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ВЫСОКИХ ТЕХНОЛОГИЙ

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ԲԱՐՁՐ ՏԵԽՆՈԼՈԳԻԱՆԵՐԻ ՏԵՂԵԿԱԳԻՐ
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Տեղեկագիրը հրատարակվում է Ակադեմիկոս Ի.Վ.Եղիազարովի ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտի, Հիդրավլիկական հետազոտությունների հայկական ազգային ասոցիացիայի, Երևանի կապի միջոցների գիտահետազոտական ինստիտուտի և Շուշիի տեխնոլոգիական համալսարանի կողմից: Հիմնադրվել է 2016թ.: Լույս է տեսնում տարեկան 4 անգամ:

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DESIGN APPROACHES TO VISUALIZING LITERARY TEXT

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Abstract

This article defines the importance of design methods for visualizing literary text for the purpose of its popularization. The author's experience in searching for visual metaphors for the graphic presentation of one of A.P. Chekhov's most significant works, "Sakhalin Island," serves as the basis for this research.This project analyzes how, in the context of the prevalence of clip-based thinking, contemporary artistic techniques and communication design help to actualize literary ideas and visually convey the urgency of social issues.

Keywords: information visualization, transmission of meaning, artistic metaphor, clip thinking, communication design.

Introduction

The mission of design in the age of the information society goes beyond the artistic design of the objective world of the habitat of human civilization. With the rapid increase in the number and speed of information dissemination, it is extremely important to set priorities and place accents for a more confident orientation of a person in the ocean of messages that he receives every second. Graphic, or more relevant, defined, communicative design becomes a navigator in an oversaturated information space.

Design visualizes information, helps to increase its attractiveness and competitiveness. His possibilities in building ideological attitudes, principles and attitudes that determine public attitudes towards the most pressing problems of our time are truly limitless. It is no coincidence that communicative design is considered the most effective tool of social advertising, which forms a system of moral and moral values that determine a person's attitude to the world around him and himself in it.

The most important theme of social advertising is to draw attention to national history and artistic culture. The problem of our century is the fragmented perception of information, provoked by modern media and social networks that broadcast messages in the form of disparate, superficial narratives [1,2]. It is possible to gain a complete and in-depth understanding of the logic of cultural and historical events that determine the essence of civilizational processes only through a thorough and consistent study of their nature, causes and consequences.

As before, the most effective form of cognition is reading classical fiction and scientific literature. Unfortunately, the need for reading in the era of clip thinking is being lost by a significant part of society.

Conflict Setting

This study is an attempt to understand the possibilities of design in attracting interest in reading and studying history through acquaintance with the works of classical writers. The material for the research was the author's experience of visualization in the format of advertising and educational posters and infographics of Anton Pavlovich Chekhov's great work "Sakhalin Island".

Research Results

The book Sakhalin Island occupies a special place in Russian classical literature. This is not fiction or dry reportage, but a deep experience of documentary immersion, a "book about the people" [3], written at the cost of personal risk and the author's health. Despite its uniqueness, this text remains one of the most unread and underestimated in the writer's legacy, being overshadowed by his famous plays and short stories. Anton Chekhov's decision to go to Sakhalin in 1890 was a deeply personal, long-suffering act. The successful writer, who is at the peak of literary fame, deliberately abandoned a comfortable life in the capital in order to undertake a grueling and dangerous journey to the "edge of the world." He was motivated not by journalistic excitement, but by an existential need (Fig. 1).

Being not only a writer, but also a doctor by profession, Chekhov felt the need to break out of the circle of the literary environment and turn to a genuine, harsh life [4]. In this Chekhov's intention, the human factor became decisive — the desire to see through the eyes of a doctor and a writer and to comprehend the extreme degree of human suffering, which was penal servitude.

Fig.1 Design of a multi-page publication dedicated to A.P. Chekhov's book "Sakhalin Island"

On Sakhalin, he not only studied the life of convicts, but also, following his medical duty, treated people for free, trying to somehow alleviate their plight. Chekhov conducted a real research work: he personally communicated with thousands of convicts and settlers, filled out statistical cards of almost ten thousand people, studied everyday life, working conditions, and social ties [5].

The synthesis of an unbiased scientific method and active compassion is the unique value of the book. The main significance of A.P. Chekhov's work lies in its unprecedented authenticity. This is not an observation from the outside, but the result of a dangerous journey, personal testimony based on vivid impressions, interviews with convicts and accurate statistics. Chekhov consciously went to this work in order to overcome the feeling of lack of familiarity with genuine Russia and the Russian man in his most tragic manifestations [4,5].

In order to attract interest in this literary and civic feat, the idea arose to translate the unique documentary text of Chekhov into a visual form. Moreover, the task was not to illustrate the book in the traditional way, but to create a multifaceted visual image that would allow us to understand the Russian character and history of Russia in a new way, to see them through the prism of Chekhov's experience.

The modern cultural context is radically different from the Chekhov era. We are witnessing a fundamental change in the way information is perceived. The phenomenon of clip thinking has become an integral feature of modern man. The brain, overloaded with an avalanche of information, tends to "save energy" by filtering out the verbose, clinging to the short, vivid and dynamic. Deep analysis gives way to fast scanning.

In this reality, infographics are experiencing their finest hour. It is an ideal response to the request of fragmentary consciousness [6]. Instead of a long text, she offers a ready-made visual image, which, thanks to an expressive metaphor, becomes clear in a few seconds. The popularity of infographics is not just a fashion, but a direct consequence of the changed way of perception.

However, the bright picture, which was once the guarantor of attention, is now drowning in the general flow of competitors. Aesthetics for aesthetics' sake stopped working effectively. Design is forced to evolve and take on a new, deeper role. Its function shifts from attracting the eye to the "beautiful wrapper" to involving the mind in a social problem, to an important idea through the cultural code. Thus, modern design becomes a bridge between a complex topic and the viewer, a tool for communication and enlightenment. It turns information not just into an object of consumption, but into an occasion for reflection, becoming a powerful language of modern culture [7].

The relevance of a classic work is only increasing today, but the modern rhythm of life and the changed patterns of information perception create a barrier between a complex, multi-layered text and a potential reader. This project offers a solution to the problem through the creation of a visual interpretation of Sakhalin Island in the format of a ZINe (author's small-circulation magazine) and infographics. The visual language helps the book, which is undeservedly in the shadow, to reveal to the viewer the harsh truth about life on the edge of the empire, which becomes the key to unraveling the "mysterious Russian soul" [8]. The images created based on the book Sakhalin Island shed light on Russia and its people, while

simultaneously introducing the viewer to the harsh, businesslike and compassionate side of Chekhov's documentary work (Fig. 2).

The visual interpretation of Sakhalin Island creates an opportunity to see the authentic Russia through Chekhov's most unexpected text. This is a chance to rediscover a forgotten masterpiece, which, when translated into the language of images, allows you not only to learn, but to experience the history of Russia and the mentality of its people without embellishment and excessive romanticization.

Fig.2 Compositional and artistic design of the author's small-circulation magazine of A.P. Chekhov's book "Sakhalin Island"

Such a visual reading becomes a window into understanding Russian life — its hierarchy, absurdity, steadfastness and humility, showing history not through dates and wars, but through human destinies [9, 10].

Fig, 3 Journalistic page design style of the author's small-circulation magazine of A.P. Chekhov's book "Sakhalin Island"

Today's pace of life leaves less and less space for slow, thoughtful reading. By compressing time and meaning, the project strives to ensure that every frame, every image is a visual summary of the book. The interactive aspect of this task was not just to tell, but also to encourage the viewer to experience the pain, despair and stoicism described by Chekhov. To see is to learn and want to understand more deeply.

To emphasize the journalistic nature of Anton Chekhov's work, the design of the ZINE pages in the style of document design was chosen. Visual materials convey the expression of Chekhov's text through such artistic and compositional techniques as emotionally vivid color, dynamic diagonal rhythms that literally cut through the pages, expressive contrasts that emphasize the writer's feelings of anxiety and pain. The author's concept is based on the memorable imagery, sensuality, and appeal of a visual language that combines documentary logic with artistic expression. The purpose of this design solution was to attract the reader-

viewer first at the level of interest in the illustrative material, and then at the level of desire to decipher the visual codes by immersing himself in the writer's text.

The design creates visual quotes that speak louder than any retelling. This is not a substitute for reading, but a powerful impulse to his interest. Thus, design visualization becomes the key to actualizing classics, turning them from an object of academic study into an acute, socially significant statement available here and now.

Conclusions

Chekhov went to Sakhalin for the truth, which could not be conveyed in words alone. The design method allows turning Chekhov's complex, multi-layered text into instantly recognizable visual archetypes, creating an emotional portrait of the book that does not discourage the desire to read it, but creates a deep personal need to do so. In order to understand the depth of the great Chekhov text, one glance will not be enough and the hand itself will reach for the book.

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T.O. Berdnik, P.V. Lenivkina
DESIGN APPROACHES TO VISUALIZING LITERARY TEXT

ԳՐԱԿԱՆ ՏԵՔՍՏԻ ՎԻԶՈՒԱԼԱՑՄԱՆ ԴԻԶԱՅՆԵՐԱԿԱՆ ՄՈՏԵՑՈՒՄՆԵՐ

Տ.Օ. Բերդնիկ, Պ.Վ. Լենիվկինա
Դոնի պետական տեխնիկական համալսարան

Քննարկվում է գրական տեքստի վիզուալիզացիայի դիզայնի մեթոդների կարևորությունը: Ուսումնասիրությունը հիմնված է հեղինակների փորձի վրա՝ Ա.Պ. Չեխովի «Սախալին կղզի» ստեղծագործության գրաֆիկական դիզայնի տեսողական փոխաբերություններ փնտրելու համար: Այս նախագիծը վերլուծում է, թե ինչպես է հոլովակների վրա հիմնված մտածողության տարածվածության համատեքստում, ժամանակակից գեղարվեստական տեխնիկան և հաղորդակցման դիզայնը նպաստում գրական գաղափարների իրականացմանը և սոցիալական խնդիրների նշանակության տեսողական փոխանցմանը:

Բանալի բառեր՝ տեղեկատվության վիզուալիզացիա, իմաստի փոխանցում, գեղարվեստական փոխաբերություն, հոլովակների վրա հիմնված մտածողություն, հաղորդակցման դիզայն:

ДИЗАЙНЕРСКИЕ ПОДХОДЫ К ВИЗУАЛИЗАЦИИ ХУДОЖЕСТВЕННОГО ТЕКСТА

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Рассматривается важность дизайнерских методов визуализации художественного текста с целью его популяризации. Основой для данного исследования послужил опыт авторов в поиске визуальных метафор для графического оформления одного из самых значительных произведений А.П. Чехова «Остров Сахалин». В этом проекте анализируется, как в условиях засилья клипового мышления современные художественные приемы и коммуникационный дизайн помогают актуализировать литературные идеи и визуально донести значимость социальных проблем.

Ключевые слова: визуализация информации, передача смысла, художественная метафора, клиповое мышление, коммуникационный дизайн.

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PLACEMENT OF PLANTS IN COMBINATION WITH SCULPTURES NEAR WATER BODIES IN THE IMPROVEMENT OF SUBURBAN PARKS

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Abstract

Aquatic systems play a vital role in the development of civilization and have significant socioeconomic significance. Freshwater ecosystems provide a wide range of vital services that benefit communities.

Public spaces are centers of individual and social well-being, places of collective life where the expression of various intangible values becomes most tangible. The modern city is the epicenter of economic and social life. It is not only a place where people live but also a hub for various activities (leisure, work, etc.). In this context, suburban parks with small ponds are an integral part of maintaining an attractive environment. However, it should be noted bodies of water are subject to significant anthropogenic impact and are often in a state of degradation.

This article examines some issues related to the creation and maintenance of suburban parks with ponds.

Keywords: recreation, water, urban environment, pond, bioplateau.

Introduction

Recreation is a set of activities aimed at maintaining well-being, spirit, and productivity. However, due to the constant clearing of green spaces in large cities, finding natural habitats is becoming increasingly difficult.

Ponds make a significant contribution to global biodiversity in heterogeneous environmental conditions [1]. Small urban water bodies facilitate the formation of plant and animal biotopes in urbanized areas, often with a fairly diverse biotic component. Some researchers view the areas around these bodies as refuges, where diverse plant and animal species survive in urbanized areas. However, some biotopes create conditions for the life of organisms whose mass development or unbalanced increase in their numbers in cities is undesirable. These species can be roughly divided into three groups [2]:

- organisms whose mass development degrades the ecological state of urban water bodies and their social attractiveness;
- organisms whose development worsens the sanitary and epidemiological situation;

- organisms whose excessive increase in numbers can lead to a decrease in the biodiversity of urban biota.

The primary focus should not be on various methods for eliminating these organisms, but on creating conditions that prevent their development. At the same time, measures must be taken to combat the mass development of unwanted organisms and limit the numbers of individual species [3].

A natural body of water is a biologically balanced ecological system, designed for self-purification and self-regeneration. A wide range of aquatic organisms—planktonic and benthic microorganisms, higher aquatic plants, and fish—form the foundation of the body of water's ecosystem. The physicochemical and biotic processes occurring within the aquatic ecosystem are the primary mechanism for the body of water's self-purification. The term "water self-purification in ecosystems" implies that water is purified through a series of ecological processes involving the many aquatic organisms that form these aquatic ecosystems. Water self-purification processes in ecosystems are important for the stability of aquatic ecosystems, maintaining water quality, and maintaining biodiversity. Reservoirs with impaired microbiological self-purification are more quickly oversaturated with unoxidized organic matter and biogenic elements, which irreversibly leads to their eutrophication, i.e. a change in the type of aquatic ecosystem occurs. Unlike a natural body of water, an urban water body can be assessed from several perspectives simultaneously. In addition to the environmental aspect of the problem, there are almost always a number of other aspects: medical, cultural and historical, technical and operational, and socio-psychological. Most small urban water bodies are at such a stage of anthropogenic degradation that environmental protection measures alone are insufficient to restore them to a comfortable living condition. This typically requires specialized engineering and environmental measures. Modern urban water bodies are one component of the urban system. Their condition largely determines the social attractiveness of a particular urban development, its so-called «video ecology». Water bodies play a significant role in shaping sanitary and hygienic conditions in cities and can even serve as sources of infectious disease transmission [2].

The processes that facilitate the "self-purification" of water in a natural reservoir include physical, physicochemical, and biochemical processes [4, 5]:

- filtration of the water column by aquatic organisms;
- dissolution and dilution of pollutants in the water column;
- sorption processes by suspended matter, microorganisms (plankton, benthos), aquatic organisms (phyto- and zooplankton, plants), and bottom sediments;
- photochemical and catalytic reactions, oxygen evolution, and oxidation;
- release of nitrogen and phosphorus compounds by biota, which are used by algae, which in turn release oxygen to oxidize pollutants.

Solving the problems of environmental rehabilitation of water bodies will require development of regulatory documentation governing the performance of work on the following issues [6]:

- comprehensive biological survey of the coastal zone and water area of the water body, including biotesting methodology;

- methods for calculating frost heave of loamy soils in the water-shore contact zone;
- sanitary and environmental survey of the water body and coastal zone;
- calculation of frost heave characteristics of loamy soils in the watershed zone of the water body to address pile wall design issues;
- development of water management calculation methods applicable to small water bodies and watercourses located within urban areas;
- development of regulatory documentation governing the design of bioengineering structures:
- coastal protection structures;
- hydrobotanical sites and bioplateaus;
- development of regulatory documentation governing the technology for forming a reservoir ecosystem depending on the physical, geographical, and morphometric conditions, anthropogenic loads, and other characteristics of the territory;
- development of regulatory documentation governing the implementation of comprehensive monitoring of a water body during the operational phase to assess the degree of restoration of the hydroecosystem.

The technology assumes that significant improvements in water quality in the reservoir occur within 2-3 years after the intervention. The following measures are necessary during the first 2-3 years: polluted surface runoff entering the reservoir is cut off; systematic monitoring of the hydrochemical and hydrobiological parameters of the water is conducted; in winter, it is advisable to provide for aeration of the reservoir using specialized equipment; in the spring, if necessary, additional stocking of individual fish species, stock cultures of forage invertebrates, and replanting of poorly overwintered plants should be carried out. To create a natural hydroecosystem in a pond, the following measures are proposed [7]:

- Water hardness must be reduced and free carbon dioxide levels must be increased to levels necessary for the normal development of ornamental plants. For this purpose, it is recommended to replace the limestone rubble in the rock fill on the underwater slope of the pond and in the stream bed with zeolite, which is a good sorbent.
- Free CO2 levels should be increased by lowering the pH and increasing the stocking density of aquatic organisms and fish.
- To acidify and desalinate the water, it is necessary to minimize the direct supply of artesian water to the pond and organize water circulation using a filtration system;
- To create a favorable gas exchange regime in winter, a compressor must be installed.

Water is the primary factor through which most people and the environment are likely to experience climate change.[1]

Freshwater ecosystems are particularly sensitive to warming because their chief drivers, water quality and water quantity, are strongly influenced by atmospheric temperature regimes. Air temperature determines both water temperature and many chemical attributes contributing to water quality (e.g., dissolved oxygen levels), and its suitability for supporting freshwater biodiversity and maintaining critical ecological functions and services. Surface and ground water regimes, including precipitation, snow melt, run-off, soil moisture, river discharge, and

[1] World Meteorological Society (2021)

aquifer recharge, are similarly sensitive to warming, with significant changes to hydrology attributed to temperature increases already apparent across the world [8]. Current global ambitions for climate change mitigation to limit planetary warming to 1.5° C, an objective since the 2015 COP21 Paris agreement, dramatically reduce the extent and magnitude of climate risks faced by freshwater ecosystems, although these remain significant [9].

The region is already experiencing significant climate change. In particular, in Stepanakert, the average annual temperature increase over the past 50 years has been 1.3^0 C. During the same period, the average monthly temperature rise in Stepanakert reached 3.2^0 C (Fig. 1) [10].

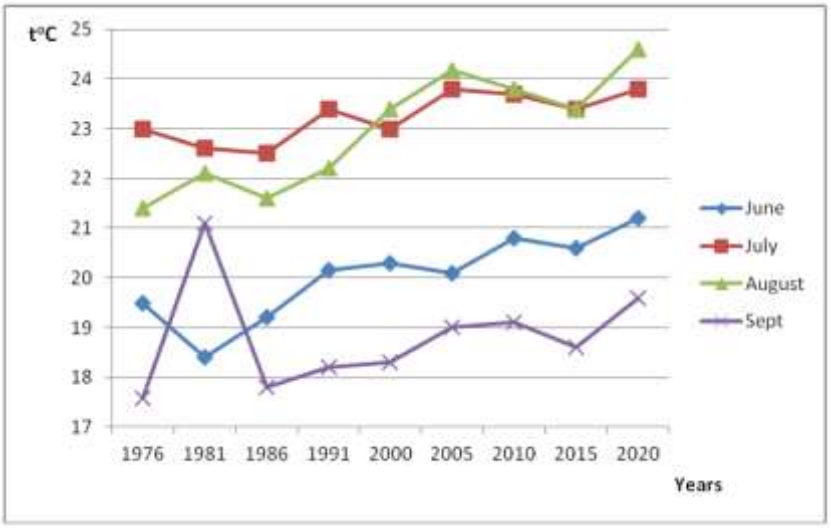

Fig. 1. Dynamics of annual change in average monthly temperature in Stepanakert during the summer period

Of further concern, however, is the additional threat to freshwater ecosystems presented by human responses to climate change (e.g., dam building for water security, meeting increased water demand for cooling), including many of the mitigation approaches being pursued to limit global temperature rise to 1.5°C (e.g., increasing hydroelectrical power generation, carbon sequestration plantations).

Freshwater ecosystems are highly vulnerable to global warming because 1) their chief drivers, water quality and flow regimes, are highly sensitive to atmospheric warming, and 2) they are already extremely threatened by a wide range of interacting anthropogenic pressures. Even relatively modest global warming of 1.5°C poses a considerable threat to freshwater ecosystems and the many critical services these provide to people. Shifts in the composition and function of freshwater ecosystems are widely anticipated with adverse consequences for ecosystem services, including those underpinning water and food security. While the extent and severity of effects is likely to be significantly reduced if global warming is limited to 1.5°C, concerted efforts to implement widely recognised priorities for policy and management are required to mitigate unavoidable impacts and reduce the likelihood of perverse outcomes of climate mitigation and adaptation efforts in other sectors—all of which rely on fresh water supply. Freshwater ecosystems and their services, including provision of fresh water, must therefore be considered first and foremost when developing and implementing any climate action. The quality of aquatic ecosystems can be assessed using chemical, physical, and biological parameters. Exceeding established parameter values poses a danger to living organisms inhabiting the ecosystems [11]. Global warming of 1.5°C has many implications for

freshwater ecosystems, with effects varying regionally, in relation to climate, and locally between different habitat types [12].

Strong relationships exist between climate change mitigation and adaptation and the management of water resources and freshwater ecosystems [13]. Consequently, it is critical that freshwater ecosystems and the many services these provide, including provision of fresh water, are considered first and foremost when developing and implementing any climate action [13, 14].

It is now almost inevitable that by some time in the middle of this century (2041–2060), global temperature will exceed 1.5°C warming relative to a 1850–1900 baseline, after which it will either stabilise or, in all but the very lowest emissions scenarios, continue to rise [15]. The vulnerability of freshwater ecosystems to warming is exacerbated by their disproportionately high levels of modification and degradation which both aggravate their sensitivity to temperature change and constrain their capacity to autonomously adapt [16].

Despite widespread acknowledgment of the pivotal role of freshwater ecosystems to the world's future under climate change, substantial knowledge gaps remain. Furthermore, conservation policy and management of freshwater ecosystems are often buried within a broader dialogue concerning terrestrial conservation, or else obscured by an overly narrow focus on meeting human water demands [11].

Suburban parks are an integral part of recreational areas. They serve as ideal centers for meeting the non-material needs of society, where citizens of all ages and interests can find satisfaction. Suburban parks are typically built near bodies of water, and where these are absent, artificial reservoirs are constructed within the area. Water, pathways, works of art (sculptures, music), diverse flora and fauna, play areas, service outlets—this combination can satisfy even the most daring public desires.

Conflict Setting

The goal of creating "green" communities is to harmoniously combine natural and spiritual values. When designing recreational areas, it is necessary to consider the full range of challenges facing the urban environment. Particular attention should be paid to increasing the area of green spaces and water bodies, while simultaneously meeting the functional and social needs of the population. It is important to recognize that small bodies of water play a vital role in suburban parks, although they are primarily subject to significant anthropogenic impact and are often in a state of degradation. Therefore, the development of new water purification technologies is necessary for the environmental rehabilitation of small bodies of water. A comprehensive study of the ecological and hydrobiological parameters of small bodies of water, taking into account Yerevan's natural conditions, will enable the development of a sound approach to the creation and operation of suburban parks.

Research Results

A multifunctional park is a landscaped, green area designed for recreation, public events, cultural and educational activities, sports and fitness, and entertainment for visitors of various age groups. They are characterized by the mandatory presence of recreational

infrastructure elements (paths, playgrounds, lighting, hardscape, attractions, buildings and structures for cultural events, games, and sports). Catering and retail facilities may also be located to service the park's territory [17]. The sculptor's creative work is intended to provide an additional emotional charge to people who expect emotional intensity and the expression of outstanding spiritual achievements from his works. Decisions regarding the installation of monuments in urban environments are aimed at creating psycho-emotional comfort. They must integrate into the public space and become an integral element, whose function is to imbue the urban environment with an aesthetic component. This approach is especially important when landscaping suburban parks [18, 19].

Classical garden and park sculpture made of natural stone and bronze remains in demand [20]. Each sculpture is unique and inimitable. Monuments based on classic works of world literature are especially significant. When placed in a park, these monuments imbue it with the mysterious atmosphere of fairy tales, poems, and ballads.

Fig. 2 shows a sculpture of a character from Hovhannes Tumanyan's poem «Sako from Lori» (sculptor: Baghdasaryan Sargis), about a shepherd whose heart breaks after an encounter with ghosts. For some reason, the shepherd decides to return to the village, and Sako is forced to spend the night alone in the shepherd's hut. Such huts can still be found high in the mountains today—shepherds spend the night there or even live for several days. And so, young and strong Sako, left in silence, begins to grow afraid. He recalls his grandmother's stories of encounters with ghosts. Eventually, these same ghosts appear to him.

Fig. 2 Example of development of suburban parks

First, Sako hears someone walking around the hut. Then the door swings open and the spirits rush in. Sako, terrified, flees from them and jumps into the Debet River. What is this? Society has been astonished for many years, unable to understand the meaning of the poem. Everyone tried to figure out what Tumanyan was trying to say. The main versions are that the poet was mocking a strong and powerful shepherd who died out of the foolishness of believing his grandmother's fairy tales. Another version is that it's a folkloric sketch. Tumanyan wrote the poem based on his notes—he went from village to village asking for local beliefs. Then he tried to reflect them as accurately as possible in his works. And this is precisely such a case. Why are the ghosts a group of women of different ages? The gist of it is that if a person is left alone at night in the mountains, certain spirits will come for him. And these aren't spirits in general, but specifically a group of female ghosts of different ages. The algorithm is quite predictable

for world folklore studies in general: spirits knock on the door. They're not simply inviting you to a wedding—they want to marry Sako himself to a beautiful spirits. A wedding in the spirit world means death on earth [21].

It remains unclear why this poem was taught for decades, even in schools. Did they think it was a good pedagogical move—that such a great man died of fear of nonexistent ghosts? But Tumanyan's text leaves no doubt that ghosts exist! And it's no coincidence that he spends so much time pondering why the shepherd Gevo suddenly left for the village—as if to suggest that Sako is destined to die that night [21]. Sako begins to have visions in which the door opens and women enter the hut. Sako runs through a dark valley. He believes evil spirits are chasing him. Thus, under the influence of fear, Sako loses touch with reality. Fig. 3 shows illustrations by People's Artist of Armenia Grigor Khanjyan.

Fig. 3 Illustrations by Grigor Khanjyan of the poem «Sako from Lori»

Every Grigor Khanjyan's illustrations could be displayed next to the "Sako of Lori" statue. In this setting, discussions could be organized with youth groups, including high school students, on the issues raised in the poem. The question arises: why is this necessary? What do we expect from these discussions? Over the past 30 years, the events unfolding in the South Caucasus, and especially in Nagorno-Karabakh (war, thousands of victims, blockade, famine), have negatively impacted the moral and psychological well-being of children and young people.

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The stressful context allows us to change the angle of view and fill with new content the clinical typology of adaptive behavior in depression, in particular such variants as a socially passive life position, refusal to fight for significant goals, small in depth and poor in content social contacts, protective and shielding with a “retreat to a small life” and dependent life [22].

Art therapy is widely used in psychology. It is used to treat neuroses, depression, phobias, stress, complexes, psychosomatic disorders, and crises, including age-related ones. Art therapy is especially effective for prolonged depression, when it is difficult to speak and analyze. Art therapy can also be successfully used with healthy clients and is especially popular among young people. Many people see no difference between art therapy and regular music, painting, or dance classes. Art in art therapy is a means of self-discovery [23]. Organizing such

discussions in suburban forests and parks is one of the goals of this work. One of the essential goals of art therapy is to create opportunities for active recreation for young people. In particular, creating the technical capacity for musical and theatrical events.

Well-maintained alleys are essential for organizing recreational areas for city residents, making strolls pleasant at any time of day. A park in the Art Nouveau style requires constant maintenance; all its elements must be not only decorative but also functional. Small architectural forms and accessories are more important than plants [24].

Fig. 4 Small architectural forms and accessories in the Art Nouveau style

The concept of a modern international park found its expression in the idea of the Parc de la Villette in Paris. Currently, the parks of Paris are mostly green spaces intended for strolls and recreation.

They are usually visited by children and the elderly. In winter and in bad weather, they are empty.

Fig. 5 Model stage for musical performances

Therefore, the need arose to create a universal park designed to serve all age groups, actively operating year-round, on weekdays and weekends until late in the evening, ensuring accessibility and safety.

The implementation of this idea was proposed through the organization of a science and technology museum, a music center with an exhibition hall. The scope of the project called for the construction of greenhouses: demonstration - with a cafe and rest areas, didactic - demonstrating new technology for growing various crops, practical use, where visitors can work; the creation of an «Astronomical Garden» with a radio telescope, observatory and meteorological instruments for the work of an amateur club, science clubs (modeling with workshops, a radio club, etc.); a system of water features; Activity centers for performances, concerts, fireworks displays, and public gatherings; theme gardens (e.g., scented gardens,

gardens of unusual plants, mythological gardens); a wide service system—kiosks, cafes, and rentals of sports equipment and tools. In recent years, wild gardens have become widespread. In them, plants are placed seemingly chaotically, but this chaos is planned and created to create the illusion of natural, wild nature, so lacking in modern urbanized man. Flora in landscape gardening of the 20th century mainly uses local planting species, and is sometimes combined with artificial plants. Parks include open spaces for recreation, various flower beds, ponds, as well as enclosed spaces: forests and groves [24].

Parks have their own unique design, operation, and safety features. All aspects of creating recreational areas revolve around ensuring the most comfortable recreational conditions, including safe movement of people within the park while minimizing harm to the ecosystem.

Fig. 6 Illuminated alleys in the park area

A small urban water body is defined as any body of water or watercourse, partially or completely located in an urbanized area, the size of which is comparable to the main elements of urban development - buildings, structures, and transport highways. Many small water bodies are parts of the city's hydrographic network, receiving its runoff and transporting it to a specific river basin [2].

Recreational use of aquatic ecosystems primarily involves the waters of reservoirs. Ensuring the safe operation of small artificial reservoirs that lack adequate water circulation is particularly important. A common characteristic of aquatic ecosystems is their sensitivity to pollution, changes in hydrological regimes, and the extraction of bioresources. Anthropogenic pollution of water bodies has significantly exceeded natural sources in recent decades.

The ecological state of water bodies shows that the water area adjacent to recreation areas is dominated by plants that indicate low water quality. Furthermore, small bodies of water subject to uncontrolled pollution have become a major factor in the deterioration of the sanitary and epidemiological situation in cities. Therefore, the restoration of small bodies of water and waterways is gradually becoming a priority for urban development [25, 26].

