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The monograph describes the theoretical and practical aspects of the development of science in Ukraine and the EU countries. There are distinguished the issues on the agricultural science, physical geography, geophysics, economic and social geography, geological sciences, applied social and communicational technologies, decorative and applied arts, etc. The publication is designed for scientists, lecturers, postgraduates, students, as well as a wide range of readers.

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CHAPTER «AGRICULTURAL SCIENCES»

STRUCTURAL MEASURES IN THE AGRICULTURAL LANDS – CONDITION AND FACTOR FOR THE FUNCTIONING OF ORGANIC AGRICULTURE IN THE REPUBLIC OF BULGARIA (BY THE EXAMPLE OF EXPERT STUDY)

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Abstract. The challenges in the agricultural sector of the Republic of Bulgaria provoke the evolutionary development and application of new approaches and new attitude towards the components of the agricultural system. The biological and conventional agricultural systems include the same elements, but their treatment of the biological system is based on current requirements for the development of environmentally friendly practices in agriculture. Organic production is an important priority in the policy for the development of the agricultural sector in the Republic of Bulgaria and one of the highlights of the common agricultural policy of the European Union for the period 2014-2020. Organic agriculture in the Republic of Bulgaria is subject to specific legislation. Integrated organic production can be defined as a model designed to optimize agricultural production by saving energy, protecting soil fertility and improving product quality. It is an alternative production model for the sustainable development of agriculture, such as the economic sector and the opportunity to put innovations at the service of sustainable agriculture, including the implementation of adequate development measures in agricultural lands intended for organic farming. The main objective of the study is to prove the role of development measures as a factor and condition in the agricultural lands designated for organic farming. For the purpose of the study, the authors chose the method of peer review.

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1. Introduction

Organic farming as a sustainable farming system dates back to the 20th century, mainly in economically developed countries such as Austria, Germany and others [2, p. 20].

Organic farming is closely linked to the landscape and the territory. In this regard, both the agricultural territories as a whole and the territories designated for organic farming are subject to specific development measures.

Sustainability of organic agriculture as a system in terms of its needs for modern infrastructure is directly dependent on the development activities.

The maintenance of soil fertility and the conservation of soil resources is also dependent on one of the varieties of development measures – reclamation.

In this regard, the subject of research in the material is the role of development measures in the agricultural lands, respectively, in the agricultural lands designated for organic agriculture as a condition and factor for the functioning of organic agriculture in the Republic of Bulgaria.

The subject of study and analysis in the material are summarized expert assessments of the development activities in the agricultural lands designated for organic farming.

For the purposes of the study – to confirm the role of development measures as a factor and condition in agricultural lands designated for organic farming, the method of expert assessments was used.

2. Organic Agriculture in the Republic of Bulgaria – Highlights

Models for conventional, integrated and organic production are more or less well-known practices. They have both similarities and differences, but in any case they represent different possibilities for food production.

Which model will the modern manufacturer choose is a matter of inner conviction and the presence of sufficient motivating factors.

In principle, models for sustainable development in agriculture are linked to the creation of agricultural systems that aim at increasing productivity, while preserving the sustainability of ecosystems. The transition to sustainable agriculture is a continuous and consistent process [4, p. 125].

The challenges in the agricultural sector provoke the evolutionary development and application of new approaches and new attitude towards the components of the agricultural system (soil, biodiversity, water and so on). The biological and conventional agricultural systems include the same elements, but their treatment of the biological system is based on current requirements for the development of environmentally friendly practices in agriculture.

In organic agriculture, soil is regarded as a dynamic system, a reservoir of nutrients. It is characteristic of organic farms that the farmer pays particular attention to the presence of a higher amount of humus (soil organic matter) where most of the nutrients are in an easily accessible plant form.

For this purpose, one specific planning event – recultivation – was required in practice.

All agricultural practices inevitably change the natural environment. Practices in the organic farming system are related to seeking to minimize the effects of impacts.

The ideal organic farm fits in with its surroundings and becomes part of the natural landscape of the area, but this could be achieved to some extent by effective landscaping on farmland.

The management and maintenance of the natural environment is carried out by rules and voluntary practices, which are adhered to by bio producers and help to improve and maintain the landscape in agricultural areas, but also by means of landscaping.

Organic production is an important priority in the policy for the development of the agricultural sector in the Republic of Bulgaria and one of the highlights of the common agricultural policy of the European Union for the period 2014-2020. Organic agriculture in the Republic of Bulgaria is also subject to specific legislation [1].

The definition of organic production under Regulation (EC) No 834/2007 is a production that involves' the use of the organic method at all stages of production (including the primary production of a biological product, its storage, processing, transport, sale or delivery of the final product consumer, and, where appropriate, labeling, advertising, import, export and subcontracting)".

As a result of the created conditions for development, by the end of 2014, the total number of food, forest, forestry, organic producers, processors and traders registered at the Ministry of Agriculture is 6 173 [5].

All this shows that in recent years, the biological sector of the Republic of Bulgaria is developing at a fast pace, and especially after 2009, organic farming has become a serious and real economic sector.

A basic principle of organic farming is that any living organism from the smallest microorganism in the soil to the largest plant is valuable.

The whole activity is aimed at maintaining and, if possible, increasing the diversity of plants and animals.

Practices that contribute to increasing biodiversity are often the result of good agricultural practices applied by organic producers and of EU rules in this regard.

Organic production is based on the following principles:

– general;

– specific.

Common principles include:

– the development and management of biological processes based on ecological systems and the use of natural resources internal to those systems through methods that: use living organisms and mechanical production methods, practice land-based cultivation of crops, animals and aquaculture in accordance with the principle for the sustainable use of resources, exclude the use of genetically modified organisms and products produced by or through genetically modified organisms and so on;

– limiting the use of external resources;

– strict limitation of the use of chemically synthesized substances;

– where necessary, adaptation of organic production provisions shall take into account health status, regional climatic differences and local conditions, stages of development and specific animal husbandry practices.

The specific principles are related to application in the following areas:

– agriculture (maintaining soil fertility, minimizing the use of non-renewable and external resources, recycling bio-waste, protecting plant and animal health, making productive decisions, while maintaining local or regional environmental balance, etc.);

– the processing of organic food (produced from organic ingredients of agricultural origin, restricting the use of nutritional supplements, organic ingredients, and the processing of food using biological, mechanical and physical methods);

– the processing of organic feed (produced from organic feed materials, limiting the use of feed additives and processing aids, feed processing using biological, mechanical and physical methods).

The conditions and procedure for support to agricultural producers in the Republic of Bulgaria who carry out agricultural activities aimed at improving environmental protection are laid down in a special ordinance for the application of the measure "Organic Agriculture" for the period 2014-2020.

During the five years of the voluntary commitment, certain basic requirements, as well as specific management requirements, must be met. In accordance with the requirements of the organic legislation, every registered bioproducer must also keep a logbook of the activities performed, the seeds, fertilizers used, the production obtained on the organic farm. In cases where, for various reasons, a logbook of the agricultural activities carried out on the holding is not kept, the State Fund for Agriculture reduces by 10% the payments to farmers.

In addition to meeting the basic and specific requirements, a good manager should also keep track of changes that have occurred in:

– the requirements for cross-compliance and the minimum requirements for fertilizing and using plant protection products. These requirements have been introduced for the first time since 2012 for farmers in the Republic of Bulgaria, in accordance with the provisions of the European Union, when the statutory management requirements are compulsory;

– the general requirements for the applicants for assistance – in accordance with the changes in the respective ordinance;

– management requirements for the selected destination.

Since 2012, a link has been made between the statutory management requirements and the direct payments received by the farmer.

Therefore, organic farmers have the advantage that they are more facilitated than other farmers in terms of cross compliance and good agricultural practices.

Therefore, every manager of an innovative farm, including a biofarm, must make greater efforts to provide timely information on the benefits of organic farming, as well as changes in national legislation in this regard.

Integrated organic production can be defined as a model designed to optimize agricultural production by saving energy, protecting soil fertility and improving product quality [3, p. 96].

It is an alternative production model for the sustainable development of agriculture, such as the economic sector and the opportunity to put innovations at the service of sustainable agriculture, including the implementation of adequate development measures in agricultural lands intended for organic farming.

3. Assessment by the method of expert assessments of development measures in agricultural lands as a condition and factor f or the functioning of organic agriculture in the Republic of Bulgaria

3.1. Hypotheses of the study. For the purpose of the study, the authors chose the method of peer review

The main argument for this choice is, first of all, the specificity of organic farming as an important, developing and prospective sub-sector of the agricultural sector.

The second argument for the choice of authors is based on the direct dependence of organic farming as a specific package of agrarian activities, on the landscaping activities on agricultural land.

In this regard, expert evaluations, in their ranking and totality, play the role of tools to confirm, prove, or reject two hypotheses:

– Hypothesis "A" – The structure of the agricultural lands and the development measures on the agricultural lands are a condition for the functioning of organic agriculture, because it is through the development measures that the basic and necessary conditions in this direction are created;

– Hypothesis "B" – The structure of the agricultural lands and the organized development activities on the agricultural lands in terms of their isolation and expediency, are a factor for the functioning and development of organic agriculture in the Republic of Bulgaria.

3.2. Profile of the experts involved in the evaluation

Capturing the expert profile of the evaluators outlines the following parameters (Figure 1):

A / Total population – 28 people

B / Age differentiation:

a / 26-30 years – 2 people – 7.14%

b / 31-36 years – 12 people – 42.86%

c / 37-42 years – 8 people – 28.57%

d / 43-48 years – 2 people – 7.14%

e / + 48 years – 4 people – 14.29%

Age differentiation of experts indicates a priority proportion of persons aged 31 to 36 years. In the second place are the persons from 37 to 42 years.

This group is followed by persons over the age of 48, and in equal shares are two age groups – from 26 to 30 years and from 43 to 48 years.

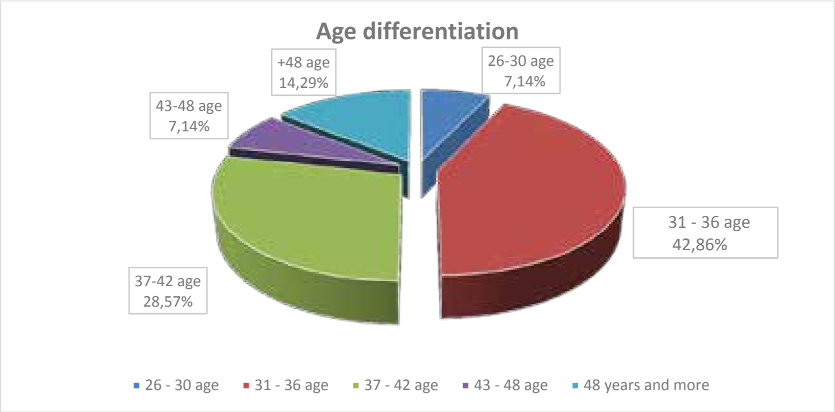

Figure 1. Age differentiation

B / Gender differentiation (Figure 2):

a / women – 13 people – 46,43%

b / man – 15 people – 53,57%

In the gender differentiation of the experts involved in the evaluation, man experts are prioritized, and women are two people less.

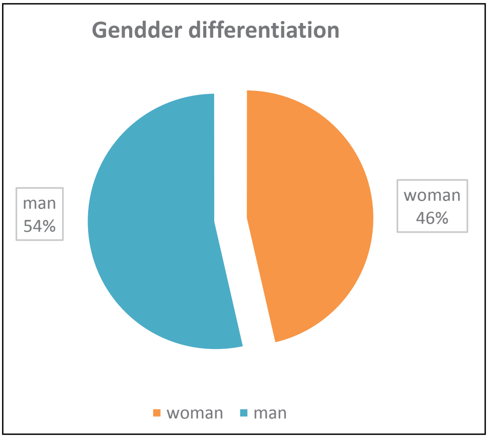

Figure 2. Gender differentiation

D / Differentiation by areas of expertise (Figure 3):

a / agrarian sciences – 4 people – 14,29%

b / development of the territory, including development of agricultural land – 9 persons – 32.14%

c / climate and climate change – 8 people – 28, 57%

d / organic farming – 7 people – 25.00%

Differentiation by area of expertise shows that the largest share is occupied by land-use experts, followed by climate and climate change experts.

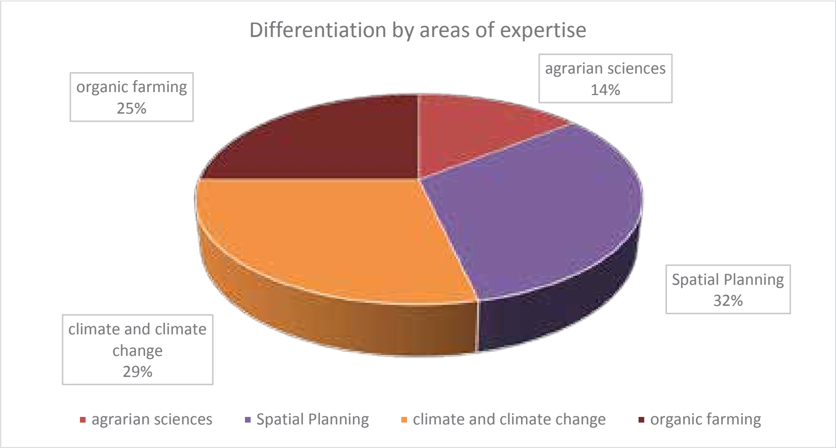

Figure 3. Differentiation by areas of expertise

E / Differentiating Exercise of Expertise in Years (Figure 4):
a / up to 5 years – 2 people – 7.14%
b / up to 10 years – 11 people – 39.28%
c / up to 15 years – 9 people – 32.14%
d / +15 years – 6 people – 21.44%

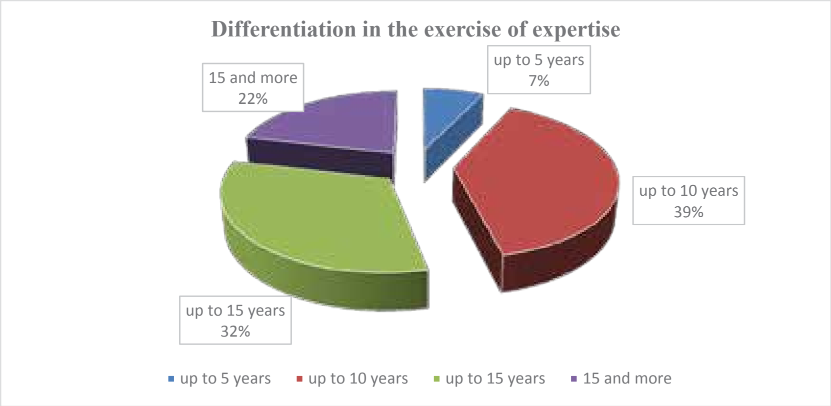

Figure 4. Differentiation in the exercise of expertise

Differentiating the exercise of expertise into years shows that the highest proportion is of experts up to 10 years, followed by experts up to 15 years and, respectively, experts of 15 and more years. Experts up to 5 years have the lowest share.

4. Expert evaluation technology

The postulates included in the expert evaluation are evaluated by experts with ratings ranging from 1 to 10 inclusive. The lowest score is 1 and the highest is 10.

Ranking in tabular form is performed on the basis of aggregated estimates.

The principle in the sequence of evaluations is from the basic issues, previously discussed with the experts and accepted by them in the proposed form, to the differentiated evaluation for the sake of completeness of the expertise.

4.1. Expert assessments

A / Factors in organic farming

The factors in organic farming can be divided into two groups:

– sustainable (factors 1);

– dynamic (factors 2).

What is the evaluation of each of these groups by experts in terms of the priority role of one or the other factor (Table 1):

The expert assessments grouped in Table 1 give rise to the following conclusions:

– Overall, despite the small difference, experts give priority to the factors of the second group, namely the dynamic factors;

– Estimates range over both groups of factors: the lowest is 2 and the highest is 10;

– Neither of the proposed estimates has a priority for both groups of factors – does not exceed 50%;

– It can be noted that both groups of factors are evaluated in parallel by experts, which means that they do not make a strict distinction between the two groups of factors and their role.

The experts agreed that the package of sustainable factors includes the following inter-structural elements:

– the common agricultural policy of the European Union, including the policy on organic farming;

Table 1

Grouping of factors in organic farming

Expert № Factors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
Factors 1	6	7	10	9	5	8	4	10	7	9	6	3	8	10	4	2	10	8	7	5	9	10	8	4	3	10	9	7	198
Factors 2	8	10	5	9	7	6	7	10	9	8	5	4	9	7	10	3	9	6	5	2	7	8	10	5	9	4	8	10	200
Total	14	17	15	18	12	14	11	20	16	17	11	7	17	17	14	5	19	14	12	7	16	18	18	9	12	14	17	17	398

Table 2

Priority of intra-structural elements

Expert № / Element №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
Element № 1	8	7	10	9	5	8	4	10	7	9	6	5	8	10	4	3	10	8	7	6	9	10	8	4	5	10	9	7	206
Element № 2	9	10	5	9	7	6	7	9	9	8	5	6	9	7	10	5	9	6	5	4	7	8	10	5	9	7	8	10	209
Element № 3	4	7	5	8	10	4	10	10	6	7	10	7	7	7	4	5	9	4	10	7	6	8	8	9	10	4	7	7	200
Total	21	24	20	26	22	18	21	29	22	24	21	18	24	24	18	13	28	18	22	17	22	26	26	18	24	21	24	24	615

– the legislation of the Republic of Bulgaria;

– The natural-geographical complex of the Republic of Bulgaria.

Each of these elements was evaluated as follows (Table 2):

The expert assessments, grouped in Table 2, justify the following conclusions:

– In summary, the highest ranking in the ranking of results is element No 2 – the legislation of the Republic of Bulgaria;

– In the second place, the evaluating experts rank element No1, namely the common agricultural policy of the European Union, including the policy on organic farming;

– In the third place in the ranking of experts – evaluators, is element No 3, namely the nature and geographical complex of the Republic of Bulgaria;

– Expert estimates for element No 1 range from 3 to 10, and for element No 2 and element No 3 range from 4 to 10;

– When evaluating element No 1, most experts give ratings 10 and 8;

– When evaluating element No 2, most experts give ratings 9, 7 and 5;

– When evaluating element No 3, most experts give ratings 7 and 10;

Structural measures on agricultural land belong to the dynamic factors in organic farming because they reflect the dynamic needs of the sub-sector.

The level of interaction in such dynamics is assessed by the experts on the principle of rights and the feedback between them (Table 3):

The expert assessments grouped in Table 3 give rise to the following conclusions:

– Overall, with higher ranking in the ranking of the results, is connection No 2 – the feedback between the development activities and organic farming;

– Secondly, cumulatively, the evaluating experts ranked connection No 1, namely the right connection between development activities and organic farming;

– Ratings are in the range of both connections of the lowest grade 5 and the highest 10;

– Neither of the proposed assessments has priority in the two connections – it does not exceed 50%, but most experts give a rating of 5 and a rating of 10;

– It can be noted that both connections are also evaluated in parallel by experts, which means that they do not make a strict distinction here between the two connections and their role.

Table 3

Rights and feedback between development activities and organic farming

Expert № / Connection №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
Connection № 1 (right)	7	7	10	9	5	8	5	10	7	9	6	5	8	10	6	5	10	8	7	5	9	10	8	5	6	10	9	7	211
Connection № 2 (the pposite)	8	10	6	9	7	6	7	10	9	8	5	6	9	7	10	5	9	6	5	8	7	8	10	5	9	5	8	10	212
Total	15	17	16	18	12	14	12	20	16	17	11	11	17	17	16	10	19	14	12	13	16	18	18	10	15	15	17	17	423

Table 4

Priority of the intra-structural elements

Expert № / Element №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
Element № 1	8	9	10	9	5	8	6	10	7	9	6	5	8	10	7	5	10	8	7	6	9	10	8	6	8	10	9	7	220
Element № 2	9	10	8	9	7	6	7	9	9	8	7	6	9	7	10	7	9	6	8	6	7	8	10	7	9	7	8	10	223
Element № 3	9	7	8	8	10	9	10	10	9	7	10	7	7	7	9	7	9	8	10	7	6	8	8	9	10	8	7	7	231
Total	26	26	26	26	22	23	23	29	25	24	23	18	24	24	26	19	28	22	25	19	22	26	26	22	27	25	24	24	674

The package of development measures in agricultural lands intended for organic farming includes the following inter-structural elements:

– recultivation of agricultural land intended for organic farming;

– construction of agricultural infrastructure;

– renovation of existing agricultural infrastructure.

Each of these elements was evaluated as follows (Table 4).

The expert assessments grouped in Table 4 give rise to the following conclusions:

– Overall, the highest ranking in the ranking of results is element No 3 – renovation of the existing agricultural infrastructure;

– Secondly, in total, the valuation experts rank element No 2, namely construction of agricultural infrastructure;

– Third in the ranking of experts – valuers is element No 1, namely recultivation of agricultural land intended for organic farming;

– Expert estimates for element No 1 range from 5 to 10, and for element No 2 and element No 3 range from 6 to 10;

– When evaluating element No 1, most experts give ratings 10 and 8;

– When evaluating element No 2, most experts give ratings 7 and 9;

– When evaluating element No 3, most experts give ratings of 7 and an equal number of experts give ratings of 8.9 and 10;

B / Solutions concerning development activities in agricultural land intended for organic farming.

Based on the ranking of expert assessments, it is also proposed to evaluate the need for a dynamic plan for some large-format solutions affecting development activities in agricultural lands intended for organic farming, namely:

– Some improvements and additions to the legislative package for developmental events;

– Adopt and implement cutting-edge practices for bio-agricultural infrastructure related to global climate change;

– Implementation of elements of flexibility and innovation in the management of development activities in agricultural land intended for organic farming.

Expert assessments of the needs for solutions are arranged as follows

The expert assessments, grouped in Table 5, give the following conclusions.

Table 5

Solution needs

The solution № \ Expert №	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	Total
The solution № 1	8	9	10	9	7	8	9	10	7	9	6	9	8	10	7	9	10	8	7	6	9	10	8	9	8	10	9	7	236
The solution № 2	10	10	8	9	8	7	7	9	9	8	7	6	9	10	10	7	9	7	8	9	7	8	10	8	9	10	8	10	237
The solution № 3	9	9	8	8	10	9	10	10	9	8	10	8	9	8	9	8	9	8	10	9	7	8	8	9	10	8	9	10	247
Total	27	28	26	26	25	24	26	29	25	25	23	23	26	28	26	24	28	23	25	24	23	26	26	26	27	28	26	27	720

– Overall, the highest ranking in the ranking of the results is solution No 3 – introduction of elements of flexibility and innovation in the management of development activities in agricultural lands intended for organic farming;

– Secondly, in total, the evaluating experts rank solution No 2, namely the adoption and implementation of avant-garde practices for bio-agricultural infrastructure related to global climate change;

– Third in the ranking of expert evaluators is solution No 1, namely some improvements and additions to the legislative package for developmental events;

– Experts' estimates for solution No. 1 and solution No. 2 range from 6 to 10 and for solution No. 3 range from 7 to 10;

– When evaluating decision No 1, most experts give a rating of 9, and an equal number of experts give a rating of 8 and a rating of 10;

– When evaluating solution No 2, most experts give grades 8, 9 and 10;

– When evaluating solution No 3, most experts give grades 8 and 9;

5. Conclusions based on ranked peer reviews

With respect to the objectives of the study, the results of the rankings of the peer reviews confirm the truth of hypothesis "A" and hypothesis "B", namely:

– Hypothesis "A":

The organization of agricultural lands and development measures on agricultural lands are a condition for the functioning of organic agriculture, because it is through development activities that the basic and necessary conditions in this direction are created.

Structural measures on agricultural lands and their accompanying conditions and actions are subjective in nature, but also legal justification, knowledge of which is a condition for the effective implementation of legal regulations, while their lack of knowledge or lack of knowledge, hinders and impairs the expected and pursued results of the implementation of the development activities.

– Hypothesis "B":

The structure of the agricultural lands and the organized development activities on the agricultural lands in terms of their isolation and expediency are a factor for the functioning and development of organic agriculture in the Republic of Bulgaria.

In connection with hypothesis "A" and as a continuation of its probative force, hypothesis "B" for the role and sustainable transformation of developmental measures on agricultural lands intended for organic farming is a necessary and permanently present instrument of agronomy, given their necessary role in providing the conditions for a number of processes in the agricultural sector, including in organic farming, to ensure their sustainability.

6. Conclusion

It is important to understand that the agrarian sector, respectively organic agriculture of the Republic of Bulgaria, is closely related not only to the economic and social processes in society, but also to two very important circumstances:

– environmental processes, including severe climate change;

– development activities in agricultural lands, including in lands designated for organic farming.

In this regard, agrarian management and legislation should focus their efforts in the interest of the sustainability of the agrarian sector, respectively on organic farming in the following areas:

– active and sustainable management of natural resources as a key tool in the search for solutions to the increasingly difficult production conditions and in reducing the effects of climate change;

– the achievement of such active management of resources, especially of soil resources and not only of them, is impossible without active, adequate, prospective development measures in agricultural lands, including agricultural lands designated for organic farming.

There are several options for successful solution to these problems and for the quality growth of the sector, but the optimum effect would only be achieved if the traditional organic farming is properly combined.

The main objective for the agricultural sector, respectively for organic farming, should be to create an intensive rather than extensive development model.

This calls for the creation and implementation of new technologies and approaches, including in spatial planning, and the ultimate goal should be the transition to integrated organic farming.

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INFLUENCE OF THE BASIC TO CULTIVATION OF THE SOIL, TERM AND A WAY OF SOWING ON ELEMENTS OF FERTILITY OF THE SOIL AND PRODUCTIVITY OF COLZA WINTER

ВПЛИВ ОСНОВНОГО ОБРОБІТКУ ГРУНТУ, СТРОКУ ТА СПОСОБУ СІВБИ НА ЕЛЕМЕНТИ РОДЮЧОСТІ ГРУНТУ І ПРОДУКТИВНІСТЬ РІПАКУ ОЗИМОГО

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Abstract. The article highlights the importance of soil cultivation in the modern period of management, shows the influence of different methods and depth of processing on the moisture content in the soil, weeds and crop yields, in particular, the value of the two main methods of soil cultivation relative to their influence factor on the yield of winter rape. The importance of soil fertility and the content of organic matter in it and the provision of plants with moisture and water-physical properties of the soil, which is especially important when climatic conditions change, is substantiated. These indicators are significantly influenced by measures of basic tillage, which is also covered in the article. The study was conducted during 2012-2015 on ordinary Chernozem to determine the measures of basic tillage. The culture was sown on the background of traditional plowing at 25-27 cm and disking, which was carried out to a depth of 12-14 cm, depending on the method of basic tillage and its depth, the main agrophysical properties of the soil, in particular, the density of addition, the content of mobile nutrients during the vegetation of winter rape plants, were investigated. It is determined that the studied factors, taken for study, significantly affect the availability and distribution in the soil layers of mobile compounds of nitrogen, phospho-

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rus, potassium. The main water-physical and agrochemical properties of the soil, in turn, affect the level of yield of winter rape seeds and individual indicators of its quality. Based on the background of two methods of basic tillage, the optimal sowing time and row spacing were studied in the cultivation of winter rape. Under the influence of all factors and weather conditions of the growing season, the yield of seeds changed. It is established that the productivity of the studied culture is most affected by the sowing period and less it depends on the tillage and row spacing. These factors affected the content of fat and protein in winter rape seeds and their conditional collection (output) per unit area. The highest protein content in the seeds and its oiliness, as well as their conditional fee for sowing in the i decade of September with a width of 15 cm row spacing. Later planting and increasing the row spacing to 30 and 60 cm led to a decrease in both the yield level and the deterioration of the main indicators of the quality of winter rape seeds.

1. Вступ

Відомо, що в останні роки родючість основних типів ґрунтів України потерпає змін, що пов'язані як з особливостями господарювання, добором елементів технології у вирощуванні сільськогосподарських культур, застосуванням добрив, зокрема недостатнім внесенням органічних, так і зі зміною клімату. Зокрема, збіднення ґрунтів на органічну речовину дуже сильно послаблює їх здатність накопичувати, утримувати вологу в ґрунті та ощадливе її використання рослинами. І навпаки, якщо органіки міститься достатньо, волога утримується в ґрунті та ефективно використовується рослинами на формування врожаю, а не на непродуктивні втрати через надмірне випаровування [1]. Залежно від умов, що склалися нині зі станом родючості грунтів і в першу чергу з їх структурно-агрегатним складом та здатністю поглинати й утримувати вологу, чільне місце посідає обробіток грунту, добір культур у сівозміні і головне систематичне поповнення грунту органічною речовиною [2]. За оптимізації усіх зазначених факторів, процеси деградації посилюватись не будуть, а навпаки, основні показники родючості залишаться на постійному рівні, стабільними у т.ч. не буде зменшуватись вміст гумусу, основних елементів живлення тощо. Основний обробіток грунту при цьому за впливом на елементи родючості грунту та продуктивність сільськогосподарських культур посідає чільне місце, його дослідження є виключно актуальними, а зі зміною кліматичних умов практично першочерговими. Проте в останні роки немає чіткої думки вчених щодо ефективності добору кращого способу основного обробітку грунту як у системі сівозмін, так і під окремі сільськогосподарські культури. Окремі дослідники вважають за доцільне переходити до більш мілких (поверхневих) способів обробітку грунту, інші пропонують проводити традиційні системи обробітку грунту, прийняті й рекомендовані для зони, а більшість дослідників вважають найбільш оптимальним використовувати диференційовану різноглибинну систему основного обробітку грунту за чергування глибоких і мілких способів грунту залежно від сільськогосподарської культури, стану грунту і погодних умов року. Тобто у теперішній час відсутня єдина думка щодо правильності добору способу і технічного знаряддя для того чи іншого заходу обробітку грунту. До того ж раніше за дотримання науково обгрунтованого чергування сільськогосподарських культур у сівозміні, за високої та середньої забезпеченості грунту органічною речовиною і NPK, на обробіток грунту в структурі сформованого рівня врожаю припадало лише 4-5 % впливу від усіх факторів, а за сучасних умов ця частка істотно зростає й особливо за посилення посушливості.

2. Властивості грунту під впливом заходів його обробітку

Сприятливі умови для життєдіяльності рослин створюються за оптимізації усіх факторів у т.ч. й за створення відповідної щільності ґрунту, яка в свою чергу впливає на поживний, водний і повітряний режими, тобто від щільності зложення значною мірою залежить забезпеченість рослин вологою, елементами живлення та повітрям і в кінцевому підсумку рівень їх урожайності.

В останні роки в землеробстві швидко зростає енергоозброєність сільського господарства, що створює необмежені можливості для інтенсифікації та оптимізації основних заходів обробітку ґрунту. Проте досвід і практика показують, що в багатьох випадках з посиленням інтенсивності обробітку все частіше проявляються негативні наслідки. Перш за все істотно зростають грошові витрати на його виконання, (адже в структурі витрат на вирощування обробіток ґрунту займає вагоме місце), які не завжди супроводжуються підвищенням урожайності, до того ж під впливом окремих заходів обробітку пришвидшується і посилюється мінералізація гумусу, ґрунт може розпилюватись, зменшується його стійкість проти ерозії. Відомо, що кожен прохід трактора і ґрунтообробних знарядь призводить до переущільнення ґрунту, що негативно впливає на якість наступних обробітків та врожайність сільськогосподарських культур [3].

За даними ряду авторів, визначено, що тривале застосування мілкої оранки, безполицевого обробітку і особливо дискування, сприяє диференціації орного шару грунту за твердістю і щільністю. Як правило, ці показники в шарі ґрунту 0–10 см зменшуються, а у глибших шарах 10–20 і 20–30 см, порівняно з оранкою збільшуються.

Теоретичною основою мінімізації обробітку слугують досягнення в галузі агрофізики ґрунту. У багатьох випадках рівноважна щільність не виходить за межі оптимальної, а розпушування ґрунту не завжди сприяє збереженню в ньому вологи [4; 5]. Загально визнаною є думка, що надмірна щільність погіршує водний і повітряний режими ґрунту, стає механічною перешкодою на шляху розвитку кореневої системи рослин, що особливо сильно проявляється за зростання посушливості клімату.

Набагато раніше проведено багато досліджень щодо вивчення реакції сільськогосподарських культур на щільність орного шару ґрунту. І.Б. Ревут зі співавторами узагальнюючи літературний матеріал, роблять висновок про те, що реакція рослин на щільність будови ґрунту носить зональний характер [6].

В останні десятиліття в більшості регіонів України все частіше з метою економії ресурсів різні заходи у т.ч. й основний обробіток грунту спрямовують у сторону мінімалізації, враховуючи при цьому ґрунтово-кліматичні умови, кількість післяжнивно-кореневих залишків попередньої культури, фітосанітарний стан посіву тощо [7; 8]. В окремих випадках науковці рекомендують використовувати навіть мульчувальний обробіток ґрунту, який залежно від умов може бути ефективним [9].

З метою зменшення енергетичних витрат досліджують і пропонують використовувати під різні сільськогосподарські культури замість традиційного полицевого безполицевий за різної глибини, пропонують поєднувати поверхневі мілкі, звичайні та глибокі полицеві і безполицеві способи обробітку ґрунту. Вказані способи звичайно ж мають як певні переваги, так і недоліки, адже якість обробітку залежить від багатьох факторів, і перш за все стану ґрунту (рівня його зволоження, вмісту органічної речовини) та конкретних кліматичних умов [10; 11; 12]. Ряд дослідників, провівши тривале вивчення і порівняння щодо ефективності заходів основного обробітку грунту, дійшли висновку про необхідність його диференціації, зокрема, оптимальною у сприятливі за зволоженням роки визначено оранку, а за посушливих умов краще застосовувати поверхневий обробіток ґрунту [8; 13; 14].

Урожайність ріпака залежно від факторів вирощування. За традиційних технологій вирощування ріпаку озимого, рівень урожайності коливається в досить широких межах. У середньому, по Україні врожайність цієї культури становить 1,73 т/га, а в окремих господарствах 3,0-3,5 т/га. Хоча для Європи врожайність ріпаку в 3,5-4,0 т/га є звичайною.

Вплив основного обробітку ґрунту на врожайність польових культур носить різнобічний, складний характер. Обумовлюється це багатьма агрофізичними показниками ґрунту, біологічними особливостями сорту чи гібриду, агротехнічними умовами вирощування культур про що ми зазначали.

У науковій літературі немає єдиної думки щодо впливу різних систем основного обробітку грунту на врожайність насіння ріпаку озимого. У вчених і виробничників існує декілька думок. Більшість з них дотримуються думки, що кращим є традиційний обробіток ґрунту – оранка, разом з тим в останні роки зростає кількість прихильників безполицевого обробітку, який, порівняно з оранкою є менш енерговитратним.

Як відомо з наукової літератури, традиційна технологія вирощування ріпаку базується на оранці, завдяки чому забезпечується безперешкодний розвиток стрижневого кореня рослини.

До того ж відомо, що на початкових фазах росту і розвитку ріпак не витримує конкуренції з бур’янами. Забур’яненість посіву в осінню вегетацію призводить до надмірного виносу точки росту над поверхнею грунту, слабкішого розвитку кореневої системи, що збільшує ризик вимерзання ріпаку озимого і призводить у подальшому до формування низької врожайності таких посівів [15; 16]. Встановлено, що за умов оптимізації живлення та недопущення зрідження посівів уміст цукрів у коренях рослин ріпаку накопичується більш високим та забезпечує сприятливу перезимівлю [17].

Часто складні кліматичні умови, в першу чергу недостатня кількість вологи на період підготовки ґрунту під сівбу ріпаку озимого та збільшення посівних площ під цією культурою, вимагають добору у застосуванні різних систем мінімального, так званого безполицевого, обробітку ґрунту.

Як відомо, ріпак озимий вважають холодостійкою культурою. Він здатен витримувати температури до -21°С, а за наявності снігового покриву 5-10 см деякі сорти не гинуть навіть при t -31°С. Дослідниками встановлено, що рослини ранніх строків сівби часто переростають в осінній період і за зиму вимерзають за відсутності або при незначному сніговому покриві, а пізніх – не встигають достатньо розвинутися і також гинуть. Саме недотримання оптимального строку сівби призводить до недобору 30-50 % урожаю [18]. Одним, із елементів технології вирощування, який здатен забезпечити високу продуктивність агроценозів ріпаку озимого, є оптимальний строк сівби. Це набуває актуальності в останні роки за зміни основних показників родючості грунтів, кліматичних умов і зростання посушливості.

Наведений аналіз щодо ефективності обробітку ґрунту пересвідчує нас, що єдиної думки і рекомендації застосування конкретного заходу його під певну сільськогосподарську культуру, зокрема і ріпак озимий, не існує. Необхідно вивчати вплив існуючих способів обробітку ґрунту для конкретної зони, умов року вирощування, виду культури, характеристики показників родючості ґрунту тощо з тим, щоб його удосконалити і визначитись, якому заходу чи системі обробітку за конкретних умов надати перевагу. Це іще раз пересвідчує актуальність напряму досліджень.

3. Матеріали і методи проведення досліджень

Мета досліджень полягала у визначенні більш ефективного способу основного обробітку ґрунту під ріпак озимий – традиційної оранки на 25-27 см або дискування на 12-14 см, його вплив на щільність зложення чорнозему звичайного, забезпеченість грунту рухомими елементами живлення, вплив на формування урожайності і якості насіння культури у роки вирощування.

Зважаючи, що спосіб основного обробітку грунту впливає на основні агрофізичні показники й перш за все накопичення вологи в грунті та у зв'язку зі зміною кліматичних умов, важливим елементом у технології вирощування ріпаку озимого є визначення найбільш оптимального строку сівби і ширини міжрядь. Ці фактори ми також включили в програму дослідження.

Дослідженнями передбачали встановити вплив факторів обробітку грунту на щільність зложення чорнозему, вміст у ньому рухомих NPK, рівень урожайності та якості насіння залежно від розробки та удосконалення елементів технології вирощування, зокрема від способу обробітку грунту під ріпак озимий сорту Чемпіон України в умовах південного Лісостепу України з метою отримання високої врожайності та якісного насіння за позитивного впливу на щільність грунту й окремі показники його родючості. Польові досліди проводили на чорноземі звичайному згідно методики польових дослідів та методичних рекомендацій.

У трифакторному польовому досліді вивчали вплив способу основного обробітку грунту на окремі показники його родючості, ріст, розвиток і формування продуктивності рослин ріпаку озимого залежно від обробітку ґрунту, а також інших важливих елементів технології – строку і способу сівби, які зі зміною клімату потребують уточнення та удосконалення.

Дослід закладено методом розщеплених ділянок у відповідності з методикою польових дослідів з вивчення агротехнічних прийомів вирощування сільськогосподарських культур. Повторність досліду чотириразова. Площа посівної ділянки – 80 м^2, облікової – 50 м^2. У досліді висівали районований сорт ріпаку озимого Чемпіон України. Попередником його була пшениця озима.

4. Зміна властивостей грунту під впливом способу і глибини обробітку

Використовуючи щільність складення як діагностичний показник при застосуванні того чи іншого способу обробітку ґрунту рекомендується зіставляти рівноважну щільність для конкретного типу ґрунту з оптимальними її параметрами для рослин. Невідповідність цих величин вказує на необхідність добору заходу обробітку ґрунту, прийоми і способи якого повинні визначатись біологічними особливостями вирощуваної культури.

Нами були проведені визначення щільності складення орного шару за різних прийомів основного обробітку ґрунту в основні періоди вегетації ріпаку озимого, результати яких наведені в таблиці 1.

Щільність складення 0-30 см шару ґрунту після збирання попередника ріпаку озимого, коливалася у роки досліджень від 1,38 г/см^3 до 1,41 г/см^3. В результаті проведення основного обробітку ґрунту щільність складення всіх варіантів досліду знизилася, однак зміна цього показника більшою мірою залежала від способу основного обробітку та його глибини. Більш рихле складення ґрунту забезпечувала оранка, яку проводили на 25-27 см. У середньому щільність складення 0-30 см шару ґрунту у цьому варіанті в фазу сходів ріпаку становила 1,16 г/см^3. На ділянках, оброблених дисковою бороною, на глибину 12-14 см, вона була більшою порівняно з варіантами оранки на 0,12 г/см^3.

Таблиця 1

Динаміка щільності складення ґрунту на посівах ріпаку озимого залежно від способу його обробітку, г/см^3 (середнє за 2013-2015 рр.)

Шар ґрунту, см	**Обробіток ґрунту**	
	оранка	**дискування**
Сходи		
0-10	1,05	1,08
10-20	1,16	1,34
20-30	1,28	1,41
0-30	1,16	1,28
Стеблування		
0-10	1,12	1,24
10-20	1,30	1,39
20-30	1,35	1,44
0-30	1,26	1,36
Цвітіння		
0-10	1,24	1,25
10-20	1,39	1,41
20-30	1,41	1,44
0-30	1,35	1,37
Повна стиглість насіння		
0-10	1,14	1,17
10-20	1,23	1,40
20-30	1,26	1,44
0-30	1,21	1,34

Аналогічні результати отримали й інші автори, що присвятили свої дослідження заходам основного обробітку грунту та визначенню цього показника [19].

Під впливом осінньо-зимових опадів спостерігали ущільнення ґрунту. Причому, незалежно від прийому основного обробітку в більшій мірі до ущільнення мав схильність верхній (0-10 см) шар ґрунту. У середньому, 0-30 см шар до фази стеблування у варіанті з оранкою ущільнився на 0,1 г/см3, а за дискування на 0,08 г/см3. Нашими дослідженнями встановлено, що орний шар грунту істотніше ущільнюється в осінньо-зимовий і ранньовесняний періоди.

Незначне ущільнення ґрунту в усіх варіантах досліду спостерігали до фази цвітіння ріпаку озимого, що частково відбувалося й під впливом атмосферних опадів. У цей період спостерігали деяке нівелювання відмінностей у щільності складення ґрунту за варіантами досліду.

Таким чином, проведення оранки на глибину 25-27 см під посіви ріпаку озимого сприяє зменшенню щільності складення ґрунту, внаслідок чого покращує умови для життєдіяльності рослин – сприяє оптимальному розвитку кореневої системи, покращує водний, поживний та повітряний режими ґрунту.

Основним джерелом елементів живлення для рослин є ґрунт. Рівень родючості грунту вважають визначальним фактором одержання високих і сталих урожаїв сільськогосподарських культур. Це явище не є постійним, у деяких випадках воно динамічне, а в оброблюваних ґрунтах ця динаміка безперервна. Численні наукові дані щодо впливу тривалого застосування різних систем основного обробітку на поживний режим ґрунту є суперечливими.

Порівняно зі щорічною оранкою довготривалий безполицевий обробіток призводить до збільшення вмісту рухомого фосфору та обмінного калію у верхній частині орного шару грунту і значного їх зменшення в нижній [20].

З метою усунення диференціації орного шару грунту за родючістю та підвищення його мікробіологічної активності ряд дослідників дійшли висновку про доцільність періодичного чергування полицевих і безполицевих обробітків грунту [21; 22].

Ріпак озимий здатен розвивати велику кореневу систему та накопичувати значну надземну біомасу, тому він засвоює з ґрунту багато елементів живлення. Для створення однієї тонни насіння він виносить із ґрунту: азоту – 45-80 кг, фосфору – 18-40 кг, калію – 25-100 кг, кальцію – 30-150 кг, магнію – 5-15 кг, сірки – 30-45 кг [23].

Поживний режим ґрунту багато в чому залежить від способу основного обробітку ґрунту. Оранка порівняно з дискуванням призводить до значного посилення мінералізації органічної речовини і збільшує ефективність використання елементів мінерального живлення [24].

Разом з тим, при проведенні основного обробітку ґрунту з обертом пласта, через активну нітрифікацію і подальшу денітрифікацію, відбувається втрата азоту [10]. За безвідвальних обробітків цей процес відбувається в анаеробних умовах, що сприяє збагаченню ґрунту елементами живлення.

Наші дослідження підтверджують вплив прийомів основного обробітку ґрунту під ріпак озимий на його поживний режим.

Проведеними дослідженнями в умовах природного зволоження, нами встановлено, що вміст нітратів у ґрунті змінювався на протязі вегетаційного періоду ріпаку озимого (табл. 2).

Таблиця 2

Вміст нітратів у ґрунті під посівами ріпаку озимого, мг/кг ґрунту (середнє за 2013-2015 рр.)

Шар ґрунту, см	Фаза росту та розвитку рослин			
	сходи*	весняна розетка	цвітіння	молочна стиглість насіння
Дискування на 12-14 см				
0-30	2,29	28,6	11,1	15,7
30-50	1,12	14,7	4,7	7,1
0-50	1,82	23,0	8,5	12,3
Оранка на 25-27 см				
0-30	2,34	30,8	2,7	16,1
30-50	1,09	15,3	5,5	7,6
0-50	1,84	24,6	9,8	12,7

*середнє за 2012-2014 рр.

Визначено, що незалежно від прийому основного обробітку ґрунту, максимальна кількість нітратів містилася у фазу утворення весняної розетки. У подальшому, у фазу цвітіння, спостерігали зниження вмісту нітратів у ґрунті, що співпадає з періодом максимального споживання азоту рослинами ріпаку. У фазу молочної стиглості насіння через відмирання дрібних коренів і часткової їх мінералізації відбувається незначне підвищення вмісту нітратів у орному і підорному шарах ґрунту 0-50 см.

Проведення оранки сприяло посиленню процесів нітрифікації і супроводжувалося більшим накопиченням нітратів у шарі ґрунту 0-50 см порівняно з дискуванням. У цьому варіанті досліду їх вміст у період вегетації рослин ріпаку озимого був на 0,02-0,16 мг/100 г ґрунту більшим порівняно з посівами, де проводили дискування.

Пояснюється це тим, що у фазу весняної розетки більша частина нітратів витрачалась на відновлення відмерлої вегетативної маси, через що їх вміст у ґрунті зменшувався. У фазу цвітіння рослини формували значну надземну масу, що й спричинило відповідно більше використання нітратів із ґрунту. До кінця вегетації споживання азоту рослинами знижується і вміст нітратів у ґрунті за варіантами досліду вирівнюється.

У рослинах фосфору міститься значно менше, ніж азоту. Однак забезпеченість рослин цим елементом живлення потребує не меншої турботи, ніж азотом. Особливо важливою обставиною, яка ускладнює живлення рослин фосфором, є низька його розчинність та рухомість у грунті. Фосфор за внесення в ґрунт у формі розчинних мінеральних добрив, швидко переходить в слабко- і важкорозчинні форми за взаємодії, перш за все, з карбонатами кальцію, утворюючи тризаміщений фосфат кальцію, який слабко розчиняється за нейтрального середовища ґрунтового розчину.

Доступність рослинам фосфатів ґрунту залежить, перш за все, від оптимізації умов для мікробіологічної активності ґрунту, шляхом створення відповідної аерації і підвищення вологозабезпеченості внаслідок структуроутворення і розпушування ґрунту, внесення органічних добрив. Особливість забезпечення рослин фосфором за різних способів обробітку грунту пов’язана з перерозподілом рухомих фосфатів у межах шару, що обробляється.

Акумуляція рухомого фосфору в 0-10 см шарі пов’язана з локалізацією в ньому добрив, а також з тим, що фосфати контактують з меншим об’ємом ґрунту і тому менше фіксуються абсорбуючим комплексом [21].

Гетерогенність орного шару ґрунту у відношенні до фосфору вважають позитивним явищем, тому що за цього покращуються умови живлення, особливо на початку вегетації рослин, коли з верхнього шару рослини використовують у 10 разів більше фосфору, ніж з нижнього шару ґрунту [22].

Нашими дослідженнями встановлено, що на початку вегетації ріпаку озимого в шарі ґрунту 0-50 см більша кількість рухомого фосфору містилася за проведення оранки на 25-27 см (табл. 3).

У варіантах з проведенням дискування ґрунту на 12-14 см цей показник був меншим на 1,72 мг/кг ґрунту. У подальшій вегетації відмінності у вмісті рухомого фосфору в ґрунті за обох способів його обробітку вирівнюються і вже у фазу молочної стиглості насіння вони були неістотними.

Таблиця 3

Вміст рухомого фосфору у ґрунті під посівами ріпаку озимого, мг/кг ґрунту (середнє за 2013-2015 рр.)

Шар ґрунту, см	**Фаза росту та розвитку рослин**	
	Сходи	**Молочна стиглість насіння**
Дискування на 12-14 см		
0-30	47,2	39,9
30-50	21,8	18,2
0-50	33,9	29,0
Оранка на 25-27 см		
0-30	42,4	33,9
30-50	38,7	29,0
0-50	41,1	31,5

Найбільшим зниження вмісту рухомих фосфатів упродовж вегетації було визначене в грунті варіанта з проведенням оранки – 9,6 мг/кг ґрунту, що лише на 0,05 мг/кг ґрунту перевищило варіант з дискуванням.

5. Вплив досліджуваних факторів формування врожаю і якості насіння ріпаку озимого

Проведені нами дослідження з визначення рівня врожайності насіння свідчать, що в середньому за три роки посіви ріпаку озимого за поверхневого обробітку ґрунту (дискування на 12-14 см) за рівнем урожайності поступались посівам, під які проводили оранку на 25-27 см: зібрано 3,2 т/га та 3,4 т/га відповідно.

Нами визначено, що врожайність насіння ріпаку істотно залежала і змінювалась під впливом погодних умов, що склались у роки досліджень. Дискування на глибину 12-14 см призводило до її зниження у сухі роки, а у вологі роки вона формується на такому ж рівні як і за проведення типового основного обробітку грунту – оранки. Так, у сприятливому за зволоженістю 2013 р. перевагу мали посіви по фону безполицевого обробітку ґрунту, за якого врожайність насіння склала 3,3 т/га. Проте у 2014 та 2015 рр. у варіантах з оранкою на 25-27 см порівняно з дискуванням на 12-14 см посіви ріпаку озимого сформували врожайність насіння на 12,9-22,6% вищу.

Оранка на глибину 25-27 см забезпечила покращення водного режиму ґрунту за рахунок акумуляції осінньо-зимових опадів, про що ми вже зазначали. Крім того, за кращої структури ґрунту на глибині його обробітку, а саме за оранки зменшувались непродуктивні втрати вологи на стік та непродуктивне випаровування. Як наслідок, створюються більш сприятливі умови для росту й розвитку рослин ріпаку в осінній період, що забезпечує значний приріст урожайності порівняно з дискуванням на 12-14 см. Тобто вплив основного обробітку ґрунту на врожайність насіння ріпаку озимого, головним чином, залежить від природно-кліматичних умов у період вегетації культури, і значно менше від способу підготовки основного обробітку ґрунту.

Результатами досліджень встановлено, що строки сівби істотно впливали на насіннєву продуктивність ріпаку. Так, у середньому за роки досліджень, за сівби у I декаду вересня врожайність насіння склала 4,0 т/га. За сівби у II та III декади вересня вона знижувалась на 15,0% і 40,0% та відповідно становила 3,4 т/га і 2,4 т/га (рис. 1). Таку ж закономірність встановлено і за роками досліджень.

Максимальну врожайність насіння у досліді – 4,3 т/га, незалежно від вивчаємих факторів, отримали за сівби у I декаду вересня у сприятливому за природно-кліматичними показниками 2015 році.

Погодні умови холодної пори 2012-2013 рр. виявилися надто складними для перезимівлі рослин ріпаку озимого. Як насідок, урожайність насіння на посівах останнього строку сівби знизилась в 1,7 рази порівняно із сівбою у I декаду вересня і склала 2,2 т/га. Для рослин за III

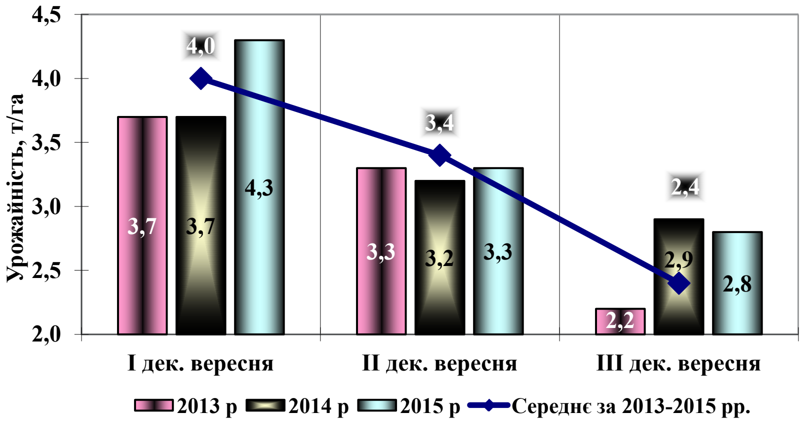

Рис. 1. Урожайність насіння ріпаку озимого залежно від строку сівби

строку сівби погодні умови осені виявилися несприятливими і перш за все за температурним режимом. Прохолодна погода з заморозками затримала розвиток рослин ріпаку в результаті чого вони на кінець листопада сформували 3,4-4,4 листки і діаметр кореневої шийки 1,7-2,3 мм, що було вкрай недостатнім для сприятливої перезимівлі.

Найсприятливіші умови для формування врожаю насіння ріпаку озимого створюються за умов, які найкраще відповідають потребам рослин. Відомо, що оптимізація густоти посіву й площі живлення рослин, бере початок із його просторового розміщення.

У середньому за роки досліджень із способів сівби, що вивчали, більш результативним виявився звичайний рядковий із шириною міжрядь 15 см, де середня врожайність склала 3,6 т/га та перевищила її у широкорядних посівах з шириною міжрядь 30 см та 60 см відповідно на 11,1% і 16,7% (рис. 2).

Таким чином, досліджувані фактори є важливими у технології вирощування ріпаку озимого та значно впливають на врожайність. Так, найвищою – 4,54 т/га вона сформована за сівби ріпаку у І декаду вересня, з шириною міжрядь 15 см по фону оранки, проти 2,18 т/га за сівби у ІІІ декаду вересня, з шириною міжрядь 60 см та дискування на глибину 12-14 см (табл. 4).

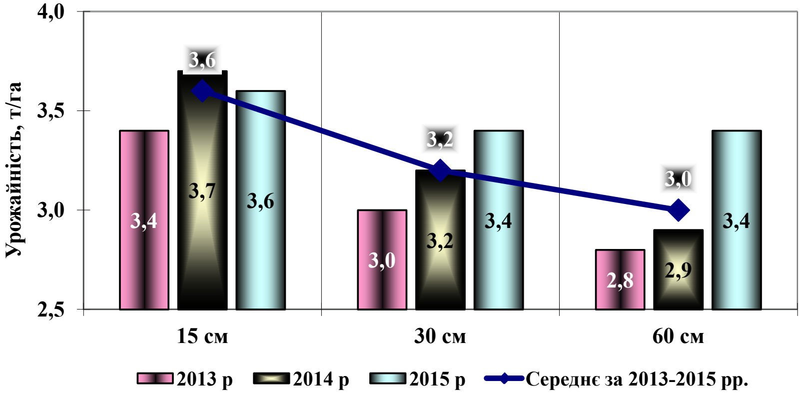

Рис. 2. Урожайність насіння ріпаку озимого залежно від способу сівби

Упродовж років проведення досліджень урожайність насіння ріпаку коливалася в межах від 1,77 до 5,02 т/га залежно від основного обробітку ґрунту, строку сівби, ширини міжрядь та погодних умов вегетаційного періоду.

Невід'ємною часткою при виконанні завдання щодо отримання високих урожаїв ріпаку озимого є покращення якості продукції. Останнім часом вимогливість до якості врожаю значно зросла.

Зумовлено це інтенсифікацією процесів у харчовій промисловості та тваринництві, забрудненням навколишнього середовища, запровадженням інтенсивних технологій вирощування польових культур, широким використанням хімічних речовин у сільському господарстві.

Основною метою при вирощуванні насіння ріпаку озимого на товарні цілі є високий вміст у ньому олії. Вміст жиру в насінні ріпаку озимого коливався в межах від 41,7%, у варіантах з поверхневим обробітком ґрунту за сівби у III декаду вересня з шириною міжрядь 60 см, до 45,5% при оранці на 25-27 см за сівби у I декаду вересня звичайним рядковим способом (табл. 5).

Дослідженнями впливу основного обробітку ґрунту під сівбу ріпаку озимого встановлено, що оранка сприяла більш високому – 42,1-45,5% вмісту жиру в насінні порівняно з дискуванням, де він коливався від 41,7% до 44,7%.

Таблиця 4

Урожайність ріпаку озимого залежно від досліджуваних факторів, т/га

Обробіток ґрунту, А	Строк сівби, В	Ширина міжрядь, см, С	Роки досліджень			
			2013 р.	2014 р.	2015 р.	Середнє
Дискування на 12-14 см	I дек. вересня	15	4,46	4,12	4,13	4,24
		30	3,86	3,65	3,84	3,78
		60	3,58	3,26	3,70	3,51
	II дек. вересня	15	3,72	3,80	3,10	3,54
		30	3,28	3,46	2,95	3,23
		60	3,12	3,02	2,81	2,98
	III дек. вересня	15	2,79	2,38	2,61	2,59
		30	2,38	2,05	2,51	2,31
		60	2,09	1,89	2,56	2,18
Оранка на 25-27 см	I дек. вересня	15	3,86	4,75	5,02	4,54
		30	3,42	4,12	4,57	4,04
		60	3,07	3,80	4,80	3,89
	II дек. вересня	15	3,58	3,96	3,70	3,74
		30	3,25	3,48	3,69	3,47
		60	2,85	3,32	3,66	3,28
	III дек. вересня	15	2,23	2,98	2,95	2,72
		30	1,94	2,53	3,04	2,50
		60	1,77	2,24	2,87	2,29
А. Оцінка істотності часткових відмінностей						
НІР05	А =		0,07	0,05	0,05	0,08
	В =		0,11	0,04	0,12	0,05
	С =		0,08	0,04	0,05	0,04

Більш чітко на олійність насіння ріпаку озимого впливали строки сівби. Із запізненням сівби вміст жиру знижувався від 44,2-45,5% за сівби у І декаду вересня до 43,3-44,3% у ІІ декаду та 41,7-42,6% у ІІІ декаду вересня. Отримані нами дані співпадають з результатами досліджень багатьох учених. Посіви ріпаку озимого в оптимальні строки довше вегетують і завдяки цьому накопичують більшу кількість сонячної радіації, яка в свою чергу є головним чинником у накопиченні жиру в насінні.

Таблиця 5

Вміст жиру й протеїну у насінні ріпаку озимого та їх умовний збір залежно від досліджуваних факторів (середнє за 2013-2015 рр.)

Обробіток ґрунту, А	Строк сівби, В	Ширина міжрядь, см, С	Вміст, %		Умовний збір, т/га	
			жиру	сирого протеїну	олії	протеїну
Дискування на 12-14 см	I дек. вересня	15	44,7	24,25	1,99	1,08
		30	44,5	24,44	1,75	0,96
		60	44,2	24,53	1,63	0,91
	II дек. вересня	15	44,2	24,27	1,59	0,87
		30	43,8	24,57	1,42	0,80
		60	43,8	24,63	1,35	0,76
	III дек. вересня	15	42,0	23,98	1,17	0,67
		30	42,1	24,07	1,04	0,60
		60	41,7	24,12	0,96	0,55
Оранка на 25-27 см	I дек. вересня	15	45,5	24,21	1,97	1,05
		30	45,0	24,32	1,75	0,94
		60	45,1	24,49	1,67	0,91
	II дек. вересня	15	44,3	24,12	1,64	0,89
		30	43,3	24,38	1,50	0,85
		60	43,7	24,41	1,39	0,78
	III дек. вересня	15	42,6	24,00	1,07	0,60
		30	42,2	24,16	0,99	0,57
		60	42,1	24,22	0,92	0,53

Серед варіантів досліду, де вивчали ширину міжрядь, найбільшу тенденцію до збільшення олійності в насінні мали ділянки з шириною міжрядь 15 см. На цих посівах, у середньому за роки проведення досліджень, вміст жиру становив 42,0-45,5% на відміну від 41,7-45,0% за широкорядних способів сівби.

Насіння ріпаку озимого крім жиру, містить ще до 21-24% сирого протеїну, а ріпакова макуха у сухій масі 37-43% протеїну, що робить ріпак джерелом кормового білка. Білок насіння ріпаку, крім того, багатий на сірчасті амінокислоти, які відсутні у складі білка бобових та зернових культур, тому при включенні цих компонентів до кормових сумішок можна отримати добрі результати при згодовуванні їх тваринам. За результатами досліджень чіткої закономірності у зміні вмісту сирого протеїну у насінні ріпаку нами не виявлено. Незалежно від досліджуваних факторів у середньому по варіантах, цей показник коливався в межах 23,98-24,63%. Лише статистичним аналізом було визначено незначну закономірність до підвищення вмісту протеїну в насінні за більшої ширини міжрядь. Так, за сівби ріпаку озимого звичайним рядковим способом вміст сирого протеїну в насінні був на 0,26% меншим порівняно з сівбою з шириною міжрядь 60 см (рис. 3).

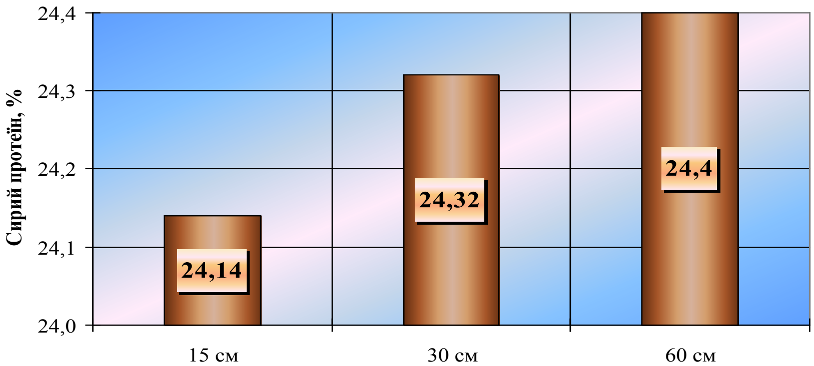

Рис. 3. Вміст сирого протеїну в насінні ріпаку озимого залежно від ширини міжрядь (середнє за 2013-2015 рр.), %

Рівень урожаю насіння ріпаку і вміст у ньому олії та сирого протеїну забезпечують різний умовний їх вихід з 1 га посіву. Ці показники є вираженням доцільності вирощування ріпаку озимого на насіння. Розрахувавши їх вихід з одиниці площі, можна більш детально аргументувати вплив досліджуваних факторів на ефективність вирощування. У середньому, за роки досліджень, найвища врожайність насіння ріпаку озимого – 4,54 т/га, сформована у варіанті з оранкою, де проводили сівбу у І декаду вересня звичайним рядковим способом з шириною міжрядь 15 см.

Найвищим вміст жиру визначений у насінні варіантів також з оранкою – 45,5%. На вміст протеїну, який коливався в межах 24,0-24,6%, досліджувані фактори суттєво не впливали. Максимальний умовний збір олії (1,97 т/га) і протеїну (1,05 т/га) отримали за сівби у І декаду вересня звичайним рядковим способом по фону оранки.

6. Висновки

Дослідженнями, проведеними на чорноземі звичайному впродовж 2012-2015 рр. з культурою ріпаку озимого сорту Чемпіон України, визначено, що спосіб основного обробітку грунту під цю культуру, а саме дискування на 12-14 см і традиційна оранка на 25-27 см, істотно впливають на окремі показники родючості чорнозему звичайного урожайність і якість насіння.

– Так, щільність складення грунту за визначення цього показника у шарах 0-10, 10-20, 20-30 і 0-30 см в основні періоди вегетації більш сприятливих параметрів для рослин досягала за проведення традиційної оранки на 25-27 см порівняно з дискуванням на глибину 12-14 см, за якого грунт ущільнюється більшою мірою й особливо у період завершення вегетації ріпаку озимого;

– Визначено, що оранка, внаслідок створення більш оптимальних агро-фізичних показників, забезпечує зростання вмісту в грунті рухомого азоту-нітратів упродовж росту і розвитку рослин за максимальної їх кількості у фазу розетки з поступовим зменшенням до періоду завершення вегетації.

– Вміст рухомого фосфору в досліджуваному шарі грунту 0-50 см, більшим визначений також по фону проведення оранки. Проте для верхнього 0-10 см шару грунту більший вміст цього елементу живлення забезпечило дискування на 12-14 см порівняно з оранкою. До збирання врожаю ріпаку озимого вміст P2O5 у грунті у грунті по обох фонах його обробітку вирівнюється, тобто зазначена різниця навіть для поверхневого шару грунту згладжується.

– Визначено, що врожайність насіння ріпаку озимого залежала і змінювалася під впливом усіх досліджуваних факторів: способу основного обробітку грунту, строку сівби, ширини міжрядь і дуже істотно різнилася від умов вегетаційного періоду рослин і кількості накопиченої грунтом вологи на початок сівби. У роки досліджень залежно від прийнятих на вивчення елементів технології вона коливалася в межах від 1,77 до 5,02 т/га.

– Максимальною врожайність насіння незалежно від умов року формується за сівби у I декаду вересня з шириною міжрядь 15 см по фону оранки. У цьому варіанті у середньому за три роки вона склала 4,24 т/га, що перевищує цей показник за III строку сівби з міжряддями 60 см на 43,7% (за рівня врожайності у останньому варіанті лише 2,29 т/га).

– Якість насіння ріпаку озимого також найкращих показників досягла за проведення оранки, сівби у I декаду вересня і ширини міжрядь 15 см. При цьому в насінні найбільше містилося жиру та сирого протеїну і максимальним був їх умовний збір з гектару: 1,99 т/га олії та 1,08 т/га протеїну.

– Таким чином за вирощування ріпаку озимого в умовах Південного Лісостепу України за сучасних змін клімату найбільш доцільно у якості основного обробітку грунту проводити оранку на 25-27 см, сівбу проводити у I декаді вересня з шириною міжрядь 15 см. За таких умов урожайність насіння формується на рівні більше 4,0 т/га з високими показниками його якості – вмістом жиру і сирого протеїну, за умовного їх збору з одиниці площі на рівні 2 та 1 т/га відповідно.

– Дослідження у даному напрямі доцільно продовжувати, адже змінюються умови господарювання, відбуваються грунтово-кліматичні зміни, з’являються нові сорти та гібриди.

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FEEDING FEATURES OF KEFAL FISHES IN NATURAL AREAS

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Abstract. Mullet has always been one of the most important species of commercial fish in the basins of the Black and Azov Seas. The water bodies in which they are grown include the estuaries and lagoons of the northwestern Black Sea. These are highly productive ecosystems that have always been of great fisheries and recreational value. Mullet fish have long been considered one of the most important pasture fish farming objects in the Black, Azov and Mediterranean Sea basins. Representatives of the mullet family have long been valuable objects of pasture fisheries. The mullet family (*Mugilidae*) belongs to mullet fishes (*Mugiliforms*), to the thorn group (*Acanthopterygii*), comprising more than ten genera and ninety-five species. There are five types of mullet in the Black Sea: *Mugil cephalus L.*, *Liza aurata (Risso), Lizas saliens (Risso)*, *Chelon labrozus (Risso)*, *Liza ramada* (*Risso*). The first three described species are of industrial importance. For the proper rational organization of the pasture fisheries in the Black Sea estuaries, the information about a state of the food base and the peculiarities of mullet fish feeding, as a major object of mariculture, is essential. *The purpose* of the study was to investigate the qualitative feeding characteristics of *Mugil cephalus L.*, *Liza aurata (Risso)*, *Liza saliens (Risso)*, and *Liza Haematocheilus (Pelengas)* in the natural waters of the Azov-Black Sea basin. The studies have shown that mullet larvae choose the fodder organisms by their morpho-physiological features and the properties of the forage objects. The availability of the fodder organisms and the electivity (the larvae preference for one or another forage) were determined. When

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switching to external feeding, the availability of a feed organism for the larvae is determined by its size. The smallest forage organisms are necessary for the *Mugil cephalus* larvae (50 microns). Forage organisms of 60 microns in size are available for *Liza aurata* larvae and forage organisms of more than 70 microns are available for *Mugil soiuy* larvae. The youngest larvae prefer trophophores of mollusks and copepods nauplii. The electivity of rotatoria at all stages of cultivation is negative. *Mugil soiuy* has the highest nutritional plasticity. The food spectrum of 6 – 25 day larvae includes up to 27 food objects. The Black Sea mullet larvae are less plastic. Their ration includes from 20 to 22 food objects. In addition to animal organisms microalgae occupy a prominent place in the diet of even the early larvae of mullet fish. As larvae grow, the concentration of fodder organisms may decrease and their size increases. An increase of the concentration of food organisms does not provide an increase of the ration but only leads to an irrational food consumption, so it makes no sense.

1. Introduction

Ukraine has a large enough coastline along the Black and Azov Seas with adjacent vast shelf zones and highly productive soloed inland water bodies occupying several hundreds of thousands of hectares and are located in a friendly natural zone, and have a big science and login-technical base for reproduction and commercial cultivation of hydrobionts.

In the northwestern part of the Black Sea within Ukraine there are shallow estuaries and lagoons: Sasyk, Shagany, Alibey, Burnas, Shabolat, Dnestrovsky, Sukhy, Hadzhibeysky, Kuyalnytsky, Dauphinsky, Grigoryevsky and Tiligulsky. Their total area is more than 1200 square kilometers.

The estuaries and lagoons of the northwestern Black Sea are highly productive ecosystems that have always been of great fisheries and recreational value. These water bodies are under the influence of significant anthropogenic impact. This fact applies to the Black Sea as a whole, but it is the most characteristic for its northwestern part.

The features of natural conditions (the shallowness of the water bodies, desalination, high water temperature, a large number of biogenic elements, etc.), combined with the presence of freshwater, brackishwater and marine forms in the flora and fauna determine a great biological diversity.

More than 200 fish species live in the waters of the Azov-Black Sea basin. Mullet has always been one of the most important species of commercial fish in the Black and Azov Sea basin.

A general history of mullet farming dates back to ancient times since the Ottoman Empire. The Burnas, Alibey, Shagany, Sasyk, Shabolatsky, Tiligulsky, Utluksky estuaries, Sivash and others have long been used as feeding ponds for mullet fish.

An abundant forage base of these water bodies and the favorable conditions for fish growing allowed to obtain a significant amount of delicate fish production.

For the proper, rational organization of pasture fisheries in the Black Sea estuaries, the information about the state of the food base and the peculiarities of mullet fish feeding as a major object of mariculture is essential.

2. Literature review

Mullet fish has long been considered one of the most important pasture fish farming objects in the Black, Azov and Mediterranean Sea basins. Representatives of the mullet family have long been valuable objects of pasture fisheries. Even in the Roman times mullet fish were used as a mariculture object. They were grown in limans, estuaries, lagoons of the Mediterranean and the Black Seas [1].

The mullet family (*Mugilidae*) belongs to mullet fishes (*Mugiliforms*), to the thorn group (*Acanthopterygii*), comprising more than ten genera and ninety-five species.

Representatives of the mullet family live in the tropical and subtropical seas, as well as in the southern part of the temperate latitudes ranging from 40°C north latitude to 40°C south latitude. They inhabit coastal seawater, river mouths and lagoons that are connected to the seas. Representatives of this family are characterized by wide plasticity, eugalinality. They are adapted to live over a wide range of temperatures, they are unpretentious to a high oxygen content in the water, which probably accounts for their widespread distribution in the oceans [1].

There are five types of mullet in the Black Sea: *Mugil cephalus L.*, *Liza aurata (Risso), Lizas saliens (Risso)*, *Chelon labrozus (Risso)*, *Liza ramada* (*Risso*). The first three described species are of industrial importance.

Chelon labrozus (Risso) and *Liza ramada* (*Risso*) are rare, mainly in the western part of the sea and at the Bosphorus. All these species are the Mediterranean invaders [1]. *Mugil cephalus L.* live in many water bodies throughout the world. These fish can be found in the tropical, subtropical, and partly in the temperate zones of the Pacific, Indian and Atlantic oceans. In the eastern Atlantic *Mugil cephalus L.* extends from the Gulf of Biscay to the coast of the western Africa. On the territory of Ukraine *Mugil cephalus L.* is found almost all over the waters of the Azov and Black Seas. It can also go for feeding into lagoons, estuaries, and gulfs [2]. The habitat of *Liza aurata (Risso)* is also quite wide. It can be found along the Atlantic coast from the southern shores of Norway and Sweden (and sometimes even of England) and to the south to Morocco and Madeira. This species inhabits the Mediterranean Sea, the Marble Sea and also it has been acclimated in the Caspian Sea. On the territory of Ukraine, like *Mugil cephalus L.*, it is found almost all along the Black Sea and the Azov Sea. It can enter the lakes, estuaries, gulfs and lagoons [3].

Lizas saliens (Risso) is met along the Atlantic coast starting from the Bay of Biscay and ending with the coast of Morocco. It can be met in the Mediterranean Sea (hence the Suez Canal) and the Marble Sea. This species has been acclimated in the Caspian Sea. Within the boundaries of Ukraine it, like others, can be met along all the coast of the Black and Azov Seas. From the coastal shallows it can enter salty and desalinated estuaries, lakes, gulfs. Occasionally it can enter the mouth of the large rivers [2].

In 1972-1973 the far-flung mullet *Liza haematocheilus* was introduced into the water bodies of the northwestern Black Sea and adapted well to the conditions of the basin due to the mild climate and a rich food base of this basin. *Liza haematocheilus* has naturalized in the Azov-Black Sea basin and today its quantity exceeds the native Black Sea species [1].

Liza haematocheilus belongs to estuary– maritime type of fish and has the most northerly habitat boundaries among all mullets. Today distributed in the Far Eastern Seas (maternal habitat), in the Azov Sea, the Black Sea and the Mediterranean Sea basins *Liza haematocheilus* is one of the most valuable commercial fish in Ukraine and occupies a significant place in marine fishing.

3. Feeding characteristics of mullet fish

3.1. Feeding features of *Mugil cephalus L.*

A spectrum of the mullet fish ration is quite similar but it is not surprising since the fish belongs to the same family. *Mugil cephalus L.* is characterized by a narrow oral cavity. Its lower jaw has a pointed appearance and is somewhat like a scoop. Even more adult *Mugil cephalus L.* (especially two year old and adult fish) prefer microbenthos, detritus and silt (with a high content of various bacteria) as their main food. When opening the cavity of their stomach, representatives of zoobenthos – multiform worms and crayfish – are also common. In general a mouth and a throat of the mullet are quite well adapted to seizure the food and to strain it.

In his work Andriyashev A.P. considers a pharyngeal apparatus of the mullet as a special functional-morphological type, which has been developing in the course of the evolution of this group as a kind of device for detritus feeding. He described *Mugil cephalus L.* feeding process as follows: A fish is swimming over the bottom with its head towards the bottom at an angle of 45 degree and with the help of its jaw it is cleansing the layers of detritus with its microbenthic organisms from the bottom using its transverse mouth, which can stick out and has flattened, like knives, jaws. The detritus that enter the oral cavity is filtered through a thick gastric filter and enters the esophagus via the pharyngeal apparatus [4].

Mugil cephalus L., like other mullets, feeds throughout the year (except during the migration and reproduction periods) and it intensifies feeding before the beginning of spring migrations (in March) and especially during the summer grazing and it is the least during the winter.

In a food spectrum of young *Mugil cephalus L.* in the marine area the same objects as in the ration of young *Liza aurata (Risso) and Lizas saliens (Risso)* are usually found.

According to the scientists for young mullets the predominance of planktonic food is mainly characterized. In particular Zambroborsch F.S. notes that approaching the coast this year *Mugil cephalus L.* feeds on zooplankton till the deep autumn [5].

In autumn when the amount of plankton decreases, young *Mugil cephalus L.* switches to peritoneal food and the bottom organic film (microbenthos) capturing detritus too. This author also notes that the bottom film consisting of diatom blue-green and brown algae becomes an integral part of this young fish feeding in the second half of the growing season, when a strainer apparatus has already formed [6].

In the Suhoy estuary *Mugil cephalus L. fry*, unlike *Lizas saliens (Risso)* fry, feed mainly diatoms (*Conscinodiscus, Cocconeis,* Navicula, Pleurosigma, Gyrosima, Nitzschia), with blue-green algae (*Oscillatoria, Lyngbya*) among them [7]. According to Duka L.A., in the feeding of 1.5-2.5 cm long *Mugil cephalus L. fry*, which were caught near the Karadag shore, these species of algae are noted.

According to him in the biocenosis of cystosirs the fry of *Mugil cephalus L.*, with a total length of about 23-24 mm, mainly feed on planktonic forms of copepods (which are about 98% in the ration) and bivalve mollusks. So at such sizes they are typical planktonophages. However when they reach a length of about 32 mm, young fish start feeding on detritus and periphyton [8]. The food of this year and one-year mullet including the 2.5-5 cm long *Mugil cephalus L.* in Suhoy Liman before the beginning of shallow water feeding includes crayfish, worms, mollusks, chironomids, as well as the particles that have settled on the surface of the water. And when young mullet go to the shallow waters they switch to feed on detritus, which is about 90% of their intestines.

In the work of Bryskina M.M., who studied the peculiarities of *Mugil cephalus L.* feeding in Karkinitsky Bay, was noted that in the ration of these fish there are detritus, mineral particles of the soil, pieces of algae (Cladofora), the remains of planktonic animals. Phytoplankton, namely diatomaceous leaflets, is also very common, and the composition of food may vary at different times of the year [9]. There is also a great coincidence of a species composition of algae found in the mullet intestines with the bottom macrophytes in the estuaries of the northwestern part of the Black Sea, and even the quantitative relationship between algae species from the mullet stomachs and at the bottom of the estuaries was the same. All this led to a conclusion that mullet feeds on algae bottom films. The author also points to the fact that the fish with the stomachs overflowing with algae without impurities of detritus and animal food were often met [10].

With age there is an increase in the intensity of nutrition: According to Meshidze D.H., the average fullness indexes for one-year mullet are 163%; for 5-year fish – 359%. According to the author's estimates, one-year fish during the next year (i.e. up to two years of age) consume 13 times more food than the weight of their body; this ratio decreases with age (five-year fish 4 times, six-year – 3,5 times) [11].

The young *Mugil cephalus L.* starts to feed at 5-6 o'clock in the morning, the maximum intensity comes at 12-16 o'clock in the afternoon, and it finishes eating at 8 – 10 in the evening (there is no food in the stomachs at night). Sometimes adult fish can feed intensely at night. The composition of organic substances in the stomachs of mullet (mainly the soil and detritus) is 7,096 (1.20 23.90)% [11].

3.2. Feeding features of *Liza aurata (Risso)*

Searching the food the *Liza aurata (Risso)* organs of smell and the external taste sensitivity of the lips and the snout, where the taste buds were found in the epidermis, play the main role. Vision organs play a less role in the taste reactions, but are easily start to search and capture the prey, as well as to seek a food area. At the same time, vision is main in the defense reactions. All this applies not only to *Liza aurata (Risso)*, but also to the other two species – *Mugil cephalus L.* and *Lizas saliens (Risso)*.

According to scientist Zaitsev Yu.P., who studied the nutrition of *Liza aurata (Risso)* larvae and early fry in the water areas of the eastern and western parts of the Black Sea, nutrition components: *Lamellibranchiata* larvae, *Sagitta* and *Copepod* eggs, *Copepoda* naupilus, including *Anomalocaram, Monstrilla* and other, copepod stage *Copepoda*, including *Pontellidae*, *Copepoda* adults *(Animolocare, Pontella, Oithoneminuta, O.similis, Monstrilla, Paracalanus, Acartia, Centropages, Harpacticoida), Cladocera (Podon, Evande, Penilia)*, small *Amphipoda* and terrestrial insects were the most common. With regard to a quantitative composition, for example, 354 specimens of *O. Minuta,* 13 speciments of *Paracalanusparvus*, 70 *Copepoda* eggs and 4 *Lamellibranchiata* larvae were found in the stomach of larvae weighting 2 mg and 5.3 mm long, and in the stomach of 22 mm long fry 10 adult *Pontellamediterranea* and 3 *Paracalanusparvus* were found [12].

Some authors point out that young *Liza aurata (Risso)* prefer plankton. In particular Zambriborsch F.S. indicates that these calves and perennials feed mainly on zooplankton.

Almost similar feeding character can be presented in the youth from the Tuzla group of estuaries.

In July and August only the microbenthic algae, detritus, silt, and sands are abolished in the stomachs of the large fish. In particular in the second half of summer a composition of *Liza aurata (Risso)* food in the Shabolat and Tuzla estuaries, according to the extent of meeting in this area, has indexes.

In addition much less *Microcolius wecksii, Phormodium monile, Amphora, Achnantes, Gyrosigma, Coscinodiscus* and other were found in the fish stomachs.

According to other authors young *Liza aurata (Risso)* consume more benthic organisms in the first months of their feeding. Duka L.A. (1973) in his work argues that *Liza aurata (Risso)* has two feeding periods:

1) when young fish migrate to and along the coast searching the feeding places and

2) when young fish feed directly at the feeding grounds.

If we study the first period we can say that planktonic organisms can be considered as a basis among the components of nutrition. Thus during this feeding period the mass accumulations of planktonic organisms (*Copepoda, Cyclopoida, Calanoida* – 45-48% of the total amount) are a food base. Surface film organisms also occupy a fairly large place [12].

As the young fish gradually grow and become more in size, the number of planktonic organisms of *Copepoda* genus gradually decreases in the ration, and *Harpacticoida* (up to 85%) and the bottom molluscs larvae (47%) take the first place. Also young fish start to take in the benthic organisms of the *Amphipoda, Carpellidae, Halacarida, Tanaida* and others genus in small quantities [13].

Young *Liza aurata (Risso)* comparing with young *Lizas saliens (Risso)* has slightly less pronounced food plasticity. *Liza aurata (Risso)* begins to move to planktonic-benthic lifestyles earlier, and individuals of this species having reached a length of about 16 mm already begin to feed on necto-benthic forms and having reached a size greater than 20 mm begin to consume typical benthic forms of tanaid and settled mollusk larvae [14]. Young fish living in the thicket biocenoses usually feed on planktonic and benthic life forms: Calanoida, Cyclopoida, Harpacticoida, plankton and settled mollusk larvae. In general in the biocenosis of cystosirs young fish begin to eat up to 19 different forms of animal plankton among which the different species of naupilus (*Copepoda, Cladocera*), *Lamellicoida* planktonic larvae, the larvae of different insects and other species can be distinguished [10]. There is also a rather large plasticity in the ration of young *Liza aurata (Risso)*, which is shown by the fact that in the different parts of the sea different organisms form a food basis for the fish that are fairly close in size.

The quantitative and qualitative composition of *Liza aurata (Risso)* food depends largely on a combination of several factors such as a size of the fish, a season of the year and a type of the water body in which these fish graze. According to Dovgiy N.V. a food spectrum of *Liza aurata (Risso)* during its graziery varies slightly depending on a season of the year, a size of the fish and a type of the water body in which the fish graze [15].

