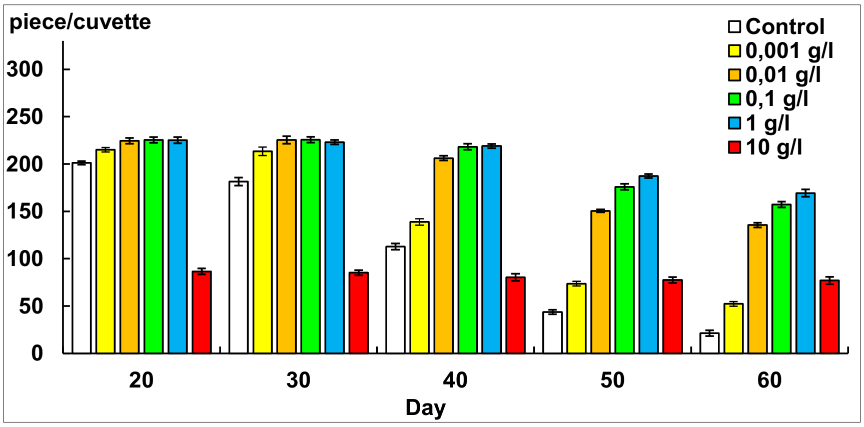


Figure 4. The influence of Sedaxane on the damage of Scots pine seedlings by root rot disease.

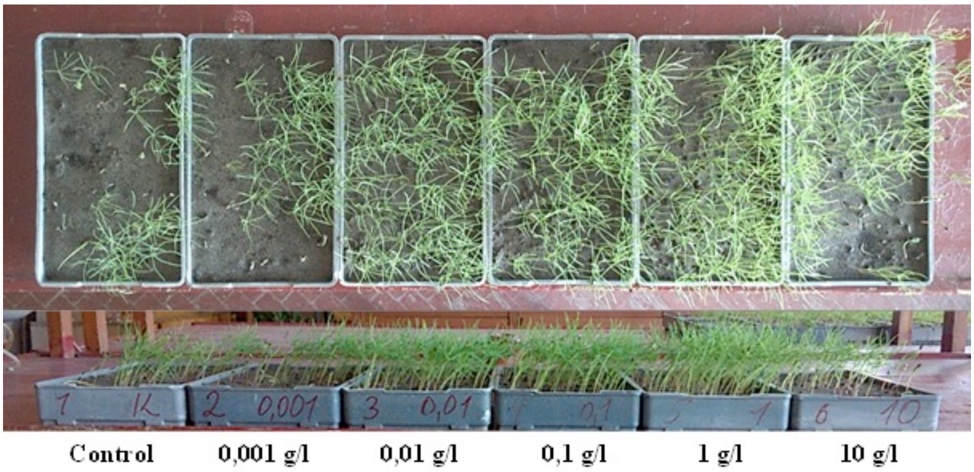


Figure 5. The state of Scots pine seedlings under the influence of Sedaxane on the 60^{th} day of the experiment on the study of inducing resistance against root rot disease.

The effect of Sedaxane on the resistance of seedlings to soil drought. Under conditions of artificial drought, the positive effect of Sedaxane on the linear growth of seedlings was manifested in concentrations from 0.001 to 1 g/l (Figure 6). The highest concentration of 10 g/l alone inhibited growth in height (Figure 1), but significantly contributed to its preservation under drought conditions (Figure 6). At the same time, Sedaxane concentrations from 0.01 to 10 g/l showed a visible positive effect on turgorescence of seedlings (Figure 7).

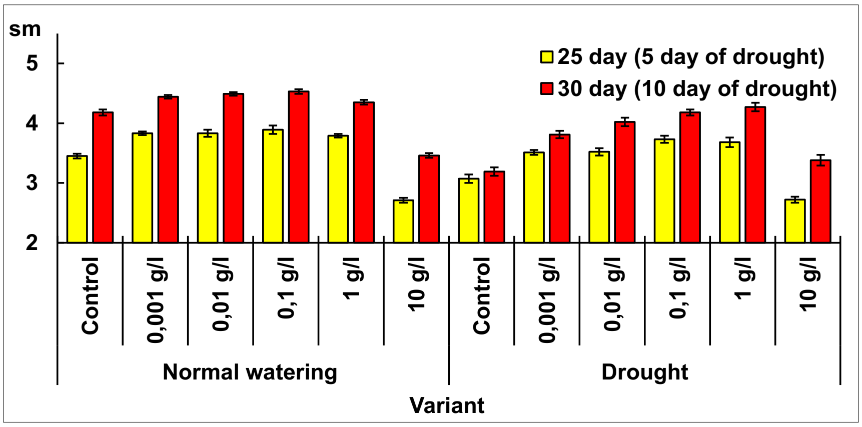
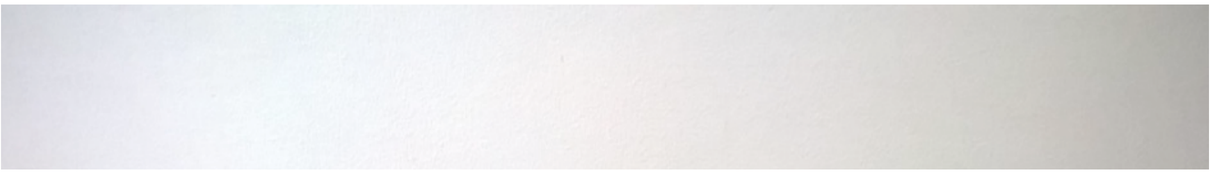