Recent decades have been characterized by a sharp increase in anthropogenic pressure on water bodies and waterways. The quality of the aquatic environment is deteriorating progressively, posing a threat to the planet's environmental, food, and national security. The widespread degradation processes occurring in the hydrosphere are leading to various events and phenomena. The ever-increasing level of anthropogenic impact on the environment is leading to environmental degradation, defined as a deterioration in the quality of the human

habitat, characterized by a cumulative deterioration of natural and social conditions [2, 25]. During a 10-minute swim, a person introduces over 3 billion saprophytic bacteria and from 100 thousand to 20 million E. coli into the water. With the increase in the number of swimmers, an increase in the concentrations of nitrates, mineral phosphorus, sodium and sulfates in the water of the reservoir is observed. However, mass swimming is not a significant source of water pollution in terms of bacterial and chemical indicators. In general, changes in water quality in terms of bacterial and chemical indicators are localized and decay quickly over time. Experimental studies show that during the recreational period, significant increases in the upper soil horizons along the shores of water bodies are observed: chlorides (by 5-15 times), sodium (by 3-7 times), and mineral compounds of nitrogen and phosphorus (by 2-3 times). By the next recreational season, the chemical composition of soils in recreational areas is virtually restored and differs only slightly from control samples [27]. However, in suburban parks, which operate year-round, this process causes serious problems.

All anthropogenic impacts – whether they affect the lithosphere, atmosphere, soil (pedosphere) or urbanized environment – reach the hydrosphere through atmospheric precipitation, soil runoff, groundwater migration and other processes associated with the water cycle [26].

In large cities, particularly Yerevan, wastewater enters water supply systems, and its use to fill artificial reservoirs can lead to various health problems. In this regard, certain problems can arise from petroleum product discharges from car washes, the treatment of which has become an important task before discharge into the water supply.

The legislation of the Republic of Armenia permits the discharge of industrial wastewater into the centralized sewer system, provided that the centralized sewer system has sufficient capacity and the composition and characteristics of the wastewater comply with the requirements for industrial wastewater discharge into the sewer system established by the Water Code of the Republic of Armenia. If wastewater from industrial organizations may contain harmful pollutants, its discharge into the centralized sewer system is limited. In the event of non-compliance with the requirements for industrial wastewater discharge into the sewer system, organizations discharging industrial wastewater are required, at their own expense, to pre-treat it at local treatment facilities before discharging it into the centralized sewer system [28]. This requirement should also apply to car washes in recreational areas. Discharging waste containing oil components into small bodies of water can be extremely harmful to the aquatic ecosystems of suburban parks. To address this problem, it is necessary to develop and implement simple and inexpensive technologies for wastewater treatment at car washes.

The fundamental difference between urban reservoirs and watercourses and similar natural water bodies is that they are not part of a macroecosystem, but rather are part of a specific urban system. Urban systems are fundamentally different from natural ecosystems. They are dynamically developing natural-anthropogenic systems consisting of architectural and construction objects and transformed components of the natural environment. Urban systems are the habitats of people living in cities and are created specifically for them. Even the natural environmental elements (park areas, etc.) that remain in urbanized areas are intended primarily to create a favorable living environment for the urban population. As a rule, the true goal of

measures aimed at maintaining the natural elements of urban systems is not the restoration of natural communities within them, but the preservation of their recreational potential and video-ecological properties. For this purpose, for example, all parks are cleared of unwanted vegetation, wetlands are eliminated on the shores of lakes within urban development zones, etc. Thus, the structural and functional organization of urban systems is based on completely different principles than in natural ecosystems. [29].

Therefore, the natural course of self-cleaning and self-healing processes is impossible here.

A bioengineering technology for improving pond water quality is based on the self-purifying properties of natural hydroecosystems. The primary purification mechanisms are planktonic and benthic filter-feeding microorganisms and higher aquatic vegetation. It is recommended to stock the pond with higher aquatic vegetation, planktonic and benthic hydrobionts (filter-feeding organisms), and zooplankton. A balanced, interconnected ecosystem develops around aquatic vegetation. Aquatic vegetation can absorb phenols and petroleum products, and reduce water turbidity.

The water lily (Nymphaea) is recommended for use in artificial ponds. Found in freshwater in the foothills of the Lori and Shirak regions, it is a beautiful plant in the Armenian flora.[2] It is listed in the Red Book of the Republic of Armenia. The leaves are large, floating freely on the surface of the water. The flowers are bisexual, large, solitary, on long peduncles, white, and fragrant.

Fig. 7 The water lily (Nymphaea)

They open during the day and close and sink into the water after sunset. It blooms from late May until late autumn. The fruits are green, multi-seeded, berry-like. When ripe, the fruit falls to the bottom, rots, and the seeds rise to the surface of the water and are spread by waterfowl. It also reproduces vegetatively, by creeping rhizomes. The water lily has been acclimatized in the pond of the Yerevan Botanical Garden, where it grows, flowers, and bears fruit well. The flowers contain alkaloids and essential oils.

Oxygenating plants promote active oxygenation of the water and help establish ecological balance in the pond. Few of these species have decorative flowers. Their role is more interesting: oxygenating plants act as a green backdrop and maintain the pond's health. These include marsh grass, water buttercup, pondweed, water lily, turcha, hornwort, elodea, and others. They can float in the water or be rooted in the pond's bottom soil.

[2] https://econews.am/?p=7106&l=am

A.A. Ohanyan

PLACEMENT OF PLANTS IN COMBINATION WITH SCULPTURES NEAR WATER BODIES IN THE IMPROVEMENT OF SUBURBAN PARKS

A bioplateau is a unique "swamp," densely planted with plants, located in close proximity to the main body of water or integral to it.[3]

The primary function of this artificial shallow water is water filtration by plants. Water from the pond, passing through the bioplateau, is purified of impurities by the stems, leaves, and roots of the plants that fill it. Nitrates, phosphates, and heavy metals are also removed by microorganisms (the so-called biofilm) that inhabit the bioplateau.

Fig. 8 Example of a bioplato device

The resulting water is naturally purified and oxygenated, brimming with a variety of microorganisms. Water is supplied to the bioplateau by a pump that draws water from the bottom of the main pond (Fig. 9). A second pump may also be installed, collecting water from the pond's surface. The bioplateau can be positioned at a slight slope toward the pond, with a slightly higher water level to promote natural runoff.

Water can flow along a constructed channel like a stream or simply overflow the edge of the dividing wall between the "marsh" and the pond. This natural purification system begins to function fully in the third or fourth year, but the first results (the actual water purification) are noticeable within two weeks to a month after its installation. The bioplateau's surface area should be 30-50% of the pond's surface area. The bottom of the bioplateau is lined with plastic film, and crushed rock, pebbles, or gravel are used instead of soil for plants. This is necessary to stimulate the plants to absorb organic matter from the flowing (polluted) water and "feed" on it [30].

A bioplatform should be planted abundantly. The planting is typically done with shallow-water species that are tolerant of your climate. Dense planting will not only ensure high-quality purification but also provide shade for the water, preventing it from overheating. However, when creating a bioplatform, don't overplant it immediately: with proper arrangement, plants will grow quickly. The bioplato operates from May to October. At the end of the season, if possible, remove plant debris (leaves, stems).

[3] https://7dach.ru/Anastasia/chto-posadit-v-vodoeme-rasteniya-dlya-krasoty-i-ochistki-vody-267325.html

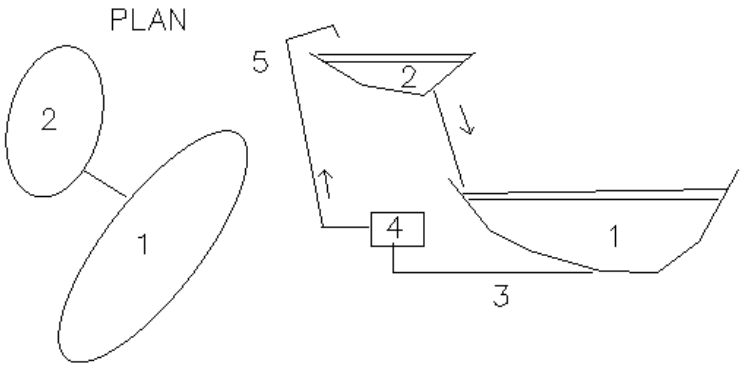

Fig. 9 Water supply scheme to the bioplateau using a pump

1-pond, 2-bioplateau, 3-water intake from the pond, 4-pump, 5-water supply pipeline to the bioplateau

If the bioplateau is placed high enough above the pond, water can be returned through the springboard, providing the pond with additional oxygen.

It's crucial to build high walls around the bioplateau to prevent water from overflowing away from the pond. Traditionally, a 50-cm-deep pit is dug (the walls must be insulated), which is then filled with 20-30 cm of rock. If the bioplateau is being created at a higher level, with a slope toward the pond or a waterfall, a pit is not dug, but walls are required along all sides not bordering the pond.

Tests of the "Grunt-PMM" cartridges show that by increasing the concentration of PMM in the soil, they can be used as a waterproofing material in water supply systems and in urban construction [31].

The results of our laboratory studies suggest that waterproofing of bioplato walls can be achieved using 7 cm thick cartridges, mixing «PMM» with soil in a proportion of 9 kg per square meter of surface area. In the case of sandy-clayey soils, the proportion of polymer-mineral material «PMM» can be reduced to 7.5 kg/m^2.

During pond operation, it is necessary to stop the flow of polluted surface water into the reservoir and regularly monitor the hydrochemical and hydrobiological parameters of the water. During winter, it is advisable to aerate the reservoir using specialized equipment. In the spring, if necessary, supplementary stocking with individual fish species and broodstock of forage invertebrates should be carried out.

Conclusion

1. Preventing rotting processes in standing water is one of the main problems of artificial reservoirs in suburban city parks. A bioengineering technology developed for the climatic conditions of Yerevan, based on the use of the self-purifying capacity of natural hydroecosystems, can improve the water quality in small reservoirs of suburban parks.
2. During pond operation, it is necessary to stop the flow of polluted surface water into the reservoir and regularly monitor the hydrochemical and hydrobiological parameters of the water.
3. The results of our laboratory studies suggest that waterproofing of bioplato walls can be achieved using 7 cm thick cartridges, mixing PMM with soil in a proportion of 9 kg per square meter of surface area. In the case of sandy-clayey soils, the proportion of polymer-mineral material "PMM" can be reduced to 7.5 kg/m^2.

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ՋՐԱՎԱԶԱՆՆԵՐԻ ՄՈՏ ՔԱՆԴԱԿՆԵՐԻ ՀԵՏ ՀԱՄԱԽՄԲՎԱԾ ԲՈՒՅՍԵՐԻ ՏԵՂԱԲԱՇԽՈՒՄԸ ՔԱՂԱՔԱՄԵՐՁ ԶԲՈՍԱՅԳԻՆԵՐԻ ԲԱՐԵԿԱՐԳՄԱՆ ԺԱՄԱՆԱԿ

Ա.Ա. Օհանյան
Հայաստանի ազգային պոլիտեխնիկական համալսարան

Ջրային համակարգերը կարևոր դեր են խաղում քաղաքակրթության զարգացման գործում և ունեն զգալի սոցիալ-տնտեսական նշանակություն: Քաղցրահամ ջրերի էկոհամակարգերը ապահովում են կենսական ծառայությունների լայն շրջանակ, որոնք օգտակար են համայնքների համար:

Ժամանակակից քաղաքը տնտեսական և սոցիալական կյանքի կենտրոնն է: Այն ոչ միայն մարդկանց բնակության վայր է, այլև տարբեր գործունեությունների կենտրոն (հանգստի, աշխատանքի և այլն): Հանրային տարածքները կարևոր դեր են խաղում անհատական և սոցիալական բարեկեցության ապահովման գործում, որտեղ տարբեր ոչ նյութական արժեքների կարևորությունն առավել շոշափելի է դառնում: Այս համատեքստում, փոքր լճակներով քաղաքամերձ զբոսայգիները կարևոր դեր են խաղում գրավիչ միջավայր պահպանելու գործում: Միևնույն ժամանակ, ջրային մարմինները ենթարկվում են զգալի անթրոպոգեն ազդեցության և հաճախ գտնվում են անմխիթար վիճակում:

Ներկայացված հոդվածում քննարկում են փոքր լճակներով քաղաքամերձ զբոսայգիների ստեղծման և պահպանման հետ կապված մի շարք հարցեր:

Բանալի բառեր. ռեկրեացիա, ջուր, քաղաքային միջավայր, լճակ, կենսասարահարթ:

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PLACEMENT OF PLANTS IN COMBINATION WITH SCULPTURES NEAR WATER BODIES IN THE IMPROVEMENT OF SUBURBAN PARKS

РАЗМЕЩЕНИЕ РАСТЕНИЙ В СОЧЕТАНИИ СО СКУЛЬПТУРАМИ ВБЛИЗИ ВОДОЕМОВ ПРИ БЛАГОУСТРОЙСТВЕ ПРИГОРОДНЫХ ПАРКОВ

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Водные системы играют важнейшую роль в развитии цивилизации и имеют важное социально-экономическое значение. Пресноводные экосистемы предоставляют широкий спектр жизненно важных услуг, приносящих пользу сообществам.

Современный город является эпицентром экономической и социальной жизни. Это не только место проживания людей, но и центр различных видов деятельности (досуга, работы и т. д.). Общественные пространства играют ключевую роль в обеспечении индивидуального и социального благополучия — места коллективной жизни, где выражение различных нематериальных ценностей становится наиболее ощутимым. В этом контексте пригородные парки с водоемами играют решающую роль в поддержании привлекательной окружающей среды. Однако они часто подвергаются значительному антропогенному воздействию и находятся в состоянии деградации.

В данной статье рассматриваются некоторые вопросы, связанные с созданием и содержанием пригородных парков с водоемами.

Ключевые слова: рекреация, вода, городская среда, пруд, биоплато.

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IMPACT OF THE APPLICATION RATE OF THE "PMM" AMELIORANT ON FERTILITY AND YIELD STRUCTURE OF WINTER WHEAT UNDER RAINFARMED CONDITIONS

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IMPACT OF THE APPLICATION RATE OF THE "PMM" AMELIORANT ON FERTILITY AND YIELD STRUCTURE OF WINTER WHEAT UNDER RAINFARMED CONDITIONS

Abstract

Rain fed lands (rain fed fields, rain fed agriculture) – are lands in the zone of irrigated agriculture on which crops are cultivated without artificial irrigation, i.e. they mainly use moisture which the soil gets in spring. Mostly these lands are located in foothill plains and margins of oases where drought-resistant corn, food and garden plants are grown.

Over the past seven years, the authors of this article have been conducting research on the use of polymer-mineral material (PMM) to increase soil moisture and the ability to retain sufficient additional water collected from precipitation and groundwater.

Over the past seven years, research has been conducted to increase soil moisture and maintain a sufficient supply of additional moisture collected from precipitation and groundwater through the use of the PMM ameliorant.

A number of technologies for increasing crop yields using the PMM ameliorant have been developed. Numerous laboratory studies have been conducted.

Based on the results of laboratory tests, field studies were conducted in 2024–2025 in the Tsaghkahovit community of the Republic of Armenia under rainfed farming conditions to determine the effect of the PMM ameliorant on winter wheat yield under real-world conditions. At a PMM ameliorant application rate of 0.3 kg/m² (3 g PMM/kg of soil), the average winter wheat yield exceeded the control by 48.2%.

Keywords: water, irrigation, plant, ground, filtration, polymer.

Introduction

When growing crops under rainfed conditions, water shortages are the main cause of low yields. In regions of Armenia with annual precipitation of 250-450 mm, agriculture is carried out with artificial irrigation, while in the foothill and mid-mountain zones, where average annual precipitation is 450-650 mm, it is mostly carried out without artificial irrigation. Furthermore, frequent droughts cause serious damage to agriculture, creating the risk of desertification. In rainfed conditions, where crops are grown without artificial irrigation, spring moisture from melted snow and groundwater is primarily used, as well as rainfall during the spring, summer, and fall growing seasons, which is absorbed by the soil.

Water-swelling polymer additives, which increase their volume many times over when swollen, can be effectively used in agriculture, including growing ornamental plants, vegetable gardening, and horticulture. Polymer additives are particularly effective for growing lawn grasses and grain crops in under rainfarmed conditions. The artificial ameliorant «Hydrogel» is widely used for this purpose. However, hydrogel is ineffective: it degrades when exposed to sunlight and negatively impacts the plant's root system [1].

In the territories of land where crops are cultivated without artificial irrigation, the use of polymer-mineral material (PMM) will improve the water regime which may lead to increased yields by reducing the root system of grown plants and reducing the coefficients of filtration and soil evaporation. In particular, the use of polymer-mineral material in soil under rainfed conditions will ensure the rapid growth of trees and increase their viability [2].

At the field capacity of the soil (in early spring or after full irrigation), approximately 30 liters of water can accumulate in a 10 cm soil layer over an area of 1 m². Some of this water will be used by the plant as nutrition, while some will remain in the soil (approximately 13 liters – 13%), which will not be used by the plant under any natural circumstances (wilting capacity). It is known that out of 30% - 30 liters of water in a 10 cm soil layer, plants cannot use 13 liters of water, they consume another 7 liters with difficulty, practically surviving and not developing, and only 10 liters of water - a third of the accumulated - they easily absorb and assimilate for growth and development.

Thus, most of the moisture accumulated in the soil evaporates from the soil surface during the growing season under the influence of sunlight and warm weather. Therefore, to increase the water reserves in the soil required for plant consumption, two options are possible: reducing water evaporation from the soil surface (for example, by covering it with a thin film, which creates a greenhouse effect and significantly reduces evaporation from the soil surface), or increasing the soil's water holding capacity using a «PMM» (for example, to 40%-45%), which allows for the accumulation of 40-45 liters of water per square meter in a 10-cm soil layer, where the roots of many plants, including winter wheat, are primarily located. An additional 10-15 liters of water accumulated in the soil will provide plants with the water they need for favorable development and growth for a significant period.

Therefore, if the volume of water in the soil decreases by 30-35% of its field moisture capacity, additional water is required for plant growth and development – from artificial irrigation, precipitation, or additionally collected water using a «PMM», increasing field moisture capacity by up to 40% – by 10 liters per square meter.

It should be noted that adding PMM to the soil not only increases its water holding capacity, and therefore doubles the amount of water readily absorbed by plant roots, but also reduces the rate of evaporation under the same conditions, compared to soils without PMM. Therefore, plants easily develop for a period of time that is twice or more longer than without PMM, in the absence of rain and artificial irrigation.

Conflict Setting

A number of technologies have been developed to increase crop yields using the PMM ameliorant. A large number of joint laboratory studies have been conducted by the I.V. Yegiazarov Institute of Water Problems and Hydraulic Engineering and the Lomonosov Moscow State University Research Institute of Mechanics. Laboratory experiments, growing plants in small plots and the most recent field experiment on an area of 1 hectare have shown that the application of PMM to the soil at a rate of 100-300 grams per square meter leads to a significant increase in winter wheat yields [3]. During the research, biometric calculations and measurements were carried out, according to which the ameliorant "PMM" had a significant impact on the growth dynamics of winter crop stems (Fig. 1).

S.B. Galstyan, A.Kh. Markosyan, V.G. Khachaturyan, A.A. Vartanyan, A.P. Khachatryan, H.V. Tokmajyan

IMPACT OF THE APPLICATION RATE OF THE "PMM" AMELIORANT ON FERTILITY AND YIELD STRUCTURE OF WINTER WHEAT UNDER RAINFARMED CONDITIONS

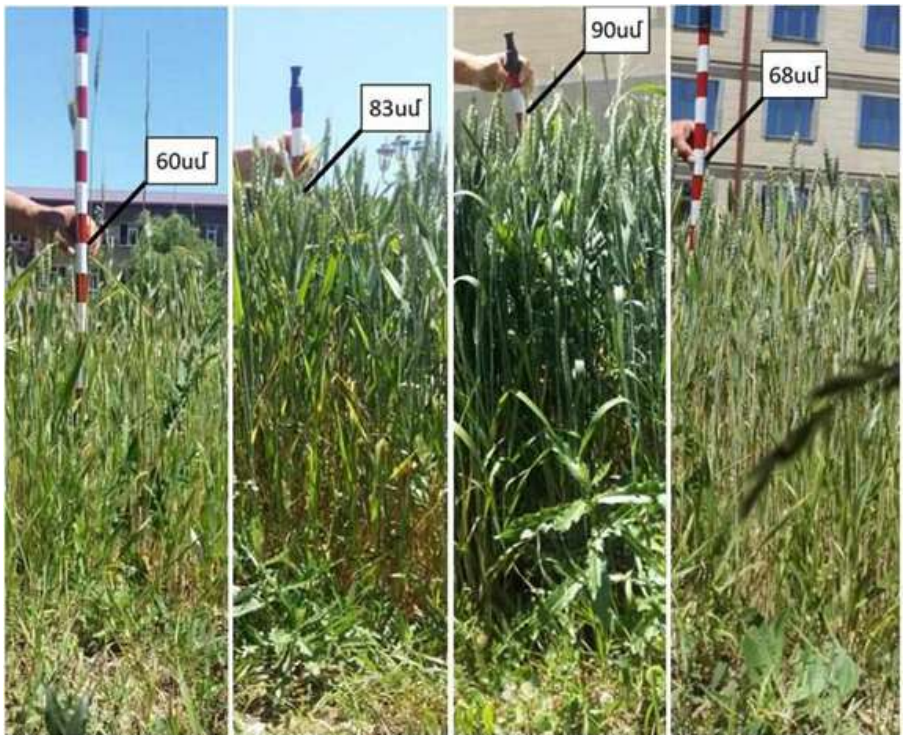

Fig. 1 Biometric observation data [3]

The following four conditions were studied in 1 m² plots under natural conditions:
1. Without PMM and fertilizers (control); 2. Without PMM with fertilizer (P60N90);
3. With P60N90 fertilizer, a 0.5 cm thick layer of PMM was applied to a depth of 10 cm;
4. A 0.5 cm thick layer of PMM without fertilizer was applied to a depth of 10 cm

Based on the laboratory test results, a task was set to conduct natural (field) studies in 2024-2025 in the Tsaghkahovit community of the Republic of Armenia, under rainfed conditions, to determine the real-world impact of the "PMM" material on winter wheat yields. The application rate of the "PMM" ameliorant is 0.3 kg/m² (3 g_{PMM}/1 kg_{soil}).

Research Results

According to climate change forecasts, the following changes can be expected in the region's agricultural sector in the near future [4]:

- a 10-30% decrease in soil moisture levels;
- a 7-13% decrease in soil moisture availability for various agricultural crops;
- by 2030, a decrease in agricultural yields by 8-14%.

In order to identify the dependence of the structure and yield of winter wheat crops on the volume of the "PMM" ameliorant applied to the soil, field experiments were conducted in 2024-2025 in the mountain chernozem subzone of the mountain-steppe landscape zone of the Republic of Armenia (Tsakhkahovit community), located at an altitude of 2000 m above sea level, where the average annual precipitation is 550 mm, and the average annual air temperature is 4°C.

The experiments were conducted in triplicate. The following treatments were studied:

1. Without "PMM" – control;
2. "PMM" – 2 T/ha;
3. "PMM" – 3 T/ha.

Experimental replicates and treatments were placed systematically, with treatments in all replicates arranged in the same order, without a common boundary. Each experimental plot was surrounded on all sides by a 3-meter-wide protective layer. A 1-meter-wide protective layer was also left between adjacent experimental plots. Thus, each experimental plot had a total length of 60 meters and a width of 18 meters, including the 1-meter-wide protective layer, for a total area of 1,080 m² and a calculated area of 1,000 m².

According to the experimental design, the "PMM" ameliorant was applied to the soil before sowing using an SZ-3.6 grain seeder to the seed placement depth, followed by continuous tillage. All other wheat cultivation procedures were carried out using the technology adopted in the region.

To determine the relationship between winter wheat yield and the amount of "PMM" ameliorant applied to the soil, plants of all treatments and replicates were uprooted from an area of 0.25 m² before harvesting, tied into bundles, labeled, and delivered to the laboratory. Structural elements of the crop and biological yield were determined using the established methodology.

Ten randomly selected plants from each bundle were measured for height, spike length, number of grains per spike, 1,000-grain weight. The number of plants per 1 m² of area, the total number of stems, and the number of effective stems were calculated. The total and effective tillering coefficients were determined.

All the above calculations were carried out both for individual repetitions, and the average value from three repetitions was calculated (Tables 1-4).

Table 1

The structure of the biological yield of winter wheat depending on the amount of introduction of the ameliorant «PMM» into the soil (Repetition 1)

Option	Plant height (cm)	In 1m2			Germination		For 1 ear			Weight of 1000 grains (g)	Biological yield (T/ha)			Straw to grain ratio
		Number of plants	Number of stems		Total	Effective	Length (cm)	Number of grains (pieces)	Grain weight (g)		Total	From which		
			Total amount	Effective								Grain	Straw	
Control plot without the “PMM” ameliorant	48	225	356	240	1,58	1,06	5,6	23,2	0,8	34,48	4,05	1,92	2,13	1,1
PMM 2T/ha	52	251	341	275	1,35	1,09	6,3	27,4	0,9	32,84	4,92	2,47	2,45	0,98
PMM 3T/ha	52	247	335	268	1,35	1,08	6,4	28,6	1,2	41,95	6,37	3,21	3,16	0,98

Table 2

The structure of the biological yield of winter wheat depending on the amount of introduction of the ameliorant «PMM» into the soil (Repetition 2)

Option	Plant height (cm)	In 1m2			Germination		For 1 ear			Weight of 1000 grains (g)	Biological yield (T/ha)			Straw to grain ratio
		Number of plants	Number of stems		Total	Effective	Length (cm)	Number of grains (pieces)	Grain weight (g).		Total	From which		
			Total amount	Effective								Grain	Straw	
Control plot without the "PMM" ameliorant	50	201	261	215	1,29	1,06	6,2	26,2	1,0	38,16	4,41	2,15	2,26	1,05
PMM 2T/ha	53	238	296	254	1,24	1,06	6,3	26	1,1	42,30	5,59	2,79	2,8	1,0
PMM 3T/ha	54	293	371	307	1,26	1,04	6,8	28,2	1,0	35,46	6,04	3.07	2,97	0,96

Table 3

The structure of the biological yield of winter wheat depending on the amount of introduction of the ameliorant «PMM» into the soil (Repetition 3)

Option	Plant height (cm)	In 1m2			Germination		For 1 ear			Weight of 1000 grains (g)	Biological yield (T/ha)			Straw to grain ratio
		Number of plants	Number of stems		Total	Effective	Length (cm)	Number of grains (pieces)	Grain weight (g)		Total	From which		
			Total amount	Effective								Grain	Straw	
Control plot without the "PMM" ameliorant	48	254	312	275	1,22	1,08	6,2	21,4	0,8	37,38	4,54	2,20	2,34	1,06
PMM 2T/ha	54	220	303	237	1,08	1,07	6,2	27,2	1,1	40,44	5,29	2,60	2,69	1,03
PMM 3T/ha	55	256	371	281	1,44	1,09	6,4	26,0	1,1	42,30	6,24	3,09	3,15	1,0

Table 4

The structure of the biological yield of winter wheat depending on the amount of introduction of the ameliorant «PMM» into the soil
(Average of 3 repetitions)

Option	Plant height (cm)	In 1m2			Germination		For 1 ear			Weight of 1000 grains (g)	Biological yield (T/ha)			Straw to grain ratio
		Number of plants	Number of stems		Total	Effective	Length (cm)	Number of grains (pieces)	Grain weight (g)		Total	From which		
			Total amount	Effective								Grain	Straw	
Control plot without the "PMM" ameliorant	48,6	226,6	309,6	243,3	1,3	1,06	6,0	23,6	0,86	36,67	4,33	2,09	2,24	1,07
PMM 2T/ha	53,0	236,3	313,3	255,3	1,2	1,07	6,2	26,8	1,03	38,52	5,27	2,64	2,63	1,0
PMM 3T/ha	53,6	265,3	359,0	285,3	1,3	1,07	6,5	27,6	1,1	39,90	6,21	3,12	3,09	0,98

As shown by the averaged data presented in tab. 4, both doses of the ameliorant introduced into the soil had an impact on the height of plants, the total and effective number of stems per unit area, the total and effective tillering coefficient, as well as the length of the ear, the number of grains in the ear, and the weight of 1000 grains. The highest plant height was observed in the variant with a seeding rate of 3 t/ha. This variant also resulted in higher total and effective stem numbers, as well as higher total and effective tillering, on average across three replicates.

Among the most important parameters in the yield structure elements, grain number and 1,000-grain weight were also highest in the PMM 3 t/ha variant. As a result, the highest biological yield of both straw and grain—3.09 and 3.12 t/ha—was observed in the PMM 3 t/ha variant, exceeding the control by 37.9% and 49.2%, respectively, while in the PMM 2 t/ha variant, these yields were 17.4% and 18.1% higher.

Actual yield (arguably the most important indicator) was determined during field harvesting by weighing the yield of each experimental plot across replicates (Table 5). According to the data presented in the table, different rates of soil ameliorant applied to the soil in all replicates significantly impacted the increase in winter wheat grain yield. The highest average yield across three replicates was observed in the PMM 3 T/ha variant – 2.89 T, exceeding the control by 0.94 T, or 48.2%. In the PMM 2 T/ha variant, the deviation from the control was only 0.61 t/ha, or 31.2%.

The climatic conditions for growing grain in the Republic of Armenia are unfavorable. On the other hand, in a country like Armenia, with small, fragmented, and privatized land plots, crop rotation is practically nonexistent, resulting in lower yields. In this case, growing grain is economically

infeasible. Will growing grain, then, bring farmers enough profit to encourage them to abandon other crops? According to professional estimates, the profit from growing one hectare of grain does not reach 100,000 drams. In countries like Russia or Canada (where yields are incomparably higher), where millions of hectares of grain are grown, significant profits can be realized by cultivating several hundred or thousands of hectares. In the Republic of Armenia, where the largest areas under wheat cultivation are 20-30 hectares, and mostly 2-3 hectares, this is not economically feasible.

Table 5

Actual yield of winter wheat depending on the rate of application of the «PMM» ameliorant to the soil (average of three repetitions)

N	Option	Grain yield by repetitions (T/ha)			Average grain yield (T/ha)	Deviation of the yield from the control	
		1	2	3		T/ha	%
1	Control plot without the "PMM" ameliorant	1,88	1,96	2,02	1,95	0	0
2	PMM 2T/ha	2,36	2,84	2,60	2,56	0,61	31,2
3	PMM 3T/ha	2,90	2,96	2,82	2,89	0,94	48,2

According to professional estimates, Armenia requires 420,000–450,000 tons of wheat annually. According to experts at the Food Risk Assessment Center, the average daily bread consumption per capita in Armenia is 319 grams. 82.4% of this is high-quality wheat bread, and 16.9% is lavash. Daily pasta consumption per capita is 19.3 grams, and vermicelli consumption is 8.5 grams. According to calculations conducted in the 1980s, annual bakery product consumption in Armenia, calculated as flour, was 130 kg per person. This figure was projected to reach 142 kg per person in the future. Based on the above data, it was calculated that 450,000 tons of wheat per year are needed to ensure food security in Armenia. The list of grain zones in Armenia for 2010–2024 is provided in tab. 6.