It was noted that fish with a length of 3 cm and a weight of 0.3 g (by weight,%):

– in April have: naupilus *Copepoda* – 0,5, *Acartia*– 1,0, *Harpacticoida*– 2,0, *Gammarus* – 72,0, detritus – 11,5, *Algae* – 12,0;

– in May, at a length of 4.5 cm and weight of 1.0 g: detritus – 9,0, *Algae* – 10,0, *Nematodes*– close 0,01, *Nereis* – 1,0, naupilus *Copepoda* – 0,008, *Acartica* – 1,0, *Harpacticoida* – 1,0, *Gammarus* – 77,9, *Corophium* – 0,012;

–in June (5.7 cm and weight 1.99 g): detritus – 4,4, *Algae*– 10,0, *Nematodes* – 0,01, *Nereis* – 2,70, *Nephthys* – 0,01, *Gastropoda* larvae– 0,011, *Lamellibranchiata* larvae – 0,02, naupilus *Copepoda* – 0,001, *Acartia* – 0,04, *Harpacticoida* – 0,012, *Gammarus* – 83,4, and young adults of large sizes (7.8 cm and weight 5.01 g): detritus – 12,5, *Algae* – 58,0, *Foraminifera* – 0,01, *Nereis* – 6,10, *Nephthys* – 1,0, *Gammarus* – 22,2, *Chironomus* – 0,19;

– in July (9.8 cm and 9 g): detritus 16,9, *Algae* – 65,8, *Foramenifera* – 0,01, *Nereis* – 6,8, *Hydrobia* – 0,05, naupilius *Copepoda*– 0,01, *Acartia* – 0,01, *Harpacticoida* – 0,06, *Sphaeroma* – 0,37, *Gammarus* – 10,0, and larger ones (11 cm and 14.3 g): detritus – 41,0, *Algae* – 46,0, *Nereis* – 2,20, *Nephthys* – 1,0, *Harpacticoida* – 0,40, *Gammarus* – 9,4;

– in August (12.7 cm and weight 22.0 g): detritus – 2,81, *Algae* – 57,0, *Nereis* – 2,0, larvae *Gastropoda* – 0,01, *Ostracoda* – 0,06, *Harpacticoida* – 0,04, *Gammarus* – 12,8, and larger (17 cm and weighing 62 g): detritus – 20,0, *Algae* – 49,0, *Foraminifera* – 0,004, *Nereis* – 0,99, *Ostracoda* – 0,002, *Gammarus* – 30,0, *Corophium* – 0,004;

– in September (22.0 cm and weighing 112 g): detritus – 15,0, *Algae* – 54,3, *Nereis* – 2,0, *Ostracoda*– 1,7, *Harpacticoida*– 1,0, *Gammarus* – 26,0;

– in October (23cm and 115g): detritus – 60,0, Algae – 35,9, *Gammarus* – 4,10 [15].

The study of *Liza aurata (Risso)* feeding in the East Sivash, where the fish with a length of 2.5-19.0 cm were analyzed during the entire feeding period (May-November), has led to the conclusion that in this water body

Liza aurata (Risso) mainly consumes the bottom organic film, which has microphytobenthos, phytoplankton, bacteria, and benthic animals (shellfish and foramonifers). In addition amphipod mollusks, equinoid crayfish, chromonid larvae and polychaetes were found in the *Liza aurata (Risso)* diet (Zaitsev and Grin, 1960).

Quite often scientists note that *Liza aurata (Risso)* can feed for quite a long time (about 16-17 hours a day). The fish starts to eat at about six in the morning and finishes at about 10 pm. The largest single ration is between 11 and 13 o'clock and is equal to 4-6% of the body weight. The rate of food digestion differs for different types of consumed food, for example at an average water temperature of 23-24°C algae can be digested during 3 – 4 hours, and polychaetes and hammarids during 8-9 hours. If the water temperature rises by 2°C, the rate of food digestion can increase twice from the rate typical for the different food types.

In his work Karpevich A.F. noted that the degree of *Liza aurata (Risso)* breathing intensity certainly depends on the rate of food digestion. Hungry fish have been shown to consume 0, 640 mg of oxygen per 1g of the body weight during one hour; after being fed the fish increase the consumption of oxygen to 0.750 mg and reduces to 0.460 mg after 5 hours. Also this scientist believed that the maximum portion of these fish ration is at a later time between 12 and 16 in the afternoon but the *Liza aurata (Risso)* intense feeding can also be observed at night [15].

In his work studying the seasonal changes in the *Liza aurata (Risso)* ratio Long N.V. noted that the increase in the level of feed intake runs approximately in parallel with the increase in the water temperature from April to October, with a maximum in June and July. In particular the daily rations of these fish in May are 5-6%, in June 7-8%, in July 10-11%, in August 10-11%, in September 8-9%, and in early October 3-4% from the body weight. According to the calculations of the same author *Liza aurata (Risso), that* entered the estuary for grazing with a body weight of 0.2-0.4 g and grew an average to 100 g, consumes about 500-700 g of animal and vegetable food, that is, in average you need somewhere around 5-7 kg of feed for 1 kg of fish gain. Under favorable conditions, in particular in quiet and warm weather, young and adult fish do not stop feeding even during the cold season. At this time feeding can be very intensive [14].

3.3 Feeding features of *Lizas saliens (Risso)*

In the ration of young *Lizas saliens (Risso)*, while traveling near the coast, the qualitative composition of the food includes the larvae of *Lamellibranchiata, Cladocera (Evandetergestine, E.normandi* and other species), naupilus and copepoid stages of *Copepoda (Monstrilla, Anomalocera, E.normandi* and other species), adults *Copepoda (Oithona, Acarti, Paracalanus, Pseudocalanus* and other species).

Zaitsev A.V. in his work gives the following data regarding the amount of the consumed food: in the stomachs of 4.3mg and 7.7 mm long larvae 99 pieces of *Oithonaminut*a, 4 pieces of *Evand*e, 1 piece of *Acartia* were found, and in the stomachs of the 6 mg and 8.9 mm long individuals respectively 3 pieces of *Paeacalanusparvus*, 2 pieces of *E. tergestina*, 3 pieces of *Calanoida* were found. Young fish is feeding for most of the whole day (at night, less than 14% of empty stomachs are found), the highest degree of stomach fullness is observed in the periods from 8 till 10 and from18 till 22. Feed belongs mainly to the layer of hyponeiston. As they grow, the young fish feed on the larger prey – pontellids, Decapoda larvae and terrestrial insects.

Grazing in the estuaries zooplankton is the main food of the young fish and detritus microbenthic plays a less role. Specifically it is for the Shabolatsky estuary.

In the second half of the growing season, the bottom film, which includes diatomaceous, blue – green and brown algae, is an integral part of the *Lizas saliens (Risso)* food. Under intensive feeding conditions, all food passes through the entire gastrointestinal tract for approximately 2-3 hours.

Even more mature fish feed on mainly microbenthos, which includes detritus, blue – green and diatomaceous algae, and silt that contains a very large number of bacteria. The qualitative food composition of this year *Lizas saliens (Risso)* in the Suhoy Estuary is quite varied and consists of subspecies of the class of *Vermes, Copepoda, Cyclops, Harpacticoida, Amphopoda,* crustacean eggs, diatoms and other.

In the work of Gordina A.D. this species young fish feeding in the thicket biocenoses is considered in great detail. For example, in the biocenosis of cystosirs, 33 forms are noted in the food spectrum of mullet, and with the growth of the fish the qualitative food composition also changes: the about 20-27 mm in length fry prefer planktonic copepods – colanoid and cyclopid (to almost 90% of the total number of organisms consumed), but in the ration of the 30-35 mm in length fry nectobenthic forms – harpacticoids, as well as typical benthic forms – amphipods, caprellids, tanaids, marine mites and settled mollusks larvae appear in the ration, in addition to planktonic copepods and diatoms, reds, browns and green algae are also found in a large quantity in the 60 mm in length fry [16].

A size of single serving of *Lizas saliens (Risso)* varies depending on a size and a weight of the body. In his work Sinyukov V.I. gives the following data regarding to a size of a single serving: for *Lizas saliens (Risso)* with an average body weight of 23 g the weight of a food portion is on average 1.5 mg, ie, this figure is about 5% of the total body weight. The daily ration of young *Lizas saliens (Risso)* with a length of 14 -20 mm and a mass in the range of 15–40 mg (at a temperature of 23.5-25°C) was from 16 to 28% of the total body weight, and besides the smaller fry (12 to 14 mm) weighting 16–19 mg have the highest daily food consumption. It was also found that an average daily gain was about 6% and it used 20-35% of the food consumed per day, and the maximum daily gain was 10% (respectively 36-60%) of the total body weight. The food digestion has continued for 3-3.5 hours, and in the absence of the food the 23 mm fry weiting 82 mg lost up to 3% of the body weight in the daytime [17].

When the cold season comes the intensity of *Lizas saliens (Risso)* feeding is somewhat suppressed but it does not finish completely.

Currently the daily rations of young *Lizas saliens (Risso)* are calculated depending on the temperature of the water and a size of the fish, which are fed with a food mixture in the cold season. At a water temperature of 5°C for the young fish weighing from 0.6 to 3.8 grams the daily ration is from 45 to 400 mg of food per person a day (from 4 to 8% of the total body weight), at a water temperature of 8°C it is 50-180 mg (5 – 9%), and at a water temperature of 12°C (spring) it is 83-225 mg (7-14%), that is about twice as much as during the cold months [18].

On the basis of the direct observations the ability of young *Lizas saliens (Risso)* to conduct collective hunting for atherina fry that held in the large flocks, was established. The mullet, that is held in the flock in the form of a crescent moon, captures the floating young atherini, thereby cutting some of them off and quickly catching these fish [2].

According to the feeding charachter adult *Lizas saliens (Risso)* is not much different from other types of mullets and feeds throughout the year, except perhaps only the breeding season.

3.4. Feeding features of *Liza Haematocheilus (Pelengas)*

In the Azov-Black Sea basin, besides detritus, polychaetes, chironomils, juvenile shrimp, shellfish and filamentous algae are the basic food for *Liza Haemaocheilus*.

In his work Chechun T.I. gave the data on *Liza Haemaocheilus* feeding in the Kerch Strait and in the Sea of Azov [19]. In the Kerch Strait region an average stomach fullness index from May to September ranged from 2.3 to 18.5. The maximum index was 60.7. During this period seasonal fluctuations were detected in *Liza Haemaocheilus* feeding [20].

In May 1996 *Foramenifera* – 89,9% was the basis of the food lump (at the same time *Cirripedia* content was only about 7.5%) and in June of the same year it was *Crustacea* (including *Acartiaclause* – 51%). In May-June 1996-1997 the occurrence of *Copepoda* in the stomach of *Liza Haemaocheilus* fluctuated in the range of 31– 78%, *Malacostraca*, *Gastropoda* were maximum at the level of 21% and 10% respectively, *Bivalvia* – 35%, macro– and microalgae – 72% and 20% maximum. In June 1997 crayfish were of great importance in *Liza Haemaocheilus* feeding, the number of Crustacea reached 98.6% including 89.9% of *Copepoda*, 6.9% of *Ostracoda*. 77% of microalgae, 17% of *Ostracoda*, 33% of *Bivalvia*, *Copepoda*, *Malacostraca* were found there. In August 1997 the proportion of microalgae and gill stamens in the food breast and the frequency of their occurrence in the stomachs was 100% (the number of fish equals 4 specimens) [19].

In June 1997 the author collected a large number of stomachs (90 pieces), that made it possible to give a more detailed description of *Liza Haemaocheilus feeding*. Like in the other months *Liza Haemaocheilus* favored *Copepoda*: 63.6% of a total number were found in the food breast (*Acartiaclause* – 80 and *Bivalvia* – 22.7). An average number of *Copepoda* and *Bivalvia* per *Liza Haemaocheilus* stomach was 275 and 274 with a maximum of 4.8 and 3.0 thousand specimen; *Ostracoda*, *Malacostraca* and *Gastropoda* were 3.8 and 20 times less than *Copepoda* and *Bivalvia*, respectively [19].

The frequency of macroalgae occurrence in the stomachs was 71% out of 89 stomachs, they were found in 60 of them. The frequency of *Copepoda* occurrence was 42% that was twice as much as *Malacostraca* and four times as much as *Ostracoda*, *Bivalvia* and microalgae.

Out of 89 *Liza Haemaocheilus* stomachs there were fragments of their own gill-stamen epithelium in 20 stomachs. 40, 45 and 15% of *Liza Hae-*

maocheilus had respectively, 50, from 51 to 95 and 100% of the epithelium of the gill stamens. This phenomenon is probably explained by the fact that when the filter apparatus is clogged (sticking of sludge, mechanical particles, grease, sand, winding algae), the old epithelium begins to flake and collapse. In the stomachs of other Black Sea mullets (*Liza aurata (Risso)*, *Lizas saliens (Risso)* and *Mugil cephalus L.*), the particles of the gill stamens epithelium were also found. Most likely for *Liza Haemaocheilus* as well as for other types of Black Sea mullets, a peculiar renewal of the filter apparatus is characteristic [19].

In the Sea of Azov a stomach fullness index of *Liza Haemaocheilus* increased from 0.3 to 61.6 from April to July 1997. Wherein, the maximum individual stomach fullness index was 170 [19].

In March there were 6 microalgae species in the stomach of one single *Liza Haemaocheilus*, most of them (5 species) – *Diatomea*, belonging to two classes: *Centrophyceae* and *Penatophyceae*, and one species – *Dinophyceae*. The frequency of microalgae occurrence in the stomach of *Liza Haemaocheilus* was 100%.

In April *Foraminifera* – 88,2%, *Copepoda* та *Gastropoda* – 5.6% and 5.4% respectively were the basis of the food lump. The rate of microalgae occurrence in the stomach of *Liza Haemaocheilus* was 67%, *Copepoda*, *Gastropoda* and *Foraminifera*–50% each, *Ostracoda* – 33%, veligers *Bivalvia* and *metatrophoraPolychaeta* – 17% each. In June-July veggie, sedentary and quite infrequent adults of *Gastropoda* were found in the food breast (53,7%, out of them *Hydrobia* – 98,0%), *Ostracoda* (39,2%).

The frequency of occurrence of *Ostracoda* in *Liza Haemaocheilus* stomachs was 74%, *Gastropoda* – 65, *Bivalvia* – 35%, *Copepoda* – 26% and microalgae – 18 %.

In July 1997 the ration of *Liza Haemaocheilus* was consisted of *Ostracoda* (55.1%), *Gastropoda* was about 2 times less (30%, *Hydrobia* was 99% out of them). *Bivalvia*, in turn, was almost 2 times less than *Gastropoda* – 14.3%. The occurrence of *Ostracoda* and *Gastropoda* in the stomachs was the same and was 100%, *Bivalvia* – 75, *Copepoda* – 25%, and other food components – 12%.

In June – July 1996 and 1997, an average number of ostracods per a stomach was 732, *Gastropoda* – 558, the maximum was 3.3 and 4.8 thousand specimen, respectively. An average number of *Bivalvia* and *Copep-*

oda per a *Liza Haemaocheilus* stomach was 3.7 and 12.6 times less than *Gastropoda*, respectively. In the stomachs of two fish approximately 600 veligers of the new Black and Azov Sea invader – the two-billed mollusk *Cuncarcacarnea* – have been found [21].

In 1996-1997 a size of the food components of *Liza Haemaocheilus* in the Kerch Gulf and in the Sea of Azov did not exceed 1100 microns: *Copepoda* – 150-400, *Cladocera* – 500-700, *Ostracoda* – 400-1100, *Bivalvia* – 80-500 microns.

Among the filter fish a filter apparatus plays a very important role in feeding. *Liza Haemaocheilus* gill stamens are similar to those found in the plankton-eating fishes such as some herring (*Clupeidae*), whitefish (*Corengonidae*), anchovy (*Engraulidae*) and others. However *Liza Haemaocheilus* gill stamens are much shorter than the other filter fish have [22].

For example, in the case of 15 cm long *Alosa Kessleripontica* herring and 25 cm long *Liza Haemaocheilus* the gill stamens are 9 and 3 mm respectively. The ratio of planktonoid fishes gill petals and stamens is equal to one another. Sometimes a slight increase to one or the other part may be observed. For adult 25 and 60 cm long *Liza Haemaocheilus* this ratio is one to three and one to six. Probably relatively small gill stamens do not allow the *Liza Haemaocheilus* filtration apparatus to detain large organisms [22; 23; 24].

Thus it can be concluded that the *Liza Haemaocheilus* food spectrum was consisted of the representatives of six animal types as well as of micro- and macroalgae.

In the Kerch Strait *Liza Haemaocheilus* mainly consumes naupilius and adult *Copepoda* and *Bivalvia* at various stages of the development. *Copepoda*, *Malacostraca*, *Bivalvia* as well as macro– and microalgae prevailed by frequency of the occurence. In the Azov Sea *Ostracoda*, *Gastropoda* prevailed by a number in the food breast and in average per one stomach. *Octracoda*, *Gastropoda*, micro- and macroalgae were the most frequent per one stomach.

According to the results the stomach fullness index was different in the Azov Sea and the Kerch Strait at the same period and the food components differed. For *Liza Haemaocheilus* in the Kerch Strait this index was lower. This may be due to the fact that the intensity of food consumption is reduced for the fish from the strait going to spawn.

In addition *Liza Haemaocheilus* bearing move to spawn was observed in the coastal area, where some food shortages for fish are possible. The low *Liza Haemaocheilus* stomach fullness indexes in the Kerch Strait at the end of spring and in the beginning of summer and in the Azov Sea in early March are most likely due to the deterioration of a food base during these periods of the year. In the Kerch Strait *Copepoda* and *Bivalvia* mainly dominated in a food spectrum of *Liza Haemaocheilus*, and in the Sea of Azov *Ostracoda* and *Gastropoda* dominated. Obviously this is due to the fact that these food components were the most widespread and available for *Liza Haemaocheilus* feeding in these areas [25].

From the microalgae *Peridinium, Consinidiscus, Diatomea, Nitzschia, Sceletonema*, of macroalgae – *Enteromorpha, Cladophora, Ectocarpus, Cystoseira, Polysiphonia, Ceramium* were the most often found in the stomachs of *Liza Haemaocheilus*.

In his work Shekk P.V. [26] provides data on a number of differences in the *Mugil cephalus L.*, *Liza Haemaocheilus*, *Lizas saliens (Risso)* and *Liza aurata (Risso)* feeding in the Shabolat estuary in different periods from August to September during 1992-2002.

4. Conclusions

A food spectrum of mullet fish is quite similar but this is not surprising because all represented species belong to the same family.

As for the marine area, a food spectrum is not qualitatively different for all presented species of mullets, there are only quantitative differences.

One year *Mugil cephalus L.* prefer zooplankton when feeding in the marine area. In autamn when a number of zooplankton gradually decreases young *Mugil cephalus L.* switches to periphoton feeding and to the bottom organic film capturing detritus at the same time.

In the Suhoy estuary *Mugil cephalus L.* fry, unlike *Lizas saliens (Risso)* fry, consumes overwhelmingly diatomaceous algae and blue-green algae which are sometimes found among them. As for this year *Mugil cephalus L.* in the Suhoy estuary the crustaceans, worms, mollusks and chironomids are also included in their food spectrum.

In the biocenosis of cystosir *Mugil cephalus L.* fry prefer planktonic forms of the copepods, which make up about 98% of the total food spectrum of the fry.

Young *Liza aurata (Risso)* prefer plankton food, namely zooplankton, which is the main nutrient for young fish. But for adults the composition of a food spectrum is different. Algae, detritus, silt and sand occupy the main place instead of zooplankton.

In the Gulf of Carnitine a *Liza aurata (Risso)* food spectrum includes detritus, mineral soil particles, algae peaces and planktonic plant residues. Phytoplankton and algae bottom films are also included but in much less quantities.

Comparing the composition of a food spectrum of *Liza aurata (Risso)* and *Lizas saliens (Risso)* it can be seen that *Liza aurata (Risso)* food plasticity is much less pronounced. *Liza aurata (Risso)* begin to migrate to the benthic lifestyle and feed on benthic organisms at an earlier age than *Lizas saliens (Risso)*.

In the eastern Sivash one-year and two-year old *Liza aurata (Risso)* feed on primarily organic film, which includes microphytobenthos, phytoplankton and bacteria throughout the entire grazing period.

For young *Lizas saliens (Risso)* zooplankton is a major component of the food and microbenthos and detritus are much less in a food spectrum. One-year and two-year-old fish primarily consume detritus, blue-green and diatoms. Mule that contains a fairly large number of bacteria is also included in their food composition.

Planktonic animals, micro- and macroalgae are the main components of a food spectrum of *Liza Haematocheilus* in the Kerch Strait and in the Sea of Azov.

In the Kerch Strait *Copepoda*, sedimenting *Bivalvia*, as well as micro– and macroalgae are the main constituent of a food spectrum of *Liza Haematocheilus*. In the Azov Sea *Liza Haematocheilus* mainly feeds on different stages of *Copepoda*, young and adult *Ostracoda*, mollusk larvae, micro– and macroalgae, sedentary forms of *Gastropoda*. This difference in *Liza Haematocheilus* feeding is explained by the fact that in these two areas these food components are main and the most widespread.

Liza Haematocheilus, on the example of the Shabolatsky estuary, consumes primarily detritus and zoobenthos. During the summer a food spectrum also includes residues of aquatic plants and periphyton.

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ANALYSIS ON APPLICATION OF CHLORELLA IN THE FEEDING OF FARM ANIMALS

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Abstract. Today the problem associated with rational feeding of farm animals is relevant and requires the new approaches and technologies satisfying the natural need of animals for food without using expensive fodders at the same time that determines the chosen theme of this article. The purpose of the paper is to summarize and analyze data related to *chlorella* application in feeding of farm animals. The object of current research is alga of chlorella and its forms including suspension, extract and dry paste. The research consists of introduction and five parts that explain the action of *chlorella* on farm animals in particular on physiological and productive functions, immune system. The first part provides the modern information about the current state of feeding industry in order to determine the main its problems including ignorance of digestion and metabolism of farm animals and increase of feed costs. Determination of chemical composition of chlorella as critical factor of using it in feeding of farm animals is the aim of second part. According to investigations written by a large number of scientists *chlorella* has the biochemical composition with high value due to presence of protein, carbohydrates, lipids, aminoacids, vitamins and trace elements. The physiological and productive action of *chlorella* in feeding of farm animals shown in third part of monography is manifested in increase of the indices of live weight gain, animal body resistance, improvement of reproductive functions, and the chemical composition of meat. *Chlorella* use as a source of pigments and trace elements for farm animals is proved by major of researchers whose works are analyzed in fourth part. Different forms of *chlorella* using contain pigments, which synthesize the enzymes necessary for normal metabolism of living organisms embracing chlorophyll, a wide

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range of orange and yellow carotenoids. In addition, in specific conditions chlorella can accumulates such important trace elements as *Se* and *I* that will be able to prevent of a number of diseases, including malignancies, thyroid gland dysfunction, cardiovascular disease, neurological diseases, aging, infertility and infections of farm animals. The next part of monography provides data about effect of chlorella using on immune system of farm animals namely the aqueous extract of chlorella promotes tissue regeneration, growth and cell division, stimulates leukocyte production and phagocytic activity, and contributes to the production of antibodies that produce lymphocytes. Also the extracts based on alga have probiotic activity influencing the composition and activity of the microflora of the gastrointestinal tract of farm animals. Consequently, introduction of *chlorella* in the diet of farm animals is proved to be able to help to improve their physiological and immune systems and increase of meat production simultaneously.

1. Introduction

Obtaining environmentally friendly and completing products from farm animals requires the constant improvement of feed technology, selection of the right diet, study of physiological needs of animals.

The full feeding is known to be one of the most important conditions formed the level of productivity in livestock. However, the value of feeding rations depends not only on the presence of all essential substances in them, but also on the degree of bioavailability of each of them. To obtain maximum productivity, reduce the cost of livestock production and to realize the genetic potential of the animal's organism farmers should use the high-quality and high-grade compound feed, including the various biologically active substances [1, p. 365; 2, p. 158].

Besides the basic nutrients functioned the plastic and energy material, the presence of a wide range of compounds with high biological activity including vitamins, macro and microelements, enzymes and many others are required in the feed rations of animals. According to investigations these components have very low concentrations in the feed composition, but play the significant role in the metabolic processes in the animal body and directly affect the absorption of the diets themselves [3, p. 65; 4, p. 15; 5, p. 125].

Therefore, balanced feeding based on the nature of the plant, a new planktonic strain of microscopic algae of *chlorella*, which, due to its composition, has a very high biological value [6, p. 148; 7, p. 7725]. *Chlorella* has the following biochemical composition (in% of dry biomass): protein 55%, lipids 12%, carbohydrates 25%, and ash 8% [8, p. 528; 9, p. 35]. Some scientists suggest that the total protein content of mature *C. vulgaris* is 42-58% of dry biomass [10, p.498; 11, p. 136]. *Chlorella* protein is superior in quality to known plant proteins, as it contains all the necessary amino acids, including essential ones [12, p. 212; 13, p. 238]. Starch is the most common polysaccharide in *chlorella* [14, p. 1059]. In addition, one of the most important polysaccharides present in *chlorella* is β1-3 glucan [15, p. 166], which has numerous beneficial health and nutritional properties. The richness of vitamins of chlorella exceeds all plant feeds and crops of agricultural production [16, p. 77]. Vitamins D and B_{12} are not produced by plants, but they are contained in *chlorella*. The content of vitamin C in *chlorella* corresponds to its content in lemon, and unlike higher plants algae contains vitamin A in its pure form. Inositol is found 1.5 times more, biotin – 2 times more, pantothenic acid – 1.3 times, paraminobenzoic acid – 2.9 times more in *chlorella* cells than in yeast (a rich source of vitamins) [17, p. 14]. Thus, the addition of *chlorella* to the diet of farm animals will fill the deficiency of amino acids, vitamins, minerals and trace elements.

The possibility of obtaining such feed additives with low cost in the own conditions, in the presence of high efficiency of its application, puts it out of competition not only in all major economic parameters, but also in the environmental purity and quality of the animal products obtained [18, p. 729]. Moreover, using of *chlorella* suspension in animal husbandry is known as a vitamin-feed additive and a preventive agent [19, p. 259]. Thus, **the aim of current work** was the following statements:

1. to analyze the current state of feeding industry in order to determine the main its problems;
2. to clarify the reasons of *chlorella* using in feeding of farm animals based on alga composition;
3. to defense *chlorella* effect on physiological and productive functions of farm animals including sows, piglets and poultry;
4. to analyze the *chlorella* use as a source of pigments and trace elements for farm animals;
5. to determine the effect of *chlorella* on the immune system of farm animals.

2. Materials and methods

In order to obtain the abovementioned answers analyzing of the scientific and practical literature was decided. To our knowledge, in scientific sources there is not sufficient number of articles published about *chlorella* composition and its effect on farm animals embracing the whole completed state of its alga in agriculture science. Therefore, the chosen direction of research is relevant and requires the comprehensive analysis based on proved facts. Different databases were used to find the necessary information.

3. Research results

3.1. The current state of the feed base and characteristics of its compound and additives for feeding of farm animals

The introduction of intensive development of industrial poultry and pig production depends, first of all, on the complete feeding of animals, which, in turn, depends on the quality composition of compound feeds. The main task of compound feeds is to provide the physiological need of energy for animals, nutrients and biologically active substances. It is known that compound feeds are distinguished by sources of production, chemical composition and nutrition [20, p. 88]. The number of compound feed formulations increases every year, both in Ukraine and around the world. The leader in animal feed production for 2017 is China (187 million tons per year), the United States of America (US, 170 million tons) and Brazil (69 million tons) [21].

However, scientists have concluded that the use of uniform feed adversely affects the natural resistance of the animal body, which leads to various pathologies, diseases, reduced productivity and efficiency of the industry as a whole [22, p. 22]. It is expected that the production and consumption of pork and poultry meat will increase by 70% in the period 2000-2030 and 120% – in the period 2000-2050 [23, p. 158].

Currently, world meat production has quadrupled from 84 million tons in 1965 to 330 million tons in 2017 [24]. According to the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) [24], this tendency will continue due to the inclusion of a large number of semi-finished meat products that so-called "Western diet" of people in North America and Europe in the diet of urban middle-class in China and other countries with developing economies.

Also, according to calculations by the United Nations Environment Program [24], the calories lost while feeding animals, instead of using them directly as food, could theoretically provide an additional 3.5 billion people. The calorie conversion factor for plant-based calories for animals is: ideally, two kilograms of grain is needed to produce one kilogram of chicken, four kilograms – per pound of pork, and seven kilograms – per kilogram of beef [25].

Statistical estimates from the Food and Agriculture Organization of the United Nations show [26] that the number of chickens breed for human consumption increased from 4.4 to 22.7 billion between 1966 and 2016. In the same period, the number of pigs increased by 92% and accounted 981 million heads. According to the consulting company IBIS World [26], in the United States of America over the past five years, the livestock feed industry has declined by 3.2% with revenue of 33 billion American dollars in 2017. At the same time, the number of enterprises increased by 0.6% and the number of employees decreased by 1.2%. All of these facts are related to a global decrease in prices for poultry and pig feeds, on average by 4.6% and 13.4%, respectively [27]. However, according to market analysis by experts, this does not solve the main tasks of the industry – ensuring a balanced feeding of animals to obtain quality meat [28]. During 2017-2018 in Ukraine other trends were observed than in the world.

According to the State Statistics Committee of Ukraine [29], in 2018 the lowest production of compound feed over the past 7 years has achieved. Thus, only cattle had a slight increase (+ 3.7%) accounted 592 thousand tons, but the largest share was determined for compound feed for farm poultry – more than 40% (Figure 1). In general, the other three positions (poultry, pigs and "not included in other categories"), the trend of production was currently negative.

According to researchers, the production of compound feeds by 2030 will reach 20 million tons per year [28]. However, to date, imports of compound feeds and feed additives represent a significant share of the industry. Thus, in 2017, almost 32.9 million kg of feed amino acids, 35.9 million kg of feed phosphates, 2.8 million kg of vitamins, 36,3 million kg of feed additives were imported to Ukraine [30].

It is a well-known fact that the limiting factor in the development of poultry and pig breeding industries is the inability of animals to rapidly digest nutrients concentrated in compound feed [31, p. 64]. Therefore, to obtain a

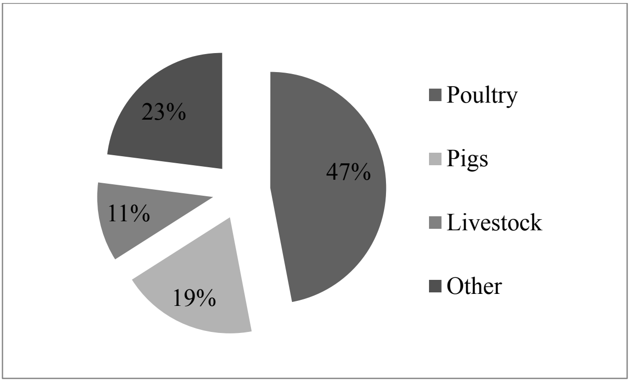


Figure 1. Structure of compound feed production for farm animals in Ukraine in 2018 [29]

healthy poultry when using compound feed rationally, one must concentrate on the physiology of the animal itself and its needs. Thus, special attention in the diet of poultry should be paid attention to sufficient protein content, essential amino acids (lysine, methionine) and available carbohydrates, i.e., fast digestible feeds [32, p. 227; 33, p. 8; 34, p. 395]. A complete diet in pig feeding should include protein and a limited amount of fiber fetlock [35, p. 126], because pigs have a single ventricle that does not have the enzymatic ability to hydrolyze it [36, p. 149; 37, p. 89; 38, p. 47].

In this regard, protein-vitamin supplements, veterinary drugs for preventive and therapeutic purposes, mainly antibiotics, probiotics, and feed additives of mineral origin are used in the diet of farm animals [39, p. 92; 40, p. 95; 41, p. 460].

The European Association of Specialty Feed Ingredients and their Mixtures (FEFANA) identifies five main groups of additives [42]: technical additives that directly affect feed, such as organic acids; sensory additives affecting the consumption of feed, such as aromatizing agents; nutritional supplements that provide the necessary level of amino acids, vitamins and trace elements in the diet; zootechnical additives that improve the use of nutrients such as enzymes, coccidiostats and histomonostats.

Knowledge of the characteristics of digestion and metabolism in farm animals is crucial in improving its productivity. The main regulators of the digestive system include feed enzymes, feed antibiotics, probiotics and prebiotics. They have a different biological nature and, accordingly, different primary mechanisms of action. However, they all affect the health and productivity of the animal equally, namely by regulating the microbial population in the gastrointestinal tract [43, p. 153].

In countries with high hygiene requirements for livestock products, the use of feed antibiotics is completely forbidden or severely restricted. In the search for alternatives, experts have paid more attention to feed enzymes, probiotics and prebiotics [44; 45, p. 511; 46, p. 12].

Thus, it has been established that in recent times the problem based on necessity of introduction of resource-saving technologies of keeping and feeding of animals is becoming more and more frequent in agriculture. One of the directions in its solution is possible to use various additives and premixes, enzyme preparations, protein-vitamin supplements. But now the rational feeding of farm animals is considered the using of organic alga named *chlorella*.

3.2. Chemical composition of *chlorella* as critical factor of using it in feeding of farm animals

The only real method to produce the most complete feeding in animal husbandry is to supplement existing diets with products of natural origin, which also has a wide range of biologically valuable substances in their easily digestible form. Important here is not only the value of the product itself, but also its cost, as well as the availability of biotechnology in relation to livestock conditions.

The habitat of chlorella is usually freshwater reservoirs, where this microscopic alga, possessing a large stock of chlorophyll and a complex of rare nutrients, participates in the process of photosynthesis, absorbing carbon dioxide, saturating the air with oxygen, forming a green precipitate, and in rivers and lakes it is suspended [47, p. 510]. At present, industrial production of chlorella is increasing through its cultivation in phytobioreactors [48, p. 398].

Some scientists suggest that the total protein content of mature *chlorella* is 42-58% of dry biomass [49, p. 55]. *Chlorella* protein is superior in quality to known plant proteins, as it contains all the necessary amino acids, including essential ones [50]. The content of amino acids in *chlorella* (g / kg air-dry matter) consists of glutamic acid 31,84; asparagine 25.66; leucine 21.68; alanine 20.13; valine 17.58; glycine 17.02; threonine 13.66 (Table 1) [50, p. 135-136].

Table 1

Chemical composition and nutrition of chlorella

The biochemical composition of chlorella,%	
Protein	55
Lipids	12
Carbohydrates	25
Ash	8
Content of aminoacids in chlorella, g / kg	
Glutamic acid	13,84
Aspartic acid	25,66
Leucine	21,68
Alanine	20,13
Valine	17,58
Glycine	17,02
Threonine	13,66
Phenylalanine	12,06
Serine	11,60
Isoleucine	11,30
Proline	9,78
Lysine	8,78
Tyrosine	8,25
Arginine	8,17
Cystine	7,53
Tryptophan	5,11
Meteonin	4,82
Histidine	1,51
Content of some vitamins, mcg / g	
Carotene	1341
Tocopherol	180
Nicotinic acid	140
Riboflavin	7,0
Pyrodixine	5,3
Thiamine	4,2
D	1,0
B12	0,8

Due to the *chlorella* protein contains all the essential aminoacids, its nutritional value is 2 times greater than the value of soy protein: 1 kg of *chlorella* is equivalent to 4-5 kg of soy [51, p. 46]. By adding 5-7 kg of dry matter content of chlorella to 1 ton of grain, its biological value increases by 1.5 times. In terms of calorie content, *chlorella* is equivalent to chocolate, and its protein is equivalent to that of milk powder [52, p. 88].

Chlorella also has an extremely strong cell wall, consisting mainly of a layer of chitosan, cellulose, hemicellulose, proteins, lipids and minerals [53, p. 630]. The composition of cell wall sugars is a mixture of rhamnose, galactose, glucose, xylose, arabinose, and mannose (Table 2). According to studies [54, p. 3825], the main saccharide of *chlorella* is rhamnose.

Table 2

The content of saccharides of the cell wall of chlorella [54]

Saccharides	%
rhamnose	45–54
arabinose	2–9
xylose	7–19
mannose	2–7
galactose	14–26
glucose	1–4

The amount of vitamins, both in cells and in the culture medium, varies basically depends on the growing conditions and the phase of algae development [55, p. 18]. The macroelements and trace elements that are part of the chlorella include: phosphorus, calcium, potassium, magnesium, zinc, iron, cobalt, manganese, rubidium, zirconium and others [56, p. 301].

Consequently, *chlorella* has the great biological importance according to its chemical composition. Improving the health of farm animals, increasing their resistance by *chlorella* using in feeding can become a prerequisite for the production of livestock and poultry products of high quality.

3.3. The physiological and productive action of chlorella in feeding of farm animals

The issue of the impact of the use of *chlorella* in feeding of animals was addressed by many soviet scientists, such as Bogdanov N., Gafarov S., Muzafarov A., Melikhov V., Shatskikh E., Boyarintseva G., foreign including Kotrbáček V., Kang HK, Salim HM, Janczyk, P. and others. Recent investigations by Ukrainian scientists on the effects of *chlorella* as a feed additive in feeding of farm animals have not been found generally.

The physiological and productive effect of *chlorella* in feeding of farm animals is reflected to the indices of live weight gain, animal body resistance, reproductive functions, and the chemical composition of meat.

Expanding the study of valuable substances of *chlorella* algae has led to the search for new forms of its application. Thus, Muzafarov A. emphasizes that dry biomass of chlorella is worse absorbed by animals, so *chlorella* in the form of a suspension is better for animals [57, p. 114]. Sprug Y. considered that *chlorella* in the form of liquid has advantages, as animals consume not only the biomass of cells, but also the products of their vital activity contained in the solution [58, p. 38]. The optimal density of *chlorella* suspension for feeding to farm animals is 50-60 million cells in 1 ml. Consequently, a positive effect of the inclusion of *chlorella* in the main diet of animals in the form of suspension, dry biomass and aqueous extract was found to increase their productivity.

There are many studies of information on the effectiveness of the use of *chlorella* in the diet of farm poultry to increase their live weight, including the feeding of broiler chickens and ducks in the world modern scientific sources. Thus, Ahmedkhanova R. and Hamid N. investigated the effect of *chlorella* with the enzyme cellovyridine G3x on broiler chickens. They found an increase of the live weight by 5.75%, improved conservation by 5.0% and reduced feed consumption by 6.54%, compared with the control group [59, p. 76]. Scientists from Czechoslovakia have found a significant increase of the phagocytic activity of leukocytes of broiler chickens in response to the enrichment of *chlorella* feed by 0.5% [60, p. 327]. Duck feed based on 0.2 and 0.3% of *chlorella* led to improved nutrient use by these animals and also their mortality was reduced.

Gafarov S., Shatskikh E. and Boyaryntseva G. studied the increment of piglets number which were drinking *chlorella* suspension. At the end of the research, the scientists obtained the following results: one month after feeding the suspension of chlorella the live weight of the piglets was higher than in the control group by 7.6%, and the average daily increment was increase by 16% [61, p. 17]. Other scientists also confirmed in their own work that adding of algae to feeding of piglets had led to increasing of their weight.

Another investigation showed depending on the amount of suspension, the weight of the experimental calve group compared with the control group may be greater by 25 – 40%, that were 5 and 6 months of age. Then the calves were weighed at 9 months of age and the difference in weight was already 50%, which indicates the prolonged action of the *chlorella* suspension [62, p. 65].

Also experiments were conducted to determine the effect of *chlorella* suspension for 50 days on the productivity of dairy cows by soviet scientists. At the end of the study, it was found that the milk yield of the control group of cows was 1070 kg, and in the experimental group – 1194 kg, which is 124 kg more [63, p. 1746].

It was found that nutrient uptake was increased, fecal NH_3 and H_2S content and fecal gas emissions were reduced when hog fattening with adding 0.1% of *chlorella* was conducted. In the gut microbiota of pigs, a higher content of Lactobacillus microorganisms and a lower content of Escherichia coli were also determined. These studies show that *chlorella*, even at low concentrations, as a feed additive for animals, can have a positive effect and is probably associated with an improvement in the taste quality of feeds, as well as a higher digestibility of minerals [64, p. 333].

In animal technology, hematological studies are often used to measure the degree to which animals meet nutritional requirements [65, p. 25]. Thus, not only the calculation of the total number of leukocytes, but also the determination of the percentage of individual forms of white blood cells, namely the leukocyte formula, is important in assessing the physiological state of the animal body [66, p. 45]. The decrease in lymphocyte content in peripheral blood in pigs makes compensation for a simultaneous increase in its phagocytes (neutrophils and monocytes). Consequently, the introduction of chlorella into the diet promotes the process of hematopoiesis in the red bone marrow, which to some extent contributes to the enhancement of the body's defenses of pigs.

The reproductive functions of animals play an important role in the procreation of the species, thereby providing the required amount of meat. Studies show that using *chlorella* as a feed additive for feeding roosters allowed to increase the activity of their sperm by 1.2%, the volume of ejaculate – by 8.5%, the sperm concentration by 4.7%. Egg fertilization was increased by 1.2%, and numbers of young animals were raised by 3.8% [67, p. 33]. The feeding biologically active additives of *chlorella* to sows in the volume of 1 l per head as part of the main daily diet for 30 days before farrowing and for 28 days after it contributed to the increase of the number of live piglets at birth per 1 sow by 25.0%. In addition, survivability of piglets aged 28 days increased by 38.2%, the live weight of 1 pig on the 28th life day increased by 6.8%, the gross weight of the young piglets increased by 49.1% [68, p. 112]. Depending on the amount of *chlorella* suspension for feeding sows per 1 kilogram of live weight during their preparation for fertilization contributed to the increase of sexual hunting of young pigs by 5-30,0%; fertilization of young pigs by 2.6-11.1%; their multiplicity – by 1.8 – 7.5% [69, p. 199].

Meat quality depends on many factors, such as the species, breed, sex, age of the animal and composition of feed [70, p. 180]. It is proven by science that today it is not possible to obtain meat possessing the high quality of any animal without the use of biologically complete diets, which include vitamins, minerals, amino acids, etc. The results of studies [71, p. 96] show that the use of *chlorella* suspension for feeding pigs increases the slaughter yield by 6,4% compared with the control group without the inclusion of algae in their diet, the output of pulp per kg of bone and muscle area raised by 20,77 and 10,52% respectively.

The data published by Park K. [72, p. 40] showed that using of *chlorella* in the feed for geese, their mass of meat increases and exceeds by 2.6-8.0% of geese meat in the control group without the addition of microalgae. In addition, the use of a suspension of *chlorella* in the composition of the feed for geese contributed to the increase in the amount of dry matter in their muscles of the chest and thigh.

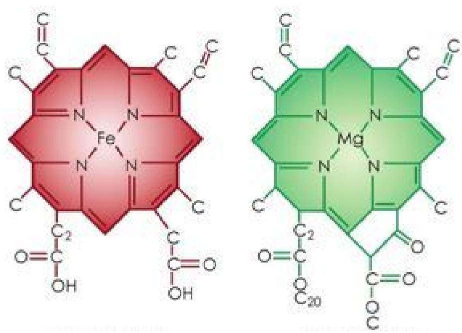
The practical and scientific work of many researchers has shown that the use of chlorella, as an additional source of valuable substances in the feeding of farm animals, can reduce the cost of maintaining them, including the cost of feed [73, p. 120]. Depending on the period of fattening, the species, the sex of the animals, it is possible to reduce the amount of their feed by 1.5-12.5% if it includes *chlorella*.

Therefore, the mechanism of action of chlorella suspension is determined by its effect on all systems and functions of the animal body. *Chlorella* suspension is a natural probiotic, as it improves the quality of feed, it lacks feed toxins, which increases the live weight of farm animals, and can be used more widely in animal production.

3.4. Analysis of chlorella use as a source of pigments and trace elements for farm animals

According to a published global report, the global carotenoid market reached 1.3 billion American dollars at the end of 2017 [74], explained by increased consumer awareness of the health benefits offered by various carotenoids and the transition to healthy and natural foods. A considerable amount of carotenoids also contain microalgae, in particular *chlorella*.

The composition of the microalgae of *chlorella* is not limited by the high content of protein, vitamins and trace elements. It also contains pigments, which synthesize the enzymes necessary for normal metabolism of living organisms. The most important pigment is chlorophyll, which is called "green gold" for the identity of its molecular structure of the hemoglobin molecule [75, p. 2811] (Figure 2). As known, chlorophyll provides significant support for the cardiovascular system, and also prevents the development of tumors, has antiseptic and regenerative properties. Some pigments of *chlorella*, as well as in terrestrial plants, have been proven to protect chlorophyll molecules from degradation and bleaching during heavy irradiation and oxygen [76, p. 1529].



A B

Figure 2. The molecule of hemoglobin (A) and chlorophyll (B)

Adverse conditions, such as a lack of biogenic elements, increasing concentrations of sodium chloride, lead to significant changes in the ratio of the pigment composition in algae cells towards predominance of carotenoids [77, p. 633]. Besides chlorophylls, which account 1–3% of the weight of dry algae cells [77, p. 631], *chlorella* contains a wide range of orange and yellow carotenoids, promoting photosynthesis, as well as protecting cellular structures from free radical damage and ultraviolet radiation.

The most valuable pigment found in *chlorella* is β-carotene, which mammalian cells cannot synthesize. Its concentration in *chlorella* is in the range of 0.1–0.2% [78, p. 145]. Known as provitamin A, β-carotene has been shown to prevent cancerous growth [79, p. 384].

The carotenoid pigmentation efficiency of the algae is extremely high. Thus, the enrichment of the feed mixture for laying hens with 2% concentration of dry *chlorella* increased the concentration of carotenoids in egg yolk fivefold [80, p. 287]. Similar studies have been confirmed even after using only 0.3% of dry chlorella in the poultry diet [81, p. 563]. A significant effect on the color of egg yolk was also found by Zheng et al. [82, p. 263] who had added 0.1 and 0.2% fermented chlorella to the chicken diet. Yolks of eggs of chickens, which are provided with chlorella as a feed additive, have an increased content of xanthophylls [82, p. 264]. Given the direct relationship between pigment intake and the protection of human vision from macular degeneration, eggs with high xanthophyll levels can be considered useful nutritional supplements [83, p. 199].

Scientists [71, p. 100] concluded that Beijing duck breast meat is characterized by a high amount of carotenoids, indicating a more yellowish tinge to meat than duck meat, the feeding of which had not involved the *chlorella*-based preparation. It was also found that the pH and water content of duck meat were directly proportional to the amount of *chlorella* used. According to a study by Park et al. [72, p. 42], the quality of edible meat can be determined by its pH, which is related to water retention ability and color.

The effect of high-β-carotene extracted from *chlorella* has been studied on reproductive system of sows [84, p. 282]. The experimental group of sows was fed with synthetic β-carotene at a concentration of 100 mg per day for animal during 1 month before the expected first fertilization, the other group – with synthetic β-carotene and dry *chlorella* powder in the amount of 1.5 g per animal. In both cases, the reproductive function of the sows improved significantly.

Laboratory studies have shown that heterotrophically cultured *Chlorella sp.* produces a significant amount of lutein, which plays an active role in delaying chronic diseases, preventing the development of cataracts and the progression of early atherosclerosis, and preventing blindness or reduced vision [85, p. 448]. The ability of heterotrophic growth in fermenters makes *Chlorella sp.* as potential alternative resource for commercial lutein production [86, p. 507].

Annual sales of *Chlorella sp.* exceed 38 billion American dollars [190], because algae are the major source of β-1,3-glucan [87, p. 500]. β-1,3-glucan can inhibit cancer cell growth *in vivo* by stimulating three important cytokines [88, p. 260]. Institute in Germany produces natural algae feed including *Chlorella sp.* and *Arthrospira sp.* for chickens called «Algrow» [89, p. 4].

Consequently, *chlorella* is used as a medicine in animal feed because it contains many important natural pigments.

Selenium (Se) and iodine (I) are important trace elements for human and animal health. The role of Se in the prevention of a number of diseases, including malignancies, thyroid gland dysfunction, cardiovascular disease, neurological diseases, aging, infertility and infections is proved by many scientific works [91, p. 645]. Iodine deficiency leads to serious disorders related to mammalian growth and development. Se and I play a significant role in the synthesis of thyroid hormones, which control the level of metabolism in almost all mammalian tissues [91, p. 400].

In European countries, soil and plants are mainly Se deficient [92, p. 60]. Therefore, several authors have grown *chlorella* as an additional source of Se or I in an inorganic medium enriched with selenium or iodide salts [93, p. 121]. In cell Se binds to proteins, 70% of which is represented by selenomethionine [93, p. 127]. Thus, a higher content of Se was found in eggs of chickens, whose diet contained *chlorella* that has been pre-enriched by Se [94, p. 1002]. Also, the high content of vitamin E in meat of chickens-boilers after feeding them with *chlorella* grown in selenium medium was determined [95, p. 166]. Se accumulation using feed additives of chlorella as a source of this trace element was also found in pig meat [96, p. 456].

Much of the enzyme glutathione peroxidase in mammals and humans consists of selenium-containing tetrameric proteins and glycoproteins. Low levels of glutathione peroxidase activity suggest that many diseases are likely to occur [97, p. 580], so the inclusion of Se foods in the diet is one of the important health benefits. The effect of the addition of selenium inorganic and organic forms (used inorganic selenite and an equal amount of organically bound Se in the chlorella biomass) on the activity of glutathione peroxidases was investigated in three groups of sheep and lambs [98, p. 44]. Thus, the content of Se in milk was increased, and the activity of glutathione peroxidase in the blood of sheep was found at a higher level when feeding consisted of selenium-containing chlorella. In addition, the fertility of lambs doubled when sheep were fed with *chlorella*-enriched of Se. Also enhanced development of immunoglobulin G in the serum of sheep and their generation is observed upon inclusion in the basic diet including Se-rich chlorella [99, p. 264].

Low content of I in soils, as well as Se, often leads to deficiency of this trace element in feeds made from plants [100, p. 380]. Typically, chlorella biomass contains low level of *I*, but the algae can also be enriched with iodine under specific conditions to sufficiently high level of *I* in order to meet the dietary requirements fully. Chlorella enriched of *I* was used in feeding for sows, resulting in the use of organically bound *I* led to significantly higher levels of immunoglobulin A in the blood of these animals [101, p. 31].

Two weeks before parturation and after the scientists Baňoch T., Fajt Z., Kuta J., Kotrbáček V., Konečný R., Trávníček J., Svoboda M. [102, p. 516] analyzed the accumulation of I in serum in two groups of sows. Iodine at a concentration of 0.6 mg / kg in the form of salt KI and *chlorella* enriched by I were added in diet of first and second groups of sows respectively. 100 mg of iodine per animal in the form of esters of iodized fatty acids were added to control group of sows. Lower levels of I, as well as hormone T3, were found in the serum of sows in the control group and piglets after 10 days of life.

Based on the results of studies [103, p. 958], the use of a suspension of *chlorella* grown on a nutrient medium of sodium selenite for feeding of piglets, had a positive effect on the live weight of pigs reared on meat, increased the protein content in meat, because Se activates protein metabolism and it is a part of more than 100 proteins.

The results of the above experiments show that *chlorella* is a new form of dietary supplement compared to traditional inorganic forms and it can be an effective source of pigments and trace elements including Se and I.

3.5. Effect of *chlorella* use on the immune system of farm animals

In the late 1980s and early 1990s, considerable attention was focused on the aqueous extract of chlorella cells, known as the *Chlorella Growth Factor* (CGF) containing free amino acids, peptides, glycoproteins, polyamines, phytohormones, minerals and other components [104, p. 590]. As is known, the aqueous extract of *chlorella* promotes tissue regeneration, growth and cell division, stimulates leukocyte production and phagocytic activity, and contributes to the production of antibodies that produce lymphocytes. The extracts also have probiotic activity, which influences the composition and activity of the microflora of the gastrointestinal tract [105, p. 1683].

Studies show that the use of an aqueous extract of *chlorella* has a positive effect not only on the immune system in broiler chickens, but also it can improve the quality of poultry meat [106, p. 229]. Other scientists have concluded that a dietary supplement for broiler chickens in the form of *chlorella* extract can enhance their productivity, increase the concentration of immunoglobulin A, metabolic nitrogen in the blood, and reduce ammonia emissions.

As noted earlier, *chlorella* allows the most complete use of feed by increasing its digestibility by 40%, resulting in a significant increase in additional growth of animals [], which confirms the positive effect of microalgae on the animal body in general. Thus, the introduction of this feed additive in the diet of pigs contributed to the reduction of energy feed units and exchange energy per 1 kg gain by 15-20% [107, p. 1120], the cost of digestible protein per 1 kg gain in young pigs also tended to reduce by 10-12% [108, p. 18], the content of erythrocytes increased by 28,3-32,1%, the amount of glucose increased to 40,7-45% in comparison with the control, the content of total calcium and inorganic phosphorus in the blood increased an average by 1,5-2 times [109, p. 23].

In the 1950's, the Carnegie Institution in Washington explored and cultivated the microalgae of *chlorella* to reduce CO_2 emissions. Today, Japan is the world leader in the use of chlorella and people of this country utilize it for treatment [110, p. 660], because it has been proven that *chlorella* has immunomodulatory and anticancer character. It has also been noted in medical practice that these microscopic algae are an effective tool in the control of anemia. In addition, chlorophyll which is one of the main pigments of *chlorella* provides significant support to the cardiovascular system, and prevents the development of tumors, has antiseptic and regenerative properties. Also *chlorella* synthesizes a natural antibiotic named «chlorellin» that successfully destroys pathogenic microflora.

It is especially necessary to note the effect on the animal body of the alkaline media of *chlorella*. Acidic environment allows fungi and pathogenic microflora to develop rapidly inside animal organism. In the reconstituted suspension of *chlorella* in an alkaline medium, fungi die. The growth factor contained in *chlorella* by 4 times accelerates the growth of natural microflora. As a result, work of the animal digestive tract normalizes. Due to the rich content of chlorophyll, the animal's body is able to defeat diseases of various etiologies, both non-infectious and infectious, including viral.

Therefore, *chlorella* has a wide range of biological activity, and in addition its use as a feed additive in diet of farm animals can increase resistance to infectious diseases, normalize metabolism, improve the function of the digestive system, and remove toxins from the body.

4. Conclusions

Based on previous investigations microalgae of *chlorella* as vitamin-feed and prophylactic additive is common used because its composition contains various biologically active substances. Introduction of *chlorella* in the diet of farm animals helps to improve their physiological and immune status due to the high content of proteins, lipids, amino acids, vitamins, minerals and others.

Also, the biological value of *chlorella* in feeding farm animals is the presence of pigments, carotenoids, which have a positive effect on their health and quality of food produced from these animals. Many scientists have noted the effectiveness of the use of feed additives of *chlorella* as a source of accumulation of *Se* and *I*, which are important trace elements for the full life of both animals and humans.

Complementing the diets, *chlorella*, due to its rich composition, has a pronounced therapeutic prophylactic and immunostimulating effect on the body of animal. The use of *chlorella* suspension in animal rations allows farms to comprehensively solve the problem of increasing productivity in animal husbandry. From the point of view of biological value, the great importance of feeding by *chlorella* to animals is in the form of a suspension, and not in a dry or pasty form, because about half of its metabolites are in the culture medium itself. The suspension is drunk by the animal almost immediately, when the cell density rises to a certain value that completely avoids the loss of especially valuable substances in its composition, which are unavoidable during long periods of storage in other preparations.

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ANTHROPOGENIC EVOLUTION OF MORPHOLOGICAL FEATURES OF CHERNOZEMS

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Abstract. The objective of the article is to study the morphological properties of typical and ordinary heavy-clay and light-clay chernozems with grain-size distribution of the Buh-Dnipro region of the right-bank southern forest-steppe and northern Steppe. The article discloses the consistencies of development of soil-forming processes in the conditions of fairly long agricultural use. The analysis and assessment of transformational changes that have occurred in soils under the influence of agricultural use has been carried out. On the basis of generalization of materials of large-scale soil studies, modular semi-stationary lots were selected in order to identify the direction of changes of anthropogenically-modified typical and ordinary chernozems with heavy-clay and lightly-clay grain-size distribution using comparative-geographical, comparative-profile-genetic, comparative-analytic and other methods. These methods are based on the principle of modular lots. Topographic and soil maps (scale 1:25000 and 1:10000), materials and agrochemical studies of the state organization Kropyvnytskyi Branch of the Institute of Soil Conservation of Ukraine, as well as the materials on geology, geomorphology and hydrogeological structure were used. In the territory of the Buh-Dnipro region of the right-bank southern forest-steppe and northern Steppe, modular lots were selected and morphological studies were conducted within their boundaries. Soil sections were based on the principle of single difference: all factors of soil formation are almost the same, except anthropogenic, which in turn makes it possible to identify quantitative and qualitative changes in agro-ecological properties of the investigated soils as a result of agricul-

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tural use. Within the modular lots, representative soil sections were formed on lands of various economic uses, namely, forest, forest belts, grass lands, arable lands with and without mechanized cultivation. Within the modular lots, soil sections were made on one-level altitude-division surfaces, on similar elements of micro ground features, on similar soil-forming rocks, within one soil difference in the post-vegetation period. In the conditions of the Buh-Dnipro region of the right-bank southern forest-steppe and the northern Steppe of Ukraine, a comprehensive study of the composition and properties of typical and ordinary chernozems was conducted. Changes of morphological properties of typical and ordinary chernozems with heavy-clay and lightly-clay grain-size distribution depending on their agricultural use have been identified. On the example of numerous variants and a comprehensive programme of observations, the conservativeness of soils with heavy-clay and lightly-clay grain-size distribution was not confirmed, but significant changes of their morphological properties were revealed. The complex of indicators revealed the degradation of the properties of typical and ordinary chernozems under anthropogenic pressure, especially in surface horizons. The tendency of anthropogenic transformation of soils, which is to increase the differentiation of the profile by morphological features due to agricultural use, has been established. The nature of intensification and direction of degradation processes of soils of agro-ecosystems has been revealed.

1. Introduction

Significant exacerbation of the ecological situation and the formation of pre-crisis, crisis, and often catastrophic conditions of land resources within the Buh-Dnipro inter-stream area require a detailed study of the processes related to agricultural activity. Only in this way the methodological basis for the improvement of the soil status of agro-ecosystems can be developed and the losses of agricultural production from the irrational use of outdated engineering technologies can be estimated.

The problem of economically advantageous and environmentally sound land use of hundreds of thousands of hectares of chernozem cannot be solved without a detailed study of anthropogenically transformed lands.

The objective of the research is to study the morphological properties of typical and ordinary chernozems with heavy-clay and lightly-clay grain-size distribution of the Buh-Dnipro region of the right-bank of southern forest-steppe and northern Steppe. It is also important to study the consistencies of development of soil-forming processes under the conditions of fairly long agricultural use.

In accordance with the objective of the research, it was envisaged to solve the following tasks:

– to analyze and assess the factors of soil formation of the studied territory of Ukraine;

– to substantiate the choice of semi-stationary lots for the study of the evolution of anthropogenically-transformed typical and ordinary chernozems;

– to analyse the changes in the morphological properties of typical and ordinary chernozems with heavy-clay and light-clay grain-size distribution depending on their use;

– to identify the nature of changes in soil properties;

– to determine the direction of anthropogenic soil evolution.

2. Morphological and genetic characteristics of the objects under study

Modular lot 1 (Oleksandrivka)

Semi-stationary soil lot № 1 in the territory of Chervono-Nerubaivka ecosite of Oleksandrivka forestry of Oleksandrivka district (Figure 3.1). The experimental lot is located in the territory of Chervono-Nerubivka forestry in the north-eastern outskirts of the village Pidlisne. The area is flat with oak and maple forest, plantation age is 50 years. The grass cover is typical forest vegetation (blackberry, stelleria, violet). The soil is a typical low humus heavy-clay chernozem on D horizon (Figure 2.2).

Figure 2.1. Panorama of the site of the soil section № 1

Description of soil profile:

H_f 3-0 – forest floor, leaves, buds, tree branches (half decomposed);

H 0-50 – humus, dark gray, dry, heavy-clay, slightly compacted, fine-grained, lumpy, intensely penetrated by the roots of grasses and trees, the transition is gradual;

Hp_k 51-80 – heterogeneous in colour, the upper part is dark gray with brown colour, the lower part is brown with dark gray hue; compacted, heavy-clay, bumpy and slightly blocky, full with roots and occasionally with mole passages. The transition is gradual;

Figure 2.2. Semi-stationary soil section № 1

PH_k 81-140 – dirty-brown, at the top with gray hue, dry, dense, heavy-clay, lumpy and slightly blocky; from the depth of 100 cm there is weak carbonate mould; slightly penetrated by roots, occasionally with mole passages. The transition is gradual. Soil effervescence is from 10% of HCl from the depth of 100 cm.

P_k 141-170 and deeper is heavy-clay carbonate D horizon.

Semi-stationary soil section № 2

Soil section № 2 is located 300m south of section № 1. The field under arable land, littered with rape plants (Figure 2.3).

Description of soil profile:

Ha_k 0 – 25 cm is arable layer, dark gray, dry, heavy-clay, lumpy powder-like soil, (partially cloddy), dense, partially blocky

H_k 26-40 cm is base layer, with much humus, dark gray, over-consolidated, wet, lumpy and blocky, light-clay, the transition is noticeable in structure and density (Figure 2.4).

Figure 2.3. Panorama of the location of the ground section № 2

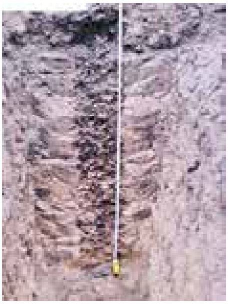

Figure 2.4. Semi-stationary soil section № 2

Hp_k 41-50 is dark gray, dry, heavy-clay, very dense, largely blocky; the transition is noticeable by colour;

PH_k 51-95 is dark gray with a brownish hint, wet, heavy-clay, lumpy, slightly blocky, dense; occasional mole passages and wormholes, the transition is noticeable by consistency;

Ph_k 96-145 is heterogeneous in colour due to its considerable loosening, dirty-brown with gray tint, wet, heavy-clay, lumpy, slightly blocky, very dense; the transition is noticeable in colour. Soil effervescence is from 10% of HCl from the depth of 95 cm;

P_k 146-170 and deeper is heavy-clay D horizon with mole passages.

In the chernozem zone, forest only after a long influence slightly increases the content of humus in the soil, slightly reduces soil effervescence, changes the reaction towards acidity and improves the structure. Indeed, we can observe a slightly lower carbonation depth in the forest than in the field. As can be seen from the descriptions of soil profiles in anthropogenically-modified soils, the organic-accumulative horizon is completely absent, and the humus layer, due to the use of machining, is much shorter than that of the natural analogue. Also for this reason, the transitional arable land horizons are consolidated, with a clear transition from one horizon to another.

Modular section 2 (Mala Vyska).

Semi-stationary soil section № 3.

Let us dwell more on soil sections which are most characteristic of this modular lot.

Section № 3, is located in Dokuchaevka forest belt № 4, 350 m from Kropyvnytskyi-Uman motorway. It is a flat area. The absolute height is 217 m. The first layer consists of oak, ash and birch bark. The age of the trees is 117 years (Figure 2.5). In the underwood there are black elderberry, Siberian pea shrub; the grass cover is represented by nettle, cow parsley, corydalis, sea flowers and bedstraw. The soil is typical deep humus chernozem in D horizon.

The following genetic horizons are identified:

H_f – 5-0 cm is forest floor, half decomposed below.

H – 0-85 cm is (where the top layer of 0-10 cm is characterised with virtually no structural macro- and microaggregates, and is represented by the dusty fraction, probably resulting from the deposition of dust from neigh-

Figure 2.5. Panorama of the location of soil section № 3

Figure 2.6. Semi-stationary soil section № 3

bouring arable land over the last 100 years. That is the elapsed period after compaction of tree seedlings), porous, humus, dark gray, wet, grainy, light-clay, penetrated with tree roots and mole passages, many coprolites. The transition is gradual (see Figure 2.6).

Hp_k – 86-105 cm is upper transitional, humus, dark gray with a brownish hue, wet, granular-bumpy, light-clay, penetrated with mole passages. The transition is gradual.

PH_k – 106-140 cm is lower transitional, weak and uneven humus, carbonate, brownish-gray, wet, granular-bumpy, slightly clayey, penetrated with mole passages, large accumulation of carbonates in the wormholes, gradual transition, the soil effervescence is from 10% of HCl from the depth of 110 cm.

P_k – 141-155 cm and deeper is D horizon of straw colour, carbonate, light-clay, penetrated with mole passages.

Semi-stationary soil section № 4

In the study of soil transformation due to anthropogenic influence, special attention was paid to the study of the genetic structure of the profile and morphological characteristics of soils. As a result of anthropogenic changes that typical and ordinary chernozems have undergone, which first of all includes ploughing with simultaneous change of hydrothermal conditions and subsequent application of fertilizers, ameliorants, cultivation, harrowing and other mechanical treatments, alienation of a large part of the phytomass with crop yield new living conditions are created, unlike natural soil (Figure 2.7).

Figure 2.7. Panorama of the location of the ground section № 4

30 m away to the north of the forest belt on a flat field, the soil is similar except for the humus horizon, which is shorter by 40 cm due to partial deflation from the field and settling of dust in the forest belt and considerable compaction of the soil of arable land.

Section № 4. The soil is deep typical chernozem with medium humic in D horizon. The following genetic horizons are identified:

H_a – 0-18 cm is arable humus layer, dark gray, wet, dusty-lumpy, light-clay, penetrated with winter wheat roots, compacted;

H – 19-45 cm is base layer, well-humic, dark gray, compacted, wet, lumpy and blocky, slightly clayey. The transition is noticeable by consistency.

Hp_k – 46-85 cm is upper transitional, humus, very dense, carbonate (soil effervescence of HCl from the depth of 80 cm; mould carbonates from 80 cm and to the bottom of the section); dark gray with a brownish hue, wet, coarse-blocky, light-clay, penetrated with mole passages, carbonate-accumulated wormholes, the transition is noticeable by consistency.

PH_k – 86-140 cm is lower transitional, slightly and unevenly humic, carbonate, brownish-gray, wet, compacted, coarse-blocky, light-clay, almost not penetrated with mole passages, some carbonates are observed in wormholes.

P_k – 141-155 cm and deeper is of straw colour, carbonate, compacted, light-clay, penetrated with mole passages.

Modular section 3 (Kropyvnytskyi).

Semi-stationary soil section № 5 in the village of Sozonivka, Institute of Steppe Agriculture of the National Agrarian Academy of Sciences of Ukraine, is located in the transitional lane of the Buh-Dnipro physical and geographical region of the right bank of the northern Steppe and the southern forest-Steppe. Soil section # 5 is located on a semi-stationary research site which is on the crossing part on the plain terrain at the distance of 600m from the Kropyvnytskyi-Znamyanka motorway in the north direction. Plant cover is represented by grasses. The surface type is a flat plain (Figure 2.8).

Figure 2.8. Panorama of the location of soil section № 5

Figure 2.9. Semi-stationary soil section № 5

The soil is ordinary deep chernozem, medium humic, carbonate and light– clay:

H_d – (5-0) dogwood, consisting of half of the living and dead roots of grass vegetation;

H_k is a humus horizon, uniformly humic, with a thickness of 55 cm, dark gray with a greyish hue, practically not compacted, wet, has a well-defined granular structure, heavy-clay. Coprolites are widespread throughout the horizon. The transition is gradual (see Figure 2.9); soil effervescence is 10% of HCl starts from the surface of the humus horizon;

HP_k is the upper humus-transition horizon (56-85 cm). It has gray colour with straw tint. In the upper part of this horizon, the structure is bumpy-granular, porous, which in the lower part turns into a granular-

bumpy with carbonate inclusions in the form of a white star, both in structural features and in root passages. The transition is gradual;

Ph_k – 86-120 cm, is the lower humus-transition horizon with a greyish-straw colour and many humus stubbles, porous in structural areas and in root passages, clearly visible carbonate inclusions, which in the dry form give it a slight whitishness. In the lower part of the horizon there are carbonates in the form of white stars. The lower transitional boundary extends at the depth of 95-120 cm;

P_k – 121-150 and deeper is a straw coloured D horizon, clumped with many mole passages. The upper part is brown, slightly and unevenly humic. Carbonates are present in the form of solid carbonate inclusions, which are rare. The grain-size distribution is light clay.

Figure 2.10. Panorama of the location of soil section № 5

Figure 2.11. Semi-stationary soil section № 6

Semi-stationary soil section № 6

Soil section № 6 is located in field No. 1 of forage crop rotation of the Institute of Steppe Agriculture of the National Agrarian Academy of Sciences of Ukraine in the village of Sozonivka. It is a plain area at the distance of 500m from Kropyvnytskyi-Znamyanka motorway. The vegetation is represented by grass mixtures. The surface type is planar (see Figure 2.10).

The soil is ordinary deep medium humic light-clay carbonate chernozem:

Ha_k – 0-20 cm is arable layer of humus horizon, uniformly humic (soil effervescence of HCl from the depth of 10 cm) dark gray colour with a greyish tint, compacted, wet, dusty-lumpy (see Figure 2.11);

H_k – 21-43 cm is base layer of humus horizon, uniformly humic, very compacted, especially at the depth of 30-40 cm, dark gray with greyish tint, lumpy and blocky, some mole passages are found all over the layer. The transition is noticeable by consistency;

HP_k – 44-69 cm is the first humus-transition horizon, gray with straw colour tint, very dense. At the top of this horizon the structure is lumpy and blocky, which in the lower part turns into blocky and lumpy,

and at the bottom with carbonate inclusions which are present both in structural features and in root passages. The transition is clearly visible;

Ph_k – 70-100 cm is the second humus-transition horizon, compacted, has straw-gray colour and much humus. In the dry state the horizon breaks down into lumps of different sizes and considerable hardness. The lower transitional boundary extends to the depth of 100 cm;

P_k – 101-150 and deeper, there is straw colour carbonate D horizon, lumpy with many mole passages. The upper part is dark brown, slightly and unevenly humic. The grain-size distribution is light clay.

Semi-stationary soil section № 7

Semi-stationary section № 7 is located in the western outskirts of Kropyvnytskyi in the transition zone of the Dnipro upland, on the border of the forest-steppe crossing to the Steppe. Soil section # 7 is located on a semi-stationary research site on a turning part on a plain terrain at the distance of 100m in the southern direction of Kropyvnytskyi-Mala Vyska. The plant cover is represented by grasses. The surface type is planar (see Figure 2.12).

The soil is typical carbonate chernozem with medium humus and light clay:

H_d – (5-0) dogwood, consisting of half of the living and dead roots of herbaceous vegetation;

H_k is uniformly humic, with the capacity of 47-48 cm, (soil effervescence of HCl from the depth of 5 cm) dark gray colour with grayish tint, moderately compacted, dry, has a well-expressed lumpy and blocky structure. Coprolites are widespread throughout the horizon. The transition is gradual;

Hp_k is upper humus-transition horizon, (49-77 cm). It has gray colour with a straw tint. In the upper part of this horizon, the structure is lumpy, blocky, very compacted at the depth of 50-60 cm, which in the lower part becomes a large-blocky with carbonate inclusions in the form of mould and tubules, which are widespread, both in structural areas and in root passages. The transition is clearly expressed (Figure 2.13);

Figure 2.12. Panorama of the location of the ground section № 7

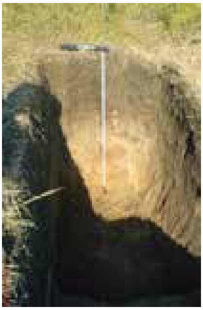

Figure 2.13. Semi-stationary soil section № 7

PH_k is lower humus-transitional horizon at 78-95 cm. It has grayish colour, compacted on the structural parts and on the root passages clearly show carbonate inclusions, which in the dry form give it a slight whitishness. The upper part of this horizon is largely blocky. In the lower part of the horizon there are carbonates in the form of mould. The lower transitional boundary extends at the depth of 85-95 cm;

P_k – 96-150 and deeper straw-coloured carbonate D horizon, clumped with some mole passages. The upper part is dark brown, slightly and unevenly humic. Carbonates are present in the form of moulds that acquire single interspersion. The grain-size distribution is light clay.

The presence of blocky structure, which is not characteristic of grass lands, especially at the depth of 50-60 cm, can be explained by the fact that this site has not yet managed to restore its structure.

Semi-stationary soil section № 8

The semi-stationary section # 8 is located in the southeastern outskirts of Kropyvnytskyi in the transition zone of the Dnipro heights, on the border of the forest-steppe crossing to Steppe. Soil section No. 8 is located on a semi-stationary research site of the State Forestry Organization on plain terrain at the distance of 500m from Kropyvnytskyi ring road. The vegetation is represented by the family of Solanaceae. The surface type is planar (Figure 2.14). The soil is typical chernozem with medium humus and heavy-clay carbonate:

Ha_k – 0-19 cm arable humic layer, dark gray, almost black, wet, lumpy and grainy, heavy-clay, loose;

H_k – 20-41 cm is base layer, well-humic, dark gray, loose, lumpy and grained, heavy-clay. The transition is barely noticeable by colouring (Figure 2.15);

H_{pk} is upper humus-transition horizon (42-75 cm). It has a gray colour with a straw tint. In the upper part of this horizon, the structure is lumpy-granular, porous, which in the lower part turns into granular-lumpy with carbonate inclusions in the form of moulds and tubes, which are distributed both in structural parts and in root passages.

Soil effervescence is 10% of HCl from the depth of 40 cm. The transition is gradual;

P_{hk} – 76-110 cm is the lower humus-transition horizon, has grayish colour and many swaths of humus, porous in structural areas and in the root

Figure 2.14. Panorama of the location of soil section № 8

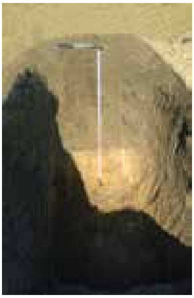

Figure 2.15. Semi-stationary soil section № 8

passages, clearly visible carbonate inclusions, which in the dry form give it a slight whitishness. In the lower part of the horizon there are carbonates in the form of white stars. The lower transitional boundary extends at the depth of 95-110 cm;

P_k – 111-170 cm and deeper is straw-coloured carbonate D horizon, clumped with many mole passages. The upper part is dark brown, slightly and unevenly humic. Carbonates are present in the form of moulds, which acquire a single interspersion, and from the depth of 170 cm solid carbonate inclusions rarely appear. The grain-size distribution is heavy clay.

As can be seen from the descriptions of soil sections, the humus horizon of natural soils is uniformly coloured in dark gray to the depth of 49-55 cm. This is due to the fact that soil tillage is applied and heavy machinery compacts it, thus degrading the agro-environmental properties. But the arable land, which has been cultivated for a long time in a non-mechanized way, is represented by section No. 8 in the humus horizon and has a distinctly lumpy-grained structure. This structure, together with low density, creates favourable conditions for the development of crops.

Modular section 4 (Oleksandria).

Soil section № 9 of Oleksandria State Variety Research Station

In order to identify the agro-ecological impact on soil condition of Oleksandria State Variety Research Station, a pilot lot was selected, which includes two soil sections: in the territory of the oak planting (see Figure 2.16) and in the territory of the experimental field. The total depth of both sections is 150 cm.

Figure 2.16. Panorama of the location of soil section № 9

Figure 2.17. Panorama of the location of soil section № 10

Soil section No. 9 is located outside the economic activity of people. The soil is ordinary deep chernozem with medium humus, heavy-clay, which is divided into the following horizons:

H_o – (3-0) forest floor, leaves, buds, tree branches (semi-decomposed);

H – (0-60 cm) is humus, porous, dark gray, wet, heavy-clay, granular structure, the upper layer (0-15 cm) was formed due to deflation processes and is characterized by almost complete absence of macrostructure;

HP_k is upper transitional (61-90 cm), moderately compacted, dark gray, with a brownish-bluish tint, closer to the lower boundary gradually lightens, heavy-clay mechanical composition, the upper boundary of the horizon is granular, the lower structure turns into thickened, slimy with many plant roots, soil effervescence is from the depth of 75 cm, carbonates are found everywhere in the form of white stars. The transition is gradual;

Ph_k is lower transitional (91-115 cm), carbonate, dark brown, wet, heavy-clay, lumpy-granular-blocky-like, compacted, strongly penetrated with mole passages, there are many carbonate inclusions along the roots;

P_k – 116-150 and deeper is D horizon, brown tint, spotted, heavy-clay granulometric composition, compacted.

Semi-stationary soil section No. 10

The land forms of Oleksandria experimental site, on which the soil section No. 10 is located, is a plateau (see Figure 2.17), with a general slope of the horizon in the southeast. In the north-east and south-western parts of the territory are cutbanks with general slope of 2°. Outside Oleksandria State Variety Research.

Station the cutbanks turn into denes of heavy-clay, dusty-granular structure. Winter wheat stubble. The experiment was carried out immediately after the harvest. The soil is ordinary deep chernozem with low humus and heavy clay. Total depth of field section is 150 cm, which is divided into the following horizons:

H_a is arable (0-25 cm), with humus, compacted, dark gray, wet;

H is under-tilling (26-35 cm), with humus, compacted, dark gray colour, heavy-clay, blocky-like structure, plant roots are present. The transition is noticeable by consistency;

HP_k is upper transitional (36-70 cm), very compacted, dark gray, sometimes almost black with a brownish-bluish tint, closer to the lower boundary gradually lightens, heavy-clay mechanical composition, the upper boundary of the horizon is coarse-grained, lower thickening with plant roots, carbonates are found from the depth of 55 cm, soil effervescence is 10% of HCl. The transition is noticeable by consistency;

Ph_k is lower transitional (71-90 cm), compacted, greyish-green colour, at the lower part of the horizon lightens, gradually gaining the colours of soil-forming rock, fine-grained, heavy-clay, carbonated, perennial; the transition is noticeable by consistency.

P_k – 91-150 cm and deeper is D horizon of straw colour, dense, light clay with granulometric composition.

Ordinary chernozem approaching deep chernozem by its features. Our research shows the reverse process, although the carbonation effervescence for forest belts is actually lower than for the arable land.

Modular section 5 (Novoukrainka).

Semi-stationary section № 11 is the grass land aged 10 years in the northern suburbs of the town of Novoukrainka, LLC "Zernovyk". It is located in the steppe part of the Dnipro upland, the subzone of the northen Steppe. It is the plain at the distance of 3km from the town. The surface type is planar. In the eastern direction of 100-150 m are small embankments formed artificially during the construction of the railway (Figure 2.18).

The soil is ordinary chernozem with low humus and light clay:

H_d – (5-0) steppe mat, remnants of herbaceous vegetation;

H_k is humus horizon, uniformly humic, 50 cm thick, dark gray with a brownish tint, heavy-clay, porous, dry, lumpy-granular, considerably pen-

Figure 2.18. Panorama of the location of soil section № 11

Figure 2.19. Semi-stationary soil section № 11

etrated by worms and insects, some mole passages and roots of plants that are traced by carbonate inclusions. Effervescence is 10% of HCl from the depth of 20 cm. The transition is gradual;

HP_k is upper transitional horizon, 30 cm thick, dark gray with a brownish tint, wet, light clay, lumpy-granular, slightly compacted, at the bottom with carbonate inclusions, which is widespread both in structural features and in roots. The transition is gradual (see Figure 2.19);

Ph_k is (81-110 cm) lower transitional horizon, dark brown, wet, light clay, lumpy, compacted, penetrated with mole passages. In the lower part of the horizon there are carbonates in the form of fibers. The lower transitional boundary is located at the depth of 110 cm, the transition is gradual;

P_k – 111 cm and deeper is D horizon of straw colour, at the upper part weakly and unevenly humic, compacted, depths of 90-140 cm. The grain-size distribution is light clay.

Semi-stationary soil section № 12

Soil section № 12 is located on the above-mentioned experimental lot. It is a plain terrain at the distance of 150m from section # 10 in the northeast direction in field № 1 of LLC "Zernovyk". The field is sown with winter barley. The type of surface is planar (see Figure 2.20)

The soil is ordinary chernozem with low humus and light clay:

H_a – 0-20 cm of arable horizon, uniformly humic, dark gray with brownish tint, moderately compacted, dry, lumpy and blocky;

Figure 2.20. Panorama of the location of soil section № 12

Figure 2.21. Semi-stationary soil section № 12

H – 21-38 cm is base layer, uniformly humic, dark gray with a brownish tint, compacted, blocky, mole passages occur throughout the layer. The transition is noticeable by consistency;

HP_k – 39-63 cm is upper transitional horizon, dark gray with more saturated brownish tint (Fig. 2.21), lumpy and blocky, very compacted, at the bottom with carbonate inclusions, which are widespread both in structural features and in root passages. Soil effervescence is 10% of HCl from the depth of 40-45 cm. The transition is noticeable by consistency;

Ph_k – 64-109 cm is lower transitional horizon, dark brown, very compacted, carbonate passages are full of visible carbonate inclusions, which in the dry form give it a slight whiteness. At the bottom of the horizon there are solid carbonate inclusions. The lower transitional boundary extends at the depth of 85-109 cm;

P_k – 110 and deeper is D horizon, compacted, with many mole passages. The upper part is light brown, slightly and unevenly humic. Carbonates are present in the form of a white star. The mechanical composition is light clay.

As can be seen from the descriptions of soil profiles in anthropogenically-altered soils, the organic-accumulative horizon is completely absent, and the humus, due to the use of machining, is much shorter than that of the natural counterpart, even if the adjacent horizon is arable, they clearly show the transition from one to another.

Modular section 6 (Dolynska).