Figure 6. The effect of Sedaxane on the height growth of Scots pine seedlings under normal watering and under the influence of drought.



Control norm. water. **Control 0,001 g/l 0,01 g/l 0,1 g/l 1 g/l 10 g/l**
Drought

Figure 7. The state of Scots pine seedlings at the end of a 10-day drought.

Sedaxane in all non-toxic concentrations had a positive effect on the accumulation of fresh and dry masses (Figure 8). Treatment of seeds with Sedaxane in concentrations of 0.01-1 g/l increased the hydration of seedlings (Figure 9, A). Under the influence of Sedaxane in the entire range of concentrations, a decrease in the water deficit index was noted under drought conditions, while such a decrease was proportional to the value of the used concentration (Figure 9, B).

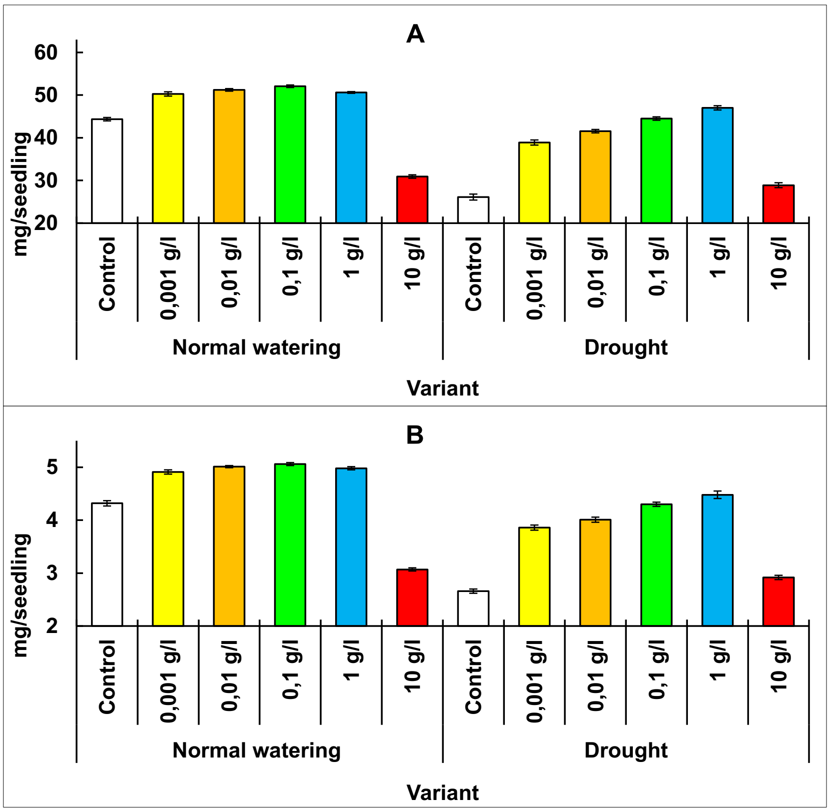


Figure 8. Effect of Sedaxane on the fresh (A) and dry (B) mass of the above ground part of Scots pine seedlings at the end of 10-day drought.