Wheat is grown in virtually all regions of the republic. It is cultivated, in particular, in the Shirak Plain (Akhuryan, Ani, Artik), the Sevan River basin (Vardenis, Martuni, Kamo), Sisian, and the Armavir region. Smaller areas are also grown in Ashotsk, Amasia, Tashir, and Tavush. Again, primarily in arid conditions.

Thus, wheat is primarily grown in arid conditions, primarily at altitudes of 1,500-2,000 meters. Irrigation at such an altitude is associated with high costs. Even on the Ararat Plain, with gravity irrigation, the cost of wheat reaches 100-120 drams/kg, which brings virtually no profit to the producer. According to the statistical service, in 2022-23, In the Armavir and Ararat regions, where wheat is grown primarily on irrigated land, the average yield was approximately 4 centners

per hectare, reaching 6-7 centners per hectare in some cases. In Syunik, Gegharkunik, and Shirak, where cultivation occurs on rainfed land, the yield is 1.5-2 centners per hectare, and in some cases 2.4 centners per hectare. According to professional estimates, the cost of wheat on irrigated land fluctuates between 75-90 drams per kg. The cost of growing wheat is 110-120 drams per kg. Even with a 5-ton harvest, a farmer's profit is, at best, 100,000 drams per hectare. In rainfed conditions, profits are significantly lower. For this reason, the sown area in the republic is decreasing year after year. In recent years, farmers have been provided with a subsidy of 80,000 drams per hectare of wheat. In this case, the "profit" per hectare approaches 160,000-170,000 drams. Observations show that this significantly stimulates wheat production. Moreover, without subsidies, the area sown to wheat declines year after year, while with subsidies, it grows.

Table 6

Grain crop areas in Armenia 2010-2025 (ha)

Years	Total grain	Wheat	Barley
2010	159307	87585	61160
2012	172206	93710	65291
2014	188695	106365	67637
2016	198148	108738	71600
2018	131400	66680	52460
2020	121656	59393	50294
2021	124929	59110	50632
2022	114409	56757	42110
2023	127091	71360	40074
2024	116400	56520	42035

Experts estimate that investments of one to two billion drams create a significant positive effect in agriculture. Related industries begin to thrive, greater added value is created in rural areas, and population outflow is reduced.

Each new, previously uncultivated plot of land is developed, which has a positive impact on soil protection and environmental protection. And "dry water," which effectively increases yields by approximately 50 percent in arid conditions, improves soil structure, which is an important prerequisite for further cultivation and high yields. The area sown to wheat in the republic is 55,000-56,000 hectares. Of these, approximately 40,000 hectares are cultivated under rainfed conditions. With this type of cultivation, the average yield is 1.8-2, and sometimes as high as 2.2-2.3 centners per hectare. Approximately 80,000 tons of wheat will be harvested

from 40,000 hectares. Using «Dry irrigation», the yield will reach 120,000 tons, which is 26-27% of the country's food wheat needs. In purely economic terms, this generates an additional income of almost 5 billion drams. Foreign imports will decrease by a similar amount. And this is with the same sown area. Meanwhile, with such an increase in income, the sown area will obviously expand, and this additional income could increase significantly in practice. In any case, from a food security perspective, it is desirable to have locally produced wheat, which is at least slightly more expensive than imported wheat.

In 2023, Armenia imported 343,500 tons of milling wheat worth $62.8 million, as well as 65,500 tons of finished flour worth $10 million. In 2024, 316,000 tons of milling wheat worth $60.7 million and 42,300 tons of flour worth $10.2 million were imported, respectively. Even a modest increase in wheat acreage would reduce imports by millions of dollars.

Regarding food security, it should be noted that bread is a vital commodity, and based on the country's strategic security goals, at least half of the bread consumed should be produced domestically. Meanwhile, Armenia currently produces less than 20% of its milling wheat needs. Some of the 120,000–130,000 tons are produced as feed. Meanwhile, experts estimate that the republic has the potential to produce 200,000–250,000 tons of wheat. More than 200,000 hectares of agricultural land in the republic remain uncultivated due to water shortages and low yields. This problem could be partially solved with dry irrigation. New wheat varieties are currently being introduced that, with more or less appropriate agricultural practices, yield up to 7–8 quintals per hectare under irrigated conditions and 2–3 quintals or more on dry lands. Therefore, production of 200–220,000 tons is certainly feasible. In this case, this would bring the republic additional revenue of up to 8 billion drams, based on purely economic calculations, and, more importantly, would provide a significant incentive to reduce, stop, and stabilize the outflow of population from mountain, foothill, and border villages. During Soviet times, Armenia consumed up to 1.2 million tons of grain annually, of which 450,000 tons were used for bread production and the rest for livestock feed. In Armenia, this figure has been reduced by approximately half. The problem of feed wheat production can be solved by using a "dry irrigation" mechanism.

Conclusions

1. The application of the PMM ameliorant to the soil has a significant impact on increasing winter wheat yields. According to field studies conducted in 2024-2025 in the arid conditions of the Tsaghkahovit community of the Republic of Armenia, with an

ameliorant application rate of 0.3 kg/m² (3 g PMM/kg of soil), the average winter wheat yield exceeded the control by 48.2%.

2. In the same experimental field, it is necessary to re-sow winter wheat (without adding an additional dose of the ameliorant «PMM») to evaluate the residual effect of the ameliorant on reducing yield increase.
3. To improve the effectiveness of the proposed project, it is necessary to establish production of the «PMM» ameliorant in Armenia, as well as conduct research to find a suitable (replacement) polymer-mineral material of natural origin. This will significantly reduce the cost of the ameliorant used (and, if a local substitute is found, several times over).

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ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱԾՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

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Բնական պայմաններում, որտեղ մշակաբույսերը աճեցվում են առանց արհեստական ոռոգման, օգտագործվում է հողի կողմից կլանված գարնանային խոնավությունը: Դրանք հիմնականում գտնվում են նախալեռնային հարթավայրերում, որտեղ աճեցվում են

երաշտին դիմացկուն հացահատիկային, սննդամթերքի և բանջարանոցային մշակաբույսեր:

Վերջին յոթ տարիների ընթացքում հետազոտություններ են կատարվել «PMM» բնական ծագման պոլիմերահանքային նյութի կիրառման միջոցով, հողի խոնավությունը բարձրացնելու և տեղումներից ու ստորգետնյա ջրերից հավաքված լրացուցիչ ջրի բավարար քանակություն պահպանելու ուղղությամբ: Մշակվել են «PMM» մելիորանտի կիրառմամբ, մշակաբույսերի բերքատվության բարձրամանն ուղղված մի շարք տեխնոլոգիաներ: Կատարվել են մեծ թվով լաբորատոր հետազոտություններ:

Հաշվի առնելով լաբորատոր փորձարկումների արդյունքները, 2024-2025թթ. Հայաստանի Հանրապետության Ծաղկահովիտ համայնքի անջրդի տարածքում, իրականացվել են բնօրինակ (դաշտային) հետազոտություններ, իրական պայմաններում, աշնանացան ցորենի բերքատվության վրա «PMM» նյութի ազդեցությունը որոշելու համար: «PMM» մելիորանտի 0,3 կգ/մ2 (3 $գ_{PMM}/կգ_{հող}$) հող ներմուծման չափաքանակի դեպքում, աշնանացան ցորենի միջին բերքատվությունը ստուգիչ տարբերակին գերազանցել է 48,2%:

Բանալի բառեր. ջուր, ոռոգում, բույս, հող, ֆիլտրացիա, պոլիմեր:

ВЛИЯНИЕ НОРМЫ ВНЕСЕНИЯ МЕЛИОРАНТА «ПММ» НА ПЛОДОРОДИЕ И СТРУКТУРУ УРОЖАЙНОСТИ ОЗИМОЙ ПШЕНИЦЫ В УСЛОВИЯХ БОГАРНОГО ЗЕМЛЕДЕЛИЯ

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В богарных условиях, где сельскохозяйственные культуры выращиваются без искусственного орошения, используется весенняя влага, впитываемая почвой. Эти земли расположены преимущественно на предгорных равнинах, где выращиваются засухоустойчивые зерновые, продовольственные и овощные культуры.

За последние семь лет проводились исследования по повышению влажности почвы и поддержанию достаточного количества дополнительной воды, собранной из атмосферных осадков и грунтовых вод, за счет применения мелиоранта «ПММ».

Разработан ряд технологий по повышению урожайности сельскохозяйственных культур при применении мелиоранта «ПММ». Проведено большое количество лабораторных исследований.

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IMPACT OF THE APPLICATION RATE OF THE "PMM" AMELIORANT ON FERTILITY AND YIELD STRUCTURE OF WINTER WHEAT UNDER RAINFARMED CONDITIONS

С учетом результатов лабораторных испытаний, в 2024-2025 гг. в общине Цахкаовит Республики Армения, в богарных условиях были проведены натуральные (полевые) исследования для определения в реальных условиях влияния материала «ПММ» на урожайность озимой пшеницы. При норме внесения мелиоранта «ПММ» 0,3 кг/м² ($3г_{ПММ}/кг_{почвы}$) средняя урожайность озимой пшеницы превысила контрольный вариант на 48,2%.

***Ключевые слова*:** вода, орошение, растение, почва, фильтрация, полимер.

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IMPROVING SOIL MOISTURE CAPACITY WITH POLYMERIC-MINERAL MATERIALS FOR GROWING PLANTS

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Abstract

The amount, quality and cost of growing plants are determined not only by biological traits, but also by environmental factors such as soil moisture capacity. Water, nutrients and air, in addition to light and heat, are required for regular plant development. The authors conducted tests to boost the field moisture capacity of various substrates using polymer-

mineral materials (PMM) inserted into them, allowing them to conserve additional water for plant development and survival gathered through precipitation or artificial irrigation.

Keywords: water, soil, polymer-mineral material (PMM), soil moisture capacity.

Introduction

Water content in the soil, as well as meteorological circumstances, have a substantial impact on the viability of cultivated plants [1]. Regular monitoring of soil moisture, plants and the work done with them can be ensured by collecting data from the objects and processes under study and transferring it to application and database servers for processing and making timely management decisions on creating favorable conditions for plants and regulated application of fertilizer, water, heat, light and other vital factors.

It should be noted that plants grow normally in structural soils that have adequate levels of water, fertilizer and air. Aside from traditional approaches, agro-industrial firms have repeatedly attempted to improve the physical and chemical qualities of soil through the use of ameliorants. The authors of this study recommend utilizing PMM to raise the field moisture capacity of the soil by 20-30% in order to greatly minimize the consumption of water and other resources by plants while increasing their viability and productivity.

The fertility of the soil is determined by its structure, porosity, moisture capacity, absorption capacity and the presence of organic and mineral colloidal particles. The more such particles there are, the greater the soil's absorption capacity, and thus the volume of water and salts and gases dissolved in it, which plants ingest through the root system for development.

The plant dies fast if there is a lack of water and air in the soil with enough nutrients. Therefore, the soil receives the necessary amount of water and air, which are located in the pores and occupy up to 40% of its volume depending on the soil. Pores fewer than 3-5 mm in size are generated in the soil to boost agricultural efficiency. At the same time, water is mostly kept in small pores, whereas air is required in large pores for the respiration of plants, their root systems and the microorganisms that live in them.

Plants’ water regimes are defined by physical processes running in the soil when water is given to it, such as movement, consumption, moisture conservation, position in different horizons, etc.

The main sources of moisture in the soil in boghara conditions are precipitation (rain, snow and hail), groundwater and rivers. The type of plants, topography, tillage system, winds, air and soil temperature, its filtration and moisture capacity can be boosted by PMM, which slowly dissolves in water, increasing its viscosity and, thus, surface tension, which leads to better water retention in the pores.

Water penetrates into the soil via big pores and is subsequently filtered into the depths via microscopic pores and capillaries due to gravity. The filtration rate in sandy soils is substantially higher than in clay soils. If the soil has a lot of calcareous chemicals, little particles clump together and form huge porous grains that may withstand crushing and water erosion for a long time. Cracks occur between the grains, resulting in clay soils with strong filtering capabilities. The higher the porosity of the soil, the more water and air it can hold. The higher the porosity of the soil, the more water and air it can hold. The maximum amount

of water collected in the soil corresponds to the soil water holding capacity criterion (total soil moisture capacity), which must be distinguished from the soil's water-holding capacity (soil field moisture capacity), which is determined by the amount of moisture remaining in it after complete water saturation until the final free squeeze.

Deep tillage, extensive layer loosening and turning, crop rotation, organic and mine fertilizers, limestone treatment of acid soils and gypsum treatment of saline lands are all traditional ways for maintaining soil structure.

Deep tillage, with intensive loosening and layer overturning, is the main cause of negative events, resulting in rapid degradation. Today, in order to retain, improve and raise soil fertility, farmers use low and zero tillage, as well as science-based crop rotation, ameliorants, organic and mine fertilizers.

The authors conducted laboratory experiments with substrates to streamline the mode of water change in them using PMM developed at the Research Institute of Mechanics of Moscow State University, in order to increase the yield of grown plants and reduce their cost in rainfed and greenhouse conditions and also gave recommendations to provide plants with water in arid regions.

In agriculture, plants will be grown in natural rainfed conditions for a long time to come, so the efficient use of solar energy, moisture from precipitation and groundwater are the most important tasks in such regions of the Earth. Solar energy and soil nutrients are abundant, especially in the Republic of Armenia, but water is frequently a concern. In areas where agriculture is practiced without irrigation, natural disasters frequently cause major harm to agriculture, increasing the danger of desertification and crop loss. Processed dacite tuff rich in potassium, as well as organic fertilizers against a background of mineral ameliorants, were utilized to rapidly improve the physical and chemical qualities of soils in the Republic of Armenia. It is important to note that adding PMM to the soil will allow offering plants with more water and air while also slowing or stopping the process of soil degradation.

The high yield of cultivated crops is the most important characteristic of agriculture, which affects their cost and increases competitiveness. Due to the lack of water, the yield of many plant species in rainfed conditions is significantly lower than in irrigated soils.

Boghara is a land in the zone of irrigated agriculture used for cultivation of agricultural crops without irrigation, i.e. using rainfall. Boghara occuies the piedmont plains and the borders of oasis, where drought-tolerant grain, fodder and melon plants are produced [2, 3].

Therefore, in locations where crops are produced without irrigation, the application of PMM will considerably enhance the water regime of feeding of grown plants, potentially leading to a considerable increase in output, particularly by lowering the root system of grown plants.

By chemical composition water-soluble synthetic and natural polymers include such elements as cellulose, gelatinized starches, polyethylene oxides, alginates, polyacrylamides and polymers. Soil moisture is influenced by the type of plant, topography, agricultural system, presence of winds, ambient temperature and other factors. The filtration coefficient is a feature of soil permeability in relation to filtering water, and it equals the water filtration

rate at a unit pressure gradient with a linear filtration law. Carboxyvinyl and vinyl alcohol increase the viscosity of water.

The property of the soil to retain water by sorption and capillary forces is called water-holding capacity, which is associated with the formation of productive water reserves in the soil. Plants easily use only 30 % of the field moisture capacity for their nutrition, and when the moisture capacity decreases to 13 %, their wilting begins. In addition, such indicators as evaporation, buoyancy properties of the soil, etc., are important for plants.

Thus, all the physicochemical and biological properties of the soil are important for plant growth, which acquire their best performance in structural soils, where water, air and fertilizers are simultaneously contained in sufficient quantities.

Agrotechnical procedures and the incorporation of artificial structure formers into the soil are used to restore and preserve soil structure. Sowing perennial grasses, tillage in the ripe condition of the plant, liming acidic soils, gypsuming solonetzic soils and applying mineral and organic fertilizers are all agrotechnical approaches for enhancing soil structure.

To prevent signs of soil deterioration in boghara agriculture and to regulate the water and food regimes of cultivated crops, the authors used laboratory research to determine the nature of the impact of PMM on the parameters of the water regime in soil without plants over time.The study's goal is to increase the moisture capacity of the soil and keep an additional amount of water in it from precipitation and groundwater for growing plants without or with a drastically decreased irrigation regime. The effects of introducing PMM into the soil can be used to grow a variety of plants in boghara and greenhouse environments. They will aid in increasing yields and lowering production costs, particularly resource costs, so increasing the competitiveness of agro-industrial firms.

Laboratory and field tests on the cultivation of various plants, conducted by many partner companies and agricultural institutes with PMM in the soil in recent years, indicate the possibility of: increasing their viability and productivity by 20 % or more, reduction by 20 % or more of their fallout, fertilizer consumption, as well as the cost of water supply, electricity, human and other resources [4, 5, 6]. It should be noted that with an increase in the capacity of agricultural machinery, the intensity of agriculture, the depth of land cultivation, the use of enhanced loosening and traditional overturning of the reservoir, conditions are created for significant depletion and degradation of the soil. Therefore, minimal or no tillage, with the use of effective agrotechnical measures, such as science-based crop rotations, use of organic fertilizers and ameliorants, is becoming important.

Thus, PMM is proposed to boost yield while decreasing plant-growing costs [3, 7]. Studies were conducted to increase the field moisture capacity of the soil by injecting PMM into it in various doses in compliance with the Technical Requirements of the customers involved in growing plants. Based on non-plant tests, recommendations on the technology of their laying for growing plants in open ground and greenhouses are made.

Conflict Setting

Various formulations of water-accumulating soil mixtures with additions of H1 and PMM materials were tested, their properties were studied, pilot batches were created for testing, and recommendations were made to agricultural enterprises and agricultural institutes

on the technology of laying PMM in the soil, allowing them to retain additional moisture in it, increasing its moisture capacity by 10 – 30%.

The present study presents the outcomes of water retention in soil without a plant to increase its field capacity. The moisture capacity of the substrates was assessed both without and with PMM additions added in different amounts, as well as the dynamics of the decrease in soil moisture content in containers due to filtration and evaporation. The containers were filled with water until full capacity was reached, and then the total amount of water pouring from the perforations at the bottom of the container was studied until the field water capacity was reached.

The experiments indicated the possibility of acquiring an increased volume of water in the substrate with PMM in contrast to the substrate without it, as well as how it varies over time due to evaporation.

To obtain reliable results, studies were carried out with soil without plants indoors at room temperature and humidity (under natural conditions, wind and temperature changes significantly affect the rate of evaporation) in order to exclude the consumption of liquid for the consumption of moisture by plants, i.e. only changes in the collected water in the substrate affecting the dynamics due to evaporation and filtration of water from the container were analyzed. The soil moisture capacity and weight of water in the substrate were determined over time based on the manner and amount of PMM used.

To determine the moisture capacity of the substrate, a container with a mixture of soil with PMM was placed in a bath with water to fill it up to the maximum value to achieve a volume of liquid corresponding to the total moisture capacity of the soil. Previously, the substrate of natural moisture was weighed. The time during which the container was kept in the water bath varied over a wide range: from 15 minutes to 1 day. Next, the container was placed on the surface to drain excess water and reach the field capacity, when the flow of water from the holes in the bottom of the container stops. The difference between the results of measurements of the mass of the "dry" mixture and thus impregnated mixture in the container was determined by the absolute and relative values of the collected water.

After soaking in the bath to field capacity, containers with substrate without PMM and with PMM collected water, which was retained throughout time. The masses of the containers were measured until the balance revealed a mass close to the value corresponding to the masses of the containers before the experiment began (water in the containers evaporates at a rate depending on the temperature and humidity of the air in the room, and the thickness of the substrate layer in it). The tests were carried out multiple occasions.

Below are the measurements of the masses of containers with H1 and PMM.

Options for mixing the substrate with H1 and PMM for laboratory testing:

1. Substrate without PMM and H1, to control the measurements of mixture options.
2. Substrate with H1 in a ratio of 1 to 4 (75 g of H1 and 225 g of the substrate are mixed: the total weight of the mixture is 300 g).
3. Layer of 0.5 cm or 1 cm of H1 was laid on the bottom of the container (layer of H1 more than 2 cm: practically does not let water through).
4. Two-layer laying: layer of substrate mixed with H1 is placed in the bottom of the container, and a substrate without H1 is placed on top.

5. Three-layer laying: bottom and top layers of substrate with H1, and between them a layer of pure substrate.
6. PMM and H1 rods with a diameter of 0.5 to 1.0 cm and a depth of up to 10 cm inside the substrate.

The number of rods and their dimensions are determined by the amount of PMM or H1 introduced into the substrate (1 g of H1 absorbs up to 1.5 g of water, and 1 g of PMM - up to 20 g of water). The larger the diameter of the rod, the slower moisture is absorbed into it. An increase in the number of rods at a fixed diameter leads to an increase in the surface area for water absorption. From above, the rods were covered with a small layer of substrate.

It is important to note that a mixture of the substrate with PMM or H1 can be used repeatedly because the materials are practically washed out of the soil little, their modest concentration should not lead to plant withering due to excess moisture, and pores for air must be left in the substrate.

The amount of water taken up by the substrate is defined as the difference between the mass of the container with the substrate before filling it with water and the mass of the container after filling with water and then settling it to field capacity. The substrate, before watering, was in a state of natural humidity in the room at room temperature. The relative moisture capacity of the substrate in the container is calculated as the ratio of the amount of water to the initial mass of the substrate of natural moisture before it is saturated with water (in %).

Research Results

Experiment №1

A substrate weighing 300 g in a container at room temperature was wetted with water in a bath for 10-15 minutes. After the “extra” water was glassed through the bottom, the container weighed 430 g, that is, we additionally have 130 g of water, compared to the weight before irrigation, which completely evaporated and flowed out of the container in 20 days (the accuracy of measuring weights is 5 g). The results of the experiments are shown in the table 1.

Table 1

Mass of water in a container with soil without H1

Days	0	1	2	3	4	5	6	14	17	18	20
Mass of water in the container, g	130	100	90	85	80	75	70	40	30	20	0
Relative moisture capacity, %	43.3	33.3	30	28.3	26.6	25	23.3	13.3	10	8.33	0

Experiment №2

A substrate weighing 5 kg was deposited in two 225 g containers: one with 5 kg of land and no PMM, and the other with 4.99 kg of land with 10 PMM. The containers were then filled with 3 liters of water, allowed to drain for 15-20 minutes, and the mass was measured (tab. 2).

Table 2

Changes in the mass of water in containers

Days	0	1	4	8
Weight of 1 container	5975	5875	5850	5780
Weight of 2 container with PMM, g	7060	6145	6120	6045

The extra water in the second container fell to 270 g on the second day and then varied little. The large discrepancy on the first day is explained by the poor filtering due to PMM, and once all of the surplus water was gone, the weight of the container began to decrease due to evaporation, but the weight of additional water in the second container with PMM essentially did not change and was equal to 265 g. We have a 265x 100/5000 = 5.3 % increase in soil moisture capacity, and when we compare it to the amount of water left in the first container on the eight day (5780 g – 5225 g = 555g), we see that 265x100/555 = 47.75 % of the water in the second container is more than in the first, and in a month, when the weight of the first container returns to what it was before watering, 265 g of water will remain in the second one. As a result, PMM enables to gather additional water and store it for an extended period of time.

Experiment №3

Experiment with 5 containers weighing 15 g: with clean earth, two containers with earth with PMM, and two containers with earth with H1 (in the first 400 g of earth without material, in the second and third in 400 g of earth added 2 g and 3 g PMM, and in the fourth and fifth added 15 g H1 and 23 g H1, respectively). 200 g of water was poured into the containers, weighed after 15 minutes (tab 3, first column).

Table 3

Changes in the mass of water in containers

Days	1	4	6	10	11	18	24	31	33	36	38
Weight of the first container 505 g	495	490	485	480	475	465	450	430	425	415	405
Weight of the second container 535 g	520	515	510	505	500	485	470	450	440	430	420
Weight of the third container 600 g	600	520	510	505	500	490	475	455	450	440	430
Weight of the fourth container 525g	510	505	500	490	485	475	465	445	435	425	420
Weight of the fifth container 555 g	535	535	530	520	515	500	485	465	450	445	435

On the 36th day of experimentations, all of the water (200 g) in the first container practically evaporated, and the weight of the container began to diminish in the following days due to the evaporation of water that had been in the ground prior to the start of the

experiments. On the 36th day all PMM containers had additional water: 15 g, 25 g, 10 g and 30 g, respectively.

Furthermore, the water in the containers continued to drop after 38 days, while the added water remained constant.

The poured water leaves the containers with PMM and H1 more slowly in the early days of the experiment, and the weight difference with the first container was 25 g, 105 g, 15 g and 40 g, respectively. The containers weighed 395 g on the 40th day of the test, 415 g, 425 g, 410 g and 425 g, respectively. The weight in all material containers continued to exceed the initial weight before the test. Thus, after 40 days, the land with PMM and H1 retains the ability to feed the plant due to the additionally collected water. At the same time, 20 g less water remained in the first container than before the start of the experiment.

This fact has been exploited when growing potted plants. On the 40th day, in pots where there was no material, the plants died, and on the 40th day, in pots where there was material, they watered and the plants continued their growth.

Experiment №4

370 g of soil were placed in three containers weighing 5 g each one: the first container contained clean soil of natural moisture, the second contained 0.75 g of PMM, and the third one contained 1.5 g of PMM. The mixtures were stirred and poured with water, 200 g each one, allowed to stand for an hour, then weighed. In the Figure 4. the results of observations are given. The weight of the containers decreased over time due to evaporation and filtration. The main mechanism for reducing the weight of the containers is the evaporation of water from the soil surface. After 1.5 months, the weights of the containers returned to their original values. The water remaining in them, 20 g in the second and 40 g in the third container, increased the soil moisture capacity by 5.4 % and 10.8 %, respectively. To increase the moisture capacity, we can increase the concentration of PMM in the soil.

Experiment №5

Similar results were obtained in containers with peat, to which PMM was added in different volumes (0.2 g, 0.5 g and 0.8 g) and zeolite (powder) (tab 4).

Table 4

Dynamics of mass changes in peat-filled containers

Experimentation schedule		Jan 13	Jan 21	Jan 28	Feb 4	Feb 11	Feb 17	Feb 28
		1st day	8th day	15th day	22nd day	29th day	35th day	46th day
№	Name							
1	Peat	405	390	370	330	285	210	170
2	Peat + Zeolite	430	410	390	350	305	265	200
3	Peat+Powder	430	410	395	355	310	270	205
4	Peat+0.2 PMM	425	400	385	350	305	255	185
5	Peat + 0.5 PMM	425	400	380	345	300	255	185
6	Peat+0.8PMM	445	425	405	370	325	280	215

In this paper, the authors present a new method for increasing the moisture capacity of soil using PMM, which will enable to save an additional volume of water in it due to

increased viscosity, as well as various options for its laying, including determining the best amount and mixing recipe.

Polymer-mineral ameliorants are successfully used in practice to improve the physical and chemical properties of soil and increase the yield of agricultural crops; research has been conducted for decades with the goal of using potassium-rich processed dacite tuff (Danilova 2016; Tokmajyan et al. 2018; Galstyan et al. 2020), as well as on the economic and environmental efficiency of organic fertilizers versus mineral fertilizers in eggplant crops (Vartanyan et al. 2021).

Therefore, growing plants without IT-based systems for monitoring vital activity and without artificial irrigation results in non-competitive, if not completely lost, production.

Plant cultivation is crucial for countries in the continental subtropical zone. However, in difficult climatic conditions, various agrotechnical measures must be developed to achieve a high yield at a low cost. Drought, hail and other natural disasters wreak havoc on agriculture, posing the threat of desertification.

Fertility depends on the structure of the soil, porosity, moisture capacity, absorption capacity, on the presence of colloidal particles in it and of organomineral origin (Vartanyan et al. 2020b; Vartanyan et al. 2021; Avanesyan 2022).

In the conditions of rainfed agriculture, establishing the dependence of the yield on the reserves of soil moisture is important for assessing the condition of crops and plantations, for determining the effectiveness of agrotechnical measures.

Only productive moisture, a portion of the soil moisture that ensures the formation of crop yields, i.e. exceeds the moisture content of stable wilt, is very important for agricultural production. Therefore, growing plants without systems for monitoring their vital activity using IT and without artificial irrigation leads to non-competitive production, up to its complete loss.

At the same time, seed germination begins only when the soil warms up to certain positive temperatures. Photosynthesis, respiration, transpiration, assimilation of nutrients and other physiological processes are carried out in plants only in a certain range of ambient temperatures.

Air humidity, as an abiotic factor, has a significant effect on plants. With a deficiency of water vapor saturation, evaporation from the soil surface increases sharply and plant transpiration increases.

Precipitation is the main source of moisture for agricultural land. The fluctuation in the yield of cultivated crops in different regions is largely associated with fluctuations in precipitation during the growing season.

Wind is an abiotic factor of nature; it contributes to the pollination of plants, the transfer of seeds, wild trees and grasses. The negative effect of the wind is to increase unproductive evaporation from the soil surface, which causes soil drought, as well as wind erosion and increased damage to plants during droughts.

It is necessary to automate the activities of agro-industrial enterprises by selecting appropriate sensors, controllers and applied information systems that are appropriate to the target architecture and IT strategy in order to determine the characteristics of the soil and environment, as well as manage the processes of growing plants [8].

In order to prevent soil degradation in rainfed agriculture, regulate the water and food regimes of cultivated crops and reduce production costs, ICT is required that informs and performs certain actions in a timely manner to solve problems, in addition to introducing PMM into the soil to improve the parameters of the water regime and increase yields, plant-growing tasks were assigned.

Humidity sensors, PH meters, dosimeters and executive valves are provided to maintain a comfortable state of plant development and are implemented in the form of the Internet of Things, which turn on according to a set time schedule or at the time of a precedent and transmit information to the data processing center.

Humidity sensors, PH meters, dosimeters and executive valves are provided for maintaining a comfortable state of plant development and are implemented in the form of the Internet of Things, which turn on according to a set time schedule or at the time of a precedent and transmit information to the data processing center.

Depending on the method and amount of the applied ameliorant, the specific and volumetric mass of the soil, porosity, moisture capacity, absorption capacity, humidity, displacement and inaccessible amount of water for plants in the soil, dynamics of changes in humidity during the vegetative period, field germination of seeds and safety of plants during the growing, period are recorded the number and mass of nodule bacteria on the roots of the plant, its mass, biological and total yield.

Traditional forms of land cultivation lead to an increase in the rate of humus splitting, pulverization of the arable layer, destruction of soil aggregates, loss of moisture, increase in the cost of resources for growing plants, etc.

Experiments with PMM were conducted in the Moscow Region when growing flowers, cuttings of fruit trees, in the Krasnodar Territory on the Black Sea coast when planting young apple trees and plums with different amounts of PMM (250 g, 300 g, and 350 g PMM) under a tree and in the Republic of Armenia for the cultivation of winter wheat (100 - 200 PMM per m^2 of soil), where the main source of water is rainfall and wells, as well as in other regions.

The Institute of Mechanics of Moscow State University began to develop such mixtures back in the 80s of the twentieth century. The Kavelast material based on bentonites and polymer additives was tested in the cultivation of various crops in the arid regions of Georgia and Uzbekistan, where small-scale production of the material was established. Experiments have shown that the introduction of 1% kavelast into the soil leads to significant increase in productivity, reduction in the consumption of irrigation water and fertilizers.