Semi-stationary soil section № 13

In the territory of Dolynska district, which is steppe zone, the most widespread are ordinary low-humus shallow chernozems. There are

Figure 2.22. Panorama of the location of soil section № 13

Figure 2.23. Semi-stationary soil section № 13

also ordinary, medium illuvial chernozems; ordinary low-humus chernozems, and ordinary low– and medium-humus, deep chernozems (Figure 2.22). The landscape of the experimental lot of the landscape park is a plateau surrounded by mixed forest with the slope of the horizon in the eastern direction. The soil is ordinary medium humus, light-clay chernozem.

he total depth of the soil section is 150 cm, which is divided into the following horizons (see Figure 2.23):

H_d – (5-0) is steppe mat, remnants of herbaceous vegetation (half decomposed);

H – 0-60 cm is light clay, lumpy-grainy, intensely dark gray, wet, porous, significantly penetrated with the roots of herbs and trees. The transition to the next horizon is gradual;

HP is upper transitional (61-85 cm), well humic, light clay, poorly compacted, gray, wet,

granular-lumpy, from the depth of 60 cm weak carbonate inclusions appear, as evidenced by a moderate soil effervescence of 10% HCl, the transition gradual;

Ph_k is lower transitional (86-125 cm), gray with a brown tint, wet, light clay, blocky, compacted. The transition is gradual;

P_k is 126-150 and deeper light-clay, yellowish, wet, largely blocky, carbonate inclusions in the form of lumps 0.5-1.5 cm in size;

Figure 2.24. Semi-stationary soil section № 14

Semi-stationary soil section № 14

In order to determine the agro-ecological impact on the soil condition as a result of agricultural use, an experimental lot was selected in the territory of the third field of the production rotation in Bokovenky Landscape Parknamed named after Davydov. One soil section was made on it. The soil is ordinary, medium humus, light-clay chernozem. The total depth of the soil section is 150 cm, which is divided into the following horizons:

H_k is tillage pan (26-40 cm), humic, very compacted, dark gray, wet, heavy-clay, blocky with traces of plant roots. The transition is noticeable by consistency, soil effervescence is 10% of HCl from the depth of 35 cm (Figure 2.24);

HP_k is upper transitional (41-70 cm), lumpy-blocky structure, compacted, dark gray with slight brownish tint in the lower part gradually luminous, light-clay, the structure of the upper part is coarse-blocky, in the lower part turns into coarse-lumpy and compacted. At depths of 45-50 cm there are carbonate inclusions in the form of moulds;

Ph_k is lower transitional (71-95 cm), carbonate, dark brown, light-clay, lumpy-granular-blocky, slightly compacted. In the traces of the roots there are many carbonate inclusions. The transition is noticeable by consistency;

P_k is 96-150 and deeper D horizon, the upper part is light-brown, slightly below the yellow colour, light-clay grain-size distribution with carbonate inclusions.

3. Anthropogenic changes in soil structure

Soil structure is its property to form aggregates of certain shape and size and to decay under the influence of little effort into the elements. The elements are called structural. Structural elements can be different in size, shape and hardness. The size of the lumps is distinguished as follows: soil microstructure – the aggregates with the diameter up to 0.25mm, soil macrostructure (lumpy-granular) – 0.25-10 mm and soil mega-structure – more than 10mm. By the form of aggregates, the structure can be lumpy, blocky, granular, dusty, columnar, prismatic and plastic.

The agronomic value of the structure depends on the roughness of the aggregates, which in turn is related to the density of the micro-aggregates in the macro-aggregates. The considerable lumpiness of lumps together with moisture resistance determines positive physical properties of soils. It is an indicator of the structure and high degree of cultivation of the soil (Table 1).

Table 1

Changes in soil structure depending on the type of land use

Agro-eco system type	Type of structure by depths, cm			
	0-20	30-50	60-90	90-120
Forest-steppe zone				
Forest	small-granular – lumpy	small-granular – lumpy	lumpy-light blocky	lumpy-light blocky
Forest belt	granular	granular	granular-lumpy	lumpy-light blocky
Arable land	cloddy	lumpy-blocky	lumpy-light blocky	lumpy-light blocky
Transitional line				
Forest belt	granular	granular	granular-lumpy	lumpy-granular-blocky
Grass land	granular	granular	lumpy-granular	lumpy-granular
Arable land (machine cultivation)	dusty-lumpy	lumpy-blocky	lumpy-blocky	lumpy
Arable land (non-machine cultivation)	clumpy-granular	lumpy-granular	lumpy-granular	lumpy-granular
Steppe zone				
Forest	lumpy-granular	lumpy-granular	granular-lumpy	blocky
Grass land	lumpy-granular	lumpy-granular	lumpy	lumpy
Arable land	light-cloddy	blocky	lumpy-blocky	lumpy-granular-blocky

Structural aggregates may be unevenly located in the bulk of the soil. The porosity of the soil and its bulk depends on it. The ratio of soil solids to pore volume, as well as capillary and non-capillary porosity, depends to a large extent on the soil structure and the methods and intensity of its cultivation. No less important feature of soil is its structure, that is, the ability to break up into separate elements [1, p. 99]. Structure is one of the most important properties of soils, which significantly affects fertility. Considering structure as a morphological feature, it is first of all necessary to pay attention to the shape, size and qualitative state of aggregates in different types of soils, as well as different genetic horizons of the same soil, where they are different.

The agro-ecological importance of soil structure is that it directly affects physical, water, physical-mechanical properties and resistance of soil to erosion phenomena.

The soil structure, which is dominated by aggregates of lumpy-granular structure with the size from 10 to 0.25 mm, has a loose soil composition, lower density and greater porosity. The unstructured soil has only capillary slots, and the structural soil has capillary and large pores, both between the aggregates and inside them, which are filled with air (see Table 3.1). Soils of natural ecosystems in all study areas have a distinct lumpy-granular and granular structures, and therefore they evaporate (and lose) moisture, unlike agro-ecosystems where mechanized tillage is used, which is a non-structural soil. As can be seen from the table, the soils of agro-ecosystems where mechanized tillage of the soil in the layer are used have a dusty-lumpy structure. This indicates that they are gradually turning into unstructured soils. Down the profile of their structure changes dramatically and takes the form of natural analogues.

The depth of difference between natural and agro-ecosystems coincides with the depth of difference in soil density. Agro-ecosystems without mechanization have a lumpy-granular structure and hold an intermediate position between natural and agro-ecosystems. The structure has a great influence on the permeability to the air. In the unstructured soil of agro-ecosystems with mechanized tillage and with sufficient moisture content of the plant roots and aerobic microflora suffer from the lack of free oxygen. And with sufficient air content, on the contrary, they suffer from the lack of moisture. That is why the relationship between solid and liquid and gaseous phases of soils is optimal in structural soils of natural ecosystems.

Moisture is slowly absorbed by soil of agro-ecosystems. In spring, during melting of snow and heavy rainfalls (especially they are characteristic of the steppe zone), a large amount of water on the slopes flows down to the surface of the soil, is lost and causes erosion, and the plaques show water stagnation and flooding of the topsoil. In such conditions, soils that are formed, have a cloddy structure. The predominance of this structure significantly impairs, and sometimes makes impossible the processes of moisture and air exchange between soil and plant, and as a consequence leads to their degradation.

There is no antagonism between water and air in the soil cover of grass land and forest ecosystems. With sufficient moisture available to plants, the structural soil contains the optimum amount of air.

At the same time, soils of grass land and agro-ecosystems without mechanized tillage are more resistant to water and wind erosion. Loose (structural) soil composition promotes better seed germination, propagation of plant roots in the soil. The dusty-lumpy structure of soils of agro-ecosystems after wetting floats, when it dries, forms a crust, which impedes the germination of seeds. The range of optimal soil moisture for cultivation is broader in the soil of the steppe eco-systems compared to the dusty-lumpy and cloddy agro-ecosystems throughout the study areas.

Therefore, these features just cause higher soil fertility of natural ecosystems compared to agro-ecosystems. No less important argument in favour of soils of agro-ecosystems where mechanized cultivation was not applied is that its cultivation consumes less energy costs [2, p. 292; 3, p. 170].

4. Conclusions

A significant improvement of the ecological status will result in the introduction of soil protection system of soil tillage, which will impede the development of water and wind erosion processes, significantly reduce the cost of labour, fuel and lubricants during this activity.

Paying attention to the comprehensive biologicalisation of agriculture, enriching its environmental functions can increase the efficiency of agricultural production, ensure high quality indicators of production and entering the world market. According to S.H. Chornyi, in modern agriculture, the role of the concept of "soil quality" is increasing, especially its definition, which consists not only of production functions, but also of ecological and social components. They are the main means of agricultural production, an indispensable material condition of human life and society, an inexhaustible source of its national wealth and prosperity [4, p. 7].

For the rational and highly efficient use of land and restoration of soil fertility it is necessary not only to know deeply and comprehensively the origin, composition and properties of soils, but also to have an objective and reliable assessment of their quality as a natural and historical basis for the development and implementation of soil protection systems of agriculture aimed at reproduction of soil fertility [5, p. 14].

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EVALUATION OF SWITCHGRASS SOURCE MATERIAL PRODUCTIVITY FOR PLANT BREEDING

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Abstract. The scientific research envisages: to study switchgrass varietal specimens according to economically valuable traits as well as to distinguish the most yielding ones, which have a high yield of certified seed in relation to the weather conditions of the vegetation period by HTC (hydrothermal coefficient). *The research object* is switchgrass varietal specimens (Zoriane, Morozko, Liniia 1307 and Cave-in-Rock), biometric indicators, seed yield, and weather conditions. *The methods* used in the research are general and special: methods of scientific research in agronomy, laboratory-field method – to determine the quantitative indicators of vegetative and generative parts of plants and the weight of 1000 seeds, quantitative-weight methods – to establish crop productivity and yield of certified seed; statistical processing of research results was performed by a dispersion analysis and variation statistics. *Research results.* Variety Zoriane and Liniia 1307 formed the highest quantitative indicators of the vegetative (height of plants, number of stems and leaves and length of flag leaf) and generative part of plants (length and width of panicle, number of twigs of the first order and number of panicles and weight of seeds from panicle) independently of the cultivation conditions. The impact of biometric (quantitative) indicators of the generative part of plants, in close relation with the weather conditions by HTC during the vegetation period, on the seed productivity, which affect the total crop yield, has been determined according to the research

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results. Seed yield of switchgrass varietal specimens by the determination coefficient (d) depends on: 53-59% – the number of twigs of the first order, 48-52% – the number of panicles, 12-21% – the seeds size, and 6-12% – the length and width of panicle. *Conclusions*. Variety Zoriane and Liniia 1307, which produce weighty seeds, high seed yield (more than 500 kg/ha) of certified seed (about 65%) and can be used in further breeding work to create and expand switchgrass assortment have been distinguished. In future, this will allow to obtain seed material of high quality at no additional cost, to establish new energy plantations for the production of plant biomass for energy purposes and additional products for various industries.

1. Introduction

In Ukraine, along with food security, the energy sector is equally important in order to ensure high indicators of economic efficiency of agriculture. Energy sector requires comprehensive study and implementation of plant energy resources. Plants that accumulate solar energy are a renewable resource and can be used as an alternative energy source for agriculture, industry, housing and communal services. In this regard, energy crops are the most effective, as their crops are established on the marginal lands, and they do not compete with food crops. Among the energy crops, switchgrass holds the leading position in terms of integrated use of phytomass: for use in animal husbandry, pulp production, production of biofuels, etc. [1-6].

However, the biofuel direction of switchgrass use needs further researches to study the ways to increase biomass yield and to improve seed productivity of the crop. Therefore, studying the ways of obtaining switchgrass material of high quality in order to establish new energy plantations is a relevant area of research as well.

2. Literature review

Today, scientists have determined that Ukraine has a strong potential for agrobiomass of crops and phytomass of energy crops being cultivated on marginal lands [7]. At the same time, in the publications of the authors [8], it has been determined that miscanthus giganteus and switchgrass are the most productive, in terms of biomass, energy crops with high economic indicators of its efficiency. These researches correspond with the results obtained by other authors [9-11]. According to their research, it has been established that high yields of energy-intensive biomass and switchgrass seed can be achieved through special agricultural measures of growing and pre-sowing seed preparation. Besides, it is necessary to take into account the weather conditions and the identified ways of reducing their negative impact on switchgrass phytocenosis. Another publication gives the economic effectiveness of the switchgrass biomass production, taking into account the optimized cultivation technology [12].

In the formation of the switchgrass yield, along with the weather conditions of cultivation period and varietal traits, a significant contribution belongs to the yield structure. Yield structure includes productivity elements: plant density per unit area, number and height of stems, number and weight of seeds in panicle, weight of 1000 seeds, etc. [13]. That is why in order to obtain high yields of biomass or seeds, it is necessary to ensure the most optimal ratio of all elements of the yield structure of energy crops, in particular, switchgrass.

A considerable number of foreign scientific works is devoted to the research of the targeted issue. Significant contribution to the solution of the problem of the use of biologically renewable plant resources application, including energy crops, their introduction, selection and improvement of the cultivation technology elements have been made by V. L. Kurylo, M. V.Roiik, D. B. Rakhmetov, M. Ya. Humentyk, V. A. Doronin, V. V. Dumych, S. D. Orlov, H. H. Heletukha, T. A. Zheliezna, H. M. Kaletnik, S. M. Mandrovska and others (Table 1).

However, information concerning the ways of obtaining high switchgrass yield is insufficient in order to understand the regularities of its seed productivity formation in Ukraine. In view of the above-mentioned facts, it can be argued that the evaluation of the breeding material according to the economically valuable traits is of high importance for creation of new high-yielding varieties for the following establishing of the effective energy plantations.

3. Research material and methods

Field experiments were conducted during 2015–2019 period with the collection of energy crops of Poltava State Agrarian Academy, which belongs to the central part of the Forest-Steppe of Ukraine according to the zonal distribution.

Table 1

Analysis of the research results

Authors	Short description of the research results
Kulyk M., Shokalo N., Dinets O. [14]	The impact of the morphometric indicators of energy crops (switchgrass, miscanthus, sida, castor, rumex, etc.) on their productivity has been established.
L. E. Moser and K.P. Vogel [15]	It has been determined that all switchgrass varieties originating from South America have the best adaptive reactions to the conditions of the southern territories of Eurasia. They will also be productive in the northern Europe, but their cold resistance will be less in comparison with varieties of North American origin.
Rakhmetov D.B., Verhun O. M., Rakhmetova S. O. [16]	It has been established that while growing introduced switchgrass varieties, their morphometric parameters should be taken into account as a result of adaptation to the new cultivation conditions.
Kulyk M. [17]	It has been determined that the yield of switchgrass biomass depends on the stem density, to a lesser extent on the stem height and the number of leaves on it.
Kulyk M. I., Rozhko I. I. [18]	It has been determined that the yielding properties and sowing qualities of switchgrass seeds depend on the weather conditions of the cultivation period.
Kulyk M., Rozhko I., Kurylo V., at all. [19]	It has been established that the seed productivity is determined by the number of twigs and seeds on the plant, their weight. Seed yield depends on the height of the stem and the length of the flag leaf to a lesser extent. This trait is distinctive to plants both on productive soils and on marginal lands.
Moroz O. V., Smirnykh V. M., Kurylo V. L., at all. [20]	It has been found out that in Ukraine, varieties Sunburst and Cave-in-Rock of the second vegetation year produce seed productivity of 0.597 and 0.373 t/, respectively.
Wolf D. D. and D. A. Fiske [21]	It has been determined that switchgrass seed productivity varied in the range of 220 - 560 kg/ha, and in some cases can reach 1000 kg/ha
Orlov S. D. [22]	Breeding specimens of switchgrass 737-10 (P. v. L.) Cave-in-Rock / 377 -10 (P. v. L.) Alamo, 398-10 (P. v. L.) Sunburst / 737-10 / (P. v. L.) Cave-in-Rock, 1025-10 (P. v. L.) Forestburg / 737-10 (P. v. L.) Cave-in-Rock have been selected. They are a valuable source for creating new domestic hybrids and varieties.

The climate of the experiment is moderate continental, with warm summers and moderate cold winters. January average temperature is -4° C ... -8°C, and July – +16 ... +22°C. Precipitation is about 500 mm per year, with frequent droughts during spring – summer period.

The soil cover of the experiment plots consists of podzolized chernozem having the following characteristics: humus content – 3.85%, soil nitrogen – 214.0 mg per 1 kg of soil, phosphorus – 148.7 mg per 1 kg of soil, potassium – 94.3 mg per 1 kg of soil, pH – 7.6.

The predecessor of switchgrass is wild grasses, agro-technology of cultivation is generally accepted for the cultivation area, in accordance with the scientific and practical recommendations [23].

The object of research was switchgrass varietal specimens of foreign and Ukrainian plant breeding: Zoriane – conditional standard (c. st.), Cave-in-Rock, Morozko and Liniia 1307. These varieties have corresponding characteristics [24-25].

The research aim is to study switchgrass varietal specimens in terms of economically valuable traits, and to distinguish among them the most yielding with high yield of certified seed in relation to the weather conditions of the vegetation period by the HTC (hydrothermal coefficient).

Research tasks are the following:

1. to determine the variability of quantitative indicators of the generative part of plants of switchgrass varietal specimens, depending on the cultivation conditions;
2. to determine the impact of the cultivation conditions on weight of 1000 seeds, to determine the most adaptive varieties;
3. to find out the impact of the cultivation conditions by HTC on productivity and yield of switchgrass certified seed according to the investigated varietal specimens.

The experiment plots were established according to the methodology of agronomy research [26], with a randomized placement of four time repetition in the soil with low content of humus determined by the method of Turin (3.9%), characterized by the following agrochemical parameters: nitrogen, phosphorus and potassium content is increased.

Quantitative indicators of vegetative and generative parts of plants of each variety were determined by the method of sampling diagonally of the plot in the fourfold repetition (50 plants per plot), with subsequent determination of the average indicator by the calculation results [27].

Evaluation of switchgrass varietal samples by economic traits, in particular, the number of plants and seeds per plant, the weight of seeds from one plant and others, was carried out in accordance with the scientific methods [28]. The seed size by the weight of 1000 seeds was studied according to the generally-accepted methods [29].

Accounting of switchgrass yield was done according to the methods [30]: at the time of the vegetation completion, sheaf samples were selected diagonally from the plot of 1 m (running meter) in the fourfold repetition, from which the seeds were threshed and weighed before-, and after cleaning from impurities– parts of panicle twigs, seed scales, etc. The research results were analyzed by the methods of variation statistics and, using the analysis of variance in Statistica 6.0, the least significant difference (LSD) has been determined according to the significance level ($p < 0.05$).

4. Research results and discussion

Throughout the research years, the hydrothermal coefficient (HTC) during the switchgrass vegetation period varied from 0.6 to 1.4. The least favorable (arid) weather conditions were during the 2017 and 2019 vegetation period, the weather conditions in 2015 and 2018 were close to the optimum value by the HTC (the HTC is close to 1), and 2016 was excessively moisty (HTC was more than 1.2). Figure 1–2.

Weather conditions and varietal traits affected the quantitative indicators of the vegetative part of switchgrass plants (figure 3–4).

Among the studied varieties, Cave-in-Rock was characterized by the greatest plant height (173.3 cm), variety Morozko produced significantly shorter stems (154.5 cm), plant height of Liniia 1307 (170.3) was at the conditional standard level. According to the number of stems, Liniia 1307, varieties Zoriane and Cave-in-Rock have been distinguished. They form plant density more than 300 pieces/running meter, this indicator of variety Morozko was at the level of 287.8 pieces/running meter.

Variety Zoriane and Liniia 1307 have been distinguished according to the number of leaves on the stem (more than 51.0 cm) and internodes (more than 8.5 pcs.), this indicator of other varieties was significantly lower.

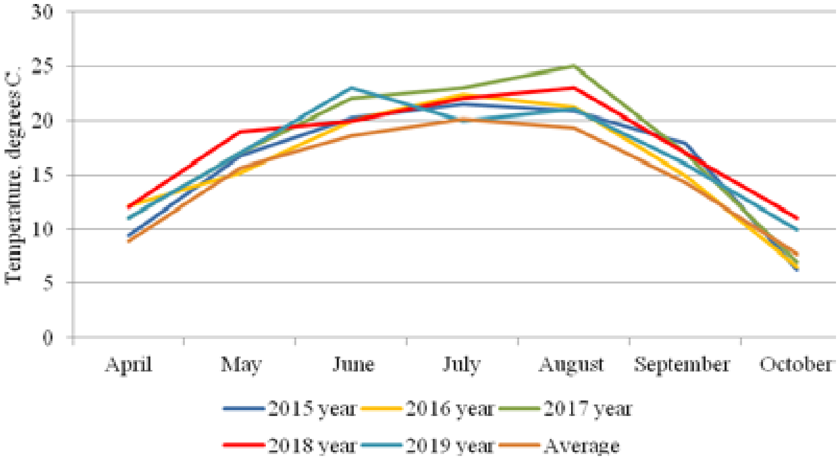


Figure 1. Weather conditions (air temperature) of the switchgrass vegetation period, 2015-2019

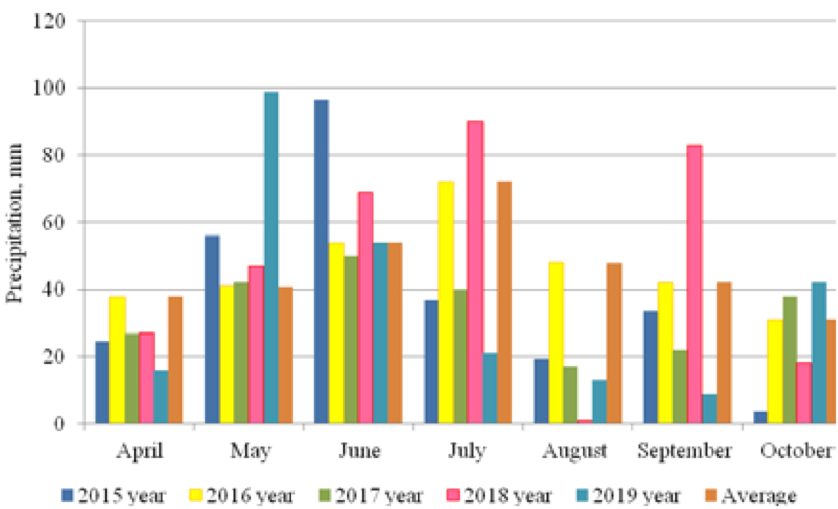
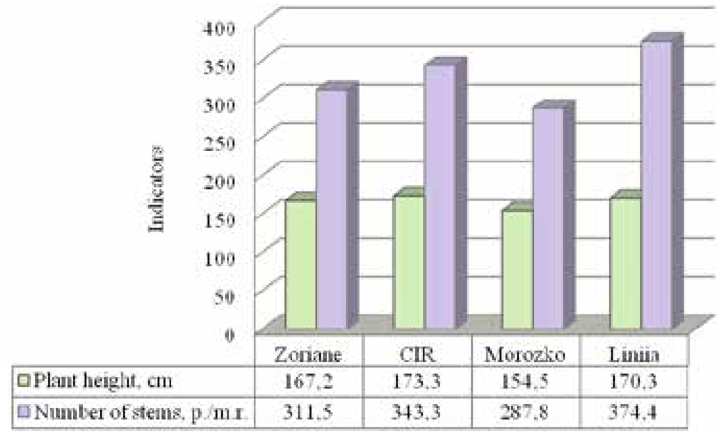
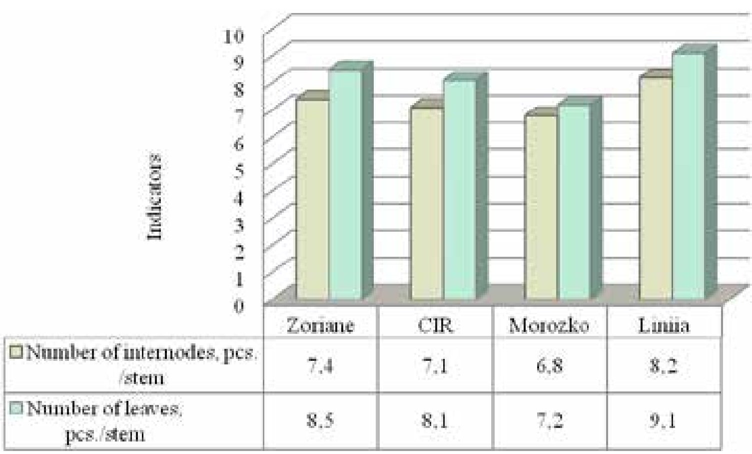


Figure 2. Weather conditions (precipitation) of the switchgrass vegetation period, 2015-2019



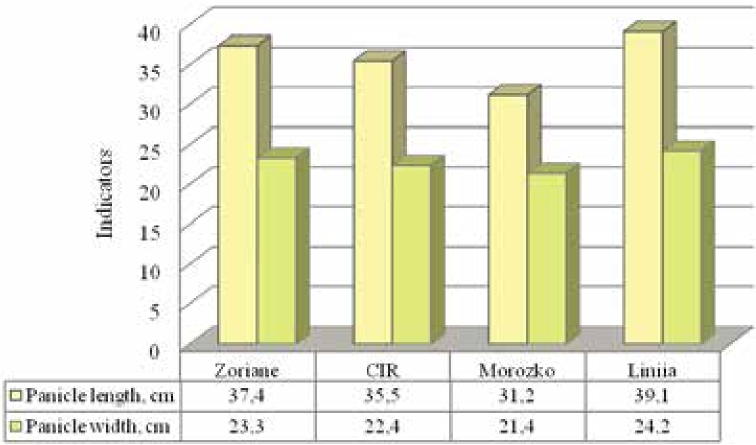
LSD$_{05}$ (Plant height, cm) 3.4; LSD$_{05}$ (Number of stems, pcs./r. m) 21.3

Figure 3.Quantitative indicators of the vegetative part of switchgrass plants (plant height and number of stems), average for 2015-2019



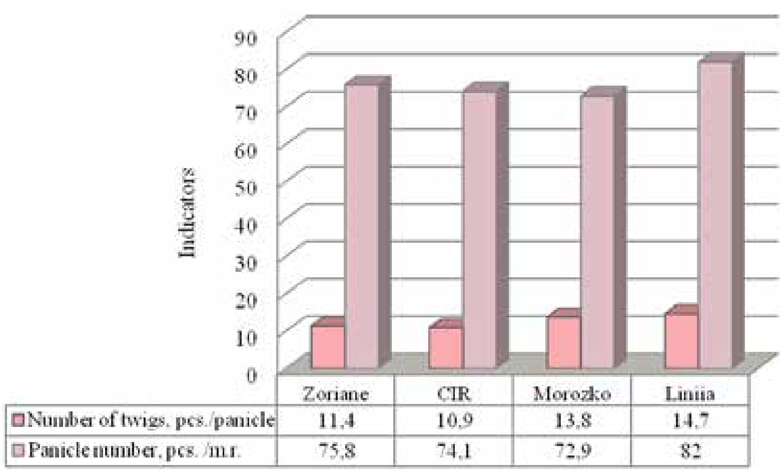
LSD$_{05}$ (Number of internodes, pcs./stem) 0.3; LSD$_{05}$ (Number of leaves, pcs./stem) 0.2

Figure 4. Quantitative indicators of the vegetative part of switchgrass plants (number of internodes of leaves on the stem), average for 2015-2019



LSD$_{05}$ (Panicle length, cm) 1.1; LSD$_{05}$ (Panicle width, cm) 0.4

Figure 5.Quantitative indicators of the generative part of switchgrass plants (panicle length and width), average for 2015-2019



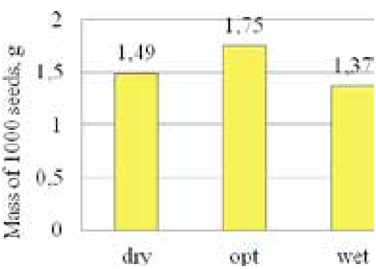
LSD$_{05}$ (Number of twigs, pieces) 0.6; LSD$_{05}$ (Number of panicles, pieces./м.п.) 5.3

Figure 6. Quantitative indicators of the generative part of switchgrass plants (the number of twigs of the first order and panicles) average for 2015-2019

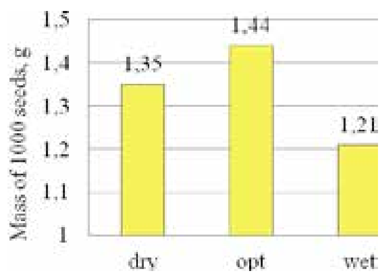
The yield structure elements of the generative part of the plants (length and width of panicle, their number, as well as the number of twigs of the first order, and the weight of seeds from panicle) varied widely, and had the following indicators (Figures 5–6).

According to the morphometric parameters, variety Cave-in-Rock and Liniia 1307 showed the highest indicators, compared with the conventional standard. These varietal samples formed the largest seed weight from panicles that resulted in high seed productivity.

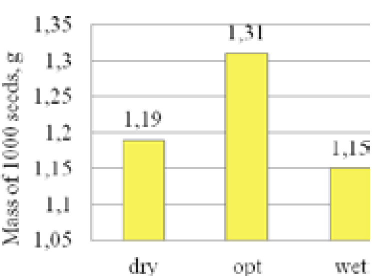
The weight of 1000 seeds depends on the impact of the weather conditions of the vegetation period and the variety properties. Significant variation in the seed size of varietal specimens has been determined, which averaged 1.15–1.75 g during the research years (Figure 7).



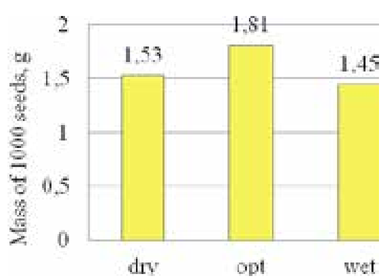
a – Zoriane



b –Cave-in-Rock



c – Morozko



d –Liniia1307

Note: dry – dry conditions, opt – optimal conditions, wet – wet conditions.

Figure 7. Weight of 1000 seeds depending on the cultivation conditions, average for 2015-2019

In the optimal years, under the water availability, variety Morozko formed minimum weight of 1000 seeds (1.31 g), variety Cave-in-Rock formed significantly bigger weight (1.44 g), and the maximum weight was provided by Zoriane and Liniia 1307, respectively 1.75 and 1.81 g.

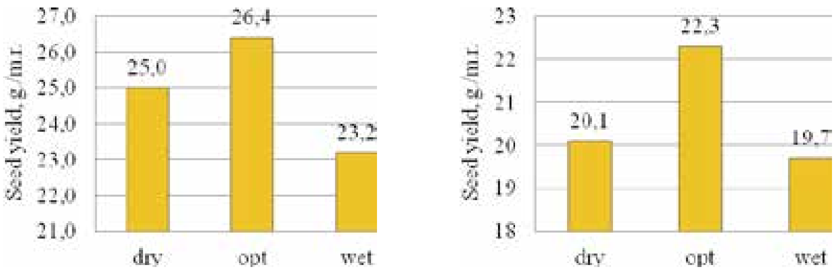
It has been determined that in the dry conditions of the vegetation period, the weight of 1000 seeds of the studied varieties varies in the range from 1.19 to 1.53 g, the periods of excessive moisture – from 1.15 to 1.45 g, and in the conditions close to optimal, seeds size will be the largest – from 1.31 to 1.81 g. Variety Zoriane and Liniia 1307 produce the weightiest seeds. A slight variation of this characteristic (V) has been established for these varietal specimen, respectively 1.81 and 2.75%. An average variation of variety Morozko (12.4%) and a considerable variation of variety Cave-in-Rock (25.6%) have been established as well.

By establishing the correlation between the quantitative indicators of the generative part of the plants, it has been found that the indicator of weight of 1000 seeds has strong relations with the number of twigs of the first order (r 0.78…0.81), and the average – with the length (r 0.31…0.36) and the width of panicle (r 0.41…0.43). This trait is typical for all switchgrass varieties.

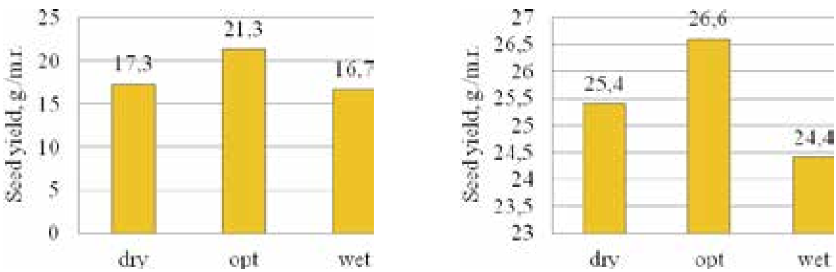
The correlation between the quantitative indicators of the generative part of the plants and the seed yield (SY) demonstrate that the indicator of weight of 1000 seeds has average relations with SY (r 0.35…0.44), the number of twigs of the first order and SY has strong relations (r 0.73…0.77), the number of panicles – strong relations (0.69…0.72), and average relations with panicle length (r 0.30…0.32) and width (r 0.31…0.35). This regularity was observed for all studied switchgrass varieties.

In general, throughout the research years, the highest yields of certified seed were formed by the variety Zoriane (25.0 and 26.4 kg/running meter) and Liniia 1307 (25.4 and 26.6 kg/running meter) in the dry and optimal years according to HTC. Seed yield was significantly lower for all varietal specimens in the conditions of excessive moistening during the vegetation period (Figure 8).

Compared to the conditional standard (variety Zoriane) and other varietal specimens, the newly created Liniia 1307 provided significantly higher yields of certified seed with a slight variation of the trait. A similar dependence was observed for variety Cave-in-Rock, but with a much lower seed yield.



a – Zoriane b –Cave-in-Rock



Note: dry – dry conditions, opt – optimal conditions, wet – wet conditions

Figure 8. Yield of certified switchgrass seed depending on the cultivation conditions, average for 2015-2019

Among the studied varieties, the lowest seed yield was provided by the variety Morozko, both in optimal moisty, and in arid and excessively moisty vegetation periods. A similar tendency was observed in the variety Cave-in-Rock, but with higher yields of certified seed. Variety Zoriane and Liniia 1307 form a significantly higher yield level in both arid and optimal years according to HTC.

6. Conclusions

1. In the conditions of the central Forest-Steppe of Ukraine, switchgrass plants are able to form seed since the first vegetation year. It has been established that along with the weather conditions of the vegetation period, varietal traits greatly affect productivity and yield of the certified seed. Variety Zoriane and Liniia 1307 formed the highest productivity and yield of

certified seed, respectively, 26.4 and 26.6 kg/running meter, which may be valuable for further breeding activity.

2. It has been determined that in the drier or close to the optimum conditions of the switchgrass vegetation period (according to the HTC), the seed yield will be much higher in comparison with more humid conditions. This is typically for all switchgrass varieties, which characterizes their average plasticity to the cultivation conditions.

3. Variety Zoriane and Liniia 1307 have the most stable manifestation in terms of the weight of 1000 seeds, which has an average impact on the seed yield by the coefficient of correlation; other varieties have an average and strong coefficient of variation according to this indicator. This trait should be used in plant breeding.

4. Quantitative indicators of the generative part of switchgrass plants make a substantial contribution to the level of seed yield. The seed yield of switchgrass varietal specimens by the determination coefficient (d) depends on 53-59% the number of twigs of the first order, 48-52% – the number of panicles, 12-21% – the size of seeds, and 6-12% – the length and width of panicle.

The perspectives for further researches will be to study the impact of pre-sowing seed preparation measures on sowing quality of the seed material in order to reduce the adverse effect of the weather conditions of the initial stages of seed germination.

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CLIMATE ASSESSMENT IN MODERN SUSTAINABLE CATTLE BARNS USING TEMPERATURE-HUMIDITY INDEX

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Abstract. The purpose of the study was to study the microclimate in modern uninsulated cattle barns, built with application of the resource-saving technology under the conditions of both natural ventilation and additional normalization of the air environment through the use of powerful axial fans during the heat of summer. The temperature and relative humidity of the cattle barns were investigated directly at the location of the animals in different areas of the premises, recording the indicators continuously for more than a day using remote sensors. Given the high negative correlation between these indices in indoor air (r = -0.88, P <0.05), the use of a temperature-humidity index (THI) to characterize the state of the air environment and to evaluate the combined effect of temperature and humidity on the body of the animals was quite reasonable. The mathematical processing of the results was performed using the software STATISTICA 10 (StatSoft, Inc., USA). Differences between indicators determined by the U-test of Mann-Whitney (*U-test*) were considered significant at P <0.05. A high correlation was found between the indoor temperature and humidity conditions and its state in the environment (r = 0.95, R^2 = 0.90). It was found that the state of the air environment in the premises was significantly influenced by their design features. The results of the studies show that the difference in average temperatures inside and outside the premises was up to 4°C. During the heat, it was cooler at the cattle barns at the account of the roof, which created shady protection from the sun's rays. The relative humidity in the cattle barns was 7-14% higher than outside, due to the release of

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moisture by the animals and evaporation from the surrounding structures. Differences in THI indoors and outdoors were up to 2–3 units ($P<0.05$), exceeding the comfortable value for cows (THI<68) during 18–22 hours per day. The location of the cattle barn relative to the sides of the world and the degree of its heating with sun rays influenced the value of THI in the premises. The difference between their central and lateral parts reached up to 5 units ($P<0.05$). The uneven distribution of THI in cattle barns may affect the milk performance of individual animals, requiring a differentiated approach to additional premise cooling. The constant operation of the axial fans and the open side curtains did not provide the necessary comfort for the animals, which should include the use of additional technical solutions (for example, irrigation) to normalize the microclimate in the cattle barn during the hot summer. The strong reliable relationship between the parameters of the air environment in the cattle barns and the external environment, determined on the basis of multiple simultaneous paired measurements of temperature and relative humidity, as well as their high interdependence, indicates the possibility of applying mathematical modeling methods for the prediction and normalization of microclimate, which will be the subject of our further research.

1. Introduction

Current livestock development strategies envisage the introduction of efficient resource-saving technologies. In this sense, particularly in dairy cattle breeding, the construction of new lightweight cattle barns for loose housing is becoming increasingly popular. Premises of lightweight construction (or non-insulated ones) are considered to be the most suitable from the point of view of milk production and cow health [6, p. 331; 16]. Compared with the capital premises, they have a lower concentration of harmful gases and more comfortable conditions for animals [4, p. 104; 9]. Due to the use of lightweight enclosures and modern natural ventilation systems, the cattle stall costs less by 24-28%, but the cost of milking and other technological equipment reduces the cost of construction by a third. In addition, the concept of lightweight construction is only economically viable for large dairy farms with more than 300 milk cows [16].

There are also problems in ensuring an optimal microclimate in such premises. Due to the large dimensions, the provided in them ventilation systems through the side curtains and light aeration lamps are able to provide the necessary parameters of the air environment only in a narrow range of outside temperatures [7, p. 66; 17, p. 1]. Problems with the functionality of non-insulated premises usually occur in winter at temperatures below -15°C, when purulent passes begin to freeze [16] and during summer heat, when in the resting place of animals it rises to +34°C when the outside air warms up to +36°C [1, p. 37]. The elimination of these problems involves the use of additional (in addition to natural) ventilation systems, which require significant energy consumption and, as a consequence, lead to rise in price of production output.

Among the current trends in the development of microclimate equipment [3, p. 212] the automatically controlled processes for maintaining the microclimate, depending on the time of day and day of the week, intermittent heating (cooling) and ventilation of the premises, the algorithm for which are multiple simultaneous studies of the parameters of the ambient air in the premises and outside are especially noteworthy. Being great theoretical importance for further construction of mathematical models and applied one for efficient use of ventilation equipment, such studies require considerable time and effort and are particularly valuable in the context of a particular facility, given the possibility of further implementation of their results in production.

The purpose of the research was to study the microclimate in modern uninsulated barns under conditions of only natural ventilation and with additional normalization of the air environment by the use of powerful axial fans during the heat of summer. The temperature-humidity index (THI), which characterizes the combined effect of air temperature and relative humidity on animals, was selected as an integral indicator of the microclimate condition in the premises, as previous studies [11, p. 103] found a reliable relationship between this indicator and dairy productivity of cows. This manuscript is the continuation of previous reports [12, p. 394; 13, p. 84], made within the framework of the project Biotechnological justification of resource-saving technologies for the production and processing of organic livestock and aquaculture products under the sponsorship of the Ministry of Education and Science of Ukraine (Decree of the Ministry of Education and Science dated 22.12.2018 No.1439) and registration at the Dnipro State Agrarian and Economic University (БМ-11/2019).

2. Research methodology

The researches were conducted under the conditions of industrial dairy complexes of the Limited Liability Company MVK Yekaterynoslavskyi and the Private Joint-Stock Company Argo-Soiuz in Dnipropetrovsk region. Indoor and outdoor temperature and humidity were evaluated using an Ambient Weather WS-10 thermohygrometer (Ambient LLC, USA) for more than 30 hours continuously, with sensor readings every 5-20 minutes. The remote sensors (F007TH) were placed at the resting level of the animals (at a height of 50 cm from the floor) directly between the first and second boxes on the side of the end sections (from the south-east and northwest) and in the central part (between the 1st and the 2nd boxes), just away from the interstall pass with the group drinking pan. Protective covers for the sensors in the form of a solid metal mesh were fixed in the stalls in advance so that the animals could get used to them. The WS-10 thermohygrometer panel was placed outside the premise in shade (Figure 1). Before operation, the sensors and thermohygrometer were adjusted using an Assman aspiration psychrometer [5] in accordance with GOST 6353-52. As well as in our researches, scientists [2, p. 203] measured the temperature and humidity of the air in real time using electronic sensors that were directly above the animal's stalls at a height of 2.5 m. The location of the recorders above the floor at such a distance was motivated by their inaccessibility by animals and maintenance staff (they should not have impede the execution of technological processes on operations). Although the location of the sensors was convenient for data collection, it did not fully reflect the state of the environment at the location of the animals, which directly affects them. We understand that in our case, the presence of animals near the sensors could have influenced their measurements by direct contact (licking, etc.), but the advance (few days before) fastening of covers from the metal mesh without the sensors in the boxes had to prevent "excessive interest" of the cows in the placed equipment.

The condition of the microclimate in the premises and the comfort of the animals were determined by the calculation of the temperature-humidity index (THI) by the equation [11, p. 103; 12, p. 394]

$$THI = 1.8 \times T - (1 - B/100) \times (T - 14.3) + 32$$

where THI is the temperature-humidity index, T is the air temperature, °C, B is the relative humidity, %.

a b

Figure 1. Measurement of temperature and humidity mode in one of the uninsulated barns: one of the sensors (F007TH) is located in the cow resting stall (a), the Ambient Weather WS-10 thermogigrometer is placed outside the barn (b)

The mathematical processing of the obtained results was performed using the software package for statistical analysis STATISTICA 10 (StatSoft, Inc., USA). The differences between the samples, determined by the U-test of Mann-Whitney (*U-test*), were considered significant at $P < 0.05$.

3. Climate in an uninsulated barn with natural ventilation

The LLC MVK Yekaterynoslavskyi (48°34'03.1"N, 34°54'47.0"E) is a high-tech innovative dairy complex for keeping Swiss breed. The cows are kept in modern housing for 600 units of milking herd (Figure 2). The premises are placed longitudinally in a direction from northeast to southwest relative to the sides of the world. Each of them has two rows of stalls (1.2×2.5 m) in four sections (150 units each). Special rubber mattresses create comfort for resting in stalls. The dimensions of the premises in the axes are 240.0×32.4 m. The side walls, 3.0 m high, have a reinforced concrete base (0.4 m high) with tarpaulin curtains. Additional day and night (infrared) illumination provides the necessary light mode indoors. The roof is double-pitch, made of sandwich panels, which allows to maintain the relative constancy of the temperature in the cattle barn, preventing it from overheating or cooling. The ridge height of the premise is 9 m. In the hot season, fans with a large diameter are included to enhance the air exchange. The DeLaval milking parlor collector with Dairy Comp-350 herd monitoring system (2×20parallel type) also has an irrigation system. A mixed diet, balanced according to the nutrition requirements of Nutrient Requirements of Dairy Cattle (2001), is distributed to the feed tables. Balancing of feeding and selection of components of feed mix depending on live weight and performance of cows is carried out in cooperation with the representatives of Cargill (Cargill AT, LLC). Each technological section is equipped with separate feeders with salt, chalk and soda, which allows the animals to eat them freely when needed. In interstall passes there are placed group automated drinking pans with water heating in winter. Manure from the passes is removed by a mobile vehicle (Bobcat S250) when the animals are in the milking parlor.

The side curtains in the pemise under study were constantly open. The ventilation of the premises was natural (powerful fans did not work). During observations, daily temperature fluctuations in ambient air were recorded in the range of +16.6 to +37.2°C, and relative humidity – 19 to 81%.

It was found that the air temperature in the premise was different from the environment. In particular, it was warmer in the evening, night and morning


a


b

Figure 2. Lightweight premise frame for 600 milk cows: a) inside view of the premise from the side of feed table; b) boxes for cows rest

(19:00 to 7:00). The difference between maximum indoor and outdoor temperatures was between 0.3 and 3.7°C. From 9:00 am to 19:00 pm, the premise temperature remained cooler (0.2–4.0°C) than outside (with rapid warming by the sun).

Differences were also observed in the mean temperature in different parts of the premise. In particular (Table 1), during the day in its central part (25.5°C) it was cooler by 0.3 and 0.9°C than in the south-east and north-west. The maximum temperature difference between the individual sections of the premise was observed at night (at 2:00): between central and southeast – it was 1.1°C; between central and northwest – 3.6°C, between southeast and northwest – 2.5°C. Moreover, in the hot period of day (from 11:00 to 16:00) the temperature difference between the individual sections did not exceed 0.8°C. In general, taking into account the dynamics of premise temperatures, it was found that for 18 hours straight (from 16:00 to 9:00) it was warmer on the northwest side. The difference between the average temperatures in the frame (at all observation points) and the northwestern side ranged from 0.1 to 2.0°C. From 10:00 to 15:00, the temperature was slightly higher on the southeast side. It exceeded the average one in the frame by 0.2–0.4°C. In general, temperature fluctuations in the premise occurred in the range of +17.7 to +34.0°C (from the southeast side – 17.7-34.0°C; in the central part – 18.3-33.2°C; from the northwest side – 20.2–33.2°C).

Humidity in an uninsulated premise also differed from the outside air. In particular, between midnight and 7:00 am, the relative humidity in the livestock building was lower. The difference between its average indoor and outdoor values ranged from 0.7 to 6.8%. In the morning (after 8:00) and until night (24:00), the humidity in the premise was higher by 0.2-11.4%. It was found (Table 2) that during the day the average value of relative humidity (54.2%) from the northwestern side was higher by 1.1 and 2.4%, respectively, than in the central and southeastern parts. The maximum difference between the individual sections of the premise according to this parameter of the air environment was observed in the evening (from 19:00 to 22:00): between central and southeast – 10.6%; between central and northwest – 6.8%, between southeast and northwest – 11.8°C. During the heat period from 11:00 to 16:00 the maximum difference in humidity between these parts of the livestock building was only 5.4; 6.7 and 7.8%, respectively. Given the dynamics of relative humidity, it can be affirmed

Table 1

Dynamics of air temperature (°C) in an uninsulated cow barn during 24 hours (n=162, $\overline{X} \pm SE$)

	Outside	Premise		
Day time	**in shade**	**southeast side1**	**cetral part2**	**northwest side3**
1:00	18.2±0.08	20.6±0.13*(2,3)	19.6±0.16*(1,3)	21.9±0.32*(1,2)
2:00	17.5±0.13	19.5±0.19*(2,3)	18.4±0.05*(1,3)	22.5±0.36*(1,2)
3:00	16.7±0.11	18.7±0.04	18.6±0.07	20.6±0.28
4:00	16.7±0.14	19.4±0.71	20.2±0.92	20.8±0.21
5:00	17.7±0.22	20.4±0.15*(2,3)	21.3±0.17*(1)	21.3±0.09*(1)
6:00	19.9±0.32	20.7±0.08*	21.3±0.06*	21.2±0.08*
7:00	22.9±0.62	22.9±0.47	22.5±0.39	23.5±0.43
8:00	25.9±0.27	26.0±0.39	25.2±0.36(3)	26.2±0.29(2)
9:00	27.6±0.25	27.8±0.26(2)	26.9±0.28*(1)	27.9±0.35
10:00	29.2±0.46	29.1±0.41	28.7±0.45	28.7±0.53
11:00	31.3±0.52	30.9±0.52	30.5±0.53	30.1±0.53
12:00	33.1±0.60	31.7±0.56*	31.3±0.56*	31.5±0.45*
13:00	33.8±0.81	31.8±0.69	31.4±0.67*	31.5±0.59*
14:00	34.3±0.47	31.3±0.46*	31.0±0.41*	31.1±0.38*
15:00	34.6±0.62	32.4±0.70	31.7±0.66*	32.7±0.56*
16:00	32.6±0.23	30.9±0.29*(2,3)	30.5±0.24*(1,3)	31.3±0.19*(1,2)
17:00	31.8±0.18	30.5±0.12	30.3±0.04	31.1±0.11
18:00	34.3±1.78	30.1±0.15	30.2±0.11	30.7±0.22
19:00	30.1±0.46	29.7±0.18	30.3±0.19	31.4±0.41
20:00	27.4±0.51	27.9±0.46(3)	28.1±0.27(3)	29.6±0.08*(1,2)
21:00	24.5±0.32	25.7±0.18*(3)	26.2±0.26*(3)	27.4±0.42*(1,2)
22:00	22.3±0.23	24.3±0.21*	24.3±0.22*	24.6±0.31*
23:00	20.4±0.28	22.0±0.26*(3)	21.3±0.48*(3)	22.9±0.27*(1,2)
24:00	19.1±0.12	21.3±0.07*(2,3)	20.0±0.19*(1,3)	22.3±0.19*(1,2)

Note: * – significant difference (P <0.05) between indices outside and indoors; (1), (2), (3) is a significant difference between individual parts according to the U-test of Mann-Whitney (*U-test*).

that during 13 hours of the day (from 8 am to 9 pm), the southeast side of the premise was drier than other areas. The difference between the average relative humidity in the building and separately in the southeastern part increased to 6.4%. In general, its values in the air of the premise ranged from 27 to 76% (outside, the variation ranged from 19 to 81%).

Table 2

Dynamics of the air relative humidity in an uninsulated cow barn during 24 hours (n=162, $\overline{X} \pm SE$)

	Outside	Premise		
Day time	in shade	southeast side1	cetral part2	northwest side3
1:00	73.1±0.50	71.1±0.80(2,3)	68.9±0.37*(1)	68.3±0.47*(1)
2:00	74.9±0.15	70.9±0.28*(3)	71.1±0.55*	66.5±1.08*(1)
3:00	77.7±0.41	70.1±0.03	72.7±0.41	70.6±1.87
4:00	80.0±1.41	74.5±2.12*	74.5±0.71*	74.5±0.71*
5:00	78.8±0.34	74.2±0.66	75.2±0.44	73.8±0.52
6:00	73.6±1.13	70.3±0.51*	69.4±0.46*(3)	71.6±0.32(2)
7:00	65.3±2.09	64.3±1.83	65.8±1.25	63.8±2.52
8:00	51.5±0.97	52.3±0.92	54.7±1.32	54.7±1.15
9:00	44.0±0.47	47.4±0.52*	48.3±0.65*	48.4±0.78*
10:00	39.6±0.78	43.9±1.04*	44.1±1.13*	43.7±0.56*
11:00	35.2±0.75	37.7±0.82(2,3)	43.1±2.38*(1,3)	43.4±0.52*(1,2)
12:00	29.4±0.64	34.3±0.56*(3)	35.4±1.74*(3)	41.3±0.63*(1,2)
13:00	25.9±1.01	32.7±1.37*	35.6±2.13*	37.1±1.37*
14:00	23.8±0.82	31.6±0.74*(2,3)	35.8±1.53*(1)	38.2±0.74*(1)
15:00	23.1±1.23	30.9±1.72(3)	32.0±2.30*(3)	38.7±1.05*(1;2)
16:00	27.7±0.91	37.5±1.81*	39.4±1.21*(3)	37.9±0.36*(2)
17:00	30.7±0.41	36.7±0.41	40.7±0.41	39.3±1.08
18:00	34.3±1.78	38.7±1.08	42.5±0.71	44.7±3.08
19:00	39.0±1.41	39.7±0.41	50.3±2.16	48.3±0.41
20:00	46.6±0.84	43.2±0.55*(2,3)	48.2±0.42(1,3)	55.3±2.74*(1,2)
21:00	48.8±0.47	49.3±1.12(2,3)	51.8±0.65*(1,3)	56.4±0.84*(1,2)
22:00	52.1±0.44	58.1±1.50*	55.3±0.21*	55.6±0.57*
23:00	57.7±1.02	63.9±1.78*(2)	56.9±0.57(1,3)	65.6±2.05*(2)
24:00	67.2±1.59	70.3±0.23(2,3)	65.2±1.95(1)	66.7±0.88(1)

Note: see Table 1.

During the day, the THI fluctuations outside the premises occurred in the range of 61.4 to 80.6. In the uninsulated barn, this figure ranged from 63.7 to 82.8. The difference between the average value of THI outside and inside the premise was 1.5 units. (Table 3). The maximum difference in THI magnitude was observed at night and especially in the morning. This figure was 3.2-5.1 units higher than outside. However, during the heat (from 12:00 to 16:00), the differences in indoor and outdoor air values were only 0.1-1.5 units, with THI values being higher outside the premise. In the same building, the maximum difference in this indicator between separate parts of the premise during the day was: at night (0:00-2:00) – 5.1; in the morning (3:00-11:00) – 1.7; at lunch (12:00-15:00) – 1.6 and in the evening (16:00-23:00) – 3.2. Although the average value of the index in the southeast, central and northwestern parts did not differ significantly and was respectively 72.5 ± 0.96; 72.4 ± 1.03 and 73.9 ± 0.90. That is, on the northwest side, the THI is 1.4-1.5 units higher than in other parts of the premise.

Table 3

Dinamics of the temperature-humidity index in an uninsulated cow barn during 24 hours (n=162, $\overline{X} \pm SE$)

	Outside	Premise		
Day time	**in shade**	**southeast side1**	**cetral part2**	**northwest side3**
1:00	63.7±0.11	67.3±0.17*(2,3)	65.6±0.25*(1,3)	68.9±0.49*(1,2)
2:00	62.7±0.22	65.6±0.28*(2,3)	63.9±0.07*(1,3)	69.3±0.48*(1,2)
3:00	61.6±0.15	64.5±0.04(2,3)	64.3±0.11(1)	67.2±0.36(1)
4:00	61.6±0.21	65.7±1.25	66.8±1.48	67.7±0.28
5:00	63.2±0.35	67.1±0.23*(2,3)	68.8±0.27*(1)	68.6±0.18*(1)
6:00	66.3±0.44	67.4±0.09*(2,3)	68.2±0.13*(1)	68.2±0.12*(1)
7:00	70.2±0.75	70.1±0.52	69.7±0.47	70.9±0.59
8:00	73.0±0.39	73.2±0.42	72.4±0.34(3)	73.8±0.35(2)
9:00	74.2±0.28	75.0±0.36(2)	73.8±0.30(1,3)	75.2±0.42(2)
10:00	75.6±0.51	76.2±0.43	75.5±0.44	75.6±0.64
11:00	77.3±0.55	77.2±0.52	77.7±0.83	77.1±0.62
12:00	78.3±0.64	77.6±0.59*(3)	77.3±0.39(3)	78.6±0.48(1,2)
13:00	78.3±0.73	77.4±0.73	77.4±0.55	77.9±0.67
14:00	78.5±0.35	76.6±0.39*(3)	77.2±0.23*	77.5±0.37*(1)
15:00	78.7±0.41	77.8±0.47*	77.2±0.36*	78.8±0.68
16:00	77.5±0.19	77.2±0.24	77.1±0.12(3)	77.8±0.26(2)
17:00	77.1±0.23	76.7±0.08	77.1±0.11	77.8±0.29
18:00	77.0±0.07	76.5±0.11	77.2±0.04	78.1±0.32
19:00	76.5±0.32	76.1±0.15	78.2±0.58	79.6±0.45
20:00	74.3±0.54	74.5±0.51(3)	75.4±0.35(3)	78.4±0.41*(1,2)
21:00	70.9±0.38	72.5±0.13*(3)	73.1±0.27*(3)	75.7±0.67*(1,2)
22:00	68.3±0.28	71.6±0.23*(2)	70.8±0.33*(1)	71.7±0.42*
23:00	66.2±0.33	68.8±0.25*(3)	67.3±0.62(3)	70.3±0.48*(1,2)
24:00	64.8±0.11	68.3±0.12*(2,3)	66.1±0.39*(1,3)	69.5±0.35*(1,2)

Note: see Table 1.

Environmental parameters such as temperature and relative humidity are closely related. The correlation coefficient between them was negative (r = -0.939; P <0.001) with high interdependence (R^2 = 0.88). In the indoor air, this relationship has increased (to r = -0.972; R^2 = 0.94), and it is therefore quite evident that the use of THI for the joint assessment of their effect on the animal's condition is quite convenient. Overall, the indoor climate was largely related to the state of the environment (r = 0.95; R^2 = 0.90). However, the highest correlation between the environment THI and the value of this indicator indoors was observed on the southeast side (r = 0.98; R^2 = 0.96).

Based on our data, during the 24 hours, cows located in the central and southeastern parts of the premise could have felt discomfort for 18 hours, and in the northwest for 22 hours. At the same time, indicators of temperature and humidity, which corresponded to the stressful condition of animals (THI> 68) outside the premise in the shade lasted only 16 hours. The differences found in the uneven distribution of temperature and humidity in the premise are attributed to its design features and location relative to the sides of the world. The obtained data indicate the need for additional use of active ventilation not only during the hot period, but also other hours of the day, depending on the area of the premise.

4. Microclimate in an uninsulated barn with normalization of air environment

The dairy complex of Private Joint-Stock Company Agro-Soiuz (48°28′44″N, 35°36′46″E) has breeding status for breeding Holstein breed. Cows are kept free in lightweight buildings built with resource-saving technology A microclimate study was conducted in a hangar type premise with medium-lactation animals (91 to 210 days). Their number in the sections, designed for 150 cows, was 127-143 units. The average daily milk yield for this technology group was 24-26 kg. This barn is located from north to south relative to the sides of the world, has tent covering, fitted with plastic side curtains, its dimensions in the axes are 124 × 34.5 m, ridge height – 8.25 m. The total area of the premise per cow is 4.3 m^2 (including the stall – 2.24 m^2). It is equipped with a feed table and group automated drinking pans (Figure 3).

Studies of the air temperature and the relative humidity in the premise were conducted in the range of outdoor temperatures from +19.2°C to

Figure 3. Non-insulated barn of hangar type with tent coating

+36.9°C. It was found that the microclimate in the barn was dependent on the state of the environment. The correlation between indoor and outdoor air temperatures was r = +0.962 (R^2 = 0.93), with the mean temperature inside and outside of the cattle barn not significantly different (Figure 4). At an outside temperature of + 20-23°C (at night and early in the morning) the temperature difference inside and outside the premise did not exceed 0.3°C. In the morning and at noon, when the outside temperature warmed up to +32°C, the cattle barn was warmer by 1.5–2.0°C. We associate this with the ability of the premise to preserve the heat produced by the animals.

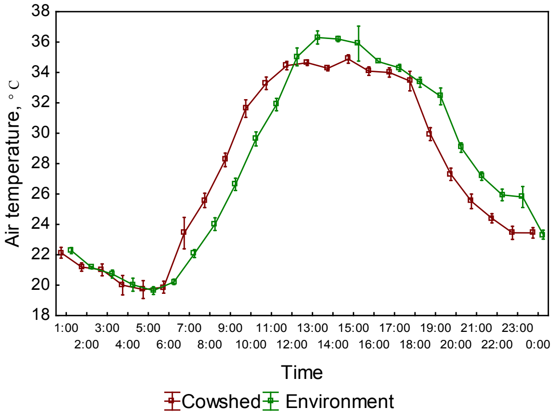

Figure 4. Dynamics of average temperatures outside (green line) and inside (dark-red line) of an uninsulated barn, n = 402

During the heat, when the ambient air heated above +35°C, the tent of the cattle barn served as a shadow protection for the animals. The premise was cooler. The average temperature difference was up to 1.9°C. In the evening, when the outside temperature drops below +32°C and till midnight, the uninsulated barn cooled by 1.5-2.5°C, which is due to the faster cooling of the premise in which the axial fans are operated.

The temperature in different parts of the premise, which has a north-south location relative to the sides of the world, differed significantly (Table 4). From 7:00 am to noon, the southwestern part of the premise was warmer by 0.5-3.0°C than the southeastern part of the premise, which was probably due to the warming of the barn by the rays of the rising sun.

At noon and 6:00 pm the northwest side was warming more strongly. The temperature here was higher by 0.3-1.2°C. The temperature difference in the center and ends of the barn during the day ranged from 0.1 to 3.7°C.

The relative humidity of the barn depended on the state of the environment (Figure 5). The correlation between the relative humidity inside and outside the premise was r = + 0.954 (R2 = 0.91). Its average values in the cattle barn were the highest (48.2–55.9%) at night and early in the morning before sunrise. The difference between the relative humidity indoors and outdoors at this time was low (0.7-3.4%). At noon and up to 16:00 with maximum warming of atmospheric air, its humidity decreased (up to 13.5%). However,

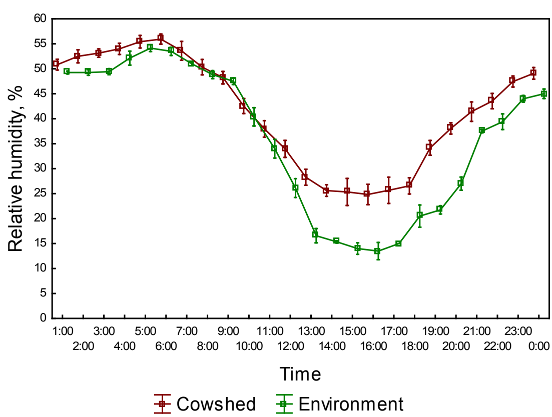

Figure 5. Dynamics of average relative humidity outside (green line) and inside (dark-red line) of uninsulated barn, n = 402

Table 4

Dynamics of air temperature (°C) in an uninsulated cow barn during 24 hours (n=134, $\overline{X} \pm SE$)

	Outside	Premise		
Day time	**in shade**	**southeast side1**	**cetral part2**	**northwest side3**
1:00	22.3±0.20	22.1±0.31	22.6±0.23	21.8±0.25
2:00	21.2±0.07	21.1±0.14	21.6±0.29	20.9±0.12
3:00	20.7±0.25	21.3±0.24	20.9±0.51	20.8±0.24
4:00	20.0±0.40	20.2±0.54	19.8±0.79	20.0±0.41
5:00	19.6±0.23	20.3±0.58(2)	19.0±0.54(1,3)	19.8±0.38(2)
6:00	20.2±0.17	20.0±0.40(3)	19.3±0.23*(3)	20.4±0.24(1,2)
7:00	22.1±0.25	25.7±0.44*(3)	22.0±0.50(3)	22.7±0.44(1,2)
8:00	24.0±0.40	26.6±0.22*(2)	24.8±0.36(1,3)	25.6±0.38*(2)
9:00	26.6±0.39	28.8±0.37*	28.1±0.42*	27.8±0.31
10:00	29.6±0.43	32.0±0.46*	31.9±0.65*	31.0±0.38*
11:00	31.9±0.38	34.2±0.31*(2,3)	32.7±0.25(1)	33.0±0.31*(1)
12:00	35.0±0.54	34.9±0.27(2)	34.0±0.14(1,3)	34.5±0.21(2)
13:00	35.0±0.54	35.0±0.13*(2)	34.2±0.09*(1,3)	34.5±0.21*(2)
14:00	36.2±0.16	34.3±0.05*(2,3)	34.0±0.09*(1,3)	34.6±0.15*(1,2)
15:00	35.9±1.41	34.7±0.23	34.8±0.28	35.2±0.21
16:00	34.7±0.19	34.0±0.21	34.2±0.35	34.2±0.35
17:00	34.3±0.28	33.8±0.21	34.3±0.21	34.0±0.28
18:00	33.4±0.31	32.5±0.40	34.2±0.65	33.7±0.43
19:00	32.4±0.52	30.0±0.34	30.2±0.47*	29.6±0.33*
20:00	29.1±0.29	27.3±0.55*	27.5±0.25*	27.1±0.24*
21:00	27.2±0.28	25.9±0.47*	25.3±0.49*	25.4±0.35*
22:00	25.9±0.37	23.9±0.32*	24.6±0.12*	24.7±0.12*
23:00	25.8±0.73	23.7±0.12	23.8±0.12	22.8±0.41
24:00	23.3±0.30	23.3±0.17	23.6±0.25	23.5±0.49

Note: see Table 1.

in the cattle barn, it remained on average 7.9–11.7% higher than outside. In the evening, even before sunset, the difference was significant (6.1–12.4%), and only after dark and at midnight did it make only 3.4–4.1%. Throughout the day, the relative humidity in the cattle barn was higher than outside, due to the release of moisture by the animals and evaporation from the surface of the frame structures.

In different parts of the uninsulated barn, the relative humidity was also different (Table 5). From 9:00 am to 6:00 pm it was 0.5-7.2% higher in the central part of the premise than in its front parts. In the morning and evening hours, as well as at night in the southeastern part of the premise, the relative humidity was higher (by 0.5–6.2%). In the northwestern part of the barn, this figure was lower throughout the day.

Table 5

Dynamics of the air relative humidity in an uninsulated cow barn during 24 hours (n=134, $\overline{X} \pm SE$)

	Outside	Premise		
Day time	**in shade**	**southeast side1**	**cetral part2**	**northwest side3**
1:00	49.3±0.29	49.5±0.75(2,3)	50.8±0.73*(1)	52.3±0.29*(1)
2:00	49.3±0.55	51.0±0.47(3)	51.5±0.75(3)	55.0±0.47*(1,2)
3:00	49.5±0.49	51.5±0.45*(2,3)	51.9±0.43*(1,3)	55.3±0.39*(1,3)
4:00	52.5±1.20	52.5±0.61(3)	55.0±1.14(3)	57.1±0.74*(1,2)
5:00	54.1±0.64	52.7±0.65(2,3)	56.1±0.96(1)	57.4±0.74*(1)
6:00	53.5±0.79	53.5±0.37(2,3)	56.5±0.24*(1,3)	57.8±0.44*(1,2)
7:00	51.0±0.35	50.2±1.98	55.0±0.71*	55.6±0.45*
8:00	48.8±0.77	46.8±0.66(2,3)	51.3±0.67*(1)	52.8±1.00*(1)
9:00	47.5±0.62	45.0±0.49*(2,3)	50.2±0.34*(1)	49.5±0.37*(1)
10:00	40.4±1.71	40.8±0.83(2)	44.3±1.21(1,3)	42.6±1.67(2)
11:00	34.0±1.75	35.9±1.47(2)	40.4±0.97*(1,3)	37.6±1.57(2)
12:00	26.1±1.75	30.9±1.10(2,3)	38.1±0.48*(1,3)	32.9±1.48*(1,2)
13:00	16.6±1.35	25.9±1.26*(2,3)	29.9±1.61*(1)	29.1±0.98*(1)
14:00	15.3±0.23	22.7±0.37*(2,3)	27.3±0.37*(1)	26.8±0.52*(1)
15:00	14.0±1.41	22.5±0.71	28.0±1.41	25.5±0.71
16:00	13.5±2.12	23.0±0.51	27.0±1.41	24.5±0.71
17:00	15.0±0.51	23.0±0.49	28.5±0.71	25.5±0.71
18:00	20.5±2.13	25.2±0.52(2)	28.8±1.18*(1,3)	25.7±1.93(2)
19:00	21.8±0.78	30.1±0.65*(2,3)	36.1±0.82(1,3)	36.3±0.83*(1,2)
20:00	27.0±1.25	36.0±1.15*(3)	38.3±0.56*(3)	39.9±0.50*(1,2)
21:00	37.5±0.33	39.8±0.29*(3)	40.3±2.42(3)	44.3±0.29*(1,2)
22:00	39.4±1.52	41.0±1.54	44.6±0.97*	45.0±0.61*
23:00	44.0±0.71	46.0±1.22	48.0±0.51	48.3±0.41
24:00	45.0±0.94	47.3±0.99(3)	49.5±0.33*(3)	50.5±0.75*(1,2)

Note: see Table 1.

The obtained data indicate that the temperature-humidity regime in the uninsulated barn was changing significantly during the day (Figure 6). The correlation coefficient between the temperature and the relative humidity of the premise was high r = -0,884 (P <0,05).

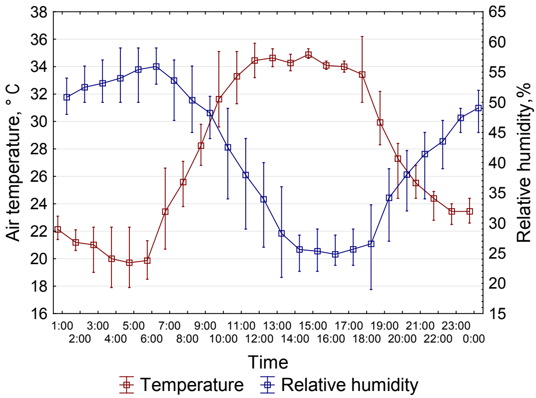

Figure 6. Temperature and humidity regime inside the uninsulated barn (temperature – dark-red line; relative humidity – blue line), n = 402

The construction of a linear regression model (Figure 7) shows the high relative conditionality of the premise temperature and relative humidity

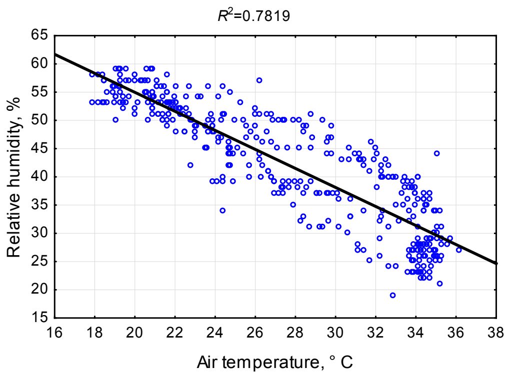

Figure 7. Relationship between air temperature and relative humidity in an uninsulated barn, n = 402

(R^2 = 0.78). As the temperature in the cattle barn rises by 1°C, the relative humidity will decrease by about 1.7%.

Under such conditions, to characterize the state of the indoor air environment, as well as to evaluate the individual effect of temperature and relative humidity on animals is quite difficult without the use of an integral indicator that would take into account their joint effect on the body of dairy cows. The temperature-humidity index (THI) has long been used to assess the comfort of cattle in heat conditions and is perfectly acceptable under these circumstances.

During the study, the THI in the external environment was found to range from 64.9 to 79.7 units. In the uninsulated barn, the THI varied from 64.1 to 81.0 units. The difference between the average THI outside and inside the uninsulated barn, depending on the part of the building (Table 6), was 0.1-2.7 units.

However, in different parts of the premise (Figure 7), depending on the time of day, the largest difference in the value of THI was 2.5-4.4 units, exceeding the comfortable value for dairy cows (THI <68), even in the morning and evening hours.

We associate the observed differences in the temperature-humidity index in different parts of the premise with its design features and the location relative to the sides of the world, i.e. with different level of their heating by rays of sunlight, which should include a selective approach to the application of additional cooling (for example, irrigation) based on the differences found.

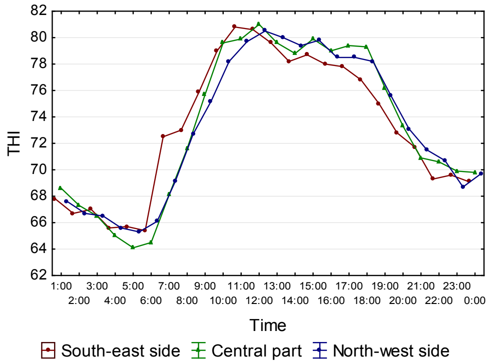

Figure 8. Dynamics of temperature-humidity index in the uninsulated barn (southeast side – dark-red line; central part – green line; northwest side – blue line), n = 134

Table 6

Dynamics of the temperature-humidity index value in an uninsulated cow barn during 24 hours (n=134, $\overline{X} \pm SE$)

	Outside	Premise		
Day time	**in shade**	**southeast side1**	**cetral part2**	**northwest side3**
1:00	68.1±0.26	67.8±0.41	68.6±0.23	67.6±0.31
2:00	66.6±0.10	66.7±0.16	67.3±0.36	66.7±0.19
3:00	66.1±0.31	67.0±0.31	66.5±0.67	66.5±0.33
4:00	65.3±0.61	65.6±0.71	65.0±1.05	65.6±0.60
5:00	64.9±0.28	65.7±0.73	64.1±0.67	65.3±0.47
6:00	65.7±0.21	65.4±0.52(2)	64.5±0.32*(1,3)	66.1±0.33(2)
7:00	67.9±0.32	72.5±0.65*(2,3)	68.1±0.63(1)	69.1±0.59(1)
8:00	70.3±0.45	73.0±0.21*(2)	71.6±0.47(1,3)	72.7±0.41*(2)
9:00	73.5±0.47	75.9±0.44*	75.7±0.54*	75.2±0.37*
10:00	76.2±0.26	79.0±0.43*(3)	79.6±0.71*(3)	78.2±0.24*(1,2)
11:00	77.8±0.24	80.8±0.25*(2,3)	79.9±0.19*(1)	79.7±0.19*(1)
12:00	79.7±0.28	80.6±0.32(3)	81.0±0.12*(3)	80.5±0.12(1,2)
13:00	78.9±0.17	79.6±0.31(3)	79.6±0.35(3)	80.0±0.17*(1,2)
14:00	78.6±0.17	78.2±0.03(2,3)	78.8±0.16(1)	79.4±0.21*(1)
15:00	78.1±1.63	78.7±0.21	79.9±0.05	79.8±0.35
16:00	76.8±0.42	78.0±0.21	79.0±0.07	78.5±0.21
17:00	76.8±0.21	77.8±0.21	79.4±0.07	78.5±0.42
18:00	76.9±0.51	76.8±0.37(2,3)	79.3±0.51*(1)	78.2±0.57(1)
19:00	76.2±0.45	75.0±0.30(2)	76.2±0.42*(1,3)	75.6±0.26(2)
20:00	73.5±0.16	72.8±0.53	73.3±0.25	73.1±0.23
21:00	72.9±0.34	71.7±0.57	70.9±0.79	71.5±0.42
22:00	71.6±0.42	69.3±0.40*(2,3)	70.6±0.09(1)	70.7±0.10(1)
23:00	72.0±0.92	69.6±0.24	69.9±0.16	68.7±0.57
24:00	69.0±0.30	69.1±0.21	69.8±0.32	69.7±0.62

Note: see Table 1.

It is known from literature [8, p. 56; 10, p. 47; 14, p. 14; 15, p. 379], an increase in THI up to 72 units causes a decrease in milk yield in dairy cows, with THI thresholds being even lower for milk fat and protein content. Consequently, the found differences of 2-4 units of THI in different sections of the barn can affect the milk yield and composition of individual animals.

It should be noted that this study in an uninsulated premise was conducted in the conditions of round-the-clock operation of axial fans of large diameter. However, the air velocity at the rest place of the animals was small (up to 0.9 m/s), and only near the feed table did its maximum mobility reach 2.8–3.6 m/s. However, no significant difference in air velocity in the ends of the barn and its central part was found.

5. Conclusions

Simultaneous continuous 24-hour recording of temperature and relative humidity in uninsulated cattle barns built according to the resource-saving technology and in the external environment during the hot summer allowed us to find out some peculiarities in the formation of their microclimate. The use of a temperature-humidity index (THI) for both the characterization of the state of the air environment and its effects on the animal body was convenient and informative. Not only differences between the state of the ambient air inside and outside the premises were revealed, but also a significant difference in its formation in different parts of the premises. They were related to the location of the cattle barn relative to the sides of the world – that is, the intensity of the warming of individual parts of the premises by the sun during the light period of the day. Despite the high dependence of the climate in the cattle barns on the state of the environment, their design features prevent excessive air overheating during the heat of the day on the one hand (creating shady protection for animals), and on the other – lead to capture of the heated indoor air when it cools in the environment – thus prolonging the effects of elevated temperatures on the body. The revealed peculiarities regarding the formation of the air environment indicate the need for a differentiated approach to the mode and duration of the application of cooling systems during the day for different parts of the premise with natural ventilation. The results of our studies showed that even round-the-clock use of powerful axial fans was insufficient to create satisfactory microclimate conditions at the animal resting place, as the temperature-humidity index exceeded cow-friendly values (THI> 68) for 18 hours per day. This points to the need for additional technical solutions (for example, irrigation) to normalize the microclimate in cattle barns in hot summer.

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WATER AVAILABILITY OF WINTER WHEAT CROPS AND THEIR PRODUCTIVITY IN THE NORTHERN STEPPE OF UKRAINE

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Abstract. The main objective of the research was to develop scientific and methodological bases for the development and adaptation of ecologically-adaptive winter wheat cultivation technologies in the northern Steppe of Ukraine. The studies were conducted from 1986 till 2005. Winter wheat was sown after black fallow and corn for silage three times. The main method of research is the field method. It is proved that in the conditions of the northern Steppe of Ukraine winter wheat crops after black fallow and corn for silage are characterized by almost identical indicators of total water transpiration during vegetation period, which is 3256 and 3293 m^3/ha on average. Winter wheat crops, irrespective of weather conditions, forecrops and sowing dates, consume the greatest amount of moisture in the northern Steppe of Ukraine in the early spring and from the ear stage to the firm ripeness of the grain. On average, the transpiration ratio is 1070 m3/ha in early spring before the booting of plants after black fallow, and after corn for silage it is 1069 m^3/ha, which is 32.9 and 33.1% of the total water transpiration for the whole period. Changing sowing period from August 25 to September 25 reduces water transpiration of winter wheat after black fallow from 3613 to 3303 m^3/ha, and after corn for silage from 3615 to 3303 m^3/ha. In this case, the most significant changes in total water transpiration under the influence of sowing periods are observed in the autumn period. After black fallow, total water transpiration in autumn decreases from 711 to 374 m^3/ha, and after corn for silage it was from 853 to 446 m^3/ha. Sowing winter wheat after non-fallow forecrop corn for silage reduces water efficiency of the plants. The average

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evapotranspiration ratio for the crops after corn for silage was 95.1 m^3/c, and for black fallow – 71.8 m^3/c. After both forecrops, the increase in total transpiration for the entire vegetation period of the plants has a positive effect on grain productivity level of winter wheat. The correlation coefficient between the productivity level and total water transpiration for the entire period of plant growth and development after black fallow is 0.34, and after corn for silage is 0.39. There is a close negative correlation between evapotranspiration and winter wheat productivity, which, when sown after black fallow, is minus 0.87 and, after non-fallow forecrop is minus 0.79. Winter wheat sowing after corn for silage, irrespective of sowing time, is the most dependent on water resources from the time of spring vegetation renewal until the start of booting. Their influence on the formation of the crop, depending on the time of sowing is in the range of 38.56-45.62%. The later sowing time of winter wheat after corn for silage is made, the more sensitive are the crops to water resources during the period. When sowing winter wheat after black fallow, the sensitivity of crops to water resources during spring and summer growing season depends on the sowing time. Sowing on August 25 is the most sensitive to water resources during booting of plants. The crop sown on September 10 is the most sensitive to water resources from the booting stage to firm ripeness, and the crop sown on September 25 is the most sensitive to water resources from the time of spring vegetation renewal until the start of the booting stage.

1. Introduction

Water is one of the most important factors in plant life. Its content in the cells of the vegetative organs is about 85%. It serves not only as the environment for various biochemical reactions that take place in cells, but also for the relationship between plants and the environment [1, p. 99].

Numerous studies show that water balance of plants, including field crops, is extremely variable and depends on weather conditions and agro-technical methods of their cultivation. At the same time, the effect of one or another agricultural technique on the efficiency of water use by plants is largely modified by a large number of natural factors. Therefore, many studies pay particular attention to the regulation of the plants moisture status during the growing season or in general crop rotation [2, p. 165; 3, p. 38; 4, p. 18]. The studies can serve as the basis for the development of new ecologically-adaptive technologies of growing crops or for the adjustment of agro-technology in the process of plant vegetation in the conditions of changing environment.

The transpiration ratio is often used to assess the efficiency of water transpiration from plants. However, the results of a number of studies show that this ratio is extremely variable, not only from climatic and weather conditions, but also from almost all agro-technical techniques that are part of the cultivation technology [5, p. 146]. Therefore, the total water transpiration ratio is suggested to use in practice, which includes not only the transpiration of water from plants, but also physical evaporation from the soil surface. At the same time, it is suggested to assess the efficiency of water use by the indicator of evapotranspiration [6, p. 7].

The main objective of the research was to develop scientific and methodological bases for the development and adaptation of ecologically-adaptive winter wheat cultivation technologies in the northern Steppe of Ukraine. Winter wheat was sown in three periods after black fallow and corn for silage.

2. Transpiration of water by winter wheat crops during vegetation

The results of our research clearly show obvious consistency of plant consumption by crops of winter wheat under different weather conditions in the area of the northern Steppe of Ukraine. Regardless of the forecrops, the largest total plant consumption in winter wheat crops is observed in the early spring growing season and from the ear stage to the firm ripeness of grains. The lowest plant consumption is observed in the autumn growing season, the average plant consumption is from the beginning of the booting stage to the ear stage (Table 1). On average, during the years of research, the total plant consumption of winter wheat crops after black fallow from the time of spring vegetation to the beginning of booting of plants amounted to 1070 m^3/ha with fluctuations from 691 to 1285 m^3/ha in different years. It was 1190 m^3/ha during the ear stage to firm ripeness. However, the variation of indicators during this period was much larger than in the previously indicated period and ranged from 148 to 2447 m^3/ha. The large total plant consumption in early spring is mainly due to the physical evaporation of water from the soil surface.

Table 1

Indicators of plant consumption by winter wheat crops at one meter layer of soil after different forecrops, m³/ha (sowing on September 10)

	Inter-stage periods				
	sowing period – stop of vegetation	**vegetation renewal – beginning of booting stage**	**beginning of booting stage – ear stage**	**ear stage – firm ripeness**	**for the whole period**
Black fallow as forecrop					
average	366	1070	630	1190	3256
variation	128 – 661	691–1285	352–925	148–2447	2361-4694
Corn for silage as forecrop					
average	495	1069	600	1128	3293
variation	108 – 1015	613-1464	296-1080	151-2118	2804-4503

The highest amount of productive moisture in a meter layer of soil in winter wheat crops in the area of the northern Steppe of Ukraine is observed at the time of spring renewal of vegetation [7, p. 79], but at the time the accumulation of aboveground mass of plants is insignificant before booting stage in comparison with the booting stage or the grain formation period. At the same time, strongly developed above-ground mass of plants can cause high plant consumption by crops from the time of the ear stage to firm ripeness of the grains. A strongly developed above-ground mass of plants is characterized by high intensity of transpiration and high evaporation of water from the soil surface. Identification of moisture content in a meter layer of soil has repeatedly convinced that during favourable years, when dense crops with more than 750 pc/m^2 spikes were formed during the ear stage, despite heavy rainfalls, productive moisture stocks sharply decreased over the days. The bulk of the water was pumped by the plants in the process of transpiration, since physical evaporation of water from the soil in dense crops is much smaller than in thin crops.

The total transpiration during autumn period is much lower and averages 366 m^3/ha after black fallow, with changes in the range of 128-661 m^3 in the years with different weather conditions.

It is established that the average water transpiration from winter wheat crops after black fallow during the whole growing season averages 3256 m^3/ha.

In general, there is a direct correlation between water resources and total water transpiration. In the years with heavy rainfalls, the total water transpiration of winter wheat plants increases, and in the drier years, on the contrary, decreases.