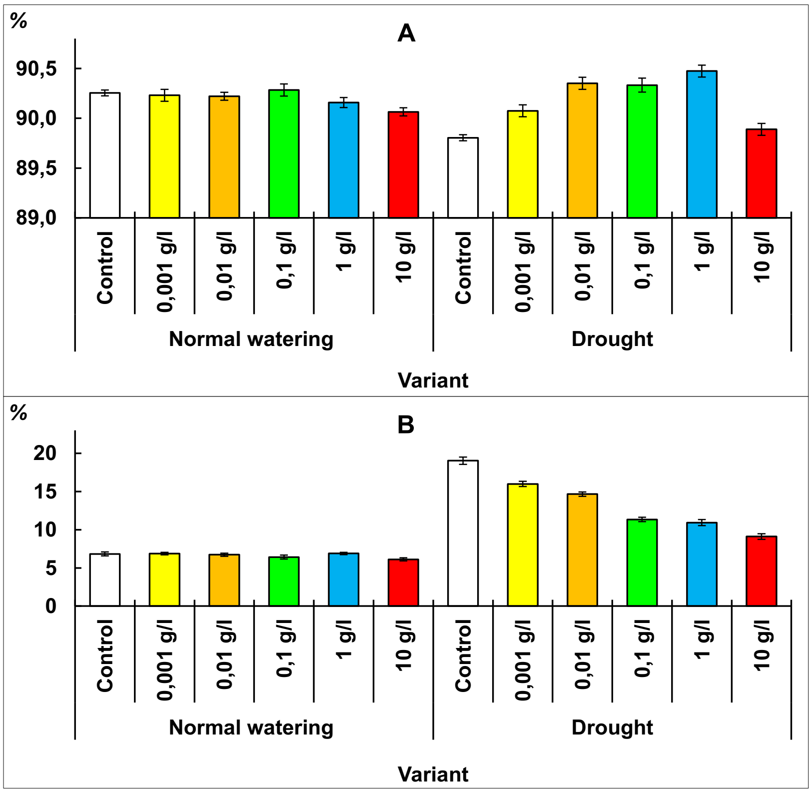


Figure 9. The effect of Sedaxane on the hydration (A) and water deficit (B) of Scots pine seedlings under the normal watering and under the influence of 10-day drought.

Discussion. The conducted studies showed a positive effect of Sedaxane both on the resistance to the causative agents of infection (actually, a fungicidal effect), and on the growth of uninfected plants and their resistance to soil drought. So, it can be stated that its effects are not limited to fungicidal action.

In separate studies conducted on herbaceous agricultural plants, data were obtained indicating the manifestation of physiological activity of Sedaxane in relation to plants (Tong et al., 2022; Dal Cortivo et al., 2017; Walter et al., 2015; Kolupaev et al., 2017; Shkliarevskyi et al., 2019). In particular, the growth effects obtained on corn plants allow us to ascertain the presence of Sedaxan, at least phenomenological manifestations of auxin and gibberellin activity (Dal Cortivo et al., 2017).

Another reason for the positive effect of Sedaxane on plants may be its modification of succinate dehydrogenase activity. It was established that Sedaxane can affect not only the succinate dehydrogenase of fungi, but also plants enzyme of different taxonomic affiliations (Kolupaev et al., 2017; Shkliarevskyi et al., 2019; Tong et al., 2022). Under the influence of Sedaxane on wheat and corn seedlings, a decrease in the activity of succinate dehydrogenase, a decrease in the formation of hydrogen peroxide, and a decrease in the accumulation of the product of lipid peroxidation under conditions of osmotic stress were recorded in them (Kolupaev et al., 2017; Shkliarevskyi et al., 2019). It is possible that the inhibition of succinate dehydrogenase under stress conditions can lead to the reduction in development of oxidative stress associated with the functioning of mitochondria.

Another component of the positive effect of Sedaxane on plants under stress conditions may be its ability to activate enzyme phenylalanine ammonium-lyase and, as a result, to increase the accumulation of phenolic compounds (Dal Cortivo et al., 2017). As it is known, these compounds have antioxidant properties (Kolupaev, Karpets, 2019). In addition, they can participate in strengthening cell walls, which is important for the resistance of plants to both abiotic and biotic stressors.

Conclusions. Thus, in this research, the growth-stimulating and stress-protective effects of Sedaxane on young Scots pine plants were revealed for the first time. An increase in the resistance of seedlings to infectious lodging has been established by treating seeds with Sedaxane in concentrations of 0,01-1 g/l. Under drought conditions, pre-sowing seed treatment with Sedaxane in the same concentration range had a positive effect on plant growth and water balance. The obtained phenomenological data are the basis for further studies of the influence of Sedaxane on redox processes, primary and secondary metabolism of compounds associated with the response of woody plants to the action of stress factors.

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Monograph

According to the scientific edition
Candidate of Economics Sciences, Professor T.I. Melnyk

Published 28.05.2024.
Typeface Times New Roman.
RS Global Sp. z O.O., Warsaw, Poland, 2024
Numer KRS: 0000672864
REGON: 367026200
NIP: 5213776394

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