However, with the collapse of the USSR work was halted and material production ceased. In recent years, research has resumed, and new materials such as PMM and H1 have been developed for growing plants in open and closed ground, as well as in containers with various substrates.

Conclusions

The amount of water retained in the soil can be controlled by adding a polymer-mineral material (PMM) to the substrate, which reduces the frequency of watering by half or more, and under certain circumstances, even eliminates watering completely during dry

periods. Tests conducted without plants allow us to recommend methods for adding PMM to the substrate to increase its water-holding capacity, as well as the optimal amount for obtaining a specific volume of additional water. Specifically, in soil with a field water-holding capacity of 30%, 2-3 g/kg PMM can be added to increase it by 20-30%, providing an additional 60-90 g of water per kg of soil, which is equal to the volume of water the soil easily releases to the plant without this material.

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ԲՈՒՅՍԵՐԻ ԱՃԵՑՄԱՆ ՀԱՄԱՐ ՀՈՂԻ ԽՈՆԱՎՈՒՆԱԿՈՒԹՅԱՆ ԲԱՐՁՐԱՑՈՒՄԸ ՊՈԼԻՄԵՐԱՀԱՆՔԱՅԻՆ ՆՅՈՒԹԵՐԻ ՕԳՆՈՒԹՅԱՄԲ

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Հողում պահպանված ջրի քանակը կարելի է կարգավորել ավելացնելով պոլիմերահանքային նյութ (PMM)։ Այդպիսով հնարավոր կլինի կիսով չափ կամ ավելի

նվազեցնում ոռոգման հաճախականությունը, իսկ չորային ժամանակահատվածներում՝ ամբողջությամբ դադարեցնել այն: Բույսերի բացակայության պայմաններում անցկացված փորձարկումները թույլ են տալիս մեզ առաջարկել PMM մելիորանտի կիրառման արդյունավետ մեթոդներ: Մասնավորապես, դաշտում 30% ջուր պահելու ունակություն ունեցող հողին կարելի է ավելացնել 2-3 գ/կգ PMM՝ 20-30%-ով մեծացնելով ջրի կուտակման ծավալը: Այդպիսով, հողի մեկ կգ զանգվածում, լրացուցիչ կկուտակվի 60-90 գ ջուր, ինչը հավասար է այն ջրի այն ծավալին, որը հողը հեշտությամբ տալիս է բույսին, առանց այս նյութի:

Բանալի բառեր. ջուր, հող, պոլիմերահանքային նյութ, հողի խոնավունակություն:

ПОВЫШЕНИЕ ВЛАГОЕМКОСТИ ПОЧВЫ С ПОМОЩЬЮ ПОЛИМЕРНО-МИНЕРАЛЬНЫХ МАТЕРИАЛОВ ДЛЯ ВЫРАЩИВАНИЯ РАСТЕНИЙ

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Количество воды, удерживаемой в почве, можно регулировать, добавляя в субстрат полимерно-минеральный материал (ПММ), который сокращает частоту полива вдвое и более, а при определенных условиях даже полностью исключает полив в засушливые периоды. Испытания, проведенные без растений, позволяют рекомендовать способы внесения ПММ в субстрат для повышения его водоудерживающей способности, а также оптимальное количество ПММ, для получения определенного объема дополнительной воды. В частности, в почву с полевой водоудерживающей способностью 30% можно внести 2-3 г/кг ПММ, чтобы увеличить ее на 20-30%, обеспечивая дополнительные 60-90 г воды на кг почвы, что равно объему воды, который почва легко отдает растению без этого материала.

***Ключевые слова*:** вода, почва, полимерно-минеральный материал (ПММ), влагоемкость почвы.

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Abstract

This study evaluates the antioxidant activity of pork meat during maturation as influenced by different starter cultures. The performance of *Lacticaseibacillus rhamnosus* 2012 MDC 9631, *Lactobacillus plantarum* 66 MDC 9619, and a commercial BactoFlavor® culture was compared with traditional salting. Antioxidant activity was measured using the DPPH radical scavenging assay.

Results showed that all samples exhibited concentration-dependent antioxidant activity. Traditionally salted pork showed the highest activity, but *L. rhamnosus* 2012 MDC 9631 also demonstrated strong antioxidant potential, surpassing the other two cultures. Its proteolytic and antimicrobial properties suggest practical applicability in dry-cured ham production.

The findings support the use of *L. rhamnosus* MDC 9631 as a natural biopreservative that can enhance product quality, improve oxidative stability, and reduce maturation time in pork processing.

Keywords: Pork meat, Lactic acid bacteria cultures, salting, antioxidant.

Introduction

Starter cultures used in meat production can be described as viable microorganisms capable of multiplying within meat products, thereby extending their shelf life, ensuring sanitary and hygienic safety, improving food quality, and being harmless to the consumer [1-2]. Lactic acid bacteria (LAB) have been used by humans for millennia to preserve perishable foods such as milk, fermented sausages, and others.This is mainly due to their ability to synthesize lactic acid and antimicrobial compounds, which inhibit the growth of spoilage-causing microorganisms[3].The effectiveness of lactic acid bacteria (LAB) has been scientifically proven from a health and safety perspective, and they are known to have great potential for use as biopreservatives to improve the quality and extend the shelf life of various food products. In meat production, starter cultures are used for the enzymatic conversion of various components present in the raw material, which in turn contributes to the development of the flavor, stable color, and quality characteristics of the meat products.The biochemical composition of raw materials and the caloric content of finished meat products depend on the ratio of different tissue types and the technological processes used [4]. Starter cultures can reduce the amount of biogenic amines in fermented meat products.The accurate selection of cultures during the maturation process of raw materials makes it possible to shorten the

maturation time and obtain a semi-finished product with high biological value.Oxidative processes in meat lead to quality deterioration. Meat has endogenous antioxidants and prooxidants and living cells have several mechanisms of protection against oxidative processes, including antioxidant enzymes such as superoxide dismutase (SOD), catalase and glutathione peroxidase (GSH-Px).Catalase and glutathione peroxidase (GSH-Px) are considered major peroxide-removing enzymes located in the cytosol[5].The biological value and shelf life of meat are determined by its maturation process.

Conflict Setting

Currently, starter cultures have become widely used and have established their unique role in the field of meat production.Total antioxidant activity is also considered an indicator of meat preservation and quality characteristics, as it provides insight into pork defects, including fatty acid oxidation.LAB as a bio-preservative alternative to chemical and physical preservatives, are used in various food products to eliminate pathogenic and spoilage microorganisms.The impact of lactic acid bacteria (LAB) on the microbiological safety of food is due to their production of various compounds, such as organic acids (lactic acid, pyruvic acid, oxo-acids), bacteriocins, diacetyl, acetyl-methyl-carbinol, hydrogen peroxide, carbon dioxide, and other yet-undescribed substances that inhibit foodborne pathogens and spoilage microorganisms[6].Currently, there is a growing emphasis on reducing the duration of the maturation process and optimizing the conditions for the use of starter cultures in technological processes.

This study evaluated the optimal exposure time, salting process, and antioxidant activity of different starter cultures during pork maturation. Salting is one of the oldest preservation methods, during which meat acquires a number of sensory characteristics beneficial for production. It is noteworthy that salting of meat is carried out to achieve the desired consumer and technological properties of the finished product (flavor, aroma, color), as well as to prevent microbiological defects [7-8].

Materials and Methods

In our studiey the selection of strains was based on salt tolerance (3.5%) and psychrophilicity (4–6°C).Based on the above criteria, the following starter cultures were selected: the widely used BactoFlavor® BFL-T0 culture from ***Hansen (Denmark)***, which includes the starter cultures *Pediococcus pentosaceus* and *Staphylococcus carnosus*, as well as the strains *Lactobacillus plantarum* 66 MDC 9619 and *Lacticaseibacillus rhamnosus* 2012 MDC 9631.these were compared with traditional salting. The latter two strains, *Lactobacillus plantarum* 66 MDC 9619 and *Lacticaseibacillus rhamnosus* 2012 MDC 9631 (previous Lactobacillus rhamnosus MDC 9631), were obtained from the Microbial Depository Center (MDC) of the ArmBiotechnology Scientific and Production Center, National Academy of Sciences of the Republic of Armenia. All lactic acid bacteria are stored in sterilized milk with a 40% glycerine content at 20 ˚C. The viability of LAB is up to 6 months.

The strains of LAB are maintained on de Man, Rogosa and Sharpe (MRS) agar medium under refrigerated conditions (+4–6 °C). Subculturing is performed once every 1–2 months.

The sensitivity of LAB strains to NaCl was tested in MRS broth containing various salt concentrations (2–12%) at 37°C for 24 hours of incubation [9-10].

The strains *Lacticaseibacillus rhamnosus* 2012 MDC 9631 and *Lactobacillus plantarum* 66 MDC 9619 are resistant to NaCl concentrations up to 8%, as they were isolated from salted cheese samples. The bacterial activity is evident in almost all technological stages of raw smoked meat processing.

Table 1

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Characterization of LAB strains: *Lactobacillus plantarum* 66 MDC 9619 and *Lacticaseibacillus rhamnosus* 2012 MDC 9631

N	Species Affiliation	Characterization of LAB strains								
		Proteolytic activity	Antioxidant activity (%)	Antibiotic Resistance, (%)	NaCl Tolerance (6%)	Antimicrobial activity pH=4,5-5,5 U/ml			Adhesion ability	Viability in pH range 2–9, %
						S.typhimurium G-38.	*B.subtilis* 17-89	*E.coli* K12		
1	*L. rhamnosus* 2012 *MDC* 9631	+	59.6	34.0	+	2000	4000	2500	+	90
2	*L. plantarum 66 MDC 9619*	+	21.0	55.6	+	1200	3000	1200	+	80

Notably, strains of *Pediococcus pentosaceus* and *Staphylococcus carnosus* have a positive effect on meat color development, as they contribute to the conversion of nitrate to nitrite through nitrate reductase activity. Moreover, staphylococci are capable of producing the catalase enzyme, which helps prevent oxidative defects during storage by breaking down the resulting hydrogen peroxide.Hydrogen peroxide and other peroxides are strong oxidants that react with myoglobin, causing it to lose color [11-12] Notably, the above-mentioned cultures can survive at temperatures below the optimal level, but they do not multiply under such conditions.

The research sample was collected from the thigh of a 7-month-old female pig. Four types of salting were performed: traditional salting, salting using the BactoFlavor level recommended by the manufacturer, and salting with lactic acid bacteria *Lactobacillus plantarum* 66 MDC 9619 and *Lacticaseibacillus rhamnosus* 2012 MDC 9631 strains. The pork thigh was divided into four parts, each weighing 150 g. For all variants, a brine solution (50 ml) was prepared, with a salt concentration of 11.13% and a density of 1.077, under conditions of 15 °C. Injection was performed using 10% of the prepared 50 ml brine solution, applied to each 1 cm² of the surface. The quantity of lactic acid bacteria *Lactobacillus plantarum* 66 MDC 9619 and *Lacticaseibacillus rhamnosus* 2012 MDC 9631 was 1 ml, with a culture titer of 10^9 CFU/ml. In addition, sucrose was added at 0.1% of the raw meat weight. The titer of the BactoFlavor culture was 10^7 CFU/ml, and in the case of this culture, fructose was also added at 0.1% of the raw meat weight. The objective is to establish identical conditions including temperature, brine density, and the same anatomical part of the meat while applying different starter cultures simultaneously. The aim is to compare the resulting changes with traditional salting, focusing on aspects such as reduced maturation time, increased biological value, enhanced antioxidant activity, and improved safety indicators.

Four salting samples were studied at different stages of maturation: on the 1st day, the 4th day, and in the fully matured state, which varies depending on the starter culture used.The pH value was considered an indicator of maturation, and the experiments were conducted in triplicate[13].

In the technological process of raw smoked products, when the salt content increases and the moisture level in the meat decreases, the species composition of the microflora changes

depending on various factors: raw material, technological process, and time. During salting, an increase in the number of lactic acid bacteria (LAB) is observed, which contributes to meat maturation. The strains of *Lactobacillus plantarum* and *Streptococcus lactis* show resistance to high salt concentrations [14].

Table 2

Physiological data of *Pediococcus pentosaceus* and *Staphylococcus carnosus Subs. Utilis*

Culture composition	***Pediococcus pentosaceus***	***Staphylococcus carnosus Subs. utilis***
Growth temperature Opt/max/min	35ºC/48 ºC/15 ºC (95 ºF/118 ºF/59 ºF)	30ºC/45ºC/10ºC (86 ºF/113 ºF/50 ºF)
Salt limit	7% salt-in-water	16% salt-in-water
Characteristics	Facultative anaerobic DL(+/-)- lactic acid producing	Facultative anaerobic Catalase positive Nitrate reductase positive Lipolitic Proteolytic
Fermentable sugars Glucose (dextrose) Fructose Maltose Lactose Saccharose (sucrose) Starch	 + + + (+) + -	 + + - + - -

The antioxidant capacity was evaluated during the different stages of pork maturation. Several methods exist for assessing antioxidant capacity, including ABTS, FRAP, CUPRAC, DPPH, and others[15]. For evaluating antioxidant activity in pork, the spectrophotometric method using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) reagent is considered the most suitable[16].

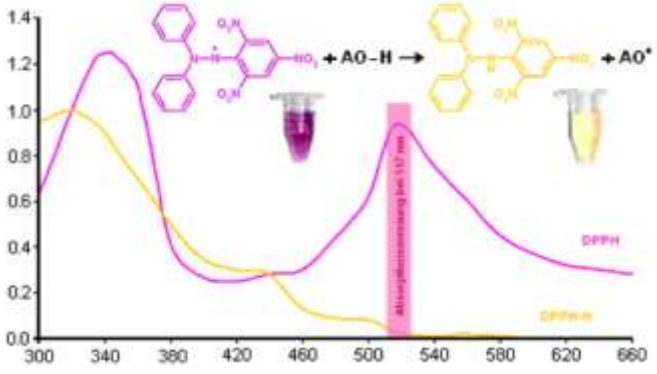

Fig. 1 Changes in the spectrophotometric absorption intensities of the DPPH• radical

Photometric measurements were carried out using a Thermo Scientific Genesys 50 UV-Vis spectrophotometer, at a wavelength of 517 nm.

During data analysis, the violet chromogenic radical is reduced by the antioxidant compound to 2,2-diphenyl-1-picrylhydrazine (DPPHH), which exhibits a yellow coloration. The degree of decolorization is directly proportional to the antioxidant activity the greater the decolorization, the stronger the antioxidant properties (Figure 1). Measurements were

performed using a spectrophotometer in the visible range at a wavelength of 517 nm, corresponding to the absorption intensity of the DPPH color.

To determine the IC50 values for DPPH radical scavenging, stock solutions with a concentration of 0.1 g/mL, prepared from the homogenized aqueous extracts of the final stage of pork maturation of each variant, were used.Subsequently, 250, 300, and 600 µL aliquots from each variant were diluted to a final volume of 2000 µL and mixed with 2000 µL of 0.2 mM DPPH solution in methanol-water. The mixtures were vortexed and incubated in the dark for 30 minutes. The absorbance (A1) was then measured at 517 nm.In addition, the DPPH solution was replaced with an equal volume of absolute methanol, and its absorbance (A2) was measured. Besides the test samples, a control measurement was performed using an equal volume of distilled water to determine the initial absorbance of the DPPH solution (A0). The DPPH radical scavenging activity was calculated using the following equation.

Scavenging activity (%)=[1-((A1-A2))/A0]*100

Research Results

During the determination of antioxidant activity by the DPPH method, an important indicator is the neutralization (scavenging) of 50% of the DPPH reagent by the antioxidant substance (IC50). Tab. 3 presents the results of the interaction between extracts obtained from the application of various starter cultures in pork and the DPPH reagent.

Table 3

Results of optical density measurements of pork samples at the start and at the matured stages

Type of salting	Maturation phase	D_{517}		
		V, mkl 250	V, mkl 300	V, mkl 600
Traditional salting	Start	1.0	0.9	0.6
	8th day	0.8	0.7	0.4
BactoFlavor®	Start	0.9	0.9	0.7
	7th day	0.9	0.8	0.6
L. plantarum 66 MDC 9619	Start	1.0	1.0	0.7
	6th day	1.0	0.9	0.8
L. rhamnosus 2012 MDC 9631	Start/	1.0	0.8	0.7
	5th day	0.9	0.9	0.6

The obtained results show that the antioxidant activity (the ability to neutralize the DPPH radical) in the samples with traditional salting and applied starter cultures is directly proportional to the concentration of the tested meat extract. Specifically, at 600 µL of extract, all samples exhibited higher activity compared to the 250 µL or 300 µL concentrations.

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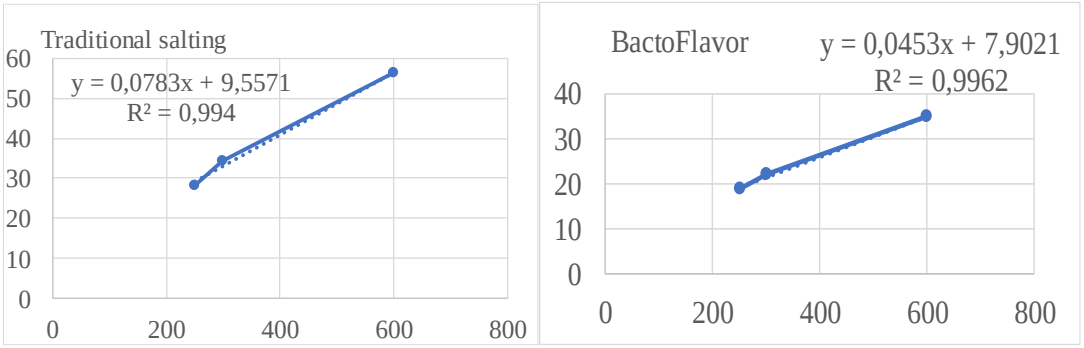
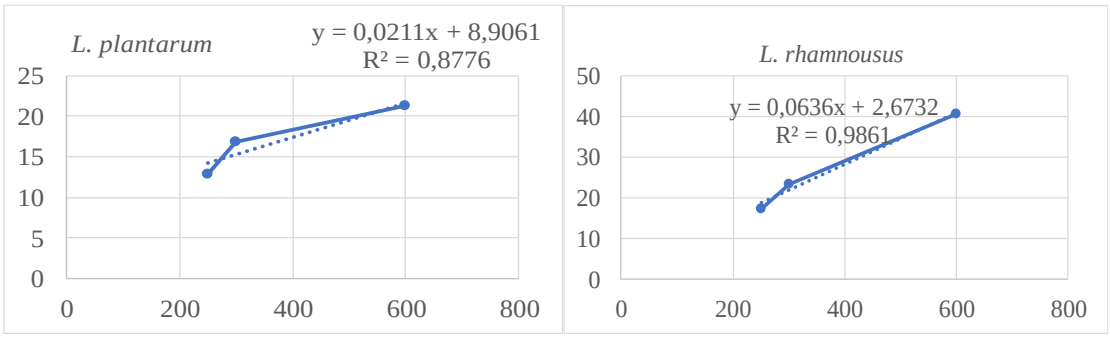


a – Traditional salting b- BactoFlavor



c- *L. plantarum* d- *L. rhamnousus*

Fig. 2 Dependence of antioxidant activity on concentration: a – traditional salting, b – BactoFlavor, c – *L. plantarum*, d – *L. rhamnosus*

Table 4

Antioxidant activity of pork samples during the initial and maturation stages

Type of salting	Maturation phase	Sqavenging %		
		V, mkl 250	V, mkl 300	V, mkl 600
Traditional salting	Start	8.0	16.3	32.7
	8th day	28.0	34.2	56.3
BactoFlavor®	Start	17.0	18.0	28.3
	7th day	18.7	22.0	35.0
L. plantarum 66 MDC 9619	Start	6.7	11.9	21.6
	6th day	12.8	16.8	21.3
L. rhamnosus 2012 MDC 9631	Start	10.2	13.8	24.7
	5th day	17.2	23.2	40.6

Our findings demonstrate that among the four tested samples, the traditionally salted meat exhibited the highest antioxidant activity. Interestingly, while the sample inoculated with *Lacticaseibacillus rhamnosus* 2012 MDC 9631 showed slightly lower activity compared to the traditionally salted variant, it nevertheless surpassed those prepared with BactoFlavor® and *Lactobacillus plantarum* 66 MDC 9619 starter cultures. Considering the recorded antioxidant

activity of the *Lacticaseibacillus rhamnosus* 2012 MDC 9631 strain in the sample during pork maturation, along with the strain's proteolytic and lipolytic activities, as well as its demonstrated antagonistic properties, strong prerequisites are established for the practical application of the *L. rhamnosus* strain. Consequently, a technological prospective model for the production of dry-cured ham incorporating the use of *L. rhamnosus* strain will be proposed.

Technological recommendation

Based on the proposed technological scheme, the integration of *Lacticaseibacillus rhamnosus* 2012 MDC 9631 into ham production can enhance both antioxidant stability and overall product quality. The recommended technological process is as follows (Figure 3):

1. Raw Meat Preparation (Step 1): Select high-quality pork cuts, ensuring uniformity in size and anatomical location to maintain consistency in maturation.
2. Salting / Brine Injection (Step 2): Prepare a brine solution with controlled salt concentration and add the *L. rhamnosus* culture (10^9 CFU/mL). Inject the brine uniformly into the meat to achieve optimal distribution of starter cultures, while optionally including sugars to support bacterial activity.
3. Fermenter Cultivation of L. *rhamnosus* (Step 3): The *L. rhamnosus* 2012 MDC 9631 strain is cultivated in a bioreactor under optimized conditions—pH 5.8–6.0, temperature 37 °C, and gentle aeration—to achieve maximum viable cell density. The fermentation process continues until the culture reaches the target cell concentration suitable for inoculation ($\geq 10^9$ CFU/mL).
4. Cell Harvesting by Flow Centrifugation (Step 4): After cultivation, the bacterial biomass is separated from the culture medium using a continuous flow centrifuge. The concentrated cell suspension is then either directly incorporated into the brine solution or stored short-term at 4 °C before use to ensure cell viability and metabolic activity.
5. Additive/Dosing System (Step 5): Additional natural antioxidants or flavor-enhancing agents can be introduced during brine preparation, promoting both microbial growth and oxidative stability.
6. Maturation (Drying/Oven and Smoking) (Steps 6–7): Maintain controlled temperature and humidity conditions to allow for optimal bacterial activity and enzymatic reactions. L. rhamnosus contributes to the development of flavor, color stabilization, and antioxidant activity, reducing lipid oxidation and enhancing shelf life. Additional natural antioxidants or flavor-enhancing agents can be introduced during brine preparation, promoting both microbial growth and oxidative stability.
7. Packaging (Step 8): Once the desired maturation stage is reached, vacuum-pack or otherwise appropriately package the product to prevent contamination and preserve the functional properties conferred by the starter culture.

Incorporating *L. rhamnosus* 2012 MDC 9631 into the process not only ensures improved antioxidant activity and oxidative stability but also supports safer microbiological quality by inhibiting spoilage microorganisms. This approach allows for a shorter maturation period without compromising the sensory and nutritional quality of the final ham product [17].

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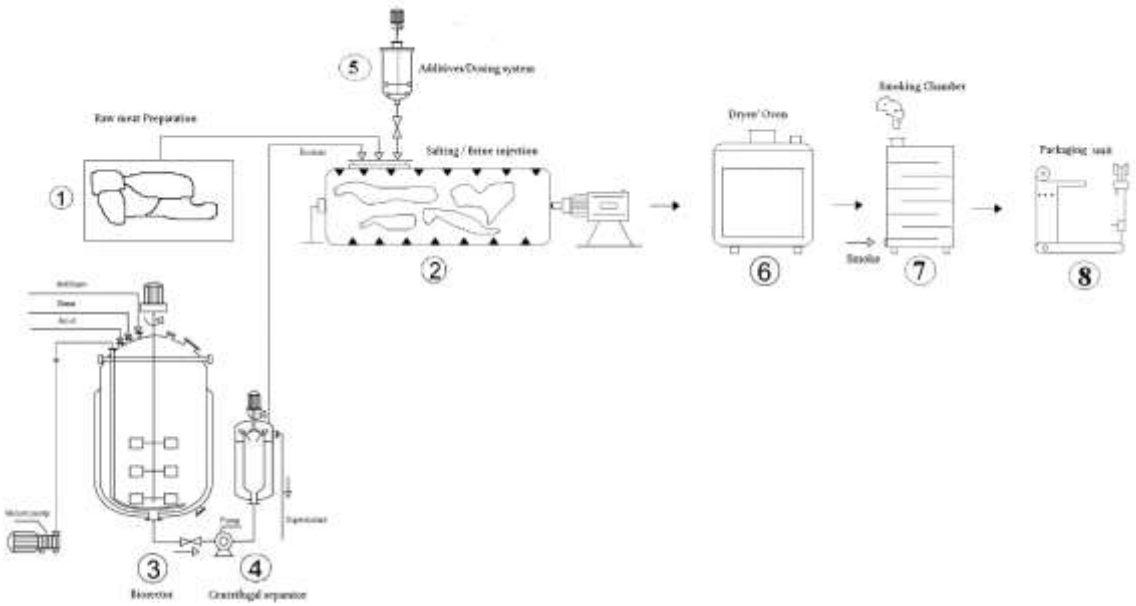

Fig 3. Technological Scheme of Ham Production with Integration of *Lacticaseibacillus rhamnosus* 2012 MDC 9631.

Conclusions

The study demonstrated that the antioxidant activity of pork meat during maturation is significantly influenced by the type of starter culture used. Among the tested variants, traditionally salted meat exhibited the highest antioxidant activity, while the sample inoculated with *Lacticaseibacillus rhamnosus* 2012 MDC 9631 showed slightly lower but still superior activity compared to those treated with BactoFlavor® and *Lactobacillus plantarum* 66 MDC 9619. The results indicate that the proteolytic and lipolytic activities, along with the antagonistic properties of *L. rhamnosus* 2012 MDC 9631, contribute to the maintenance of meat quality and oxidative stability during ripening. The study also confirmed that antioxidant activity is directly proportional to extract concentration, highlighting the importance of starter culture selection for optimizing meat maturation processes.

From a practical perspective, *L. rhamnosus* 2012 MDC 9631 demonstrates strong potential for application in the production of dry-cured ham and other pork products, providing a natural biopreservative effect while enhancing biological value and safety. The use of this starter culture could contribute to reduced maturation times, improved oxidative stability, and extended shelf life of meat products, representing an effective alternative to conventional chemical preservatives. These findings provide a technological basis for the incorporation of selected lactic acid bacteria in meat processing, supporting both product quality and consumer safety.

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ՀԱԿԱՕՔՍԻԴԱՆՏԱՅԻՆ ԱԿՏԻՎՈՒԹՅԱՆ ՈՒՍՈՒՄՆԱՍԻՐՈՒՄԸ ԽՈԶԱՄՍԻ ՀԱՍՈՒՆԱՑՄԱՆ ԸՆԹԱՑՔՈՒՄ ԿԱԽՎԱԾ ՄԵԿՆԱՐԿԱՅԻՆ ԿՈՒԼՏՈՒՐԱՆԵՐԻՑ

Հ.Գ. Գրիգորյան

Հայաստանի Ազգային Ագրարային Համալսարան

Հետազոտության նպատակն էր գնահատել խոզի մսի հակաօքսիդանտային ակտիվության օրինաչափությունը հասունացման ընթացքում՝ տարբեր մեկնարկային կուլտուրաների ազդեցության պայմաններում: Համեմատվել է *Lacticaseibacillus rhamnosus* 2012 MDC 9631, *Lactobacillus plantarum* 66 MDC 9619 և արտադրությունում կիրառվող BactoFlavor® կուլտուրաների արդյունավետությունը՝ ավանդական աղադրման մեթոդի հետ: Հակաօքսիդանտ ակտիվության գնահատման համար կիրառվել է DPPH ռադիկալների կապման թեստը:

Արդյունքները ցույց են տվել, որ բոլոր փորձանմուշները դրսևորել են կոնցենտրացիայից կախված հակաօքսիդանտային ակտիվություն: Ամենաբարձր արժեքները արձանագրվել են ավանդական եղանակով աղադրված մսի դեպքում, սակայն *L. rhamnosus* 2012 MDC 9631- ը նույնպես ցուցաբերել է էական հակաօքսիդանտային ակտիվություն՝ գերազանցելով մյուս մեկնարկային կուլտուրաներին: Վերջինիս արտահայտված պրոտեոլիտիկ և հակամանրէային հատկությունները վկայում են դրա գործնական կիրառելիության մասին խոզապուխտի արտադրության մեջ: Ընդհանուր առմամբ, ստացված տվյալները հաստատում են, որ *L. rhamnosus* 2012 MDC 9631–ը կարող է դիտարկվել որպես բնական կենսապահպանիչ, որն ունակ է բարձրացնել արտադրանքի որակը, ամրապնդել օքսիդատիվ կայունությունը և կրճատել մսամթերքի հասունացման տևողությունը:

Բանալի բառեր. խոզամիս, կաթնաթթվային կուլտուրաներ, աղադրում, հակաօքսիդանտ:

H.G. Grigoryan

INVESTIGATION OF ANTIOXIDANT ACTIVITY DURING THE RIPENING OF PORK MEAT AS INFLUENCED BY STARTER CULTURES

ИССЛЕДОВАНИЕ АНТИОКСИДАНТНОЙ АКТИВНОСТИ В ПРОЦЕССЕ СОЗРЕВАНИЯ СВИНИНЫ ПОД ВЛИЯНИЕМ СТАРТОВЫХ КУЛЬТУР

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Целью исследования являлась оценка закономерностей антиоксидантной активности свинины в процессе созревания под воздействием различных стартовых культур. Сравнивалась эффективность *Lacticaseibacillus rhamnosus* 2012 MDC 9631, *Lactobacillus plantarum* 66 MDC 9619 и промышленной культуры BactoFlavor® с традиционным методом посола. Для определения антиоксидантной активности был применён тест связывания радикалов DPPH. Результаты показали, что все образцы проявили концентрационно-зависимую антиоксидантную активность. Наибольшие значения зафиксированы у традиционно посоленного мяса, однако *L. rhamnosus* 2012 MDC 9631 также продемонстрировал значительный антиоксидантный потенциал, превысив остальные стартовые культуры. Его выраженные протеолитические и антимикробные свойства свидетельствуют о практической применимости в производстве сыровяленой свинины.

В целом, полученные данные подтверждают, что *L. rhamnosus* 2012 MDC 9631 может рассматриваться как природный биоконсерват, способный повышать качество продукции, усиливать окислительную стабильность и сокращать сроки созревания мясопродуктов.

Ключевые слова: свинина, молочнокислые культуры, посол, антиоксидант.