When sowing winter wheat after a non-fallow forecrop, the above-mentioned consistency is generally preserved. The highest water losses are observed in early spring and from the ear stage to firm ripeness. The lowest water losses take place during autumn growth period of winter wheat. In addition, the indicators of total water transpiration by crops after corn for silage during spring-summer growing season, as well as for the whole growing season, are close to those of black fallow. For example, the total water transpiration of winter wheat crops for the whole period after black fallow averaged 3256 m^3/ha, and after corn for silage – 3293 m^3/ha. In early spring period the figures were 1070 and 1079 m^3/ha, respectively. In this case, the data in Table 1 show that in one year, i.e. in the same weather conditions, the indicators of total water transpiration in spring-summer period of vegetation of plants after black fallow and corn for silage are close. This suggests that the total water transpiration of winter wheat crops from a meter of soil in spring-summer period of plant growth and development under the same weather conditions is almost independent of its forecrops. However, the accumulation of the total amount of dry matter by winter wheat plants in the end is not the same, and therefore the efficiency of water use after the studied forecrops is different.

The research revealed some differences between winter wheat crops after different forecrops according to the total water transpiration during autumn growing season. In most years, it was higher compared to black fallow and non-fallow forecrops and averaged 495 and 366 m^3/ha, respectively. In our opinion, higher water transpiration in autumn after corn for the silage was due to its physical evaporation and penetration into the deeper layers of soil. In none of the years, the above-ground mass of winter wheat plants at the time of cessation of autumn vegetation after corn for silage was greater than that of black fallow. Higher water losses of winter wheat crops after corn for silage are caused by the condition of the surface of the field, in the state of loosening of soil and the presence of plant residues in the upper layer of soil.

The calculations of the structure of total water transpiration by winter wheat crops in relative terms confirm the existence of the above-mentioned consistencies. After both forecrops, the largest water losses of winter wheat crops are observed in two periods – early spring and from the ear stage to firm ripeness of grains. After black fallow, on average, over the years of the studies, these figures account for 32.9% and 36.5% of the total amount of water transpired, and after corn for silage – 33.1% and 32.4% (Table 2).

In autumn, total water transpiration of winter wheat crops after black fallow averages 11.3% of the total, varying from 3.9 to 23.4% in different weather conditions. When sowing winter wheat after corn for silage, the proportion of water transpiration in autumn period is slightly higher than that after black fallow and equals 15.0%. This consistency has been observed throughout the years of the study, regardless of weather conditions that are too variable in the area of the northern Steppe of Ukraine.

Table 2

Effect of forecrops on the structure of water transpiration at one meter layer of soil with winter wheat crops, % of total (sowing time is September 10)

	Inter-stage periods			
	sowing period – stop of vegetation	**vegetation renewal – beginning of booting stage**	**beginning of booting stage – ear stage**	**ear stage – firm ripeness**
Black fallow as forecrop				
Average	11,3	32,9	19,3	36,5
Variation	3,9-23,4	24,5-40,4	7,7-29,1	6,3-56,8
Corn for silage as forecrop				
Average	15,0	33,1	19,5	32,4
Variation	3,9-31,2	25,8-41,9	4,6-38,5	6,0-58,8

Changing sowing time of winter wheat significantly affects the conditions of growth and development of winter wheat plants during autumn growing season [8, p. 61]. The postponement of sowing at a later date primarily shortens the period of autumn vegetation, and the development of plants occurs at lower air temperatures and reduced duration of daylight. The consequence of such conditions is a decrease in tilling capacity of plants at the time of the cease of autumn vegetation and, accordingly, the density of the stem of winter wheat crops [9, p. 50].

Table 3 shows that the shift in the sowing period from August 25 to September 25 causes identical changes in the total water transpiration of winter wheat crops after both of the studied forecrops. It is clearly seen that the later the sowing of winter wheat is, the smaller the indices of water loss in autumn period and increase from the beginning of booting stage to the ear stage of plants. Thus, in the variants of the experiment after black fallow with sowing on September 25, water loss averaged 374 m^3/ha, and with sowing on August 25 it was 711 m^3/ha, which is almost twice as much. When sowing winter wheat on non-fallow forecrop, the sowing shift from August 25 to September 25 reduced the total water transpiration from 853 to 446 m^3/ha.

Table 3

Indicators of water transpiration by crops of winter wheat at one meter layer of soil depending on the sowing time (average for 1992-2004)

sowing time	Inter-stage periods				
	sowing period – stop of vegetation	vegetation renewal – beginning of booting stage	beginning of booting stage – ear stage	ear stage – firm ripeness	For the whole period
Black fallow as forecrop					
25.08	711/19,7	943/26,1	746/20,7	1212/33,6	3613/100
10.09	366/10,8	1004/29,7	772/22,8	1240/36,7	3382/100
25.09	374/11,3	981/29,7	772/23,4	1177/35,2	3303/100
Corn for silage as forecrop					
25.08	853/23,6	892/24,7	708/19,6	1162/32,1	3615/100
10.09	495/14,7	915/27,3	755/22,5	1191/35,5	3357/100
25.09	446/13,5	903/27,3	799/24,2	1155/35,0	3303/100

– In the numerator, the indicators of water transpiration are in m3/ha
– In the denominator, the share of water transpiration of the total amount for the entire growing season, %

In the sowing variants on September 10, both after black fallow and after corn for silage, the total water losses during the period from the renewal of vegetation to the beginning of the booting stage and from the ear stage to firm ripeness were higher than the sowing variants carried out on

August 25 and September 25. Thus, in case of sowing on September 10, after black fallow, the total water transpiration during the early spring period was 1004 m^3/ha against 943 m^3/ha when the crops were sown on August 25, and 981 m^3/ha when sowing tine was September 25.

It is well known that the transpiration of water through the leaves does not belong to synthetic processes that take place in plant cells. However, it is an essential part of the plant's biological and physiological function, which ensures the normal course of all biochemical reactions in plants. Therefore, the transpiration productivity ratio is widely used in both scientific and industrial practices. It correlates the amount of water transpired by the plant with the amount of solids that have been synthesized during that time. The performance of transpiration can be judged on the efficiency of water use by plants. But, like the transpiration coefficient, transpiration performance in the same plant species exhibits excessively high variability under the influence of climatic, weather, and agro-technical factors. In agriculture, the determination of transpiration coefficient and transpiration performance has considerable complexity. This is due to the inability to identify the volumes of water that were actually used by the plants from the soil.

Evapotranspiration indicators, which take into account all water transpiration by crops for crop formation, including physical evaporation from soil surface, as shown in Table 4, fairly objectively assess the efficiency of water use by plants. The process of physical evaporation of water from the surface of the soil at first glance has nothing to do with the formation of the crop. However, if winter wheat crops with high stem density have the same amount of rainfalls, the rate of water evaporation from the soil surface will be less than in thin crops, and therefore the amount of water that will be absorbed by the plants in such crops will be greater. Accordingly, increasing the amount of available water for plants will certainly have a positive impact on improving crop productivity.

It is established that with almost equal amount of water resources, the efficiency of their use by winter wheat crops after black fallow is much higher compared to its non-fallow forecrops. On average, during the years of research, the evapotranspiration coefficient after black fallow was 71.8 m^3/c, and after corn for silage – 95.1 m^3/c. During nine years out of eleven, evapotranspiration coefficients of winter wheat crops after black fallow were higher than after corn for silage. In severely dry and unfavourable years in winter, the evapotranspiration coefficients after corn for silage were several times higher than after black fallow crops. So, in 1996, with only 58.2 mm of rainfalls during the entire spring and summer growing season, the evapotranspiration coefficients of crops after corn for silage amounted to 201.5 m^3/c against 84.0 m^3/c after black fallow. In the conditions of the year 2000, under extremely unfavourable conditions in winter in combination with arid conditions of spring-summer vegetation (110 mm of rainfall), the evapotranspiration coefficients of crops after corn for silage were three times higher than after black fallow and were 455,2 and 152,7 m^3/c, respectively.

Table 4

Evapotranspiration coefficients of winter wheat crops after different forecrops (sowing on September 10)

Years	Black fallow			Corn for silage		
	Total water transpiration, m^3/ha	Productivity, c/ha	Evapotranspiration coefficient, m^3/c	Total water transpiration, m^3/ha	Productivity, c/ha	Evapotranspiration Evapotranspiration coefficient, m^3/c
1993	3263	52,1	62,6	3579	58,0	61,7
1994	2819	67,2	41,9	3011	54,8	54,9
1995	3184	49,4	64,5	2804	40,6	69,1
1996	2361	28,1	84,0	2519	12,5	201,5
1997	4694	40,1	117,1	4503	30,0	150,1
1998	3212	65,8	48,8	3339	41,7	80,1
1999	2552	22,9	111,4	2563	18,3	140,1
2000	2962	19,4	152,7	2777	6,1	455,2
2001	3777	68,0	55,5	3578	43,1	83,0
2002	2998	43,7	68,6	2668	23,5	113,5
2004	3554	61,8	57,5	3106	59,9	51,9
Average	3382	47,1	71,8	3357	35,3	95,1
Correlation coefficient	0,34			0,39		
		– 0,87			– 0,79	

All adverse factors that impair the conditions of plant growth and development lead to the reduction of the efficiency of water consumption by winter wheat crops. The evidence of this is that the lower the productivity of winter wheat crops, the higher the evapotranspiration coefficients. There is a close inverse relationship between the grain productivity and evapotranspiration coefficients, which is confirmed by the correlation coefficient calculations. If sowing after black fallow, it is minus 0.87, and if sowing after corn for silage, it is minus 0.79. The relationship between total water transpiration and winter wheat crop productivity is positive but much smaller. It is 0.34 after black fallow and 0.39 after corn for silage.

Sowing periods have significant effect on the productivity of winter wheat, and therefore the efficiency of water resources use with different crops is different (Table 5).

Table 5

Evapotranspiration coefficients of winter wheat crops at different sowing periods, (average for 1993-2004)

Year	Black fallow			Corn for silage		
	Total transpiration, m^3/ha	Productivity, c/ha	Evapotranspiration coefficient, m^3/c	Total transpiration, m^3/ha	Productivity, c/ha	Evapotranspiration coefficient, m^3/c
25.VIII	3613	38,1	94,8	3615	29,7	121,7
10.IX	3382	47,1	71,8	3357	35,3	95,1
25.IX	3303	40,5	81,6	3303	36,7	90,0

When sowing winter wheat after black fallow, as can be seen from the data in Table 5, the shift of sowing time from August 25 to September 25 causes a decrease in the amount of water resources from 3613 to 3303 m^3/ha. At the same time, the highest grain productivity of winter wheat was formed at sowing on September 10 and amounted to 47.1 c/ha, which is 9.0 c/ha more than at sowing on August 25 and 6.6 c/ha more than the sowing variants on 25 September. Evapotranspiration coefficient according to the obtained data amounted to 71.8, 94.8 and 81.6 m^3/c, respectively. After corn for silage, changing the sowing time in these terms reduced the evapotranspiration coefficients from 12.2 in sowing variants of 25 August to 9.0 m^3/c of winter wheat in sowing variants on 25 September. On average, in the years of non-fallow forecrops, winter wheat sown on September 25 had most effective water consumption.

3. Winter wheat productivity depending on water availability during spring and summer

The spring-summer growing season is extremely important for the formation of winter wheat crop. During this period the potential of crops planted in autumn and the processes that will positively affect productivity are realized. In such cases, the losses caused by the negative factors of autumn growing season are to some extent compensated.

In the northern Steppe of Ukraine, the moisture content of crops in spring and summer, together with the air temperature, are the determining factors for the growth and development of winter wheat. Research results show that during the whole growing season of winter wheat crops, their highest moisture content is reached in early spring. Due to winter rains, soil moisture is replenished, but differences among forecrops still remain. On average, over the years of research, the content of productive moisture at a meter layer of soil under winter wheat after black fallow was 164.4 mm against 156.3 mm in crops after corn for silage. However, significant differences among the crops of different sowing periods within one forecrop were not observed.

Starting from the time of spring vegetation renewal, the productive moisture reserves in a meter layer of soil under winter wheat crops, regardless of their forecrops, are constantly reduced and are minimal at firm ripeness stage. Rains that occur during the period of active growth do not change the specified consistency. Even in the years with heavy rainfalls, the increased soil moisture persists for a short period of time. This is especially evident with the significant development of aboveground vegetative mass of plants. Such plants, on the background of high air temperature, intensively transpired and the amount of available moisture in a meter layer of soil rapidly decreases. This is also facilitated by the intense physical evaporation of water from the soil surface at high air temperatures.

In winter wheat, sown on September 17, both after black fallow and after corn for silage (at all stages of plant development during spring-summer period), the moisture content in a meter layer was higher than in the plants sown on August 25 and September 25. Thus, the reserves of productive moisture in the variant sown on September 17 after black fallow, from the time of renewal of spring vegetation to the ear stage varied from 167.1 mm to 79.5 mm, respectively. And in the variant sown on September 17 the productive moisture varied from 162.6 mm to 77.2 mm. In some years of study, the difference between variants with different sowing periods was significantly greater than the average for the years of study (Table 7). Winter wheat sown on August 25 and September 25, unproductive moisture losses could be caused by excessively high evaporation of water from the soil surface.

Table 7

Indicators of content of productive moisture in a meter layer of soil during growing season of winter wheat crops depending on the sowing time, mm (average for 1993-2005)

Sowing time	**Indicator**	**Stages of crops development**			
		at the time of spring vegetation renewal	**at the beginning of booting stage**	**at the ear stage**	**at the firm ripeness stage**
1	**3**	**3**	**4**	**5**	**6**
Black fallow					
25.08	average	163,4	106,4	76,5	63,9
	variation	124,2 – 196,8	91,9 – 142,2	27,8 – 187	32,4 – 128
10.09	average	167,1	107,4	79,5	62,1
	variation	133,4 – 210,0	71,7 – 146,2	29,7 – 189,0	35,1 – 124,0
25.09	average	162,6	106,3	77,2	63,5
	variation	128,4 – 199,8	72,5 – 136,9	22,3 – 188,0	23,1 – 127,0
Corn for silage					
25.08	average	154,3	97,9	66,5	57,4
	variation	125,0 – 180,7	59,8 – 125,8	20,1 – 115,5	26,0 – 108,3
10.09	average	158,4	101	69,5	54,8
	variation	137,7 – 190,4	60,4 – 139,1	22,7 – 173,9	17,9 – 106,2
25.09	average	156,2	100,3	69,4	56,7
	variation	122,5 – 187,4	60,2 – 138,8	23,3 – 169,9	28,2 – 107,0

At the same time, as it can be seen from the data in Table 7 after such forecrops at the firm ripeness stage on average during the years of research, such dependence is not observed. Higher moisture reserves in a meter layer of soil are characteristic of sowing time which was carried out on August 25 and September 25. On average, during the years of research in the sowing variants on August 25 and September 25, after corn for silage, the moisture content in a meter layer of soil was 57.4 and 56.7 mm, respectively, against 54.8 mm of the variant sown on September 17.

Weather conditions of the spring-summer growing season of winter wheat crops in the northern Steppe of Ukraine are too variable both in the amount of rainfalls and the air temperature. These factors are crucial to soil moisture accumulation as a major source of aquatic nutrition for plants. Plant consumption of winter wheat crops in spring and summer depends to a large extent on the state of their development. More powerful crops require more water than less developed ones.

The regression analysis revealed that there is a fairly complex relationship between productivity levels of multiple-aged winter wheat crops and the reserves of productive soil moisture during the main stages of plant growth and development. The reserves of productive moisture in soil have different effects on grain productivity of different crops of winter wheat after different forecrops (Table 8).

After black fallow, the reserves of productive moisture in the soil at the time of spring vegetation renewal and the beginning of the booting stage have the greatest influence on productivity level of varied crops of winter wheat. It is in the range of 39.7-55.2% and 24.8-42.1% respectively. When sowing winter wheat after corn for silage, the most important for the formation of the grain productivity of winter wheat are moisture reserves in the soil at the beginning of spring vegetation renewal and during the ear stage of the plants. According to the results of the regression analysis, the share of influence of moisture reserves in a meter layer of soil on the productivity level of such crops of winter wheat is 49.7-66.4, and 22.3-39.9%, respectively.

At the same time, sowing times within one forecrop can significantly change the dependence of productivity of winter wheat crops on the reserves of productive moisture in the soil at different stages of their development. So, for crops sown on August 25 after black fallow, the main influence on the productivity has soil

Table 8

Dependence of productivity level of multiple-aged crops of winter wheat on the reserves of productive moisture in the soil, % (average for 1993-2004)

Forecrop	Stage of crops development	Sowing time		
		25.VIII	10.IX	25.IX
Black fallow	Renewal of spring vegetation	39,7	55,2	36,3
	beginning of booting stage	42,1	24,8	33,8
	ear stage	9,3	18,7	22,8
	remaining factors	8,9	1,3	7,1
Corn for silage	Renewal of spring vegetation	49,7	51,3	66,4
	beginning of booting stage	9,8	9,8	10,6
	ear stage	39,9	34,8	22,3
	remaining factors	0,6	0,3	0,7

moisture reserves at the time of spring vegetation renewal and at the beginning of the booting stage. The share of the influence of soil moisture reserves at the ear stage does not exceed 10%. Sowing on September 10 is also most dependent on soil moisture at the time of spring vegetation (55.2%) and early booting (24.8%), but the share of soil moisture at the ear stage reaches 18.7%. For sowing on September 25, the importance of productive soil moisture at the ear stage (22.8%) increases, and at the same time plants' dependence on moisture reserves at the beginning of spring vegetation is reduced.

It should also be noted that winter wheat productivity, regardless of the sowing period after corn for silage forecrop, unlike sowing after black fallow, is more dependent on moisture content of the soil during the ear stage. On average, during the years of research, the influence of soil moisture reserves at the ear stage on the productivity of crops after black fallow varies from 9.3 to 22.8%, and after corn for silage it varied from 22.3 to 85.8%.

During spring-summer period of winter wheat, dry matter accumulates through crops. At the beginning of booting, their weight intensely increases to the ear stage. Later, the rate of accumulation of dry matter by plants decreases. Water requirements for plants during the booting stage are greatest, which is why this period is considered critical. Water scarcity primarily causes a decrease in the aboveground weight of plants, which in turn leads to a sharp decrease in crop productivity.

The water resources available to winter wheat plants during spring and summer growing season have a huge impact on winter wheat crop production process. But according to the results of the research, they are extremely variable in different years, and therefore winter wheat crop grows in spring under different conditions of wet crop provision, starting from severely arid and ending with sufficient wet supply. The data in Table 9 show that, in the spring and summer, water resources for winter wheat crops average 348.4 mm. They are slightly higher for crops sown after black fallow (358.1 mm) and smaller for crops on non-fallow forecrop (336.7 mm). At the same time for crops on black fallow they can vary from 214,3 to 540,3 mm, and after corn for silage – 203,2-438,0 mm.

The calculations of water resources in separate inter-stage periods of crop vegetation showed that the best conditions for water supply of winter wheat crops are created in the period from the time of spring vegetation renewal to the beginning of plant booting. On average, over the years of research, they are 204.3 mm for the crops after black fallow, and for the crops after corn for silage (190.1 against 154.1 and 143.9 mm, respectively), in the period from the beginning of booting to the ear stage.

The above data indicate that the greatest variability of water resources for winter wheat crops during spring and summer vegetation is characteristic of the period from the ear stage to firm ripeness of the grain. The least variability occurs from spring vegetation renewal to the beginning of booting stage. The variation of water resources during the period from the ear stage to the firm ripeness for the plants sown after black fallow is 58.1-368.7 mm/ha, and after corn for silage it is 34.0-342.5 mm/ha against 164.4-237,5 mm and 152.5-233.8 mm/ha respectively from the beginning of spring vegetation to booting of plants.

The sowing time does not significantly alter water resources for winter wheat sown after black fallow and after corn for silage. Thus, on average during the years of research water resources for winter wheat crops after black fallow for the whole spring-summer period depending on sowing periods make in the range of 354,1-363,7 mm/ha, and for crops sown after corn for silage is 333,7-341.4 mm/ha.

The main elements of the structure of winter wheat crop are formed during spring and summer growing season. Among them, the density of the productive stem, the number of grains per a spike and the weight of grains

Table 9

Water resources of winter wheat crops during spring and summer vegetation, mm/ha (average for 1993-2005)

	Stages			
	Vegetation renewal – beginning of booting	**Beginning of booting – ear stage**	**Ear stage – firm ripeness**	**For the whole period**
Black fallow				
Average	204,3	154,1	184,1	358,1
Variations in years	146,4 – 237,5	83,0 – 265,2	58,1 – 368,7	214,3 – 540,3
Corn for silage				
Average	143,9	172,9	338,7	143,9
Variations in years	73,7 – 278,8	34,0 – 342,5	203,2 – 438,0	73,7 – 278,8

per a spike are of great importance. Due to the fact that the formation of the aforementioned elements of the structure of the crop occurs consistently in different periods of growth and development of winter wheat plants, it is quite often observed that the achievement of the maximum productivity level is possible at different levels of their development.

The reasons for the variability of winter wheat agrocenoses according to the indicators of basic elements of the crop structure are weather conditions during the vegetation of plants and, particularly, the level of their moisture supply. The results of the regression analysis convincingly show that productivity of winter wheat crops after corn for silage depends more on the amount of water resources from the time of spring vegetation to the beginning of booting. At the same time, when winter wheat is grown after black fallow, the sowing time (Table 10) has a significant effect on the sensitivity of crops to water resources during different phases of plant development during spring vegetation.

The data in Table 10 show that the impact of water resources from the time of spring vegetation to the beginning of booting of plants on productivity level of wheat after corn for silage, depends on the sowing period and it is 38.56-45.62%, whereas the impact of water resources in the period from the ear stage to firm ripeness is 13,58-16,12%. Crops of winter wheat after corn for silage are the least dependent on water resources during the period from the ear stage to the firm ripeness of plants. In addition, the

Table 10

Influence of water resources during spring-summer period on the formation of winter wheat crops, % (1993-2004)

Forecrop	Stages	Sowing time		
		25.VIII	10.IX	25.IX
Black fallow	renewal of spring vegetation – beginning of booting	21,71	14,82	26,91
	beginning of booting – ear stage	32,79	11,01	22,29
	ear stage – firm ripeness	27,25	27,44	22,38
	remaining factors	18,25	46,73	28,42
Corn for silage	renewal of spring vegetation – beginning of booting	38,56	41,95	45,62
	beginning of booting – ear stage	18,98	13,71	28,02
	ear stage – firm ripeness	15,12	13,58	16,12
	remaining factors	27,34	30,76	10,24

later the sowing of winter wheat after corn for silage is made, the greater dependence of such crops on water resources in early spring.

Similar consistency is typical of winter wheat sown on September 25. The influence of water resources in the period from the ear stage to the firm ripeness of the plants on the formation of the crop, according to the results of regression analysis is 26.91%. However, productivity of these crops is also largely conditioned by water resources from the beginning of the booting to the ear stage of plants and from the ear stage to their firm ripeness. Their impact on productivity level is 22.29% and 22.38% respectively. Early winter wheat crops sown after black fallow on August 25, which during autumn growing season form a powerful above-ground mass, are sensitive to water resources from the beginning of the booting to the ear stage (32.79%) and from the ear stage to the firm ripeness (27,25%).

4. Conclusions

Based on the above-mentioned material, we can make the following conclusions:

– in the conditions of the northern Steppe of Ukraine, winter wheat crops after black fallow and corn for silage are characterized by almost identical indices of total water loss during the vegetation period of plants, which average 3256 and 3293 m3/ha, respectively. The difference between the total water loss in winter wheat crops after these forecrops, depending on weather conditions, may be in the range of 4.0-11.9%;

– winter wheat crops, irrespective of weather conditions, forecrops and sowing times, consume the greatest amount of moisture in the Northern Steppe of Ukraine in early spring and from the ear stage until the grain is firm. On average, in early spring, water transpiration before booting of plants after black fallow is 1070 m^3/ha, and after corn for silage – 1069 m^3/ha, which is 32.9 and 33.1% of the total water transpiration for the whole period. During the period from the ear stage to the firm ripeness of the grain, the total water transpiration by crops is respectively 1190 and 1128 m^3/ha, which is 36.5 and 32.4% of the total;

– the shift of winter wheat sowing time from August 25 to September 25 reduces water transpiration of winter wheat after black fallow from 3613 to 3303 m^3/ha, and after corn for silage from 3615 to 3303 m^3/ha. However, the most significant changes in total water transpiration are observed in autumn. According to its forecrops, black fallow, total water transpiration in autumn decreases from 711 to 374 m^3/ha, and after corn for silage from 853 to 446 m^3/ha;

– sowing winter wheat after a non-fallow forecrop corn for silage reduces water efficiency of the plants. The average evapotranspiration ratio for sowing crops after corn was 95.1 m^3/c, and after black fallow – 71.8 m^3/c of grains. After both forecrops, the increase in total water transpiration for the entire vegetation period of the plants has a positive effect on grain productivity level of winter wheat. The correlation coefficient between the productivity level and the total water transpiration for the entire period of plant growth and development after black fallow is 0.34, and after corn for silage, it is 0.39. There is a close negative correlation between evapotranspiration and winter wheat productivity, which is minus 0.87 when sown after black fallow, and it is minus 0.79 after the non-fallow forecrop;

– winter wheat sowing after corn for silage, regardless of sowing time, is the most dependent on water resources from the time of spring vegetation renewal until the start of booting. Their influence on the formation of the crop, depending on the time of sowing is in the range of 38.56-45.62%. The later the sowing of winter wheat after corn for silage is made, the more sensitive the crops to water resources are in the period from the time of the renewal of spring vegetation to the ear stage;

– when sowing winter wheat after black fallow, the sensitivity of crops to water resources during spring and summer growing season depends on the sowing time. The crops sown on August 25 are most sensitive to water resources during booting of plants. The crops sown on September 10 are sensitive to water resources from the booting stage to firm ripeness of the crop, and the crops sown on September 25 are sensitive to water resources from the time of spring vegetation renewal until the start of booting of plants. The impact of the aforementioned water resources on productivity of different crops is 32.79; 27.44% and 26.91%;

– according to the regression analysis, the productivity of winter wheat after black fallow depends to a large extent on the content of productive moisture in the soil at the time of spring vegetation renewal and at the beginning of booting, and is respectively 39.7 and 42.1% for sowing on August 25; 55,2 and 24.8% – for sowing on September 10, and 36.3 and 33.8% – for sowing on September 25. The productivity of winter wheat after corn for silage is most influenced by the productive moisture content of the soil at the time of spring vegetation renewal and, depending on the sowing period, ranges from 49.7 to 66.4%, and at the ear stage of plants it ranges from 22.3 to 39, 9%. The shift of sowing dates from August 25 to September 25 increases the dependence of crops on the content of productive moisture in the soil at the time of spring vegetation renewal and reduces the impact of productive moisture in the soil at the booting stage.

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MANAGEMENT OF THE ELEMENTS OF TECHNOLOGY OF GROWING OF SUNFLOWER IN THE RIGHT-BANK STEPPE OF UKRAINE

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Abstract. The article presents the results of scientific research on the management of technology elements and the influence of factors on the productivity of sunflower in the Right Bank Steppe of Ukraine. The studies were conducted in the fields of the Institute of Agriculture of the Steppe NAAS, which is located in the black earth zone of the Right-Bank Steppe of Ukraine. Studies have beenestablished that the level of productivity of sunflower is determined by the level of provision of plants with factors of life. The water regime is formed by weather conditions, the amount of soil moisture reserves, the amount and intensity of rainfall during the year, incl. and during the vegetative period. To a large extent, the soil's water regime depends on the morphological features of the hybrids, the plant standing density, the sowing time, and the cultivation technology. It was found that the moisture available to plants in the meter layer of soil before sowing, in flowering phase and before harvesting was different during the years of research and varied in terms of sowing and depended on the density of plants. Of particular importance for sunflower plants is the content of available moisture in the 0-100 cm layer of soil after the formation of baskets. Considering the annual variation of the weather conditions of spring period of sowing, it should be differentiated with regard to water and heat regimes. High soil moisture reserves during the vegetative period serve as a prerequisite for high sunflower crop yields. Studies have shown that the amount of nitrogen, phosphorus and potassium has varied significantly over the years and under the influence of different fertilizer backgrounds. Appli-

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cation of nitrogen fertilizers in combination with phosphorus and potassium $N_{40}P_{40}K_{40}$ + PP and $N_{40}P_{40}K_{40}$ improves soil nutrition and creates more favorable conditions for growing and developing sunflower plants and maintaining soil fertility. Under these conditions, plant density of 60 thousand hectares contributes to the formation of the highest yield per hectare. The highest seed yield was provided by the LG55.82 hybrid for the first sowing period – 3.85 t/ha. Considering the economic indicators, it is efficient to grow LG 54.85, LG 55.82 hybrids for the first sowing period. Forward, LG 56.32 Sunflower Hybrids provide the highest economic performance for the third sowing period. Among the hybrids, it is most economically apropriate to grow LG 55.82 when sowing at soil temperatures of 5-6°C and plant density of 60 thousand/ha. The net profit in this variant was 22043 UAH / ha, the level of profitability was 224.1%. The energy efficiency ratio was the highest in the first sowing period of the LG 55.82 hybrid and was 4.44.

1. Introduction

In today's intensive agriculture, there is a growing need for increased production of agricultural products, including sunflower seeds. By scale of distribution, versatility of use and energy value, sunflower is the most important oilseed crop in Ukraine and Europe.

Increasing sunflower productivity is possible through the development of new and improvement of existing elements of technology of cultivation of crop [7, p. 75].

The choice of the optimum sowing time and plant standing density is a prerequisite for the efficient use of environmental resources for the formation of high crop yields [4, p. 23].

The value of the sunflower crop is determined by many factors, among which is the existence in the soil of moisture and nutrients necessary for the growth and development of plants.

Among the reasons that deter the growth of sunflower seeds, a significant role is played by the lack of soil nutrients [9, p. 204], and the moisture content of the soil in conditions of unstable moisture is limiting and one of the most important factors for creating favorable conditions for plant growth and development [6, p. 173].

It is ground water reserves and nutrients that in most cases is the cause of low or high sunflower productivity.

The better the crops are provided with moisture, the higher the crop yield the seeds form. The decisive role is played by the fall-winter period and the first half of vegetation [8, p. 591].

The use of moisture by sunflower crops can to some extent be regulated by the sowing time. Shifting the sowing time to earlier allows changing the conditions of growth and development of sunflower plants, namely – better provided by plants with moisture, and it is possible to bypass critical temperature periods of plant development.

The consumption of plants by elements of nutrients is largely determined by the moisture content of the soil: the better the plants are provided with moisture, the greater the consumption of nitrogen, and on the contrary, the worse the plants are provided with moisture, the lower their doses [3, p. 27].

In the system of fertilizers in the steppe areas, the main fertilizer should be dominated which used for soil tillage. It provides the placement of fertilizers in the soil layer with guaranteed moisture, which increases the availability elements of nutrients for plants [1, p. 376].

The background of nutrition is one of the main elements in the technology of cultivation of crop. Fertilize application increases the content of minerals available to plants in the soil. This changes the chemical composition of soil, its physical and other qualities. Improvement of mineral nutrition has positive effect on the processes of photosynthesis, provides normal growth and development of plants, crop formation and quality of seeds [2, p. 35].

Sunflower forms high-energy biomass, which consumes a large number of mineral nutrients. It uses an average of 5.8–6.2 kg of nitrogen, 2.5–2.7 phosphorus and 18.3–18.9 kg of potassium to form 1 centner of seed. The level of consumption elements of nutrients depends on many factors: terms and methods of fertilizer application, moisture supply weather conditions, as well as the genetic characteristics of the variety or hybrid [5, p. 62].

In the face of climate change and the emergence of new hybrids in the production of research to optimize the sowing time and density of plants of different hybrids is actual and important for science and production.

Goal. The purpose of research is to increase productivity by optimizing the sowing time and density of sunflower plants and their effect on water and nutrient regime of soil in the conditions of the Right-Bank Steppe of Ukraine.

2. Materials and methods of research

The research was conducted in the fields of the Kirovohrad State Agricultural Research Station of the National Academy of Agrarian Sciences of Ukraine (KSASRS NAAS) now the Institute of Agriculture of the Steppe NAAS, which is located in the Black Earth zone of the Right-Bank Steppe of Ukraine.

In the three-factor field experiment investigated: Factor A – medium-early Forward sunflower hybrids, LG 56.32, LG 54.85, LG 5582; Factor B – early sowing time (And – at soil temperature at a depth of 10 cm – 5-6°C, II – 7-8°C, III – 9-10°C); Factor C is the plant density of 50 thousand/ha, 60 thousand/ha, 70 thousand/ha. Replication of the experiment three times, the total area of the sowing area is 50.4 m^2, the accounting area is 25.2 m^2. The precursor-spring barley.

The main difference of the soil cover is the ordinary heavy soil loam. Humus content is 4.72%, easily hydrolyzing nitrogen – 104, mobile phosphorus – 191 and exchangeable potassium – 142 mg per kilogram of soil, mobile forms of manganese, zinc and boron accordingly – 3.1; 0.35 and 1.76 mg per kilogram of soil. Reaction of soil solution pH-5,8.

The climatic conditions of the Institute of IAS NAAS are typical for the Right-bank Steppe of Ukraine with temperate continental climate. This is confirmed by the daily and annual amplitude of air temperature, as well as by significant fluctuations in the annual weather conditions. The average annual rainfall is 499 mm per year.

The weather conditions for research differed, both from each other and from the average long-term indicators in terms of precipitation and temperature.

3. Dynamics of soil moisture content

The researches made it possible to establish that the level of sunflower productivity is determined by the conditions of water and nutritional regime of soil.

Stocks of productive moisture in a meter layer of soil during sowing significantly influenced the dynamics of emergence of seedlings (Figure 1).

So in 2016, the moisture reserves for the first sowing period – 5-6°C (April 6) were 181.9 mm, for the second – 7-8°C (April 10) – 178.8 mm, for the third – 9-10°C (April 13) – 175.0 mm; in 2017, respectively, for the

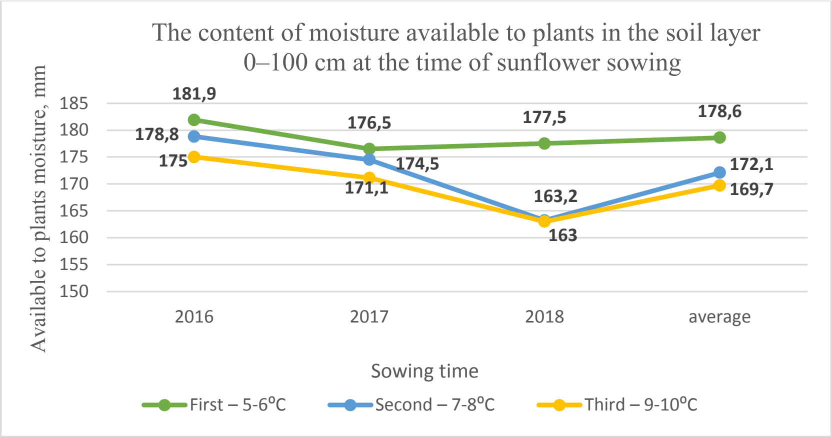

Figure 1. The content of moisture available to plants in the soil layer 0-100 cm at the time of sunflower sowing

first sowing period – 5-6°C (April 7) was 176.5 mm, for the second – 7-8°C (April 12) – 174.5 mm, for the third – 9-10°C (April 28) – 171.1 mm; in 2018, respectively, for the first sowing period – 5-6°C (April 6) were 177.5 mm, for the second – 7-8°C (April 12) – 163.2 mm, for the third – 9-10°C (April 24) – 163.0 mm. On average, during the years of research, the most available moisture in the 0-100 cm soil layer was during the first sowing period – when it was heated to a depth of seed 5–6°C – 178.6 mm for the second sowing period – 172.1 mm for the third sowing period – 169.7mm.

Moisture reserves in the 0-10 cm soil layer remained high at the time of sowing (Figure 2).

This is due to low temperatures, compensated by the increased relative humidity, low evaporation of soil moisture and precipitations during this period. Thus, during the first sowing period, moisture reserve were – 25.0 mm, in the second – 24.4 mm, and in the third sowing period, 23.6 mm, that is, a gradual decrease in the amount of moisture available to plants in the sowing layer of soil.

Studies show that the moisture available to plants in the meter layer of soil in the flowering phase was different during the years of research and varied in terms of sowing and depended on the density of plants (Figure 3).

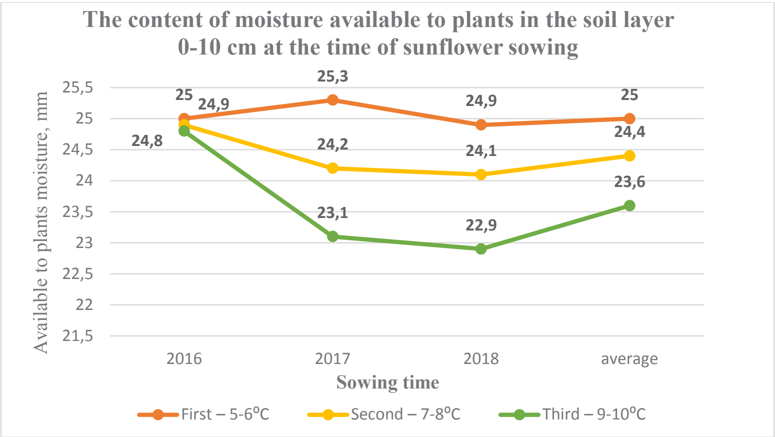

Figure 2. Content of moisture available to plants in the soil layer 0–10 cm at the time of sunflower sowing

Figure 3. Content of available moisture in 0-100 cm layer of soil, mm, depending on the sowing time and density of standing sunflower plants in flowering phase (average for 2016-2018)

Thus, according to the average data of 2016-2018, the highest reserve of moisture available to plants in the soil layer 0-100 cm., In crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 were at the density of standing plants 60 thousand per hectare, for the first sowing period – in the flowering phase was 127 mm, for the second sowing period – 121 mm, for the third sowing period – 121 mm. For plant densities of 50 thousand per hectare for the first sowing period – 5-6°C, in crops of Forward hybrids, LG 56.32, LG 54.85, LG 55.82 the available moisture in the flowering phase was 124 mm, for the second sowing period – 7-8°C – 118 mm, for the third sowing period – 9-10°C – 117 mm. In case of increase of plant standing density up to 70 thousand per hectare, the reserve of moisture available to plants were 125 mm in the first sowing period, 125 mm in the flowering stage, 120 mm in the second sowing period, and 119 mm in the third sowing period.

4. Influence of elements of nutritios on the fertility of soil and productivity of sunflower

For the formation of high productivity of sunflower, as well as for maintaining the fertility of the soil at the proper level, conditions must be created for the complete providing soil with nutrients.

In general, for three years of studies, the content of nitrate nitrogen in the arable soil was at the level of low NO_3 (0.60-6.60 mg/kg), ammonium nitrogen at the average level of NH_4 (17.5-28.4 mg/kg), phosphorus and potassium at high and high levels of safety (P_2O_5 – 166.9-324.0 mg/kg; K_2O – 96.0-193.0 mg/kg) table 1.

The amount of nitrogen, phosphorus and potassium changed significantly over the years and under the influence of different fertilizer backgrounds.

The application of the fertilizer system for growing sunflower in 2016 contributed to a significant increase in phosphorus on plots when making $N_{40}P_{40}K_{40}$ + PP. and was 232.8 mg/kg of soil, in the non-fertilizer version the phosphorus content was 210.9 mg/kg of soil and in the variant $N_{40}P_{40}K_{40}$ – 195.3 mg/kg of soil, accordingly.

The introduction of $N_{40}P_{40}K_{40}$ contributed to the reduction of phosphorus by 37.5 mg/kg of soil or by 16.2% compared to the variant $N_{40}P_{40}K_{40}$ + PP. and 15.6 mg/kg of soil or 7.4% compared to the fertilizer-free version.

Making $N_{40}P_{40}K_{40}$ + PP contributed to the increase of nitric nitrogen (NO_3) content by 1.35 mg/kg of soil or by 37.5% compared to the version

Table 1

The content of nutrients in the arable soil (0-30 cm), depending on the fertilizer of sunflower for 2016-2018

Years	Fertilizer system	NO_3 mg/kg	NH_4 mg/kg	P_2O_5 mg/kg	K_2O mg/kg
2016	No fertilizer	2,25	17,5	210,9	96,0
	$N_{40}P_{40}K_{40}$	2,83	24,6	195,3	122,5
	$N_{40}P_{40}K_{40}$+ P.P.	3,60	18,8	232,8	137,3
2017	No fertilizer	3,50	18,6	186,0	109,6
	$N_{40}P_{40}K_{40}$	6,60	19,9	266,5	163,0
	$N_{40}P_{40}K_{40}$+ P.P.	6,20	28,4	166,9	169,0
2018	No fertilizer	0,81	17,9	271,9	152,0
	$N_{40}P_{40}K_{40}$	0,76	24,2	166,9	193,0
	$N_{40}P_{40}K_{40}$+ P.P.	0,60	17,6	324,0	145,0

*PP by-products of the predecessor.

without fertilizers. Ammonium nitrogen (NH_4) content in the soil was higher when $N_{40}P_{40}K_{40}$ was applied and amounted to 24.6 mg/kg of soil, which is 28.9% compared to the fertilizer-free version.

In 2017, the phosphorus content was higher in the $N_{40}P_{40}K_{40}$ background and was 266.5 mg/kg of soil, which is higher than in the non-fertilizer version by 80.5 mg/kg of soil or 30.3% and in the variant $N_{40}P_{40}K_{40}$ + PP on 99.6 mg/kg soil or 37.4%.

The introduction of $N_{40}P_{40}K_{40}$ contributed to an increase in nitrate nitrogen (NO_3) content of 3.1 mg/kg soil or 47.0% compared to the non-fertilizer version and 6.1% with the $N_{40}P_{40}K_{40}$ + PP variant. Ammonium nitrogen (NH_4) content in soil was higher when $N_{40}P_{40}K_{40}$ + PP was applied. and amounted to 28.4 mg/kg of soil, up 34.6% compared to the non-fertilizer version.

Making $N_{40}P_{40}K_{40}$ + PP while growing sunflower in 2018 significantly increased the phosphorus content of the fertilizer-free background and the $N_{40}P_{40}K_{40}$ background. The phosphorus content was 324.0; 271,9; 166.9 mg/kg of soil, which is more than the fertilizer-free version by 16.1% and the $N_{40}P_{40}K_{40}$ variant by 48.5%.

Nitrogen (NO_3) content in soil was almost unchanged with $N_{40}P_{40}K_{40}$ and $N_{40}P_{40}K_{40}$ + PP, this indicator varied from 0.60 to 0.81 mg/kg of soil and was higher in the non-fertilizer version by 26%.

The introduction of $N_{40}P_{40}K_{40}$ increased the content of ammoniacal nitrogen (NH_4) by 6.3 mg/kg of soil or by 26.1% compared to the non-fertilizer variant.

Thus, when growing sunflower in 2016-2017, making $N_{40}P_{40}K_{40}$ + PP contributed to the increase in soil potassium content of 137.3 and 169.0 mg/kg of soil, which is 10.8 and 3.6% more than the $N_{40}P_{40}K_{40}$ variant, and by 30.1 and 35.2% compared to the non-fertilizer variant.

In 2018, the potassium content of soil was higher in the $N_{40}P_{40}K_{40}$ background and was 193.0 mg/kg, which was 24.9% more than in the $N_{40}P_{40}K_{40}$ + PP version. and by 21.3% in the fertilizer-free version.

5. Photosynthetic activity of sunflowers

An important showing of the intensity of sunflower growth is the net productivity of photosynthesis, which shows the ratio of daily growth of dry matter to the area of leaves (table 2). Studies have shown that the net productivity of photosynthesis varies widely depending on the phases of growth and development, the structure of sowing, nutrition and biological characteristics of hybrids.

Table 2

Net productivity of photosynthesis of sunflower, depending on the sowing time and density of plants, g/m2 per day (average for 2016-2018)

Hybrid	Soil temperature 5-6°C			Soil temperature 7-8°C			Soil temperature 9-10°C		
	Plant density, thousand pieces / ha								
	50	60	70	50	60	70	50	60	70
Forward (control, standard)	9,3	9,4	9,0	9,4	9,5	8,9	9,3	9,4	9,2
LG 56.32	9,5	9,8	9,3	9,5	10,0	9,5	9,6	9,9	9,7
LG 54.85	9,8	10,4	9,5	9,9	10,1	9,4	10,0	10,0	9,2
LG 55.82	10,3	11,1	9,7	10,0	10,7	9,9	9,9	10,2	9,9
NIR 05	factors A – 0,30; factors B – 0,26; factors C – 0,26; ABC – 0,91								

The highest net photosynthesis productivity was observed in the LG 55.82 hybrids (10.2-11.1 g/m^2 per day) and in the LG 54.85 (10.1-10.4 g/m^2 per day) hybrids. In other hybrids studied, the net productivity of photosynthesis was at the same level – 9.2-10.0 g/m^2 per day. The lowest productivity of this parameter was found in the hybrid Ford and LG 56.32.

The net productivity of photosynthesis in all variants increases to 60 thousand/ha, after which it decreases in the Forward hybrids by 2.2-6.4%, LG 56.32 by 2.1-5.2%, LG 54.85 by 8.0-8.7%, LG 55.82 by 3.0-12.7%, due to the features of their architectonics, in particular, the greater number of leaves.

Studied LG 54.85 and LG 55.82 sunflower hybrids provided the highest net productivity in the first sowing period, and the Forward, LG 56.32 sunflower hybrids in the second sowing period contributed primarily to appropriate moisture supply. In the third sowing period, net productivity decreased by 3.9-8.2% and 1.0-2.0%. Such decrease was caused by increase in air temperatures and lack of soil moisture.

The most objective indicator that allows to determine the possibility of using photosynthetically active radiation by crops during vegetation period is photosynthetic potential. It means the total leaf surface that participated in photosynthesis from the beginning of vegetation to the end of photosynthesis.

Studies have been established that the magnitude of photosynthetic potential was due to the characteristics of hybrids, sowing time and density of plants. During the vegetative period of sunflower, the crops of hybrids produced photosynthetic potential at the level of 2,04-2,55 million m^2/ha. (table 3). This gives grounds to affirm that the sunflower crops in the experiment were in good condition.

Increasing plant standing density from 50 to 60 thousand/ha provided growth of photosynthetic potential. In Forward hybrids, LG 56.32, LG 54.85, LG 55.82 it increased by 12.1–13.0%. At plant density of 70 thousand/ha, the photosynthetic potential decreased by 4.1–5.0% compared to the density of 60 thousand/ha. Sunflower sowing at soil temperature 5-6 and 7-8°C contributed to its higher performance in comparison with the third term by 4.1-1.8%. The largest photosynthetic potential was found in the LG 55.82 hybrid during the first sowing period at density of 60 thousand hectares – 2.55 million m^2 days / ha. The LG 54.85 hybrid is slightly smaller – 2.51 million m^2/ha. It was the smallest in the hybrids of Forward and LG 56.32 for the third sowing period with the placement of 50 thousand plants/ha –

Table 3

Photosynthetic potential of sunflower, depending on the sowing time and density of plants, million m² days / ha (average for 2016-2018)

Hybrid	Soil temperature 5-6°C			Soil temperature 7-8°C			Soil temperature 9-10°C		
	Plant density, thousand pieces / ha								
	50	60	70	50	60	70	50	60	70
Forward (control, standard)	2,15	2,40	2,35	2,09	2,35	2,28	2,07	2,34	2,24
LG 56.32	2,17	2,42	2,35	2,06	2,37	2,28	2,04	2,33	2,21
LG 54.85	2,21	2,51	2,37	2,07	2,44	2,34	2,04	2,37	2,27
LG 55.82	2,16	2,55	2,41	2,18	2,49	2,33	2,13	2,44	2,29

2.07 and 2.04 million m²/ha, respectively. Therefore, the larger the leaf area and the duration of the vegetation, the higher the photosynthetic potential and better opportunities for gettng high yield.

6. Sunflower productivity depending on sowing time and plant standing density

Research established significant dependence of yield of sunflower hybrids on the density of plants, weather conditions, biological features of hybrids and sowing time (table 4).

In general, over the three years of research, the highest yields of the hybrids LG 5582, LG 54.85, LG 56.32, Forward was obtained at a density of 60 thousand plants/ha. In the first sowing period, the highest seed yield of 3.85 t/ha was provided by the LG 55.82 hybrid, which was 5.5% more than in the third term and 3.2% in the second sowing period. The plants of the LG 54.85 hybrid formed a seed yield of 3.64 t/ha for sowing in the first term, which is 0.9% more for the third term and 3.6% for the second sowing period. For the sowing in the third term, the highest seed yields were formed by hybrids of Forward and LG 56.32 – 3.09 and 3.62 t/ha, which is higher by 3.6 and 3.4% for the second term, 4.9 and 8.9%, respectively first term. Hybrids of sunflower LG 56.32, LG 54.85 and LG 55.82 by seed yield significantly exceeded the control variant. Thus, the LG 55.82 sunflower hybrid exceeded the Forward hybrid yield by 0.91 t/ha, or 23.7%; LG 54.85 at 0.7 t/ha, or 19.3%; LG 56.32 – up 0.53 t/ha, or 14.7%.

Table 4

Yield of sunflower hybrids, depending on sowing time and density of plants, t / ha (average for 2016-2018)

Hybrid	Year	Soil temperature 5-6°C			Soil temperature 7-8°C			Soil temperature 9-10°C		
		Plant density, thousand pieces / ha								
		50	60	70	50	60	70	50	60	70
Forward (control, standard)	2016	2,70	2,62	2,65	2,87	2,74	2,41	2,79	2,73	2,70
	2017	3,02	2,91	2,66	3,27	3,29	2,79	3,21	3,37	3,27
	2018	3,12	3,29	2,99	2,82	2,93	3,06	2,87	3,17	2,81
	average	2,94	2,94	2,76	2,98	2,98	2,75	2,95	3,09	2,92
LG 56.32	2016	2,79	2,75	2,68	3,06	3,62	3,29	3,24	3,41	3,35
	2017	3,11	3,42	3,56	3,19	3,47	3,23	3,30	3,55	3,7
	2018	3,46	3,76	3,46	3,28	3,51	3,33	3,53	3,90	3,30
	average	3,12	3,30	3,23	3,17	3,5	3,28	3,35	3,62	3,45
LG 54.85	2016	3,26	3,50	3,00	3,33	3,33	3,18	3,23	3,12	2,93
	2017	3,49	3,69	3,62	3,7	3,99	3,52	3,98	4,10	3,58
	2018	3,53	3,74	3,41	3,37	3,24	3,27	3,58	3,63	3,15
	average	3,42	3,64	3,34	3,46	3,51	3,32	3,59	3,61	3,22
LG 55.82	2016	3,22	3,27	2,70	3,26	3,21	3,38	3,28	2,96	3,38
	2017	3,95	4,04	3,74	3,91	4,16	3,54	3,69	3,98	3,59
	2018	3,74	4,24	3,58	3,47	3,83	3,84	3,86	3,99	3,79
	average	3,63	3,85	3,33	3,54	3,73	3,58	3,60	3,64	3,58
NIR 05, t/ha for	factors A 0,13 factors B 0,11 factors C 0,11 total ABC 0,40									

7. Economic and energy efficiency of improved elements of sunflower production technology

The calculation of the cost-effectiveness of growing sunflower confirmed that early sowing time leads to a higher level of profitability than late ones. The criteria for the degree of efficiency were: the level of cost of production, the amount of net profit per 1 ha, calculated as the difference between the cost of the crop per unit area and the cost of its production (table 5).

It should be noted that production costs increased from the first to the third sowing period due to the additional sowing cultivation in the second term and two – in the third. Costs were also determined by the pre-harvesting moisture of grain. Costs for the first sowing period fluctuated within 8677-9835 UAH/ha, for the second – 8793-9951 UAH/ha and for the third increased to 8909-10067 UAH/ha.

Table 5

Economic efficiency of cultivation of sunflower at standing density of 60 thousand/ha at different sowing periods (average for 2016-2018)

Hybrid	Sowing time	Yield, t/ha	The cost of the crop, UAH / t	Cost of seeds, UAH / t	Costs, UAH / ha	Net profit, UAH / ha	Profitability level,%
Forward (control, standard)	5-6°C	2,94	24343	2951,3	8677	15666	180,5
	7-8°C	2,98	24674	2950,6	8793	15881	180,6
	9-10°C	3,09	25585	2883,1	8909	16676	187,1
LG 56.32	5-6°C	3,30	27324	2827,8	9332	17992	192,7
	7-8°C	3,5	28980	2699,4	9448	19532	206,7
	9-10°C	3,62	29973	2641,9	9564	20409	213,3
LG 54.85	5-6°C	3,64	30139	2701,0	9832	20307	206,5
	7-8°C	3,51	29062	2834,1	9948	19114	192,1
	9-10°C	3,61	29890	2787,8	10064	19826	196,9
LG 55.82	5-6°C	3,85	31878	2554,5	9835	22043	224,1
	7-8°C	3,73	30884	2667,8	9951	20933	210,3
	9-10°C	3,64	30139	2765,6	10067	20072	199,3

The lowest seed cost was obtained when growing the hybrid LG 55.82 – 2554.5 UAH / t for the first sowing period, and this variant recorded the highest profitability in the experiment – 224.1%. Among hybrids, it is most economicaly feasible to grow LG 55.82 when sowing at 5-6°C soil temperatures. The net profit in this variant was 22043 UAH / ha, the level of profitability was 224.1%.

In addition to the economic evaluation of the technology of sunflower cultivation was carried out and energy assessment of the level of total energy costs, the cost of production of 1 centner of seeds, energy output per hectare, as well as the level of energy efficiency (LEE). The energy efficiency ratio was the highest during the first sowing period and was 3.38-4.44. In the second term, the value of LEE ranged from 3.22 to 4.03 and the third period from 3.13 to 3.69.

8. Conclusions

The water regime is formed by weather conditions, the amount of soil moisture reserves, the amount and intensity of rainfall during the year, incl. and during the vegetative period. To a large extent, soil's water regime depends on the morphological features of the hybrids, the plant standsng density, the sowing time, and the cultivation technology. Under these conditions, crops with plant density of 60 thousand/ha, contributed to the formation of the highest yield, compared with other options.

For the first sowing period, the highest seed yields were provided by the LG 55.82 3.85 t/ha and LG 54.85 – 3.64 t/ha hybrids, while the Forward and LG 56.32 hybrids for the third term sowed 3.09 and 3.62 t/ha, respectively.

Application of nitrogen fertilizers in combination with phosphorus and potassium $N_{40}P_{40}K_{40}$ + PP and the $N_{40}P_{40}K_{40}$ improves soil nutrition and creates more favorable conditions for the growth and development of sunflower plants and for maintaining soil fertility.

Considering the economic indicators, it is efficient to grow LG 54.85, LG 55.82 hybrids for the first sowing period. Forward, LG 56.32 Sunflower Hybrids provide the highest economic performance for the third sowing period.

Among the hybrids, it is most economically appropriate to grow LG 55.82 when sowing at soil temperatures of 5-6°C and plant density of 60 thousand/ha. The net profit in this variant was 22043 UAH/ha, the level of profitability was 224.1%.

The energy efficiency ratio was the highest in the first sowing period of the LG 55.82 hybrid and was 4.44.

Thus, the high requirements of sunflower for environmental resources do not exclude early sowing, but rather confirm the relevance of research on their effectiveness.

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IMPROVEMENT OF THE SYSTEM OF REARING PEDIGREE AND REPAIR YOUNG PIGS IN THE CONDITIONS OF MODERN TECHNOLOGIES

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Abstract. The issue of improving the rearing pedigree and repair young pigs in conditions of modern technologies is particularly relevant for small farms, which are still working on the round system for farrowing. Under such a system, irregular use of boars and maintenance personnel, low turnover of machine spaces, overspending of feed and other production materials are noted. The main purpose of this work is the development of new volumetric-planning and technological decisions in the conditions of transfer of breeding enterprises from the round to the current production system with the determination of efficiency of rearing pedigree and repair of young pigs. The methodological basis was the theory and practice of technological and economic research on the improvement of technology of production of pig breeding products based on the introduction of modern volumetric–planning decisions for the reconstruction of new technological approaches to the production process. In the course of the research, a technological model of transfer of farms from a round to a current system of farrowing was developed and implemented. Design and technological solutions have been developed and their application in the reconstruction of the premises and transfer of the farm to the current system of obtaining farrows have been substantiated. The developed method of the current production is characterized by the fact that in order to reduce the age difference of piglets when applying a large rhythm step (more than 21 days), the operation of the rhythm step up to 7 days is performed, which ensures the rhythmic forma-

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tion of technological groups and receiving farrows in optimal terms with a relatively aligned litter at within the technology group. The transfer of pedigree enterprises from round to current production technology with simultaneous reconstruction of premises and entry into a predetermined rhythm of production contributed to the increase of the main indexes of pig productivity, namely: litter weight in 60 days (by 25.0%), number of farrows (by 25.5%), average daily gain of suckling piglets (by 18.6%), weaned pigs (by 31.3%), fattening young animals (by 26.2%), pedigree young animals (by 19.7%). The introduction of new volumetric-planning and technological decisions reduced the use of the total production area of the premises for sows by 63.4-65.1 m2, increased the efficiency of the use of farrowing machines by 5-6 times and increased the intensity of the use of sows by 26-35%. After the transfer to the current production technology in the SE "EE imeni Dekabrystiv ”with a reduction of 36 heads of the main sows, the number of pigs increased by 12%, the output of piglets per 100 main sows increased by 552 heads, the production of pork per main sow increased by 12.7%, the average daily gain of pigs increased from 389 up to 428 g. In SE "Stepne", with the same number of maternal livestock, the number of pigs increased by 18.6%, the average daily increase – by 15.2%, the output of piglets per 100 main sows increased by 992 heads. and increase pork production by one main sow to 431 kg.

1. Introduction

The issue of the improvement of rearing pedigree and repair young pigs in modern technologies is particularly relevant for small farms, which are still working on the round system for receiving farrows. The work on increasing the profitability of pedigree and commercial pig breeding should be based on modern economically justified low-cost technologies [1, p. 49; 4; 8, p. 33]. On this basis, the enterprises should concentrate their activity in finding ways to improve and realize production and marketing opportunities [3, p. 126; 5]. The topical directions of increasing the economic efficiency of business activities in pig breeding can be considered: improvement of the system of housing animals; rationalization of the feeding system; formation of a qualitative breeding base of pig breeding [2; 6, p. 9]. Despite the steady progress in pig breeding in Ukraine, most breeding factories that are not part of the large industrial complexes carry out their work on a round or seasonally round system of receiving farrows. Under these conditions, the main offspring are obtained in relatively comfortable spring and summer conditions, which allows to rear a strong and promising breeding stock in terms of use in the breeding process. However, such a system of work in enterprises shows irrational use of boars and maintenance staff, low turnover of machine spaces, over-consumption of feed and other production materials. As the maternal stock to receive farrows in spring and summer and autumn has a forced idle time, the management of such technology impedes the efficiency of using the maternal stock and the sale of reared young pigs. The transition to new progressive forms of pig breeding with a current-based system of receiving farrows is primarily constrained by the fact that having a small number of basic sows makes it difficult to form efficient technological groups and, as a consequence, production facilities are scattered in their service, and the presence of small technologically diverse pig groups requires special conditions for housing, feeding and care. The transition to the use of new technological approaches is also conditioned by the lack of experience of transferring pedigree enterprises from round to a current-based system of receiving farrows. There are also almost no data on the features of the farm premises reconstruction with such technologies, so that the created conditions take into account the biological features of the age-old livestock as much as possible. In addition, a market economy requires the development and implementation of energy and resource-saving technologies using new types of facilities for the production of breeding and commercial pig production. Under this approach, the reconstruction can be undertaken to address the following issues: improving pig feeding through the use of new, effective, fully-fledged compound feeds that maximize the genetic potential of animals; modernization of the equipment for pig housing all technological groups with modern means of feeding; improvement of own perspective breeds, types and lines due to enrichment with imported genotypes and improvement of breeding work; modernization of ventilation and creation of optimal microclimate during the whole period of rearing pigs; gradual replacement of the hydro-flushing system of manure removal on self-alloy with the equipment of machine tools with modern slot floors. Therefore, the development of new technological approaches to the reconstruction of pig farms and the transfer of breeding farms to a stream production system is relevant and has considerable theoretical and practical interest. The main purpose of this work is to develop new volumetric-planning and technological solutions in the conditions of transfer of pedigree enterprises from the round to the stream production system and to determine the efficiency of breeding and repair of breeding pigs by modern technologies.

2. Survey methodology

The methodological basis was the theory and practice of technological and economic research on improving the work of enterprises made on the basis of the implementation of modern volumetric-planning desecions for the reconstruction of new technological approaches to conducting the production process. The main tasks in the development of new volumetric-planning and design-technological decisions for the reconstruction of premises were: to unlock the genetic potential of the maternal and fattening livestock to create comfortable conditions for housing animals under new technological solutions; search for new approaches to the development of pre-project proposals for the reconstruction of premises for the housing of animals, taking into account new parameters of their productivity; optimization of placement of machine equipment and division of premises into technological blocks for housing animals of different technological groups; providing recommendations for replacing the scraper slurry removal system with modern closed-type self-alloys; introduction of year-round control systems to ensure optimal microclimate; maximizing the use of natural lighting, modern thermal materials and the introduction of energy-efficient space heating technologies. The research material was a herd of the Large White and Myrgorod breeds of pigs and breeding technology for pedigree pigs in traditional premises with a round system for receiving farrows. The research was carried out in two directions: 1)analysis of the work of pedigree enterprises and the development of technological and economic bases for the transfer of pedigree enterprises from the round to the current system of receiving farrows; 2) development of volumetric-planning and design-technological decisions for the construction of modern farms for the production of pedigree pig breeding products. In the first direction of research the work was carried out in two stages. At the first stage, the analysis of existing technologies for breeding the pedigree pigs in SE "EE Stepne" and SE "EE imeni Dekabrystiv "and it has been developed the technology for the current production of pork with new volumetric-planning decisions for the reconstruction of pig premises. At the second stage of the work after the reconstruction of farm premises was carried out according to the volumetric-planning decisions, it was curried out the transfer of pig breeding field in enterprises into to a current system of receiving farrows and evaluated the fattening, meat, reproductive qualities of pigs and technological and economic indicators for new production conditions. In the article it is presented the results of the implementation of the developed volumetric-planning and technological decisions in changing the technology of housing and the efficiency of the introduction of current technology in the State enterprises of experimental enterprises (SE EE) "Stepne", "imeni Dekabrysty ”and“ 9 Sichnia”, which are part of the research enterprises of the National Academy of Agrarian Sciences of Ukraine.

3. Results of own research

Research was focused on the development of a new technological model for the transfer of pedigree enterprises from seasonal-round to the all year current rearing pedigree and fattening pigs with the use of new volumetric-planning and technological decisions. According to the research topic, the work was carried out in two stages. At the first stage, the enterprise were surveyed, the existing technologies of breeding pig production in SE “Stepne” and SE “SE. Decembrists”, developed the technological and economic basis for the transition of tribal enterprises from the round to the current system of receiving farrows. In the second stage, technologies for the current production of pork were developed for each enterprise, with new volumetric-planning decisions for the reconstruction of pig premises. In all enterprises which were studied, a seasonal-round system of farrows was applied, during which 1.7–1.8 farrows per sow were obtained during the year. With this technology, the production cycle was 6 months: 4 months – idle and dusty and 1.5–2 months – feeding period. In all the farms studied, a seasonal-tour system of farrowing was applied, during which 1.7–1.8 farrowings per sow were obtained during the year. With this technology, the production cycle was 6 months: 4 months – idle and dusty and 1.5–2 months – feeding period. On the basis of the conducted scientific researches, for the first time in the conditions of production of pedigree products, a technological model of transfer of a farm from a round to a current system of reciving farrows was developed and introduced. Design and technological solutions have been developed and their application in the reconstruction of the premises and transfer of the farm to the current system of obtaining farrows have been substantiated.

4. Effectiveness of introduction of current technology in SE EE "Stepne"

The analysis of the existing technology of rearing pedigree pigs showed that in the State Enterprise "Stepne" of Poltava district of Poltava region all premises where pigs were housed, equipped with conveyors for removal of TSN-2B manure, carts for distribution of forages like UTR, teat self-priming. Indoor ventilation is natural with the help of exhaust mines. With seasonal-round technology of receiving of farrows created a situation where, at the end of the production cycle, the farm contained almost 1000 heads of fattening pigs that the sausage shop was unable to process. The realization of commercial livestock with live weight at meat processing enterprises led to a loss of profit and loss of production of products of pig breeding. The pig live-stock of the pedigree factory of the SE EE "Stepne" were housed in six premises: in the first – boars (20 heads) and single sows, in the second – pregnant sows, in the third, fourth and fifth – lactating sows and weaned piglets, in the sixth – fattening young pigs. The floor area in the lactating sow machine was 7 m^2, on the pregnant sow – 2.5 m^2, at the idle sow – 1.2 m^2, for the young pigs – 0.9-1 m^2. The main task of the pedigree factory is to breed the pedigree young pigs, but due to seasonality of farrowing and unregulated demand, the farm sold only 12% of the pedigree stock and the rest of the high-quality pedigree stock was forced to sell as commodity. Productive indexes of pigs for reconstruction are given in Table 1.

In the course of the research, a comparative study of the impact of technological approaches on the reproductive indexes of pigs was carried out for the first time and the results confirmed the feasibility of the proposed measures in the transition from round to the current system of production in pedigree enterprises. The introduction of the developed model of the current production and introduction of artificial insemination ensured the rhythmic formation of technological groups of single sows in 21 day increments, their insemination within 7 days and obtaining farrowing in the optimum time. The current-shop pork production technology always implies a high level

Table 1

Indexes of the productivity of pigs before reconstruction

Indicators	Value
Pigs received in a year, heads	278
Average multiplicity, heads	3041
The total weight of weaned piglets, kg	10,9
Loss, heads	29227
Stuck, heads	40
Transfer for repair, heads	216
Transfer for fattening, heads	188
The realized piglets in the group 0-2, heads	1177
the Realized young pigs in group 2-4, heads	429
Realized youngsters in group 2-4, goals	905
Implemented breeding young animals, goals	90
All realized, head	1424

of concentration of animals, a narrow specialization of premises and service personnel. Accordingly, the technologies developed were based on the following basic principles of current production: 1) the rhythm of receiving of offspring during each rhythm step; 2) year-round receiving farrows; 3) the formation of the required number of sows in the technological group and their synchronization; 4) placement of sows in groups according to their physiological condition, productivity, age and other factors; 5) adherence to accepted technology and duration of the reproductive cycle for the all stock of sows and the rejecting schemes; 6) clear production rhythm for all production groups. The reconstruction of the shop for the reproduction provided: development of a cycle diagram of current production of pedigree products, the use of artificial insemination, construction of an artificial insemination point. After an analysis of the work of the pedigree factory it has been developed the strategy for the effective reconstruction of pedigree enterprises without reducing the rate of reproduction of the herds. This process was accompanied by a number of tactical steps. At the first stage, a production program was developed to transfer the pedigree pig breeding of the pedigree factory of SE "EE" Stepne "to the current technology. The calculations and the developed cycle diagram showed that it was necessary to reconstruct the premises where the boars and sows were housed and to arrange artificial insemination of pigs. We have developed volumetric-planning decisions for the point of artificial insemination and the premise for pigs with individual machines for housing sows and boars, and proposed a new method of feeding boars. Based on the calculations, the scheme of reconstruction (Figure 1) and the schedule of livestock movements of different technological groups (Figure 2) were proposed.

The peculiarity of the reconstruction was that for the first time we developed a method of the current production characterized in that in order to reduce the age variability of piglets, when using a large rhythm step (more than 21 days), the rhythm step operations are sealed, that is, the insemination of the technological group of idle sows takes place in short term – up to 7 days, the remaining 14 days of insemination does not occur.

Similarly, a technological group of lactating sows is formed within 7 days (with a deviation of ± 2 days), but the sector closes only on the 21st day, that is at the end of the rhythm step. Weaning of piglets also occurs within 7 days, and the remaining 14 days of piglets are housed in the same machines without sows, which minimizes the stress factor in weaned piglets. Then they are transferred to the rearing and fattening section. This technology allows pigs to be fattened in different ways. For example, in the case of small groups, the technological group of piglets is formed within a week. If you need to fatten a large group of animals, the formation is best done in one day. Changing the technology of production of pig products was carried out after the reconstruction and filling the premises with animals of different technological groups. According to the technology developed in the enterprise, the following technological operations were performed during the 21-day rhythm of the breeding factory by employees: **at the precinct № 1** (the premise for housing boars and sows): to form a buffer group of single sows in the amount of 30 heads; to reject sows having two bays and transfer to the **precinct № 5**; to transfer infertile sows and sows after weaning pigs from section № 3, repair pigs from the fifth section and enter them into the buffer group; to select from the buffer group 30 sows in estrus, to transfer them into individual machines for insemination in a pig farm № 1; take sperm from 1-2 boars at the point of artificial insemination, check its quality, to dilute, to pack into vials and fertilize during seven days 30 sows housed in individual machines in a pig farm № 1; to identify with the help of the boar-sampler unfertilized sows (in estrus) (a pig farm № 1) and to transfer them into machines for re-insemination; transfer sows

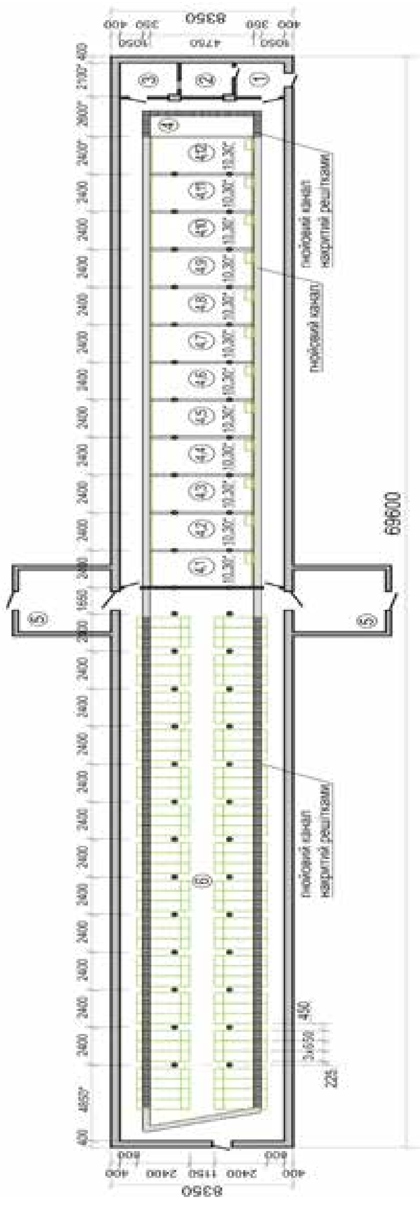

Figure 1. Scheme of reconstruction of the premises for pigs

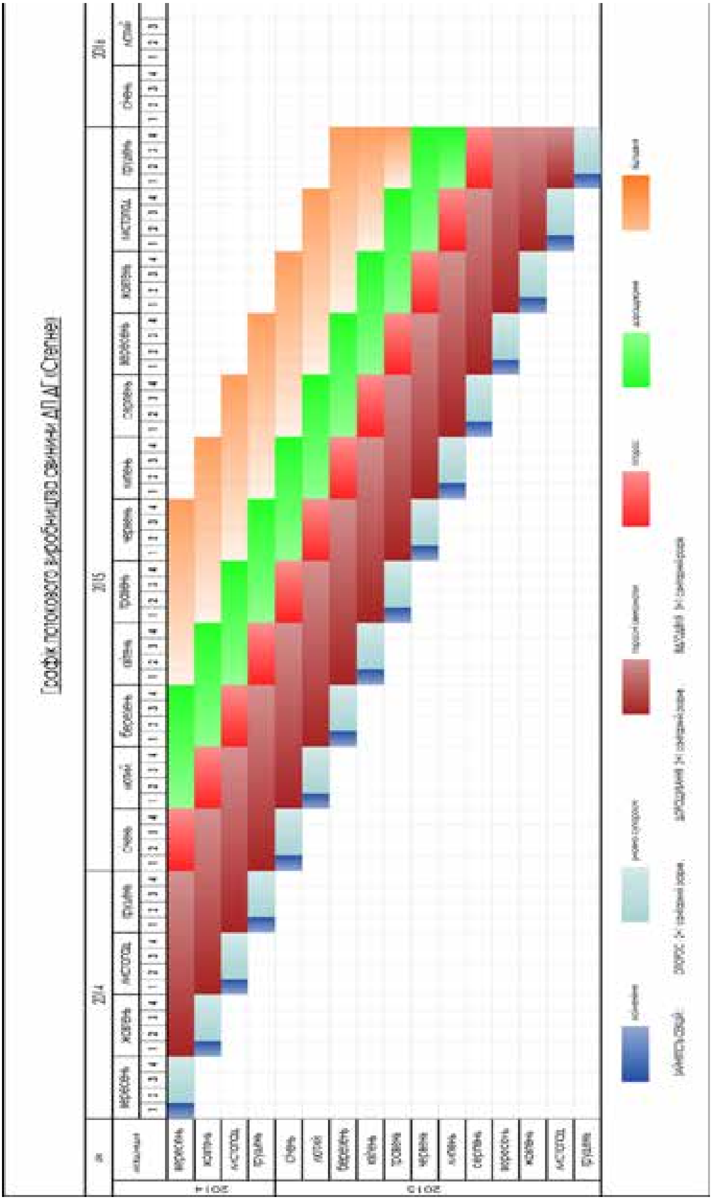

Figure 2. Cycle diagram of current production of products

(after 32 days of conditional pregnancy) to the second section; to accept 2 repair boars from section №4; carry out repairs and disinfect discharged machines. **At the precinct № 2** (a pig farm № 1): to place sows from the first section in group machines of 10 heads; identify unfertilized sows (main and inspected sows) and send for re-insemination to the precinct № 1; to select 25 sows of the second half of pregnancy (96 days of pregnancy) and transfer to the precinct № 3; carry out repair work and disinfect machine tools. **At the precinct № 3** (pig farms № 2 and 4): to place 25 sows transferred from the precinct № 2 to the machines for 5-7 days before farrowing; to take a farrowing in sows, and after that to form a technological group of 24 lactating sows and suckling piglets; to wean sows from suckling pigltns in 28 days; to select the 22 best sows and transfer to the precinct №1, and transfer the selected sows to the precinct № 5, to remain the piglets to grow to 42 days; sort the technology group of 42-day-old piglets into 2 batches. One part to sell to the population, the other – to pass for fattening in a pig farm № 5 (the precinct № 5); carry out repair work and disinfect machine tools. **At the precinct № 4** (a pig farm № 3): sort and place the repair young animals (boars and gilts); to transfer repair gilts and boars to the precinct № 1; send 2 boars for sale, or to castrate them and transfer for fattening (the precinct № 5); carry out repair work and disinfect machine tools. **At the precinct № 5** (a pig farm № 5): to accept from section № 3 young pigs, to sort and place them in group machines on 25-30 heads; to accept sows having two absences from the precinct № 1; to accept low-productive sows from precinct № 3 and 2 castrated boars from precinct № 5; to send for sale breeding young pigs and (unfertilized and rejected after lactation) adult sows; to reject the pigs and send them to slaughter; carry out repair work and disinfect machine tools. Table data. 2 indicate that as a result of reconstruction, the need for boars has decreased (by 3 times), for young boars (by 2.5 times), but the need for sows to be tested has increased (by 1.6 times).

Studies have shown the economic feasibility of transition of a pedigree farm to current technology of rearing of pigs. Thus, the change of the traditional round system of pork production to current increased rate of using sows from 1.8 to 2.0, multiplicity from 11.5 to 12.3 heads per a sow, reduced piglet output: under the sow by 1.4–2.8 , on the rearing – by 0.4–0.8% (Table 3). Along with other indexes, pig interiors indexes have also improved, which has made them more attractive to sell.

Table 2

The structure of the herd of pigs before and after reconstruction

Production group	Livestock structure,%			
	before the reconstruction		after reconstruction	
	heads	%	heads	%
Boars	12	3,12	4	0,97
Main sows	140	36,40	140	33,82
Checking boars	3	0,80	4	0,97
Repair boars	15	3,00	6	1,45
Cheking sows	39	10,12	64	15,45
The gilts are over 4 months old	176	45,71	196	47,34

Table 3

Efficiency of using sows in the current technology of receiving piglets at the pedigree factory of SE "EE "Stepne"

Index	indicator value		To the basic, ±
	basic version	New version	
The intensity of using sows, farrows per year	1,8	2,0	+0,2
Multiplicity of main sows, heads	11,5	12,3	+0,8
Leaning piglets under sow,%	2,5-3,9	1,1	-1,4-2,8
Leaning piglets on rearing,%	0,8-1,2	0,4	-0,4-0,8

The annual economic effect obtained from the reconstruction of the premises under the new volumetric-planning decisions in the studied interprise amounted to UAH 54.7-56.1 thousand, or UAH 273-400. per 1 main sow.

5. Effectiveness of the introduction of current technology in the SE “EE imeni Dekabrystiv”

The second pedigree factory, where a study was carried out on the efficiency of the farm's transfer to a new technological scheme of production of pig breeding products, was in the State Enterprise "EE imeni Dekabrystiv” in Myrhorod district, Poltava region. Analysis of existing technology of rearing pedigree pigs showed that prior to the start of work on changing the technology of production of pig breeding products and the transfer of the farm from a round to a current system for receiving farrows, pigs were housed in five premises, where mechanical removal of manure using TSN conveyors was used. 2B, and the microclimate was maintained by natural supply and exhaust ventilation. Feeding pigs was carried out with wet crossbreds. The main live– stock of pigs was fed compound feed of its own production using premixes of AGRO-FID. Design and technological parameters and volumetric-planning decisions for the farm reconstruction were developed for the farm, which included partial redevelopment of the premises for housing lactating sows and piglets for rearing of Mirgorod breed of pigs and premises for breeding of hybrid pigs with the transfer of pig breeding field on current technology of production. During the reconstruction of the farm, a new production technology was based on a current production system for receiving pedigree and commercial pork. Under the new project, at the first stage of the pig farm's transition to a current system for receiving farrows and breeding pigs of Myrhorod breed, the premise for sows № 1 was divided into 2 blocks: the premise for sows for 36 machine places and a sector for rearing for 400-seats (18 paired looms). For farrowings there are 3 sections on 12 machines (Figure 3). The turnover period of 1 section for farrowing is 42 days: 7 days the section is occupied by sows before farrowing; 28 days – suckling period; 7 days – sanitation of machines after weaning of piglets.

To obtain high-quality pork, increase meaty of carcass and provide the population with high-productive hybrid piglets for the economy, volumetric– planning decesions for the reconstruction of the pig premise № 5 were developed. According to the scheme, the point of artificial insemination of pigs with housing three boars (Duroc, Landrace and Peitren) is placed in front of the premises (Figure 4).

The general appearance of sections with machine tools for individual housing conditionally pregnant sows and group housing sows with defined pregnancy is shown in Figure 5.

The third section for s lactating sows with piglets has 48 individual machines and an automated feed system (left), and the fourth section for housing piglets for rearing is equipped with group machines with local heating (right) (Figure 6).

For automated distribution of feed, feed bunkers with rope-washer with giving feed to feeders are placed on a concrete platform near the pig premise

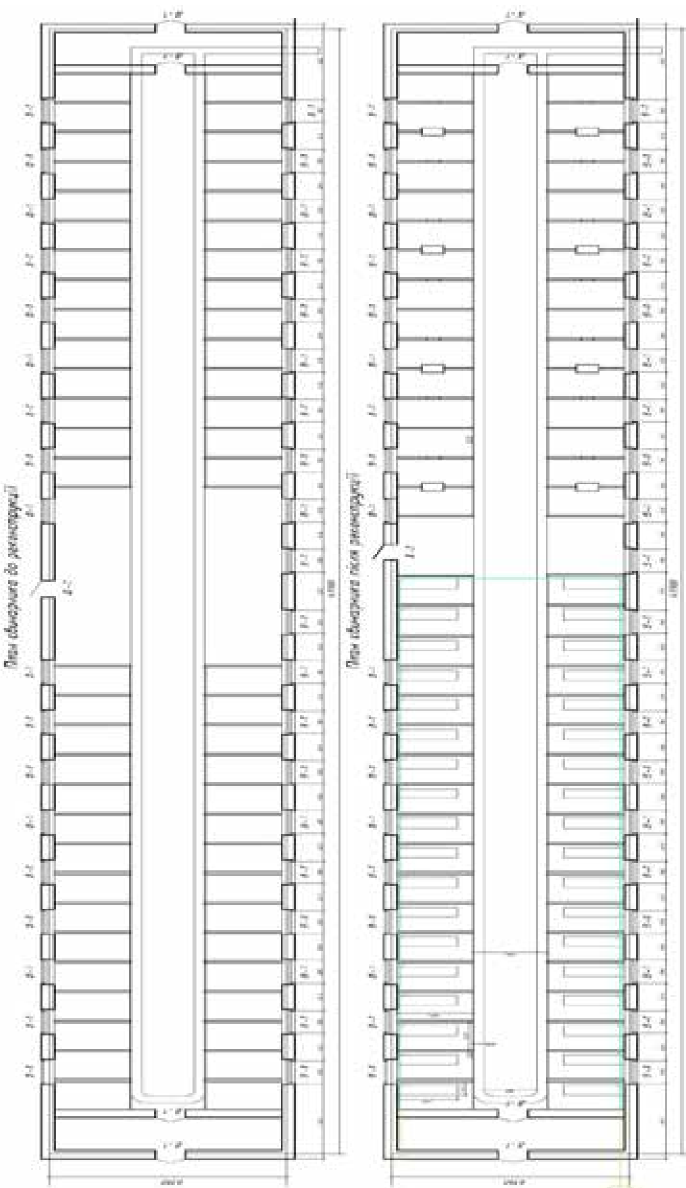

Figure 3. Scheme of reconstruction of the premises for housing sows

Figure 4. Volumetric-planning decisions for the reconstruction of the premises for receiving of hybrid piglets for commercial fattening

Figure 5. Housing conditionally pregnant sows (left) and sows with defined pregnancy (right)

Figure 6. Fragment of the reconstructed premise for lactating sows with piglets (left) and fragment of retention machine for piglets on rearing with free-for-feed in feeders and a thermal comfort zone (right)

(Figure 7). Existing slurry channels were used to remove manure where new slurry was installed. Exhaust fans are installed to remove contaminated air.