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PHYSICAL PRINCIPLES OF GROUND-LEVEL WIND FORMATION AT THE BASE OF HIGH-RISE BUILDINGS

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Abstract

For almost two centuries, research into the causes of ground-level winds at the base of skyscrapers has failed to produce a consensus among scientists on how to diagnose and counteract them. The proposed hypothesis is based on fundamental physical laws and considers the process of ground-level wind formation as a consequence of the sun heating the building and the formation of areas of low and high pressure on its south and north sides, causing air movement around the building. The impact of the heat capacity of building materials on the degree of building heating is considered, and computer modeling of this process is carried out for the coordinates of London and New York on June 22 and December 22. For the obtained building surface temperatures, computer modeling of the temperature, speed, and volume of the upward flow forming a low-pressure zone on the south side of the building was performed. The characteristics of wind movement in a residential complex with a skyscraper in the center were obtained, and a method for reducing the intensity of ground-level winds was proposed.

Keywords: upward air flow, ground-level wind of high-rise buildings, computer simulation, air pressure.

Introduction

The issue of the environmental impact of high-rise buildings on urban climate conditions arose in the mid-19th century during the construction of the first skyscrapers in Chicago and was largely viewed negatively. This was manifested in the fact that hurricane-

force winds arose at the bases of high-rise buildings, causing great inconvenience to pedestrians and even knocking them off their feet [1].

The growing awareness among the public of their right to a safe and comfortable living environment has led to considerable interest in studying the impact of high - rise buildings on wind conditions in cities. However, after almost two centuries, scientists have not been able to create a unified physical picture of the observed phenomenon and develop technical methods for its diagnosis and prevention. Therefore, the authorities of large megacities, which are particularly overloaded with skyscrapers, are forced to limit themselves to administrative measures in the fight against ground-level winds caused by high-rise buildings.

Administrative measures to counteract ground-level winds

This was reflected in the fact that, for example, in New York and Chicago, railings were built along sidewalks after an accident in 1903, when a cyclist was blown onto the roadway by the wind and hit by a car. In London, the government introduced strict restrictions on licenses for the construction of high-rise buildings [2] to ensure the safety of pedestrians and cyclists. After an accident in Leeds (England) in 2011, when a pedestrian on the sidewalk was crushed by a truck overturned by the wind [3], court hearings were initiated and a law was passed to suspend traffic on streets near the Bridgewater Place skyscraper when wind speeds at its base exceeded 20 m/s.

Japan made a special effort to combat ground-level winds due to the overpopulation of its cities. Starting in 1971, significant sums were spent on research, inviting European and American scientists [4]. However, even after that, Japan had to limit itself to administrative measures - after the construction of the 147-meter Kasumigaseki Building in 1968 and many years of public debate, it was only in 1981 that a law was passed requiring wind tunnel testing of models of all skyscrapers exceeding 100 meters in height. Since October 1978, Japan has had municipal regulations on state mediation in disputes between residents and developers. However, disputes often escalate into lawsuits that require developers to plant rows of artificial and natural trees, build canopies, windbreaks, wind protection panels, and handrails for pedestrians.

Hypotheses about the causes of ground-level winds

Analysis of all patterns of ground-level wind movement at the base of high-rise buildings is based on one well-known hypothesis: when wind hits a building, it splits into parts, one of which moves downward and increases its speed when it hits the street, moving along it [3]. However, this hypothesis contradicts the law of conservation of energy, since the wind loses some of its energy when it hits the building, and energy losses also occur due to the friction of the wind against the floors of the building as it moves downward. And hitting the street cannot be a source of additional energy for the wind, giving it acceleration.

Research conducted at the Architecture and Construction University of Armenia has shown that ground-level winds around skyscrapers occur in full accordance with the fundamental laws of physics governing the movement of air masses from cold areas with high pressure towards warm areas with low pressure. These areas occur on both sides of a high-rise building facing south [5]. When the facade of a building is heated by the sun's energy across its entire height and width, a powerful upward air flow is formed, resulting in the formation of

a low-pressure area at the base of the building, into which air is drawn from all nearby streets, primarily colder air from the north side of the building, where it has formed a large shaded area and retained the coolness of the night for a long time. This wind swirls around the building and moves precisely along the streets, as observed by many scientists, who explain this as the result of the vertical impact of the wind on the street [3,6].

It is evident that taller buildings have a larger surface area exposed to the sun and generate a more powerful upward air flow, which, according to the hypothesis, creates stronger ground-level winds. While well-known hypotheses explain the presence of stronger winds at the base of the tallest buildings by the fact that stronger winds prevail at high altitudes [6], which, after colliding with the building, direct a large flow of air downward. However, in this case, such a flow would have to overcome the resistance of many floors before reaching street level.

The correctness of the proposed hypothesis and the contradictions of the well-known concept are also supported by the fact that the wind blowing at the level of the upper floors of the city collides with all of its buildings. However, ground-level wind is formed only near some of them, while there are taller buildings in the city, which the well-known hypothesis does not explain. At the same time, the proposed hypothesis asserts that ground-level winds arise only near buildings that have a non-standard architectural layout, with their wide side facing north to south, which is usually associated with the characteristics of the territory provided to the developer.

The influence of the heat capacity of building materials on ground-level winds

The validity of the new hypothesis is also confirmed by the fact that the strongest winds are formed at the base of buildings whose cladding contributes to their strong heating, resulting in a more powerful upward air flow, the volume of which determines the speed of the wind drawn into its place. An example of this is the Bridgewater Place skyscraper (Fig. 1), which has a distinctly decorative architectural style of office buildings, based on cladding all window-free surfaces with aluminum, which has a lower heat capacity coefficient than concrete (Tab. 1) and heats up more from solar energy than the facades of standard residential buildings.

This effect is clearly evident in the Walkie Talkie skyscraper (Fig. 2), which is more problematic from a wind perspective. Its design is dominated by glass edged with steel frames, which have a lower heat capacity coefficient than aluminum (Tab. 1). In addition, the thickness of the glass, steel frames, and sheet aluminum used to clad the buildings is 3-5 mm, which means that their mass, converted to a unit of sun-heated surface area, is significantly lower than that of concrete walls 10-20 cm thick. This explains the severe overheating of such buildings in accordance with the definition of heat capacity as the amount of energy required to heat 1 kg of a substance by 1^0 C (tab. 1).

Table 1

Thermal capacity of building materials

material	joule / kg * ^{0}C	material	joule / kg * ^{0}C
concrete	1000	glass	840
aluminum	920	ceramic tile	840
limestone	900	steel	470
terracota	880	iron	400
brick	880	copper	380
armored concrete	840	gold	120

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Fig. 1 Bridgewater Place Skyscraper

Fig. 2 Walkie Talkie Skyscraper

These properties are also evident in the UN Secretariat building in New York (Fig. 3), whose main entrance, according to its employees, is littered with broken umbrellas in rainy weather [1], which scientists explain by the fact that "the building catches the prevailing westerly winds and directs them downward." In fact, the reason for this lies in the building's technical specifications published on the UN website: height - 154 m, orientation - north to south, materials - reinforced concrete, glass, steel, the combined effect of which leads to severe overheating of the building's facade and creates wind at its base in accordance with the hypothesis outlined above.

The example of the aforementioned Kasumigaseki Building (Fig. 4) is very illustrative. Numerous studies of the causes of winds at its base led to the adoption of a law on testing models of high-rise buildings in a wind tunnel, which was based on scientists' belief that ground-level winds were formed as a result of the collision of buildings with winds blowing over the city. And from the point of view of the new version, models should be built to diagnose ground-level winds, allowing the process of their formation to be simulated as a result of buildings heating up under the influence of solar energy [5].

Fig. 3 UN Secretariat Building (154 m) in New York

Fig. 4 Kasumigaseki Building (147m) in Tokio

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In terms of analyzing the thermal characteristics of materials used in construction, the Flatiron Building (Fig. 5) is particularly noteworthy. Built in 1902 in Manhattan, it has become a New York City landmark not only because of the hurricane-force winds at its base, but also because of its unique triangular shape, which was a necessary measure dictated by the fact that the developer was given a triangular plot of land at the intersection of Broadway and Fifth Avenue. The architects designed a steel frame for the building to ensure its stability and used advanced technologies for its thermal insulation - the entire surface of the building was clad with limestone and glazed terracotta (Tab. 1), which not only gave the building a rich golden-brown hue, but also, in accordance with the properties of ceramic materials, created a thermal shell for the building, preventing the penetration of cold and solar heat [7]. However, this advantage had a downside: all the sun's energy was concentrated on the facade of the building and overheated it significantly. In addition, for decorative reasons, all the window frames were clad with copper (Fig. 5), which has a very low heat capacity (Tab. 1).

Fig. 5 Flatiron Building (87m) in New York, top view and fragment of facing

As a result, hurricane-force winds formed at the base of the Flatiron Building, the strongest ever recorded in the history of ground-level wind observations - they knocked pedestrians off their feet and tore newspapers from their hands. Their strength allowed experts to make a very valuable observation: columns of dust, debris, and cardboard boxes rose up along the wall of the building. However, this observation did not allow scientists to draw correct conclusions about the physical nature of this wind and the updraft that formed it - all studies continued to be based on the concept that the wind first moves down along the building and then rises after hitting the street.

The heat capacity of building materials was not taken into account in the case of the Lefcourt Colonial Building, known for its winds, built in New York in 1930. Advertisements

for office space in this building specifically stated that "the offices have floor-to-ceiling glass walls and an impressive conference room made entirely of glass." These glass structures occupy the entire central part of the building (Fig. 6) with crossbars between floors made of bluish steel beams (Tab. 1). The New York building database "Buildings DB" indicates that the first six floors of the building are clad in limestone, while the rest are clad in brick (Tab. 1) and porous corrugated stone, which are easily heated by the sun. The upper part of the building is clad in blue terracotta and decorated with spires (Fig. 7) covered with gold, which has the highest heat capacity (Tab. 1). Each of the materials used contributes to the upward air flow on the building's facade in accordance with its thermal characteristics.

Fig. 6 Lefcourt Colonial Building (164m) in New York

Fig. 7 Fragment of Lefcourt Colonial Building

Thus, it can be stated that the upward air flow in each building is the result of the combined effect of the heating temperature of each of its structural elements facing the sun. It is obvious that the predominance of glass, metal, and ceramic surfaces in building architecture will have a dominant effect on the degree of their heating. Therefore, to diagnose the power of the upward flow and the speed of the ground-level wind of a particular building, it is necessary to take into account the ratio of its surfaces covered with certain materials.

Computer modeling of the formation of ground-level winds

Undoubtedly, studying the problem of ground-level winds from the perspective of the proposed concept of their formation will require the efforts of many scientists from fields related to architecture. However, computer modeling allows us to take a first look at the observed phenomenon from the perspective of fundamental physical laws and to identify the direction, methodology, and basic principles of subsequent research and experimental work.

To simulate the process of heating a building facade under the influence of solar energy, a generalized case of a building clad with 4-millimeter sheet aluminum over its entire surface was considered, which has the lowest heat capacity compared to all the buildings considered and the building materials used in their construction. The simulation was performed using the "Flow Simulation 2024 SP2.0.Build: 6320" version of the SOLIDWORKS computer program for London coordinates at two extreme points of solar activity: June 22 and December 22.

Calculations of the building facade temperature TF were performed at 1-hour intervals in the time range from sunrise to solar noon, for which the angle of elevation of the

sun above the horizon α^0 for each hour and the temperature of the air surrounding the building TA at that time, referred to in forecasts as the "temperature in the sun," which, according to data from the UK National Meteorological Service (Met Office),"exceeds" the temperature "in the shade" Ts, officially published in weather forecasts. For real-time physical calculations, the temperature data "in the shade" published in the "by the hour" section is used, since the "by the month" and "by the day" sections often give the average temperature for daytime or nighttime intervals.

The results of computer modeling at two calculation points are shown in Fig. 8 and Fig. 9, where the side view of the building shows the color spectrum of the temperature of its facade TF and inside the structure itself, as well as the temperature of the air surrounding the building TA and the temperature in its shadow Ts according to the temperature scale. Calculations show that on June 22, the maximum heating of the building occurs at 11 a.m. at an angle of elevation of the sun of 53.4^0, and as the sun continues to move towards its zenith of 61.9^0, the temperature begins to drop due to the decrease in the angle of the sun's rays hitting the building. On December 22, the sun rises to a zenith of only 15.1^0, so in this case the phenomenon described above is not observed, and the maximum temperature of the building is reached at the zenith at 11:59. Calculations also show that in winter, at lower building heating temperatures, a higher difference with the temperature in its shadow is formed, which determines the speed of its ground-level wind, which moves from the shadowed area of the building to its facade. This explains the observations of scientists who have noted that ground-level winds intensify in winter [1].

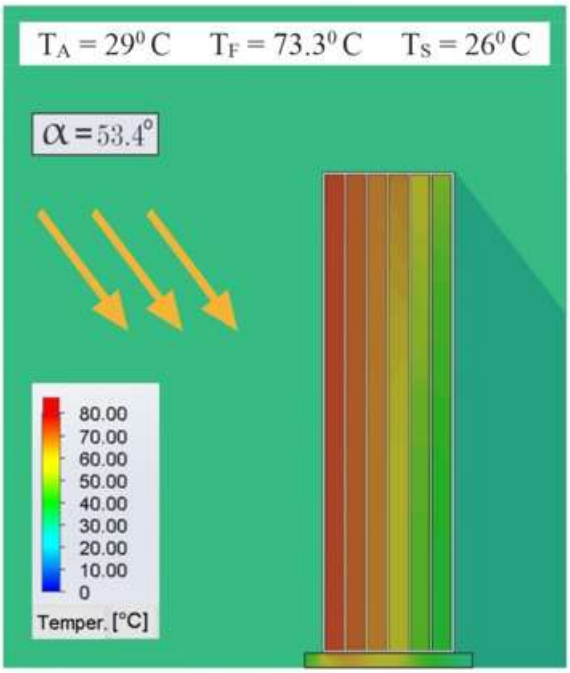

Fig. 8 Simulation of the heating of a high-rise building by the sun on June 22 in London

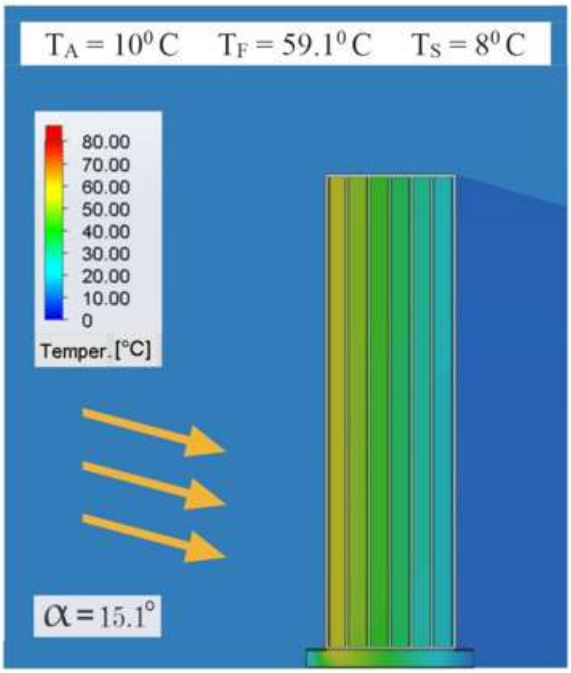

Fig. 9 Simulation of the heating of a high-rise building by the sun on December 22 in London

To more clearly identify this and other patterns of solar heating of buildings, computer modeling of this process was also carried out for New York coordinates, which are

characterized by a higher angle of elevation of the sun at the zenith points. To this end, by analogy with London, the temperature of the air surrounding the building TA and the temperature in its shadow Ts were entered into the program in accordance with data from the US National Weather Service (NWS). It should be noted that the modeling was carried out only up to the zenith point due to the fact that in terms of solar radiation intensity, the process is mirrored until sunset, but processes are identified whose degree of influence on the phenomenon under study requires the development of a special methodology. In particular, the temperature "in the sun" begins to decrease immediately after the sun reaches its zenith, while the temperature "in the shade" continues to rise for 1.5-2 hours, depending on the time of year, due to the inflow of air from surfaces heated by the sun into the shaded area.

The results of the program calculations shown in tab. 2 more clearly demonstrate the process of reducing the intensity of building heating due to the fact that the angle of elevation of the sun corresponding to the beginning of this process is further from the zenith than was observed for London. For the conditions adopted in this simulation, the noted angle is reached between 10 and 11 a.m., but the calculation of its exact value cannot be considered a universal characteristic of this phenomenon, since it can vary significantly for each building and the conditions associated with it. At the same time, the calculation of this time for a particular

Table 2

Simulation of the heating of a high-rise building by the sun on June 22 in New York

June 22	α^0	T_A (^{0}C)	T_F (^{0}C)	T_S (^{0}C)	$T_F - T_S$
12:58	72.74	34	78.9	29	49.9
12:00	68.82	33	80.4	28	52.4
11:00	59.81	31	82.7	27	55.7
10:00	49.04	29	83.2	26	57.2
9:00	37.75	27	80.1	24	56.1
8:00	26.43	26	75.0	23	52.0
7:00	15.41	24	64.1	22	42.1
6:00	4.91	22	31.9	21	10.9
5:25	0	20	20	20	0

skyscraper, taking into account the reflective properties of its surface, the heating of neighboring structures, cloud cover, and the degree of sunlight scattering, may be the subject of separate studies and serve as a basis for taking administrative measures or warning citizens about increased wind speeds near the skyscraper.

A comparison of tab. 2 and tab. 3 confirms the pattern identified for London, whereby a greater difference between the temperature of the building facade and the temperature in its shadow occurs during the winter period.

Table 3

Simulation of the heating of a high-rise building by the sun on December 22 in New York

Dec 22	α^0	T_A (^{0}C)	T_F (^{0}C)	T_S (^{0}C)	$T_F - T_S$
11:54	25.96	11	72.0	9	63.0
11:00	24.55	9	71.2	7	64.2
10:00	20:48	6	67.6	5	62.6
9:00	14.06	4	56.8	3	53.8
8:00	5.84	2	24.7	1	23.7
7:17	0	1	1	1	0

The calculations of the building facade's warm-up temperature allow us to simulate the upward flow of the building, heated to 60^0 C, which is achieved by 10 a.m. in both summer and winter. For the simulation, the dimensions of Bridgewater Place were used: width - 30 m, length - 80 m, height - 112 m. Fig. 10 shows the results of modeling the upward flow of the building with the distribution of temperature inside it, which, according to the temperature scale, decreases with distance from the building and has a width of 15.3 meters at the point where it decreases to the ambient air temperature. Fig. 11 shows the characteristics of the upward flow velocity, which in the widest section has a velocity of 9.428 m/s and a volume of air moved of 8 954.5 m ^{3}/s (Tab. 4).

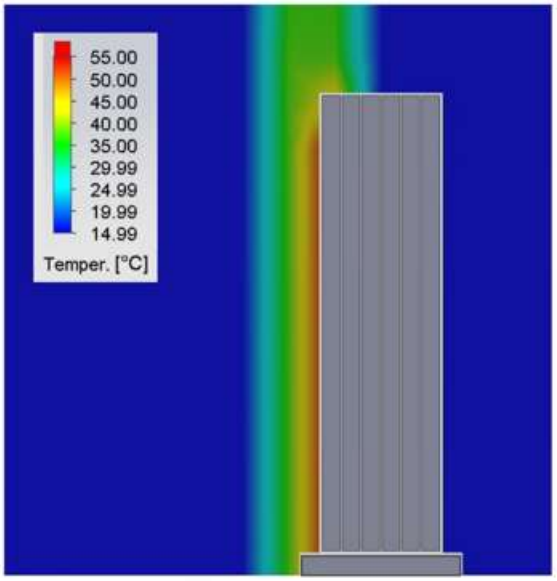

Fig. 10 Computer model of temperature distribution in an updraft

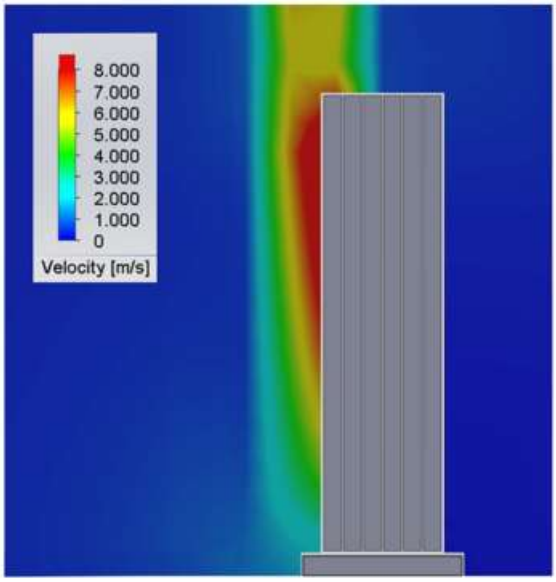

Fig. 11 Computer model of the updraft velocity of a high-rise building

The upward movement of such a volume of air forms an area of low pressure at the base of the building, into which the same volume of air is drawn from all nearby streets and from the shadow area of the building, where, due to its large size, a mass of cold air has formed with a pressure exceeding the pressure in the shadow areas of neighboring houses (Fig. 12).

Table 4

Value of the updraft of a high-rise building

Goal Name	Unit	Value
SG Surface temperature	[°C]	60,102
SG Volume Flow Rate	[m^3/s]	8954,537
SG Velocity Flow Rate	[m/s]	9,428
SG Width Flow Rate	[m]	15,3

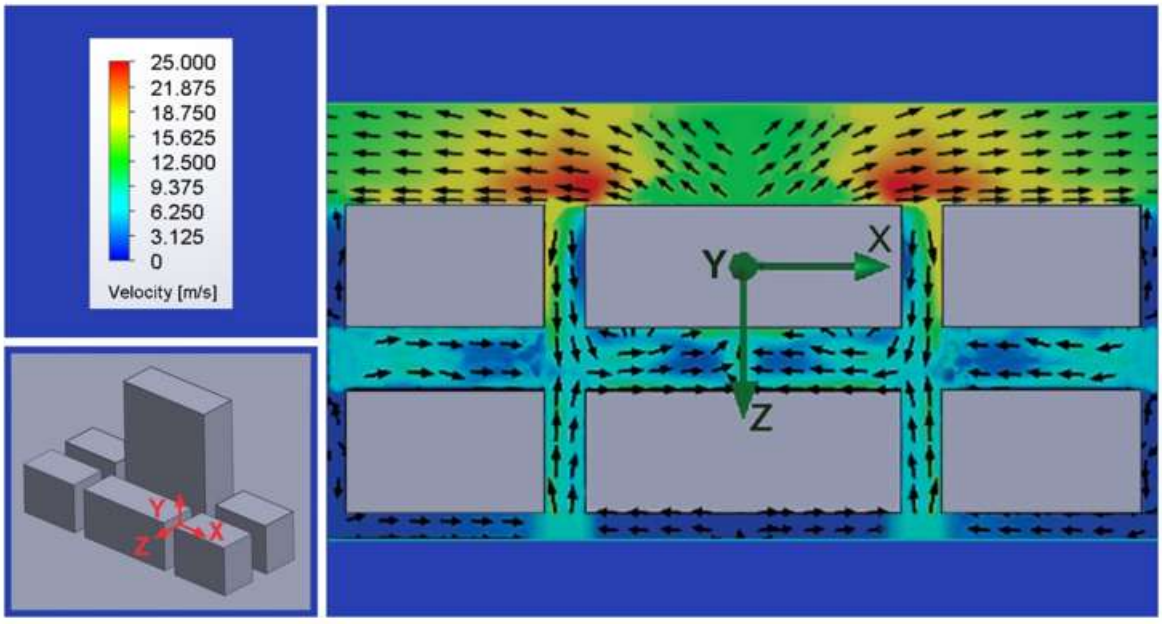

Fig. 12 Models of the residential complex and ground-level wind movement within it (top view)

Because of this, the strongest ground-level wind, about 25 m/s (red zone), occurs in the shadowed part of the building and decreases in speed as it moves towards the facade of the building, where it combines with weaker winds from neighboring streets and compensates for pressure losses at the base of the skyscraper. The assessment of the ground-level wind speed conducted for Bridgewater Place is comparable to a speed of 20 m/s, above which the Leeds authorities prohibit traffic near this skyscraper. In the computer model of the residential complex shown in Fig. 12, the buildings adjacent to the skyscraper are included in the program only to perform the function of directing the wind flows caused by the skyscraper itself, since the impact of all buildings in the microdistrict is the subject of more long-term research, the results of which must be tested on models of microdistricts in which directional heating of structures is applied with the fixation of air flows by means of smoke or micro-sensors [5].

Method of counteracting ground-level winds

The analysis of the causes and patterns of ground-level winds can be of considerable assistance to architects in the design of high-rise buildings and the assessment of their

interaction with the environment. At the same time, the hypothesis considered allows us to propose a technical method of counteracting ground-level winds for already constructed skyscrapers, based on providing cold air with a shortened corridor from the shaded part of the building to its facade by means of pipes laid from north to south in the technical floors of the building [5,8]. This technical solution prevents the movement of ground-level winds along the entire perimeter of the building, as the cold air that forms these winds is able to move towards the sun-warmed facade of the building via a shorter route. Consideration of this method from the standpoint of the physical theory of air mass movement is based on the fact that the cold air entering through the pipes compensates for the pressure loss at the base of the southern wall of the building caused by the upward flow of heated air, which leads to a reduction in the pressure difference between the sides of the building and a decrease in wind speed. It should be noted that a complete cessation of wind movement around the building would only be possible if the pipes offered zero resistance to air movement.

Pipes should enter the building from the area of highest pressure at the base of its northern wall and exit at the level of the second floor of the southern wall so as not to interfere with pedestrians and traffic. The pipe outlets can be designed as portholes or other decorative structures. A numerical assessment of the characteristics of this method should be based on the optimal selection of the number and diameter of pipes, their internal resistance, and the resistance of the entire pipe route associated with the configuration of their passage inside the building. Preliminary calculations show that the air flow at the pipe outlets can have a speed of 20-30 m/sec and be ejected up to a distance of 40 meters. Therefore, for the safety of nearby buildings, the pipes should be directed upwards at an acute angle to the building, which will further contribute to reducing the temperature of its facade and the upward flow.

Conclusion

The correctness of the proposed hypothesis is confirmed by comprehensive explanations of all known manifestations of ground-level wind properties, as well as by the regularity of their clearly pronounced intensification near office buildings with characteristic cladding, which is most susceptible to heating by the sun. Studies have shown that in the summer months, the highest surface temperature of a building is reached within 11 hours, as the angle of contact between the sun's rays and the building decreases as the sun moves further towards its zenith. In the winter months, at lower building surface temperatures, a greater difference with the temperature in its shadow is formed, which contributes to the formation of stronger winds at this time of year. Computer modeling confirms all the aspects of the hypothesis and determines the methodology for more in-depth research in each of the areas considered. A numerical assessment of the characteristics of the method of counteracting ground-level winds should be based on the optimal selection of the number and diameter of pipes, their internal resistance, and the resistance of the entire pipe tract associated with the configuration of their passage inside the building. Analysis of the causes and patterns of ground-level wind formation can be of considerable assistance to architects in the design of high-rise buildings and the diagnosis of their interaction with the environment.

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PHYSICAL PRINCIPLES OF GROUND-LEVEL WIND FORMATION AT THE BASE OF HIGH-RISE BUILDINGS

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ԲԱՐՁՐԱՀԱՐԿ ՇԵՆՔԵՐԻ ԳԵՏՆԱՄԵՐՁԱՅԻՆ ՔԱՄԻՆԵՐԻ ԱՌԱՋԱՑՄԱՆ ՖԻԶԻԿԱԿԱՆ ՀԻՄՈՒՆՔՆԵՐ

Մ.Վ. Մարկոսյան, Հ.Հ. Այվազյան
Երևանի կապի միջոցների ԳՀԻ ՓԲԸ

Գետնամերձային քամիների առաջացման ուսումնասիրությունները արդեն մոտ երկու հարյուրամյակ չեն ձևավորում գիտնականների մոտ ընդհանուր կարծիք նրանց ախտորոշման և կանխարգելիչ միջոցների վերաբերյալ: Առաջարկվող վարկածը հիմնավորված է ֆիզիկայի ֆունդամենտալ օրենքների վրա և դիտարկում է գետնամերձային քամիների առաջացումը որպես շենքի երկու կողմերում արևից տաքանալու շնորհիվ տարբեր ճնշման գոտիների ձևավորվելու հետևանք, ինչը առաջացնում է օդի շարժում շենքի շրջագծով: Դիտարկված են շինանյութերի ջերմակլանման գործակցի ազդեցությունը շենքի արևից տաքանալու վրա, կատարված է այդ երևույթի համակարգչային մոդելավորում Լոնդոնի և Նյու Յորքի կոորդինատների համար հունիսի 22-ին և դեկտեմբերի 22-ին: Ստացված ջերմաստիճանների համար

մոդելավորված են վերընթաց օդի հոսքի արագության և ծավալի արժեքները: Արված է բնակելի թաղամասի տարածքում գետնամերձային քամու շարժման մոդելավորում, առաջարկված է այդ քամու նվազեցման տեխնոլոգիա:

Բանալի բառեր՝ օդի վերընթաց հոսք, բարձրահարկ շենքերի գետնամերձային քամի, համակարգչային մոդելավորում, օդի ճնշում:

ФИЗИЧЕСКИЕ ОСНОВЫ ФОРМИРОВАНИЯ ПРИЗЕМНЫХ ВЕТРОВ У ОСНОВАНИЯ ВЫСОТНЫХ ЗДАНИЙ

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Изучение причин возникновения приземных ветров у основания небоскрёбов уже почти два столетия не приводит учёных к единому мнению об их диагностике и мерах противодействия. Предложенная гипотеза основана на фундаментальных физических законах и рассматривает процесс возникновения приземных ветров как следствие прогрева здания солнцем и формирования на его юге и севере зон пониженного и повышенного давления, вызывающих движение воздуха вокруг здания . Рассмотрены вопросы воздействия теплоёмкости строительных материалов на степень прогрева зданий, проведено компьютерное моделирование этого процесса для координат Лондона и Нью-Йорка 22 июня и 22 декабря. Для полученных температур поверхности здания проведено компьютерное моделирование температуры, скорости и объёма восходящего потока, формирующего зону пониженного давления на южной стороне здания. Получена характеристика движения ветра в жилом комплексе с небоскрёбом в центре, предложен метод снижения интенсивности приземного ветра.

Ключевые слова: восходящий поток воздуха, приземный ветер высотных зданий, компьютерное моделирование, давление воздуха

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DESIGN AND OPERATIONAL FEATURES OF TRASH RACKS FOR SMALL HYDROPOWER PLANTS ON MOUNTAIN RIVERS

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Abstract

The article examines the specific aspects of designing trash racks for small hydropower plants (SHPs) operating on mountain rivers characterized by high turbidity and strong seasonal flow variability. Dependencies to automate the selection of the optimal bar spacing of trash racks are presented depending on the type of installed turbines, based on the recommendations of SHP equipment manufacturers. Empirical relationships and guidelines for the hydraulic parameters of racks are proposed, taking into account operational conditions in mountainous areas. A critical review of existing design recommendations for racks used on high-altitude rivers is also provided.

Keywords: Small hydroelectric power station, high-altitude conditions, trash rack, Pelton turbine, Crossflow turbine.

Introduction

Operating conditions for small hydropower plants (SHPs) on mountain rivers are characterized by high heads, uneven discharges, elevated concentrations of suspended and bed material, and an increased probability that solid particles and floating debris will enter intake structures. Under such conditions, an improper choice of the trash rack design and its geometric parameters inevitably leads either to frequent clogging of turbine components—causing unjustified downtime—or to damage to guide vanes and runner blades and, as a consequence, a loss of unit output.

Summer Operating Conditions of Trash Racks

Regulatory sources [1–3] provide practical rules for selecting bar spacing, setting angle, and permissible head losses, but predominantly as limiting and tabulated recommendations. The literature cites three principal criteria for assigning the spacing between bars of trash racks.

Equipment protection.

This is the primary criterion for setting bar spacing: the turbine and its components must not be fouled by debris and floating objects. It should be noted that, according to statistics over the past 20 years, high-mountain SHPs tend to favor Crossflow turbines (for

heads up to ~200 m) and Pelton turbines (for heads of ~180 m and above), both maintaining comparatively stable efficiency over a wide range of flow variation.

For Pelton turbines, source [2] recommends that the bar spacing of the rack be less than the minimum dimension of any opening in the turbine's inlet assembly. In practice, the suggested range for bar spacing is 15–25 mm.

Source [7] proposes determining the bar spacing b from a relationship that relates the spacing to the jet diameter at maximum needle opening.

$$b \leq \frac{1}{5} D_{jet.max} \quad (1)$$

where: $D_{jet.max}$ — jet diameter at maximum needle opening.

Our appraisal of this relationship across different ranges was based on consolidated data from European Pelton turbine manufacturers. The results of the analysis are shown in Fig. 1.

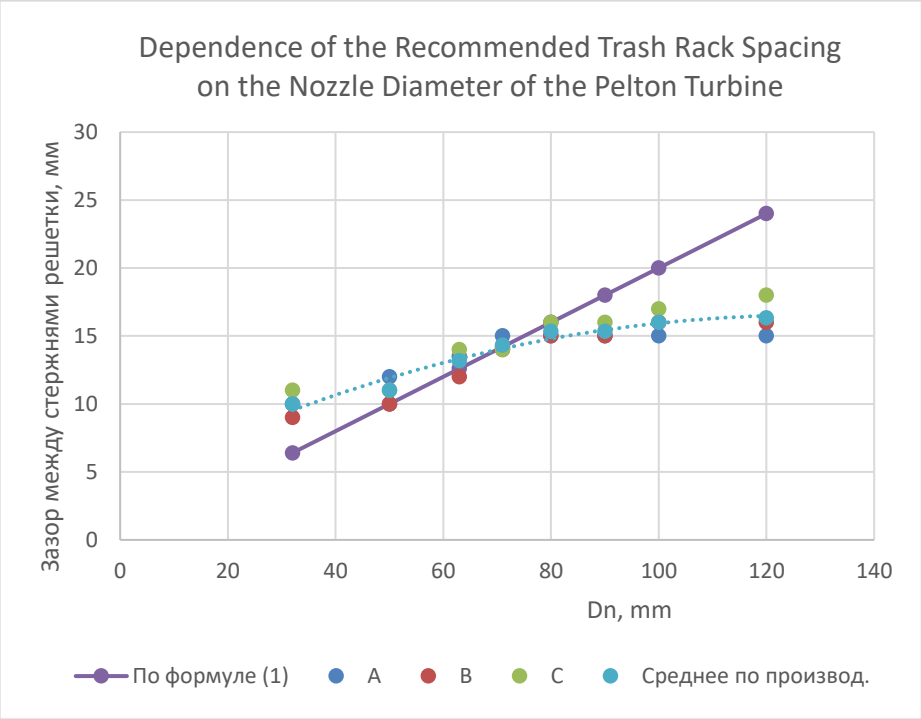

Fig. 1. Recommended grate rod clearance versus Pelton turbine nozzle diameter

The analysis shows acceptable agreement between the proposed relationship and manufacturers' recommendations only within a narrow nozzle-diameter band of approximately 60–80 mm. The averaged manufacturer data are well approximated by a second-order polynomial ($R^2 \approx 0.962$).

$$b = -0.0008D_n^2 + 0.1949D_n + 4.079 \quad (2)$$

where: D_n — nozzle diameter in mm.

For Crossflow turbines, published information is fragmentary: the recommended bar spacing ranges from 15 to 35 mm, yet without reference to turbine size or characteristic dimensions. The most complete information on the principle for choosing rack spacing in

relation to Crossflow turbine dimensions was kindly provided by "Ossberger GmbH + Co. KG" (Germany), a leading developer of the modern Crossflow turbine. According to these data, the rack spacing correlates with the turbine runner diameter, which indirectly reflects the inter-blade gap. To automate design calculations for SHP settling basins, these data were approximated with a second-order polynomial, which demonstrated very good agreement ($R^2 \approx 0.987$).

$$b = -7 \times 10^{-7} D_{rd}^2 + 0.0349 D_{rd} + 2.4496 \quad (3)$$

where: D_{rd} — turbine runner diameter in mm.

Therefore, for Crossflow turbines, the spacing determined by this dependency varies from about 9 mm (runner diameter 200 mm) to about 40 mm (runner diameter 1800 mm).

Conflict Setting

Many recommendations are founded on calculating head losses across clean racks, which is relevant for low-head plants. However, for high-head SHPs on mountain rivers this approach has little practical importance in terms of total head. Moreover, project calculations for a number of SHPs showed that, when the first criterion is observed and settling-basin velocities are within limits, head loss on a clean rack is minimal and does not exceed 2–3 cm. When assessing rack capacity, actual clogging by debris and floating objects during operation must be taken into account. Where the upstream catchment includes many settlements and economic activities, and where vegetation is abundant, intense clogging can occur. According to [1], calculations should be performed assuming 30–35% of the rack area is clogged. (Fig.2).

Fig. 2. Clogging of the settling tank screens. A) Fallen tree leaves in the autumn at the Chirukhi SHPP (Georgia), b) Clogging of the small screen at the Shaki SHPP (Armenia) with aquatic vegetation and debris

According to [1], calculations should be performed assuming 30–35% of the rack area is clogged. Source [3] suggests using a clogging factor of 1.25. Some references recommend estimating the expected amount and maximum size of debris, which in practice can only be

done qualitatively, depending on the level of development in the basin and on vegetation subject to shedding and washout into the river.

Research Results

The most effective solution when high clogging is anticipated is to equip racks with automatic raking machines (Fig.3). These devices typically operate by monitoring the maximum permissible differential head across the rack. In practice, the threshold differential is set at about 5–7 cm, which prevents air entrainment into the pressure conduit due to a drop in water level within the intake forebay.

Fig. 3. Automatic cleaning machine at SHPP

Ecological aspects of selecting rack spacing.

The intake rack is not only a mechanical shield for the turbine; it is also a biotechnical barrier that determines the feasibility of fish migration, the risk of entrainment and mortality, and the degree to which the rack disturbs the hydrodynamics of the channel and benthic fauna. Large bar spacing entails a risk that juveniles and small fish will enter the pressure conduit and die when passing through the turbine. In addition to spacing, the approach velocity at the rack is prescribed.

To determine environmentally acceptable spacing, recommendations from various sources [13–18] were reviewed. For example:

- DFO (Canada) suggests ≤ 2.54 mm openings for protecting 25 mm fish;
- NMFS/NOAA (USA, SW Region) commonly requires 6.35 mm maximum openings for wire/perforated screens for juvenile anadromous salmonids; USFWS/NMFS recommends around 3.2 mm for salmonid juveniles < 60 mm;

- California DFG uses 3.2 mm for fry/fingerlings (~L ≈ 60 mm);
- New Zealand DOC (Canterbury) cites 2–3.2 mm for small salmonid juveniles;
- the UK Environment Agency provides screen sizes tied to juvenile length classes (8–26 mm), numerically giving about 0.05–0.10·L.

Generalizing these sources, the recommended spacing for downstream migration through intakes can be expressed as a proportionality to the body length of the smallest protected species.

$$b \leq 0.1DL_{min} \quad (4)$$

where: Lmin — body length of the smallest protected species (fry aged 0.2 years).

In practice on small mountain rivers, where protected fish are present, this criterion is limiting and nearly impossible to meet. As an illustration, the fish assemblage in rivers flowing into Lake Issyk-Kul—an area experiencing intensive energy development—features species whose juvenile sizes would dictate extremely fine screens.

Table 1

Migratory and Semi-Migratory Fish Species of the Issyk-Kul Basin

Fish	Migration Elevation, m	Migration		Body length, cm			Recommended bar spacing [13-18]
		Start	End	Mature	Juvenile h=1 yar	Fry t=0.2 yar	
Trout	2100	March	April	55	18	5.5	0.55
Naked Osman	2500	April	June	30	10	3	0.3
Matinka	1800	June	July	40	13	4	0.4
Chebak	2200	May	June	28	9	2.8	0.28
Small Chebak	1900	May	June	20	7	2	0.2
Lip fish	2200	June	June	16	5	1.6	0.16
Cyprinus carpio	1700	May	June	60	20	6	0.6
Maximum		March	July	60	20	6	0.6
Minimum				16	5	1.6	0.16

Analyzing the species and their size ranges shows that under the harsh climatic and morphological conditions of mountain rivers used for high-head SHPs, it is practically impossible to comply with ecologically driven spacing recommendations for conventional trash racks. A potentially acceptable option is the use of Coanda screens at the intake, feasible only on very small rivers with modest design flows.

Based on design and operational experience in high-mountain regions, it is necessary to develop alternative fish-protection methods tailored to local conditions; a strict requirement to limit bar spacing for ecological reasons is often inappropriate in these settings. As alternatives, one can consider fish deterrent systems, aerators, and bypasses for downstream

migrants—always adapted to local conditions. The lack of realistic guidance for downstream fish protection is a key reason why, at the vast majority of SHPs built or under construction in many developing countries, fish-protection measures are limited at best to a fishway—sometimes of questionable design that does not ensure passage.

To prevent the entrainment of small fish, approach velocity limits at the rack are used. According to [12], the maximum permissible velocity at the rack face is 0.3–0.5 m/s. This condition is almost always satisfied when a single-chamber settling basin is provided without narrowing the width at the entrance to the forebay, because design velocities for high-mountain basins are typically held to about 0.4 m/s.

Winter Operating Conditions of Trash Racks

Numerous studies address winter operation of racks [3–5], focusing on the negative effects of frazil ice, anchor ice, slush, and hummocked ice. Adverse impacts are considered primarily as:

- clogging of racks due to icing;
- blockage of nozzles and turbine blades due to ice fragments entering the pressure conduit.

Conclusions

However, experience from the last two decades of SHP construction in high-mountain areas shows that most plants are of the derivation type, with relatively long pressure conduits (2–12 km) buried in trenches below native ground. Under such conditions, even if ice and slush enter the conduit, they are unlikely to reach the units. Therefore, for these stations in winter, the principal concern is preventing rack icing.

A critical analysis of various measures recommended in the literature, based on operational experience in Armenia, Kyrgyzstan, and Georgia, is as follows.

1. **Increasing bar spacing by 10–30 mm relative to the calculated value**

Effective mainly at low-head plants and only for modest subzero temperatures. For high-mountain SHPs with temperatures below –20 °C, even with 40 mm spacing, a solid ice crust formed within 1–2 hours (e.g., Tegirmenti SHP, Issyk-Kul Region, Kyrgyzstan).

2. **Heating the bars (electric or thermal fluid)**

This method is of limited effectiveness and is rarely used at SHPs for several reasons: it requires a reliable power supply at the intake node with high cost; and in crisis situations (heavy snowfall, blizzards) it is ineffective on its own and demands additional anti-icing measures.

3. **Enclosing the settling basin (closed-type basin)**

Ineffective in terms of raising temperature in the basin and forebay. There were cases where icing even intensified—for example, at the Dzhradzor SHP (Armenia) icing increased above the settling basin and on the fine rack due to higher humidity in the enclosed space and airflow between the basin entrance and the rack zone. A practical mitigation is to use flexible curtains at the basin inlet and outlet. Nevertheless, a closed-type basin can be very effective—and sometimes the only solution—if heavy snow drifts and wind-driven snow are expected.

4. **Increasing the embedment depth of the rack at the design stage**

In winter, river discharges in mountains are typically minimal. This allows ensuring adequate open (ice-free) rack area at the bottom by deeper placement to maintain acceptable face velocities. The drawback is that deeper embedment lengthens the forebay/settling chamber.

5. Installing an automatic raking machine on the rack

One of the most effective measures. The machine activates regardless of the cause of the differential—debris in summer or icing in winter. In winter, it is often necessary to reduce the activation threshold by 30–40%. The exact setting is determined empirically so as to prevent the formation of a solid ice layer beyond the rake's cutting capacity.

In practice, depending on local conditions, combined anti-icing strategies are usually the most effective. For very high-elevation intakes (~2000 m and above), closed-type settling basins are typically combined with automatic rakes.

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ԼԵՌՆԱՅԻՆ ԳԵՏԵՐԻ ՎՐԱ ԳՈՐԾՈՂ ՓՈՔՐ ՀԷԿԵՐԻ ԱՂԲ ՈՐՍԱՑՈՂ ՉԱՂԱՎԱՆԴԱԿՆԵՐԻ ՆԱԽԱԳԾՄԱՆ ԵՎ ՇԱՀԱԳՈՐԾՄԱՆ ԱՌԱՆՁՆԱՀԱՏԿՈՒԹՅՈՒՆՆԵՐԸ

Ս.Գ. Գաբայան
Ակադեմիկոս Ի.Վ. Եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ

Հոդվածում դիտարկվում են լեռնային գետերի վրա գործող փոքր հիդրոէլեկտրակայանների (ՓՀԷԿ) աղբորսիչ վանդակների նախագծման

առանձնահատկությունները, որոնք բնութագրվում են ջրի բարձր տիղմայնությամբ և հոսքի սեզոնային փոփոխականությամբ: Ներկայացվում են կախվածություններ, որոնք թույլ են տալիս ավտոմատացնել վանդակների ձողերի օպտիմալ բացի ընտրությունը՝ կախված տեղադրվող տուրբինների տեսակից՝ հիմք ընդունելով ՓՀԷԿ սարքավորումների արտադրողների առաջարկությունները: Առաջարկվում են էմպիրիկ հարաբերություններ և ուղեցույցներ՝ հաշվի առնելով լեռնային պայմաններում շահագործման հիդրավլիկ պարամետրերը: Կատարվել է գործող նախագծային առաջարկությունների քննադատական վերլուծություն՝ բարձրալեռնային գետերի համար նախատեսված վանդակների նախագծման առումով:

Բանալի բառեր. փոքր հիդրոէլեկտրակայան, բարձրալեռնային պայմաններ, աղբ որսացող ցանց, Պելտոնի տուրբին, լայնակի հոսքի տուրբին:

ОСОБЕННОСТИ ПРОЕКТИРОВАНИЯ И ЭКСПЛУАТАЦИИ СОРОУДЕРЖИВАЮЩИХ РЕШЁТОК МАЛЫХ ГЭС НА ГОРНЫХ РЕКАХ

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Рассмотрены особенности проектирования сороудерживающих решёток малых гидроэлектростанций (МГЭС), работающих на горных водотоках с повышенной мутностью и сезонной изменчивостью стока. Приведены зависимости для автоматизации выбора оптимального зазора между прутьями решёток в зависимости от типа устанавливаемых турбин, основанный на рекомендациях производителей оборудования для МГЭС. Предложены эмпирические соотношения и рекомендации по гидравлическим параметрам решёток с учётом условий эксплуатации в горных районах. Проведен критический анализ существующих рекомендаций по проектированию решеток в условиях высокогорных рек.

***Ключевые слова*:** малая гидроэлектростанция, условия высокогорья, сороудерживающая решетка, турбина Пелтона, турбина с поперечным потоком.

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ASSESSMENT OF BIRD SPECIES DIVERSITY IN THE JRVEZH FOREST PARK AND THEIR INFLUENCE ON MAINTAINING THE STABLE ECOLOGICAL CONDITION OF SMALL WATER BODIES

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Abstract

Jrvezh Forest Park, located on the outskirts of Yerevan, represents an important green area characterized by small water bodies, rich vegetation, and diverse fauna. Owing to its geographical position, climatic conditions, and location along migratory routes, the area holds particular significance for bird communities. Recent international studies have shown that the creation of small water bodies in similar forested and urban green zones can promote increases in bird abundance, enhance biodiversity, and contribute to the establishment of natural purification mechanisms, where birds and water-surface–cleaning organisms operate in symbiosis. This study presents a model assessment using the example of Jrvezh Forest Park, focusing on evaluating bird species diversity and examining the potential ecological benefits of integrating small artificial water bodies. The findings aim to provide a scientific basis for understanding how water body installation may support ecosystem stability, contribute to habitat quality improvement, and strengthen the ecological resilience of urban forest parks.

Keywords: water body, birds, ecosystem, habitat quality, ecological stability, natural purification mechanisms.

Introduction

Urban and peri-urban green areas represent primary hotspots for global biodiversity conservation, as they ensure ecological connectivity and multi-layered ecosystem structure [1, 2]. Contemporary ecological approaches indicate that even small-scale environmental interventions—particularly the establishment of small water bodies—can substantially increase

the diversity of birds, insects, and amphibians by creating ecological nodes within the urban landscape. Small water bodies serve as essential ecological elements, providing drinking water; feeding resources; natural regulation of insect populations; stabilization of hydrobiotopes.

According to international research, urban areas enriched with small water bodies exhibit higher biodiversity, more stable food webs, and greater resilience to anthropogenic pressures [1]. Long-term ornithological observations conducted in [3] have demonstrated that bird distribution and species composition are closely linked to microclimatic conditions and the presence of water sources. Between 2017 and 2023, a total of 38,164 individuals were recorded, with the highest species richness observed in parks (73 species) and riparian zones (69 species). These findings confirm that water availability and vegetation density are key drivers shaping habitat preferences of birds.

Given that Stepanakert and Yerevan share comparable altitudes and similar landscape structures, these observations can be applied to Jrvej Forest Park as a foundation for model ecosystem assessment. In the present study, Jrvej Forest Park was selected as a model area—an ecologically valuable site with high potential for habitat enhancement—where the possible positive impact of integrating small water bodies is evaluated. Such water bodies are expected to support symbiotic interactions, in which birds benefit from water access while simultaneously contributing to the stability of food webs and the regulation of water quality, for example through insect population control and the processing of organic matter.

Special attention is given to waterbirds, which play a key functional role in many aquatic ecosystems, acting as predators, herbivores, and vectors of seeds, invertebrates, and nutrients—roles that are often overlooked. Waterbirds can maintain the diversity of other organisms, regulate pest populations, serve as effective bioindicators of ecological conditions, and signal potential disease outbreaks [4].

Nummi and Hahtola [1] emphasize that small water bodies in urban green spaces function as key ecological elements that increase habitat diversity and improve the structural stability of ecosystems. The authors note that even minimal hydrological interventions can significantly enhance bird abundance and overall biodiversity. In line with this, Nummi and Hahtola [5] demonstrate that beaver-created wetlands substantially increase the availability of food resources and attract higher densities of waterfowl, further underscoring the ecological value of small aquatic habitats.

Lewis-Phillips [6] highlight the importance of microhabitats in shaping bird community composition, pointing out that water availability is one of the most influential environmental factors in urban landscapes. The authors discuss how vegetation density and water resources create favorable conditions for both resident and migratory species.

Aydinyan, Ayrapetyan, and Yaitskiy [3] examine long-term bird distribution patterns in the South Caucasus and report that species richness is closely linked to the presence of wetlands and microclimatic stability. Their study demonstrates that areas with water sources support more diverse and stable bird communities.

Green and Elmberg [4] specifically focus on waterbirds, noting their essential ecological functions as predators, herbivores, and dispersers of nutrients and seeds. The authors emphasize

that waterbirds serve as effective bioindicators of ecosystem health and may signal potential environmental or disease-related changes.

Collectively, the reviewed literature indicates that the integration of small water bodies in urban forest parks can enhance ecological resilience, strengthen food-web interactions, and contribute to the conservation of urban biodiversity.

Methodology

The study was conducted in Jrvej Forest Park (Fig 1), located on the outskirts of Yerevan, Armenia. The park was selected as a model urban ecosystem due to its high ecological value for avifauna, heterogeneous vegetation cover, and potential for habitat enhancement through small water body creation.

The area's topography and climatic conditions are comparable to Stepanakert (average altitude ~994 m in Yerevan vs. ~813 m in Stepanakert), allowing the application of previous long-term ornithological observations as a reference for ecological modeling [3]. The research was conducted from 2023.

Fig 1. Jrvezh forest park, showing the main study area

Conflict Setting

This research aimed to evaluate the potential ecological impact of micro-ponds on avian diversity and ecosystem functioning. The study focused on the following hypotheses:

- Small artificial water bodies increase the availability of drinking water for birds and contribute to habitat suitability. Birds utilizing these ponds act as "detoxifiers" by controlling invertebrate populations and facilitating nutrient cycling, thereby maintaining water quality and supporting a symbiotic network;
- Enhanced water availability positively influences bird species richness and spatial distribution within the urban forest.

Research Results

Avifauna Surveys: Bird counts and species identification were conducted along predefined transects within the park. Observations followed standard point count and transect methodologies used in urban ecological studies [1, 6]. Surveys were performed seasonally over one year to account for temporal variation in bird presence and abundance. Species were identified in the field using the field guide by Adamyan [7]. Birds were observed using a Navigator 12×50 binocular and a 3PT 457 spotting scope at ×60 magnification.

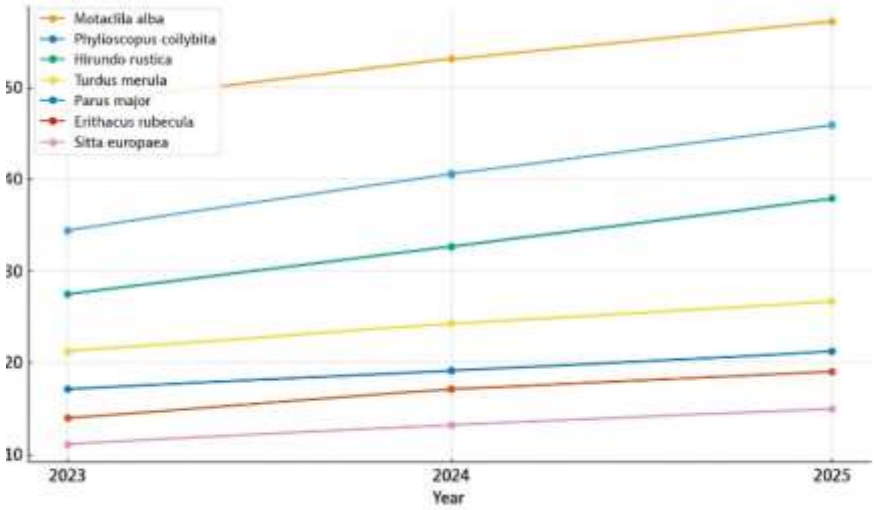
Unmanned aerial vehicles (Mavic 2) (Fig. 2) were also used to record birds, allowing for high-precision data collection while minimizing anthropogenic disturbances that could disrupt the natural behavior of the birds.

Habitat Assessment: For each transect, vegetation cover, water body presence, and microclimatic parameters (temperature, humidity) were recorded.

Water Quality Monitoring: To evaluate the indirect effect of birds on pond ecosystems, water parameters including turbidity, nutrient concentration, and macroinvertebrate density were measured monthly, following protocols adapted from Green and Elmberg [8].

Fig. 2 Use of UAV (Mavic 2)

Data Analysis: Correlations between water body use and invertebrate abundance were assessed to evaluate the symbiotic role of birds in ecosystem regulation. Population Counting and Methodology: Numerical bird counts along transects were conducted following established protocols [9,10]. Bird fauna and habitat data along transects were obtained using the Ravkin method, which is widely applied in ornithological geography [11]. This method allows data collection for all bird species encountered on transects, is applicable for both forested and open habitats, and can be used for both singing and non-singing species observed at close or distant range. Seasonal comparisons were performed. This method does not require prior training and is suitable for single-route surveys and for counting rare species.



As shown in Fig. 3, the populations of the main bird species in Jrvej Forest Park increased steadily from 2023 to 2025, with *Turdus merula* showing the most pronounced growth.

Fig 3. Population trends of major bird species in Jrvezh Forest Park from 2023 to 2025.

The data indicate a gradual increase in the abundance of key species, reflecting the positive impact of habitat features and management practices on the park's avian community.

Discussion

The study results confirmed that the introduction of small water bodies significantly alters the spatial behavior of bird fauna, the intensity of food-web interactions, and overall ecosystem dynamics. Observations in Jrvej Forest Park indicated that even water areas ≤5 m² can serve as biodiversity hotspots, attracting both resident and migratory species.

1. Changes in Bird Species Diversity

The results showed that areas with water bodies exhibited significantly higher species diversity (Figs. 4-6) compared to control areas without water features (tab.1).

Fig 4. Turdus merula Linnaeus, 1758 *Fig.5.Turdus philomelos C.L.Brehm,1831 Fig. 6.Passer domesticus Linnaeus, 1758*

Specifically, species richness in these areas was 35–48% higher, In the summer and spring months, insectivorous and shrub-dwelling species (Sylviidae, Muscicapidae) were most active. Increased activity was most pronounced during morning and evening hours.These findings are consistent with international studies that regard water bodies as «Ecological Nodes» [2], where water functions as a key limiting resource.

Table 1.

Comparison of Species Diversity (Mean Values)

Area	Number of Species	Mean Individuals per Observation	Activity Increase (%)
Water body	27 species	68.4 individuals	+48%
Control	18 species	46.2 individuals	—

Influence of Small Water bodies on Insect Populations

Observations indicated that insect density around the water bodies increased by 1.8–2.6 times, which directly enhanced the visitation frequency of insectivorous birds. The most frequently recorded species were: *Motacilla alba; Turdus merula; Phylloscopus collybita*.

These results are consistent with the "ponds as insect chimneys" model, in which water surfaces serve as rapid centers of insect production [] (Lewis-Phillips et al., 2020).

Stability of Aquatic Ecosystems with Bird Involvement: Bird activity near water bodies contributes to several ecosystem services, including:

- Natural regulation of parasitic insect populations;
- Circulation of organic sediments;
- Nitrogen and phosphorus recycling to surrounding vegetation.

These findings are consistent with Green & Elmberg (2014, 2021), who note that even low abundances of waterbirds can enhance the biological stability of aquatic systems.

Spatial Distribution Characteristics: In areas with water bodies, bird spatial concentration was on average 2.3 times higher than in control areas. The difference was most pronounced during July–August, when water availability reached its minimum (Tab. 2).

Table 2

Assessment of Spatial Concentration

Indicator	**Water body**	**Control**	**Difference**
Mean bird density (individuals/100 m²)	12.4	5.3	+134%
Peak activity hours	07:00–10:00 / 17:00–20:00	08:00–09:00	—
Migratory species frequency	+62%	Decrease	—

Role of Small Water bodies in Urban Landscapes

The study confirmed that even small (≤5 m²) artificial micro-ponds can restore ecological functions by:

- Increasing biodiversity;
- Providing water resources;
- Supporting resting sites for migratory species;
- Enhancing food availability.

These findings align with Nummi & Hahtola (2008, 2011), who consider urban ponds as "biological concentrators" within city ecosystems.

Comparative Assessment: Stepanakert vs. Yerevan

Long-term data from Stepanakert (Aydinyan, Ayrapetyan & Yaitskiy, 2023) show that the presence of water bodies plays a decisive role in maintaining avian diversity. Our study demonstrated that:

- Bird spatial concentration increased in Stepanakert by ~2.0–2.4 times;
- In Yerevan/Jrvej, by ~2.3 times.

Indicating that the water body model is effective in both locations, regardless of landscape differences. Therefore, the introduction of water bodies can serve as a simple, cost-effective, and efficient approach to restoring biodiversity in urban forest park areas in Yerevan.

Conclusion

1. Ornithological studies conducted in Jrvej Forest Park demonstrated that the area represents an important urban ecosystem rich in biodiversity, where bird species diversity and spatial distribution respond sensitively to changes in habitat conditions. The results indicate that the creation of small water bodies (water-body) has a significant impact on enhancing bird diversity, stabilizing and maintaining food resources, and influencing species' behavioral activity.

2. Observations confirm that the availability of water resources in urban green spaces improves conditions for both resident species, such as Motacilla alba (White Wagtail) and Phylloscopus collybita (*Common Chiffchaff*), and migratory species, such as *Hirundo rustica* (*Barn Swallow*), supporting their nesting, feeding, and breeding opportunities (Adamyan,

2000). This is particularly valuable in contexts where urban degradation limits access to natural habitats.

3. The study's findings are important not only for the conservation and management of Jrvej Forest Park but can also serve as a model for environmental programs in other urban green spaces in Armenia. The data suggest that small-scale, targeted ecological interventions can produce measurable and meaningful positive effects on avian ecosystems. Furthermore, the establishment of water bodies is not only crucial for forest birds but also provides essential conditions for water-dependent species, offering a moist, protected, and permanent aquatic environment that supports their survival and reproduction.

4. In conclusion, the introduction of water bodies in Jrvej Forest Park serves as an effective conservation tool, enhancing ecosystem functionality, supporting bird biodiversity, and increasing the ecological value of urban areas. Continued long-term monitoring will further deepen knowledge and provide a robust data foundation for sustainable management and conservation strategies.