Studies conducted on the development and implementation of new technological approaches have shown the economic feasibility of the transition of the pedigree farm from round to current technology of rearing pigs (table 4).

The installation of 36 machines for farrows (3 sections of 12 machines) allowed 84 sows to be used annually and to receive 51 piglets per year, which is 2 times more than with the use of basic (seasonal-round) technology. With a reduction of up to 28 days of suckling period, the intensity of sows usage increased from 1.7 to 2.1 farrowing per year, and the out-

Figure 7. Bins for storage and giving feeds to the premises

Table 4

Technological and economic characteristics of the use of machine equipment for the premise for housing sows before and after the reconstruction at the pedigree factory in the SE "EE imeni Dekabrystiv"

Index	Indicator value		To the basic, ±
	basic version	new version	
Number of machines, pcs.	60	36	-24
Turnover of machines for a year, times	2	8	+6
Average annual use of easel equipment, days	134	305	+171
Number of sows, heads	120	84	-36
Piglets were obtained for 1 farrowing machine, heads	24,6	51,0	+26,4
Business piglets (heads) were obtained for: 1m^2 of production area	4,5	5,9	+1,4
1st worker	410	612	+202
1st sow	15,8	21,8	+6,0

put of weaned pigs per 1 sow increased by 6 heads. The period of use of machines increased from 134 to 305 days, the annual output of business pigs increased by 1 m^2 of production area by 1.4 heads, by 1 worker – by 202 heads [7, p. 221]. The new technology has improved the meat quality of pigs. According to the results of slaughter, animals of the experimental group had an average of 1.2 cm greater length of the half-carcass, on 4.5 cm^2 of area of the "muscular eye" and on 0.4 kg of weight of the back third of the half-carcass. The thickness of the spike on the animal's shoulder was less than 5.5 mm. The transfer to the current technology has improved the interior indexes of pigs. Studies have shown that the animals of the experimental group in comparison with the control analogues prevailed in such interior indexes as the content of protein in the blood (by 11.36%; $p < 0,05$), the area of the "muscular eye" (by 13, 5%; $p < 0.05$). In our opinion, this is due to the adaptation processes that took place in the new animal habitat. Concerning the physical and chemical properties of meat and fat, our studies also found no significant difference between the experimental groups. This is understandable, since these indexes are largely dependent on genotypic rather than paratypical factors. Thus, when assessing the muscle tissue of fattening young animals by chemical parameters, no significant difference in the experimental groups in meat of the Large White breed was found between the content moisture, ash, protein, calcium and phosphorus). Total moisture was in the range of 74.28-74.42%; ash – 1,26-1,33; protein – 22,4-22,5 and fat – 1,19-1,22%. An important qualitative factor in the culinary properties of pork is its ability to retain sufficient moisture. Meat that contains enough bound water – more juicy, has a softer texture, better aroma and taste. In the context of the experimental groups, the result on the moisture content was in the range – from 51.53 to 52.32%. Equally important indexes is the color that characterizes the commodity meat's appearance and the technological properties of the meat. Analysis of the results for this index between the experimental groups of animals did not reveal a significant difference, it ranged from 62.33-63.01. The heat treatment losses in the animals of the experimental groups were almost the same. Based on the conducted research, it should be noted that the annual economic effect obtained from the reconstruction of the premises under the new volumetric-planning decisions in the State Enterprise "imeni Dekabrystiv" amounted to UAH 54.7 thousand, or UAH 273. for one main sow, and in the State Enterprise "EE "Stepne" – UAH 56.1 thousand or 400 UAH. per 1 main sow. The transfer of pedigree enterprises to the current production technology is the most appropriate in terms of efficient use of labor and material resources and implies a high level of intensity and economic efficiency of the industry.

After the transfer to the current production technology in the SE "EE imeni Dekabrysty" with a reduction of 36 heads of the main sows, the number of pigs increased by 12%, the output of piglets per 100 main sows increased by 552 heads, the production of pork per main sow increased by 12.7%, the average daily gain of pigs increased from 389 up to 428 g. In SE "Stepne", with the same number of maternal livestock, the number of pigs increased by 18.6%, the average daily increase – by 15.2%, the output of piglets per 100 main sows increased by 992 heads. and increase pork production by one main sow to 431 kg.

6. Conclusions

The analysis of pig production technologies in pedigree enterprises was carried out and new volumetric-planning desisions for the reconstruction of premises for rearing pedigree and repair young pigs during the transfer from the round to the current production system of allowed to increase the output of piglets per 1 sow and 1 worker. This increased the load per sow to 2.1-2.2 farrowing per year, while increasing the turnover of farrowing machines up to 8 times per year: 1. The introduction of new volumetric– planning and technological decisions in the studied farms reduced the use of the total production area of the premises for sows by 63.4-65.1 m^2, increased the efficiency of using the machines for farrowing by 5-6 times and increased the intensity by 26-35% use of sows. 2. The developed method of the current production is characterized by the fact that in order to reduce the age difference of piglets when applying a large rhythm step (more than 21 days), the operation of the rhythm step up to 7 days is performed, which ensures the rhythmic formation of technological groups and obtaining farrows in the optimum time with relatively balanced litter within the technological group. 3. It has been determined that the transfer of pedigree enterprises from the round to current production technology with simultaneous reconstruction of premises and entry into a predetermined rhythm of production, allows to increase the multiplicity of sows to 12,1-12,3 piglets per farrow, to increase the output of piglets by 100 main sows on 35.8-58.5%, pork production per one main sow – by 12.7-35.0%, and the number of breeding stock sold by 32-57 percent. 4. The use of the current technology for receiving farrows and the introduction of weaning piglets in 28 days, contributed to the increase of the main productive indexes of pigs, namely: the weight of the litter at 60 days (by 25.0%), the number of farrows (by 25.5%) average daily gain of piglets (by 18.6%), weaned piglets (by 31.3%), fattening young animals (by 26.2%), breeding young animals (by 19.7%). 5. The annual economic effect obtained from the reconstruction of the premises under the new volumetric-planning decisions in the studied farms amounted to UAH 54.7-56.1 thousand, or UAH 273-400. per 1 main sow.

7. Offers to production

In order to increase the efficiency of production of pedigree products of pig breeding, it is advisable to transfer pedigree enterprises operating on a season-round system of farrowing to the current technology of production of pig breeding products according to the developed model with the use of compacted farrowing at an extended rhythm step.

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FEEDING FEATURES OF MULLETS

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Abstract. Mullets have long been considered as one of the most important objects of sea ranching in the Black, Azov and Mediterranean basins. Representatives of a family (Mugilidae) have long been valuable objects of ranching fish farming in brackish estuaries and lagoons of the Mediterranean and Azov-Black Sea basins. *Mugilidae* family belongs to *Mugiliforms* and *Acanthopterygii* group consisting of ten genera and about one hundred species. There are five native species of mullets in the Black Sea: flathead grey – *Mugil cephalus L.*, golden grey mullet – *Liza aurata (Risso)*, leaping mullet – Lizas saliens (Risso), thicklip grey mullet – *Chelon labrozus (Risso)*, and the thinlip mullet – *Liza ramada (Risso)*. The first three species are of industrial importance. In the 1980s, so-iuy mullet– Liza *hematocheilus (Temmink et Schlegel)* was acclimated in the Black Sea and later in the Sea of Azov. Due to its high environmental plasticity, the species quickly naturalized and spread. At the same time, the abundance of native species of mullets has significantly decreased in the natural waters, as well as the number of so-iuy mullet over the last years. To ensure fingerling rearing in the Black Sea lagoons and estuaries, it is necessary to solve the problem of artificial reproduction of mullet. One of the key points of biotechnology – the larval rearing – is to provide them with adequate live food. This factor is crucial. It gives juvenile growth, survival and viability. The paper is devoted to the study of feed composition and feeding preferences of mullets: flathead grey mullet, golden grey mullet and so-iuy mullet in early ontogeny. It is established that the choice of forage organisms of mullet larvae is determined by their morpho-physiological features and properties of forage

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objects. The paper defines the availability of forage organisms and the selectivity of food objects by larvae of different mullet species. When switching to external feeding, the availability of the feed organism for the larva is primarily determined by its size. The larvae of *Mugil cephalus* need the smallest forage organisms (50 μm). The larvae of *Liza aurata* have access to forage organisms in size of 60 μm, and the larvae of *Liza hematocheilus* – of more than 70 μm. Early larvae prefer trophophores of molluska and nauplii copepoda. The selectivity of the rotifers is negative at all stages of rearing. *L. hematocheilus* is characterized by the most nutritional flexibility. The feeding range of the larvae of this species is from 6 to 25 days and includes up to 27 food objects. The larvae of the Black Sea mullets of the flathead grey mullet and golden grey mullet are less flexible. Their diet includes from 20 to 22 food objects. In addition to animal organisms, microalgae occupy a prominent place in nutrition even in the early stages of development. After metamorphosis, the juvenile fish is reared at natural forage base and fed with artificial feeds with high-protein content (35–50%). It follows from the features of their biology. As larvae grow, the concentration of forage organisms may decrease, and their size increases. The increase in the concentration of forage organisms does not provide an increase in the diet but causes irrational consumption of feed, thus, it makes no sense.

1. Introduction

Today, the world aquaculture quite successfully reproduces about 30 species of marine fish artificially, and many of them are promising objects of domestic mariculture.

Methods of collecting brood fishes, forming of brood stocks, keeping and stimulating maturation of brood fishes as well as obtaining and incubating of eggs of many species of fish are developed quite well, but the larval rearing does not always produce stable results. This is primarily due to the fact that at the early stages, most of them use exclusively living forage organisms, which have a high nutrition value and are complete in terms of amino acid composition. Thus, the selection and cultivation of adequate live food for larvae of marine fish in industrial-scale volumes is one of the most topical problems of modern mariculture.

The larvae of most marine fishes are very small, often inactive and require forage organisms which are accessible in size and speed of movement, and the feeding with those organisms can satisfy the energy needs of their organisms in ontogeny fully. The period of resorption of the yolk sac is usually short, and the period of allowable food deficiency passes quickly enough, and lack of the necessary forage can cause mass death of the larvae. When switching to active feeding, the larvae of marine fishes require live food organisms the sizes of which vary from 30 to 500 µm for different larvae. The volume of food objects depends not only on the size of the larvae but also on the features of the morphological structure and structure of the mouthpart and alimentary canal, the ability of the larvae to move, etc.

The smallest (starter) feed in mariculture is usually flagellar algae, larvae of molluscs (30–100 µm), rotifers (120–200 µm). At the later stages of ontogeny, it is used nauplii of *Artemia salina*, 300 to 600 µm in size, to feed the larvae.

Methods of mass cultivation of microalgae, rotifers and Artemia under artificial conditions have been developed quite well [1]. Therefore, according to the classical schemes [2], the technology of feeding with such food objects was used for larvae of righteye flounders, mullet and other marine fish after switching to external feeding.

Research has shown that the use of microalgae, artificial rotors and nauplii of Artemia as the basic starter feed do not provide a strong survival and rapid growth of marine fish larvae [3]. Therefore, along with the cultivation of live food for larvae feeding, it is used natural zooplankton which is previously filtered through special sieves. Its use often produces a much better result than the feeding of the larvae with standard forage. It is very important to change the food objects timely, corresponding to the needs of the larvae of this species at each stage of development.

Marine fishery currently pays much attention to the creation of artificial starter dry feeds balanced by the basic nutrients and appropriate for long-term storage. It would greatly simplify the technology of rearing of marine fish larvae and make it possible to avoid large losses of cultivation objects, especially at the early larval stages, due to the lack of live food required.

It is very effective to grow larvae of marine fish together with unicellular algae the presence of which in the rearing tanks contributes to the elimination of fish metabolism products, repelling of bacterial flora and maintenance of water saturation with a high level of oxygen. In addition, algae also serve as food for the small invertebrates which are fed by the larvae of marine fish.

In determining the food objects most appropriate for specific species and stages of larval rearing, ones rely on their consumption value, the convenience of cultivation, profitability of production, etc. Moreover, the food object used must have a fairly rapid growth rate, differ in high feed efficiency, give greater production at high stocking density and be resistant to various diseases, the risk of which increases at high concentration in a limited space. Besides, cultivation of the object must be technological and have low cost price.

During the initial larval period, the concentration of food organisms should be the highest. As the larvae grow, they become more mobile and consume organisms of a relatively larger size the concentration of which may be less than of the small "starter" food organisms. The issue of the minimum concentration of food organisms for early larvae which can ensure their high survival is important. This problem has not yet been resolved.

Thus, in each particular case, to ensure a high percentage of output in the mass cultivation of larvae of marine fishes, it is necessary to establish an adequate set of food organisms, their size and concentration at different stages of ontogeny. This research is devoted to the above problem.

2. Availability of food organisms for larvae in size

The most important problems in the mass cultivation of marine fish at the early stages of ontogeny are as follows: the selection of food organisms adequate in size and species composition, the determination of their optimal concentration in the process of cultivation, the required amount of daily diet. Optimization of feeding conditions of the larvae allows accelerating their growth, increasing the viability and ensuring a high level of survival.

The selection of dietary components is defined by the morpho-physiological features of the larvae and the properties of the food objects. In this regard, two basic concepts are considered: the availability of a food object and feeding selectivity – the preference of the larvae of a particular food object [4].

When investigating the peculiarities of the feeding of the larvae of mullet fish, the authors pay major attention to the study of patterns of choice of species and size of food organisms, determination of their optimal concentration, diet and feeding regime of larvae. It is used a wide range of food organisms both collected in natural conditions ("wild" zooplankton) and cultivated [5].

Under conditions of cultivation, which are close to optimal (temperature, salinity, light, hydrochemical composition of water, etc.), larvae of soil-mullet (*L. Hematocheilus*) switch to active feeding on day 3–4 after hatching, flathead grey mullet (*M. cephalus*) and golden grey mullet (*L. aurata*) – on day 4.

The period of mixed feeding depends on the temperature regime of cultivation, size, type and concentration of food organisms. Under optimal conditions, it lasts from 5 to 7 days in mullets. Shortening of the mixed feeding period negatively affects the development, growth and survival of the larvae. Species, which have not filled the fish-maw and have not started eating, die. At the moment of switching to external feeding, the availability of a feed organism for larva is primarily determined by its size. The larvae of flathead grey mullet (*M. cephalus*) need the smallest food organisms (50 µm). The larvae of golden grey mullet (*L. aurata*) have access to feed organisms of 60 µm size, and the larvae of soi-mullet (*L. hematocheilus* pilengas) – up to 70 µm and more.

As larvae grow, the average size of food organisms consumed increases.

The dependence of the average size of food organisms of the linear size of the larvae in the early stages of ontogeny is well approximated by the logarithmic equation:

$$Y = a \cdot \ln X + b \tag{1}$$

where Y – the average size of the selected feed organism, µm;

X – larva length, mm; a & b – coefficients.

To study species of marine fish, the parameters of equation (1) are calculated based on data on the peculiarities of their nutrition under conditions of artificial rearing (Table 1).

Table 1

Parameters of the equation $Y = a \cdot \ln X + b$ connecting the length of marine fish larvae and the size of the victims selected

Fish species	**a**	**b**	***R**
Soi – mullet *L. hematocheilus*	673,5	639,0	0,982
Golden grey mullet *L. aurata*	712,7	671,58	0,964
Flathead grey mullet *M. cephalus*	762,4	680,5	0,972

***R** – R-squared value

The most dynamic process takes place in soi-mullet *L. hematocheilus*, which is able to consume large planktonic crustaceans at the age of 15–16 days. Golden grey mullet *L. aurata* and flathead grey mullet *M. cephalus* are the most demanding of the size of food organisms.

It would seem that the determining factor for the selection of a particular food object of larvae should be its available size, high concentration in the rearing tanks and relatively low mobility (such that energy consumption during the capture of feed objects does not exceed the amount of energy received from it) [5].

In practice, during the cultivation of marine fishes, relatively large and motile organisms, whose concentration in the breeding storages is lower than of small and low-moving objects, predominate in the feeding of early larvae.

3. The quality characteristic of the feeding of mullet larvae

The larvae of mullet are characterized by high nutrition plasticity. When it is used zooplankton from natural reservoirs for the feeding of larvae, the range of their diet mainly depends on the set of food organisms put into the breeding trunk, and may include more than 30 different objects (Table 2).

Planktonic crustaceans are the most significant for the nutrition of the larvae (*Acartia clausi; Harpacticus littoralis; Paracalanus parvus; Calanus helgolandicus; Calanipeda aquafulcis; Podon intermedius; Cladocera; Moina micrura; Diaptomus salinus*) rotifers (Rotatoria), Harpacticoida, nauplial and copepodid stages of crustaceans, mollusc larvae, polychaete and other food objects [6].

The highest food plasticity is peculiar to soi-mullet *L. hematocheilus* (fig. 1). Up to 27 food objects are available in the food bolus of larvae of this species at the age from 6 to 25 days. Black Sea mullet larvae have less food plasticity.

In their diet, there are from 20 (in flathead grey mullet *M. cephalus*) to 22 (in golden grey mullet *L. aurata*) food objects. In addition to animal organisms, microalgae (mainly benthic diatoms) and epiphyton, which larvae eat at the bottom and walls of storage, take a prominent place in the feeding of the early larvae of mullet.

Since the switch to active nutrition, the main food of larvae of all species of mullet (flathead grey mullet *M. cephalus*, golden grey mullet *L. aurata*

Table 2

The occurrence of food objects in the nutrition of mullet larvae Mugilidae aged from 6 to 25 days

№№	Forage organisms	Flathead grey mullet *M. cephalus*	Golden grey mullet *L. aurata*	Soi-mullet *L. hematocheilus*
1	Acartia clausi	+	+	+
2	Centropages kroyeri	+	–	–
3	Harpacticus littoralis	+	+	+
4	Paracalanus parvus	+	+	+
5	Calanus helgolandicus	+	+	+
6	Calanus euxinus	+	+	–
7	Calanipeda aquafulcis	+	+	+
8	Tintinnoinea (Infusoria)	+	–	+
9	Penilia avirostris	–	+	+
10	Pleopis polyphemoides	–	–	+
11	Podon intermedius	+	+	+
12	Evadne nordmani	–	–	+
13	E. spinifera	+	+	+
14	Oithona minuta	–	+	+
15	O. simtlis	–	+	–
16	Pleopis tergestina	–	–	+
17	Cladocera	+	+	+
18	Moina micrura	+	+	+
19	Diaptomus salinus	+	+	+
20	Tisbe furcata	–	+	–
21	Harpacticoida	+	+	+
22	Rotatoria	+	+	+
23	Larva: Bivalvia	+	+	+
24	Gastropoda	–	–	+
25	Isopoda	–	–	+
26	Cumacea	–	–	+
27	Decapoda	–	–	+
28	Polychaeta	+	+	+
29	Nauplii: Copepoda	+	+	+
30	Calanoida	+	+	+
31	Cyclopoida	+	+	+
Total of food objects:		20	22	27

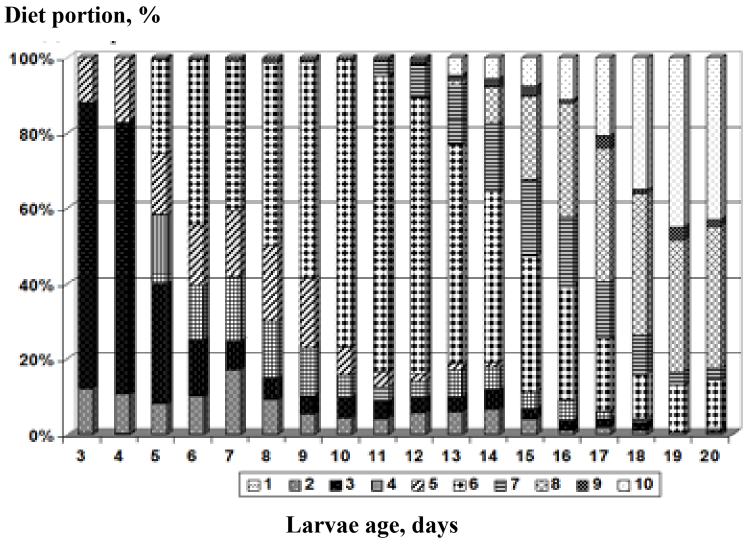


Figure 1. The spectrum of the feeding of the larvae of soi-mullet.
1 – rotifers; 2 – nauplii copepod; 3 – copepodites; 4 – infusorian; 5 – trocophores; 6 – copepods; 7 – polychaetes and decapods; 8 – artemia nauplii; 9 – other organisms; 10 – artificial feed

and soi-mullet *L. hematocheilus*) are nauplii copepods, rotifers and trochophores of molluscs.

In the diet of *L. hematocheilus*, nauplii copepods make up from 15 to 76%, and in *M. cephalus* – 45.5–51.5% (Fig. 2), and in *L. aurata* – 50.5–65.7 %. Trophophores of molluscs hold second place in terms of importance (12–17; 36–37.6 and 20.2–25.5% respectively) [8].

4. The selectivity of larvae feeding

The data obtained confirmed the priority of molluscs larvae and nauplii copepod in the feeding of early marine fish larvae (Fig. 3; Fig. 4). The larvae, which have begun to feed on, favor the larvae of the molluscs. Even if their concentration in the rearing tanks does not exceed 0.1–0.2%, their selectivity of soi-mullet *L. hematocheilus* during the first 10 days is from 0.54 to 0.99, and flathead grey mullet *M. cephalus* has from 0.50 to 0.97 up to 20–days age.

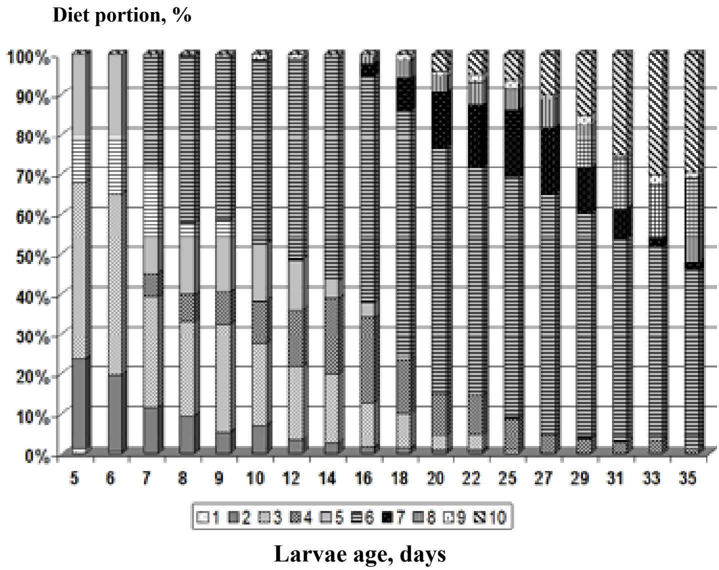


Figure 2. The spectrum of the feeding of the larvae of flathead grey mullet
1 – rotifers; 2 – nauplii copepod; 3 – copepodites; 4 – infusorian; 5 – trocophores; 6 – copepods; 7 – polychaetes and decapods; 8 – artemia nauplii; 9 – other organisms; 10 – artificial feed.

Nauplii copepods hold second place in terms of selectivity, even if their concentration in the rearing tanks is 0.2-0.4 species · cm^{-3} and lower. Moreover, the concentration of, for example, rotifers can reach 5-8 species · cm^{-3} and more.

The selectivity index of nauplii copepod by larvae of *L. hematocheilus* varies from 0.18 to 0.26 during the first 5 days since the start of feeding. Black Sea turbot has from 4 to 7 days – 0.34-0.45, and from 8 to 10 days – 0.18-0.29. At the later stages, nauplii copepods, obviously, are of secondary importance in the feeding of the larvae and the indicator of their selectivity does not exceed 0.1–0.02.

Due to a small size and low mobility, the rotifer, as forage, is available even for the weakened dwarfed larvae.

However, the low nutrition value of this object does not repay the larvae’s consumption on food production fully. It is perhaps a reason that they

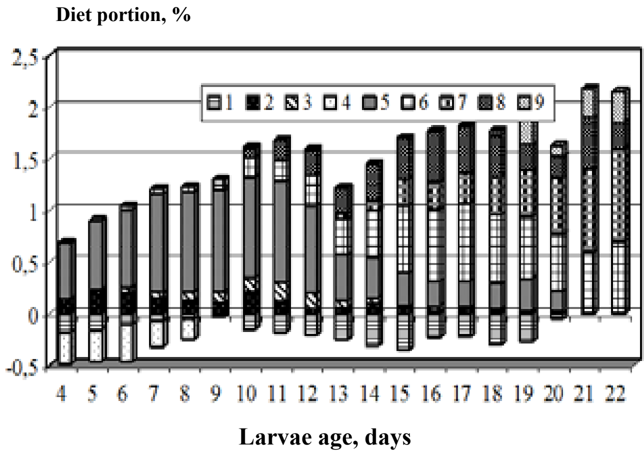


Figure 3. The selectivity of the feeding of soi-mullet larvae.
1 – rotifers; 2 – nauplii copepod; 3 – copepodites; 4 – infusorian; 5 – trocophores; 6 – copepods; 7 – artemia nauplii; 8 – polychaetes and decapods; 9 – artificial feed

prefer energy-efficient, albeit more mobile and larger objects, such as nauplii copepods or mollusk larvae.

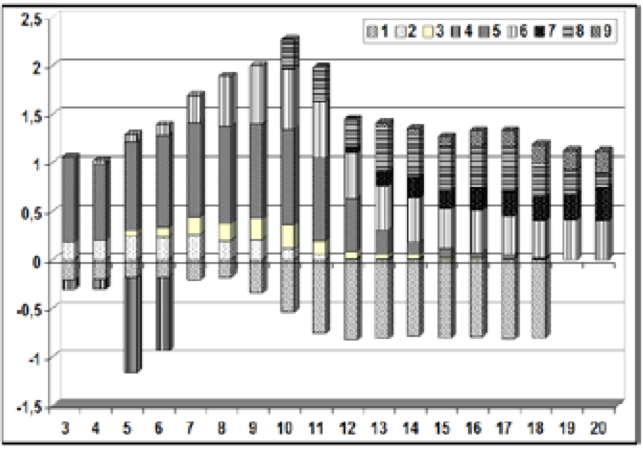
During the rearing of larvae of marine fishes, it was found that the survival of the larvae, whose diet consisted exclusively of rotifers in early ontogeny, was lower in 5–7 times in soi-mullet and in 3–5 times lower in golden grey mullet than those receiving nauplii copepods and trophophores of molluscs (Figure 5).

At 8–days age, the selectivity of adult copepods by the larvae increases. The maximum indicator of their electivity 0.60 – 0.61 is marked on the 9–10th day, that is, at the beginning of metamorphosis.

In the next 10 days, the electivity of these organisms remains high enough (E – 0.44–0.47).

The significance of polychaete larvae in feeding of the larvae of *L. hematocheilus* has been increasing since 10–11 days. Their electivity is 0.45–0.46 and remains consistently high until the beginning of the juvenileperiod. At the age of 9–10 days, the larvae can be fed with nauplii artemia and artificial feed. Consumption of naupelia artemia is limited only by the size of the larvae, and election increases as the larvae grow.

Selectivity



Larvae age, days

Figure 4. The selectivity of the feeding of the larvae of flathead grey *mullet M. cephalus*.

1 – rotifers; 2 – nauplii copepod; 3 – copepodites; 4 – infusorian; 5 – trocophores; 6 – copepods; 7 – artemia nauplii; 8 – polychaetes and decapods; 9 – artificial feed

At first, the larvae reluctantly eat artificial feed preferring living organisms. By the age of 15–17 days, their portion in the diet is 5–10%, and by the end of metamorphosis – 60% and more.

A similar pattern of nutritional benefits is also observed among the larvae of other marine fish.

When feeding mullet larvae at the early ontogeny, one of the most important problems is the selection of forage organisms adequate in the size and species composition, the determination of their optimal concentration in the rearing tanks, diet volume.

Optimization of the conditions for larvae feeding allows accelerating their growth, increasing the vitality and ensuring a high survival level. The choice of nutrients in the diet is determined by the morphophysiological features of the larvae and the properties of the food objects. In this context, two basic concepts are considered: the availability of a food object and elective feeding or the preference of the larvae to certain forage organisms.

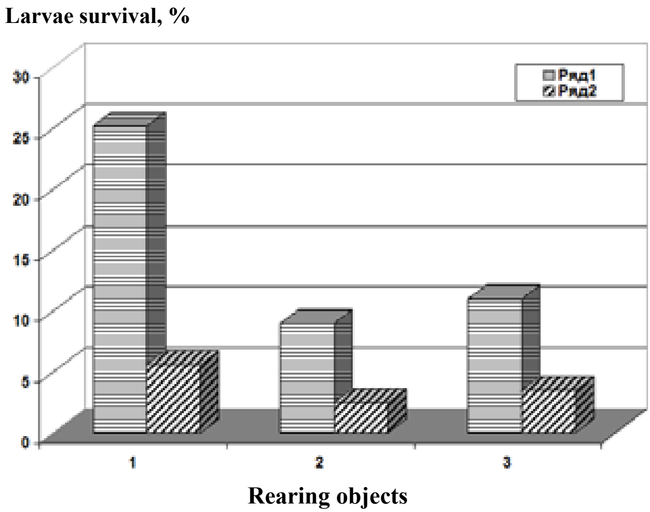


Figure 5. Survival of mullet larvae during feeding with nauplii copepods and trophophores of molluscs (1) and artificially cultivated rotifers (2) in the early xontogeny

The fodder organisms that act as the larvae's food are divided into: favorite, changeable and forced food, or, in the terms of real value: the main, minor and occasional.

The favorite means the food that the larvae prefer to any other. Changeable is a food which the larvae ignore when their favorite one is available but when it isn't they prefer changeable. Forced food is preferred when the main and changeable one is not available.

When developing the methods of mass cultivation, the emphasis is upon the choice of species and size of forage organisms, the determination of their optimal concentration, diet volume and feeding pattern of the larvae.

In the process of switching to external feeding, the availability of forage organisms is determined, first of all, by their size. The smallest food objects are essential for the larvae of flathead grey mullets *M. cephalus* (50 μm averagely).

Organisms of 60 μm in size are available for golden grey mullets *L. aurata*, and organisms to 70 μm or more in size are available for soi-mullet larvae *L. hematocheilus*. As larvae grow, the average size of food organisms consumed increased. This process most dynamically takes place among soi-mullet *L. hematocheilus* and flathead grey mullet *M. cephalus*, which can feed on organisms in size of 800 µm or more on the 10 –11th day (Figure 6).

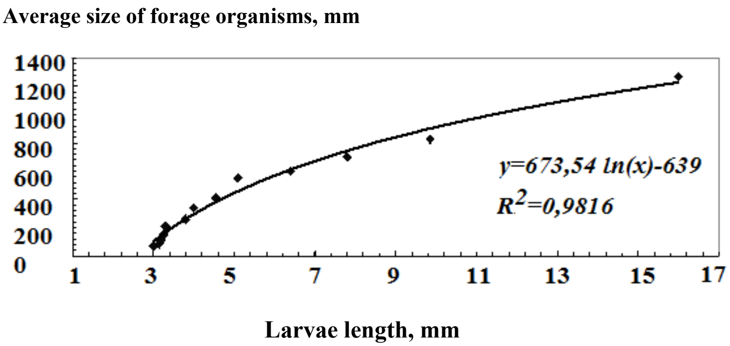


Figure 6. Dependence of average size of forage organisms on the linear size of soi-mullet larvae *L. hematocheilus*

The larvae of flathead grey mullet *M. cephalus* are able to consume forage organisms of size 500–600 µm on the 20 –25th day and golden grey mullet *L. aurata* – at the 25–30th day (Figure 7; Figure 8).

It is interesting that the larvae of all mullet species can feed on large planktonic organisms at about the same size [7].

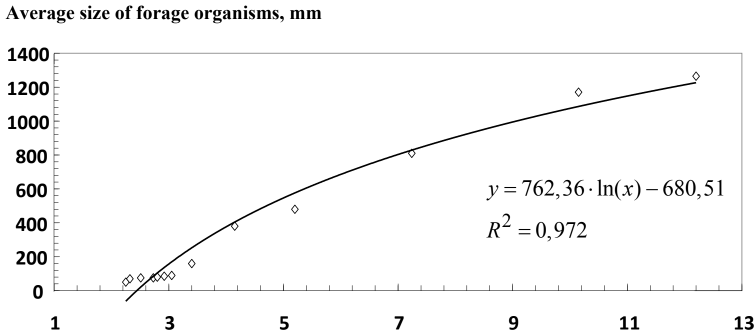


Figure 7. Dependence of average size of forage organisms on the linear size of the larvae of flathead grey *mullets M. Cephalus*

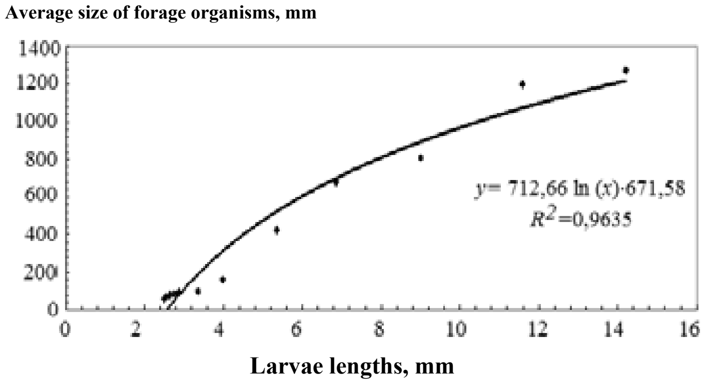


Figure 8. Dependence of average size of forage organisms on the linear size of the larvae of golden grey mullets

Despite the fact that the growth rate significantly varies among different species, there is a differentiation in time over the size of available food objects.

The dependence of the average size of the larvae and their victims is well approximated by the logarithmic equation at the early stages of ontogeny:

$$Y = a \cdot \ln L + b\,, \tag{2}$$

where Y – the average size of the selected forage organism, µm;
L – larval length, mm;
a & b – coefficients

The parameters of equation (2) for different species of marine fish were calculated on the basis of the actual data obtained by the authors (Table 3).

Table 3

Parameters of the equation $Y = a \cdot \ln L + b$, which connects the length of the larvae size of the organisms selected by them.

Species	a	b	r
Soi-mullet *L. hematocheilus*	673,5	639,0	0,982
Goldern grey mullet *L. aurata*	712,7	671,58	0,964
Flathead grey mullet *M. cephalus*	762,4	680,5	0,972

In switching to external feeding, the availability of forage organisms. Soi-mullet *L. hematocheilus* has the most dynamic process, and it is able to consume large planktonic crustaceans at the age of 15–16 days. Golden grey mullet *L. aurata* and flathead grey mullet *M. cephalus* are the most capricious to the size of the food objects of the larva.

5. The dependence of the diet volume of larvae on the density of forage organisms

In studying the patterns of feeding of larvae of marine fish during their mass rearing, the analysis of the dependence of volume of their diet on the density of the population of forage organisms takes an important place. At the same time, it is necessary to deal with both homogeneous and mixed populations.

In the first case, a common population of even-aged larvae close in size and their victims – planktonic organisms – is formed in the rearing tank. Otherwise, in the basin it is formed larvae population, which is complex, heterogeneous in size and age, small larvae consuming planktonic organisms become first-order predators, and second-order predators are large larvae which are capable of consuming small dwarfed larvae besides planktonic organisms.

The concentration of planktonic organisms 5 spec. $\cdot$ cm^{-3} creates favorable conditions for feeding for an ordinary population of early larvae of soi-mullet *L. hematocheilus* (6–7 days) at low stocking density (30 spec. $\cdot$ cm^{-3}). Under such conditions, the diet of the larvae reaches a maximum and further increase in the density of forage organisms does not lead to its growth, and therefore it does not make sense since it is not accompanied by rational feed consumption. At high density of larvae stocking (100 spec. $\cdot$ cm^{-3}), the optimal feeding conditions are ensured by the concentration of forage organisms 6–7 spec. $\cdot$ cm^{-3}.

For the population of larvae at the age of 10 days, which were fed with nauplii artemia and copepods (stocking density 80 spec. $\cdot$ cm^{-3}), the concentration of forage organisms 4 spec. $\cdot$ cm^{-3} was optimal. Similar data were obtained for flathead grey mullet. The concentration of forage organisms 7 spec. $\cdot$ cm^{-3} provided the optimal feeding conditions (maximum diet) for larvae at the age of 8 days under the stocking density for growing 60 spec. $\cdot$ cm^{-3}, and 50 spec. $\cdot$ cm^{-3} – 4–5 spec. $\cdot$ cm^{-3} was the stocking density for the juvenile larvae (15–17 days).

The dependence of the diet volume (*R*) on the concentration of forage organisms (*C*) for the 10–days larva of soi-mullet (stocking density 80 spec. · cm^{-3}, feed – nauplii artemia – 80% and planktonic crustaceans – 20%) renders the equation (3):

$$R = 0,080 \cdot \ln C + 0,29 \quad (3)$$

Under such conditions, the lowest level of cannibalism on the part of large larvae was observed in the rearing basins.

The diet volume of 6–7 days larvae of soi-mullet (stocking density is 30 spec. · cm^{-3}) were fed with "wild" zooplankton (copepods – 72–87%, rotifers – 10–22%, mollusks trochophore – 2–6%) is approximated by the equation (4):

$$R = 0,0563 \cdot \ln C + 0,147 \quad (4)$$

Under the stocking density of larvae 100 spec.•cm^{-3} and other equal conditions, the equation has the following form (5)

$$R = 0,0517 \cdot \ln C + 0,135 \quad (5)$$

Cannibalism is observed among complex populations of large larvae which are heterogeneous in size. Predominantly it concerns the larvae of soi-mullet, flathead grey mullet and golden grey mullet, which were fed with artemia, copepods and other large forage organisms (size – 1000–1500 μm and larger). The proportion of small larvae in the diet of large individuals, under the concentration of planktonic forage organisms 4–5 spec. · cm^{-3} did not exceed 5–7%.

Intensification of the concentration of forage organisms in the rearing tank up to 6–7 spec. · cm^{-3}, reduction of the density of stocking of larvae and their sorting by size reduces or completely stops cannibalism. By reducing the concentration of forage organisms in the tank up to 2–3 spec. · cm^{-3}, the part of small larvae in the feeding of juvenile individuals increases up to 7–15%.

The mullet larvae feed only during daylight hours. In the context of natural light and photoperiod, 5–8 days larvae of soi-mullet feed on dawn (from 4 a.m.) and continue to hunt throughout photoperiod (until 10–11 p.m.). They don't have expressed feeding rhythm, which is determined only by the time of digestion. Upon constant maintenance of optimal concentration of forage organisms in the rearing tanks, 9–10 days larvae have a three-peak daily rhythm of feeding. When forage organisms (zooplankton) are put into the tanks in the morning (8 –10 a.m.) and daytime (4 –6 p.m.) time, there are two peaks of the feeding intensity coinciding with foddering.

Larvae do not feed at night. In the context of 24-hour artificial daylight, they continue to feed at night but less intensively than in the daytime. Under such light conditions, the natural daily rhythm gets broken after 10–15 days. There are from 4 to 8 less expressed peaks with an increase in the feeding intensity in 1.5–2 times that affects the growth rate of the larvae.

Usually the transition of the larvae of marine fish to external feeding occurs simultaneously with the filling of the fish-maw. Sometimes, because of different circumstances, some of the larvae that fill the fish-maw don't start to feed. Starvation can last for up to 4–5 days, if larvae begin to consume forage organisms during this period they survive. Although, they significantly lag behind in growth and development, otherwise, their death is observed on the 7–10th day.

Larvae, which have switched to external feeding in time, may stop feeding in extreme conditions (rapid decrease or increase in temperature, oxygen deficiency, lack of adequate feed in the required concentration, etc.). When the conditions of cultivation are optimized, they start eating again without pronounced negative effects.

The turnover period of starvation for early (up to 10–15 days) larvae is from 5 to 7 days. In this case, up to 90–100% of soi-mullet larvae and 60–80% of the larvae of flathead grey mullet, golden grey mullet and Black Sea turbot can start feeding again when optimizing of growth environment and the availability of a sufficiently high (5–7 spec. · cm^{-3}) concentration of small forage organisms (mollusks trochophore and rotifers) in the rearing tanks. The larvae of Pleuronectes flesus luscus can survive aLonger period of reversible starvation. At the optimum temperature they can live without food up to 10–14 days and up to 14–17 days in terms of the temperature decrease (up to 12–14°C) during the cultivation.

They start to feed again in the context of the optimization of the conditions and the availability of a sufficiently high concentration of the relevant forage organisms up to 85–95% of the larvae without visible consequences.

Soi-mullet larvae can consume artificial feeds since the 10–12th day, flathead grey mullet – since the 28–30th day, and golden grey mullet – since the 37–40th day. At first, larvae take artificial feeds reluctantly preferring living organisms. But after 5–7 days, artificial feeds compose 5–10% of the diet, and 60% or more – by the end of the metamorphosis. The larvae and young marine fish require feed with a high content of animal protein. This follows from the features of its biology. The basis of the diet of young fish in natural conditions is animal food (up to 80%). Therefore, under rearing in the artificial conditions, granular feed with high protein content are preferred. In an experiment with early soi-mullet, they were fed with standard artificial feed. The maximum monthly average gain of weight 8.5–8.0 g (0.283–0.267 g · day^{-1}) was obtained using feeds РГМ-6М and КР-С containing 46–45% of protein, 8–11% of fat. The feed ratio was 2.5–3.3. The use К-III-I and ПК-IIO-I with a protein content of 24–26% and fat content of 2.5% slowed their growth. The average monthly increase in fry did not exceed 3 g (0,101 g · day^{-1}), and the feed coefficient was 7.5-8.8. РГМ-8М and Ст-4аАз (44–54% of protein and 9–15% of fat) provided an average monthly increase amounting 7.0–7.2 g (0.233-0,240 g · day^{1}) with a feed factor of 3.0–3.2. It is obvious, the last two types of feed guarantee the same good results as РГМ-6М and КР-С, but it is inexpedient to use them in the industrial cultivation of soi-mullet due to its high cost.

6. Conclusions

1. Based on the obtained nutrition characteristics of mullet larvae, the authors calculate the parameters of the equation $Y = a \cdot \ln X + b$ connecting the linear sizes of the larvae and the sizes of their victims. After switching to external feeding, the smallest forage organisms are needed by the larvae of flathead grey mullet *M. cephalus* (45–50 μm). The larvae of golden grey mullet *L. aurata* and soi-mullet *L. hematocheilus* have access to feed organisms of size 60–70 μm or more.

2. Early larvae prefer trophophores of mollusks and nauplii copepods. The selectivity of the rotary wheel at all stages of cultivation is negative.

3. As larvae grow, the concentration of forage organisms in the rearing tanks decreases, and their size increases.

4. The diet of even-aged larvae depends on the density of their stocking for the cultivation and concentration of forage organisms. It is established the concentrations of forage organisms which ensure the maximum diet and growth rate depending on the density of stocking of the larvae for cultivation. It is shown that an increase in the concentration of forage organisms does not lead to an increase in the diet, and therefore it does not make sense since it is accompanied by unreasonable consumption of feed.

5. The scheme of larvae breeding for all mullet species remains the same regardless of the reproduction object. It is changed bio-standards that are specific and vary depending on the biological and physiological characteristics of the reproductive object (larvae size, time of transition to active feeding, degree of mouth opening, etc.).

6. Technology of feeding mullet larvae (regardless of species) includes the following main stages: at the beginning of the third (fourth) day after hatching, it is put live feeds into the rearing systems – nauplii copepods, trochophores of molluscs and rotifers. The primary concentration of forage organisms should be 7–8 spec. $\cdot$ cm^{-3}. On the fourth or fifth day, about 80% of the larvae switch to active feeding. They are fast growing, active and can consume larger food objects. At the age of 7–9 days, the larvae eat adult cyclops, kalaniped, acartia and other crustaceans. On the 8–15th day of the cultivation, it is put nauplii artemia in the tank which gradually occupy a leading place in the feeding of the larvae. After the metamorphosis, the larvae begin to feed on artificial fodder like "Еквізо", Ст-4 Аз, РГМ-6 М etc. in parallel with live food. After the metamorphosis, the larvae are put up in fry ponds. Fry is reared on a natural forage base and fed with artificial feeds with high protein content (35–50%). This follows from the features of their biology.

7. Golden grey mullet is characterized by longer larval development. The transition to external feeding and filling of fish-maw with air occurs on the 5–6th day, and metamorphosis begins on the 23–25th day and ends on the 40–45th day. Accordingly, the mode of their feeding differs from that the above one in terms of the introduction of live and artificial feed.

8. When switching to external feeding, larvae of soi-mullet and golden grey mullet can feed on larger objects than the larvae of flathead grey mullet. At the age 7–8 days, they consume organisms up to 750 microns in size, and feed nauplii artemia and adult copepods at 10–11 days of age. From 20–day age, they easily react to starter artificial feeds the proportion of which is gradually increasing in the diet.

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THE CONTINGENCY OF AGROLANDSCAPES ACCORDING TO ECOLOGICAL-AGROCHEMICAL INDICES AND PERSPECTIVES OF SELECTING TRADITIONAL AGRICULTURAL CROPS IN EASTERN PODILLIA, UKRAINE

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Abstract. The paper considers spatial and temporal dynamics of mobile forms of phosphorus, nitrogen, potassium, pH, and humus content in agrocoenoses soils of Eastern Podillia. The contingency of administrative districts of Vinnytsia Region is represented according to the Sorensen-Chekanovsky coefficient based on the studied ecological-agrochemical indices of agricultural lands. The compliance of ecological-agrochemical indices of Eastern Podilian soils with the optimal parameters required for the growth of priority agricultural crops are analysed by the example of the wheat, sunflower, maize and sugar beet. A joint analysis of ecological-agrochemical soil indices shows substantial dynamics of contingency coefficients of administrative districts of Vinnytsia Region. Given the ecological valence of different agricultural crops according to the proposed set of ecological and agrochemical indices, different coefficient values are recorded that indirectly reflect the degree of area suitability for the corresponding plants cultivation. From the list of traditionally grown crops, the wheat meets the greatest degree of compliance with the proposed soil indices. Next in rank come the sunflower, maize, and sugar beet, respectively. This fact should be taken into account when planning the selection of agricultural plants in the region as a whole and in an individual administrative district in particular.

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1. Introduction

The rational use and protection of natural resources is an important factor in the socio-economic development of the country. Environmental problems arise when natural resources are inappropriately used and economic activities are carried out without the introduction of safe production technologies. The acute environmental crisis in many regions is deepening and encompassing all large territories, and may in the future turn into a general environmental and economic catastrophe [39].

As agrolandscapes make up approximately 80% of the territory of Ukraine, the issue of ensuring the sustainability of agrolandscapes in modern conditions is an urgent problem.

In the context of the sustainable development of the state, agrolandscapes must be resistant to anthropogenic load, ensure sustainable yields at an environmentally acceptable and economically sufficient level, and must stably resist degradation processes, which is achieved by natural influences and special measures to streamline agrolandscapes [40].

In the process of reforming land relations, anthropogenic influence on agroladscapes has increased considerably and the irrationality of land use has increased. The current difficult economic situation of business entities determines, in particular, the direction of land use for obtaining economic benefits in the short term. Thus, in large areas cultivate crops without taking into account the natural conditions and opportunities of specific land, which leads to depletion of soils [41].

Given the unsatisfactory quality of land in Ukraine, which tends to deteriorate, and the international community's focus on global environmental issues (desertification, biodiversity conservation, food security), land reform should embrace the internalisation of external effects of land use with particular use of land use [42].

The intensive use of agricultural land without proper environmental justification not only does not ensure the reproduction of soil fertility, but also causes significant disturbances in agroecosystems, leads to a deterioration of the quality of agricultural landscapes, and therefore their degradation [43].

Therefore, the task of ensuring the effective management of land resources should be considered within the broader process of landscape transformation (changing the structure of the land fund) and its negative consequences [42].

To date, agricultural production should follow the path of rational use of nature and be oriented to the effective maintenance of its adaptability, sustainability, resource-saving, environmental and environmental role and be based on the maximum use of agro-climatic resources, biological and ecological factors.

In this regard, agro-ecological studies, including those related to the issues of conjugacy of agro-landscapes by ecological-agrochemical parameters and prospects of selection of traditional crops, are of particular importance. The relevance of this subject is primarily determined by prospects of increasing the yield of agricultural crops through studying soil cover of agroecosystems and further selection of the crops taking into account the species tolerance. These manipulations make it possible to group agricultural lands from different areas in accordance with the total set of their studied ecological and agrochemical indices and differentiate them by their "suitability" so as to sow certain plants. Therefore, the relevance of research on this particular subject is indisputable.

The current surveys provided in different countries of the world in the field of studying ecological-agrochemical indices of soil cover, including pH [23-24; 26], nitrogen [21; 35-38], potassium [22; 29; 31-32], phosphorus [20; 28; 29; 33] and humus [25; 27; 34] are multidirectional. Many national scientists were engaged in the research of ecological and agrochemical indices, thanks to which the assessment of growing technologies [1; 6-9; 11-12], application of fertilizers [10; 13; 17; 19], forecasting of yields [11-12; 14-16; 18] and the optimal ratio of nutrients in the soil for main agricultural crops (winter wheat, sunflower, sugar beet and corn) [2-5; 10] have been made for the territory of Ukraine. However, for particular administrative districts the issues of crop selection, aimed at reducing pressure on soil and preserving nutrients, still remain poor studied. Additionally, this subject has never been considered by the example of Eastern Podillia. Though some light has been shed on the problem by now, more detailed elaboration and search for new approaches to its solution including the methods of mathematical analysis are required.

The purpose of the paper is to establish the contingency of agrolandscapes of Eastern Podillia and to determine prospects of planting the main agricultural crops (winter wheat, sunflower, maize, sugar beet) in the region on the basis of ecological and agrochemical indices (soil content of humus, nitrogen, phosphorus, potassium, and pH).

Objectives: to establish the contingency of agrolandscapes of Eastern Podillia in accordance with ecological and agrochemical indices; to identify the crops which are the most relevant to the proposed ecological and agrochemical soil parameters from the list of traditionally planted crops.

2. Material and methods

The paper is based on the original studies carried by the authors in Eastern Podillia during 2008-2012 and 2013-2017.

Prior to sampling, the objectives and the degree of required accuracy of the expected results were determined. Samples were taken during the growing season not earlier than 2 months after fertilization. Sampling points were selected so as to avoid the influence of extraneous factors. On arable lands, cluster samples were taken at a depth of 0-10 and 15-25 cm of the arable layer. The cluster sample consisted of 20 point samples. The sample weight was not less than 1 kg. From the samples taken, visible remains of vegetation and foreign impurities were removed.

The laboratory analysis of samples included a set of proper manipulations required to determine such indices as pH, mobile forms of nitrogen, phosphorus, potassium, and humus content. To calculate pH, a soil suspension was prepared in a fivefold volume of 1 mol/L potassium chloride (KCl) solution in water. Then pH of the suspension was measured using a pH-meter. The content of organic matter in soils was assessed by the oxidometric method. The nitrogen content in the soil was evaluated using the titrimetric method.

To determine the content of phosphorus and potassium compounds in the soil, an extract was prepared (the soil sample was placed in a conical flask adding 100 cm^3 of the extracting solution; then the solution was stirred and remained in the vertical position for 18-20 hours). To determine the phosphorus, a reagent was added to the soil sample in a volume of 45 cm^3 and the photometry was carried out. The determination of potassium was carried out by flame photometry.

To analyse the results basis the Sorensen-Chekanovsky coefficient was calculated, used for further design of corresponding graphic models.

3. Results and discussion

3.1. Agrolandscape ontingency by ecological and agrochemical parameters within the Eastern Podillia

The area of Eastern Podillia (Vinnytsia Region) is located within the Podillia-Dnieper Territory of the forest-steppe zone of Ukraine. A significant part of Eastern Podillia is occupied by the Podilian structural-denudation upland correspondent to the slopes of the Ukrainian crystal shield that descends south-west. Podilian Upland is heavily indented by valleys of numerous small rivers and ravines. Though it does not represent a continuous plane surface, flat areas are typical for all its watercourses.

The soil cover of Vinnytsia Region has been formed under the impact of a temperate continental climate characterized by fluctuations in the annual temperature regime within 7-9 °C, annual solar radiation at the level of 4300-4400 MJ/m2, precipitation in the range of 569-639 mm, and a humidity factor of 1.8.

The main soil-forming rocks are loess and loess-like loam, which granulometric composition varies from light loam in the north to medium loam in the centre and heavy loam in the south of the area. Their characteristic feature is low humus content and sufficiently high thickness of the humus horizon.

Vinnytsia Region is dominated by grey forest soils – 50.5% and chernozems – 42.1%. The podzolized grey and dark grey soils, podzolized chernozems are the most fertile. They contain 3.5-5.5% of humus and occupy 1.7% of Eastern Podillia.

The land resources of Vinnytsia Region consist of 2,649.2 thousand hectares, including 76.1% (2,016.5 thousand ha) of agricultural lands and 13.3% (379.1 thousand ha) of forests. The rest is occupied by developed lands (4%), open swampy areas (1.1%), open areas without vegetation cover or with insignificant vegetation cover (0.9%), and others (1.9%).

According to the results of the laboratory analysis of soil samples of the studied agrocoenoses of Eastern Podillia, the dynamics of the corresponding ecological-agrochemical indices (Table 1) was found, showing the spatial-temporal heterogeneity of values of pH, mobile forms of nitrogen, phosphorus, potassium, and humus content.

Comparison of average indices for the proposed time intervals (2008-2012 and 2013-2017), taking into account the administrative-territorial division of the Vinnytsia Region, indicates that the values of pH ($\bar{x}$ =5.6) and humus content ($\bar{x}$ =2.7%) remains at the same level, though the range of their dynamics is slightly different. Thus, in the period from 2008 to 2012, the minimum pH was equaled to 5.1, maximum – 6.2; in 2012-2017 the minimum pH was 5.0, maximum – 6.3. The minimum value of humus in 2008-2012 was 1.84%, maximum – 3.89%. Next five years (2013-2017) showed that the h—umus content varied from 1.9% to 3.75%.

The average values of mobile forms of nitrogen, potassium and phosphorus differ between the studied periods showing a clearly expressed decreasing trend in 2008-2012 (mobile forms of nitrogen $\bar{x}$ =79.0 mg/kg, phosphorus $\bar{x}$ =79.7 mg/kg, potassium $\bar{x}$ =99.5 mg/kg) and increasing in 2013-2017 (mobile forms of nitrogen $\bar{x}$ =82.0 mg/kg, phosphorus $\bar{x}$ =3.5 mg/kg, potassium $\bar{x}$ =109.9 mg/kg).

In 2012-2017 the maximum of average nitrogen values was recorded in Koziatyn District ($\bar{x}$ =111.0 mg/kg), minimum – in Zhmerynka District ($\bar{x}$ =64.0 mg/kg); the minimum values of phosphorus were found in Chernivtsi District ($\bar{x}$ =54.0 mg/kg), maximum – in Orativ District ($\bar{x}$ =110.0 mg/kg); potassium content ranged from 77.0 mg/kg (Lypovets District) to 146.0 mg/kg (Kryzhopil District).

Results of the cluster analysis according to the Sorensen-Chekanovsky quantitative coefficient allow distinguishing the districts of Eastern Podillia into 5 groups based on the average values (pH, content of mobile forms of potassium, nitrogen, phosphorus and humus), which dynamics has been monitored over 5 years from 2008 to 2012. Each of these groups includes the districts as follows:

– Bar, Sharhorod, Bershad, Illintsi, Orativ, and Teplyk;

– Haisyn, Zhmerynka, Tomashpil, Nemyriv, and Lityn;

– Vinnytsia, Kalynivka, Lypovets, Koziatyn, Khmilnyk, and Pohrebyshche;

– Kryzhopil, Trostianets, Yampil, Tyvriv, Tulchyn;

– Mohyliv-Podilskyi, Chechelnyk, Murovano-Kurylivetskyi, Pishchanka, and Chernivtsi, shown by a dendrite in Figure 1.

The cooperation of agricultural ecosystems in cluster blocks is dictated not only by agrotechnology of agricultural land cultivation, but also by their geographical location, which is represented by a map compiled according to the results of cluster division of agricultural habitats.

The dynamics of this spectrum of chemical indices shows a relative instability in time (Figure 2). It should be taken into account when developing identical approaches to the agricultural crop growing technique in regions with similar ecological-agrochemical indicators so as to differentiate them in time, taking into consideration the dynamic rate of transformation of qualitative and quantitative soil indices. Thus, the averaged monitoring results for 2013-2017, based on the above-mentioned ecological-agrochemical soil indices, demonstrate a different picture of the contingency of administrative districts of the Eastern Podillia, reflected not only in numerical changes of the Sorensen-Chekanovsky coefficient but also in different graphic principle of the relationships between the administrative-territorial units of the study area.

3.2. Prospects for the selection of traditional crops within the Eastern Podillia, taking into account their ecological tolerance to a given set of agrochemical soil parameters

Analysis of the literature data [1-5; 8; 12] with descriptions of optimal variation limits of the ecological-agrochemical indices discussed above for the traditional crops of Eastern Podillia allowed establishing that for the winter wheat the most suitable are the soil acidity limits at the level of 6.3-7.5 ($\bar{x}$ =6.9), for mobile forms of potassium – from 100 to 130 mg/kg ($\bar{x}$ =115 mg/kg), nitrogen – 85 mg/kg, phosphorus – 110-140 mg/kg ($\bar{x}$ =125 mg/kg), humus – about 4%.

When comparing the averages of the optimal limits for the winter wheat cultivation with the actual values obtained during monitoring studies of ecological-agrochemical soil indices in Eastern Podillia for 2013-2017 (Table 1), it can be noted that the values of the Sorensen-Chekanovsky coefficients vary from 78 to 93% (Figure 3). It suggests the good prospects of growing this crop in the region (taking into account the values of the studied soil indices and not taking into account other ecological-agrochemical indices and other environmental factors of the study area). The optimal ratio of the established ecological-agrochemical indices and the averages of optimal limits for the winter wheat cultivation were recorded in Teplyk (92%), Bar, Orativ and Khmilnyk districts (91% each). Lityn, Murovano-Kurylivetskyi (78% each), Chernivtsi, Mohyliv-Podilskyi (79% each) and Lypovets (80%) districts had the least coefficient value and were, correspondingly, less suitable for the winter wheat cultivation according to the ecological-agrochemical indices.

Table 1

Ecological-agrochemical soil indices of agrocoenoses in Eastern Podillia

Districts	2008-2012					2013-2017				
	Average value					Average value				
	pH_{Cl} or pH_{H2O}	P_2O_5 mg/kg	N mg/kg	K_2O mg/kg	humus, %	pH_{Cl} or pH_{H2O}	P_2O_5 mg/kg	N mg/kg	K_2O mg/kg	humus, %
Bar	5,3±0,4	87±7,2	70±6,1	104±9,2	1,92±0,1	5,3±0,4	96±8,3	69±5,6	119±9,2	1,96±0,1
Bershad	5,6±0,38	78±6,7	95±8,3	112±9,9	2,91±0,1	5,6±0,4	81±7,1	82±7,1	124±9,3	2,78±0,2
Vinnytsia	5,4±0,42	95±8,3	96±8,3	74±6,1	2,63±0,2	5,4±0,4	94±8,2	77±6,4	88±7,5	2,72±0,2
Haisyn	5,4±0,41	73±6,4	80±7,1	88±7,5	2,28±0,2	5,3±0,4	76±6,3	82±7,1	99±8,8	2,24±0,2
Zhmerynka	5,2±0,39	76±6,5	69±5,6	88±7,5	1,84±0,1	5,1±0,4	84±7,2	64±6,3	99±8,8	1,90±0,1
Illintsi	5,7±0,45	93±8,3	90±8,1	86±7,3	2,80±0,2	5,6±0,4	88±7,3	76±6,5	85±7,4	2,81±0,2
Kalynivka	5,8±0,48	98±8,7	99±8,4	75±6,3	3,50±0,3	5,9±0,5	100±9,8	98±8,5	83±7,2	3,52±0,3
Koziatyn	6,2±0,51	100±9	92±8,1	70±6,1	3,78±0,3	6,2±0,5	109±9,9	111±9,9	78±6,5	3,78±0,3
Kryzhopil	5,8±0,48	76±6,5	65±5,4	132±10,3	2,70±0,2	5,8±0,4	84±7,2	92±8,1	146±10,2	2,66±0,2
Lypovets	6,0±0,5	95±8,7	105±9,3	78±6,3	3,89±0,3	6,0±0,5	85±7,3	93±8,2	77±6,4	3,85±0,3
Lityn	5,5±0,41	78±6,5	71±6,1	73±6,2	2,06±0,2	5,4±0,4	76±6,3	70±6,1	79±6,7	2,02±0,1
Mohyliv-Podilskyi	5,5±0,44	65±5,2	79±6,5	127±10,2	2,57±0,2	5,5±0,4	55±4,2	75±6,3	130±10,2	2,58±0,2
Murovano-Kurylivetskyi	5,3±0,41	62±5,1	74±6,2	127±10,2	1,89±0,1	5,3±0,4	59±4,6	65±5,4	140±10,3	2,00±0,1
Nemyriv	5,3±0,41	71±6,0	69±5,8	96±8,3	2,26±0,2	5,3±0,4	74±6,2	78±6,5	101±9,1	2,18±0,1
Orativ	5,7±0,45	86±7,3	77±6,3	89±7,5	3,29±0,3	5,8±0,5	110±9,9	91±8,1	96±8,4	3,28±0,2
Pishchanka	6,0±0,51	62±5,1	73±6,2	124±10,2	2,86±0,2	5,9±0,5	69±5.6	83±7,2	136±10,3	2,88±0,2
Pohrebyshche	5,8±0,47	88±7,4	92±8,1	69±5,4	2,98±0,3	5,7±0,4	96±8,2	83±7,2	79±6,6	3,10±0,2
Teplyk	5,6±0,43	85±7,3	78±6,6	96±8,3	2,80±0,2	5,5±0,4	96±8,2	91±8,1	117±9,3	2,80±0,2
Tyvriv	5,1±0,4	73±6,1	60±5,1	111±10,1	2,16±0,2	5,0±0,4	83±7,1	71±6,1	116±9,3	2,12±0,1
Tomashpil	5,7±0,45	76±6,3	74±6,2	93±8,1	2,00±0,1	5,6±0,4	81±7,1	82±7,1	105±9,1	1,90±0,1
Trostianets	5,3±0,41	78±6,4	69±5,8	113±10,1	2,52±0,2	5,3±0,4	86±7,3	78±6,5	135±10,2	2,63±0,2
Tulchyn	5,3±0,41	67±5,3	68±5,7	109±10,0	2,38±0,2	5,2±0,4	77±6,4	76±6,4	131±10,2	2,40±0,1
Khmilnyk	6,2±0,5	100±9	93±8,1	78±6,3	3,74±0,3	6,3±0,5	108±9,2	102±9,1	93±8,2	3,76±0,3
Chernivtsi	5,6±0,46	61±5,0	77±6,4	119±10,1	2,74±0,3	5,5±0,4	54±5,2	76±6,4	132±10,2	2,84±0,2
Chechelnyk	5,9±0,47	69±5,4	74±6,2	127±10,2	3,14±0,3	5,8±0,5	65±5,3	84±7,3	132±10,2	3,00±0,2
Sharhorod	5,6±0,45	85±7,2	82±7,1	109±10,1	2,05±0,1	5,4±0,4	81±7,1	65±5,3	117±9,6	2,10±0,1
Yampil	6,2±0,51	77±6,3	68±5,4	120±10,2	3,10±0,2	6,2±0,5	87±7,4	88±7,5	131±10,2	3,20±0,2

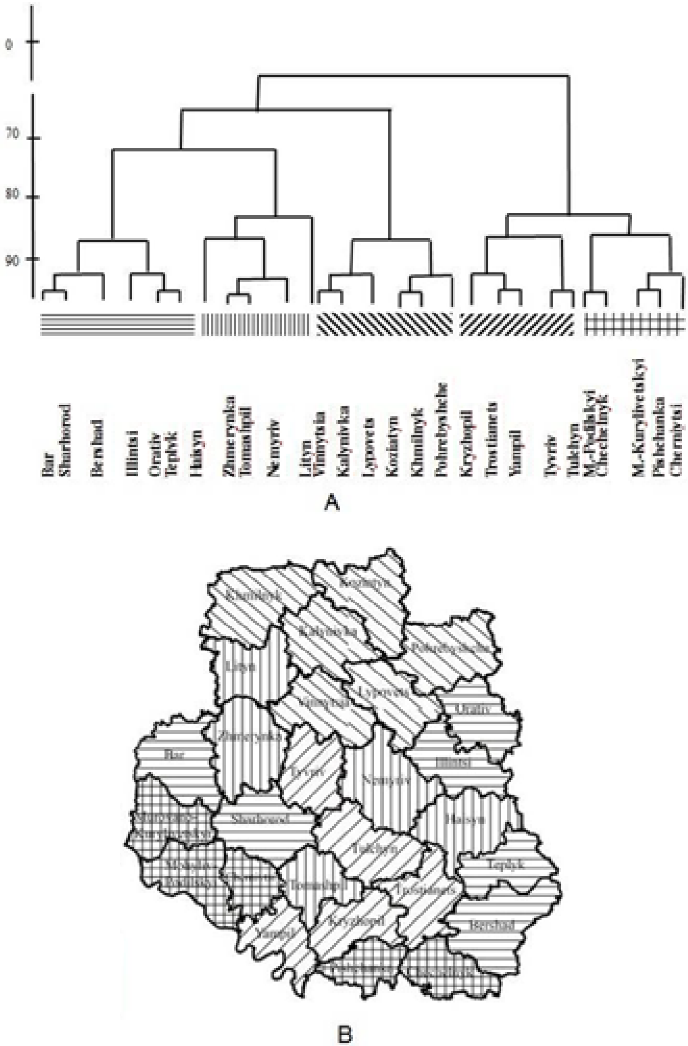

Figure 1. Graphic (A) and cartographic (B) models of contingency of administrative districts of Vinnytsia Region according to the Sorensen-Chekanovsky coefficient based on the studied ecological-agrochemical soil indices of agrocoenoses (2008-2012)

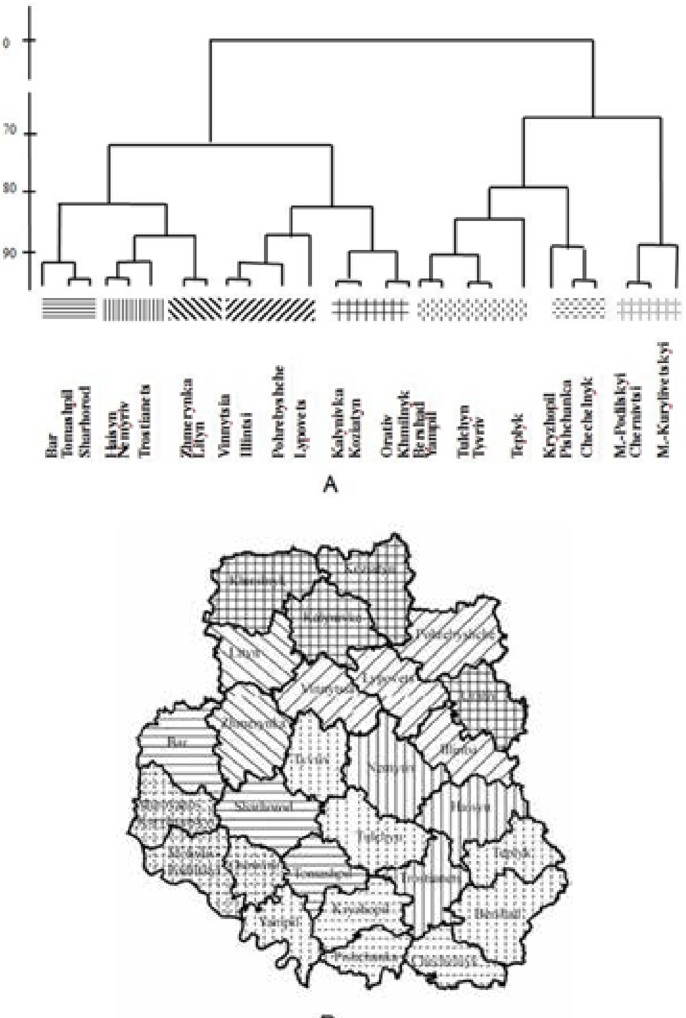

Figure 2. Graphic (A) and cartographic (B) models of contingency of administrative districts of Vinnytsia Region according to the Sorensen-Chekanovsky coefficient based on the studied ecological-agrochemical soil indices of agrocoenoses (2013-2017)

For the sunflower, soil acidity at the level of 6-6.8 ($\bar{x}$=6.4) are the most suitable, the content of mobile forms of potassium – from 120 to 140 mg/kg ($\bar{x}$=130 mg/kg), phosphorus – 100-110 mg/kg ($\bar{x}$=105 mg/kg), humus content should be at the level of 3.5% [14-15].

Two of the 27 administrative districts of Vinnitsia Region mentioned in the list showed the highest degree of similarity of ecological-agrochemical indices of the sunflower vegetation. These are Yampil and Bar districts for which the Sorensen-Chekanovsky quantitative coefficients make up 95%. Close to these values are Trostianets, Teplyk (94% each), Bershad, Tulchyn (93% each), Kryzhopil (92%), Orativ, Sharhorod, Khmilnyk, Tyvriv (91%), Chechelnyk, Pishchanka (90% each) districts, with percentages varying from 90 to 95%. The range from 85 to 90% is recorded for Mohyliv-Podilskyi, Tomashpil (88% each), Murovano-Kurylivetskyi, Koziatyn, Kalynivka, Zhmerynka, Vinnytsia, Chernivtsi (87% each), Nemyriv, Illintsi, Haisyn, Pohrebyshche (85% each) districts. The less optimal set of the studied ecological-agrochemical indices for the sunflower is found in Lypovets (82%) and Lityn (79%) districts (Figure 3).

For the maize, according to the literature data, the variation range of the pH, content of mobile forms of potassium, phosphorus and humus should be kept within 6.0-7.0 ($\bar{x}$=6.5), 130-150 mg/kg ($\bar{x}$=140 mg/kg), 140-150 mg/kg ($\bar{x}$=145 mg/kg), 3-4% ($\bar{x}$=3.5%), respectively [9-11; 13]. Moreover, any changes in the thresholds of the given set of indices inevitably lead to changes in the Sorensen-Chekanovsky coefficients, which, in this case, have the lower limit of 71% and the upper limit of 87% (Figure 3).

The sugar beet requires soil acidity within 7.0-7.5 ($\bar{x}$=7.3), the content of mobile forms of potassium – 160-180 mg/kg ($\bar{x}$=170 mg/kg), phosphorus – 160-180 mg/kg ($\bar{x}$=170 mg/kg) and humus – 3.5% [16-19].

In accordance with the performed calculations, the threshold values of the indices are set at the level of 63-80%. The values in Lityn, Lypovets, Illintsi, Haisyn, Pohrebyshche, Nemyriv, Zhmerynka and Kalynivka districts range between 63-70%; Mohyliv-Podilskyi, Koziatyn, Chernivtsi, Tomashpil, Sharhorod, Chechelnyk, Murovano-Kurylivetskyi, Tyvriv, Bershad, Khmelnyk, Pishchanka, Tulchin, Orativ, Bar, Teplyk, Vinnitsia, Yampil, Trostianets and Kryzhopil shows the coefficient value from 71 to 80% (Figure 3).

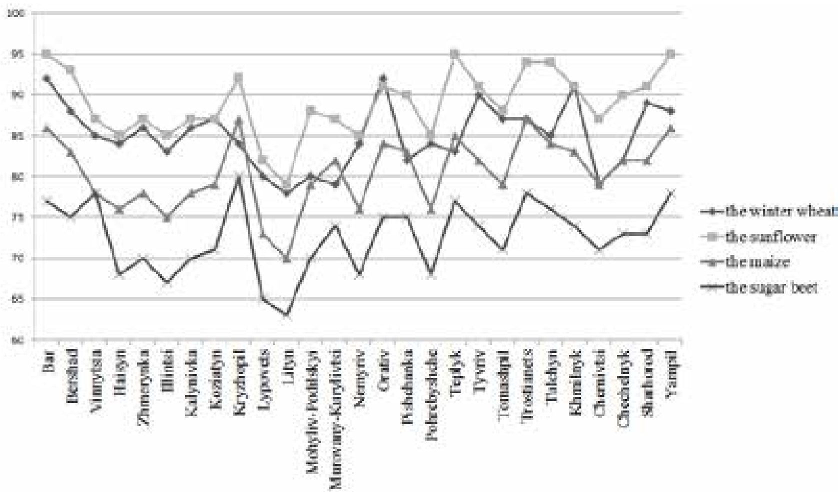

Figure 3. Compatibility of ecological-agrochemical soil indices of Eastern Podillia with the optimal indices required for the winter wheat, the sunflower, the maize, the sugar cultivation (2013-2017)

4. Conclusions

The dynamics of pH, mobile forms of nitrogen, phosphorus and potassium, as well as humus content in the soils of agrocoenoses of Eastern Podillia is determined by spatial and temporal coordinates. A joint analysis of the ecological-agrochemical soil indices shows a significant dynamics of the coefficients of contingency of administrative districts of Vinnytsia region.

Given the ecological valence of different agricultural crops according to the proposed set of ecological-agrochemical indices, the different coefficient values are recorded that indirectly reflects the degree of area suitability for the corresponding crops cultivation. Thus, from the list of traditionally grown crops, the wheat is identified as the most compatible with the proposed ecological-agrochemical soil indices. Next in rank come the sunflower, maize and sugar beet, respectively. This fact that should be taken into account when planning the agricultural plant selection in the region as a whole and in an individual administrative district in particular.

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CHAPTER «GEOGRAPHICAL SCIENCES»

THE LANDSCAPE-LYMNOLOGICAL ANALYSIS OF THE KEY LAND «OSTRIVSKY LAKES» (NOBEL NATIONAL PARK, UKRAINE)

ЛАНДШАФТНО-ЛІМНОЛОГІЧНИЙ АНАЛІЗ КЛЮЧОВОЇ ДІЛЯНКИ «ОСТРІВСЬКІ ОЗЕРА» (НОБЕЛЬСЬКИЙ НАЦІОНАЛЬНИЙ ПРИРОДНИЙ ПАРК, УКРАЇНА)

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Abstract. With the creation in 2019 of the Nobel National Natural Park (Nobel National Park), located within Volyn Polessia (Ukraine), landscape-geographical and limnological studies have been intensified. Such studies are aimed at studying geo-components (geological-geomorphological structure, hydrological and climatic conditions, soils, flora and fauna) of landscapes and natural-territorial and aquatic complexes in general with the purpose of development of conservation and recreational zoning of this protected area. Due to the large area (25318.81 hectares) of the territory of the national park studies are conducted within the key (test) sites or model catchments. *The purpose* of the study was to reveal the landscape-geographical features of the key area (KA) of «Ostrivsky Lakes» (Nobel NNP) and to perform limnological and geo-ecological assessment of the lake-basin systems for the needs of optimization of nature conservation and recreational use. *The subject* of the study is the structure and features of different rank geocomplexes (natural-territorial and lake-basin), its geo-ecological status

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and issues of optimization of nature management. The researches are based on field expeditionary and semi-stationary landscape-limnological searches, which we have conducted at «Ostrivsky Lakes» KA in different seasons since 2011. The concepts of the natural system «lake-catchment», basin nature management, landscape-limnological analysis of lake-basin systems and nature protection of landscape science have been used as *the methodological bases* of the researches. In the course of the research *the methods* of complex physical-geographical researches, landscape GIS-mapping, soil-geochemical profiling, limnological assessment and analysis of natural-aqual complexes of lakes have been used. According to the *results of the researches*, a landscape map of «Ostrivsky Lakes» KA has been created with the allocation of local geocomplexes of rank of the tract, and the bathymetric model of Velyke lake has been developed on the basis of hydrological profiling and morphometric and hydrological parameters of the group of lakes have been calculated, the geochemical features of the lake sediments of Velyke lake have been analyzed, the hydrochemical evaluation of lakes has been made, the digital map of the natural-aquatic complex of Velyke lake has been constructed and its landscapemetric evaluation has been worked out, the cartographic models of the spatial and typological structure of the watersheds of lakes have been created, and geo-ecological assessment of the economic development of their basins and zoning of the 100-meter water protection zone of lakes by the degree of anthropogenic loading has been made. *Conclusions of the study***.** The geocomplexes of small river valleys on modern wetlands and alluvial deposits receive considerable anthropogenic modifications as a result of drainage reclamation. Further development of agrarian nature management in the lake basin system of Ostrivske lake should be aimed at organic farming, with a ban on plowing a 50-meter zone around the lake. The geo-ecological state of the catchment area of Velyke lake has been evaluated by us as a benchmark in terms of economic development. There is a need to initiate hydro-environmental monitoring of lakes in order to develop conservation and recreational management measures.

1. Вступ

Відповідно до указу Президента України від 11.04.2019 р. № 131/2019 [24] на території Волинського Полісся був створений Нобельський національний природний парк (НПП). В адміністративному відношенні територія парку розташована у Зарічненському районі Рівненської області. До новоствореної природоохоронної території увійшли частина територій регіонального ландшафтного парку «Прип'ять-Стохід», гідрологічного заказника «Острівський», іхтіологічного заказника «Прип'ятський» та низка інших заказників і пам'яток природи місцевого значення. Передбачено, що загальна площа Нобельського НПП становитиме 25318,81 га.

Важливе місце у ландшафтній структурі Нобельського НПП посідають унікальні водно-болотні геокомплекси, які у 2009 р. увійшли до складу транскордонної Рамсарської території «Прип'ять-Стохід-Простир» [23]. Територія парку в геоморфологічному відношенні приурочена до Верхньоприп'ятської акумулятивної рівнини з острівним поширенням у її межах водно-льодовикових плоско-хвилястих геокомплексів, які ускладнені моренними грядами, піщаними валами та дюнами різної конфігурації та форм.

У рослинному покриві парку переважають лучно-болотні угруповання. Серед лісів тут переважають мішані дубово-соснові, менші площі посідають листяні ліси – вільхові та дубові, а також соснові ліси. Флористичне ядро цих лісів, крім домінуючих видів, складають типові для Полісся види, зокрема брусниця, щитник шартрський та інші. На підвищених ділянках та надзаплавних терасах зростають соснові ліси, іноді у комплексі з дубово-сосновими та дубовими лісостанами. Часто трапляються чорновільшняки з великим розмаїттям болотних і трав'янистих видів. За попередніми даними, тут зростає 500-550 видів рослин, у тому числі й такі, що занесені до Червоної книги України (зозулині черевички звичайні, росичка середня, баранець звичайний, щитолисник звичайний, плаун колючий, вовчі ягоди пахучі, горіх водяний плаваючий та інші). Трапляються регіонально рідкісні види: авран лікарський, водяна сосонка звичайна, юринея волошкоподібна, жовтозілля болотяне та деякі інші [22].

Ландшафти Нобельського НПП відзначається розгалуженою гідрографічною мережею. Найголовнішими водними об'єктами парку є річки Прип'ять, Стохід, Веселуха Млинок, а також низка озер (Нобель, Сосно, Ніговище, Омит, Засвітське, Задовже, група Острівських озер). Територія парку досить відома в атракційно-туристичному плані. Поруч з мальовничими озерами тут проходить найдовша у Європі вузькоколійна залізниця «Антонівка-Зарічне», відома для туристів як «Поліський трамвай».

Тривалий час на згаданій території нами ведуться ландшафтно-лімнологічні та конструктивно-географічні дослідження [8; 14; 18; 20], головним завданням яких є створення електронних геоекологічних паспортів басейнових систем «озеро-водозбір». Такі паспорти необхідні для кадастрової інвентаризації поверхневих вод, ландшафтного планування та зонування локальних територій і об’єктів національного парку, а також для започаткування моніторингових спостережень водойм.

2. Мета та завдання дослідження

Мета дослідження – розкрити ландшафтно-географічні особливості ключової ділянки «Острівські озера» (Нобельський НПП) та здійснити лімнолого-геоекологічну оцінку озерно-басейнових систем для потреб оптимізації заповідно-рекреаційного природокористування.

Головними завданнями дослідження були такі:

– обґрунтування ландшафтної структури ключової ділянки (КД) «Острівські озера»;

– гідрологічне профілювання озер та створення батиметричних моделей водойм;

– оцінка морфометричних та гідрологічних параметрів озер;

– геологічне зондування донних відкладів озер та їхня геохімічна характеристика;

– гідрохімічна оцінка водних мас озер й визначення видового складу рослинних угруповань водойм;

– побудова цифрової ландшафтної карти модельного природно-аквального комплексу оз. Велике;

– геоекологічна оцінка господарського освоєння водозборів й зонування 100-метрової водоохоронної зони озер за ступенем антропогенного навантаження;

– розробка пропозицій щодо оптимізації заповідно-рекреаційного природокористування на КД «Острівські озера».

3. Методологія та методика дослідження

Дослідження ґрунтуються на польових експедиційних та напівстаціонарних ландшафтно-лімнологічних пошуках [6; 11; 17], які проводяться нами на КД «Острівські озера» у різні сезони року починаючи з 2011 р. Методологічними засадами досліджень послужили концепції природної системи «озеро-водозбір» [4], басейнового природокористування [10], ландшафтно-лімнологічного аналізу озерно-басейнових систем [9; 16] та природоохоронного ландшафтознавства [3; 19]. У процесі дослідження використовувалися методи комплексних фізико-географічних досліджень [1], ландшафтного ГІС-картографування [25] та геоекологічної оцінки стану угідь локальних територій [21], ґрунтово-геохімічного профілювання [12], лімнологічного оцінювання та аналізу природно-аквальних комплексів озер [7; 13].

Частково у роботі були використані фондові матеріали з пошуків озерного сапропелю Київської геолого-розвідувальної експедиції (Київської ГРЕ). Лабораторні аналізи зразків ґрунтів були виконані у лабораторії Рівненської філії державної установи «Інститут охорони ґрунтів України», а гідрохімічна оцінка проб води з озер здійснювалася у лабораторії Рівненської санітарно-епідеміологічної станції. Згадані лабораторії мають ліцензію на проведення такого типу досліджень та сертифіковані у відповідності до екологічного законодавства України.

4. Результати дослідження та їх обговорення

4.1. Локалізації КД «Острівські озера»

КД «Острівські озера» розташована у межиріччі Веселухи і Ножика й знаходиться у Нижньостирському фізико-географічному районі східної частини Волинського Полісся (рис. 1).

З тектонічної точки зору досліджувана територія цікава тим, що тут проходить Стохідсько-Могильовська тектонічна зона [5], а з гідролого-геоморфологічної – унікальна розміщенням чотирьох живописних озер, зокрема Острівське, Велике, Середнє й Хоромне, рис. 2.

З метою збереження заболоченої ділянки сосново-вільхово-березового лісу, що має водорегулююче значення для згаданих озер у 1984 р. був створений гідрологічний заказник загальнодержавного значення «Острівський» загальною площею 2381 га. Головними землекористувачами заказника є Острівське лісництво (кв. 14-29), Локницьке лісництво (кв. 58-61) ДП «Зарічненський лісгосп» та ДП СЛАП «Зарічненський держспецлісгосп».

Рис. 1. Місце ключової ділянки «Острівські озера» на схемі фізико-географічного районування Волинського Полісся

Умовні позначення:

Східноєвропейська (Руська) рівнина.

Зона мішаних (хвойно-широколистяних) лісів.

Поліський край (провінція).

Область Волинського Полісся.

<u>Підобласть Верхньоприп’ятського Полісся.</u> Фізико-географічні райони: 1. Шацький. 2. Верхньоприп’ятський. 3. Любомльсько-Ковельський. 4. Нижньостирський.

<u>Підобласть Буго-Горинського Полісся.</u> Фізико-географічні райони: 5. Маневицько-Володимирецький. 6. Льва-Горинський. 7. Колківсько-Сарненський. 8. Турійсько-Рожищенський. 9. Ківерцівсько-Цуманський. 10. Костопільсько-Березнівський.

Кордони (межі): а) державна, б) фізико-географічних районів, в) фізико-географічних зон, г) фізико-географічних областей.

Найбільші площі у заказнику займають змішані заболочені ліси. У реліктових долинах стоку переважають мезотрофні і еумезотрофні болотні ценози, серед яких трапляються такі рідкісні види, як осоки багнова та тонкокориневищна, верба лапландська, їжача голівка мала, три види пухирників (великий, середній і малий). Серед видів, що занесені до Червоної книги України тут зустрічається плаун річний, любка дволиста, росичка середня [22].

б) Модельна ділянка на фрагменті топографічної карти м-бу 1:100 000	в) Модельна ділянка на фрагменті космознімку (за даними *Google maps*)

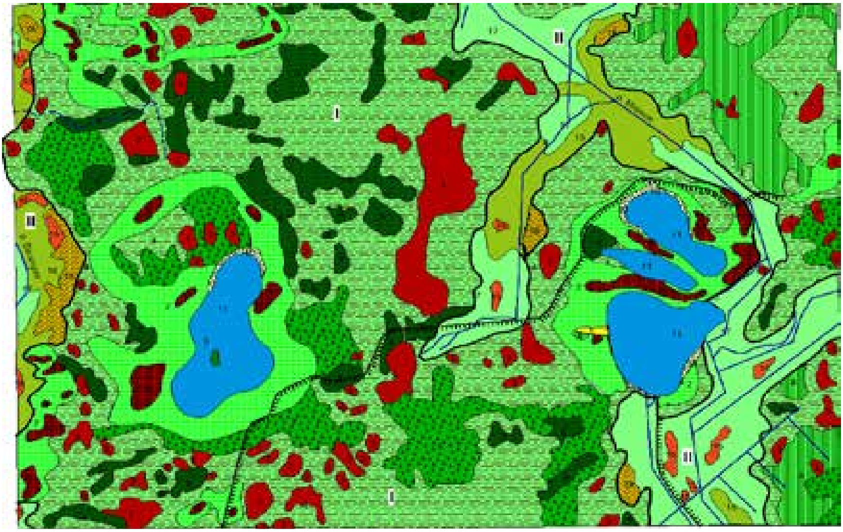
Рис. 2. Територіальна локалізація ключової ділянки «Острівські озера»

4.2. Обґрунтування ландшафтних особливостей КД «Острівські озера»

За результатами польових ландшафтно-лімнологічних досліджень нами виявлено дві місцевості (рис. 3): 1) міжрічкових заболочених рівнин на флювіогляціальних та давніх алювіальних відкладах; 2) долин малих річок на сучасних болотних та алювіальних відкладах.

I. Місцевості міжрічкових заболочених рівнин на флювіогляціальних та давніх алювіальних відкладах.

Урочища: **1.** Горби та дюни зі слабо спадистими (6-10°) схилами, вкриті лишайниково-чагарничковими сосновими лісами на прихованопідзолистих, іноді щебенюватих, піщаних ґрунтах, частково розорані та забудовані. **2.** Підвищені ділянки межиріч, ускладнені карстовими лійками, вкриті лишайниково-чорничниково-зеленомоховими сосновими та березово-сосновими лісами на слабопідзолистих, іноді глеюватих, піщаних ґрунтах, частково розорані та забудовані. **3.** Локальні підняття, з пологими (<3°) схилами, вкриті орляково-чорничниковими, березово-сосновими та дубово-березово-сосновими лісами на дерново-підзолистих глеюватих піщаних ґрунтах, іноді розорані. **4.** Хвилясті ділянки межиріч, вкриті орляково-чорничниково-зеленомоховими та різнотравно-зеленомоховими дубово-сосновими



(зменшено з м-бу 1 : 25000)

Рис. 3. Ландшафтна структура ключової ділянки
“Острівські озера” [17]

Легенда

та березово-дубово-сосновими лісами на дерново-слабопідзолистих глеюватих піщаних і супіщаних ґрунтах, іноді меліоровані та розорані. **5.** Яри та балки з крутими (20-30°) бортами, зрідка вкриті осоково-злаковим вільховим та ожиновим дрібноліссям на слабопідзолистих розмитих глеюватих ґрунтах. **6.** Локальні замкнуті купинчасті пониження, вкриті різнотравно-злаково-зеленомоховим та осоково-ситниково-зеленомоховим вільхово-березово-сосновим рідколіссям на дернових глеюватих та глейових піщаних та супіщаних ґрунтах. **7.** Обширні заболочені купинчасті пониження, вкриті війничково-пухівково-сфагновим, чагарничково-різнотравно-зеленомоховим та осоково-сфагновим вільховим та березово-вільховим рідколіссям на лучно-болотних та болотних малопотужних ґрунтах. **8.** Обширні заболочені пониження, вкриті ситниково-осоково-сфагновими та чагарничково-різнотравно-зеленомоховими угрупованнями на болотних мало- та середньопотужних ґрунтах, частково меліоровані.

9. Озерні острови із опуклими вершинами, вкриті крушиново-чорничниково-зеленомоховими дубово-сосновими лісами на дерново-підзолистих глеюватих та дернових глейових піщаних і супіщаних ґрунтах. **10.** Приозерні вузькі пониження, що в паводки заливаються водою, вкриті рогозово-осоково-різнотравним та чагарничково-осоково-очеретяним вільховим та вербовим дрібноліссям на лучних шаруватих глейових піщаних і супіщаних ґрунтах. **11.** Озерні улоговини неправильної форми, у літоральній зоні вкриті рогозово-очеретяними та ситниково-лататтєвими угрупованнями, а у субліторальній та профундальній зонах – поодинокими плаваючими водоростями на відкладах сапропелю. **12.** Русла природних невеликих водотоків. **13.** Дамби та насипи. **14.** Меліоративні канали.

ІІ. Місцевості долин малих річок на сучасних болотних та алювіальних відкладах.

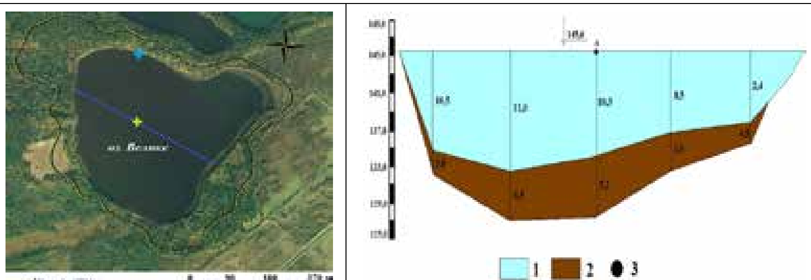
Урочища: **15.** Підвищені останці з пологими (3-6°) схилами, вкриті осоково-злаково-різнотравними луками на дернових неглибоких глеюватих ґрунтах. **16.** Вирівняні ділянки заплави, вкриті багатими злаково-осоково-різнотравними та різнотравно-злаковими луками на дернових глеюватих та глейових, місцями лучно-болотних ґрунтах, частково меліоровані. **17**. Вирівняні купинчасті ділянки заплави, вкриті ситниково-різнотравно-злаковими та осоково-різнотравно-зеленомоховими розрідженими березово-вільховими, зрідка вербовими, лісами на лучно-болотних та болотних малопотужних ґрунтах, місцями меліоровані та сплановані. **18.** Притерасні заболочені пониження, вкриті пухівково-ситниковими та чагарничково-різнотравно-зеленомоховими угрупованнями на болотних малопотужних і потужних ґрунтах, місцями меліоровані (осушені). **19.** Штучні дамби та насипи. **20.** Меліоративні канали та спрямлені русла малих річок.

Перша ландшафтна місцевість посідає відносно вищий гіпсометричний рівень, де нами виокремлено 14 геокомплексів рангу урочище, з них три аквальні (озер, русел малих водотоків, меліоративних каналів) комплекси. Місцевість долин малих річок посідає найнижчий геоморфологічний рівень. Вона є відносно молодою за віком формування й найбільше зазнає природних та антропогенних трансформацій. Тут виділено шість геокомплексів рангу урочище.

4.3. Гідрологічна оцінка озер КД «Острівські озера»

У зимовий період нами проводилося гідрологічне профілювання озер з допомогою ехолота Lycky FFW718 (безпровідний) та зондування потужності і складу донних відкладів водойм, а в літній період (за винятком оз. Острівське) відбиралися проби води на гідрохімічні показники. Зразок пунктів відбору проб води та гідрологічного профілю оз. Велике наведено на рис. 4.

За результатами польових гідрологічних вимірювань на оз. Велике нами побудовано батиметричну модель (рис. 5).



а) Лінія поперечника гідрологічного профілювання озера; жовта зірка – пункт відбору донних відкладів на геохімічні показники, синя зірка – пункт відбору води на гідрохімічні показники.	б) Співвідношення водної товщі та потужності відкладів сапропелю озера; *Умовні позначення*: 1 – вода та абсолютна відмітка над рівнем моря озера, 2 – сапропелеві відклади, 3 – пункт відбору проб (**А**) на геохімічні показники.

Рис. 4. Модельне оз. Велике з пунктами відбору проб води, донних відкладів та схемою гідрологічного профілю

Результати ехолотування на оз. Велике показали доволі круті схили озерної улоговини. Нами виявлено дві карстові заглибини у південно-західній частині озера та центральну глибоководну зону озера з глибинами понад 8,0 м, яка займає 50,0% площі водойми. Пояс вищої водної рослинності найбільше опоясує східну мілководну (до 1,0-1,5 м) частину озера, де в окремих місцях спостерігається заболочування.

Серед групи Острівських озер найбільшу площу має оз. Острівське (1,08 км^2), а найменшу – оз. Середнє (0,19 км^2). Найглибшим серед досліджуваних озер є оз. Велике (11,0 м). Середні глибини озер знаходяться у діапазоні 2,4-6,18 м. Озера живляться в основному атмосферними опадами, а також, ймовірно, водами із верхньокрейдового горизонту. Озеро Острівське є найбільшим за об’ємом водних мас

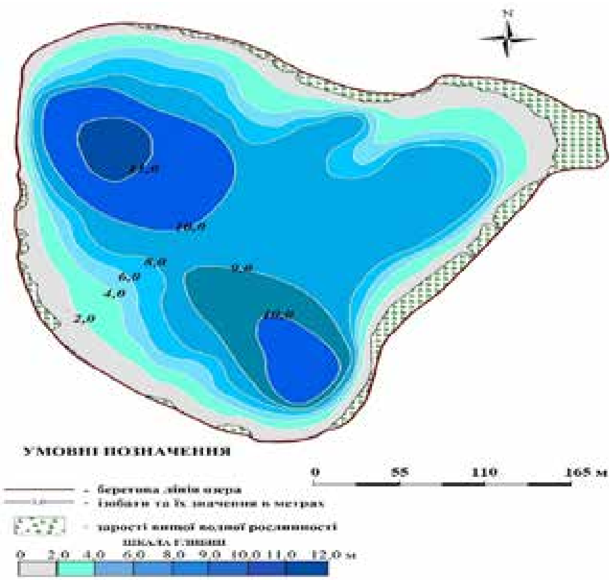


Рис. 5. Батиметрична модель оз. Велике

(6844,8 тис. м^3), а найменшим – оз. Середнє (878,0 тис. м^3). Водозбірні площі озер такі: оз. Острівське – 2,14 км^2, оз. Велике – 1,45 км^2, оз. Середнє – 0,72 км^2, оз. Хоромне – 1,07 км^2. Інші морфолого-морфометричні та гідрологічні параметри озер більш детально наведено у таблиці 1.

4.4. Геохімічні особливості донних відкладів та гідрохімічні характеристики водних мас озер

Важливою складовою у пізнанні ландшафтно-лімнологічних особливостей озер є склад, потужність та геохімічні характеристики донних відкладів. Як показали інструментальні дослідження на модельному оз. Велике, мілководна частина водойми (приблизно до 2,0-2,3 м) вкрита піщаними, піщано-мулистими, а в окремих місцях торф’яно-болотними відкладами. Глибина пелогену сягає до 0,2 м. Глибоководна частина озера, за даними Київської ГРЕ, підстеляється відкладами сапропелю із загальною площею 49,8 га (або 46,03%).

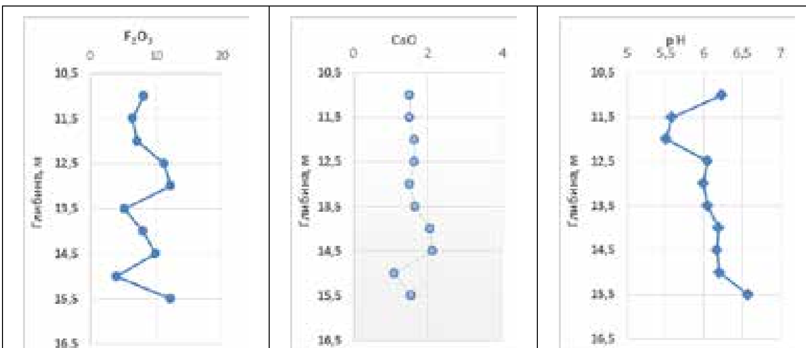
Таблиця 1

Морфометричні та гідрологічні характеристики озер ключової ділянки «Острівські озера»

Назва озера	*F, $км^2$	$H_{абс.}$, $м$	$h_{ср.}$, $м$	$h_{max.}$, $м$	L, $км$	$B_{max.}$, $км$	$B_{ср.}$, $км$	t, $км$	$K_{п.}$	$K_{вид.}$
Острівське	1,08	145,4	6,2	10,5	1,9	0,8	0,59	4,75	0,73	3,22
Велике	0,89	145,6	6,18	11,0	1,250	0,905	0,712	3,835	0,648	1,756
Середнє	0,19	145,6	2,4	5,1	1,002	0,262	0,190	2,257	0,824	5,274
Хоромне	0,42	146,5	2,7	5,8	1,172	0,450	0,358	3,031	0,745	3,274
Назва озера	$K_{ємк.}$	$K_{відк.}$	$K_{гл.}$	$V_{оз.}$, тис.$м^3$	К	ΔS, $км^2$	**$W_{пр.}$, тис.$м^3$	$а_{вод.}$,	$\Delta а_{вод.}$,	$А_{ш.}$, мм
Острівське	0,59	0,17	6,02	6844,8	0,50	1,98	270,0	0,039	25,351	3198,5
Велике	0,562	0,144	6,424	5803,0	0,614	1,629	183,0	0,032	31,710	4002,1
Середнє	0,471	0,079	4,174	878,0	0,264	3,789	90,8	0,103	9,670	1219,4
Хоромне	0,466	0,156	3,605	1493,0	0,393	2,548	135,1	0,090	11,051	1395,3

*Площа озера (F), абсолютна відмітка рівня води ($H_{абс.}$), глибина середня ($h_{ср.}$) та максимальна ($h_{max.}$), довжина водойми (L), ширина максимальна ($B_{max.}$) та середня ($B_{ср.}$), довжина берегової лінії (l), коефіцієнти – порізаності берегової лінії ($K_{п.}$), видовженості озера ($K_{вид.}$), ємкості ($K_{ємк.}$), відкритості ($K_{відк.}$), глибинності ($K_{гл.}$), об'єм водних мас ($V_{оз.}$), показник площі (K), питомий водозбір (ΔS), об'єм приточних вод з водозбору ($W_{пр.}$), умовний водообмін ($a_{вод.}$), питома водообмінність($\Delta a_{вод.}$), шар акумуляції ($А_{ш.}$). **Середньорічний модуль стоку, $дм^3/с\ км^2$ – 4,0.

Максимальна потужність сапропелю становить 5,5-6,0 м, а середня 2,62 м. Враховуючи максимальну глибину води оз. Велике та потужність донних відкладів, то максимальна глибина озерної улоговини сягає близько 17,0 м. Запаси сапропелю за категорією C_2 при вологості 88,3% становлять 1304,7 тис. м^3, а у перерахунку на умовну 60,0% вологість – 408,3 тис. т. Геохімічні аналізи сапропелю на одній із зондувальних точок (рис. 4а) показали, що вміст сполук F_2O_3 варіює у діапазоні від 4,02% до 12,2% (на суху речовину), сполуки *CaO* знаходяться у межах від 1,09% до 2,11% (на суху речовину), розподіл кислотності (*pH* сольової витяжки) у донних відкладах становить від 5,51 до 6,58. Більш детально розподіл деяких геохімічних характеристик наведено на рис. 6.



Розподіл сполук Fe_2O_3 (% на суху речовину) у донних відкладах	Розподіл сполук *CaO* (% на суху речовину) у донних відкладах	Розподіл кислотності (*pH* сольової витяжки) у донних відкладах

Рис. 6. Деякі геохімічні характеристики донних відкладів оз. Велике
(графіки побудовано за матеріалами Київської ГРЕ)

Аналізи води з озер здійснювалися за трьома блоками показників, зокрема сольового складу, трофо-сапробіологічного блоку та специфічними показниками токсичної дії (табл. 2). За блоком показників сольового складу наявна відповідність води нормативам для водойм рибогосподарського призначення усіх чотирьох озер. Стосовно трофо-сапробіологічних показників спостерігаємо незначне відхилення показника pH від ГДКрибгосп. у воді озер Велике та Середнє. У пробі води з оз. Велике у 5 разів спостерігається перевищення нітрогену амонійного за ГДКрибгосп., а в оз. Середнє за цим показником невідповідність нормативам становить у 3 рази. Дослідження показали значне перевищення ГДК для рибогосподарських водойм за хімічним споживанням кисню (метод біохроматної окиснюваності), зокрема у 2,5 рази в оз. Велике, у 3,5 рази в оз. Середнє, у 5 разів в оз. Хоромне. Для оз. Острівське цей показник не визначався. За біохімічним споживанням кисню ($БСК_5$) спостерігаємо перевищення ГДКрибгосп. в оз. Велике у 3,3 рази, в оз. Середнє в 2,5 рази, в оз. Хромне в 2,1 рази. Відповідно до блоку специфічних показників токсичної дії ми виявили невідповідність ГДКрибгосп. за показниками рухомих форм цинку для трьох озер, міді (перевищення у 8 разів) для оз. Велике, заліза загального (перевищення у 5,5 раз) для озер Велике та Хоромне. Більш детально гідрохімічні характеристики водної маси озер наведені у табл. 2.

4.5. Картографічне моделювання озер та оцінка геоекологічного освоєння водозборів

Проведені геокомплексні спостереження на КД «Острівські озера», гідролого-батиметричні, геохімічні та гідрохімічні дослідження озер послужили основою для створення ландшафтних карт озер. Розглянемо структуру модельного природно-аквального комплексу (ПАК) оз. Велике (рис. 7).

ПАК оз. Велике, за методикою [15], ми розглядаємо у ранзі складного аквaурочища, де виділили літоральне, субліторально-профундальне та профундальне аквапідурочища, а також сім видів аквафацій. Літоральне аквапідурочище (32,58% площа) включає три види мілководних аквафацій із восьми контурів (табл. 3). Аквафації з індексом 1.1 зазнають помітних природних трансформацій, що проявляється у заболочуванні; саме тут найбільша локалізація макрофітів.

I. Літоральне аквапідурочище на піщано-мулистих та торфово-болотних відкладах, що сформувалися на алювіальних пісках з видовим різноманіттям надводних і підводних макрофітів.

Аквафації: **1.1.** Мілководні, акумулятивні піщано-мулисті та торфово-болотні осоково-очеретяно-лепехових асоціацій, з однорідним температурним режимом влітку. **1.2.** Мілководні, абразійно-акумулятивні піщані та піщано-мулисті рогозово-ситникових асоціацій, з однорідним температурним режимом влітку. **1.3.** Мілководні, акумуля-

Таблиця 2

Деякі показники сольового фону, трофо-сапробіологічних характеристик та речовин біоцидної дії у воді озер ключової ділянки «Острівські озера»*

№ з/п	Показник	ГДК**	оз. Острівське	оз. Велике	оз. Середнє	оз. Хоромне
			Дата відбору проб			
			16.11.2017	**11.08.2019**	**11.08.2019**	**11.08.2019**
	А. Показники сольового складу					
1	Сухий залишок, *мг/дм³*	<300	141,8	98,3	81,9	70,3
2	Хлориди, *мг/дм³*	300	23,7	5,8	5,8	7,3
3	Сульфати, *мг/дм³*	100	7,9	53,8	41,9	21,3
	Б. Трофо-сапробіологічні показники					
1	Прозорість, *м*	>1,5	2,0	2,0	2,5	1,5
2	pH	6,5-8,1	7,0	6,25	6,20	7,3
3	NH_4^+, мгN/дм³	0,5	<0,05	2,5	1,5	0,5
4	NO_3^-, мгN/дм³	40	<0,1	0,00	0,00	0,00
5	NO_2^-, мгN/дм³	0,08	0,003	0,00	0,00	0,00
6	PO_4^{3-}, мгP/дм³	2,14	<0,01	0,00	0,00	0,00
7	ХСК за БО, *мгO₂/дм³*	<20	–	50,0	70,0	100,0
8	$БСК_5$, *мг O₂/дм³*	<1,5	1,6	5,0	3,8	3,1
9	Завислі речовини, *мг/дм³*	<15	6,0	7,0	10,0	14,0
10	Розчинений кисень	>7,5	13,3	11,4	11,2	10,4
	С. Специфічні показники токсичної дії					
1	Мідь (рухомі форми), *мг/дм³*	0,001-0,01	0,006	0,08	0,006	0,005
2	Цинк (рухомі форми), *мг/дм³*	0,01	–	0,016	0,021	0,014
3	Кадмій (рухомі форми), *мг/дм³*	0,005	–	0,0032	0,0029	0,0022
4	Плюмбум (рухомі форми), *мг/дм³*	0,01	–	0,0012	0,0008	0,0006
5	Залізо загальне, *мг/дм³*	0,1	<0,1	0,55	0,00	0,54

*Гідрохімічні аналізи проб води виконані у сертифікованій лабораторії Рівненської обласної СЕС. **ГДК для водойм рибогосподарського призначення [2]. Аналізи важких металів (Cu, Zn, Pb, Cd) виконувалися ацетатно-амонійним буферним розчином (pH 4,8)

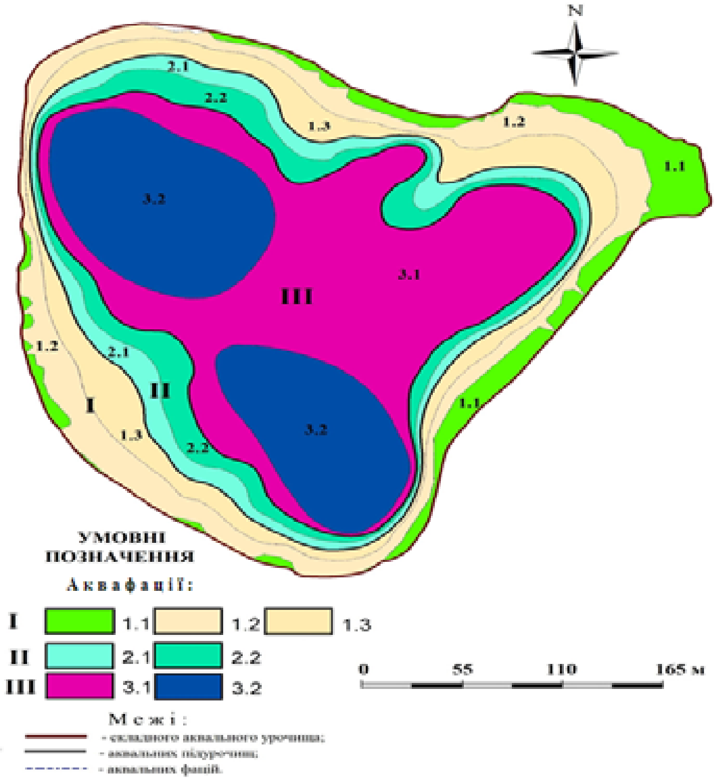


Рис. 7. Ландшафтна структура оз. Велике

тивно-транзитні піщано-мулисті розріджених елодейно-рдесникових асоціацій, з однорідним температурним режимом.

II. Субліторально-профундальне аквапідурочище на водоростево-карбонатному сапропелі, що сформувалися на алювіальних пісках з видовим різноманіттям підводної та вільноплаваючої рослинності.

Аквафації: **2.1.** Субліторальні, транзитно-акумулятивні водоростево-вапнякові сапропелеві середньопотужні (1,5-2,0 м), кушировo-рясокових асоціацій, з незначною амплітудою температур влітку. **2.2.** Профундальні, акумулятивно-транзитні глинисто-вапнякові сапропелеві середньопотужні (2,0-3,0 м), харово-нитчастих асоціацій, з незначною амплітудою температур влітку.

III. Профундальне аквапідурочище центральної частини ложа озерної улоговини на органо-вапняковому та глинисто-вапняковому сапропелі, що сформувався на суглинках карбонатних, з розрідженим видовим різноманіттям підводної рослинності.

Аквафації: **3.1.** Профундальні, акумулятивні органо-вапнякові сапропелеві середньопотужні (3,0-4,0 м), зі збідненою підводною рослинністю та поодинокими плаваючими водоростями, з незначною амплітудою температур влітку. **3.2.** Профундальні заглибин ложа улоговини, акумулятивні глинисто-вапнякові сапропелеві потужні (4,0-6,0 м), поодиноких плаваючих водоростей, з чіткою температурною стратифікацією влітку.

Таблиця 3

Ландшафтометрична оцінка ПАК оз. Велике

Вид ПАК		Площа виду ПАК (га)		% площі виду від загальної площі		Кількість контурів виду фацій в межах ПАК	% від загальної кількості	Середня площа виду (під-) урочища (га)
(Під-) урочище	Фація	(Під-) урочище	Фація	(Під-) урочище	Фація			
I		29,06		32,58		8	61,54	3,63
	1.1		6,65		7,46			
	1.2		11,74		13,16			
	1.3		10,67		11,96			
II		15,47		17,34		2	15,38	7,74
	2.1		6,89		7,72			
	2.2		8,58		9,62			
III		44,67		50,08		3	23,08	14,89
	3.1		25,51		28,60			
	3.2		19,16		21,48			
Усього		**89,20**	**89,20**	**100,00**	**100,00**	**13**	**100,00**	**6,86**

Проміжне положення у ПАК озера займає субліторально-профундальне аквапідурочище (17,34%) із двома видами аквафацій, які сформувалися на відкладах водоростево-карбонатного сапропелю різної потужності. Дане аквапідурочище фактично ототожнюється з глибинами від 4,0 до 8,0 м. Найбільшу площу (50,08%) посідає профундальне аквапідурочище центральної частини ложа ПАК на органо-вапняковому та глинисто-вапняковому сапропелі з глибинами понад 8,0 м. Середня площа видів ПАК становить 6,86 га (табл. 3).

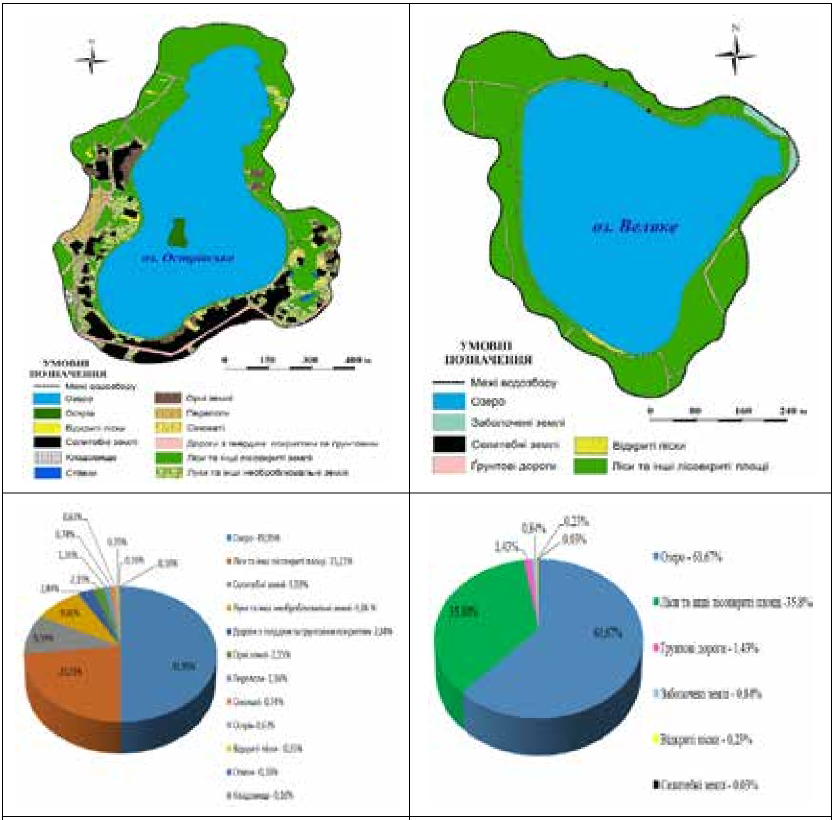
Підсистемою другого порядку цілісної озерно-басейнової система виступає його водозбір. Від особливостей господарської діяльності та геоекологічних процесів, що відбуваються у межах водозбору буде залежати гідроекологічний стан озерної екосистеми. Для озер Велике та Острівське нами побудовані картографічні моделі просторово-типологічної структури угідь їхніх водозборів (рис. 8).

У межах водозбору оз. Острівське нами оцифровано 12 типів земельних угідь (рис. 8а). Вихідними даними для оцінки структури використання земель водозбору слугували показники, зокрема: *лісистості водозбору* (сумарна площа лісів, лісосмуг, деревної та чагарникової рослинності); *територій в природному стані* (болота, землі зайняті водними об'єктами, ліси природного та штучного походження, захисні водоохоронні насадження, відкриті піски, заповідні території, пасовища, сіножаті, перелоги); *сільськогосподарського освоєння* (сільськогосподарські угіддя водозбору: рілля, багаторічні насадження, сінокоси, пасовища, перелоги, присадибні землі); *розораності* (рілля та присадибні землі); *селитебні території* (площа земель, зайнята населеними пунктами, об'єктами промисловості, транспорту, зв'язку тощо).

За методикою [21], ми визначили коефіцієнт господарського освоєння $\mathbf{K}_{\mathbf{ГО}}$ водозбору, як відношення площ антропегенно-трансформованих угідь ($\boldsymbol{S}_{АТУ}$), до площі екостабілізуючих угідь ($\boldsymbol{S}_{ЕСУ}$):

$$K_{ГО} = \frac{S\ \text{АТУ}}{S\ \text{ЕСУ}} = \frac{35{,}9483}{177{,}9687} = 0{,}20$$

де $\boldsymbol{S}_{АТУ}$ – селитебні землі, кладовища дороги, землі під сільськогосподарською фермою, орні землі, пасовища, сіножаті, перелоги, сади, ставки; $\boldsymbol{S}_{ЕСУ}$ – ліси, луки, заболочені землі, водні об'єкти, відкриті піски та інші необроблювальні землі.



а) Оз. Острівське	б) Оз. Велике

Рис. 8. Просторово-типологічна структура угідь водозборів озер

Ступінь порушення геоекологічної рівноваги у реальному співвідношенні АТУ:ЕСУ визначали за допомогою модифікованої шкали (табл. 4). За критерієм співвідношення АТУ:ЕСУ водозбір оз. Острівське характеризується оптимальним геоекологічним станом (відноситься до 0 типу господарського освоєння, оскільки АТУ становлять 16,81%, а ЕСУ – 83,19%). Ступінь господарського освоєння водозбору, за нашою оцінкою, є низький.

Аналогічний підхід щодо оцінки геоекологічного стану водозбору був застосований до оз. Велике. За нашими оцінками, водозбір оз.

Таблиця 4

Модифікована шкала для оцінки геоекологічного стану водозборів озер

Тип території водозбору	Питома вага угідь,% до їх сумарної площі		Геоекологічний стан
	АТУ	ЕСУ	
0	< 20	> 80	оптимальний
I	20-35	80-65	добрий
II	35-55	65-45	задовільний
III	55-80	45-30	незадовільний
IV	> 80	<20	критичний

***$К_{ГО}$* – коефіцієнт господарського освоєння:** <0,25 − низький ступінь господарського освоєння; 0,26-0,51 – середній ступінь господарського освоєння; 0,51-0,76 – підвищений ступінь господарського освоєння; 0,76-1,0 – високий ступінь господарського освоєння. 1,0-1,5 – дуже високий ступінь господарського освоєння; >1,5 – надзвичайно високий ступінь господарського освоєння.

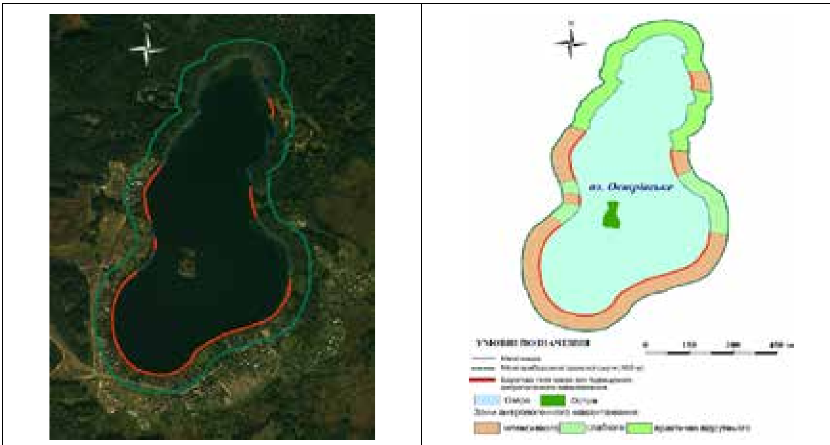
Велике характеризується еталонним геоекологічним станом (відноситься до 0 типу господарського освоєння, АТУ тут становлять 1,46%, а ЕСУ – 98,54%). Відповідно, ступінь господарського освоєння водозбору, є дуже низький.

Наступним етапом досліджень було здійснено зонування 100-метрової водоохоронної зони навколо оз. Острівське за ступенем антропогенного навантаження (рис. 9).

Як показали результати пошуків, 51,3% площі 100-метрової зони навколо озера має інтенсивний ступінь антропогенного навантаження. До цієї зони належать присадибні та городні ділянки, що прилягають до озера, а також селитебні комплекси. Зона слабкого ступеню антропогенного навантаження займає 13,4% площі – це ділянки під перелогами та пасовищами. Території, де практично відсутнє антропогенне навантаження складають 35,3% площі.

5. Висновки

Суттєву роль у генезисі геокомплексів ключової ділянки та безпосередньо озер відіграли водно-льодовикові процеси. Домінантними геокомплексами ландшафтної місцевості міжрічкових заболочених рівнин на флювіогляціальних та давніх алювіальних відкладах є урочища



а) Схема 100-метрової зони навколо озера (червоний маркер – зони інтенсивного антропогенного навантаження)

б) Модель зонування водоохоронної зони озера

Рис. 9. Зонування 100-метрової водоохоронної зони навколо оз. Острівське за ступенем антропогенного навантаження

хвилястих ділянок межиріч, які частково меліоровані та розорані, вони посідають найбільшу площу. Помітних антропогенних модифікацій у результаті осушувальних меліорацій в минулому зазнають геокомплекси місцевостей долин малих річок на сучасних болотних та алювіальних відкладах. Ландшафтна структура КД «Острівські озера» може розглядатися як репрезентативною для водно-льодовикових геокомплексів заболочених межиріч Нобельського НПП. Встановлено, що тип водозбору оз. Острівське, за переважаючим видом господарської діяльності, є селитебно-аграрно-рекреаційний, а озер Велике, Середнє, Хоромне – заповідно-лісогосподарсько-водорегулювальний. Ландшафтне-селитебне планування с. Острівськ на сучасному етапі маєураховувати екологічні нормативи щодо заборони будівництва житлових та рекреаційних об’єктів у 100-метровій зоні навколо оз. Острівське. Розвиток аграрного природокористування у басейновій системі оз. Острівське має бути спрямований на ведення органічного землеробства, із забороною розорювання 50-метрової зони навколо озера. Геоекологічний стан водозбору оз. Велике оцінений нами як еталонний з точки зору господарського освоєння. У подальших дослідженнях необхідним є розробка ландшафтного зонування території та започаткування гідроекологічного моніторингу озер з метою вироблення заходів щодо заповідного та рекреаційного природокористування.

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BASIC PRINCIPLES ON WHICH THE DEVELOPMENT OF EDUCATIONAL ENVIRONMENTAL WORKS IS BASED

БАЗОВІ ПРИНЦИПИ, НА ЯКИХ ҐРУНТУЄТЬСЯ РОЗРОБКА НАВЧАЛЬНИХ ЕКОЛОГІЧНИХ ТВОРІВ

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Abstract. Deterioration of the environmental situation in the world requires the constant environmental education of the younger generation, in particular, as well as of the whole population. Cartographic materials are an effective visual tool for the accumulation of knowledge about the patterns of development and functioning of natural complexes (ecosystems), the formation of ecological culture. One of the priorities of society is the ecological education of students which should occur primarily through the educational environment of the school. Environmental education is key for respecting nature and for achieving international agendas, including the Millennium Development Goals (MDGs); the Convention on Biological Diversity (CBD); the United Nations Convention to Combat Desertification (UNCCD); and the United Nations Decade of Education for Sustainable Development (UNDESD, 2005-2014). The process of teaching ecology at school is continually accompanied by the use of such a visual manual as a map. Herewith, the card, which is provided in the form of separate educational material (wall map, in the collection of maps – atlas) or included in the textbook, serves not only as an accessory means of learning (accompanying the teacher's explanations, illustrating some occurrences and phenomena), but also as an independent means of education and upbringing. The relevance of the problem is due to the fact that in the conditions of the modern school the use of visual aids such as maps (paper and electronic) is urgently

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needed. First of all, because of an intense increase in the information flow that is hitting a modern person (both a student and a teacher), it is difficult for a teacher to choose the necessary and useful pieces of information. A visual manual solves the problem of providing a great deal of information, when the organs of hearing and vision are simultaneously involved in the learning process, its effectiveness is greatly increased. Thus, for example, it is enough for a teacher to point to any object or phenomenon on the map, then the pupils will receive much more information about it, record in space and properly remember it. Thereby, the map eliminates the need for long, monotonous explanations, releasing this time to explore other equally important topics. At the same time, changing the form of explaining teaching material does not affect the learning process negatively; on the contrary, it facilitates learning and memorizing the material for a longer period of time. The object of the study is school cartographic materials on ecology. The subject is theoretical and practical positions for the development of the atlas structure and the system of cartographic indicators of ecological maps. The main purpose of this paper is to investigate the existing basic principles to be followed when drawing up environmental maps for the school.

1. Вступ

Сучасне суспільство висуває перед школою багато вимог, з-поміж яких – формування умінь, знань та навичок, необхідних у дорослому житті.

На підставі компетентнісного підходу знання мають стати не багажем «про всяк випадок», а ключем до розв'язання проблем, забезпечення успішної самореалізації у соціумі, облаштування особистого життя. Сьогодні неможливо навчити дитину всього, значно важливіше сформувати в неї потребу в неперервній освіті. Тому зміст навчального матеріалу з географії визначено з огляду на корисність та потрібність його за межами школи.

В програмі з географії для 6-9 класів виокремлено *компетентнісний потенціал предмета* – Екологічна грамотність і здорове життя:

Уміння: працювати в команді під час реалізації географічних проектів, застосовувати набутий досвід задля збереження власного здоров'я та здоров'я інших, оцінювати значення географічної науки для забезпечення добробуту людства.

Ставлення: турбота про здоров'я своє та інших людей, ціннісне ставлення до навколишнього середовища як до потенційного джерела здоров'я, добробуту та безпеки людини і спільноти, усвідомлення важливості ощадного природокористування, пошанування внеску кожного / кожної в досягнення команди.

Навчальні ресурси: кооперативне навчання, партнерські технології, проекти.

Екологічна культура залежить від багатьох чинників. Роль освіти у формуванні екологічної культури важко переоцінити. Як зазначив відомий італійський еколог А. Траверсо, «У міру того, як наше розуміння взаємовідносин діяльності людини і проблем навколишнього середовища поглиблюється, основні принципи освіти в галузі оточуючого середовища, якщо вони правильно вироблені, можуть цілком стати тим ядром, навколо якого формуватиметься майбутня стратегія суспільної освіти, вона сформує громадян світу з новим світоглядом, з новими настроями, які більше відповідатимуть потребам людства і природи».

Сучасна екологічна ситуація в світі та в Україні зокрема загострюється з кожним днем. Забруднення атмосфери шкідливими викидами, тисячі тон сміття, знищення цілих екосистем через вирубування лісів, розорювання, будівництво, шкідлива радіація та випромінювання — далеко не повний перелік тих техногенних факторів, які негативно впливають на екологію. Недарма екологічне виховання визнане одним із найважливіших пріоритетів ЮНЕСКО, Національної доктрини розвитку освіти України XXI століття, інших основоположних документах світового та національного рівня.

Екологічне виховання це вже не лише формування відповідних знань і вмінь у взаємодії людини та природи, а й розвиток засобами педагогічних технологій особистості, спеціальних знань, ціннісних норм та орієнтацій щодо усвідомлення екологічної цінності природного середовища у його нерозривній єдності з людиною. Ключовою метою екологічного виховання на уроках і в позаурочний час є формування відповідального та дбайливого ставлення до природи, що базується на: екологічній свідомості та самосвідомості формуванні стійкої потреби власного свідомого дотримання екологічних принципів природокористування, розвитку навичок екологічної культури, активній участі в суспільно корисній праці з захисту, догляду та оптимізації стану довкілля, пропаганді в найширших межах екологічних знань активній діяльності з вивчення та охорони природи своєї місцевості.

2. Екологічна освіта

До екологічної освіти висувають наступні вимоги:

1. Дати уявлення учням про навколишнє середовище з різних його аспектів: природного, створеного людиною, технологічного і соціально-екологічного, політичного, культурного, історичного, естетичного.
2. Починатись з дошкільного віку дитини і продовжуватися на всіх рівнях його освіти, а також самоосвіти.
3. В шкільній освіті бути пов'язаною не тільки з екологією, а носити міждисциплінарний характер, тобто включати спеціальний зміст у кожний навчальний предмет.
4. Досліджувати головні проблеми навколишнього середовища не тільки з теорії глобальної, а враховувати місцеві, національні та міжнародні точки зору.
5. Зосереджувати увагу на поточних екологічних ситуаціях, а також моделювати майбутні, для їх попередження.
6. Доносити до суспільства значення міжнародного екологічного співробітництва.
7. Докладно висвітлювати різні аспекти навколишнього середовища в процесі соціально-економічного планування і розвитку.
8. Давати можливість населенню застосовувати свої знання і досвід у плануванні, прийнятті рішень і визначенні наслідків.
9. Носити до суспільства важливість екологічної освіти будь-якої вікової групи, але надавати особливого значення розвитку розуміння чутливості навколишнього середовища в учнів у ранньому віці.
10. Допомагати учням визначати ознаки виникнення проблем навколишнього середовища.
11. Набуття навичок вирішувати проблеми навколишнього середовища, що з'являються.
12. Використовувати різноманітність навколишнього середовища, що вивчається, і широкий набір методичних прийомів для навчання, засвоєння знань про дозвілля [2, с. 171-172].

Відповідно до Концепції екологічної освіти України, екологічна освіта повинна охоплювати всі вікові, професійні та соціальні версти населення, і ґрунтуватися на таких принципах:

– системність і безперервність, що забезпечують умови формування екологічної культури між окремими ланками освіти, єдність формальної і неформальної освіти;

– орієнтацію на ідею цілісності природи; міждисциплінарний підхід до формування екологічного мислення, що передбачає логічне поєднання й поглиблення системних природних знань;

– взаємозв'язок краєзнавства, національного і глобального мислення, що сприяє поглибленому розумінню екологічних проблем на різних рівнях; конкретність та об'єктивність знань, умінь та навичок; поєднання високопрофесійних екологічних знань з високоморальними цінностями [4, с. 5-7, 10].

Екологічна освіта і виховання повинні орієнтуватись на активну взаємодію людини з природою, побудовану на науковій основі, на оцінюванні людини як частини природи. Екологічні знання, доповненні ціннісними орієнтаціями, повинні стати основою екологічної культури і екологічного мислення. Вони мають сприяти усвідомленню цінностей, допомагати вирішенню комплексних екологічних проблем, що стоять перед людством, забезпечити комфортність його проживання у майбутнього, зберегти та примножити унікальну різноманітність всієї біоти і зокрема рослинного та тваринного світу [5, с. 58-61].

3. Основні принципи, на яких ґрунтується розробка навчальних екологічних карт

Методично правильне оформлення навчальних географічних атласів грає важливу роль в набутті власне картографічних знань, в навчанні використанню карти як джерела знань, у всьому процесі навчання географії.

При укладанні карт атласу автори мають звернути увагу на деякі моменти:

1. *Сувора відповідність змісту карт навчальній програмі.* Дана вимога є пріоритетним і в зв'язку з цим позначена першою. Основна відмінність навчальних від звичайних екологічних картографічних творів, це те, що вони укладаються відповідно до навчальної програми,

затвердженої Міністерством освіти та науки України. Тобто, крім стандартних джерел для створення карт (матеріали дистанційного зондування Землі, літературні джерела, статистичні дані і т д), потрібно в першу чергу керуватись програмою.

Освітня програма – це єдиний комплекс освітніх компонентів, спланованих і організованих закладом загальної середньої освіти для досягнення учнями результатів навчання. Основою для розроблення освітньої програми є Державний стандарт загальної середньої освіти відповідного рівня. Приклад освітньої програми наведено нижче у табл. 1.

Незважаючи на високий статус картографічних видань в освітньому процесі карта (і атлас) повинна виконувати, перш за все, функцію ілюстрації навчального матеріалу, представленого в програмі або ж пояснюється в ході уроку вчителем. У разі повної самостійності карти, її невідповідності хронологічних рамок теми необхідність такого навчального посібника, можливість його використання в процесі навчання можуть стати дуже сумнівними. Карта повинна ілюструвати той матеріал, ті події, процеси і явища, які зазначені в шкільній програмі. В іншому випадку карти і атласи не сприятимуть освітнім цілям, заплутають і вчителі, і учнів.

У той же час, значною допомогою в процесі навчання служать ті карти і атласи, які наочно відображають ту інформацію, яка викладена в підручнику. Безумовно, зміст карт вимушено виходить далеко за рамки тієї інформації, яку містить підручник. Показані міста і держави, які в підручниках навіть не згадуються, відображені зміни кордонів, які в підручниках, природно, не описуються. Проте, на картах слід застосовувати ту ж термінологію, що й в підручнику, то ж хронологічний поділ, враховувати пріоритет тих подій, які описані в підручниках, щоб карта не виявилася перевантаженою, а другорядні події не заступили головні.

У той же час зміст карти може і повинен бути трохи ширше інформації, наданої підручником. По-перше, підручник відносно бідно висвітлює територію держави, її географічні особливості, сусідство та різні екологічні характеристики. По-друге, є маса інформації, яка зовсім не відображена в навчальних посібниках, але без якої неможливо обійтися.

2.*При використанні карт в процесі навчання слід звернути увагу на труднощі співвіднесення учнями події або явища*, зображеного на

Таблиця 1

Навчальна програма для 11 класу загальноосвітніх навчальних закладів рівень стандарту, академічний рівень

Кількість годин	Зміст навчального матеріалу	Навчальні досягнення учнів
2	**Тема 1. Екологія як наука про довкілля** Предмет, об’єкт, завдання і методи науки про довкілля. Структура сучасної екології та її місце в системі наук.	**Учень:** • **Розуміє** екологію як комплексну складну багатогранну науку про взаємовідносини живої і неживої природи про тактику і стратегію збереження та збалансованого розвитку життя на землі; • **Знає** складну структуру екології, яка об’єднує два основні напрямки: теоретичний (класичний) і прикладний
2	**Тема 2. Природа і людина: системний підхід** Властивості складних систем. Біосфера, основні положення вчення В. І. Вернадського про біосферу. Еволюція уявлень про роль і місце природи у житті суспільства. Ноосфера. Еволюція уявлень про місце людини у природі. Історичні етапи взаємодії суспільства і природи та їх екологічні особливості. Масштаби і наслідки антропогенного впливу на природне середовище на сучасному етапі. Практична робота: «Аналіз особливостей історичних етапів взаємодії суспільства і природи».	**Учень:** розуміє сутність складних систем; роль живої природи в організації біосфери; місце природи у житті суспільства; рушійну силу людського розуму у формуванні ноосфери; місце людини у природі; досліджує особливості основних етапів взаємодії суспільства і природи; аналізує наслідки змін і перетворень природних процесів і компонентів природи антропогенною діяльністю.

тематичній карті в масштабі, скажімо, однієї держави, з місцем цієї події або явища, та й самої держави на карті світу або частини світу. Приклад даного принципу наведено на рис. 1.

В результаті просторове сприйняття, прив'язка будь-яких подій і явищ до географічної карти, просто не формується. Тому важливо уявити конкретну карту в контексті великого регіону. Виконати це можна різними способами. Наприклад, врізкою на настінній карті атласу можна дати схематичне зображення частини земної кулі, в якому яскравим кольором виділити ту ділянку території, яка представлена на основний карті. Або помістити поруч різномасштабні карти, в одній з яких уявити безпосередньо територію, на якій відбувалися досліджувані події і процеси, а на другий – місце пріоритетного в даному випадку регіону на оглядовій карті [10, с. 18-25].

Рис. 1. Карта «Географічне положення України»

3. *Врахування вікових особливостей* – одне з основоположних педагогічних вимог, що пред'являються до створення екологічних навчальних посібників. На рис. 2, що знаходиться нижче, наведено різницю подання інформації на картах для 5-го та 8-го класах.

Спираючись на нього, слід регламентувати склад, зміст і навантаження карт, встановлювати обґрунтовані обсяги, що мають міститись в картах, інформації, визначати найбільш сприятливий для сприйняття різними віковими групами учнів зовнішній вигляд карт, кольоропередачу, розмір різних елементів (шрифти, значки, лінії кордонів і т. д.). Вікові особливості зобов'язують правильно вирішувати питання відбору та розташування на аркуші різних елементів карти (легенда, врізки, назва), змушують враховувати рівень розвитку абстрактного мислення, співставляти смислове навантаження з можливістю її аналізу з боку учня.

Так, карти в 5-6 класах повинні бути досить прості, число елементів в них повинно відповідати здібностям учнів адекватно сприйняти їх. При першому ж візуальному сприйнятті карти учні повинні мати можливість повністю тримати її в полі зору. При цьому потрібно враховувати межі короткочасної оперативної пам'яті учнів. Дуже важливо в умовах сучасної школи правильно вибрати масштаб карти, величину шрифтів і значків. Наприклад, що стосується стінних карт, то учні, які сидять навіть на перших партах в класі не завжди здатні розгледіти на настінній карті навіть основні елементи. У зв'язку з цим можливий новий підхід до створення настінних карт, при якому основним стає наголос на інформацію, що має не текстовий і значковий характер, а реалізовану за допомогою кольорових плям, великих об'єктів [9, с. 521-536].

При цьому сама карта повинна бути максимально доступна для розуміння, вона не повинна містити складних, неоднозначно інтерпретованих або погано помітних елементів. Психологами виявлено також, що заучування в цілому ефективніше заучування по частинах. Тому важливо, особливо при роботі з картами, дати цілісне розуміння обумовленості присутності в наочних конструкціях всіх їх елементів і складання їх у єдине ціле.

Таким чином, при роботі над картою необхідно враховувати вікові, психологічні та фізіологічні особливості учнів. Це і спрощена лексика, і надмірна насиченість інформацією. Необхідно застосовувати великі значки, контрастні, але в той же час, м'які, які не подразнюють зір, великий чіткий шрифт і т. д. [10, с. 15-18].

4. *Карта повинна служити тим засобом, завдяки якому в учнів може виявитися інтерес до навчання в цілому.* Красиво оформлена, наочна, приємна для сприйняття карта, крім того, виконує виховну функцію. Погано зроблена карта, що викликає нерозуміння і навіть роздратування у користувача в результаті може привести до небажання вивчати навчальний предмет.

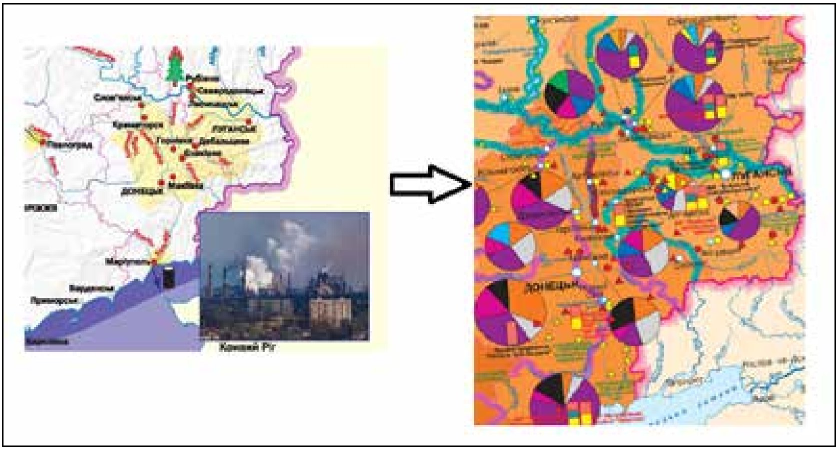

Рис. 2. Відмінність подання екологічної інформації на картах «Екологічна ситуація» шкільних атласів для 5-го та 8-го класу

Карти, що використовуються на уроках в загальноосвітніх установах, повинні бути найбільшою мірою адаптовані для візуального сприйняття учнями. Тут мається на увазі: яскравість (але не надмірна) зображення, розміщення в зручному для сприйняття місці, оптимальний масштаб, контрастне виділення окремих елементів і т.д.

5. *Карта повинна залишатися одним з основних засобів навчання.* Ось кілька можливостей її застосування: 1. Ілюстрація розповіді вчителя, акцентування уваги учнів на подіях і явищах шляхом фіксування їх на карті (включається зорова пам'ять). 2. Самостійне вивчення карти учнями. Карта – наочний засіб навчання, що привертає увагу школярів, зацікавлюють їх, прищеплює інтерес до історії. 3. Формування просторового мислення, уявлення про місце своєї країни, її історії, подій з нею пов'язаних на світовій мапі. Знання розташування тієї чи іншої держави на карті, сусідів, що його оточують, природного середовища (гори, моря і т. д.) дає розуміння відбувалися процесів.

6. *Створення карт і атласів з урахуванням принципу науковості.* У разі застосування в навчальному процесі картографічного матеріалу вимога дотримання принципу науковості має особливе значення, оскільки складові карти, її внутрішнє наповнення може довго утримува-

тися в пам'яті учнів і, в зв'язку з цим, накладатися і поєднуватися з іншим досліджуваним матеріалом. При створенні карт необхідно враховувати досягнення екологічної та картографічної науки, використовувати тільки перевірені дані, засновані на автентичних і найбільш несуперечливих джерелах. Не потрібно вводити в наочні посібники спірні, дискусійні моменти. При цьому необхідно уникати того, щоб карти перетворювалися з наукових за змістом в наукоподібні за формою [8, с. 25-32].

7. *Дотримання принципу систематичності при створенні атласів і оформлення карт.*

Вимога дотримання принципу систематичності стосовно створення карт виражається в логічній послідовності відображених на них об'єктів, явищ і процесів, що реалізується, перш за все, в умовних позначеннях (легендах) до карти. Така послідовність виражається в поступовості і поступальності відображення на карті подій і явищ, що забезпечує легкість їх розуміння і запам'ятовування в цілому. Розрив зв'язку в послідовності викладу навчального матеріалу в загальному призведе до повної неузгодженості внутрішнього змісту карти.

8. *Відповідність естетичним і етичним критеріям.* Навчальна візуальна інформація на картах повинна відповідати естетичним критеріям (відповідати композиційним вимогам: симетрії, ритму, ракурсу, контрасту і локалізації смислового центру, перспективі і колориту) і етичним критеріям (відповідність змістовним і формальним нормам моралі). У зв'язку з цим можна зробити висновок, що створення карт – це не механічний процес нанесення певної кількості елементів на аркуш паперу, але і творчість, спрямована на правильне сприйняття карти.

9. *Урахування принципу доступності для розуміння.*

Карти, які вчитель може запропонувати на уроках, в загальних рисах, в основних принципах їх побудови повинні бути знайомі і доступні для сприйняття учням. Розглядаючи карти, які є умовним відображенням місцевості, вони повинні розуміти ті принципи, за якими нанесені річки, кордони, пунсони (умовні знаки, що визначають місця розташування населених пунктів) і т. д. Типовість та однотипність карт полегшує їх читання учнями, яким не потрібно додатково пояснювати зміст того чи іншого елемента карти і можна зосередити їх увагу тільки на внутрішній зміст наочних засобів навчання, які допомагають вивчити нову тему [2, с. 171-172].

Наприклад, на карті «Екологічна ситуація України» для 5-го класу, для картографування зненіснення в якості умовних позначень обрали значки ялини. При показі особливо забруднених територій використовували більш темний, насичений колір. Фрагмент карти наведено нижче на рис. 3.

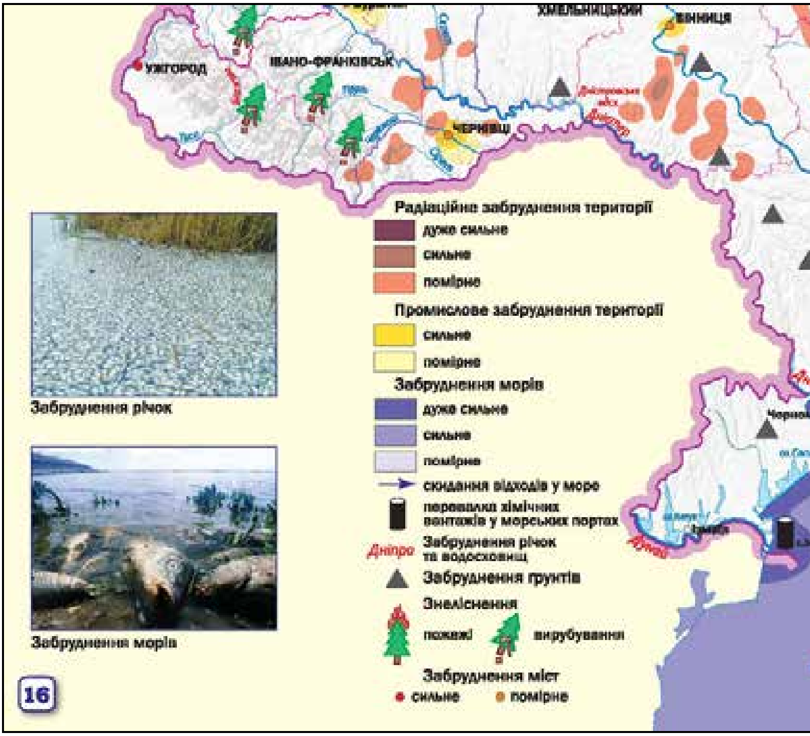

Рис. 3. Фрагмент карти «Екологічна ситуація України» для 5-го класу

10. *Прагнення до створення умов для міцності засвоєння знань.*

Процес міцного засвоєння знань є дуже складним. Традиційно вважалося, що навчання має ґрунтуватися на довільному запам'ятовуванні, що має свої підстави. Однак до теперішнього часу помічено, що в багатьох випадках мимовільне запам'ятовування є навіть більш продуктивним, ніж довільне. Розуміння цього збільшує значення карт, так як їх використання збільшує рівень мимовільного запам'ятовування. Проте, інтенсифікуючи мимовільне запам'ятовування учнів, не слід давати прямих завдань чи вказівок: краще зацікавити учнів, час від часу «підігрівати» виникнення інтересу, час від часу звертаючи увагу на карту.

11. *Вимога дотримання принципу свідомості навчання.*

Сутність освіти складають глибоко і самостійно осмислені знання, що здобуваються шляхом інтенсивної напруги власної розумової діяльності. Свідоме засвоєння знань учнями залежить від ряду умов і факторів: мотивів навчання, рівня і характеру пізнавальної активності учнів, організації навчального процесу та управління пізнавальною діяльністю учнів, що застосовуються викладачем методів і засобів навчання та ін. Власна пізнавальна активність також є важливим фактором навченості і робить вирішальний вплив на темп, глибину і міцність оволодіння навчальним матеріалом. Звісно ж, що застосування в навчанні карт природним чином стимулює пізнавальну активність учнів і формування свідомості навчання. Ніщо так не сприяє виникненню свідомості навчання, як творча активність. Застосування в процесі навчання настінних карт, контурних карт розвиває творче мислення, призводить до стійкого позитивного ставлення учнів до процесу навчання в загальному [6, с. 13-15].

12. *Орієнтація на формування патріотичних почуттів, любові до Батьківщини.*

На рис. 4 наведені елементи патріотизму, що використовуються на картах.

13. *Функціональна придатність*

У зв'язку з недотриманням ряду вимог, перерахованих вище, може виникнути питання про функціональну придатність карт і атласів, призначених для застосування в процесі навчання. Так, одне лише недотримання вимоги відповідності навчальній програмі і матеріалу підручника зробить наочну, науково обґрунтовану, доступну для розуміння карту функціонально непридатною для використання в процесі навчання.

14. *Практичність*

Як і до кожного продукту, виробленого людиною для певних цілей, до карти і атласу має бути пред'явлена вимога практичності. Ця вимога

Рис. 4. Елементи, що виховують патріотизм, на різних картах

дає розуміння того, наскільки представлена форма реалізації карти зручна для використання в якості навчального посібника в процесі навчання (як для вчителя, так і для учня).

15. *Важливе методичне значення має використання малюнків та фотографії.* Вони мають на меті привернути увагу дітей до карти, до матеріалу, необхідного до вивчення. Особливо такий прийом використовується на картах для дітей молодшого віку [9, с. 521-536]. На рис. 5 наведено приклад використання малюнків для кращого сприйняття інформації школярами.

4. Висновки

Система екологічної освіти в Україні продовжує бути фрагментарною (несистематизованою), слабкою концептуально, декларативною, а, отже, неефективною. Екологічні питання погано вписуються в систему ринкових відносин, а головне – їхнього задоволення. Екологічний світогляд орієнтований на інші цінності – життя людини у чистому середовищі, збереження усіх форм життя. Критична ситуація

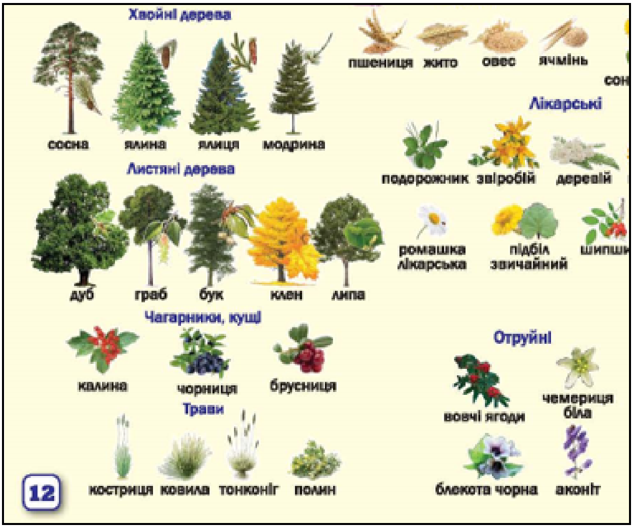

Рис. 5. Елементи карти
«Природні зони та природоохоронні території»

в галузі екологічної освіти пояснюється такими причинами, як багаторічне панування споживацького ставлення до природи; незнання та руйнування народних традицій раціонального природокористування; недооцінка екологічних знань у системі освіти.

На сучасному етапі розвитку суспільства, в період економічних реформ і бурхливого індустріального розвитку, освіта і екологічна освіта є основним фундаментом людського розвитку.

Сучасна екологічна освіта включає в себе безперервний комплексний процес формування екологічного світогляду, екологічної свідомості та культури всіх верств населення, соціальних груп і суспільства, в цілому. Таким чином екологічна освіта – це сукупність наступних компонентів: екологічні знання – екологічне мислення – екологічний світогляд – екологічна етика екологічна культура.

Існує ряд методологічних принципів розробки екологічної карти. Якщо їх дотримуватись, то грамотно створена шкільна карта допоможе у вирішенні навчальних, виховних і розвиваючих цілей в освітньому процесі.

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ENVIRONMENTAL APPROACH TO ASSESSMENT OF THE RESPONSE OF HYDROECOSYSTEMS TO ANTHROPOGENIC LOAD

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Abstract. Assessment of the state of hydroecosystems and development of mechanisms for their rational use is one of the most important tasks of modern hydroecological research. The purpose of this paper is to estimate the water quality of the Lower Section of the Dnieper River (including the Lower Section of the Ingulets River) by different methods of determining the water quality of surface water bodies in accordance with fisheries standards, as being most sensitive to changes in the ecological state of the river, on the basis of monitoring over the years 2001–2016. Estimation of the quality of surface water within the Kherson region by different methods by hydrochemical parameters in accordance with the current standards of the quality of surface water resources was executed. It was found that by hydro-chemical parameters waters of the Lower Section of the Dnieper River are mostly "moderately contaminated" and "contaminated", waters of the Lower Section of the Ingulets River are mostly "contaminated", "very contaminated", or "catastrophically contaminated". Ecological state of the Lower Section of the Dnieper River and of the Lower Section of the Ingulets River was estimated by method of calculation of integrated index. The current calculation method takes into account the effect of the total action of substances and is approved practically for the analysis of the ecological state of other rivers. Self-purification potential and capability of restoration in time and space (along the river stream) of the aquatic ecosystem of the lower section of the Dnieper River and of the Lower Section of the Ingulets

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River were established. It was discovered, that the state of surface water of region was characterized as unsteady with the low of ecological reliability. The monograph highlights the application of mathematical models in the hydroecological problems research. The analysis of anthropogenic factors affecting change of quality of the Dnieper River surface water was used. Consequently, the processes of self-purification potential and capability of the aquatic ecosystems restoration are at the low level. The ecological state of the rivers is characterized as an ecological regress. It was established that for today it is connected with certain ecological risks to consider the basin of the Lower Section of the Dnieper River as a water object of fishery significance. There is a necessity of further research using modern methods of complex estimation of surface waters sources' quality.

1. Introduction

Water resources are a source of industrial and domestic water supply, and therefore play a decisive role in the development of the economy and the life activity of the population. The level of water supply in Ukraine is insufficient, and the territorial division of the country's water resources is uneven and does not correspond to the location of water-containing economic complexes.

The main source of water supply for the population is river flow, but on average only 30% of the river flow falls on the southern economic region (Kherson, Nikolaev and Odessa regions). In this regard, in many areas of southern Ukraine there is an acute shortage of water, for the elimination of which it is necessary to transfer water through canals, build reservoirs, etc. Due to increasing anthropogenic load on river basins, issues of environmental assessment of the hydroecosystems of Low Podneproviya (the Lower Section of the Dnieper River and the Lower Section of the Ingulets River) deserve special attention.

The intensive economic use of water resources enhances anthropogenic stress on water bodies, which leads to a change in the water balance, dynamic characteristics and hydrophysical properties of water masses and bottom sediments. These changes are often so powerful that influence on the regime of ecosystems biotic components. There are frequent cases when the changes of even some elements of the natural water bodies hydrological regime cause a noticeable and sometimes radical transformation of individual sections or aquatic ecosystems in general [1, p. 259]. An example is the cascade of the Dnieper reservoirs [2, p. 181]. Theirs total reservoir capacity is greater in 14 times than the river bed volume of the Dnieper River, and as a result the velocity of currents decreased in 30–40 times, water turbidity – in 7–9 times. The wind-wave processes, lowering-raising of the water level by the effect of wind processes and seiches were activated, the temperature regime was changed. All this created the conditions for changing the species composition and productivity of live organisms. The listed effects reflect changes in the structure and functioning of aquatic ecosystems, demonstrating the dependence of biological processes of production-destruction of organic matters (self-purification potential and capability of restoration) by hydrochemical parameters [3, p. 75; 4, p. 103], and may lead to the aquatic ecosystems' destruction [1, p. 259; 4, p. 104]. Modern scientists' experience allows on the basis of the analysis of the water exchange processes and formation of the water quality [1, p. 259; 5, p. 119; 6, p. 113; 7, p. 445; 8, p. 127] to predict the consequences of the organic matter development [2, p. 181] and the capability of restoration of the aquatic ecosystem [4, p. 104; 6, p. 113]. The hydroecologists' purpose suggests, by using models of water quality dependencies and bioproductivity from water exchange, to react promptly on changes of the water ecosystem state and manage of the water quality of the cascade of reservoirs for anthropogenic pollution reduction or elimination of water bodies [6, p. 113; 7, p. 445; 8, p. 127].

2. Mathematical model of the ecological state

Water quality assessment is a key task in the field of water use, environmental management and environmental protection measures for water bodies and their basins. Water quality is assessed by a wide range of indicators – biological (hydrobiological, bacteriological) and physico-chemical (hydrochemical, hydrophysical, hydrological). Biological methods based on assessing the state of the flora and fauna of water resources are widely used to determine the ecological state of a water body.

One of the main qualitative indicators of water bodies is their hydrochemical regime, which is determined by the influence of many factors: the dynamics of runoff, naturally climatic conditions, the intensity of human economic activity, etc. The use of physical and chemical methods involves the determination of abiotic factors: temperature, water clarity, concentrations of suspended solids, ionic composition, mineralization, concentration of nutrients, organic matter, oxygen dissolved in water, various toxins, pH, etc. Traditionally, water quality is determined by chemical methods. System analysis of existing methods for determining the quality of natural waters has shown the effectiveness of the use of integrated indicators.

Assessment of the ecological state of water bodies is reduced to an analysis of the proximity of the actual values of water parameters with the maximum allowable [9, p. 20]. However, the regulated number of water parameters is large. So, for freshwaters for domestic and cultural use, there are 1345, and for water objects for fishery use – 521. Therefore, it is rational to determine the ecological state of a water body using a complex indicator that relates water parameters to maximum permissible values.

The modern calculation method [9, p. 20] allows to determine quickly the ecological state of the aquatic ecosystem by the hydrochemical parameters. It also allows according to the ecological state integrated indices of the water body to assess its ability to self-purification potential and capability of restoration (ecological reliability), to analyze the ecological sustainability of the river and to take into account the effect of the total action of substances. Integrated index of the ecological state (IIES) is formed on the basis of existing standards and also includes maximum permissible concentrations (MPC).

Assessment of the ecological state of the Lower Section of the Dnieper River and of the Lower Section of the Ingulets River was performed on the integrated index of the ecological state (IIES) [9, p. 20] in accordance with the fishery standards, as the most sensitive to changes in the ecological state of the river. For water bodies which are used for the fishery use, the mean value of IIES is calculated by the formula:

$$IIES_{mean} = \frac{1}{m}\sum_{i=1}^{m} IIES_i \ , \qquad (1)$$

where m – number of water quality indices blocks (values $IIES_i$).

From the m blocks of water quality indices, the first includes indices that don't have the effect of total action (summation), the remaining blocks include indices that have this effect. According to the sanitary norms, the effect of total action is possessed by substances of the first and second classes of danger with the equal limiting indices of harmfulness (LIH).

According to the fishery norms substances with the equal LIH without taking into account the classes of danger are analyzed.

The ecological state of a water body is classified as follows:

– if $IIES_{\min} < 0$ and $IIES_{mean} < 0$ then the ecological state of the river area is estimated as unsteady;

– if $IIES_{\min} < 0$ and $IIES_{mean} > 0$ then the ecological state of water is estimated on average as stable with sources of instability;

– if $IIES_{\min} > 0$ and $IIES_{mean} > 0$ then the ecological state of water is estimated as stable.

In the qualification of the ecological state according to the first two points it is necessary to carry out environmental protection activities in the ecosystem. The obtained results allow carrying out an assessment of the ecological reliability of the ecosystem [9, p. 20]. Ecological reliability (ER) is the ability of the ecosystem's state to perform relatively complete processes of self-purification potential and capability of restoration.

The probability of a stable state of the river is called ecological reliability (ER), which is determined by the formula:

$$ER = 1 - \chi^2/(2N - M + 0,5\chi^2), \tag{2}$$

where χ^2 – the value of the function "chi-square" with the confidence probability assumed equal to 0,9 [10, p. 370]; N – the total number of values $IIES_{mean}$; M – the number of values $IIES_{mean}$ which are less then the critical, zero value.

Distribution probability of "chi-squared" recognizing right in connection with the fact that usually the number of surveyed sections of the river is small. For a large value of N, the "chi-squared" distribution reduces to a normal distribution. Based on the fact that complex technical systems are considered reliable at a reliability level of 0,90–0,95, the following qualification of reliability levels is used with a confidence level of 0,9: a high level ($ER \geq 0,9$), an acceptable level ($0,9 > ER \geq 0,8$), a low level ($ER < 0,8$) [9, p . 20].

3. Modeling process of self-purification of hydroecosystems

The results of studies of the surface waters of the Lower Section of the Dnieper River indicate constant water pollution and excess maximum permissible concentrations (MPS) of substances (Iron, Total ammonium, Sulphates and others). The main negative factors that change the water quality of the Dnieper River are regulation of runoff, discharges of industrial and agricultural wastewater, and the built up sanitary protection zones. The main seasonal factors affecting the quality of surface waters are intense erosion-hazardous rains and snowmelt, which lead to the flushing of a large number of various pollutants with surface soil particles and their accumulation in water bodies; high summer temperature or heat, which stimulates mass flowering of green algae in the Dnieper River, rotting processes; a reduction of oxygen in water leads to a significant deterioration in its physico-chemical and trophic state and a massive pestilence of fish.

The data of the analytical monitoring of surface waters of the Kherson Water Resources Board was used to assess the ecological state of the Lower Section of the Dnieper River on points of supervisions of water: 1 – the Dnieper River – town Novovorontsovka-Ushkalka, Kakhovka Reservoir (195 km from the mouth), 2 – the Dnieper River – low tail-water of Kakhovka HPS (92 km from the mouth), 3 – the Dnieper River – city Kherson, 1 km upstream the city (40 km from the mouth), 4 – the Dnieper River – village Kizomys, arm of a river Rvach (0 km from the mouth) (Figure 1).

Figure 1. Scheme of the Lower Section of the Dnieper River and the Lower Section of the Ingulets River

The initial data for assessing the ecological state of waters in the Lower Section of the Ingulets River are the results of analytical control of surface waters by the State Ecological Inspectorate in Kherson region: 5 – the Ingulets River – village Arkhanhel's'ke (210 km from the mouth), 6 – the Ingulets River – village Kalynivs'ke (124 km from the mouth), 8 – the Ingulets River – village Dar'ivka (20 km from the mouth) and the State Ecological Inspectorate in Mykolaiv region: 7 – the Ingulets River – town Snigurivka (100 km from the mouth) (Figure 1).

The results of recent studies of the surface waters of the Lower Section of the Dnieper River indicate constant water pollution and excess maximum permissible concentrations (MPS) of substances (Total ammonium, Suspended solids, Chlorides, Sulphates, Petroleum hydrocarbons, Iron, Copper, Manganese and others) (Figure 2) [8, p. 127; 11, p. 265; 12, p. 123; 13, p. 260; 14, p. 44].

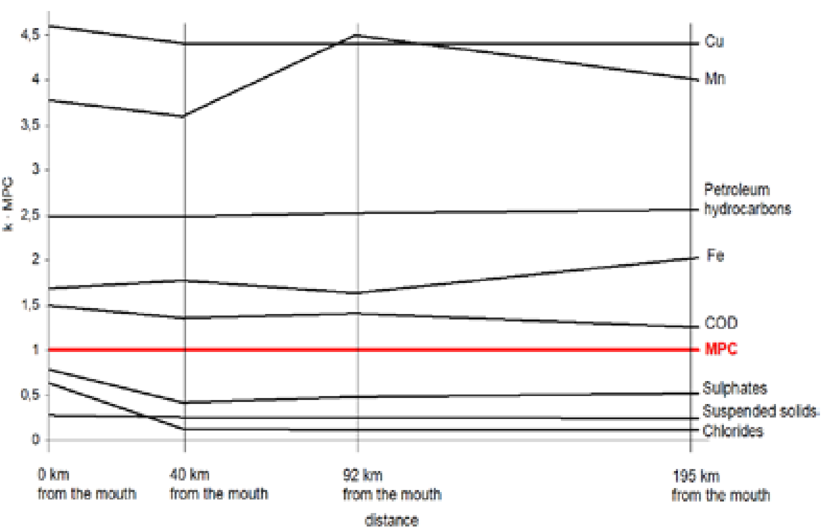

Figure 2. Excess annual average values (2013–2016) of hydrochemical ingredi-ents relative to MPC of the Lower Section of the Dnieper River

For the Lower Section of the Ingulets River, the maximum permissible concentration for Sulphates, Chlorides, Suspended solids, Iron and other substances (Figure 3, 4, 5, 6) are most often observed, which indicates that the main source of pollution is discharges of highly mineralized polluted industrial effluents of the city Kryvyi Rih serving the mining, metallurgical and chemical industries. In the Kryvyi Rih basin, 8 of 11 Ukrainian enterprises for the extraction and processing of iron ore are located. Here are enterprises serving the metallurgical industry – one of the world's largest metallurgical plants (PJSC "ArcelorMitall Kryvyi Rih"), five mining and processing combines (MPC) – Pivnichnyi MPC (PivnMPC), Pivdennyi MPC (PivdMPC), Cental'nyi MPC (CMPC), Novokryvoriz'ky MPC (NKMPC), Ingulets'kiy MPC (InMPC), three ore repair plants.

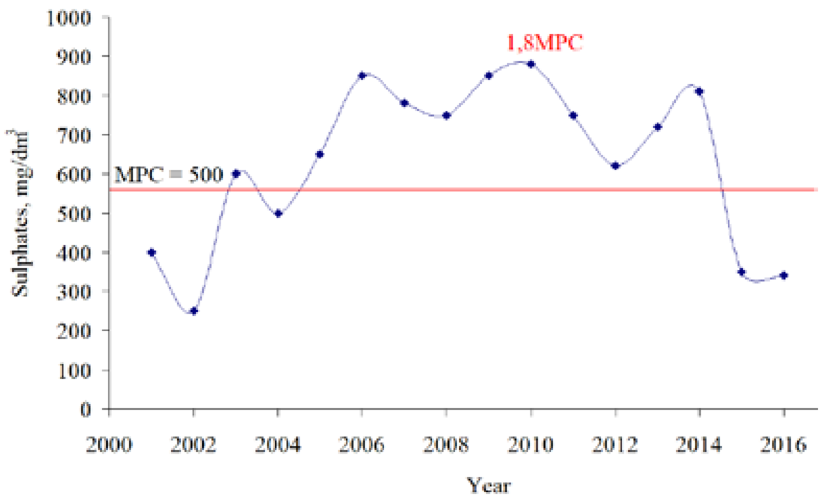

Figure 3. The dynamics of changes in the concentration of Sulfates in the Lower Section of the Ingulets River

The volume of wastewater of enterprises reaches millions of cubic meters per year, which negatively affects the quality of the water of the Ingulets River, which carries its polluted water to the Lower Section of the Dnieper River.