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ASSESSMENT OF BIRD SPECIES DIVERSITY IN THE JRVEJ FOREST PARK AND THEIR INFLUENCE ON MAINTAINING THE STABLE ECOLOGICAL CONDITION OF SMALL WATER BODIES

ՋՐՎԵԺԻ ԱՆՏԱՌԱՊԱՐԿՈՒՄ ԹՌՉՈՒՆՆԵՐԻ ՏԵՍԱԿԱՅԻՆ ԲԱԶՄԱԶԱՆՈՒԹՅԱՆ ԳՆԱՀԱՏԱԿԱՆԸ ԵՎ ԴՐԱ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ՓՈՔՐ ՋՐԱՎԱԶԱՆՆԵՐԻ ԿԱՅՈՒՆ ԷԿՈԼՈԳԻԱԿԱՆ ՎԻՃԱԿԻ ԱՊԱՀՈՎՄԱՆ ՎՐԱ

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Ջրվեժ անտառապարկը Երևանի մերձակայքում գտնվող փոքր ջրավազաններով, հարուստ բուսականությամբ և բազմազան ֆաունայով կանաչ տարածք է: Աշխարհագրական դիրքի, կլիմայական պայմանների և միգրացիոն ուղիների հատման պատճառով այն առանձնահատուկ նշանակություն ունի թռչունների համար: Միջազգային փորձը ցույց է տալիս, որ փոքր ջրավազանների ստեղծումը անտառային ու քաղաքամերձ կանաչ տարածքներում կարող է խթանել թռչունների քանակի ավելացմանը, բարձրացնել կենսաբազմազանությունը և ստեղծել բնական մաքրման մեխանիզմներ, որտեղ թռչուններն ու ջրի մակերեսը մաքրող օրգանիզմները գտնվում են սիմբիոզ կապի մեջ:

Ներկայացվում է մոդելային ուսումնասիրություն «Ջրվեժ» անտառապարկի օրինակով: Գնահատվում է ջրավազանների ներդրման հնարավոր ազդեցությունը թռչունների բազմազանության ապահովման և փոքր էկոհամակարգի կայունության վրա:

Բանալի բառեր. ջրավազան, թռչուններ, էկոհամակարգ, շրջակա միջավայրի որակ, էկոհամակարգի կայունություն, բնական մաքրման մեխանիզմներ:

ОЦЕНКА ВИДОВОГО РАЗНООБРАЗИЯ ПТИЦ В ЛЕСОПАРКЕ «ДЖРВЕЖ» И ИХ ВЛИЯНИЕ НА ПОДДЕРЖАНИЕ УСТОЙЧИВОГО ЭКОЛОГИЧЕСКОГО СОСТОЯНИЯ МАЛЫХ ВОДОЕМОВ

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Лесопарк «Джрвеж» — это важная зеленая зона, расположенная в окрестностях Еревана, характеризирующаяся наличием небольших водоемов, богатой растительностью и разнообразной фауной. Благодаря географическому положению, климатическим условиям и пересечению миграционных маршрутов, эта территория имеет особое значение для птиц. В последние годы международный опыт показывает, что создание малых водоемов в подобных лесных и городских зеленых зонах может

способствовать увеличению численности птиц, повышению биологического разнообразия и созданию природных механизмов очистки, где птицы и организмы, очищающие поверхность воды, функционируют в симбиозе. Лесопарк «Джрвеж» представлен как модель для исследования, где оцениваются разнообразие птиц и возможное влияние внедрения малых водоемов на устойчивость экосистемы.

Ключевые слова: водоем, птицы, экосистема, качество окружающей среды, механизмы естественной очистки.

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TRENDS AND CHALLENGES OF THE DEVELOPMENT OF THE CORPORATE BOND MARKET IN THE REPUBLIC OF ARMENIA

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Abstract

The financial environment of Armenia has undergone significant changes in recent years, driven by a combination of geopolitical, economic, and social factors. These processes have led to a reassessment of market rules and the emergence of new business operation models. In conditions of economic uncertainty, the mobilization of financial resources has become a crucial factor for business survival and growth. Currently, there is an increased demand for identifying efficient financing sources, considering the rising cost of bank loans and the limited availability of non-bank alternative instruments.

***Keywords*:** financing, business, lending, corporate bonds, financial market, refinancing rate.

Introduction

Over the past decade, the Armenian economy has been undergoing structural transformations directly linked to regional and global economic, political, and technological

changes. Geopolitical uncertainty, disruptions in supply chains, and the restructuring of international markets have significantly affected the country's financial and economic environment. Such changes have forced many companies to reassess their strategic directions, investment policies, and financing structures.

Financial stability and capital accessibility have become key prerequisites for business development. As a small, open economy, Armenia is sensitive to both external shocks and internal financial constraints. Consequently, the efficiency and diversification of business financing mechanisms have become essential directions of the country's economic policy, contributing to investment stability and market development prospects.

The banking system remains the primary actor in the financial environment, providing the dominant share of business financing. However, in recent years, credit interest rates have gradually increased due to tighter monetary policy and rising risk in international capital markets. As a result, higher bank lending costs limit small and medium-sized enterprises' access to financial resources, reducing investment activity and the level of production innovation.

In the current economic conditions, the development of alternative financing mechanisms is particularly important, including corporate bond issuance, private investment funds, venture capital, and financial instruments provided under state and international programs. Despite the relatively small size of the market, Armenia's corporate bond market shows gradual activation, indicating its development potential and growing investor interest.

Nevertheless, several institutional challenges hinder the effective development of the corporate bond market, such as low financial literacy, limited investor confidence, high regulatory burden, and low information transparency. Addressing these issues requires coordinated cooperation between public, private, and academic institutions.

Corporate bonds serve as an important financing tool, allowing companies to implement long-term projects without increasing equity, maintain managerial control under shareholder oversight, and simultaneously secure predictable and affordable market-based financing.

Conflict Setting

The aim of this study is to analyze the current state of the Armenian corporate bond market, assess the main factors affecting their profitability, identify development obstacles, and propose strategic measures to ensure the market's stable and long-term growth. The research utilizes official data from the Central Bank of Armenia, financial regulatory bodies, and major companies operating in the market.

The methodology includes statistical analysis, regression modeling, and comparative analysis in local and regional contexts, ensuring the comprehensiveness and policy relevance of the findings.The article presents practical recommendations for the sustainable development of the Armenian corporate bond market, increasing investor confidence, and improving the financial system.

Research Results

Corporate bonds are one of the primary instruments for raising capital for non-financial companies, providing a long-term source of financing and an additional option compared to

bank loans and equity. Economists have long studied the impact of capital structure on firm value. The seminal work of Modigliani and Miller (1958) demonstrated that in efficient markets—without taxes, market frictions, or operational costs—the value of a firm does not depend on its capital structure, as the fair prices of securities do not affect the overall firm value.

This theory underlines that ideally, a combination of equity and debt does not change the company's cash flows and, therefore, its value.

The efficiency of the corporate bond market largely depends on three main factors: market transparency, liquidity, and the activities of financial intermediaries. Transparency involves the availability of complete and timely information, including pricing structures, pre- and post-trade conditions, order volumes, and other essential transaction parameters. Liquidity depends on issuance volumes and secondary market activity, while market makers ensure price stability and continuous trading opportunities.

Morin O'Hara and Xing Zhou emphasize that institutional investors often hold bonds until maturity, which can limit secondary market liquidity during crises. Consequently, the market, despite an efficient structure, remains vulnerable to external shocks and liquidity challenges.

Monetary policy also plays a critical role in the corporate bond market. Experience shows that government bond markets are more sensitive to exchange rate changes, whereas loan and deposit markets are less affected. The corporate bond market, being smaller and dependent on financial intermediaries, is sensitive to changes in national monetary policy, particularly in interest rates and liquidity. For example, during the COVID-19 pandemic in the U.S., the Federal Reserve's Corporate Credit Facility and Special Purpose Vehicle programs stabilized the market through purchases, reduced credit spreads, and increased trading activity of corporate bonds. Similar initiatives have been implemented globally under the EU's CSPP, where targeted central bank purchases improved market conditions, stimulated new issuances, and reduced risks without compromising liquidity.

In Armenia, the presence of market makers is crucial for the development of the corporate bond market, providing continuous quoting and transparency for investors. Under conditions of high government bond influence, corporate bonds become an attractive financing tool, especially during declining yields, stimulating new issuances.

In summary, the efficiency of the corporate bond market depends on liquidity, transparency, the role of financial intermediaries, and monetary policy. Central bank support programs, well-designed structural policies, and information accessibility are essential instruments for market stability and stimulating new issuances. In a secured and stable environment, corporate bonds become an effective tool not only for raising capital but also for managing financial risks.

The development of Armenia's corporate bond market in recent years has become one of the key directions of the country's financial system. This sector's activation is simultaneously driven by several factors: maintaining macroeconomic stability, improving investment policies, enhancing the financial supervisory system, and gradually increasing investor confidence. Until 2019, the corporate bond market was considered a relatively narrow and limited source of financing; however, since 2020, it has become a factor stimulating real economic growth.

Moreover, the expansion of the bond market in certain sectors—particularly construction and infrastructure development—has begun to exhibit a multiplier effect. In recent years, some construction companies have started attracting financing through bond issuances, ensuring not only the continuity of their investment programs but also increasing overall market liquidity. This process indicates that the development of the capital market is gradually becoming the foundation for real sector growth: the expansion of construction investments, which increased by approximately 35% between 2020 and 2024, was significantly supported by the attraction of new financial sources, including corporate bonds.

Combined studies show that a 1% increase in corporate bond issuance volume can contribute to about a 0.4–0.5% increase in construction GDP. Such results indicate the deepening interconnection between financial and real sectors. In Armenia's case, this link is reflected in the fact that between 2020 and 2024, the expansion of the bond market coincided with an approximately 35% increase in investments in the construction sector. This interaction demonstrates that bond financing has effectively become an instrument for long-term economic development. The corporate bond market in Armenia has recorded significant growth in recent years, despite some fluctuations and the impact of external factors.

In 2019, the total market value was around AMD 250 billion, with an average yield of 7%. In 2020, the market experienced a slight decline—to AMD 230 billion—with a yield of 6.8%, due to global macroeconomic shocks.

In 2021 and 2022, the market recovered, reaching AMD 275 billion and AMD 340 billion, respectively, with average yields increasing to 8.4% and 9.2%. In 2023, the market reached approximately AMD 405 billion, with a yield of 8.9%. By 2024, the market value reached AMD 768.7 billion, an annual growth rate of 56.5%, with an average yield of 9.8%.

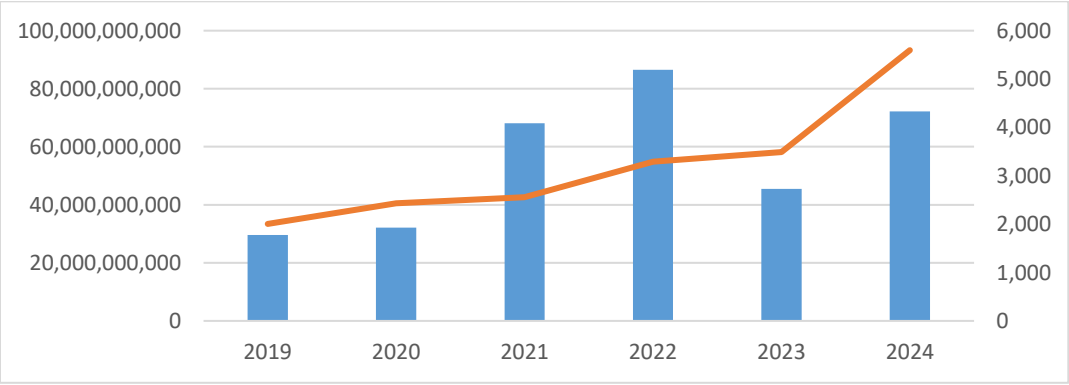

Fig. Number of corporate bond transactions and trading volume, 2019–2024
(The columns show the trading volumes; the lines show the number of transactions.)

As of early 2025, the market value is around AMD 465 billion, the number of circulating bonds is 150–160, transaction volumes are 7–10 billion AMD, and yields are still forecasted, though the market is expected to remain stable.

This period highlights market expansion, rising average yields, and the impact of external factors, emphasizing investor activity and the importance of financial risk management. In the context of Armenia's financial system development, the bond market is gradually taking on a central role, becoming one of the key mechanisms for capital mobilization and efficient allocation of investment resources. It represents a primary avenue for deepening

financial intermediation, which, in turn, contributes to financial stability, increased investment flows, and sustained economic growth.

In recent years, rapid capital market expansion has been observed, particularly through the growth of corporate bond and equity issuances. This trend reflects a gradual transformation of the financial environment, increased investor confidence, and the rising level of financialization of the economy. Overall, the analysis shows that despite dynamic growth, the corporate bond market is still in a continuous development phase. Investors remain highly sensitive to defaults and external risks, which requires not only attention to yields but also strengthening governance, disclosure, and supervisory mechanisms.

In the context of Armenia's financial system development, the bond market is gradually assuming a central role, becoming a key mechanism for capital mobilization and efficient allocation of investment resources. It represents a primary direction for deepening financial intermediation, which, in turn, supports financial stability, increasing investment flows, and sustaining economic growth. In recent years, rapid expansion of the capital market has been observed, particularly through growth in corporate bonds and equity issuance. This trend reflects the gradual transformation of the financial environment, increased investor confidence, and the rising level of financialization of the economy.

During 2024, the volume of corporate bonds in circulation amounted to approximately 7% of GDP, confirming the rapid market development trend. According to Armenia Securities Exchange data, compared to 2015, the volume of corporate bonds issued in AMD increased nearly 22 times, while foreign currency-denominated bonds grew about 27 times. Meanwhile, equity placement volumes increased almost sevenfold. These fig. indicate not only higher market activity but also development of financial culture and transformation of investment behavior.

The total volume of corporate bonds in circulation at the end of 2024 was about AMD 590 billion, while equity volume was approximately AMD 162 billion. This ratio indicates that bonds are becoming an alternative, and in some cases, a preferred source of financing. For non-financial organizations, bond issuance volumes account for around 6% of the business loan portfolio, and for financial institutions, about 4.8% of liabilities. These data suggest that bond instruments in Armenia have begun to serve not only as short-term financing but also as a strategic investment platform.

Economically, bond yields depend on several factors: interest rate environment, inflation, GDP growth, and the level of investment risks. Based on the analysis of the Armenian market, the following regression model was developed:

$$Y = 0.82X_1 + 0.37X_2 + 0.09X_3 + 3.65,$$

where Y represents the average yield of corporate bonds (%), X_1 is the refinancing rate, X_2 is the inflation rate, and X_3 is GDP growth. The resulting $R^2 = 0.983$indicates high explanatory power of the model, showing that the combined effect of the refinancing rate, inflation, and economic growth explains nearly the entire variation in yields. Specifically, each 1 percentage

point change in the refinancing rate on average leads to about a 0.8 percentage point change in corporate bond yields.

This relationship clearly demonstrates that the Central Bank's monetary policy is the primary regulator of bond yields. In 2021–2022, under the simultaneous influence of external and internal factors, the Central Bank had to implement a tightening policy to counteract accelerating inflation. As a result, the refinancing rate increased to 10.75%, significantly raising bond yields. Starting in 2023, as inflationary pressures eased and demand stabilized, the Central Bank began easing monetary conditions, reducing the refinancing rate to 7%, and by early 2025, to 6.75%. These changes contributed to market stabilization, increased lending volumes, and more predictable yield balance.

Analysis of Armenian market data shows that the correlation between inflation and yields is relatively weak (0.46), while the correlation between the refinancing rate and yields is very high (0.89). This indicates that monetary policy instruments remain the main drivers of yield dynamics. GDP growth also affects yields to some extent, but its impact is relatively limited due to the market's small size and investment demand structure.

Comparative analysis shows that the average yield of Armenian corporate bonds, about 9.5%, exceeds that of regional countries—Georgia (8.3%) and Kazakhstan (8.9%). This difference is mainly due to market size and investment risk variations; in developing markets, investors typically require higher yields to compensate for risk. Nevertheless, this level of yield also indicates increasing investment attractiveness and the ongoing transformation of the bond market.

In recent years, qualitative changes have occurred in Armenia's public financing structure. In 2024, total financing amounted to about AMD 851 billion, with 77% formed through government bond placements. In 2025, total financing is expected to rise to AMD 1.35 trillion, with a significant increase in external loans and foreign currency bonds. This indicates diversification of financing sources and deepening of external capital attraction. Such developments both stimulate market expansion and increase investment activity, while also heightening currency and interest rate risks, which could affect bond yields and market stability.

A distinctive feature of Armenia's bond market is the interconnection between government and corporate bond yields. Government bond yields form the base yield curve, serving as a reference point in pricing private sector debt instruments. In other words, any change in the government bond market—whether in yield or volume—directly impacts the demand for and valuation of corporate bond issuances.

Overall, analytical data and model calculations indicate that the monetary policy transmission mechanism in Armenia operates relatively efficiently, especially in the context of the bond market. Changes in the refinancing rate are transmitted to corporate bond yields with some time lag but fully, forming predictable market response patterns.

These trends indicate that Armenia's corporate bond market is in a stable growth phase and is gradually becoming a real source of economic financing. It contributes to diversification of capital mobilization, development of investment culture, and deepening of the financial system. If macroeconomic stability, monetary balance, and investor confidence are maintained in the coming years, the corporate bond market volume could exceed AMD 700 billion by 2027,

with average yields stabilizing in the 8.5–9.0% range, approaching Eurasian regional averages. This demonstrates that the bond market is becoming not only a component of the financial instrument toolkit but also an effective channel for implementing economic policy, strengthening Armenia's economic stability and investment attractiveness.

Based on the conducted analysis, it can be noted that macroeconomic and political factors have the primary influence on the yield of Armenian corporate bonds. One of the main challenges remains high inflation and changes in the Central Bank's refinancing rate, which directly affect average yield rates.

External macroeconomic and geopolitical factors significantly impact the stability of Armenia's financial market and investment environment. Regional economic and political instability, as well as international capital movement restrictions (cross-border capital constraints), can substantially limit both individual and corporate investment capacity and market activity. Under such conditions, certain restrictions in investor information disclosure are applied to protect local companies, reducing dependency on external markets and mitigating potential negative effects of international uncertainties and market volatility.

Another important aspect concerns the tax environment. Current tax incentives in Armenia's corporate bond market do not provide sufficient stimulus for private investments. Companies often prefer other financing sources with government support, such as bank loans, reducing the demand for bonds as a primary financing tool.

Corporate bonds are relatively riskier than government bonds, and investors often prefer government bonds to reduce portfolio risk. In this context, corporate bond yields can be seen as relatively high returns for higher risk, reflected in Armenia's market by an average yield of 9.5%, exceeding the regional average.

Domestic financial factors have a significant impact on the development of Armenia's bond market. Company financial stability and high creditworthiness reduce investment risks, ensuring predictable yields and minimizing potential capital loss or "freezing" of investment resources. This is particularly important for retail investors, who are more sensitive to market fluctuations and liquidity constraints.

At the same time, the legal framework still requires improvement. There are no clearly defined mandatory requirements for corporate bond issuance and sales agreements, especially in cases where they may convert into shares or be used in other financial transactions as collateral instruments. These gaps limit market transparency and reduce investor confidence. Clarifying regulations and strengthening legal protection will contribute to institutional development and market stability.

Conclusion and Recommendations

A comprehensive analysis of Armenia's corporate bond market indicates that it is currently in an intermediate stage of development, while simultaneously showing significant growth potential. The positive market dynamics in recent years have been driven both by the gradual stabilization of the financial environment and by increasing investor interest. However, a number of systemic and structural factors continue to hinder the market's sustainable development.

First of all, fluctuations in refinancing interest rates within the macroeconomic environment create uncertainty regarding the profitability and real value of bond instruments.

This factor increases the perceived risk for issuers and investors, limiting investment activity.

In addition, due to incomplete disclosure of information and insufficient transparency in financial reporting, investors often lack adequate data regarding the financial stability, operational risks, and market position of issuers.

The current structure of tax policy also does not sufficiently encourage investments in corporate bonds; investors do not receive tax incentives or reductions in income tax, which could enhance the attractiveness of bonds relative to alternative financial assets.

It should be noted that the relatively high default risk in the market and the low liquidity of the secondary market lead investors to prefer government bonds or other secure instruments, thereby limiting private sector financing opportunities.

Overall, despite existing positive trends, Armenia's corporate bond market has not yet reached the institutional and operational level that would allow it to be considered a fully reliable and competitive financing source for both local and international investors.

Recommendations

Considering the above observations, it is appropriate to implement the following strategic measures, which will contribute to the sustainable development of the market and improvement of the investment environment:

Predictability and Stability of Interest Rate Policy

The Central Bank’s interest rate policy should aim at ensuring predictability. This will reduce the impact of market fluctuations on profitability and strengthen investor confidence. It is recommended to publish regular assessments and forecasts regarding potential interest rate changes, thereby ensuring informational transparency.

Enhancing Financial Information Disclosure

Investor confidence largely depends on information transparency. It is necessary to ensure mandatory publication of financial statements by issuers in accordance with IFRS (International Financial Reporting Standards), including data on the nature of activities, risks, and the market dynamics of bonds.

Incentive Tax Policy

Providing tax incentives to investors can become one of the most effective drivers of Armenia's corporate bond market development. From an economic perspective, tax incentives act as a mechanism guiding investment behavior, reducing the tax burden on actual returns and increasing the comparative attractiveness of bonds relative to other financial instruments.

Specifically, temporary or partial exemptions from income tax, as well as reduced tax rates for long-term investments, can significantly increase investor participation in the corporate bond market. This approach is applied in many developed financial systems, such as in the EU, Singapore, and South Korea, where tax incentives have contributed not only to market liquidity growth but also to an expansion in issuers’ debt financing volumes.

In Armenia, targeted application of tax incentives may be especially effective for investments directed at strategic sectors of the economy (e.g., energy, IT, infrastructure, green economy) or those with long-term holding commitments. Such a policy will contribute not only to the dynamics of bond acquisitions by investors but also to the long-term stabilization of the capital market, ensuring predictability of financial flows and proportional distribution of investment risks.

Additionally, tax incentives can have secondary positive effects by promoting corporate financial transparency, as benefiting from these incentives requires maintaining standardized reporting and disclosures in accordance with international accounting standards. Thus, tax policy not only stimulates investments but also indirectly contributes to institutional strengthening and enhanced oversight of the market.

Therefore, a targeted and well-structured incentive tax policy can become an important tool for activating the corporate bond market, stabilizing investment flows, and deepening the country's financial system.

Institutional Mechanisms for Reducing Default Risk

It is necessary to establish state or private guarantee funds and insurance systems for relevant issuances. These mechanisms will reduce investment risk and contribute to increased market liquidity.

Investor Education and Awareness

Increasing financial literacy is one of the cornerstones of market development. It is recommended to organize educational programs, seminars, and online courses on the features of the bond market, assessment of profitability, and risk management.

Strengthening Market Infrastructure

Development of the secondary market should be promoted by ensuring greater accessibility for buying and selling, reducing intermediary fees, and diversifying issuances. At the same time, it is advisable to encourage both local and international investors' participation to enhance market integration and liquidity.

The proposed strategic interventions can form a predictable, transparent, and efficient corporate bond market, which will contribute not only to the stability of the financial system but also to the comprehensive development of Armenia's economy. This approach will allow Armenia to gradually move towards a financial market that meets regional and international standards.

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ԿՈՐՊՈՐԱՏԻՎ ՊԱՐՏԱՏՈՄՍԵՐԻ ՇՈՒԿԱՅԻ ԶԱՐԳԱՑՄԱՆ ՄԻՏՈՒՄՆԵՐԸ ԵՎ ՄԱՐՏԱՀՐԱՎԵՐՆԵՐԸ ՀԱՅԱՍՏԱՆԻ ՀԱՆՐԱՊԵՏՈՒԹՅՈՒՆՈՒՄ

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Հայաստանի ֆինանսական միջավայրը վերջին տարիներին ենթարկվել է էական փոփոխությունների, որոնք պայմանավորված են աշխարհաքաղաքական, տնտեսական և սոցիալական գործոնների համակցությամբ: Այս գործընթացները հանգեցրել են շուկայի կանոնների վերանայմանը և բիզնեսի գործունեության նոր ձևաչափերի ձևավորմանը: Տնտեսական անորոշության պայմաններում ֆինանսական ռեսուրսների ներգրավումը դարձել է բիզնեսի գոյատևման և զարգացման կարևորագույն պայմաններից մեկը: Ներկայիս իրավիճակում առավել պահանջված է դարձել ֆինանսավորման արդյունավետ աղբյուրների որոնումը՝ հաշվի առնելով բանկային վարկերի թանկացումը և ոչ բանկային այլընտրանքային գործիքների սահմանափակ հնարավորությունները:

Բանալի բառեր. ֆինանսավորում, բիզնես, վարկավորում, կորպորատիվ պարտատոմսեր, ֆինանսական շուկա, վերաֆինանսավորման տոկոսադրույք:

K.A. Nersisyan, S.A. Avetisyan, A.V. Arstamyan
TRENDS AND CHALLENGES OF THE DEVELOPMENT
OF THE CORPORATE BOND MARKET IN THE REPUBLIC OF ARMENIA

ТЕНДЕНЦИИ И ПРОБЛЕМЫ РАЗВИТИЯ РЫНКА КОРПОРАТИВНЫХ ОБЛИГАЦИЙ В РЕСПУБЛИКЕ АРМЕНИЯ

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Финансовая среда Армении в последние годы претерпела существенные изменения, обусловленные совокупностью геополитических, экономических и социальных факторов. Эти процессы привели к пересмотру рыночных правил и формированию новых форматов ведения бизнеса. В условиях экономической неопределенности привлечение финансовых ресурсов стало одним из важнейших условий выживания и развития бизнеса. В сложившейся ситуации поиск эффективных источников финансирования стал более востребованным, учитывая рост стоимости банковских кредитов и ограниченные возможности небанковских альтернативных инструментов.

Ключевые слова: финансирование, бизнес, кредитование, корпоративные облигации, финансовый рынок, ставка рефинансирования.

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Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱԾՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱԾՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

Բնական (անջրդի) պայմաններում, որտեղ մշակաբույսերը աճեցվում են առանց արհեստական ոռոգման, հիմնականում օգտագործվում են հալված ձյան և ստորգետնյա ջրերի գարնանային խոնավությունը, ինչպես նաև անձրևը:

Վաղ գարնանը (կամ լիարժեք ոռոգումից հետո) 1 մ² մակերեսի վրա՝ 10 սմ հողաշերտում, կարող է կուտակվել մոտավորապես 30 լիտր ջուր: Դրա մի մասը բույսն օգտագործում է, մինչդեռ մյուս մասը (մոտավորապես 13 լիտր կամ 13%), մնալով հողում, բույսի համար դառնում է անմատչելի: Եվս 7 լիտրը բույսը դժվարությամբ է կորզում,/՝ գործնականում օգտագործելով գոյատևման նպատակով, և չի զարգանում: Այսինքն,/՝ միայն 10 լիտր ջուրը՝ կուտակվածի մեկ երրորդն է բույսը հեշտությամբ կլանում և յուրացնում աճի և զարգացման համար:

Հողում կուտակված խոնավության մեծ մասը բույսի աճման շրջանում գոլորշիանում է: Հետևաբար, բույսերի սպառման համար հողում ջրի անհրաժեշտ պաշարը մեծացնելու՝ երկու տարբերակ ունենք՝ հողի մակերևույթից ջրի գոլորշիացման նվազեցում (օրինակ՝ այն ծածկելով բարակ թաղանթով, որը ստեղծում է ջերմոցային ազդեցություն և զգալիորեն նվազեցնում հողի մակերևույթից գոլորշիացումը) կամ հողում ջուրը պահելու կարողության մեծացում:

Օգտագործելով «PMM» մելիորանտը հնարավոր է դառնում 1 մ² մակերեսի վրա,/՝ 10 սմ խորության հողաշերտում (որտեղ հիմնականում տեղակայվում են բազմաթիվ բույսերի, այդ թվում՝ ձմեռային ցանքի ցորենի արմատները), կուտակել 40-45 լիտր ջուր: Արդյունքում,/՝ հողում կուտակված լրացուցիչ 10-15 լիտր ջուրը զգալի ժամանակահատված կապահովի բույսի բարենպաստ զարգացումը և աճը:

«PMM» մելիորանտի կիրառումը ոչ միայն մեծացնում է նշված տարբերակով ջուր պահելու ունակությունը և, հետևաբար, բույսերի արմատների կողմից հեշտությամբ կլանվող ջրի քանակը, այլև նույն պայմաններում նվազեցնում է գոլորշիացման արագությունը: Հետևաբար, անձրևի և արհեստական ոռոգման բացակայության պայմաններում, «PMM» մելիորանտի կիրառման դեպքում բույսերը զարգացման համար ունենում են զգալիորեն ավելի երկար ժամանակահատված, քան բնական պայմաններում:

Մշակվել են մի շարք տեխնոլոգիաներ՝ «PMM» մելիորանտի կիրառմամբ մշակաբույսերի բերքատվությունը բարձրացնելու համար: Ակադեմիկոս Ի.Վ. Եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտի և Մ.Վ. Լոմոնոսովի անվան Մոսկվայի պետական համալսարանի մեխանիկայի գիտահետազոտական ինստիտուտի կողմից անցկացվել են բազմաթիվ համատեղ լաբորատոր հետազոտություններ: Փոքր մակերեսով հողամասերում փորձարկումները ցույց են տվել,

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱԲԱԺՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՑԱՆ ՅՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

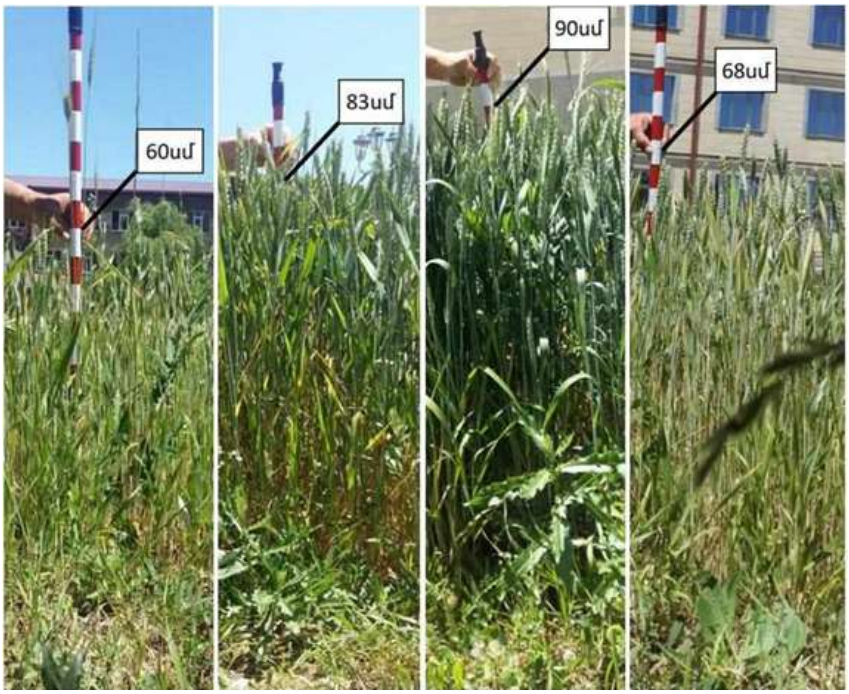
(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

որ 1 քառակուսի մետր հողի վրա 100-300 գրամ չափաբաժնով «PMM» մելիորանտի կիրառումը հանգեցնում է աշնանացան ցորենի բերքատվության զգալի աճի:

2019թ.-ից իրականացվող հետազոտությունները ցույց էին/են տալիս «PMM» մելիորանտի կիրառման արդյունավետությունը:

Նկարում ներկայացված է աշնանացան ցորենի հետազոտության արդյունքը փոքր մակերեսի վրա.