In the late 60s of the last century, in connection with the implementation of state programs for irrigation and drainage construction, the construction of large irrigation canals began, which at the same time solved the problems

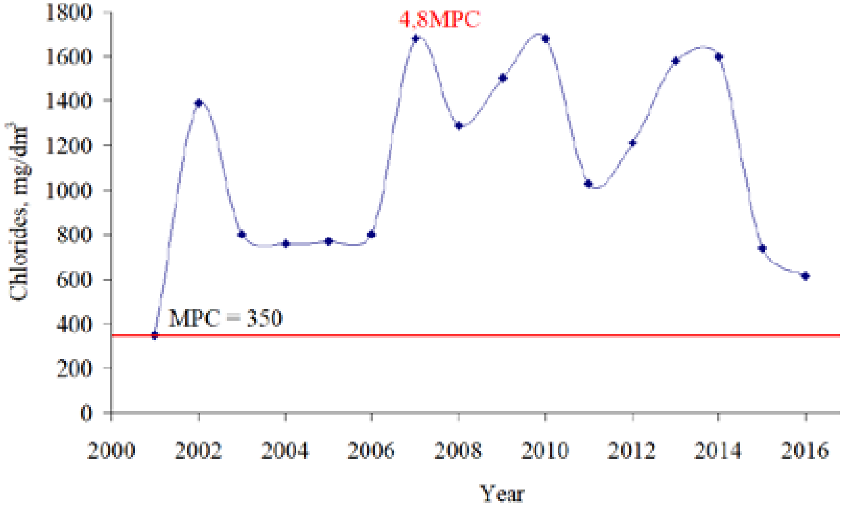

Figure 4. The dynamics of changes in the concentration of Chlorides in the Lower Section of the Ingulets River

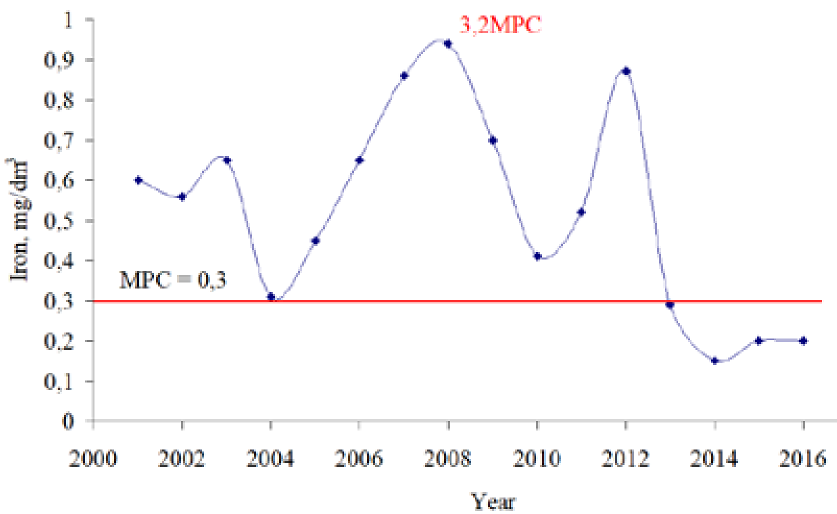

Figure 5. The dynamics of changes in the concentration of Iron in the Lower Section of the Ingulets River

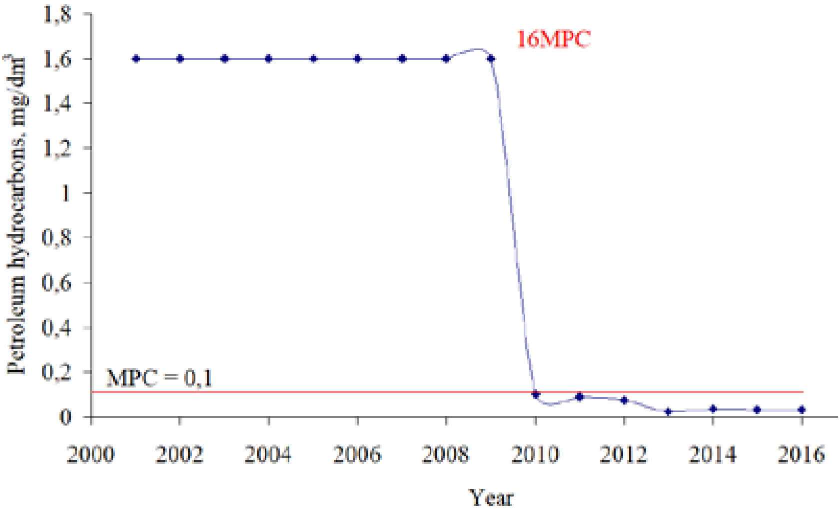

Figure 6. The dynamics of changes in the concentration of Petroleum Hydrocarbons in the Lower Section of the Ingulets River

of water supply for nearby settlements and industrial centers. The idea of expanding irrigated areas in the arid steppes of the south of the Nikolaev region was laid down in the Danube- Dnieper Canal project and was partially implemented through the operation of the Ingulets Canal (1989). Due to the transfer of runoff from the Dnieper River (donor river), the annual runoff of the Ingulets River increases. In addition, the additional flow of water into the Ingulets River occurs due to the formation of reverse filtration water from agricultural lands that are irrigated by the Dnieper River. During the transition to more arid territories, the influence of anthropogenic activity increases, and despite the artificial increase in the water exchange of the Ingulets River, the ecological state of the watercourse does not improve, since polluted waters enter the river. The agricultural development of the study area is quite high (the area of agricultural land is 69,2%), therefore, the application of pesticides leads to pollution of the soil with toxic elements, and the flowing of water from the fields by the surface and filter-ing cause the migration of carcinogens to the nearest water body – to the Ingulets River. In the mixed waters of the Ingulets and Dnieper Rivers (irrigation area 37140 hectares), the chemical composition is chloride-sulfate-hydrocarbonate, sulfate-chloride, sodium-calcium-magnesium with a total mineralization of up to 3,5 g/dm^3 (downstream the Karachunivs'ke reservoir).

The main seasonal factors affecting the quality of the surface waters of the Lower Section of the Dnieper River are intense erosion-hazardous rains and snowmelt, which lead to the flushing of a large number of various pollutants with surface particles of the soil and their accumulation in water bodies. High summer temperature or heat, which stimulates mass flowering of green algae in the Dnieper River, rotting processes; a reduction of oxygen in water leads to a significant deterioration in its physico-chemical and trophic state and a massive pestilence of fish.

The effect of the total action of the factors describe above forms the hydro-chemical marks of the water bodies of the Lower Section of the Dnieper River and determines the qualitative composition of the surface runoff. The processes of formation of the chemical composition of water occur under the influence of a powerful anthropogenic load on water resources, the consequences of which are amplified in conditions of global warming. In this regard, it is very important not only observation and control, but also timely analysis of changes in hydrochemical marks in time and space, a reliable assessment of water quality.

As a result of the study, a complex assessment of the water quality of the Lower Sections of the Dnieper River and the Ingulets River was carried out using different methods in accordance with the water quality standards of surface water bodies for fishery purposes. It was found that the water quality of the Lower Section of the Dnieper River according to different methods (water pollution index, modified water pollution index, combinatorial water pollution index and integrated assessment method) varies from "moderately contaminated" to "contaminated". Study of waters quality indicators of the Lower Section of the Ingulets River, determined based on the application of the same calculation methods to hydrochemical data, showed, that waters are mostly "contaminated", "very contaminated", or "catastrophically contaminated". Therefore, there is a need to assess the ecological state of the Low Podniproviya hydroecosystem using a complex indicator that relates water parameters to the maximum permissible indicators, namely, with the help of a complex indicator of the eco-logical state. The obtained complex indicators allow us to move on to assessing the environmental reliability of water bodies – the ability of a hydroecosystem to full relatively self-purification and self-regulation.

The Integrated indices calculation of the ecological state of the Lower Section of the Dnieper River according to the fishery norms was made. An example of assessing the ecological state of a water body by using integrated index IIES on gauge station the Dnieper River – village Kizomys, arm of a river Rvach (0 km from the mouth) for observations in 2016 according to the fishery norms is presented in Table 1.

Table 1

Assessment of water quality of the Dnieper River – village Kizomys, arm of a river Rvach (0 km from the mouth) according to the integrated index IIES fol-lowing to the fishery norms for 2016

LIH	Parameter	C_i, mg/dm³	MPS, mg/dm³	MPS – C_i	IES	IIES
General health	Suspended solids	5,0	20,0	15,0	0,75	
	BOD_5	1,63	3,0	1,37	0,46	
	pH	7,91	6,5–8,5	0,59	0,07	
	Dissolved oxygen	10,0	6,0	–4,0	–0,67	
Σ					0,61	0,15
Toxicological	Saline ammonia	0,12	0,50	–	0,24	
	Nitrites	0,03	0,08	–	0,38	
	ASAS	0,01	0,50	–	0,02	
	Iron	0,12	0,10	–	1,2	
	Copper	0,01	0,001	–	10,0	
	Manganese	0,05	0,01	–	5,0	
Σ					16,84	–15,84
Sanitary-toxicological	Chlorides	82,0	300	–	0,27	
	Sulphates	68,4	100	–	0,68	
	Calcium	48,0	180	–	0,27	
	Nitrates	0,93	40,0	–	0,02	
	Chrome	0,001	0,001	–	1,00	
	Magnesium	18,3	40,0	–	0,46	
Σ					2,70	–1,70
Fishery	Petroleum hydro-carbons	0,3	0,05	–	6,00	–5,00
$IIES_{mean}$ = (0,15–15,84–1,70–5,00)/4=–5,6, $IIES_{min}$ = –15,8 (the ecological state of the object is unsteady)						

Summary results of the assessment of the ecological state of the Lower Section of the Dnieper River in time and in space (along the river stream) over the period of 2013–2016 are presented in Table 2.

Table 2

Assessment of Ecological State of the Lower Section of the Dnieper River in space (along the river stream) and time over the years 2013–2016

Gauge station	Integrated index of the ecological state (IIES)							
	min	mean	min	mean	min	mean	min	mean
	ecological state of a water body							
	2013		2014		2015		2016	
1	–2,2	–0,6	–3,7	–1,0	–16,2	–5,7	–17,2	–5,9
	unsteady		unsteady		unsteady		unsteady	
2	–2,2	–0,5	–4,2	–1,1	–17,1	–5,1	–16,8	–5,8
	unsteady		unsteady		unsteady		unsteady	
3	–2,1	–0,5	–2,9	–0,8	–16,2	–5,6	–15,7	–5,5
	unsteady		unsteady		unsteady		unsteady	
4	–2,3	–0,7	–3,5	–1,3	–16,0	–4,8	–15,8	–5,6
	unsteady		unsteady		unsteady		unsteady	

Dnieper River in time and in space (along the river stream) is estimated as un-steady. Dynamics of quantitative parameters of mean and minimum coefficients demonstrates deterioration of river water quality in time. For the observation period 2013–2016, the environmental reliability (ER) was assessed in time and in space (along the river stream). The values of environmental reliability were calculated (ER = 0,74), which corresponds to a low level of self-purification potential and capability of restoration.

The dynamics of the results of the studies in time (Table 2) demonstrates the increase of the negative consequences of anthropogenic load and the need for the implementation of environmental events aimed at renewing the ability of the aquatic ecosystem to self-purification and capability of restoration.

The calculation of the integrated indicators of the ecological state of the waters for the gauge station of the Ingulets River – town Snigurivka in accordance with the requirements of fishery water use for the observation period 2001–2016 was completed. An example of assessing the ecological state of a water body using the integrated index IIES for the gauge station of the Ingulets River – town Snigurivka for 2014 observation period due to the fishery norms is given in table 3.

Table 3

Assessment of water quality of the Ingulets River – town Snigurivka (100 km from the mouth) according to the integrated index IIES following to the fishery norms for 2014

LIH	Parameter	C_i, mg/dm³	MPS, mg/dm³	MPS – C_i	IES	IIES
General health	Suspended solids	40,2	20,0	–20,2	–1,01	
	BOD_5	4,9	3,0	–1,9	–0,63	
	pH	7,6	6,5–8,5	0,9	0,11	
	Dissolved oxygen	11,4	6,0	5,4	0,90	
Σ					–0,63	–0,17
Toxicological	Saline ammonia	0,43	0,50	–	0,86	
	Nitrites	0,071	0,08	–	0,89	
	ASAS	0,019	0,50	–	0,04	
	Iron	0,148	0,10	–	1,48	
	Copper	0,006	0,001	–	6,0	
	Manganese	0,003	0,01	–	0,30	
Σ					9,57	–8,57
Sanitary-toxicological	Chlorides	1588,4	300	–	5,29	
	Sulphates	823,5	100	–	8,24	
	Calcium	172,4	180	–	0,96	
	Nitrates	9,9	40,0	–	0,25	
	Chrome	0,001	0,001	–	1,00	
Σ					15,74	–14,7
Fishery	Petroleum hydro-carbons	0,04	0,05	–	0,80	0,2
$IIES_{mean}$ = (–0,17–8,57–14,74+0,20)/4=–5,82, $IIES_{min}$ = –14,74 (the ecological state of the object is unsteady)						

The summary results of the assessment of the ecological state of the river for the gauge station of the Ingulets River – town Snigurivka in time are given in Table 4.

During the observation period (2001–2016), the ecological state of the Lower Section of the Ingulets River in time is estimated as unsteady. Dynamics of quantitative parameters of mean and minimum coefficients demonstrates deterioration of river water quality in time. For the observation period 2001–2016, the environmental reliability (ER) was assessed in time. The values of environmental reliability were calculated (ER = 0,56), which corresponds to a low level of self-purification potential and capability of restoration.

Table 4

Assessment of Ecological State of the Lower Section of the Ingulets River in time over the years 2001–2016

Year	Integrated index of the ecological state (IIES)		The ecological state of the water object
	$IIES_{mean}$	$IIES_{min}$	
2001	–15,3	–31,0	unsteady
2002	–15,3	–31,0	unsteady
2003	–16,9	–31,0	unsteady
2004	–14,0	–31,0	unsteady
2005	–14,9	–31,0	unsteady
2006	–19,1	–31,6	unsteady
2007	–22,3	–42,5	unsteady
2008	–20,0	–32,4	unsteady
2009	–15,5	–31,0	unsteady
2010	–7,9	–15,4	unsteady
2011	–7,3	–16,3	unsteady
2012	–7,8	–19,2	unsteady
2013	–6,7	–13,8	unsteady
2014	–5,8	–14,7	unsteady
2015	–7,2	–20,0	unsteady
2016	–6,9	–19,8	unsteady

Assessment of the ecological state and ecological reliability of the Lower Sec-tion of the Ingulets River aquatic ecosystem along the length has also been performed (the gauge stations: the Ingulets River – village Arkhanhel's'ke, the Ingulets River – village Kalynivs'ke, the Ingulets River – town Snigurivka, the Ingulets River – village Dar'ivka) for 2013–2016. An example of assessing the ecological state of the water body in the gauge station the Ingulets River – village Dar'ivka for observations in 2016 according to fishery norms is given in table 5.

Summary results of the assessment of the ecological state of the Lower Section of the Ingulets River in time and in space (along the river stream) over the period of 2013–2016 are presented in Table 6.

Table 5

Assessment of water quality of the Ingulets River – village Daryivka (20 km from the mouth) according to the integrated index IIES following to the fishery norms for 2016

LIH	Parameter	C_i, mg/dm³	MPS, mg/dm³	MPS – C_i	IES	IIES
General health	Suspended solids	16,4	20,0	3,6	0,18	
	BOD_5	3,9	3,0	–0,9	–0,30	
	pH	8,05	6,5–8,5	0,45	0,053	
	Dissolved oxygen	9,8	6,0	3,8	0,63	
Σ					0,56	0,14
Toxicological	Saline ammonia	0,14	0,50	–	0,28	
	Nitrites	0,04	0,08	–	0,50	
	ASAS	0,04	0,50	–	0,08	
	Iron	0,19	0,10	–	1,87	
	Copper	0,01	0,001	–	10,0	
	Manganese	0,07	0,01	–	7,00	
Σ					19,73	–18,73
Sanitary-toxicological	Chlorides	613,7	300	–	2,05	
	Sulphates	336,7	100	–	3,37	
	Calcium	103,7	180	–	0,58	
	Nitrates	2,15	40,0	–	0,05	
	Chrome	0,001	0,001	–	1,00	
Σ					7,05	–6,05
Fishery	Petroleum hydro-carbons	0,03	0,05	–	0,60	0,40
$IIES_{mean}$ = (0,14–18,73–6,05+0,40)/4=–6,06, $IIES_{min}$ = –18,73 (the ecological state of the object is unsteady)						

During the period of research, the ecological state of the Lower Section of the Ingulets River is assessed as unsteady. A slight improvement in water quality from 2010 to 2014 [11, p. 265; 12, p. 123] is explained by the implementation for PJSC "ArcelorMitall Kryvyi Rih" an environmental monitoring system for wastewater and modern treatment facilities, as well as the annual "flushing" of the Ingulets river bed

with Dnieper water [15, p. 28], transported along the Dnieper-Ingulets Canal. In accordance with the regulation of channel flushing and rehabilitation of the Ingulets River, during April-July 2018, the State Water Agency discharged water from the

Table 6

Assessment of Ecological State of the Lower Section of the Ingulets River in space (along the river stream) and time over the years 2013–2016

Gauge station	Integrated index of the ecological state (IIES)							
	min	mean	min	mean	min	mean	min	mean
	ecological state of a water body							
	2013		2014		2015		2016	
5	–11,2	–4,7	–7,5	–3,6	–19,6	–6,9	–17,4	–6,6
	unsteady		unsteady		unsteady		unsteady	
6	–7,8	–3,5	–7,9	–3,5	–19,7	–6,8	–18,3	–6,7
	unsteady		unsteady		unsteady		unsteady	
7	–13,3	–6,6	–14,7	–5,7	–20,0	–7,2	–19,8	–6,9
	unsteady		unsteady		unsteady		unsteady	
8	–10,2	–3,7	–8,6	–3,2	–18,9	–6,2	–18,7	–6,1
	unsteady		unsteady		unsteady		unsteady	

Karachunivs'ke reservoir with a total volume of about 120,0 million m3. The dis-placement of highly mineralized water from the river bed of the Ingulets River (completion of flushing) was carried out from June 5 to 25. In the period from April 20 to June 30, the Kakhovka hydroelectric station was operated in the basic mode with the lowest possible costs, the value of which was established in the working order depending on the hydrological situation in the Lower Section of the Dnieper River for the period of saline prism pushing out of the Lower Section of the Ingulets River.

During the observation period, the ecological state of the Lower Section of the Ingulets River in time and in space (along the river stream) is estimated as unsteady. Dynamics of quantitative parameters of mean and minimum coefficients demonstrates deterioration of river water quality in time. For the observation period 2013–2016, the environmental reliability (ER) was assessed in time and in space (along the river stream). The values of environmental reliability were calculated (ER = 0,74), which corresponds to a low level of self-purification potential and capability of restoration.

Changes in the quantitative indicators of the average and minimum coefficients demonstrate a slight deterioration in the quality of water in the section of the river downstream from village Arkhangel's'ke to town Snigurivka. This is due to the unstable mixing mode due to the significant sinuosity of the river bed. Characteristic loops of meanders 5–7 km long almost turn some sections of the river to the starting point, which leads to a deterioration in water quality. An additional factor determining the increase of IIES (Table 6) is the high degree of agricultural use of the area. The introduction of chemical plant protection products leads to soil contamination with toxic elements, and the run-off of water from the fields by the surface path and underground filtration contribute to the migration of carcinogens to the nearest water body (the Ingulets River). Further relative improvement in water quality indicators in the area of the village Dar'ivka (Table 6) is due to the reduce of the mineralization effect of the Dnieper water [15, p. 35].

Recovery of the processes which activate an ability of the Lower Section of the Dnieper River to cleanse itself is possible due to the optimization of the regime of Kakhovka HPS-1 releases [3, p. 80; 5, p. 123; 1, p. 263] and/or building Kakhovka HPS-2 [16, p. 61]. According to the calculations of the Institute of Hydrobiology of the National Academy of Sciences of Ukraine approximately twice the size of the design (at a discharge of 5100 m3/s) of the velocity of flow in the river bed and the arms of the Dnieper River. The external water exchange of the zone channel network will intensify – the period of its external water exchange will decrease from 11,4–17,2 to 5,8–8,8 days (values are given for 6 and 4-hour releases, respectively).

5. Conclusions

1. Ecological state of the Lower Section of the Dnieper River (including the Lower Section of the Ingulets River) was estimated by method of

calculation of integrated index on the basis of monitoring over the years 2001–2016 of surface waters of the Kherson Water Resources Board, the State Ecological Inspectorate in Kherson region and the State Ecological Inspectorate in Mykolaiv region.

2. Methodology for assessing the quality of surface water by hydrochemical parameters in accordance with the fishery standards as the most sensitive to changes of the ecological state of the river was used. The modern calculation method takes into account the effect of the total action of substances.

3. Self-purification potential and capability of restoration in time and space (along the river stream) of the aquatic ecosystem of the Lower Section of the Dnieper River and of the Lower Section of the Ingulets River were established. It was discovered, that the state of surface water of region was characterized as unsteady with the low of ecological reliability. Consequently, the processes of self-purification potential and capability of restoration of the aquatic ecosystem are at the low level.

4. The ecological state of the hydroecosystems of Low Podniproviya is characterized as an ecological regress.

5. Recovery of the processes which activate an ability of the Lower Section of the Dnieper River to cleanse itself is possible due to the optimization of the regime of Kakhovka HPS-1 releases and/or building Kakhovka HPS-2. The activation of the external water exchange will unambiguously increase the intensity of the river ability to cleanse water masses, will improve the water quality in the system of Low Podneproviya and the ecological state of the hydroecosystem.

6. The qualification of the ecological state of the Lower Section of the Dnieper River (including the Lower Section of the Ingulets River) determines the necessity to carry out environmental protection activities in the ecosystem (for example, reduce the volume of wastewater discharges, stop the enterprise, increase releases from Kakhovka reservoir, etc.).

7. The research results presented in this article can be the basis for establishing trends changes in the ecological state of the surface waters of the Lower Section of the Dnieper River (including the Lower Section of the Ingulets River) in time and space, determining the impact of anthropogenic load on ecosystems of water bodies, estimating changes of water quality, informing the public, solving economic and social issues, related to the rational use of natural resources and ensuring environmental protection.

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CHAPTER «GEOLOGICAL SCIENCES»

THE "WINGED FORELAND" ABRASION-ACCUMULATIVE SYSTEMS

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Abstract. *The purpose* of the study is to conduct a deep morphogenetic analysis of the "Winged forelands" coastal systems to highlight system-wide genetic features and present the most complete scientific definition, as well as to conduct morphogenetic identification and geographical allocation of these systems. *Methodology.* The object of the study is the "Winged forelands" coastal systems. The subject of the study is the analysis of genetic features of the "Winged forelands" abrasion-accumulative systems at the present stage of development. During the study we used the following methods: logical and theoretical generalization, finding empirical dependencies, analytical and cartographic analysis. Based on the results of the study, we came to the conclusion that the natural "Winged foreland" formation refers to divergent-type abrasion-accumulating lithodynamic systems. Within their limits, oppositely directed alongshore drift flows occur with a certain periodicity and they consist of three components – the indigenous area of the coast and two accumulative forms. The specific peculiarities of the "Winged foreland" are due to the presence of a certain number of genetic features, which include: morphological, lithodynamic, hydrodynamic and evolutionary. However, the manifestation of all these features at the same time is extremely rare. Therefore, in our opinion, the presence of 2-3 features is sufficient for the formation of a specific appearance

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of this coastal formation. The "Winged foreland" received a fairly limited distribution, which indicates the great specificity of the conditions in their formation. The largest number of these formations is characteristic of the shores of internal seas, where genetic factors of development do not appear regularly, but with a certain interval. That is why, in our opinion, periodic changes in development conditions, which are most often manifested in the conditions of non-tidal seas, are very important for the formation of these systems. *Practical implications.* The obtained research results can be used in solving a number of theoretical problems in the development of environmental measures; developing an overall strategy for economic and recreational development of the coastal zone within the "Winged foreland" formations. Scientific novelty. In this paper, for the first time, a general classification of genetic features of abrasion-accumulative coastal systems within the study region is summarized and their correspondence to characteristics of the "Winged foreland" formation is analyzed.

1. Introduction

The coastal zone of the World Ocean is a very complex natural formation located on the border between land and ocean and is a very important link in the global lithodynamic system [4; 5; 35; 36; 43; 51]. Structurally, this natural formation consists of a set of separate sections or coastal lithodynamic systems, which are characterized by an independent regime and sediment budget [11; 15; 35; 51]. Lithodynamic systems in the coastal zone of the World Ocean are characterized by a certain variety. The most specific and at the same time the least described are the "Winged forelands" abrasion-accumulative coastal systems.

At the present stage of development of the coastal zone of the World Ocean, within its limits, anthropogenic activity intensifies, which leads to significant changes in the direction of evolution of many coastal systems. It should be noted that these changes very often are unpredictable and destructive. Considering the insignificant degree of knowledge of the "Winged forelands" formations, it is impossible to carry out activities aimed at rational nature management within them, which is why the topic of this publication is actual.

The purpose of the study is to conduct a deep morphogenetic analysis of the "Winged forelands" coastal systems to highlight system-wide genetic features and present the most complete scientific definition, as well as to conduct morphogenetic identification and geographical allocation of these systems.

The methodological basis of this study is the English- and Russian-language publications devoted to these systems, as well as our own field studies conducted on the shores of the Black Sea and the Sea of Azov.

In this paper, we will consider the taxonomic place of the "Winged forelands" among coastal lithodynamic systems, as well as analyze the terminological definition of these formations presented earlier and propose our own. Based on an in-depth analysis of publications devoted to the "Winged forelands", we will identify the genetic characteristics of these formations, analyze their geographical allocation and identify the most famous coastal systems of this type.

2. Lithodynamic coastal systems and their diversity

Within the coastal zone of the oceans the separate large areas are distinguished, which are characterized by an independent regime and sediment budget. These areas represent unified complexly developing formations called lithodynamic systems or cells [18; 19; 35; 36; 45; 51].

In a specialized terminological reference book on marine geomorphology, the lithodynamic system is defined as a large area of the coastal zone with a sediment regime and budget that is independent of other similar areas. This concept originated due to the need to analyze the mutual influence of individual areas of the coastal zone both for research purposes and during the construction of shore protection structures that interrupt the alongshore movement of sediments. Each coastal lithodynamic system includes a sediment source, a transition zone and an accumulation area [45, p. 73].

Coastal lithodynamic systems according to the nature of the direction of sedimentation flows within their limits are divided into three groups: *abrasive, abrasion-accumulative and accumulative* [31; 35; 51].

Abrasive coastal systems are areas of the coastal zone with very active destruction processes of the surface and underwater parts. A large amount of clastic material is formed within their limits, which, due to the morphological or lithological features of the coastal zone, does not stay within it, but performs an active downward movement towards deeper areas of the nearshore slope.

Accumulative coastal systems are areas of the coastal zone within which there is a massive accumulation of coastal-marine sediments formed on the nearshore slope. They enter the accumulation region due to the transverse or alongshore drift flow.

Abrasion-accumulative coastal systems are complex lithodynamic formations, which are most widespread in the coastal zone of the World Ocean. Structurally, within these systems, three components are distinguished: an abrasion area (supply zone), an abrasion-accumulating area (transit zone) and an accumulative area (discharge zone). For the corresponding systems, the main genetic feature is the presence in the coastal zone of an alongshore drift flow. It should be noted that in most cases, this movement of sediments appears simultaneously with the transverse.

The described coastal systems are characterized by a variety of genetic and lithodynamic features that contribute to the formation of their morphological diversity. According to the direction of coastal-marine deposits movement, abrasion-accumulative systems are divided into *convergent* and *divergent*.

Abrasion-accumulative convergent coastal systems consist of two separate abrasive areas, within which alongshore drift flows are formed, directed towards a single accumulation area, where the marine accumulative form is formed [45, p. 72].

Abrasion-accumulative divergent coastal systems are characterized by the presence of one abrasion area, within which two oppositely directed alongshore drift flows are formed. These flows form two different accumulative forms, which at the same time are elements of a unified coastal system. These coastal formations are called "Winged foreland" and they are characterized by a rather limited distribution in the coastal zone of the oceans.

Structurally, the "Winged foreland" abrasion-accumulative systems are two abrasion-accumulative pairs, within which a common supply area is allocated, usually in the form of an abrasion shore, to which two transit and discharge zones adjoining on opposite sides, having the form of accumulative forms.

These coastal systems do not have a unified scientific definition; there is no consensus on their genetic features and diversity, as well as on the place of these formations in the lithodynamic system of the coastal zone of the World Ocean. All this together contributed to the fact that the "Winged forelands" were not deservedly deprived of attention and did not have an appropriate degree of knowledge.

3. The definition of the "Winged foreland" coastal system

The definition of "Winged foreland" in the original interpretation of "Winged beheadland" was first proposed by the American scientist F. Gulliver [9, p. 213]. According to this author, the "Winged beheadland" is a specific coastal formation, which comprises a section of the indigenous coast and two accumulative forms adjacent to it from opposite sides. Alongshore movement of sediments is carried out between structural elements, mainly from the indigenous section in the direction of accumulative forms, while the direction of flows has seasonal differences.

At the beginning of the twentieth century, the English scientist Douglas Johnson gave his definition to the concept of "Winged foreland" in his fundamental work "Shore process and development" [10, p. 306]. According to Johnson, the "Winged forelands" (the "Winged headland" as interpreted by the author) are specific coastal forms that look like a cape, bounded on both sides by bays and accumulative spits. At the same time, the author believes that these landforms are formed within the originally dissected bay coast, at the stage of its youth. The abrasion of the protruding indigenous capes leads to the formation of clastic material, which is involved in the alongshore movement, and contributes to the formation of accumulative forms.

V.P. Zenkovich described the "Winged foreland" coastal formations as a special type of abrasion-accumulating systems in which one abrasion section (cape) feeds two forms on either side of itself, resulting in specific formations [31, p. 295].

The author notes that this term is used regardless of whether the spits are directed inside the coastal contour or are elongated along the same line with each other and the abraded part of the cape. At the same time V.P. Zenkovich focuses on the evolutionary aspect, according to which, the consistent restoration of development phases of this form indicates that earlier both spits were directed towards the coast and made a certain angle with the edges of the cape. The subsequent pulling of the system in one line occurs due to the abrasion of the cape and the simultaneous accumulation along the entire front of the spits; for each of them the process occurs at different times. With the simultaneous direction of the waves, only the corresponding abrasion section and spit are active, while the second pair is blocked; in the other direction of the waves, they change places [31, p. 295].

V.P. Zenkovich in his fundamental specialized work "Processes of coastal development" slightly expands the understanding of the "Winged forelands" nature, focuses on the fact that this formation is a region of interaction between two adjacent abrasion-accumulating pairs. In one direction of the waves, only the abrasion section and the corresponding spit are active; the second spit is blocked at this time. In a different direction of the waves, they change places. At the same time, both spits turn into "displaced" forms [35, p. 406].

The final definition of the "Winged foreland" coastal system was presented by V.P. Zenkovich in a specialized directory [45, p. 186]:

"Winged foreland" is a combination of an eroded indigenous cape and two spits that grow due to the transfer of destruction products on either side of it. Examples are frequent on the Drumlin shores".

It should be noted that in this reference manual [45, p. 134)] the estuarine areas of one-arm deltas, which are designated as "flanking bars" [47], are also referred to "Winged foreland" coastal systems. In our opinion, the allocation of the "Winged foreland" system in the area of the river estuary does not correspond to the initial definition of such formations, at the same time, emphasizes their lithological and morphological features.

The most general definition of the studied coastal system was presented by Schukin I.S. in the encyclopedic dictionary: "Winged foreland is a cape with spits extending from both sides – "wings" washed by the sea" [49, p. 216].

In 1982, the specialized encyclopedia "The Encyclopedia of Beaches and Coastal Environments" was edited by Maurice L. Schwartz. In this work, "Winged forelands" are considered not as a natural system, but as one of the specific types of accumulative coastal forms – spits, which develop in the conditions of existence of divergent sediment flows [19, p. 790].

Thus, for more than a century of coastal science development, there is no universally accepted definition of this coastal system. That is why, on the basis of the analysis of literary, cartographic and general geographic materials, as well as our own field studies, we presented our own definition of this system.

"Winged foreland" is an abrasion-accumulative coastal system that has divergent features, within which three morphological components are identified, interconnected by alongshore sediments flows [30, p. 127].

4. Genetic features of the "Winged foreland" coastal system

Based on an analysis of the works of English-speaking [6; 9; 16; 19] and Russian-speaking scientists [25; 31; 33; 34; 39; 40; 43; 45; 51], we interpreted the generalized genetic features of the "Winged forelands" coastal systems. In our opinion, these features include: morphological, lithodynamic, hydrodynamic and evolutionary.

Morphological feature. According to the generally accepted opinion, three morphological elements are distinguished within the "Winged foreland" coastal system: the abrasive indigenous coast and two accumulative forms located on either side of it. These accumulative forms are in most cases free, that is to say extended towards the sea. Thanks to this feature, F. Gulliver applied the term "Winged headland" ("Winged foreland") to this formation. It should be noted that this feature is typical for absolutely all formations of this type.

Lithodynamic feature. The indigenous area of the coast located in the central part of the system is actively destroyed, retreats and supplies the accumulative formations adjoining it with clastic material. However, in our opinion, the alongshore drift flows that begin within the divergence zone and are directed in opposite directions are a more important system-forming factor, thereby forming morphological features of the "Winged foreland" coastal system. This feature is inherent for most of these formations, but within some it is not clearly expressed or has a seasonal character.

Hydrodynamic feature. Within the studied systems, two adjacent abrasion-accumulative systems interact, which develop in a reverse mode, depending on the characteristics of the waves. The formation of a certain wave between the indigenous abrasion area and one of the accumulative forms leads to activation of the alongshore drift flow, while the other form does not receive the supply, it remains blocked. With the formation of another direction wave, the accumulative formations change places. It is this feature that determines the existence of two accumulative forms within the studied system.

Evolutionary feature. In most of the earlier descriptions, the "Winged forelands" coastal systems are considered as an integral part of the evolution of a dismembered bay coast. Moreover, their formation occurs in the early stages of development of this coast, and eventually leads to its alignment and transformation into an abrasive-aligned.

The distinguished genetic features of the studied coastal system made it possible to analyze the diversity of abrasion-accumulative systems and to interpret "Winged foreland" among them according to morphological characteristics and to evaluate their geographical distribution [8].

5. Geographical allocation of "Winged forelands" coastal systems

The "Winged forelands" coastal systems were originally identified and described within the oceanic shores on the Atlantic coast of North America. However, they received the greatest distribution within the internal seas of Eurasia, within which there are no tidal occurrences; these include the Sea of Azov, the Black, the Baltic and the Caspian seas [8; 9]. Considering that oceanic and marine formations are formed under different hydrological situations, we decided to focus on coastal systems of internal seas, where genetic features can be analyzed using different examples.

Within the Black Sea coastal zone, systems morphologically similar to the "Winged forelands" are located exclusively in the shallow northwestern part (Figure 1). The largest coastal system of this type is *Tendra-Dzharylgach,* its total length is about 130 km, of which the indigenous area or "headland" is 22 km, the Tendra spit is 65 km, and the Dzharylgach spit is 42 km. Morphogenetically, this formation is a coastal bar that has experienced displacement and transformation [29; 38].

The Kinburnska-Pokrovska-Dovgiy coastal system has a length of about 35 km, of which "headland" is 12 km, the Kinburnska Spit is 10 km, the Pokrovska Spit is 6 km and the complex system of the island bar and the Krugliy and Dovgiy islands are about 7 km. The genesis of this "Winged foreland" is also associated with the displacement and transformation of the coastal bar [34; 54].

The Lebedina-Vustrichna coastal system has a total length of 6.1 km, of which the indigenous protrusion occupies 4.3 km, the Lebedina Spit is about 0.34 km, and the Vustrichna Spit is 1.5 km. Morphogenetically, the accumulative forms of the system are spits, the formation of which is directly dependent on the biogenic factor.

The total length of the *Burnaska-Budatska coastal system* is about 55 km, of which the "headland" is 30 km, the Burnaska barrier beach is 6 km and the Budatska barrier beach is 17 km. Genetically, this system is also an adjoining and transformed coastal bar [25; 34; 55].

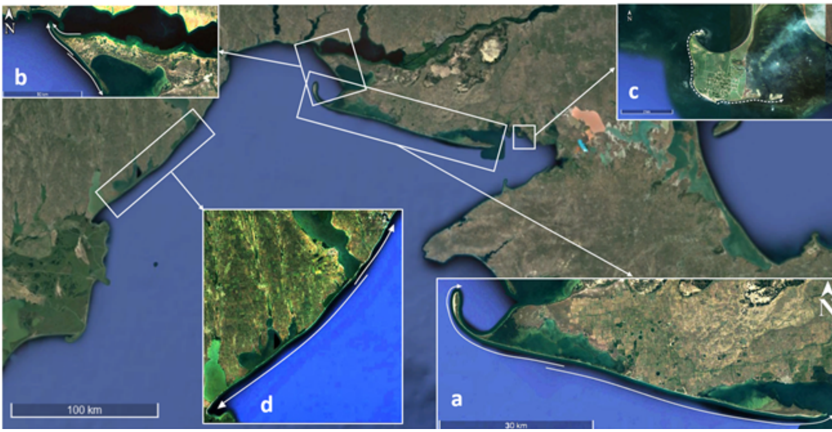

Figure 1. The Geographical location of the "Winged forelands" coastal systems within the coastal zone of the northwestern part of the Black Sea. The letters on the map mark the coastal systems: a – Tendra-Dzharylgach; b – Kinburnska-Pokrovska-Dovgiy; c – Lebedina-Vustrichna; d – Burnaska-Budatska (created based on the Google Earth resource)

The Dolgaya-Kamyshevatskaya is the only "winged foreland" within the coastal zone of the Sea of Azov located in the eastern part, in the region of the Yeysk Peninsula (Figure 2, a). The length of the system is about 53 km, of which the "headland" occupies about 30 km, the Dolgaya Spit is 17 km, and the Kamyshevatskaya Spit is 6 km. The genesis and evolution of the system is associated with the transformation of the coastal bar and the formation of arrow-shaped spit and spit within its termination [12; 35; 44].

The Curonian-Baltic coastal system is located in the southeastern part of the Baltic Sea (Figure 2, b). Its total length is about 220 km, of which the "headland" occupies about 54 km, the Curonian Spit is 98 km, and the Baltic (Vistula) Spit is 65 km. Genetically, this system is also a coastal bar that has shifted and transformed [3; 21; 22]. The indigenous cusp is composed of glacial rocks, and accumulative forms consist of alluvial and fluvioglacial sands [2; 17].

The Cheleken "winged foreland" is located in the coastal zone of the Cheleken Peninsula, in the southeastern part of the Caspian Sea (Figure 2, c).

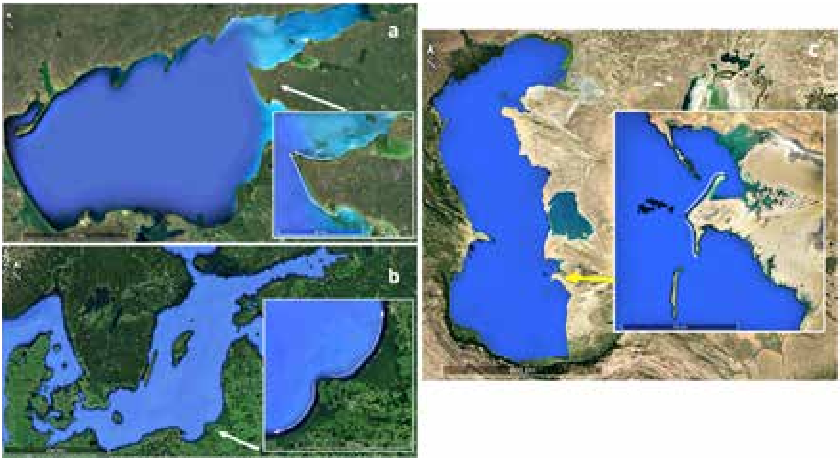

Figure 2. The geographical location of the "Winged forelands" coastal systems: a) Dolgaya-Kamyshevatskaya, eastern part of the Sea of Azov; b) Curonian-Baltic, southeastern part of the Baltic Sea; c) Cheleken, the southeastern part of the Caspian Sea

The total length of the system is about 62 km, of which the indigenous areas are 25 km, the North Cheleken Spit is 20 km, and the South Cheleken Spit is 17 km. Morphogenetically, this coastal system is also a coastal bar [32; 35; 40; 41].

6. Morphogenetic analysis of the "Winged forelands" coastal systems

Having determined the geographical allocation of coastal systems, which resemble the "Winged forelands" in their morphological appearance, we have to analyze their morphogenetic features. To do this, we will study the largest formations of this type for their correspondence to the genetic characteristics of the "Winged foreland" abrasion-accumulative coastal systems.

The Tendra-Dzharylgach coastal system is the largest coastal system of this type within the Black Sea. The central place in the system is occupied by the continental protrusion or "headland", which is formed by two acclivous anticlinal folds composed of clay and loess-clay rocks [7; 46; 56]. This protrusion genetically represents an alluvial overbottom terrace, which breaks off towards the sea with an abrasion cliff up to 2 m high. On the opposite sides, two free accumulative forms adjoin the "headland" – the Tendra Spit (in the west) and the Dzharylgach Spit (in the east) (Figure 3, a).

The accumulative forms of this system are characterized by narrowed basal areas and widened distal areas, which is known to be an indicator of the entire system pulling in line and the manifestation of accumulation only near the extremities [35].

Figure 3. Morphogenetic conditions of the Tendra-Dzharylgach coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

Morphologically this coastal system is a typical "Winged foreland", however, lithodynamic conditions have certain differences. So, the feeding of accumulative forms is carried out not due to the destruction of the abrasion area, but is the result of erosion of underwater forms and the income of a large amount of organic material [35; 38; 56]. At the same time within the system the alongshore movement of sediments with certain seasonal differences appears and there is a divergence zone located on the nearshore slope in the central part of the Tendra Spit (Figure 3, b). From this zone, the alongshore flows diverge in opposite directions, heading to the distal extremities of the Tendra and Dzharylgach spits. It should be noted that the presence of a divergence zone is the most important lithodynamic feature of the "Winged forelands".

An analysis of the structure of the wind-wave regime indicates the dominance of waves of western, southwestern and eastern exposure during the year (Figure 3, c) [27]. Comparing the orientation of the coastal system and the dominant wave directions, it should be noted that the hydrodynamic conditions correspond to the genetic characteristics of the "Winged foreland" coastal systems. That is why, from our point of view, the Tendra-Dzharylgach coastal system is an indicative formation of this type, as evidenced by two symmetrical accumulative forms [29].

From the point of view of the evolutionary feature, the elongation of the system in one line fits well into the alignment scheme of a complex bay coast, which is at the maturity stage.

An analysis of the Tendra-Dzharylgach coastal system, from the point of view of its correspondence to the genetic characteristics of "Winged foreland" formations indicates that this system is characterized by three of the four features. A lithodynamic characteristics also takes place, but with small specific features.

The Kinburnska-Pokrovska-Dovgiy coastal system occupies the western end of the Kinburnskiy Peninsula (Figure 4). Unlike other coastal systems of this type, the central place in it is occupied by the sandy protrusion of the Kinburnskiy Peninsula, which is periodically eroded.

Figure 4. Morphogenetic conditions of the Kinburnska-Pokrovska-Dovgiy coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

The Kinburnska Spit occupies the northwestern part of the system, and a complex formation of different ages represented by a relict branch (Pokrovska Spit, Krugliy and Dovgiy islands) and a modern branch (Sukha Spit and Barrier Island) locates in the southeast. Morphologically, this formation is "Winged foreland" [30].

An analysis of the lithodynamic conditions of this system indicates the dominance of bottom feeding and, as a consequence, the transverse sediments flow. However, the morphological features of the coastal zone of accumulative forms indicate a periodic manifestation of alongshore drift flows, which are reversible. During field studies, it was found that this system is characterized by a divergence zone, which is located in the region of the basal part of the Kinburnska Spit, but during severe storms it can cover the entire frontal part of the protrusion.

It should be noted that the lithodynamic conditions of the system are complicated by constant or seasonal alongshore drift flows from the Dnieper-Bug estuary and the Yagorlytska Bay. That is why the distal part of the Kinburnska Spit is a convergence zone or lithodynamic site, within which two different sediment flows are unloaded. In view of this lithodynamic situation, the Kinburnska Spit is morphogenetically an arrow-shaped spit [35; 39; 54].

The area of the relict branch of the system, which includes the Pokrovska spit (Pokrovskiy peninsula [39]), and the Krugliy and Dovgiy islands that are genetically unified with it, also previously represented a convergence zone. However, our field studies showed that there is no active interaction of alongshore drift flows in this area at the present stage.

The area of the modern branch of the system, which includes the Sukha Spit (a new generation of the Pokrovska Spit) and the Barrier Island, is an area of active unloading of both transverse and alongshore drift flow.

Accordingly, lithodynamically, the Kinburnska-Pokrovska-Dovgiy coastal system is a very specific formation, certain features of which are identical to the "Winged forelands". However, the lithodynamic situation in the system as a whole is more complex, due to the presence of a convergence zone and active bottom feeding.

An analysis of the hydrodynamic conditions in the region of the northwestern part of the Black Sea [27] (Figure 3, c) indicates the dominance of waves of the west and southwest direction, which in principle contributes to the formation of the morphological appearance of the coastal systems "Winged forelands".

A paleogeographic analysis of the area of the Kinburnska-Pokrovska-Dovgiy coastal system indicates that the formation of this system is not the result of alignment of the abrasive bay shore, but is the result of the adjoining of the coastal bar that came out from under the water to the protrusion of the Kinburnskiy Peninsula [39].

A general analysis of the Kinburnska-Pokrovska-Dovgiy coastal system, from the position of its correspondence to the genetic features of the "Winged foreland" formations, indicates that the two characteristics (morphological and hydrodynamic) are strictly correspond, the lithodynamic feature is characterized by certain specific peculiarities, and the evolutionary feature does not correspond.

The Lebedina-Vustrichna coastal system occupies the front part of the Girkiy Kut Peninsula (Khorly). Morphologically, the peninsula is not a high coastal plateau, saddle-shaped, composed of clay and loamy rocks. The central place within it is occupied by a flat elevation, elongated from north to south, with absolute heights of about 7 m. In the direction to the coast the heights decrease to 3-6 m, and within individual valleys (cloughs) up to 0.5 m [34].

Accumulative forms adjoin the peninsula from opposite sides: the Lebedina Spit is in the north-west and the Vustrichna Spit is in the east (Figure 5). The morphological appearance of the system corresponds to the genetic feature of the "Winged forelands".

Figure 5. Morphogenetic conditions of the Lebedina-Vustrichna coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

The lithological analysis of the accumulative forms of this system indicates a clear dominance of sediments of biogenic genesis and the presence in their composition of a large number of sediments of the "non-wave field". It should be noted that among the biogenic sediments the plant residues dominate in the form of various phytogenic relief forms. These relief forms also serve as a reservoir of silty, clay and detrital sediments.

Within the coastal zone of the frontal part and accumulative forms, there are only local traces of sediment movement. During field studies, only the conditional presence of a divergence zone was revealed. That is why according to the lithodynamic characteristic this system does not correspond to the "Winged foreland".

An analysis of the hydrodynamic conditions of the region of the Girkiy Kut Peninsula indicates the important relief-forming significance of the waves of the west and south-west direction [27]. The coordinated location of the accumulative forms, in relation to the dominant waves, emphasizes that it is the hydrodynamic factor that determines the specific appearance of the system.

The appearance of the peninsula and the adjacent areas indicates a significant dissection of the coastline, and the formation of a shallow bay coast in the region. Under such conditions, the active destruction of the "headlands" and the formation of accumulative forms on the periphery of the indigenous protrusions indicate an alignment of the coastline. However, this alignment occurs under conditions of a clear deficit of "wave field" sediments, which is why this process is very slow. Accordingly, the Lebedina-Vustrichna coastal system evolutionarily corresponds to the "Winged forelands" coastal systems.

A general analysis of the Lebedina-Vustrichna coastal system for its correspondence to the genetic features of the "Winged foreland" formations indicates that the three features (morphological, hydrodynamic and evolutionary) are strictly correspond, and the lithodynamic sign has no characteristic features of the "Winged forelands".

The Burnaska-Budatska coastal system is located on a coastal segment between the estuarine areas of the Dniester and Danube rivers [25; 34; 52]. This formation is formed around the protrusion of the abrasive indigenous coast, which is located between the localities Kurortne and Lebedivka. The Burnaskiy bar adjoins the corresponding "headland" in the south-west, and the bar of the Budatskiy estuary in the north-east (Figure 6, a).

Lithological analysis showed that clay, loamy and loess-clayey rocks dominate within the "headland" system, and sand-shell deposits are typical for accumulative forms. Such a distribution of rocks indicates the dominance of bottom feeding of accumulative forms, followed by alongshore transport [55].

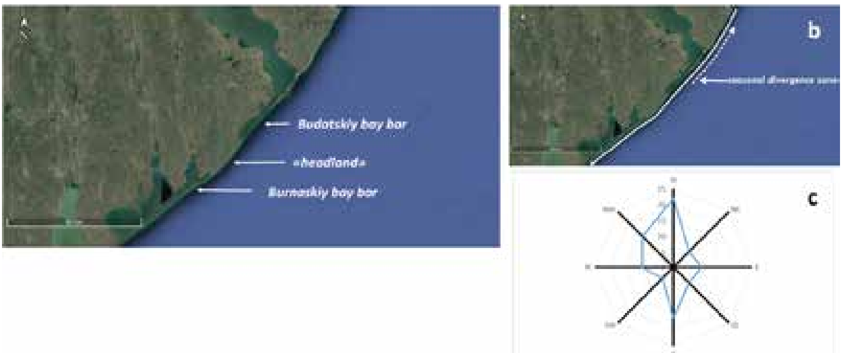

Figure 6. Morphogenetic conditions of the Burnaska-Budatska coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

Within the described system, for most of the year, a unidirectional alongshore drift flow to the Jibrieni bay appears. Periodically, in the warm season of the year, a flow directed towards the Odessa Gulf is formed in the area of the Budatskiy bar, which confirms the development of one of the divergence zone variants within this system [33; 55]. Accordingly, this coastal system is not fully, but corresponds to the lithodynamic feature of the "Winged forelands".

According to the structure of the wind regime, significant seasonal differences in the direction of the wind are appeared within the Burnaska-Budatska coastal system, which in principle leads to a reverse regime of sediment displacement [27]. Therefore, this coastal system belongs to the "Winged foreland" according to the hydrodynamic feature.

Evolutionarily, the modern morphological appearance of the Burnaska-Budatska coastal system is the result of alignment of the dissected bay coast by joining the coastal bar. Subsequently, this coastal bar was transformed by the alongshore drift flows. The modern narrowed character of the bars indicates the dominance of sediment transport within their limits without a general tendency to accumulation [35].

A general analysis of the Burnaska-Budatska system gives us reason to say that at least three genetic features of the "Winged forelands" coastal systems are inherent of this formation. Therefore, the described abrasion-accumulative system refers to formations of this kind; however, its genetic features are characterized by great specificity.

The Dolgaya-Kamyshevatskaya coastal system is an example of an abrasion-accumulative system, which by its characteristics refers to formations of the "Winged forelands" type. The pivotal place within the system is occupied by the abrasive clay protrusion of the Yeysk Peninsula. In the northwest the Dolgaya Spit adjoins it, and in the southeast – the Kamyshevatskaya Spit (Figure 7, a) [13; 35; 44]. According to morphological feature this coastal system belongs to the "Winged foreland".

Figure 7. Morphogenetic conditions of the Dolgaya-Kamyshevatskaya coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

A lithological analysis of the morphological elements of this system indicates that the indigenous land protrusion ("headland") is composed of clay rocks, while the accumulative forms consist of sandy rocks of biogenic origin, shells and detritus [50]. Consequently, the system is powered from the nearshore slope, from where the clastic material enters the coastal zone, and alongshore flows carry it in the direction of the distal parts of the Dolgaya and Kamyshevatskaya spits. That is why the region of the clay protrusion should be considered as a divergence zone, which, depending on the waves, can move along its entire frontal part (Figure 7, b).

It should be noted that morphogenetically the Dolgaya Spit is an arrow-shaped spit and it is also a convergence zone, and the accumulative Kamyshevatskaya form is a typical spit [35]. Accordingly, the Dolgaya-Kamyshevatskaya coastal system corresponds to the "Winged foreland" coastal systems lithodynamically.

In the structure of the wind regime, over the region of the eastern part of the Sea of Azov, winds of the west and south-west direction dominate [26]. Winds of this direction cause similar waves, which can induce reverse movements of sediment flows. Therefore, according to the hydrodynamic characteristic, the Dolgaya-Kamyshevatskaya coastal system corresponds to the "Winged forelands" abrasion-accumulative systems.

Evolutionarily, based on the morphology and morphometry of the accumulative forms, the Dolgaya-Kamyshevatskaya coastal system is a bay coast at the youth stage, which is aligned. Accordingly, this coastal system corresponds to all genetic features and is a classic example of the "Winged foreland".

The Curonian-Baltic coastal system is the largest abrasion-accumulative system of non-tidal seas, which according to morphological characteristics refers to the "Winged forelands". The central part of the system is occupied by the ledge of the Sambian Peninsula, which is adjoined with two spits from opposite sides: the Curonian and Baltic (Vistula) spits (Figure 8, a) [3; 22; 28].

The Sambian Peninsula is a protrusion of the indigenous coast, composed of glacial and fluvioglacial deposits [1; 20]. The accumulative forms adjoining the peninsula are composed of sand-pebble rocks of alluvial, fluvioglacial and marine genesis [1; 2; 17; 23]. Morphogenetically, both accumulative forms are complex coastal bars, which include areas formed as a result of the actions of alongshore drift flows, as well as areas of coastal plains partially flooded during marine transgressions (Badiukova, 2007).

R.Ya. Knaps [24; 37] identified the alongshore sediment movement within the southeastern part of the Baltic Sea, directed from the Sambian Peninsula to the Kolkasrags Cape, according to the lithodynamic characteristic. At the same time flow directed to the south of the peninsula, the author considered not clearly defined.

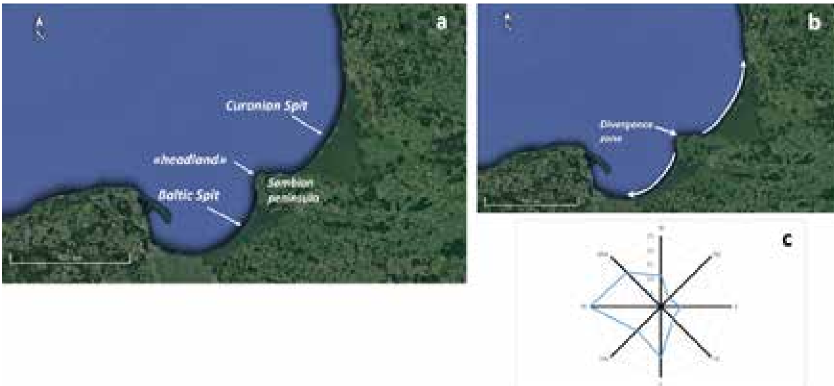

Figure 8. Morphogenetic conditions of the Curonian-Baltic coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

Over many years of research and subsequent calculations, A.N. Babakov [1] came to the conclusion that the unified directed sediment flows do not exist within the entire southeastern coast of the Baltic Sea. Instead, several local multidirectional flows are characteristic of this coastal system. However, there is no doubt that the Sambian Peninsula is a zone of divergence. That is why the Curonian-Baltic coastal system corresponds to the genetic feature of the "Winged forelands".

Analysis of the hydrodynamic factor indicates the dominance of winds and waves of the western, northwestern and southwestern exposure [48]. These wave processes perform a morphogenetic function, determining the directivity of the alongshore drift flows. Therefore, this coastal system corresponds to the hydrodynamic feature of the "Winged forelands".

The evolutionary features of the coast of this region of the Baltic Sea do not quite fit into the concept of the bay coast aligning. This is due to a shift of the accumulative forms in the direction of the mainland coast, which does not quite contribute to the theory of alignment of this type coasts [1; 3; 22].

Accordingly, this coastal system corresponds to three of the four "Winged foreland" genetic characters and is a formation of this type.

Cheleken "Winged foreland" coastal system. The corresponding system is geographically located within the frontal part of the Cheleken Peninsula (Fig. 9). Most of this protrusion is occupied by the denudation surface of the Chokrak highland, which breaks off towards the sea with a series of abrasion terraces. Structurally, this formation is the arched part of the brachianticline system [42; 46].

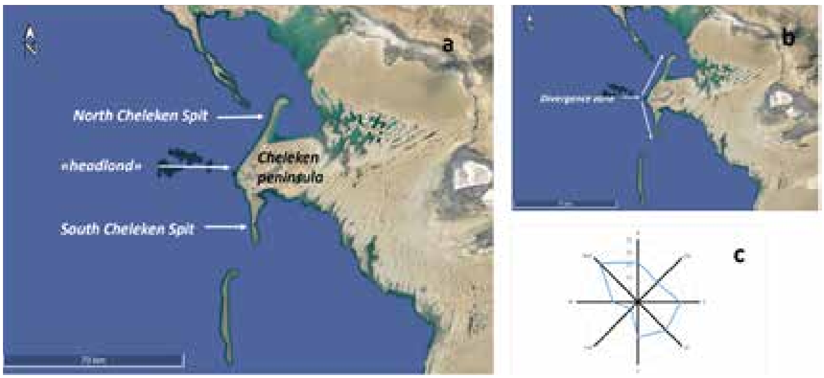

Figure 9. Morphogenetic conditions of the Cheleken coastal system: a) morphological structure; b) lithodynamic features; c) structure of the wind regime (developed on the basis of the Google Earth resource)

Accumulative forms known as the South Cheleken and North Cheleken Spits are adjacent to the peninsula from opposite sides (Figure 9 a). Morphologically, these formations are free forms, extended towards the sea and separating shallow bays from the sea. The accumulative forms that make up this system are characterized by similar morphological features: they widen to the distal part and narrow towards the basal. This similarity indicates that within the system, accumulation processes are manifested only in the area of the spits' distal, while in the basal areas the narrow parts of these forms are eroded and retreated simultaneously with the cliff. That is why it was concluded that the evolution of "Winged forelands" occurs in the direction of aligning the entire system in one line, which is an important theoretical justification of the evolutionary feature of the studied abrasion-accumulative systems [35, p. 406].

According to paleogeographic studies of the coastal zone of the Caspian Sea, the described accumulative forms are a coastal bar that adjoins the shore indigenous protrusion [14; 40]. This conclusion was made on the basis of lithological analysis of spits, according to which they are composed of sands of oolitic and biogenic genesis, with very little admixture of abrasion material [14; 42].

Accordingly, lithodynamically these accumulative formations do not feed on "headland" abrasion, since the nearshore slope is the main source of sediment. However, the distals' widened areas of both spits indicate that within the system the alongshore flows have important genetic significance simultaneously with transverse sediment transport. The symmetrical location of the spits indicates the presence of a divergence zone, which is located on the nearshore slope and is due to differences in the structure of the wave regime [40]. That is why this coastal system corresponds to the lithodynamic feature of the "Winged forelands".

An analysis of the hydrodynamic conditions in the region of the south-eastern coast of the Caspian Sea indicates a dominant position of the waves of north-west and north directions at the present stage [40; 42]. Under such conditions, a symmetrical location of the accumulative forms is not possible. That is why, within this system, we cannot find confirmation of the hydrodynamic genetic feature of the "Winged forelands".

An analysis of the evolutionary feature of the Cheleken coastal system, which is based on the deviation angle of the accumulative forms relative to the shore indigenous protrusion, indicates the initial stage of alignment of the complex bay coast in this area. However, a more accurate interpretation of the evolution of this system requires additional researches.

7. Conclusions

Based on the results of the study, we came to the following conclusions:

1. The natural "Winged foreland" formation refers to divergent-type abrasion-accumulating lithodynamic systems. Within their limits, oppositely directed alongshore drift flows occur with a certain periodicity and they consist of three components – the indigenous area of the coast and two accumulative forms.

2. The specific peculiarities of the "Winged foreland" are due to the presence of a certain number of genetic features, which include: morphological,

lithodynamic, hydrodynamic and evolutionary. However, the manifestation of all these features at the same time is extremely rare. Therefore, in our opinion, the presence of 2-3 features is sufficient for the formation of a specific appearance of this coastal formation.

3. The "Winged foreland" received a fairly limited distribution, which indicates the great specificity of the conditions in their formation. The largest number of these formations is characteristic of the shores of internal seas, where genetic factors of development do not appear regularly, but with a certain interval. That is why, in our opinion, periodic changes in development conditions, which are most often manifested in the conditions of non-tidal seas, are very important for the formation of these systems.

4. To conduct the most complete morphogenetic analysis of the "Winged foreland", we plan to study in detail each coastal system of this type, with an emphasis on field research. In this case, emphasis will be placed on the study of hydrodynamic, lithodynamic and paleogeographic conditions.

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CHARACTERISTIC PROPERTIS OF MORPHOLOGY AND FORMATION OF COMMERCIAL COAL SEAMS OF DEEP HORIZONS OF THE LVIV-VOLYN COAL BASIN

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Abstract. The Lviv-Volyn Coal Basin remains being the main fuel-power base of the western regions of the Ukraine up to now. At the same time, against the background of the planned removing of mines from service and reduction of explored reserves of coal, the necessity arises to solve the question of the basin's development in the future. Its up-to-date expansion is also connected with the development of the coal seams trom the deep horizons. We have studied the commercial coal potential and characteristic properties of morphology of the coal seams of the deep horizons of the Lviv-Volyn Coal Basin, including the Kovel coal-bearing area. To the deep horizons we attribute the parts of the section of the Carboniferous thickness that enclose the coal seams located at depths below the working coal seams. They are of Tournaisian-Serpukhovian age and belong to the lower (bog-marine) coal-bearing formation. The purpose of investigations was to determine the most perspective commercial coal seams of the deep horizons of the basin and their characteristic properties. It was noted that within the limits of the workable deep horizons of the basin the coal seams v_0^3 and v_6 are widely distributed. We have used a complex of investigations based on the formation analysis: morphological analysis of coal seams, methods of mapping and geological-industrial typification of the main morphological parameters of coal seams, correlation, paleopothamic and lithological-stratigraphical analyses, construction of detailed morphologi-

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cal sections, genetic and paleotectonic analyses of Carboniferous deposits. Results of studies have enabled us to determine characteristic properties of the formation and morphology, in particular splitting, of the Visean υ_0^3 and Serpukhovian υ_6 coal seams. Maps of morphology υ_0^3 (scale 1 : 50000) and υ_6 (scale 1 : 25000) have been compiled that reflected morphostructural and morphogenetic features, a commercial value and changes in their main mining-geological factors and phenomena in the basin area. It was established that accumulation of initial organic material of the seam υ_0^3 in the Kovel coal-bearing area depends on inherited tectonic valley-like lowering of the latitudinal strike. For the first time for the basin there was determined a new type of the peat accumulation characteristic of the platform Carboniferous coal-bearing formations located directly on the erosional surface of Pre-Carboniferous formations of different age. It was ascertained that the coal seam υ_6 was formed within the limits of the subaerial deltal plain where the most favourable conditions for accumulation of the peat bogs existed in the pre-channel parts of delta located in the interchannel space among and under the influence of the large paleohydrographical systems. For the first time for this seam, the deltaic type of the peat accumulation was determined. Thus, within the limits of the deep horizons in deposits of the lower coal-bearing sub formation the coal seams υ_0^3 and υ_6 are the main and have the most commercial value. In the Kovel perspective area and the central part of the basin: υ_0^3 and υ_6 – in Zabuske and Mezhyrichchia fields of the Chervonohrad coal production region of the basin. Stated material and executed paleoreconstructions verify and supplement the existing notions of Carboniferous coal accumulation in the south-west of the East-European platform and of the little-studied deltaic type of the peat accumulation. In the light of applied aspect, they are important for solving of practical tasks connected with predicting evaluation of the commercial coal-bearing potential of the deep horizons of the Lviv-Volyn Basin.

1. Introduction

The Lviv-Volyn Coal Basin (LVB) (Figure 1) remains being the main fuel-power base of western region of the Ukraine up to now. However, against the background of the planned removing of mines from service and reduction of explored reserves of coal, the necessity arises to solve the question of the basin's development in the future.

In the Lviv-Volyn Coal Basin, the highest potential for coal presence of commercial value falls to deposits of the Buzhanka suite. Eight basic commercial coal seams $n_7^{н}$ (n_7), n_7 (n_7^1), $n_7^{в}$, n_8, n_8^0, $n_8^{в}$, n_8^5 and n_9 (in brackets is indicated synonimics of coal seams accepted in the South-Western coal-bearing region of LVB) have the working thickness at rather great areas [3; 19–21]. At the same time, of great importance are studies, prediction and mapping of morphology of the coal seams with the working thickness that occur below at deeper horizons [10; 20].

To deep horizons belong those parts of the section of the coal-bearing thickness of LVB that contain coal seams located at great depths below working seams. They are Tournaisian-Serpukhovian in age, and belong to the lower (marshy-marine) coal-bearing formation. As results of researches have shown, within the limits of deep horizons of the basin the coal seams v_0^3, v_0^4, v_2, v_4, v_4^3, v_5^4, v_5^6, v_6, n_0^6 with working thickness are widely distributed. To such parts of the section one can attribute the northern continuation of the basin: the Kovel perspective area, the region of Carboniferous spreading along the Poland border from the town of Volodymyr-Volynskiy to the Belarus border where the coal seam v_0^3 occurs. It stretches as a strip, from 15 to 20 km wide, at a distance of about 100 kilometres along the state border. Its area is estimated at a total of 420 km^2. On the whole in deposits of the lower coal-bearing subformation, v_0^3 and v_6 are basic seams that preserve working thickness at considerable areas.

Studying of coal seams situated within undeveloped territories and active mines of the basin, at horizons that are deeper than working ones and substantiation of their commercial value for duration of operating period of mines is an urgent problem that needs to be solved. Commercial working of such seams is a perspective direction of further development of LVB and coal industry of the western region of the Ukraine.

Basing on paleoreconstructions, paleopothamic and morphological analyses and detailed studies of the structure, discomposition and washout of coal seams v_0^3 and v_6 as well as of changes in these parameters and phenomena along the area, it was possible to depict formation conditions of coal-bearing deposits and morphological features of seams indicated in the maps of morphology.

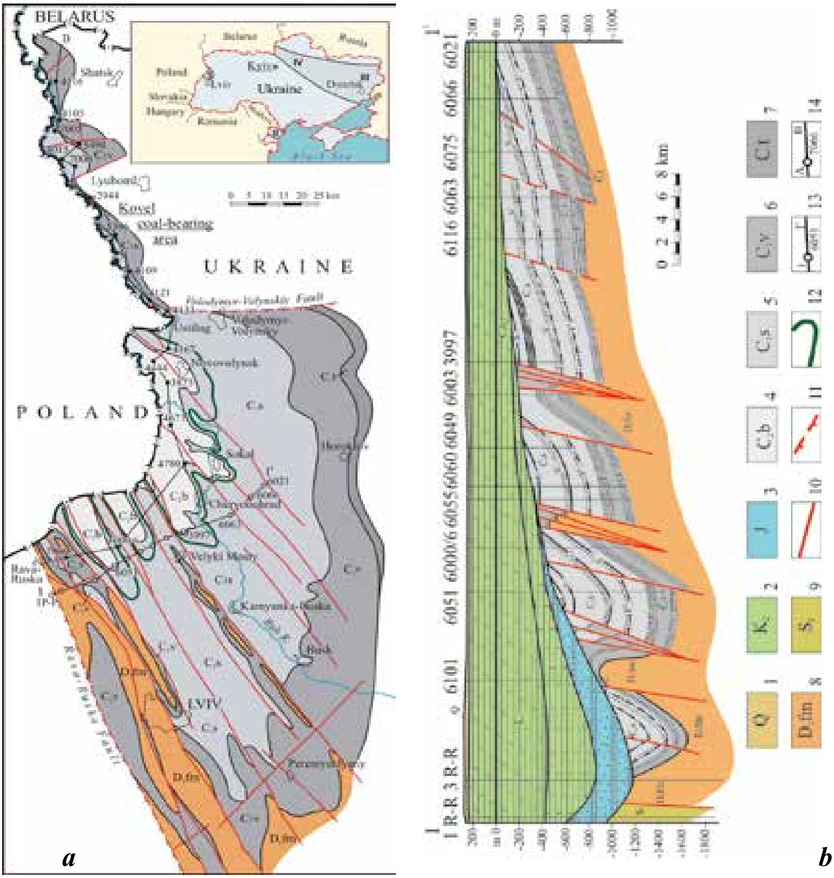


Figure 1. Geological map (*a*) and cross-section along the line I–I[1] (*b*) of the Lviv-Volyn Coal Basin (by Ihor Kostyk and Mykhailo Matrofailo, on the basis of materials of the Lviv GRE) [17]

1–3 – formation of Mesozoic and Cainozoic: 1 – Quarternary, 2 – Upper Cretaceous, 3 – Jurassic; 4–7 – Carboniferous period, *middle section*: 4 – Bashkirian stage, *lower section*: 5 – Serpukhovian stage, 6 – Visean stage, 7 – Tournaisian stage; 8 – Devonian, upper section, Famennian stage; 9 – Silurian, upper section; 10 – tectonic dislocations with a break of continuity; 11 – regional fault; 12 – contour of commercial coal presence; 13 – line of geological section and borehole number; 14 – line of correlational profile. Location of carboniferous basins and coal-bearing areas (on cutting): basins: I – Lviv-Volyn, II – Predobrogean, III – Donets, IV – Dnieper-Donets area

2. Methods of investigations

To study morphostructural and morphogenetic features of coal seams υ_0^3 and υ_6 in details, changes in these parameters and phenomena over the area, correlation of coal-bearing deposits of the basin and regional cartographical representation of the results we have used the methods developed and applied for the basin near Moscow, Donets and Lviv-Volyn basins [15; 18; 19]. Moreover, we have used the methods of mapping (scale 1 : 50000) and geological-commercial typification of main morphological parameters of coal seams, paleopothamic and lithological-stratigraphic analyses, construction of detailed morphological sections (scale: vertical 1 : 200, horizontal 1 : 50000). Maps of coalbed morphology show outlined and marked areas of the same type structure and traced boundaries of splitting, and washout as well as depicted development of coaly argillites. The isoline of the rock interbed 0.50 m thick is accepted as the outline of the splitting zone. A change in the thickness of the coal seams is represented by isopachytes drawn with line spacing of 0.20 m, and the depth of occurrence of the rock bottom: by isohypses with line spacing of 50 m.

To study geological structure, to correlate coal deposits and the morphology of coal seams and to estimate resources of the Kovel area we have used a complex of investigations based on formation analysis [20]. In addition, we have carried out lithological investigations of the section and have described lithological-facies characteristic of rocks as well as we have correlated deposits of the Lviv-Volyn basin and its northern continuation, have characterized coal-bearing potential of the thickness and have executed the morphological analysis of coal seams and genetic and paleotectonic analysis of deposits of Carboniferous.

In particular, to correlate coal seams we have constructed the correlational geological profile based on data of sections throughout the whole territory of the basin studied in detail (from the town of Rava Ruska in the south to the Belarus border in the north) (Figure 2). Correlation of the profile was conducted on the basis of methods developed with special features of the structure and formation conditions of coal deposits of LVB taken into account [19]. Incidentally we have used reliable, widely distributed marker horizons: 1 – limestone seam V_1 of the Volodymyr suite with overlain marine argillites with numerous interbeds and lenses of siderite; 2 – the thickness of limestones that contain foraminifers of the Ustilug suite with interbeds of argillites and coal; 3 – thick seams of limestone containing Late Visean foraminifers (probably from the lower part of the Porytsk suite).

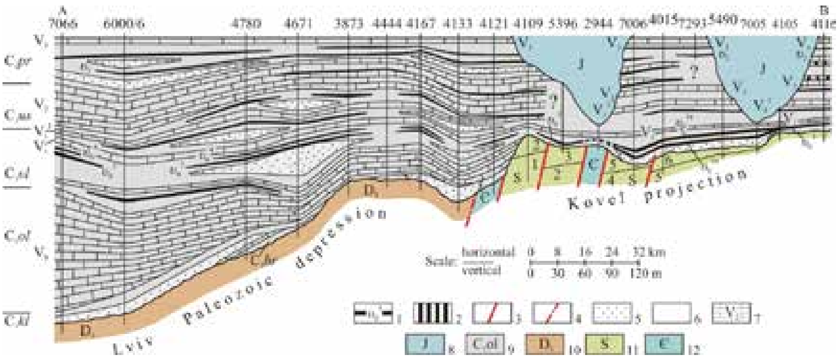


Figure 2. Correlational profile of the lower part of the coal-bearing formation of the Lviv-Volyn Coal Basin along the line A–B (line of section is indicated in Figure 1) [20]

1 – coal seam and its synonymics; 2 – coaly argillite; 3 – tectonic dislocations with a break of continuity; 4 – Volodymyr-Volynskiy (northern) fracture; 5 – sandstone; 6 – argillite; 7 – limestone and its synonymics; 8–12 – *deposits:* 8 – Jurassic, 9 – Lower Carboniferous (suites: C_1*kl* – Kulychkiv, C_1*ol* – Oleska, , C_1*vl* – Volodymyr, C_1*us* – Ustilug, C_1*pr* – Porytsk), 10 – Upper Devonian, 11 – Upper Silurian (graptolithic biozones (digits on profile): 1 – nilssoni chimaera, 2 – lentwardinensis, 3 – kozlowskii-auriculatus, 4 – formosus-spineus, 5 – ultimus-parultimus, 6 – lochkovensis); 12 – Cambrian

The geological commercial typification of coal seams was carried out in conformity with accepted gradations of classifications and standing instructions and methods with the aid of alphabetical-digital indexing of the main morphological indicators of the seam: thickness (I–IV), change in thickness ($M_{1–2}$), structure ($CT_{1–4}$), degree of distribution of washouts and substitutions ($P_{1–4}$).

3. General description

Structurally, the Kovel exploring perspective area is in the northern part of LVB situated within the Lviv Paleozoic Depression of the south-western margin of the East European Platform and is contiguous to the Volyn field. It should be also noted that it is extended within the limits the Kovel tectonic projection which is a part of the Kovel-Hrubeszów transverse uplift with distinctive high-amplitude fine-block tectonics. The formation of the projection is connected with maximum activity of horst-under-thrust dislocations in Pre-Visean time (Bretonian phase of Hercinian tectogenesis) [24]. This has caused, on the one hand, a wave-like character of the boundary-line of the distribution of Carboniferous, and on the other hand – subhorizontal occurrence of coal deposits on the deeply eroded surface of strongly dislocated rocks of the Lower Paleozoic. The depth of washing of the Pre-Carboniferous deposits in the limits of the Kovel projection reaches from 0.5 to 1.7 km [23].

Rocks of the Carboniferous system of the Kovel area occur uncomformably on washedout deposits of the Lower Paleozoic that differ in age, and they are represented by the Visean and Serpukhovian stages (Figure 3). The thickness of Carboniferous over an area does not exceed 224 m. In the basement of the Carboniferous deposits of the area there occurred rocks of a crust of weathering – argillites, massive, yellow-grey in color, fat to the touch, with silky glitter, acute-angled crack, sometimes with vegetable remains, black and brown ferrous oölites. These rocks contain high concentrations of Al_2O_3 reaching up to 36.7–37.8 per cent. Argillites are similar to basal formations of Carboniferous in LVB (Kulychkiv suite) [1; 2], as well as to "semikaolin" high-alumina kaolinite clays of the Lower Carboniferous of the basin near Moscow [7]. Within the territory studied argillites about 3 m thick are distributed locally and are very similar to those in the Kulychkiv suite of LVB that very likely indicates their development within the Kovel area.

Deposits of the Visean stage are mainly represented by rocks of Volodymyr and Ustilug suites. The Volodymyr suite is composed mainly of terrigenous rocks. In its bottom in the north-eastern part of the area there occurs thick series (about 20 m thick) of different-grained quartz sandstones with kaolin, rarely carbonate, cement with argillite interbeds and sometimes of kaolin clays. Above there occurs a series (from the first metres to 10 metres thick) of black coaly argillites among which the coal seam υ_0^3 is located and which is splitted into two conditional coal seams $\upsilon_0^{3н}$ and $\upsilon_0^{3в}$ with which the total coal presence of the area is connected. Completion of the section is represented by deposits of grey argillites with interbeds of aleurolites and organogenous limestones, often with remains of corals and mollusks. Sometimes one can observe interbeds of conglomerates of small thick (about 0.30–0.50 m) in the suite series. The thickness of the suite reaches about 40 m. It should be noted that the seam υ_0^3 is also distributed in the central part of LVB.

4. Morphology of coal seams

<u>*Coal seam υ_0^3*</u> is extended throughout the whole territory of the Kovel area: in the north – in the Shatsk area, in the central part – in the Lyuboml area, and in the south – in the Novyny area, it borders upon the the Volodymyr-Volynskiy fault. It consists of two coal seams $\upsilon_0^{3н}$ and $\upsilon_0^{3в}$ that are of working thickness and are a short way off and both in the southern and the northern directions are connected into the single coal seam of complex structure. From the above-mentioned gradations of parameters and phenomena it was possible to characterize the morphology and the main morphological indications of coal seams for the separate plots of the Kovel area and to depict them in the map of morphology (Figure 5) and in the sections (Figure 6).

The lower coal seam $\upsilon_0^{3н}$ occurs at depths ranging from 319.6 to 551.2 m and is distributed in all plots of the area. The cover of the seam is mainly composed of argillite, and the bottom: mudstone, siltstone and rarely sandstone. Its thickness changes from 0.10 to 2.17 m (borehole 7006) and corresponds to four types of gradation: I – very thin, II – thin, III – medium, IV – thick. In the Novyny and Lyuboml plots of the area it is conditional and varies from 0.59 to 2.17 m. Somewhat further north, in the

Shatsk plot, the seam is of very thin unworkable thickness reaching 0.35 m (borehole 4105) and 0.30 m (borehole 4116). Changeability of the thickness is weak (M_1), and only in the western part of the Lyuboml plot it is strong and very strong (M_2). According to reserves classification, the seam belongs to uneven group. Its structure changes from simple (CT_1) to complex (CT_3). Without rock interbeds the seam extends in the Novyny, Shatsk plots and in the east of the Lyuboml one; with one and two rock interbeds from 0.10 to 0.38 m thick: in the western, the thickest part of the Lyuboml plot. Interbeds area represented mainly by argillites, sometimes by sandstones. Coaly argillite from 0.15 to 0.25 m thick in different cases occurs in the bottom, middle part and in the cover of the seam, and in the borehole 2944 it fully substitutes the coal.

The coal seam $\upsilon_0^{3н}$ is splitted. This local splitting is exposed in the borehole 7005. It belongs to bifurcation and extends as far as 15.2 km^2. The rock interlayer represented by argillite is 1.90 m in thickness.

The upper coal seam $\upsilon_0^{3в}$ occurs at a depth of 319.6–546.7 m below the limestone V_1. Limestone predominate in its cover in the northern part of the

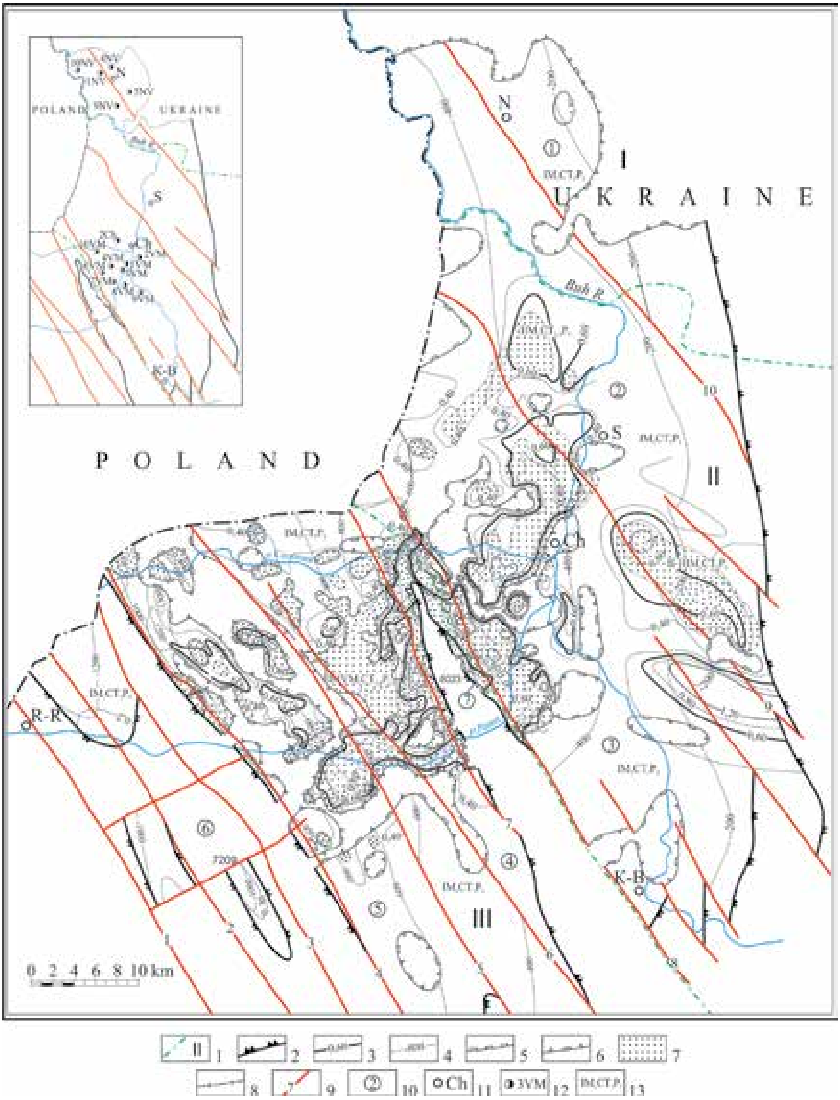


Figure 4. Map of morphology of coal seam v_6 of the Lviv-Volyn Coal Basin (authors Ihor Kostyk and Mykhailo Matrofailo)

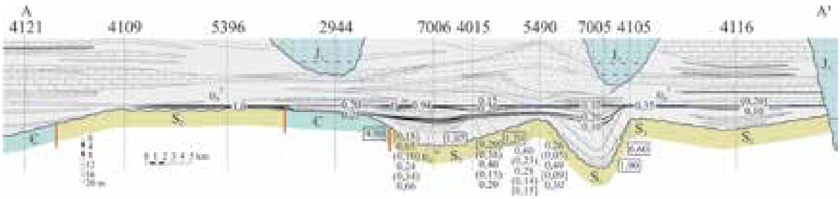
1 – boundaries of geological-industrial regions (I – Novovolynsk, II – Chervonohrad, III – South-Western); 2 – boundary of epigenetic washout of coal-bearing formation; 3 – isopaches of coal seam, m; 4 – isohipses of the coalbed foot, m; 5 – contour of mainly synpeaty and early-epipeaty washouts and substitutions of coal seam; 6 – contour of synpeaty and epipeaty washouts and substitutions of coal seam; 7 – coal seam of composite structure (two or more coal units); 8 – line of coal seam splitting; 9 – tectonic dislocations with a break of continuity: 1 – Rava-Ruska fault, 2 – Krekhiv overthrust, 3 – Zashkiv fault, 4 – Nesteriv zone of overthrusts (Nesteriv overthrust), 5 – Butyn-Khlivchany zone of thrusts, 6 – Boyanets overthrust, 7 – Belz-Kulychkiv overtrust, 8 – Belz-Mylyatyn zone of overthrusts, 9 – Zabuzkiy and Sokal fault, 10 – Volyn fault; 10 – coal fields (1 – Volyn, 2 – Zabuzke, 3 – Mezhyrichenske, 4 – Tyagliv, 5 – Lyubelya), areas and plots (6 – Byshkiv coal-bearing area, 7 – plot of Mezhyrichya-Western); 11 – populated area: R-R – Rava-Ruska, K-B – Kamyanka-Buska, Ch – Chervonohrad, S – Sokal, N – Novovolynsk; 12 – mine and its number (NV – Novovolynsk, Ch – Chervonohrad, VM – Velyki Mosty: No. 1 – "Velykomostivska", No. 2 – "Bendyuzka", No. 3 – "Mezhyrichanska ", No. 4 – "Vidrodzhennya", No. 6 – "Lisova", No. 7 – "Zarichna", No. 8 – "Vizeiska", No. 9 – "Nadia", No. 10 – "Stepova"); 13 – alphabetical-digital index of the seam

area, in the south – argillite, rarely siltstone and sandstone, at the bottom – in the east part argillite and in the west – siltstone. A sphere of its extension coincided with the lower seam. The thickness of the seam varies from 0.10 to 1.38 m (borehole 5484) and corresponds to three types of gradation (I – III). The seam with conditional thickness between 0.94 and 1.38 m extends over large areas of the Lyuboml plot. Further to the west, its thickness is very thin: from 0.10 to 0.15 m (borehole 4015, 7005). Change in the thickness is low (M_1). According to reserves classification, the seam belongs to relatively consistent. Its structure becomes changed from simple (CT_1), prevailing in the Lyuboml plot, to middle complexity and complex ($CT_{2–3}$) extended over this plot in some cases: with one rock interlayer – borehole 5484, with two – borehole 5490. Rock intercalations are composed of coaly argillite and argillite 0.04–0.09 m thick, and in the borehole 2944 coaly argillite 0.20 m thick fully constitute coal.