Ձախից՝ աջ.
1. Ստուգիչ տեղամաս.
2. Միայն պարարտանյութ.
3. PMM և պարարտանյութ
4. Միայն PMM



Խնդիր է դրվել 2024-2025**թթ. ՀՀ Ծաղկահովիտ համայնքում** բնական (անջրդի) պայմաններում լաբորատոր փորձարկումների արդյունքների հիման վրա իրականացնել դաշտային հետազոտություններ,/՝ աշնանացան ցորենի բերքատվության վրա «PMM» մելիորանտի 0.3 կգ/մ² (3 գ$_{\text{ՊՄՄ}}$/1 կգ$_{\text{հող}}$) չափաբաժնով կիրառման իրական ազդեցությունը որոշելու համար:

Խնդրի արդիականությունը պայմանավորված է նաև Հայաստանում կլիմայի ակտիվ փոփոխության իրողությամբ: Կանխատեսումների համաձայն,/՝ տարածաշրջանում գյուղատնտեսության ոլորտում կարելի է ակնկալել.

- հողի խոնավության մակարդակի նվազում 10-30%-ով,
- գյուղատնտեսական մշակաբույսերի համար հողի խոնավության ապահովման նվազում 7-13%-ով.
- ոռոգման ջրի պակաս՝ հողում ջրի դեֆիցիտի ավելացում 25-30%-ով.
- ոռոգվող հողերի արտադրողականության նվազում շուրջ 24%-ով.
- հողերի և բնական արոտավայրերի դեգրադացիա.

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

- մինչև 2030թ. ընդհանուր արոտավայրերի և արտադրողականության նվազում 4-10%-ով, արոտավայրերի բերքատվության նվազում 7-10%-ով, անասնակերի արտադրության ծավալների նվազում, մշակաբույսերի բերքատվության նվազում շուրջ 8-14%-ով:

Այսպիսով, հող ներմուծված մելիորանտի չափաքանակներից աշնանացան ցորենի բերքի կառուցվածքի և բերքատվության կախվածությունը բացահայտելու նպատակով 2024-2025թթ Հայաստանի Հանրապետության լեռնատափաստանային լանդշաֆտային գոտու՝ ծովի մակերևույթից 2000մ բարձրության վրա ընկած լեռնային սևահողերի ենթագոտում, որտեղ տարեկան թափվող մթնոլորտային տեղումների միջին քանակությունը 550 մմ է, տարեկան միջին ջերմաստիճանը՝ 4^{o}C, դրվել են դաշտային փորձեր:

Փորձերը դրվել են 3 կրկնողությամբ: Հետազոտվել են հետևյալ տարբերակները՝

1. Առանց «PMM» - ստուգիչ.
2. «PMM» - 2 տ/հա.
3. «PMM» - 3 տ/հա:

Փորձի բոլոր տարբերակներում, սիստեմատիկ կերպով պահպանելով հերթականությունը, փորձամարգերը դասավորվել են այնպես, որ տեղամասերը ընդհանուր սահման չունենան: Փորձահողամասը բոլոր կողմերից ապահովվել է 3մ լայնությամբ պաշտպանական շերտով: 1մ լայնությամբ պաշտպանական շերտ է թողնվել նաև հարևան փորձամարգերի միջև: Այսպիսով՝ յուրաքանչյուր փորձամարգ ունեցել է 60մ ընդհանուր երկարություն և 18մ լայնություն՝ ներառյալ 1մ պաշտպանական շերտը՝ 1080մ² ընդհանուր և 1000մ² հաշվարկային մակերեսով:

«PMM» մելիորանտն, ըստ փորձի սխեմայի, հող է ներմուծվել ցանքից առաջ հացահատիկացան С3-3,6 շարքացանով, ցանքի խորությամբ և կարգաբերվել հողի համատարած մշակման կուլտիվատորով: Ցորենի դաշտի մշակման մյուս ագրոտեխնիկական միջոցառումները կատարվել են՝ համաձայն տարածաշրջանում ընդունված տեխնոլոգիայի:

Հող ներմուծված «PMM» մելիորանտի չափաքանակից աշնանացան ցորենի բերքատվության և բերքի կառուցվածքային տարրերի կախվածությունը բացահայտելու համար բերքահավաքի նախօրեին բոլոր տարբերակների փորձամարգերի 0,25 մ² տարածքից բույսերը արմատախիլ են արվել, կապվել են խրձեր, պիտակավորվել և տեղափոխվել են լաբորատորիա: Բերքի կառուցվածքային տարրերը և կենսաբանական բերքը որոշվել է՝ համաձայն գործող մեթոդիկայի:

Յուրաքանչյուր խրձից ընտրվել է 10-ական պատահական բույս, չափվել է/են դրանց բարձրությունը, հասկերի երկարությունը, հասկում հատիկների թիվը, 1000 հատիկի զանգվածը, հաշվարկվել են 1մ² տարածքում եղած բույսերի թիվը, ընդհանուր ցողունների

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատուրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՑԱՆ ՅՈՐԵՆԻ ԲԵՐՔԱՑՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

քանակը, արդյունավետ ցողունների թիվը: Որոշվել են ընդհանուր և արդյունավետ թփակալման գործակիցները:

Նշված բոլոր հաշվարկները կատարվել են ինչպես ըստ փորձի առանձին տարբերակների, այնպես էլ փորձի երեք տարբերակների միջինը դուրս բերելու սկզբունքով (աղյուսակներ 1-4):

Աղյուսակ 1

Աշնանացան ցորենի կենսաբանական բերքի կառուցվածքը՝ կախված հող ներմուծված «PMM» մելիորանտի չափաքանակից (փորձի տարբերակ 1)

Տարբերակ	Բույսերի բարձրությունը, սմ	1մ²-ում			Թփակալում		Մեկ հասկի			Հազար հատիկի զանգվածը, գ	Կենսաբանական բերքը, տ/հա			Ծղոտի և հատիկի հարաբերությունը
		Բույսերի թիվը	ցողունների թիվը		ընդհանուր	արդյունավետ	երկարությունը, սմ	հատիկների թիվը, հատ	հատիկների զանգվածը, գ		Ընդամենը	որից		
			Ընդամենը	արդյունավետ								Հատիկ	ծղոտ	
Ստուգիչ st	48	225	356	240	1,58	1,06	5,6	23,2	0,8	34,48	4,05	1,92	2,13	1,1
PMM 2տ/հա	52	251	341	275	1,35	1,09	6,3	27,4	0,9	32,84	4,92	2,47	2,45	0,98
PMM 3տ/հա	52	247	335	268	1,35	1,08	6,4	28,6	1,2	41,95	6,37	3,21	3,16	0,98

Աղյուսակ 2

Աշնանացան ցորենի կենսաբանական բերքի կառուցվածքը՝ կախված հող ներմուծված «PMM» մելիորանտի չափաքանակից (փորձի տարբերակ 2)

Տարբերակ	Բույսերի բարձրությունը, սմ	1մ²-ում			Թփակալում		Մեկ հասկի			Հազար հատիկի զանգվածը, գ	Կենսաբանական բերքը, տ/հա			Ծղոտի և հատիկի հարաբերությունը
		Բույսերի թիվը	ցողունների թիվը		ընդհանուր	արդյունավետ	երկարությունը, սմ	հատիկների թիվը, հատ	հատիկների զանգվածը, գ		Ընդամենը	որից		
			Ընդամենը	արդյունավետ								Հատիկ	ծղոտ	
Ստուգիչ st	50	201	261	215	1,29	1,06	6,2	26,2	1,0	38,16	4,41	2,15	2,26	1,05
PMM 2տ/հա	53	238	296	254	1,24	1,06	6,3	26	1,1	42,30	5,59	2,79	2,8	1,0
PMM 3տ/հա	54	293	371	307	1,26	1,04	6,8	28,2	1,0	35,46	6,04	3.07	2,97	0,96

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՑՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

Աղյուսակ 3

Աշնանացան ցորենի կենսաբանական բերքի կառուցվածքը՝ կախված հող ներմուծված «PMM» **մելիորանտի չափաքանակից (փորձի տարբերակ** 3)

Տարբերակ	Բույսերի բարձրությունը, սմ	1մ²-ում			Թփակալում		Մեկ հասկի			Հաշտո հատիկի զանգվածը, գ	Կենսաբանական բերքը, տ/հա			Ծղոտի և հատիկի հարաբերությունը
		Բույսերի թիվը	ցողունների թիվը		ընդհանուր	արդյունավետ	երկարությունը, սմ	հատիկների թիվը, հատ	հատիկների զանգվածը, գ		Ընդամենը	որից		
			Ընդամենը	արդյունավետ								Հատիկ	ծղոտ	
Ստուգիչ st	48	254	312	275	1,22	1,08	6,2	21,4	0,8	37,38	4,54	2,20	2,34	1,06
PMM 2տ/հա	54	220	303	237	1,08	1,07	6,2	27,2	1,1	40,44	5,29	2,60	2,69	1,03
PMM 3տ/հա	55	256	371	281	1,44	1,09	6,4	26,0	1,1	42,30	6,24	3,09	3,15	1,0

Աղյուսակ 4

Աշնանացան ցորենի կենսաբանական բերքի կառուցվածքը՝ կախված հող ներմուծված «PMM» **մելիորանտի չափաքանակից (փորձի երեք տարբերակների միջինը**)

Տարբերակ	Բույսերի բարձրությունը, սմ	1մ²-ում			Թփակալում		Մեկ հասկի			Հաշտո հատիկի զանգվածը, գ	Կենսաբանական բերքը, տ/հա			Ծղոտի և հատիկի հարաբերությունը
		Բույսերի թիվը	ցողունների թիվը		ընդհանուր	արդյունավետ	երկարությունը, սմ	հատիկների թիվը, հատ	հատիկների զանգվածը, գ		Ընդամենը	որից		
			Ընդամենը	արդյունավետ								Հատիկ	ծղոտ	
Ստուգիչ st	48,6	226,6	309,6	243,3	1,3	1,06	6,0	23,6	0,86	36,67	4,33	2,09	2,24	1,07
PMM 2տ/հա	53,0	236,3	313,3	255,3	1,2	1,07	6,2	26,8	1,03	38,52	5,27	2,64	2,63	1,0
PMM 3տ/հա	53,6	265,3	359,0	285,3	1,3	1,07	6,5	27,6	1,1	39,90	6,21	3,12	3,09	0,98

Ինչպես ցույց են տալիս աղյուսակ 4-ում բերված միջին տվյալները, հող ներմուծված մելիորանտի երկու չափաքանակն էլ զգալի ազդեցություն է/են ունեցել ինչպես բույսերի բարձրության, միավոր մակերեսում ընդհանուր և արդյունավետ ցողունների թվի, ընդհանուր և արդյունավետ թփակալման գործակցի, այնպես էլ հասկերի երկարության,

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատուրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿԱՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

հասկում հատիկների թվի և 1000 հատիկի զանգվածի վրա: Բույսերի ամենամեծ բարձրությունը գրանցվել է 3 տ/հա տարբերակում: Այս տարբերակում, ըստ փորձի երեք տարբերակների միջինի, բարձր է եղել նաև բույսերի ընդհանուր և արդյունավետ ցողունների թիվը, ընդհանուր և արդյունավետ թփակալումը:

Բերքատվության ձևավորման կառուցվածքային տարրերում կարևորագույն ցուցանիշներով,/՝ հասկում եղած հատիկների թվով, դրանց զանգվածով և 1000 հատիկի զանգվածով նույնպես PMM 3 տ/հա տարբերակն առավելագույնն է: Արդյունքում՝ ինչպես ծղոտի, այնպես էլ հատիկի ամենաբարձր կենսաբանական բերքը՝ 3,09 և 3,12 տ/հա, գրանցվել է PMM 3 տ/հա տարբերակում, որը ստուգիչին գերազանցում է 37,9 և 49,2%-ով, իսկ PMM 2 տ/հա տարբերակին՝ 17,4 և 18,1%-ով:

Փաստացի բերքի հաշվառումը, որը թերևս ամենակարևոր ցուցանիշն է, կատարվել է կոմբայնային ուղղակի բերքահավաքի եղանակով՝ ըստ փորձի տարբերակների՝ յուրաքանչյուր փորձամարգի բերքի կշռմամբ (աղյուսակ 5): Աղյուսակում բերված տվյալների համաձայն՝ հող ներմուծված մելիորանտի տարբեր չափաքանակները փորձի բոլոր տարբերակներում զգալի ազդեցություն են ունեցել աշնանացան ցորենի հատիկի բերքատվության ավելացման վրա: Փորձի երեք տարբերակների ամենաբարձր միջին բերքատվությունը դիտվել է PMM 3 տ/հա տարբերակում՝ 2,89 տ, որը ստուգիչ տարբերակին գերազանցում է 0,94 տ կամ 48,2%-ով, իսկ PMM 2 տ/հա տարբերակում շեղումը ստուգիչից կազմել է ընդամենը 0,61տ/հա կամ 31,2%:

Աղյուսակ 5

Աշնանացան ցորենի փաստացի բերքատվությունը՝ կախված հող ներմուծված «PMM» **մելիորանտի չափաքանակից (փորձի երեք տարբերակների միջինը)**

N	Տարբերակ	Հատիկի բերքը՝ ըստ փորձի տարբերակների, տ/հա			Հատիկի միջին բերքը, տ/հա	Բերքի շեղումը ստուգիչից	
		1	2	3		տ/հա	տոկոս
1	Ստուգիչ	1,88	1,96	2,02	1,95	0	0
2	PMM 2տ/հա	2,36	2,84	2,60	2,56	0,61	31,2
3	PMM 3տ/հա	2,90	2,96	2,82	2,89	0,94	48,2

Հայաստանի Հանրապետությունում հացահատիկի մշակության համար բնակլիմայական պայմանները նպաստավոր չեն: Բացի այդ, փոքր ու կտրատված հողակտորներ ունեցող հանրապետությունում, որտեղ հողերը սեփականաշնորհված են, հացահատիկի մշակության պարագայում ցանքաշրջանառությունը գործնականում շատ

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿԱՁՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «ՔՄՄ» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՅԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

փոքր է, ինչն էլ բերում է բերքի նվազման: Այս դեպքում հացահատիկի մշակությունը տնտեսագիտական տեսանկյունից արդարացված չէ: Մասնագիտական հաշվարկներով՝ մեկ հա հացահատիկի մշակությունից ստացվող շահույթը չի հասնում 100 հազար դրամի: ՌԴ-ի կամ Կանադայի նման երկրներում (որոնցում բերքատվությունն անհամեմատ բարձր է), որտեղ միլիոնավոր հա-երով հացահատիկ է մշակվում, մի քանի հարյուր կամ հազար հա-ի մշակության դեպքում լուրջ շահույթ կգոյանա: ՀՀ-ում, որտեղ ցորենի մշակությանը հատկացվող ամենամեծ հողակտորը 20-30 հա է, իսկ հիմնականում՝ 2-3 հա, տնտեսագիտորեն արդարացված չէ:

Այս պարագայում արդյոք հացահատիկի մշակությունը գյուղացուն կապահովի՞ այն շահույթով, որից ելնելով՝ նա կհրաժարվի այլ մշակաբույսերի մշակությունից:

Մասնագետների գնահատմամբ՝ Հայաստանին տարեկան անհրաժեշտ է 420-450 հազար տոննա ցորեն: «Սննդի ռիսկերի գնահատման կենտրոնի» մասնագետների կարծիքով՝ հացի օրական սպառման միջին թիվը մեկ անձի հաշվով Հայաստանում կազմում է 319 գրամ: Սրա 82,4%-ը բաժին է ընկնում բարձրորակ ցորենից պատրաստված հացին, 16,9%-ը՝ լավաշին: Մեկ շնչի հաշվով մակարոնեղենի սպառման օրական ծավալը կազմում է 19,3 գրամ, վերմիշելինը՝ 8,5 գրամ: 1980-ականներին կատարված հաշվարկների համաձայն՝ Հայաստանում մեկ շնչի հաշվով հացամթերքը՝ վերածված ալյուրի, կազմում էր տարեկան 130 կգ: Կանխատեսվում էր, որ ապագայում այն հասնելու է 142 կգ: Վերոնշյալ թվերի հիման վրա հաշվարկվել է, որ պարենային անվտանգությունից ելնելով,/՝ Հայաստանին անհրաժեշտ է տարեկան 450 հազար տոննա ցորեն:

Հայաստանում հացահատիկի ցանքատարածությունների տվյալները 2010-2024թթ. համար բերված են աղ. 6-ում:

Հացի ինքնաբավության ապահովման «երրորդ» ծրագիրն իրականացվեց առանց պետության ուղղակի միջամտության: Այն սկսվեց հողի սեփականաշնորհումից անմիջապես հետո և շարունակվեց ընդհուպ մինչև 1998-1999թթ.: Դա ինչ-որ առումով տրամաբանական էր՝ պայմանավորված նոր կացութաձևի անցման և պատերազմական դժվարություններով: Այդ ընթացքում նույնպես ցանքատարածությունները շեշտակիորեն աճեցին: Ընդ որում՝ եթե առաջին երկուսի դեպքում դրանք աճում էին հիմնականում լեռնային, նախալեռնային արոտավայրերի ու խոտհարքների հաշվին, ապա ինքնաբավության ապահովման երրորդ «փուլում» աճը տեղի էր ունենում հիմնականում Արարատյան դաշտավայրի հաշվին (շուրջ 45 հազար հա հատկացվեց հացահատիկի մշակությանը): Այդ տարիներին, համաձայն վիճակագրական ցուցանիշների, հացահատիկի ցանքատարածությունները կազմում էին 170-190 հազ. հա:/, 1993թ-ին՝ 206 հազ. հա:

Առաջին փուլում ամենաբարձր միջին բերքը ստացվել է 1991թ-ին՝ 19,9 ց/հա: Այս ցուցանիշն իրատեսական է, քանի որ, կարելի է ասել, դա ցորենի զանգվածային մշակության առաջին տարին էր, երբ հողը դեռ բերրի էր, ցանքաշրջանառության խիստ

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱԲԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՅԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

կարիք չկար, երբ գյուղերի պահեստներում անսահմանափակ քանակի պարարտանյութ կար, երբ մեխանիզացիայի պրոբլեմ գրեթե չկար, և պայմանները խիստ նպաստավոր էին բարձր բերքի համար:

Ժամանակի ընթացքում, իրավիճակի բարելավման և ցորենի ցածր եկամտաբերության հետ կապված, ցանքատարածությունները կրճատվեցին:

Հայաստանում հացահատիկի ցանքատարածությունները 2010-2025**թթ**. (**հա**)

Տարիներ	Ընդամենը հացահատիկային	Ցորեն	Գարի
2010	159307	87585	61160
2012	172206	93710	65291
2014	188695	106365	67637
2016	198148	108738	71600
2018	131400	66680	52460
2020	121656	59393	50294
2021	124929	59110	50632
2022	114409	56757	42110
2023	127091	71360	40074
2024	116400	56520	42035

Ցորենն աճում է հանրապետության գրեթե բոլոր շրջաններում, բայց առանձնապես շատ է մշակվում Շիրակի դաշտում (Ախուրյան, Անի, Արթիկ), Սևանի ավազանում (Վարդենիս, Մարտունի, Կամո), Սիսիանում, ինչպես նաև Արմավիրի տարածաշրջանում: Իհարկե, նշյալներից զատ՝ ավելի փոքր մակերեսների վրա ցորեն է մշակվում նաև Աշոցքում, Ամասիայում, Տաշիրում, Տավուշում: Դարձյալ՝ հիմնականում անջրդի պայմաններում: Նույնիսկ Արարատյան դաշտում,/՝ ինքնահոս ոռոգման պայմաններում, ցորենի ինքնարժեքը մեկ կգ-ի համար հասնում է 100-120 դրամի և մշակողին գրեթե շահույթ չի ապահովում: Ուստի, ցորենի հիմնական մշակությունն իրականացվում է անջրդի պայմաններում, հիմնականում 1500-2000 մետր բարձրության վրա: Նման բարձրությունում ոռոգում իրականացնելը գործնականում մեծ ծախսերի հետ է կապված: Համաձայն վիճակագրական ծառայության՝ 2022-2023թթ.-ին Արմավիրի և Արարատի մարզերում, որտեղ ցորենի մշակությունն իրականացվում է առավելապես ջրովի պայմաններում, մեկ հա-ի միջին բերքատվությունը կազմել է ավելի քան 4 տոննա/հա,/՝ շատ դեպքերում հասնելով 6-7 տոննա/հա-ի: Սյունիքում, Գեղարքունիքում, Շիրակում[a], որտեղ մշակությունն իրականացվում է անջրդի պայմաններում, բերքատվությունը կազմում է համապատասխանաբար 1.5, 2.1 և 2.4 տոննա հա-ից: Մասնագիտական հաշվարկներով՝ ջրովի հողերում մեկ կգ ցորենի ինքնարժեքը տատանվում է 75-ից մինչև 85-90 դրամ մեկ կգ-ի համար, իսկ անջրդի պայմաններում՝ ավելի բարձր: Իրացման գինը կազմում է 110-120 դրամ/կգ: Նույնիսկ 5 տոննա բերքի դեպքում գյուղացու շահույթը

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿԱՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «ՔՄՄ» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱԲԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՅԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

կազմում է լավագույն դեպքում 1 հա-ից 100 հազ. դրամ: Անջրդի պայմաններում շահույթը շատ ավելի փոքր է ստացվում: Այդ իսկ պատճառով էլ հանրապետությունում տարեցտարի մշակության մակերեսները նվազում են:

Վերջին մեկ-երկու տարիներին (ինչպես տարիներ առաջ) մեկ հա ցորենի մշակության համար պետությունը 80 հազար դրամ դոտացիա է տալիս գյուղացուն: Այդ դեպքում մեկ հա-ից ստացվող «շահույթը» մոտենում է 160-170 հազ. դրամի: Դիտարկումները ցույց են տալիս, որ սա էապես խթանում է ցորենի արտադրությունը: Ավելին, սուբսիդավորման բացակայության դեպքում ցորենի ցանքատարածությունները տարեցտարի պակասում են: Մինչդեռ սուբսիդավորումը ոչ միայն արգելակում է նվազման միտումը, այլև ցանքատարածությունների աճ է արձանագրում:

Մասնագիտական գնահատականներով,/՝ այդ մեկ-երկու մլրդ դրամի ներդրումը դրական միջավայր է ստեղծում տնտեսության մեջ: Հարակից ճյուղերն են սկսում ակտիվանալ, գյուղում ավելի մեծ ավելացված արժեք է ստեղծվում, յուրաքանչյուր լեռնային, սահմանամերձ գյուղում մի քանի մլն դրամի շրջանառությունը որոշակիորեն դանդաղեցնում, ինչ-որ տեղ նաև դադարեցնում է մարդկանց արտահոսքը: Յուրաքանչյուր նոր, մինչ այդ չմշակված հողակտորի մշակությունը դրական ազդեցություն է ունենում հողապաշտպանության գործում:

«Չոր ջուրը» անջրդի պայմաններում կարող է ապահովել բերքի՝ շուրջ 50 տոկոսով ավելացում, հողի կառուցվածքի բարելավում, ինչը կարևոր նախադրյալ է հետագա մշակության ու բարձր բերքի համար:

Հանրապետությունում մշակվող ցորենի ցանքատարածությունները կազմում են 55-56 հազար հա: Սրանից մոտ 40 հազար հա մշակվում է անջրդի պայմաններում: Այս դեպքում միջինում ստացվում է 1,8-2-ից մինչև 2,2-2,3 տոննա/հա բերք (40 հազար հա-ից ստացվում է շուրջ 80 հազար տոննա ցորեն): «Չոր ջրման» կիրառման դեպքում կստացվի 120 հազար տոննա, որը կազմում է պարենային ցորենի պահանջարկի 26-27%-ը: Զուտ տնտեսագիտական առումով դա կբերի 5 մլրդ դրամի հավելյալ եկամուտ: Նույնն է, թե այդքանով քիչ ներմուծում կլինի արտերկրից: Սա հնարավոր կլինի մշակվող նույն մակերեսների պարագայում: Մինչդեռ եկամուտների նման ավելացման դեպքում ցանքատարածությունները միանշանակ կավելանան, և վերոնշյալ հավելյալ եկամուտը գործնականում կարող է էապես մեծանալ: Բոլոր դեպքերում երկրի պարենային անվտանգության տեսանկյունից ցանկալի է ունենալ թեկուզև մի քիչ ավելի թանկ տեղական արտադրությու/ան ցորեն, քան փոքր-ինչ ավելի էժան, բայց՝ ներկրովի:

2023թ.-ին Հայաստան է ներկրվել 62,8 մլն դոլար արժողությամբ 343,5 հազար տոննա պարենային ցորեն և 10 մլն դոլար արժողությամբ 65,5 հազար տոննա պատրաստի ալյուր: 2024թ.-ին՝ համապատասխանաբար 60,7 մլն դոլար արժողությամբ 316 հազար տոննա պարենային ցորեն ու 10,2 մլն դոլար արժողությամբ 42.3 հազար տոննա ալյուր:

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿԱՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «PMM» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱՔԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՑԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՏՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

Ցորենի մշակվող տարածքների՝ անգամ ոչ շատ մեծացման դեպքում ներկրումները միլիոնավոր դոլարներով կպակասեն:

Հացն առաջնային անհրաժեշտության սննդամթերք է: Ելնելով երկրի անվտանգության ռազմավարական հիմնահարցերից,՝ օգտագործվող հացի գոնե կեսը պետք է արտադրվի տեղում: Մինչդեռ այսօր Հայաստանն արտադրում է իր պարենային ցորենի պահանջարկի 20%-ից էլ պակաս մասը: Արտադրվող 120-130 հազար տոննայի մի մասը/ն օգտագործվում է որպես անասնակեր: Մինչդեռ մասնագետների գնահատմամբ՝ հանրապետությունը 200-250 հազ. տոննա ցորեն արտադրելու բոլոր հնարավորություններն ունի: Հանրապետությունում ավելի քան 200 հազ. հա գյուղատնտեսական հող չի մշակվում ջուր չլինելու և ցածր եկամտաբերության պատճառով: «Չոր ջրման» դեպքում և՛ ջուրն է ապահովվում, և՛ բարձր եկամտաբերություն: Հետևաբար, 200-220 հազ. տոննայի արտադրությունը միանշանակ իրատեսական է դառնում: Այդ դեպքում հանրապետության համար զուտ տնտեսագիտական հաշվարկներով կապահովվի մինչև 8 մլրդ դրամի հավելյալ եկամուտ, ինչն էլ որոշակիորեն կխթանի լեռնային, նախալեռնային և սահմանամերձ գյուղերից արտագաղթի նվազեցման «կայունացումը»:

Եզրակացություն

1. Հողում «PMM» մելիորանտի կիրառումը զգալի ազդեցություն ունի աշնանացան ցորենի բերքատվության բարձրացման վրա: Ծաղկահովիտ համայնքի չորային պայմաններում 2024-2025 թվականներին անցկացված դաշտային ուսումնասիրությունների համաձայն՝ մելիորանտի 0,3 կգ/մ² (3 գ PMM/կգ հող) կիրառման նորմայով ձմեռային ցորենի միջին բերքատվությունը ստուգիչ ցուցանիշը գերազանցել է 48,2%-ով:
2. Նույն փորձարարական դաշտում անհրաժեշտ է իրականացնել աշնանացան ցորենի ցանք (առանց «PMM» մելիորանտի լրացուցիչ չափաքանակ ավելացնելու)՝ մելիորանտի մնացորդային ազդեցությունը բերքատվության աճի նվազման վրա գնահատելու համար (գտնվում է իրականացման փուլում):
3. Առաջարկվող ծրագրի արդյունավետությունն ապահովելու համար անհրաժեշտ է Հայաստանում հիմնել «PMM» մելիորանտի արտադրություն, ինչպես նաև հետազոտություններ անցկացնել բնական ծագում ունեցող համապատասխան (փոխարինող) պոլիմերահանքային նյութ գտնելու համար: Սա զգալիորեն կնվազեցնի օգտագործվող մելիորանտի արժեքը (տեղական փոխարինող գտնելու դեպքում՝ մի քանի անգամ):

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1. Tokmajyan V.H., Markosyan A.Kh., Khalatyan A.A., Khachatryan N.B. The Perspectives Of Providing The Storage Of Irrigation Water In The Case Of Using Water

Սարիբեկ Գալստյան, Աշոտ Մարկոսյան, Վահագն Խաչատրյան,
Արևշատ Վարպետյան, Աշոտ Խաչատրյան, Հովհաննես Թոքմաջյան

ԱՆՋՐԴԻ ԵՐԿՐԱԳՈՐԾՈՒԹՅԱՆ ՊԱՅՄԱՆՆԵՐՈՒՄ «ՔՄՄ» ՄԵԼԻՈՐԱՆՏԻ ՀՈՂ ՆԵՐՄՈՒԾՄԱՆ ՉԱՓԱԲԱՆԱԿՆԵՐԻ ԱԶԴԵՑՈՒԹՅՈՒՆԸ ԱՇՆԱՆԱՅԱՆ ՑՈՐԵՆԻ ԲԵՐՔԱՑՎՈՒԹՅԱՆ ԵՎ ԲԵՐՔԻ ԿԱՌՈՒՑՎԱԾՔԻ ՎՐԱ

(Հրատարակվել է Բարձր Տեխնոլոգիաների տեղեկագրում՝ 2025թ. N3 (35), 2025, էջ՝ 29-41)

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2. Vartanyan A.H., Shakhnazarov A.A., Tokmajyan V.H., Sarukhanyan A.A. Increase of Soil Moisture Content by Applying Polymer-Mineral Material // Bulletin of High Technology, Shushi, 2020, N1(11), pp. 3-10.

3. Vartanyan A.A., Markosyan M.V., Tokmajyan V.H., Galstyan S.B. Management of Processes of Growing Winter Crop in Rainfed Conditions Using Innovative Technological Solutions // Bulletin of High Technology, Shushi, 2020, N2 (13), pp. 3-13.

4. Avanesyan E.V. Evaluation of Accumulation of Additional Water Resources in the Substratum Available for Plants // Bulletin of High Technology, Stepanakert, 2022, N1 (19), pp. 3-9.

Հոդվածում բարձրացված խնդիրների վերաբերյալ կկազմակերպվի մասնագիտական քննարկում (ձևաչափի և ժամկետի վերաբերյալ կտրվի համապատասխան տեղեկատվություն):

Ձեր առաջարկություններն ու դիտողությունները կարող եք ներկայացնել info@bulletin.am էլեկտրոնային հասցեով:

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