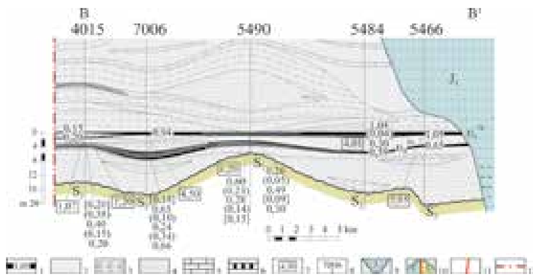
The coal seam $\upsilon_0^{3в}$ is locally splitted too. Splitting is exposed in the borehole 4015. It belongs to bifurcation and occupies the area of 7.9 km^2. The thickness of the rock interlayer represented by siltstones and partly by sandstones reaches 1.20 m. In both case local splittings are distributed in the tectonically most active central Lyuboml plot of the Kovel area. Their contours are oval and intersect the state border extending to the territory of the Lyublin basin of the neighbouring Poland.

Figure 5. Map of morphology of coal seam v_0^3 of the Kovel coal-bearing area of the Lviv-Volyn Coal Basin

1 – boundary of epigenetic washout of coal-bearing formation; 2 – isopaches of coal seam, m; 3 – isohypses of coalbed foot, m; 4 – contour of mainly epipeaty washouts of coal seam; 5 – coal seam of composite structure (two and more coal units); 6 – line of splitting of coal seam at different stratigraphic levels; 7 – tectonic dislocations with a break of continuity; 8 – borehole and its number; 9 – structure of seam and thickness of coal units and rock interlayers; 10 – location of detailed cross-sections; 11 – alphabetical index of coal seam; 12 – boggy seaside lowland; 13 – delta; 14 – directions of paleostreams; 15 – Kovel Carboniferous hydrographic system; 16 – boundary of paleogeographic zones; 17 – state frontier



a



b

Figure 6. Morphological sections of coal seam υ_0^3 along A–A[1] (*a*) and B–B[1] (*b*) (lines of section are indicated in Figure 5)

1 – coal seam and its thickness; 2 – argillite; 3 – siltstone; 4 – sandstone; 5 – limestone; 6 – coaly argillite; 7 – thickness of rock interlayer of splitting; 8 – bore well and its number; 9 – Jurassic washout of coal-bearing formation; 10 – washed surface of Cambrian and Silurian deposits underlying coal-bearing deposits; 11 – tectonic dislocations with a break of continuity; 12 – state frontier

On the whole, the coal seam υ_0^3 in the Kovel area is of composite structure and is splitted into two conditional coal seams $\upsilon_0^{3н}$ and $\upsilon_0^{3в}$ reaching the maximum thickness for the Lyuboml plot. Genetic indication of its splitting are contained in that the thickness of overall compact part of coal seam up to its splitting is comparable with total thickness of coal units (in neighbouring boreholes) composing it in the zone of splitting, and complication of their structure and gradual increase in the thickness of the rock interlayer, that consists of argillite and sometimes of siltstone, occurs in the direction of the centre of the studied area. Its greatest thickness is equal to 6.60 m (borehole 7005). This is also characteristic of the change in the thickness of the whole coal mass reaching 25–30 m in the centre of the area and decreases in the northern and southern directions. The gradient of splitting in the meridian direction for different sections becomes changed from 0.16 to 0.45 m/km, on an average 0.28 m/km. The seam υ_0^3 is splitted from the north to the south and from the south to the north over the area of 202.7 km^2. The contours of splitting stretch sublatitudinally forming a composite phasic three-time bifurcation. It should be noted-that fragments of its contours in the west of the area intersect the state border, and in the east they are destroyed by washing of the coal-bearing formation together with the whole carboniferous thickness.

Morphology of the coal seam υ_0^3 and its constituents was changed under the influence of interformational and epigenetic (formational) washout of carboniferous deposits. The fragment of interformational washout, belonging mainly to epipeaty washout of the coal seam, is located in the Novyny plot. It is caused by abrasion, because in its cover the limestone occurs. The contour of washout is directed beyond the limits of the area.

Washout of the coal-bearing thickness (epigenetic washout of the coal-bearing formation) in the territory of the Kovel area has decreased considerably the area of extension of coal seams, commercial coal presence and, mainly, has formed modern contours of their morphology that represent only a part of carboniferous deposits which occupied considerably larger territory before Post-Carboniferous washout. The modern configuration of the boundary of epigenetic washout is secondary one – denudational. It stretches submeridionally and occupies the whole Kovel area. Taking into consideration the relationship between the surface, the contour of washout and morphology of coal seams (their thickness, structure, extension of boundaries of splitting etc.) we can come to a conclusion that: destroyed at least the part of the seam together with the coal-bearing thickness is similar by volume to preserved one ($P_{2\text{-}4}$ – 25–50% and more).

Coal seam υ_6. In the Volyn field which structurally is in the northern part of the Lviv-Volyn Basin situated within the limits of the Lviv Paleozoic deep, not in all areas υ_6 is distributed (see Fig. 4). In the north and in the east of this field it is absent due to epipeaty washout, and in the rest of the area, where it is well-studied, there is no commercial value. It occurs at a depth of from 418 to 499 m in the thickness of siltstones and argillites with interlayers of sandstones, it has mainly one-unit, rarely two-unit structure (borehole 4317), thickness of 0.10–0.46 m and only boreholes 3903 and 4317 have fixed the thickness of 0.50 end 0.60 m correspondingly. Coaly argillites are developed here and there, and they occur in the cover of the coal seam (borehole 4326).

Within the limits of the Zabuhsky and Mezhyrichya fields, the seam is widely distributed and has a commercial value at most plots and mine fields. But it is not characteristic of stable thickness and structure in all areas. In the Zabuhsky field belonging to the Zabuhsky monocline, Sokal brachisyncline and the north-western edge of the Mezhyrichya syncline and is cut off from the Volyn field by relatively deep, 50–70 m, Jurassic washout of the coal-bearing deposits, the seam v_6 occurs at a depth of 508–687.5 m in the thickness of siltstones and argillites with interlayers of sandstone. Having working thickness ranging from 0.50 to 1.34 m and on an average is 0.76, 0.88, 0.62 and 0.72 m correspondingly; it is distributed in the fields of Chervonohradska–1, 2, 5, 6 mines. But only in the field No. 2 the seam belongs to the group of persistent by the thickness, and in other fields it is unpersistent. Its structure becomes changed from one-unit to composite and very-composite (from two-three unit to multi-unit). The seam of two- and three-unit structure with the thickness of the lower coal unit of 0.36–1.23 m, of the middle – 0.10–0.45 (with three-unit structure), and of the upper – 0.08–0.36 m, rarely 0.46–0.68 m is prevailing. The thickness of rock interlayers that divide the coal seam and are composed mainly by argillites and coaly argillites usually is insufficient, and becomes changed from the first centimetres to 0.15 m and only in some cases it reaches 0.23–0.50 m.

In the Mezhyrichya field belonging to the Mezhyrichya syncline separated by sloping uplift from the Sokal brachisyncline in the north-east (the Chervonohrad anticlinal zone), the seam v_6 occurs in the siltstone-sandstone thickness of rocks at a depth from 692 to 810 m. It is of commercial value in the fields of “Mezhyrichanska” “Vidrodzhennya”, “Lisova”, “Zarichna”, “Vizeiska” and “Stepova” mines where its thickness varies from 0.40 to 1.65 m with average values of 0.76 and 0.69, 0.58, 0.86, 0.82 and 0.77 m correspondingly. Based on the thickness, the seam belongs to the group of unpersistent, and only in the field of the “Zarichna” mine it is relatively persistent. In the eastern part of the deposit in the fields of the “Velykomostivska”, “Bendyuzka”, “Velykomostivska–5” and “Nadia” mines, the seam is washed-out partly, and in the rest fields – unworkable. Almost everywhere the seam is composed of two coal units divided by a thin rock interlayer reaching 0.05–0.10 m. The basic thick unit is the lower set, whereas the upper unit is low and doesn't exceed 0.25 m. The cover of the seam is composed mainly of argillites, sometimes of siltstones, the basement – of siltstones. The composite structure of υ_6 is characteristic of individual crossings of the seams in the western part of the field of the "Lisova" mine where within limits of the Zhuzhelyany overthrust it is splitted into two coal units. The area of splitting stretches along this dislocation.

In the Mezhyrichya field, the seam υ_6 belongs to the group of thin according to the thickness, and has a low changeability. Increased changeability is observed only in the board parts of synpeathy and early epipeaty washouts the area of which is insufficient on the whole within the limits of the field. Thus, its morphostructure is composite and has a zonal character formed by certain seam-forming conditions.

In the Mezhyrichya-Western area ajoining with the fields of "Lisova", "Zarichna" and "Stepova" mines of the Mezhyrichya deposit, the coal seam υ_6 is widely distributed, and it is absent only in the near-axial part of the Kulychkiv uplift where the upper part of carboniferous deposits of the basin is cut off by erosion, including the seam υ_6 and the underlying coal seam υ_5^6. The seam υ_6 occurs in the thickness of argillites, siltstones with interlayers of sandstones and rarely limestones at a depth of from 468–500 m in the region of the Kulychkiv uplift to 700–873 m in the north, the south-east and the south-west of this area. According to data of 107 crossings, in the greater part of this area the thickness of the seam is 0.50–2.0 m, and on an average – 0.84 m. It belongs mainly to the group of thin and is relatively persistent. The seam keeps the commercial value also within the limits of the lying side of the zone of Vanevsky and Zhuzhelyansky overthrusts with the amplitude of about 162 m. On the whole, the change in its thickness has a zonal, wave-like character. Zones with low thickness become changed are substituted for plots of grater area with conditional thickness. At greater part of the Mezhyrichya-Western plot it is characterized by low and average changeability of the thickness, and by composite and very composite one- near the Belz-Kulychkiv and Zhuzhelyansky overthrusts.

In the Mezhyrichya-Western plot, the structure of seam changes from the simple one-unit to composite and very composite two- and three-unit and more. Incidentally, the seam of two- and three-unit structure predominates. On the whole, the structure of the seam from the plot as well as changeability of its thickness has a marked zonal character: local fields of simple, composite and very composite structure are expressed on the background of the field of two- and three-unit structure that predominates. The most verified structure of the seam is observed on the eastern edge of the Kulychkiv anticlinal uplift and in the border line of active mines of the Chervonohrad coal industrial region. Here at most crossings of the seams it has very composite multi-unit layered structure which often is substituted for the two- and three-unit structure, and sometimes – for simple one-unit.

In the Tyagliv field, the boundaries of which are Poland state border in the north, the Butyn-Khlivchany zone of thrusts in the west, the Belz-Mylyatyn zone of thrusts in the east, in the south – the working contour of the coal seam $n_7^н$ (n_7), the seam υ_6 with commercial thickness is distributed in the south part, in the field of the Tyaglivska–3 mine. In the rest area (in the field of mines No. 1 and 2) it is splitted into two, in some cases into three coal units due to which the thickness of its units decreases considerably, and its commercial value is lost. The seam occurs in the thick series of aleurolites (44.8%), argillites (35.4%) and sandstones (14.1%) with the few interlayers of limestones (up to 5%) at a depth of from 697.8 to 1015.6 m that averages 837.4 m. With the workable thickness it occurs at a depth of from 815 to 850 m. It is characterized by simple and composite mainly two-unit structure. The upper coal unit is thin – 0.06–0.16 m. The rock interlayer is composed mainly of argillite about 0.15 m thick. Total thickness of the seam found more frequently reaches 0.70–1.00 m, in the field of the Tyaglivska–3 – 0.50–1.44 m with average value of 0.73 m. In its cover there are argillites, rarely siltstones, in the bottom – siltstones, argillites, sometimes sandstones.

In the fields of mines No. 1 and 2 the seam is inpersistent and belongs to the group of very thin, in the south and the south-east of the field of the mine No. 3 – relatively persistent and belongs to the group of thin, and in some plots – to the middle group. By changeability of thickness it is of low and medium complexity.

In the Lyubelya field located 5.0–7.7 km west of the Tyagliv field and is separated from it by a narrow Butyn anticlinal zone with a domed part complicated by Butyn-Khlivchany thrust zone, of the seam υ_6 is distributed unevenly in all minefields due to considerable affection by synpeaty and epipeaty washouts and substitutions reaching 57.7% of total area of the deposit. It is located in the thickness of terrigenous rocks composed of siltstones (51.0%), argillites (29.3%) and sandstones (15%) with interlayers of limestones (3.8%). A depth of occurrence varies from 641.7 m in the east and the south-east to 1517.8 m in the north-west of the deposit. By thickness ranging from 0.38 to 1.24 m and reaching 0.66 m on an average, the seam is inpersistent and belongs to thin and very thin groups. Its least thickness is observed mainly in the fields of the Lyubelska No. 2 and 5 mines. At a greater part of the Lyubelya field it has a low and average thickness, and only in some plots of the mines Lyubelska No. 2 and 3 and in the central part of the Lyubelska–1 mine – a strong one.

Morphology of the seam υ_6 of the field is composite, and in the fields of the Lyubelska No. 3 and 4 mines, in the western and the southern part of the field of the mine No. 1 it is mainly of simple one-unit structure, in the field of the mine No. 2 and in the southern half of the field of the mine No. 3 it has one-unit, two-unit and sometimes three-unit structure, with prevailing of the one-unit structure. In the central part of the field of the Lyubelska–1 mine the seam has two- and three-unit structure. The thickness of rock interlayers varies from 0.02 to 0.38 m. They are represented mainly by argillites and siltstones, sometimes by coaly argillites located in the cover and in the foot of the seam. The cover of the seam usually is composed of argillites and sometimes of siltstones, and the foot – of siltstones, sometimes of sandstones.

The structure of the coal seam υ_6 in the territory of LVB is complicated by splitting into two coal units $\upsilon_6^{\text{н}}$ and $\upsilon_6^{\text{в}}$. For example, Figure 7 shows bifurcation of the seam in the Tyagliv field of the South-Western region of the basin in detail that is the basic type of splitting. That's quite normal that almost all fields of decomposition belong to the Belz-Mylyatyn thrust zone. Incidentally, at most seam crossings the lower unit is the basic one, its thickness varies from 0.12–0.28 to 0.64–1.18 m. Rock interlayers, separating splitted units, are composed of argillites, sometimes of siltstones and sandstones. Their thickness varies within wide bounds from 0.52–5.60 to 6.40–14.60 m.

It should be noted that a modern configuration of the distribution contour of carboniferous deposits of LVB is a result of revealing the Asturian tectonic movements and later deep-seated pre-Upper Jurassic and pre-Upper Cretaceous erosional and abrasion truncations [20]. The LVB and especially the Kovel coal-bearing area compose the most uplifted closed peripheral part of the great Lviv-Lublin depression where Post-Carboniferous denudation processes occurred especially intensively. This has caused the absence in the basinal stratigraphical section of Carboniferous of deposits younger than Late-Bashkirian (Westphalian A) in its central part and Late Serpukhovian (Post-Ivanychi) ones in the territory of the Kovel area.

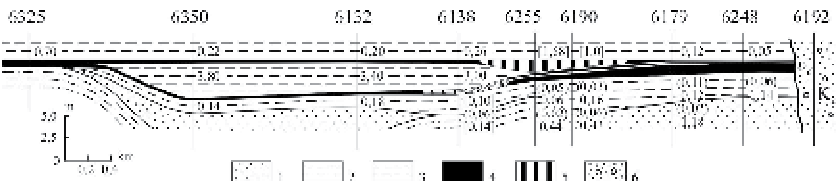


Figure 7. Splitting (bifurcation) of coal seam v_6 in the are of the Tyagliv field of the South-Western coal-bearing region

1 – sandstone; 2 – siltstone; 3 – argillite; 4 – coal; 5 – coaly argillite; 6 – deposits of Cretaceous system

5. Formation conditions of coal seams. Types of peat accumulation

Commercial coal seams of the lower subformation of the Lviv-Volyn Basin were formed in different conditions. In the north of the basin, within the limits of the Kovel coal-bearing area, the commercial coal seam v_0^3 is located in the lower part of subformation, very close to the basement represented by pre-coal deposits of Early Paleozoic. Considerable change in its morphology was caused by specific conditions of coal-forming. Before the beginning of the formation of coal-bearing deposits, the studied area was a marshy coastal lowgrounds with the rather divided erosional-tectonic relief. Its reconstruction according to known methods [9; 14; 22] using the basement of the coal seam $v_0^{3\text{н}}$ as a conventional (zero) horizon has shown that exceeding of pre-Carboniferous paleorelief is 20 m and more (Figure 8). In the central part of the territory, there existed a large (over 20 km wide) latitudinal valley-like reduction where channel and flood-plain alluvium was deposited. Increase in the thickness of alluvium in the western direction as well as results of paleopotamic analysis of the coal-bearing deposits of LVB [16] indicate the probable location of the upper reaches of paleoriver in the east – in the region of the Ukrainian Shield. Paleomorphological reconstructions, conducted by us, dave shown that during the period of the formation of the coal seams $v_0^{3\text{н}}$ and $v_0^{3\text{в}}$ and also of limestone V_1 the valley-like reduction underwent the greatest inherited subsidence in comparison with

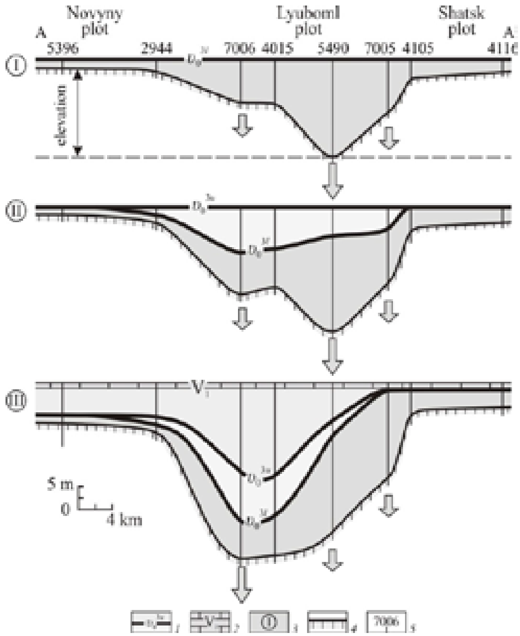


Figure 8. Reconstruction of formation stages of accumulative-tectonic splitting (bifurcation) of coal seam υ_0^3 and surface of pre-Carboniferous deposits along the line A–A[1] in the Kovel area of the Lviv-Volyn Basin

1 – coal seam and its synonymics; 2 – seam of limestone and its synonymics; 3 – formation stages of splitting: I – formation of lower coal seam, basement of splitting; II – formation of rock interlayer of splitting and upper coal seam; III – completion of splitting formation and its overburdening with rock deposits and limestone V_1; 4 – surface of pre-Carboniferous deposits; 5 – bore well its number

neighbouring (northern and southern) more uplifted areas. This has shown itself not only in the increased thickness of alluvium and coal-bearing deposits, underlying limestone V_1 on the whole but in accumulative-tectonic decomposition of the coal seam υ_0^3 into two seam in the field of paleovalley. Mother substance of the seam υ_0^3 was accumulated in the paleopeat bogs located both within the great latitudinal valley-like subsidence and in the northern and in the northern and in the southern intervalley spaces. The most favourable conditions for the formation of the paleopeat bogs were found on the slopes of paleovalleys; to a lesser extent – in its central part which was characterized by a high level of standing water, increased hydrodynamics, bringing of a considerable amount of terrigenous material into the peat bogs that caused a composite structure of the coal seams and their increased ash content. Low irrigating and intensive decomposition of a vegetable mass in aerobic conditions didn't promote forming of thick peat bogs in the uplifted areas of intervalley space.

Specific conditions of the peat accumulation in the paleovalley have predetermined a peculiar petrophysical composition of coal. In contradistinction to mainly semibright durite-clarain coal of the principal territory of LVB, indicated coal seams are composed of dull, semidull clarain-durite coal. Their main component is a group of vitrinite (on an average – 49.6%). Of macerals, kolinite (33.1%) and telinite (14.6%) are the most widespread. The composition of macerals of the group of semivitrinite averages 4.0%. Of wide development (26.2%) are macerals of the group of inertinite: semifusinite, fusinite, micrinite, inertodetrinite. Their concentration is correspondingly equal to: 9.4, 6.6, 5.1 and 5.1%. In coal the group of leptynite (27.7%) also is well-developed and mainly is represented by sporinite the concentration of which reaches 25.9% in some samples. Thus, in the coal of seams $\upsilon_0^{3н}$ and $\upsilon_0^{3в}$ not a group of microelements reaches 50%. According to the classification of the All-Russia Research Geological Institute [4], they are typical mixthohumolites in contradistinction to helitholites composing the basic coal mass of LVB. Peculiarity of the coal from the seams $\upsilon_0^{3н}$ and $\upsilon_0^{3в}$ of the Kovel area also is that kolinite predominates over telinite in the group of vitrinite to a great extent, the distribution appoximately equal quantity of such macerals as fusinite, semifusinite and micrinite in the group of inertinite; moreover, predominance of macrospores is observed in the group of leptynite.

There are notions [4] of that initial organic substance of coal of the same petrophysical composition was accumulated in well-drained peat bogs in the conditions of constant access of oxygen, microbe activity and carrying out of a greater part of humic acids. There occurred intensive decomposition of lignin-cellulose substance, and due to its washing away by the flowing water – enrichment of organic mass with the most stable to destruction microcomponents of the group of leptynite (spores, cuticle and other).

Such a dependence between the coal presence and peculiarities of pre-coalbearing paleorelief within the northern continuation of LVB was revealed for the first time. It shows itself in bifurcation of the coal seam and in complexity of its structure in the direction of the valley-like lowering. Thus, a new type of the peat accumulation was established in LVB characteristic of the coal-bearing formation of ancient platforms distributed immediatly on the erosional surface of underlying formations [6]. Formations of the basin near Moscow, Donets and other coal basins belong to such kind [7; 12; 13].

Similarity of the formation conditions of the Visean coal-bearing deposits of the Moscow Basin and the lower coal-bearing subfomation of the northern continuation of LVB becomes more obvious with consideration of almost the same substance composition of coal for both regions.

Latitudinal stretching of paleovalleys, their tracing up to the Poland state frontier and data of drilling of the Savin IG 1 borehole, that has drilled the seam 2.0 m thick located almost directly on the denuded surface of Late Paleozoic [11] confirm that indicated peculiarities of the formation of the lovers coal-bearing subformation of the northern continuation of LVB existed also in the frontier territory of the Lublin Basin [20].

Other conditions existed in the period of the formation of the coal seam υ_6, to that indicate cited peculiarities of its morphology. It is located in the thickness of terrigenous rocks between limestones V_6 and N_1 of the lower marshy-marine coal-bearing subformation that on the whore is characterized by the most expressed paralic type of coal-forming and occurs in the lagoonal-marine sedimentary cycle of the first order [19]. Common regressive character of sedimentation in the period of forming subformation led to the sea deviation in the south-western direction, in consequence continental environments of sedimentation were gradually distributed, displacing marine ones. Thus, there arouse favourable conditions for the formation of the peat bogs. In the time of the greatest regression and the formation of the coal seam υ_6 the processes of accumulation of initial organic substance occurred over the whole territory of the basin, and the shore line of the sea was displaced to the south-west beyond the studied territory (to the southwest of the Byshkiv coal-bearing area).

In the period of the formation of the seam υ_6 the locality represented a subaerial slightly dipping to the south-west deltal plain intersected by numerous very branched river beds, channels, sources of which were situated in the region of the Ukrainian Shield (Figure 9). Widely distributed within subaerial delta the river system had a great influence on the formation conditions of the seam υ_6. At that time in the territory of LVB, the Dubno and Horokhiv-Rivne hydrographic systems existed that is confirmed by the widely distributed siltstone-sandstone deposits of accumulative bodies (Figure 10).

Widly developped river system considerably influenced the formation condition of the seam. The formation of paleopeat bogs occurred mainly in uplifted plots located between water streams which are characterized by un-

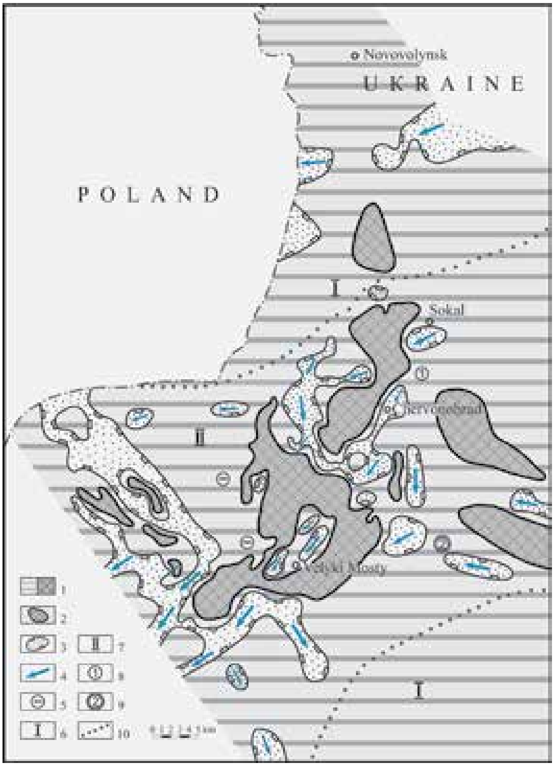


Figure 9. Paleogeographic map of the time of coalbed υ_6 formation

1 – peat bogs; 2 – plots of the most favourable conditions for peat accumulation; 3 – area where paleopeats are absent; 4 – directions of water flows; 5 – areas of the most intensive subsidence of the locality; 6 – flooded coastal lowland; 7 – delta; 8–9 – *paleohydrogtaphic systems*: 8 –Horokhiv-Rivne, 9 – Dubno; 10 – boundaries of paleohydrogtaphic zones

favourable conditions for the plant life. The explanation of this serve waved outlines of the peat massifs, their size and orientation of the boundaries. Within these bounds, synpeaty and early-epipeaty substitution and wash-outs of paleopeat bogs were widely developed in connection with that the formation of the seam υ_6 at such areas didn't occur. The smallest channels, within which accumulation of the plant material was absent, existed inside the peat massifs. From the position of the method of actualism, similar

Figure 10. Distribution of siltstone-sandstone deposits of accumulative bodies of main water currents in the period of formation of regressive part of lithocycle $V_6 - v_6$

1 – isolines of concentration of siltstone-sandstone deposits of accumulative forms, %; 2–3 – contents of sandstones and siltstones, %: 2 – 20–40, 3 – over 40; 4 – directions of currents of main water flows; 5 and 6 – paleohydrographic systems Horokhiv-Rivne and Dubno

conditions are observed in the peat bogs from the region of the delta of the Mississippi River (Figure 11) [5].

Location of the delta quite close to the sea also is a negative factor for the formation of the seam v_6. As a result of the sea transgression, water penetrated depressed plots of the relief. There the formation of coastal lakes, salted bogs with a high level of water standing, preventing the plant growth, occurred.

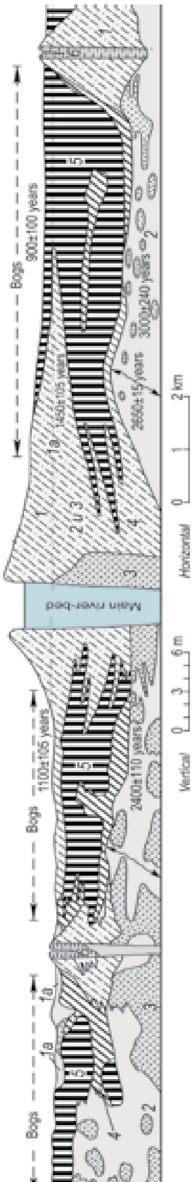


Figure 11. Cross-section of Holocenic peat bog from the region of the Mississippi River delta [5]
1 and 1 a – deposits of coastal range and crevasse splay; 2 – silt; 3 – silt sand; 4 – silt with organic material; 5 – peat; 6 – filled river-bed

The most favourable conditions for the peat accumulation existed in the central part of the peat massifs remoted from the river channels. Great peat bogs of considerable thickness were formed in the mouth part of the subaerial delta in the inner part of the Lviv tectonic deep (farther south of Chervonohrad).

In comparison with the outer zone of the deep which is situated father north-east, it was characterized by greater mobility of the basement and more intensive subsidence of the locality that promoted forming of the peat bogs of increased thickness. Consedimentary tectonic movements as well as frequent fluctuations of the level and dynamics of ground water have caused numerous splittings of the seam v_6 and formation of the rock layers in it. Apart from positive effect of the tectonic factor which determined subsidence of the locality and accumulation of great masses of organic substance, the formation of the peat bogs of increased thickness was conduced by the river beds, channels through which a considerable amount of terrigenous material passed to the area of sedimentation and a compensation regime of sedimentation was kept.

In the far south-west of the basin within the mouth part of the alluvial-deltaic plain located near the sea, the conditions for the formation of the paleopeat bogs became less favourable due to limited demension of uplifted plots which became boggy, increase in the level of water standing in the peat bogs, decrease in duration of the peat accumulation. The distribution of the plots with workable thickness of the seam has an island character. The next subsidence of the locality has led to transgression of the sea, settling of lagoonal-lacustrine environments, stopping of the formation of the seam υ_6 over the whole territory of the basin.

6. Conclusions

Investigations of the coal presence, studies of the peculiarities of morphology and substantiation of the commercial value of the coal seams of deep horizons are urgent from the point of view of the problem of possible prolongation of the period of exploitation of active mines and further development of the Lviv-Volyn Basin.

Within the bounds of deep horizons in deposits of the lower coal-bearing subformation, the coal seams υ_0^3 and υ_6 are considered to be basic and are of the greatest commercial significance, and are widely distributed with working thickness. In the Kovel perspective area and the central part of the basin – υ_0^3 and υ_6 – in the Zabugske and Mezhyrichya fields of the Chervonohrad coal industrial region.

Dependence between peculiarities of the pre-Carboniferous paleorelief and the formation of the coal-bearing thickness of the Kovel area was marked for the first time. Conducted paleogeomorphological reconstructions have revealed the existence of the latitudinal (over 20 km wide) valley-like lowering in its central part that has undergone the most inherited subsidence and has led to the increase in the thickness of the coal-bearing deposits underlying limestone V_1, and to accumulative-tectonic splitting of the coal seam υ_0^3 into two conditional coal seams $\upsilon_0^{3н}$ and $\upsilon_0^{3в}$, that is to say, to composite staged bifurcation. Thus, a new type of the peat accumulation was established in the Lviv-Volyn Basin characteristic of the platform carboniferous coal-bearing formations located directly on the erosional surface of different-age formations underlying them that needs of a special approach to exploring and prospecting.

The Serpukhovian coal seam υ_6 was formed within the bounds of the subaerial deltaic plain where the most favourable conditions for the peat accumulation were found in the mouth parts of delta located in intrachannel space among coarse paleohydrographical system as well as in the inner part of the Lviv tectonic deep which is characterized by more intensive subsidence of the location and widly developed water flows.

In the area of the basin, the most composite morphostructure of the coal seam v_6 is characteristic of the South-Western coal-bearing region, especially of the Tyagliv and Lyubelya fields and the plot of Mezhyrichya-Western. Exactly in that region it is splitted into two coal units $v_6^н$ and $v_6^в$. Especially great fields of splitting were distinguished in the south of the Tyagliv deposit and in the north-west of the plot of Mezhrichya-Western that testifies to the most unstable conditions of its formation in this part of the basin.

On the basis of detailed investigations of the peculiarities of formation and studies of the morphology of the coal seam v_6 of the deep horizons, a deltaic type of the peat accumulation was determined for the first time.

Cited material and conducted paleoreconstructions verify and supplement existing notions of carboniferous coal accumulation in the south-west of the East European Platform, and in particular of insufficiently studied deltaic type of the peat accumulation. Regarded in applied aspect, they are important in solving practical tasks connected with prognostic assessment of the commercial coal presence in the deep horizons of the Lviv-Volyn Basin.

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CHAPTER «SOCIAL COMMUNICATIONS»

ELECTRONIC RESOURCES OF UNIVERSITY LIBRARIES (CATALOG, LIBRARY, ARCHIVE REPOSITORY) AS A MEANS OF COMMUNICATION IN THE EDUCATIONAL AND SCIENTIFIC ENVIRONMENT

БІБЛІОТЕЧНІ ЕЛЕКТРОННІ РЕСУРСИ УНІВЕРСИТЕТІВ (КАТАЛОГ, БІБЛІОТЕКА, АРХІВ-РЕПОЗИТАРІЙ) ЯК ЗАСІБ КОМУНІКАЦІЇ В ОСВІТНЬО-НАУКОВОМУ СЕРЕДОВИЩІ

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Abstract. The article examines the phenomena of institutional depository, electronic library and electronic catalog in general and drawing on the specific example of Poltava National Technical Yuri Kondratyuk University, which are the basis of educational, pedagogical and scientific processes, on the resources and services of which the content of studies and scientific research of the university significantly depend, as well as the presentation of the results of its operations (first of all, in scientific, academic, learning and teaching fields). The subject of research were electronic resources of the libraries in higher educational establishments. The purpose of this work is to find out the existing and potential role of electronic resources of archives and libraries as a means of communication in the educational and scientific environment on the example of electronic resources of the scientific and technical library of Poltava National

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Technical Yuri Kondratyuk University. To solve these problems, we have applied a set of theoretical (description, analysis, synthesis, comparison, generalization) and empirical (observation) research methods. Descriptive (declarative) approach to the analysis of the essence of the studied problems made it possible to understand their peculiarities. The application of the functional approach allowed us to substantiate the functions of the educational and scientific environment in a higher educational establishment. The conducted research has made it possible to ascertain that today the libraries of Ukrainian higher educational establishments are in the process of continuous development, technical improvement, they search for and find their place in the country's information space and in the educational and scientific environment. Electronic resources have become an integral part of the educational process that affects the quality of higher education; the basic technological processes of the library are formed on the basis of electronic catalogues' resources. Electronic catalogues allow users to receive conveniently and quickly materials in electronic form and the most complete information about the documents of the traditional (paper) fund. The analyzed world and national experience of introduction of open electronic archives and features of functioning of electronic catalogs and libraries for university science and education give grounds to state that these information resources have already proved their effectiveness in providing qualitative communication for all participants of educational and scientific environment. For a scientist, these forms of open access to information have many advantages, including increasing the citation index of works, their permanent and long-term preservation, and reservation of author's rights for research papers and scientific research results. For higher educational establishments it is the reflection of the objective indicator of the quality of scientific work and raising the university's status and im-portance as a scientific center. On the example of institutional repository, electronic catalogs and scientific and technical library of Poltava National Technical Yuri Kondratyuk University, which have been implemented in the form of a site, we have demonstrated the important role of electronic archives and libraries as a driving force of modern educational, pedagogical and scientific processes, which allows to brisk up and speed the work on formation of acces-sible educational and methodological information.

1. Вступ

Розвиток системи освіти висуває високі вимоги до якості підготовки дипломованих фахівців. Більшість першочергових завдань сучасних закладів вищої освіти (ЗВО) тісно пов'язана з діяльністю бібліотеки як однієї з найважливіших ланок академічного та наукового процесів.

Молоде покоління все більше схиляється до здобуття інформації з використанням сучасних інформаційних технологій та орієнтується на мережу Інтернет. І саме бібліотека університету є тією творчою лабораторією, від ресурсів та послуг якої залежить багато в чому якість і зміст навчання та наукових досліджень. Сучасний стан розвитку освітньо-наукового середовища (ОНС) характеризується підвищенням вимог до якості електронних ресурсів наукового та навчального призначення, поширенням більш гнучких, персоніфікованих, відкритих організаційних систем, що стає можливим із використанням сервісів перспективних інформаційно-комунікаційних платформ. На думку М. Шишкіної, освітньо-наукове середовище – це системний комплексний феномен, що охоплює як різні інформаційно-технологічні, так і педагогічні аспекти у процесі проектування [17, с. 7, 138].

Сучасні виші потребують впровадження нових підходів до навчання та потреб у самоосвіті. В умовах змін, що відбуваються сьогодні в системі вищої освіти, різко зростає роль і значення самостійної роботи студентів як однієї із найважливіших складових професійного становлення майбутнього фахівця. Саме інформатизація, формування освітнього середовища навчального закладу на основі інформаційних технологій сприяє вирішенню цих задач. Ефективність самостійної роботи залежить від багатьох складових: це і впровадження сучасних освітніх технологій, і забезпеченість навчальною, навчально-методичною, довідковою й науковою літературою, і достатність робочих місць, обладнаних сучасною електронною технікою. Суттєву роль у підготовці фахівця відіграє бібліотека закладу вищої освіти, оскільки саме в ній сконцентрована спеціалізована навчальна та наукова інформація [16].

З одного боку, гігантські обсяги накопиченої інформації, безперервне їх зростання, різнорідний характер збереження й поширення, відсутність уніфікованого доступу до неї створюють істотні проблеми. Все це спонукало до пошуку нових підходів і розв'язання проблем створення сховищ інформаційних ресурсів, їх організації, засобів і способів доступу до них користувачів, тобто до створення цифрових або електронних бібліотек та електронних архівів [4].

З іншого боку, сьогодні розвиток системи освіти висуває високі вимоги до якості підготовки фахівців. Неможливо уявити сучасний університет без доступу до електронних баз даних, надання сучасних інформаційних послуг, які потрібні студентам різних видів навчання. Навчальні програми в університетах в сучасних умовах передбачають зменшення аудиторного навчання й одночасне збільшення відсотка самостійної роботи, й тому студенти проводять значно більше часу в бібліотеці. Сучасний ЗВО потребує впровадження нових підходів до навчання, що забезпечують поряд з його фундаментальністю розвиток комунікативних творчих і професійних компетенцій, потреб в самоосвіті на основі потенційної багатоваріантності змісту й організації освітнього процесу. Саме інформатизація, формування освітнього середовища навчального закладу на основі інформаційних технологій сприятиме вирішенню цих завдань. Необхідно відзначити складність і суперечність процесу інтеграції інформаційних технологій в наявне класичне освітнє середовище вишів [16].

Питання навчальних середовищ в освітніх закладах досліджували такі вітчизняні науковці: Г. Омельяненко – інформаційно-навчальне середовище, В. Биков – навчальне середовище сучасних педагогічних систем, О. Таланчук – формування інформаційно-освітнього простору університету, А. Цимбалару приділяла увагу моделюванню інноваційного освітнього простору та ін. Окремі аспекти формування та використання інформаційних ресурсів у бібліотеках деяких університетів розглядались у публікаціях В. Білоус, Н. Ніколаєнко, Л. Савенкової. Значна увага приділялася питанням, пов'язаним зі створенням та функціонуванням електронних архівів та бібліотек, а також теоретичним і практичним аспектам їх використання у навчальній діяльності та науковому середовищі. У даному контексті потрібно назвати таких дослідників, як О. Бруй, М. Жалдак, О. Кузьміна, І. Передерій, В. Резніченко, О. Спірін, Д. Тарасов. Питання електронних каталогів цікавило Т. Луцишину, О. Желай та інших. Але фундаментальні роботи з комплексного вивчення цих проблем є поодинокі. Досліджена джерельна база свідчить про недостатність і фрагментарність розроблення проблематики електронних ресурсів бібліотек університетів як засобу комунікації в освітньо-науковому середовищі закладів вищої освіти, чим і зумовлена **новизна дослідження**.

Розуміння того, що якісна освіта не може існувати без якнайширшого доступу до якісних інформаційних ресурсів, які забезпечують процеси викладання, навчання та дослідження, спонукали нас до аналізу провідних форм такого доступу, котрі вже довели свою ефективність у Західному світі протягом останніх кількох десятиліть. Тому саме електронні ресурси (електронний каталог, електронна бібліотека та інституційний репозитарій), які перетворюються наразі на основу навчально-педагогічного та наукового процесів, від ресурсів та послуг яких значною мірою залежить зміст навчання та наукових досліджень, стали **об'єктом** нашого вивчення, зумовивши **актуальність обраної теми**.

Мета роботи – з'ясувати наявну та потенційну роль електронних ресурсів архівів і бібліотек як засобу комунікації в освітньо-науковому середовищі на прикладі електронного каталогу, електронної бібліотеки та інституційного репозитарію науково-технічної бібліотеки Полтавського національного технічного університету імені Юрія Кондратюка (НТБ ПолтНТУ).

Реалізація поставленої мети передбачає розв'язання таких **дослідницьких завдань:** 1) з'ясувати функціональні можливості застосування електронних каталогів як основного інформаційного ресурсу бібліотек в освітньо-науковому середовищі ЗВО; 2) дослідити феномен інституційного репозитарію як конструктивної моделі Open Access, а також проблеми і перспективи його функціонування у сфері соціальних комунікацій загалом та в ОНС зокрема; 3) проаналізувати світовий та вітчизняний досвіди запровадження, особливості функціонування електронних бібліотек та їх роль у розвитку сучасної університетської освіти й науки; 4) навести принципи розроблення, формування та забезпечення функціонування електронних каталогу й бібліотеки та інституційного репозитарію закладу вищої освіти на прикладі ПолтНТУ.

Методологія дослідження. Для вирішення поставлених завдань застосовано сукупність теоретичних (опис, аналіз, синтез, порівняння, узагальнення) та емпіричних (спостереження) методів дослідження. Дескриптивний (описовий) підхід до аналізу сутності досліджуваних проблем дозволить зрозуміти їхні особливості. Застосування функціонального підходу дозволить обґрунтувати функції освітнього-наукового середовища закладу вищої освіти. Дослідження здійснювалося в контексті науково-дослідної роботи кафедри над комплексною науковою темою «Документно-інформаційні комунікації в умовах сучасних глобалізаційних викликів».

2. Електронний каталог як основний інформаційний ресурс ОНС ЗВО

Сучасний період розвитку суспільства позначений бурхливим розвитком інформаційних і комунікаційних технологій та невпинним зростанням кількості інформації, тому не дивно, що й у житті бібліотек відбуваються революційні зміни: автоматизація та комп'ютеризація бібліотечних технологічних процесів, впровадження новітніх технологій. У сучасних умовах інформаційні ресурси бібліотек ЗВО становлять собою органічне поєднання традиційних документних ресурсів на паперових носіях і електронних ресурсів локального або мережевого доступу, забезпечують оперативність, релевантність, повноту та якість задоволення інформаційних потреб безпосередньо присутніх і віддалених користувачів шляхом удосконалення бібліотечно-інформаційних послуг, зокрема організації електронного каталогу, електронної бібліотеки, інституційного репозитарію, електронного доставлення документів, обслуговування читачів у режимі віддаленого доступу до баз даних українських і закордонних бібліотек та інформаційних центрів.

Прагнення до якіснішого задоволення інформаційних потреб користувачів виводить бібліотеки закладів вищої освіти на новий рівень довідково-бібліографічного обслуговування. Репрезентація бібліотечних ресурсів у мережі Інтернет сприяє формуванню позитивного іміджу ЗВО та відіграє суттєву роль в організації відкритого доступу для віддаленого користувача, тому одне із найважливіших завдань наукової бібліотеки університету – створення і представлення на сайті електронного каталогу (ЕК) як багатофункціонального бібліографічного ресурсу, що має задовольняти потреби всіх користувачів Інтернету, тому дослідження стану ЕК бібліотек на сайтах є актуальним завданням сьогодення [9, с. 19].

Електронними каталогами можуть користуватися одночасно багато користувачів. Внутрішня електронна система розробляється бібліотекою самостійно, що дозволяє їй поповнювати електронну бібліотеку, розробляти додатковий функціонал, інтегрувати її з іншими інформаційними системами, наприклад, АБІС, автоматизована бібліотечна інформаційна система, призначена для автоматизації бібліотечних процесів на основі використання сучасних інформаційно-комунікативних технологій, засобів обчислювальної техніки та телекомунікаційних мереж.

Для реалізації функцій, що підлягають автоматизації, кожна бібліотека вибирає найбільш відповідне для себе програмне забезпечення. В бібліотеках України використовується різні прикладні програмні продукти. Серед них можна виділити такі: «МАРК-SQL», «ІРБІС», «ALEPF», «УФД/Бібліотека», «UniLib» та ін.

Електронний каталог науково-технічної бібліотеки Полтавського національного технічного університету імені Юрія Кондратюка (ЕК НТБ ПолтНТУ) – машиночитана бібліографічна база даних з набором сервісів для користування. Електронний каталог є основною складовою частиною довідково-бібліографічного апарату науково-технічної бібліотеки. ЕК працює в реальному режимі часу і є складовою частиною довідково-бібліографічного апарату науково-технічної бібліотеки й центральною ланкою АБІС «Університетська бібліотека «UniLib». Доступ до ЕК у мережі Інтернет, можливість мобільного пошуку інформації в зручний для користувача час роблять ЕК одним із найпопулярніших бібліотечних бібліографічних ресурсів.

ЕК організований як єдиний каталог на всі документи, які надходять у бібліотеку, починаючи з 2002 року; статті з періодичних видань із 2002 року; ретроспективний фонд документів до 2002. ЕК НТБ ПолтНТУ розкриває склад і зміст бібліотечних фондів друкованих, аудіовізуальних, електронних документів українською, російською та іноземними мовами, а також слугує для забезпечення вільного доступу до інформаційних ресурсів бібліотеки й реалізації багатоаспектного інформаційного пошуку. У каталозі показані документи, які були надруковані з 1845 року по теперішній час. Поряд з каталогізацією нових надходжень літератури проводиться ретроконверсія бібліотечного каталогу, тобто перетворення карткового ка-талогу в електронну базу даних бібліографічних описів книг, які отримані бібліотекою до початку створення ЕК (до 2002 р.). На сьогодні ЕК містить понад 216000 записів і щодня змінюється.

ЕК НТБ ПолтНТУ поєднує функції алфавітного, систематичного й топографічного каталогів, систематичної картотеки статей, алфавітно-предметного покажчика надаючи при цьому оперативність і гнучкість інформаційного пошуку за різними пошуковими елементами (автор, заголовок, ключове слово, предметна рубрика, вид/тип документа й т.п.). Результати пошуку в ЕК користувач може подивитися на екрані монітора, записати на електронний носій у вигляді списку документів, бібліографічної картки. У складі ЕК формуються такі бази даних: «Книги», «Періодичні видання», «Методичні вказівки», «Статі», «Дисертації», «Автореферати», «Нормативно-технічна документація», «Рідкісні та цінні видання».

АІБС ЕК бібліотеки організований на основі автоматизованої бібліотечно-інформаційної системи UniLib, доступ реалізується через локальну мережу університету та мережу Інтернет на сайті ПолтНТУ у розділі «Бібліотека» за посиланням «Сайт Науково-технічної бібліотеки» [11].

Автоматизована інформаційно-бібліотечна система Unilib (АІБС «Університетська бібліотека») розроблена в 1999–2004 рр. науково-дослідним інформаційно-комп'ютерним центром Національного університету внутрішніх справ (м. Харків). Завдяки базуванню, як на новітніх типових бібліотечних, так і на сучасних комп'ютерних технологіях, Unilib прекрасно функціонує в закладах будь-якого типу. Близько п'ятдесяти бібліотек України зробили вибір на її користь. Систему Unilib вигідно відрізняють простота використання одночасно з повнотою функціональних можливостей та орієнтація на сучасні методологічні, технологічні й технічні досягнення [1]. До основних завдань ЕК НТБ ПолтНТУ належать: всебічне розкриття складу й змісту фонду НТБ; забезпечення багатоаспектного оперативного пошуку інформації про наявність документів у фонді НТБ; інтеграція ресурсів НТБ в інформаційний простір навчального закладу, ре-гіону і всесвітню інформаційну мережу Інтернет; захист інформації; створення інформаційного комфорту для користувачів.

Однією з основних функцій ЕК НТБ є забезпечення навчального процесу, наукових досліджень і сфери управління університету бібліографічними даними про документи, що зберігаються у бібліотечному фонді за заголовком, описом, тематикою, вихідними даними, ключовими словами, інвентарними номерами і т.п. Співробітниками відділу комплектування та наукової обробки документів постійно проводиться поточне редагування ЕК.

Статистичні показники кількості відвідувань бібліотеки з метою здобуття традиційних послуг з видачі документів поступово знижуються, проте, одночасно зростає відвідуваність залів електронної інформації. Сьогодні практично вся робота бібліотеки орієнтована на віртуальне середовище. Для зручності користувачів (студентів і викладачів) через сайт розкривається та популяризується фонд, надається доступ до повнотекстових інформаційних ресурсів, виконуються бібліографічні довідки за допомогою сервісів віртуальної довідки та зворотного зв'язку. Бібліотека виступає в ролі інформаційного посередника, навігатора, структуруючи Інтернет-ресурси, допомагає користувачеві знаходити якісний, релевантний матеріал, здійснює пошук, відбір та аналітико-синтетичну обробку ресурсів. Інформаційно-комунікаційні технології та сервіси, що впроваджуються в бібліотеці, відкривають нові можливості в інформаційному забезпеченні користувачів. Електронна пошукова система дозволяє за лічені секунди знаходити в каталозі бібліотеки потрібні видання і складати бібліографічні списки. Каталог бібліотеки створений так, щоб з ним легко міг працювати як досвідчений читач, так і новачок [7, с. 535].

Отже, якісна освіта не може існувати без доступу до якісних інформаційних ресурсів, що забезпечують процеси викладання, навчання та дослідження. Тому можна стверджувати, що ЕК НТБ ПолтНТУ є одним із головних інформаційних ресурсів бібліотеки, складовою частиною інформаційно-освітнього простору університету, головною ланкою інформаційної системи.

3. Інституційний репозитарій – відкритий архів електронних документів

Технічний прогрес докорінно змінив спосіб опрацювання інформації, що призвело до появи документів в електронній формі та електронного документообігу. Значний масив сучасної документації все більше переходить у цифрову форму. Змінюється розуміння сутності «традиційного» документа (переважно з паперовим носієм інформації), більше уваги приділяється не матеріальній складовій, а інформаційній, тому доступ до електронних ресурсів, зокрема, ресурсів науково-освітніх мереж і відкритих інформаційних систем докорінно змінює розвиток освітньо-наукового середовища вищого навчального закладу. Поступове впровадження принципів відкритого доступу в систему вітчизняної науки та освіти, а також створення репозитаріїв на базі електронних бібліотек українських вишів викликало наше зацікавлення.

Реалізація відкритого доступу до інформації шляхом створення інституційних репозитаріїв посідає провідне місце у дослідженнях Т. Ярошенко. У ході вивчення проблем наукової комунікації дослідниця характеризує відкритий доступ до інформації як найбільш ефективний засіб обміну інформацією у сфері науки [18]. Особливу роль електронних архівів наукових публікацій для ефективної комунікації в освітньому та академічному середовищах розглядала й І. Передерій [10]. Аналіз Інтернет-джерел наукової інформації та підходи до їх збереження для наступних поколінь бібліотеками як інститутами, що забезпечують реалізацію меморіальної функції суспільства, є об'єктом наукових пошуків В. Копанєвої [8].

Виникнення ідеї відкритого доступу до інформації та процес його становлення вивчала Т. Ярошенко. Вона наголошували на тому, що на сьогодні рух за Open Access є незворотнім. Університетські інституційні репозитарії, створені зусиллями спеціалістів у галузі інформаційних технологій і бібліотекарів, дають позитивні результати у поширенні наукової інформації, її збереженні та забезпеченні швидкого доступу до неї. За цих умов бібліотекарі представляють велику групу інтелектуальних споживачів і провайдерів Відкритого доступу, які підтримують авторів, видавців і власників електронних репозитаріїв [18; 19].

Принципи відкритого доступу до інформації передбачають надання необмеженого та безоплатного доступу до наукових публікацій і досліджень двома шляхами. Перший – так званий «золотий шлях» (Gold Road) – це вільний доступ до всіх матеріалів безпосередньо у момент публікації. Одним із його варіантів є інтернет-видання, які абсолютно відкриті для користувачів. Робота видавництв при цьому фінансується з бюджетів на наукові дослідження. Існує також гібридна модель, коли автори або установи, де вони працюють, можуть заплатити видавництву кошти, потрібні для підготовки статті, після чого вона з'являється у відкритому доступі. Наприклад, Товариство Макса Планка оплачує публікації статей своїх членів. Другий – «зелений шлях» (Green Road) відкритого доступу – це депонування та самоархівування науковцями своїх праць у відкритих електронних архівах (репозитаріях) відповідно до стандартів Open Archives Initiative Protocol for Metadate Harvesting (OAI-PMH). Автори публікуються у журналі, який поширюється за передплатою і має платний доступ до статей, проте через певний час вони можуть відкрити доступ до своїх матеріалів, зазвичай розміщуючи їх в інституційному репозитарії – на платформі зі стандартним програмним забезпеченням, яке передбачає можливість пошуку потрібної інформації й загальний моніторинг усіх таких репозитаріїв. Зелений шлях не вимагає повної перебудови системи наукових публікацій, тому автори можуть друкувати свої статті у журналах, а потім архівувати їх і забезпечувати вільний доступ до них у репозитарії. Отже, на думку багатьох дослідників, саме цей шлях є найбільш оптимальним і вирішить із часом усі проблеми, пов'язані із доступом до наукової інформації [19, с. 5].

Згадані принципи втілені у низці нормативних документів міжнародного та вітчизняного значення. Зокрема, Концепції відкритого доступу відбиті у міжнародних Будапепештській (2002 р.), Берлінській (2003 р., 2004 р., 2005 р.), Шотландській (2004 р.) деклараціях.

На сьогодні існує кілька видів відкритих електронних архівів: інституційні репозитарії (університетські, науково-дослідних інститутів тощо), тематичні репозитарії (за галузями знань), так звані агрегатори (містять дані з кількох електронних архівів), державні репозитарії (містять урядові дані) [5].

Для університетської науки й освіти особливо привабливим і ефективним є саме зелений шлях реалізації відкритого доступу до інформації, тобто створення університетських репозитаріїв, адже університет – це основний виробник наукової продукції у світі. За свідченням дослідниці Т. Ярошенко, на сьогодні значна частка наукових публікацій вітчизняних науковців (від 170 до 200 тисяч на рік) залишаються невідомими не лише світовій, а й українській академічній спільноті [18, с. 49]. Змінити ситуацію і покликане запровадження інституційних (зокрема, університетських) репозитаріїв.

Інституційний репозитарій, як відомо, це відкритий електронний архів для тривалого зберігання, накопичення та забезпечення довготривалого й надійного відкритого доступу до результатів наукових досліджень, що проводяться в установі. Університетський інституційний репозитарій може містити такі матеріали: наукові статті, автореферати дисертацій та дисертації, навчальні матеріали, монографії чи їх розділи, навчальні посібники, підручники, студентські роботи, матеріали конференцій, патенти, зображення, аудіо- та відеофайли, веб-сторінки, комп'ютерні програми, статистичні матеріали, навчальні об'єкти, наукові звіти, навчально-методична література тощо. З огляду на це, головна мета інституційного репозитарію полягає у створенні глобальної оглядовості наукових матеріалів установ і надання вільного доступу до них.

Перший інституційний репозитарій у світі був створений 1991 р. у Швейцарському державному інституті технологій (ETH E-collection). Станом на 1 травня 2015 р. він налічував у своїх фондах 27000 матеріалів. Ініціативу відкритого доступу до наукової та навчальної інформації на початку нового тисячоліття підтримали найбільші університети світу та розпочали процеси щодо їх запровадження і розвитку. На сьогодні у світі функціонує близько 4000 інституційних репозитаріїв, із яких близько 85 відсотків – університетські. Причому майже половина з них виникли протягом останніх чотирьох років, що свідчить про стрімке зростання інформатизації освітньо-наукового середовища [5].

В українському правовому сегменті принципи відкритого доступу до інформації регламентуються Постановою Верховної Ради України «Про рекомендації парламентських слухань з питань розвитку інформаційного суспільства в Україні» (2005 р.) [15] та Законом України «Про основні засади розвитку інформаційного суспільства в Україні на 2007–2015 рр.» (2007 р.) [15]. Загалом Українська держава активно підтримує згадані два шляхи організації відкритого доступу. В січні 2009 року на її території стартував проєкт за назвою E-LibUkr «Електронна бібліотека: створення центрів знань в університетах України». Кожен науковець може долучитися до підтримки руху відкритого доступу для отримання якнайкращого ефекту від своїх наукових публікацій.

Говорячи про призначення інституційних репозитаріїв, які створюються як системи відкритого доступу до інформації у вищих навчальних закладах, потрібно сказати, що вони включають зібрання, систематизацію та зберігання в електронному вигляді інтелектуального продукту науковців, інших електронних документів із фондів бібліотек, на які не встановлено обмеження щодо авторського та суміжних прав; забезпечення відкритого доступу до публікацій засобами Інтернет-технологій, поширення цих матеріалів у середовищі світової науково-освітньої спільноти.

Як бачимо, інституційний репозитарій організовується з метою забезпе-чення місця та способу централізованого і довготривалого зберігання в електронному вигляді повних текстів наукових публікацій. Його головними завданнями є: сприяння зростанню популярності навчального закладу шляхом представлення його наукової продукції у мережі Інтернет; збільшення індексу цитування (імпакт-фактору) шляхом забезпечення вільного доступу до наукових публікацій; створення надійної та доступної системи обміну публікацій наукових робіт. Інституційний репозитарій виконує навчальну, науково-дослідну, довідкову-інформаційну функції. Він відіграє провідну роль щодо поповнення бібліотечного фонду оригінальними електронними документами та електронними копіями друкованих видань та їх збереження.

Необхідно визнати той факт, що в Україні, як і в більшості держав пострадянського простору, практична реалізація відкритого доступу до інформації розпочалася із деяким запізненням, лише з другої половини минулого десятиліття, а тому організація інституційних репозитаріїв та відкритого доступу до них у бібліотеках вишів нашої країни залишається ще й досі одним із нагальних завдань. Першими ВНЗ в Україні, які запровадили інституційні репозитарії 2006 р., були Національний університет «Києво-Могилянська академія» та Український католицький університет (м. Львів). На сьогодні їх вже 75 (що охоплює приблизно 18% всіх українських вишів). Отже, як бачимо, більшість установ вітчизняної вищої школи досі не створили відкритих електронних наукових архівів.

Відкритий доступ до інформації не порушує авторського права, оскільки репозитарії не виконують видавничої функції, а лише зберігають матеріали та репрезентують їх через мережу Internet. Автори мають змогу архівувати свої публікації без будь-якого дозволу. Якщо автор статті передає авторське право видавцеві (цього вимагають, як правило, комерційні закордонні видавництва), то наступне архівування власних матеріалів потребує дозволу видавця [19, с. 7].

Дослідницькі статті, заархівовані науковцями у репозитарії, мають багато переваг, адже їх цитують набагато частіше, ніж статті з традиційних журналів, суттєво зростає читацька аудиторія. У більшості галузей науки рейтинг цитування зростає як мінімум удвічі завдяки самоархівуванню. А подекуди і набагато вище. Отже, такий різновид відкритого доступу робить дослідження значно впливовішим. Окрім того, життєвий цикл статті (коли дослідження публікують, цитують і надалі розвивають у дослідженнях інших науковців) інтенсифікується та прискорюється, якщо результати дослідження представлені у відкритому доступі.

Не менш важливу роль інституційний репозитарій відіграє й для функціонування цілого наукового підрозділу (наприклад, для кафедри чи наукової лабораторії в університеті), адже поширює про нього інформацію серед академічної спільноти, сприяє зростанню рівня цитованості наукових публікацій його представників, забезпечує тривалість та постійність їх збереження. Для самого ж університету наявність такого інформаційного ресурсу є чинником загальної підтримки наукової діяльності, покращення якості наукової комунікації, підвищення рейтингу, забезпечення відкритого доступу до досліджень [10, с. 112].

Інституційні репозитарії мають неабиякий потенціал служити реальним показником якості університетів як науково-освітніх центрів, оскільки демон-струють наукову, соціальну та економічну значущість дослідницьких робіт, а, отже, й статус та суспільне значення вищого навчального закладу. У цьому контексті не можна обійти увагою й відповідний наказ МОН України № 707 від 04.07.2018 р., яким затверджено Регламент роботи Національного репозитарію академічних текстів» [14].

Говорячи про університетський репозитарій, не можна забувати й про ще одного суб'єкта, який виграє від його використання, – студента. Відкритий електронний архів вишу дає можливість цій категорії його користувачів мати швидкий і необмежений доступ до навчально-методичної та наукової літератури, створеної університетською академічною спільнотою, і, таким чином, не залежати від наявних книжкових фондів, а, отже, ефективно засвоювати навчальний матеріал. Крім того, у такому електронному архіві можуть розміщувати свої роботи не лише науковці (викладачі та аспіранти), а й окремі студенти, наприклад ті, які навчаються на магістерських програмах, за рекомендацією представників академічної спільноти.

У 2015 році у ПолтНТУ створено Репозитарій Полтавського національного технічного університету імені Юрія Кондратюка (далі – ePNTUIR) – це інституційний репозитарій (електронний архів), що забезпечує накопичення, систематизацію та зберігання в електронному вигляді інтелектуальних продуктів наукового, освітнього та методичного призначення, створених авторами творів, та забезпечує постійний довготривалий безкоштовний відкритий доступ до них через мережу Інтернет. Репозитарій Полтавського національного технічного університету імені Юрія Кондратюка є складовою електронних ресурсів науково-технічної бібліотеки. Назва репозитарію ePNTUIR є скороченням повної назви електронного Інституційного репозитарію Полтавського національного технічного університету імені Юрія Кондратюка англійською мовою (Electronic Poltava National Technical University Institutional Repository) [12].

Отже, інституційний репозитарій як феномен конструктивної моделі Open Access є ефективною формою комунікації у сучасному освітньо-науковому середовищі, яка безперечно сприятиме розвитку університетів у сучасному світі та в Україні.

4. Електронна бібліотека ЗВО – невід'ємний складник ОНС

Інституційні репозитарії частково пов'язані з поняттям електронної бібліотеки (ЕБ) – інформаційного ресурсу, який забезпечує збирання, зберігання, класифікацію, каталогізацію й доступ до цифрового контенту, аналогічного до функцій звичайних бібліотек.

Приєднання України до Болонського процесу та перехід на кредитно-модульну систему побудови навчального процесу стали важливим кроком на шляху України до євроінтеграції. І саме на бібліотеки закладів вищої освіти покладена важлива роль у забезпеченні доступності інформаційних ресурсів.. Зміни в організації навчального процесу потребують перебудови у діяльності бібліотек. Тому актуальним напрямком є створення ЕБ, оскільки доступ до електронних ресурсів через мережу надає можливості зовсім іншого порядку [2, с. 215].

ЕБ (також доволі широко як синонім вживається термін «цифрова бібліотека») – сукупність матеріалів, що зберігаються в електронній (цифровій) формі, доступ до яких здійснюється за допомогою комп'ютерної техніки. Доступ до матеріалів ЕБ може здійснюватися як в окремому визначеному місці (наприклад, приміщенні бібліотеки чи спеціально обладнаному приміщенні навчального, культурного, іншого громадського закладу), так і через будь-яку точку доступу до всесвітньої мережі Інтернет [6].

Як зазначає В. Білоус, поняття «електронна бібліотека» означає зберігання, виведення інформації в машиночитаній формі на комп'ютер користувача, швидкий доступ до інформації, а також наявність у бібліотечному фонді електронних видань [3, с. 30].

Однією з основних переваг ЕБ є здатність накопичувати і використовувати інформацію у вигляді документів. Електронні бібліотеки дедалі стають одним з популярних та перспективних напрямів організації електронних інформаційних ресурсів через необхідність забезпечення інформаційних потреб сучасних користувачів. Саме тому перед бібліотеками ЗВО постає завдання комплектування фондів спеціалізованими електронними документами та забезпечення техніко-технологічних умов їхнього ви-користання.

Щодо історії виникнення ЕБ, то одним із перших проєктів створення зібрання електронних версій книг був проєкт «Гутенберг», започаткований 1971 р. М. Хартом у Лабораторії дослідження матеріалів Іллінойського університету (США). В його основу було покладено технологію відтворення, тобто все, що введено в пам'ять комп'ютера, могло бути відтворено у будь-який час, у будь-якому місці.

Стрімких обертів набирають роботи з формування ЕБ в Україні у наш час. На сьогодні всі бібліотеки закладів вищої освіти III–IV рівнів акредитації в Україні є універсальними за змістом, мають різноманітні ресурси, зібрання документів на різних носіях інформації, який здійснює бібліотечно-бібліографічне та інформаційне обслуговування науковців, студентів, викладачів, аспірантів, співробітників вишу.

Інформаційні ресурси ЕБ ЗВО, як правило, складаються з електронних підручників, навчальних посібників та навчально-методичних розробок, що спрямовані на опанування студентами навчального матеріалу, а також з електронних книг, авторефератів дисертацій і наукових статей, які забезпечують розширення можливостей для навчального процесу та проведення наукових досліджень.

Основна мета ЕБ ПолтНТУ – створення інформаційної системи, яка забезпечує доступ до інформації, що існує лише в електронній формі. При створенні ЕБ університету вивчався досвід інших наукових бібліотек, враховувалася необхідність організації для користувачів середовища повного, якісного та швидкого доступу до інформації. Вихід в Інтернет надав змогу бібліотеці не тільки одержати доступ до всесвітніх сховищ інформації, а й увійти у світовий інформаційний простір, створити свою сторінку, розмістити інформацію про власні ресурси.

Робота ЕБ ПолтНТУ регламентована «Положенням про науково-технічну бібліотеку Полтавського національного технічного університету імені Юрія Кондратюка», доступ до якої реалізується через локальну мережу університету та мережу Інтернет на сайті ПолтНТУ у розділі «Бібліотека» за посиланням «Сайт Науково-технічної бібліотеки» [14]. ЕБ складається з різного виду колекцій електронних документів. Вона містить зібрання методичних та навчальних посібників, статей та авторефератів дисертацій, систематизованих та доступних індивідуально для електронних засобів. Доступ до ЕБ забезпечується за допомогою сучасної пошукової системи, яка дозволяє отримати результати пошуку з Web-інтерфейсу користувача. Тематичний склад ресурсів ЕБ визначено відповідно до наукового, навчального та виховного процесів університету. Електронні колекції для їх включення до електронної бібліотеки ПолтНТУ подаються кафедрами, окремими науковцями, викладачами та спеціалістами університету, колективом та адміністрацією бібліотеки, опрацьовуються роботи професорсько-викладацького складу ПолтНТУ за темами наукових робіт і дисциплінами, що викладаються за спеціальностями.

ЕБ реалізована у формі сайту, що значно спрощує організацію системи доступу до нього зовні, та робить його незалежним від якоїсь конкретної операційної системи. Для виключення можливості несанкціонованого доступу до інформаційних ресурсів ЕБ ПолтНТУ вхід, реєстрація та умови роботи з електронною інформацією представлено у вигляді реєстраційної сторінки. Користувачі мають інформацію, що всі матеріали, які містяться в електронній бібліотеці ПолтНТУ, представлені виключно для підтримки навчально-виховної та наукової роботи, вони не призначені для використання з комерційною метою, про що користувачі попереджені та несуть відповідальність згідно з чинним законодавством України, також до уваги користувачів доведено, що всі авторські права належать їх власникам.

В. Білоус основними завданнями ЕБ вважає: 1) тематичне упорядкування накопичених масивів інформації для реалізації інформаційного пошуку та задоволення інформаційних потреб користувачів бібліотеки; 2) аналітико-синтетичне опрацювання електронних документів; 3) надання комфортного онлайнового доступу до наукової інформації; 4) ефективність швидкого доступу та використання електронних ресурсів бібліотеки [3, с. 36].

Саме ці завдання успішно виконує ЕБ Науково-технічної бібліотеки Полтавського національного технічного університету імені Юрія Кондратюка, яка забезпечує літературою та інформацією освітньо-виховний та науковий процес університету.

Отже, ЕБ ПолтНТУ як один з найвагоміших елементів в основі освітнього простору створює усі необхідні умови для одержання ефективного співробітництва між учасниками освітнього процесу та створення єдиного інформаційно-освітнього середовища закладу вищої освіти. Вона доповнює традиційні форми та є ефективним засобом наукової комунікації, що сприяє реалізації як індивідуального творчого потенціалу, так і наукової колективної співпраці.

5. Висновки

Здійснене дослідження дозволило констатувати, що:

1) сьогодні бібліотеки закладів вищої освіти в Україні знаходяться в процесі постійного розвитку, технічного удосконалення, шукають і знаходять своє місце в інформаційному просторі країни та в освітньо-науковому середовищі. Електронні ресурси стали невіддільною складовою частиною навчального процесу вишу, що впливає на якість вищої освіти;

2) на базі ресурсу ЕК формуються основні технологічні процеси бібліотеки. ЕК дозволяє користувачам комфортно й оперативно отримувати максимально повну інформацію про документи традиційного (паперового) фонду й матеріали в електронному вигляді;

3) принципи відкритого доступу до інформації передбачають надання необмеженого та безоплатного доступу до наукових публікацій і досліджень декількома шляхами: 1) «золотий шлях» (Gold Road) – вільний доступ до всіх матеріалів безпосередньо у момент публікації;

2) «зелений шлях» (Green Road) – депонування та самоархівування науковцями праць у відкритих е-архівах (репозитаріях);

4) проаналізований у роботі світовий та вітчизняний досвіди запровадження відкритих електронних архівів та особливості функціонування електронних каталогів та бібліотек для університетської науки й освіти дають підстави твердити, що ці інформаційні ресурси вже довели свою ефективність щодо забезпечення якісної комунікації всіх учасників освітньо-наукового середовища;

5) для науковця ці форми відкритого доступу до інформації мають такі переваги: 1) підвищення індексу цитувань праць; 2) постійне та тривале їх зберігання; 3) збереження авторських прав на наукову продукцію. Для закладів вищої освіти – відбиток реального показника якості наукової роботи та підвищення статусу й значущості вишу як наукового центру.

6) На прикладі інституційного депозитарію, електронних каталогу та бібліотеки НТУ ПолтНТУ імені Юрія Кондратюка, які реалізовані у формі сайту, доведена важлива роль електронних архівів та бібліотек як рушійної сили сучасного навчально-педагогічного та наукового процесів, що дозволяє активізувати та значно прискорити роботу з формування доступної наукової та навчально-методичної інформації.

7) успішне розв'язання багатоаспектних проблем створення локальних ОНС гарантує покращання забезпечення інформаційними ресурсами всіх користувачів даної системи, створює необхідні умови для більш ефективної наукової роботи викладачів та студентів, забезпечує індивідуальний підхід до кожного та дозволяє використовувати наявні ресурси для самостійної роботи.

Бібліотеки сучасних ЗВО намагаються швидко та якісно забезпечувати інформаційні потреби своїх користувачів, віддаючи перевагу абсолютно новим послугам і формам обслуговування. Бібліотеки значною мірою оптимізують процес пошуку інформації та дають змогу створювати мобільне довідково-інформаційне середовище, яке відповідає реальним запитам віддалених користувачів.

Перспективи подальших досліджень програмують окреслення оптимальних підходів до організації пошуку інформації, зокрема сервісів «Віртуальна бібліографічна довідка» та «Електронна доставка документів», які також є ефективною формою комунікації у сучасному освітньо-науковому середовищі.

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NORM AS A LINGUISTIC CONCEPT: DYNAMICS AND CODIFICATION

НОРМА ЯК ЛІНГВІСТИЧНЕ ПОНЯТТЯ: ДИНАМІКА ТА КОДИФІКАЦІЯ

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Abstract. This academic research is devoted to the problem of understanding the norm as a sociolinguistic category. The relevance of a conducted study is linked to the fact that there is no single approach in modern linguistics to the normativity interpretation in a general context and some specific norms of literary language particularly. In the course of our research changes and specification of the "norm" concept have been identified in scientific definitions that occurred at the 20th and the beginning of the 21st centuries. Moreover, new aspects of understanding the norm have been determinated. It is found that at the beginning of the 20th century linguists pointed the systemic nature of the norm and interpreted it as a complex well-ordered structure, the top of which is occupied by literary language. This aspect has remained constant in a sense of the "norm" concept to this day. However, modern research workers recognize the dual nature of the norm as a systemic and social phenomenon all the while. They interpret it as the most everlast linguistic fact, selected in the process of public communication, which corresponds to the language system and has got public approval and recognition. It is proved that the recognition of a language norm results in its codification in authoritative publications, particularly dictionaries. It was found out that the development of the Ukrainian literary language was significantly influenced by the codification of the 20-30's years of the 20th century. After all, it was then when principles of scientific studies of a language vocabulary were determined. Researchers

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controverted spontaneous norms and focused on systemic principles of normalization of the Ukrainian literary language, which has not lost its relevance to this day. It is confirmed that the most reliable fixers of changes in a language lexical and semantic system and codifiers of literary language norms are standard language lexicographic works. They reflect the level of literary norms development and the state of social linguistic consciousness of an ethnic group in one or another period. Linguistic normative dictionaries help us foster a person culture and are means of a purposeful and scientifically based language policy. Users of linguistic dictionaries enhance their own language culture and develop a linguistic taste and a sense of word. The study makes the differentiation between descriptive and prescriptive norms by the following criteria: an attitude to a language (appraisive/non-evaluative); description / selection of a language material; presence / absence of recommendations for use of a language material. A descriptive norm is considered to be a system of multilevel units that actually function in a language. A prescriptive norm is mainly a codified system of language units that is regulated by means of instructions and recommendations.

1. Вступ

Праці з ділянки кодифікації літературної мови завжди мають підвищений попит у суспільстві, особливо сьогодні, коли з одного боку українське в «тренді», а з іншого – доводиться знову відстоювати право української мови на повноцінне функціонування в усіх сферах суспільної комунікації, такі дослідження є особливо актуальними, адже засвідчують високий потенціал української мови у формуванні власними засобами «свого» мовного простору.

Поняття «мовна норма» є засадничим для формування корпусу літературної мови, адже лише нормативний опис літературної мови відкриває перспективу формулювання положень правопису, перенесення теоретичних узагальнень мови у практику її викладання в навчальних закладах і поширення в різних комунікативних ситуаціях.

Аналіз наукових досліджень і публікацій засвідчив, що в різні періоди розвитку літературної мови мовознавці приділили увагу дослідженню мовної норми, однак природа й обсяг поняття «норма» потребують подальшого детального вивчення з урахуванням розвитку лінгвістичної теорії та практики.

Актуальність проведеного дослідження зумовлена тим, що в сучасній лінгвістиці не існує єдиного підходу до трактування нормативності взагалі, й окремих конкретних норм літературної мови зокрема. Сучасне визначення терміна «норма» в науковій практиці неоднозначне. Розбіжності в його трактуванні зумовлені різними підходами до проблеми нормативності. Це стосується загальної теорії мови, культури мови, а також практичних міркувань мовної культури [41, с. 34]. Тому в поняття «норма» часто вкладають різний зміст.

Метою дослідження є простеження змін та уточнень у наукових дефініціях поняття «норма», що відбувалися протягом XX – початку XXI ст., виокремлення нових аспектів розуміння норми.

2. Динаміка поняття мовної норми в діахронії

Підвалини сучасного розуміння процесів мовного нормування закладено у 30-ті рр. XX ст. представниками Празької лінгвістичної школи В. Матезіусом, Б. Гавранком, Й. Вахком, положення яких і сьогодні не втратили своєї актуальності. Зокрема, Б. Гавранек 1936 р. ставив питання, чи може бути норма, нормування літературної мови й мовна культура предметом лінгвістичних досліджень, і довів, що вивчення мовної норми належить до наукових лінгвістичних завдань.

Празькі мовознавці наголосили на свідомому «перетворенні мови як простого засобу, простого представника об'єктивного світу, в самостійний об'єкт наших роздумів, наших емоцій» [54, p. 2]. У їхніх розвідках, як доводить О.С. Клименко, поняття реальної норми звільняється від конотацій оцінки і припису та відокремлюється від кодифікації норм [15, с. 155]. Таке розуміння норми стало значним кроком уперед і сприяло переходу від фактуального й нормативного способів дослідження мови до порівняльно-історичного методу. Теза вчених Празької лінгвістичної школи про реальність існування мовної норми, за результатами спостереження О.С. Клименка, дала змогу вивчати реальну картину буття мови, не спотворюючи її упередженим розглядом у світлі ретроспективних, естетичних, суб'єктивно-оцінних категорій [15, с. 155].

Спостереження за зміненнями норми в часі й у її функціональній варіативності уможливило з'ясування її діалектичної сутності і власне мовної природи [41, с. 34]. У цілому заслугою представників Празкої лінгвістичної школи є вивчення норми як «лінгвосоціологічного і конкретно-історичного феномена» [33] й визначення її як сукупності структурних засобів, які регулярно використовує мовний колектив.

Значно вплинула на формування сучасного розуміння поняття «норма» теорія Л. Єльмслева та Е. Косеріу. Для Л. Єльмслева мовна норма – фікція, штучна абстракція: нею, переконаний дослідник, замінюють факти узусу, а це призводить до непотрібних ускладнень; із лінгвістики категорію норми можна вилучити, резюмує автор [8, с. 173]. Однак Г. Нельсон не погоджується з такою думкою: норму не можна вилучати з лінгвістики, оскільки мета нормотворчої діяльності полягає в розробленні й поширенні правил, яких мовці мають дотримуватися в мовленні [56, p. 463].

У 50-ті рр. XX ст. С.І. Ожегов сформулював відому дефініцію норми, на якій ґрунтувалися наступні наукові формулювання: «Норма – це сукупність найбільш придатних («правильних», «найкращих») для обслуговування суспільства засобів мови, які складаються як результат добору мовних елементів .. з наявних, утворюваних знову чи добутих із пасивного запасу минулого в процесі соціальної, в широкому розумінні, оцінки цих елементів» [28, с. 15].

Протягом 50–70-х рр. XX ст. у межах соціолінгвістики вперше здійснено спробу комплексного підходу до мовних проблем: починаючи від регулювання функціонального розподілу мов у складних мовних ситуаціях (мовної політики) до питань літературних стандартів (правописної та термінологічної кодифікації тощо) [52, с. 11]. Однак основну увагу дослідники зосереджують не на мовнонормативних завданнях, а на розробленні відповідних методів і прийомів (праці Е. Хаугена, Ч. Фергюсона, Дж. Фішмана та ін.).

Поняття «мовна норма» зазнає змін та уточнень у 80-х – середині 90-х рр. XX ст. у працях представників Московсько-Тартуської семіотичної школи Ю.М. Лотмана, Б.А. Успенського, В.М. Живова, які досліджували історію літературної норми з детальним урахуванням політичних та ідеологічних позицій учасників процесів мовного нормування, а також характеристик соціального та культурного процесів у певних історичних обставинах. Цей підхід сформувався в руслі загальної переорієнтації лінгвістики, яку тепер найчастіше позначають як перехід від системоцентризму до антропоцентризму [52, с. 12].

Антропоцентризм у лінгвістиці передбачає послідовне врахування «людського фактора» або «людської перспективи» у процесах мовного функціонування.

Вагомий внесок у дослідження поняття «норма» зробив Л.П. Крисін. Досліджуючи сучасну літературну норму, він відзначив, що в лінгвістиці термін «норма» функціонує у двох значеннях – широкому й вузькому. Так, у широкому сенсі норма – це традиційно і стихійно сформовані засоби мовлення, які відрізняють даний мовний ідіом від інших мовних ідіомів. У вузькому ж розумінні нормою є результат цілеспрямованої кодифікації мови [20, с. 233]. Таке бачення норми нерозривно пов'язане з поняттям літературної мови, яку інакше називають нормованою, або кодифікованою. Сам же дослідник мовною нормою вважає «сукупність найбільш стійких мовних засобів та правил їх вживання, які є традиційними та прийнятними в певному суспільстві в певну епоху» [20, с. 233].

Л.А. Вербицька трактує норму як усвідомлення певних засобів мовного вираження правильними, зразковими та припис їхнього використання (кодифікація) [2, с. 12]. Тобто, на думку дослідниці, літературна мова не так утілює в собі ідеальні норми, як відображає загальномовну тенденцію до їх створення з точки зору оптимальності мовного вираження.

В українському мовознавстві питання норми було актуалізоване ще на початку 20-х років XX ст. – часу особливого розквіту українознавства. Це був період, за словами Т.П. Мельник, «усталення та наукової легітимації норм літературної мови» [25, с. 7]. На заваді виробленню мовних стандартів у цей період стала різноговіркова основа літературних праць, що були написані впродовж століття. Зважаючи на цю потужну традицію літературної мови, було б нерозумно, на думку Ю.В. Шевельова, відкидати ті її елементи, які вже прищепилися, навіть якщо вони не мають підґрунтя в жодній київській чи полтавській говірці [48, с. 13]. Для того, щоб обрати й закріпити в літературній мові найдоцільніший варіант мовознавці мали врахувати не лише традиційне (минуле), а й простежити тенденції розвитку мови в майбутньому, «знайти балянс між вірністю традиції й розумінням лінії розвитку» [48, с. 13].

М.Ф. Сулима стверджував, що літературна норма – це «конче потрібна річ», оскільки вона «становить найпершу та найхарактернішу ознаку літературної мови» [42, с. 132]. С.П. Шевченко зазначає, що О.Н. Синявський та М.Ф. Сулима, критично підійшовши до надбань представників етнографічної школи в українському мовознавстві 20-х рр. XX ст., переглянули їх у контексті традиції та перспектив розвитку мови [49, с. 50]. Це стало можливим завдяки ретельному вивченню особливостей мови провідних письменників минулого й сучасності.

М.А. Жовтобрюх наголошував на важливому соціальному значенні мовної норми, адже «тільки єдиний правопис і стала вимова, обов'язкові для всіх правила відмінювання слів і синтаксичних зв'язків між словами, однакове розуміння змісту вживаних слів, єдиний наголос у словах по-справжньому створюють ті якості літературної мови, що потрібні їй як засобу спілкування між людьми, об'єднаними у великий колектив» [12, с. 4]. Погоджуючись із цим, Є.Д. Чак переконувала, що «для визначення нормативності мови треба дослідити не тільки правильність лексем, а й доречність вживання їх» [46, с. 4–5]. Це, на думку дослідниці, одне з найважчих і найважливіших завдань лінгвістики.

А.П. Коваль стверджувала, що норми літературної мови – це історично змінне явище. Середовищем, у якому вони творяться, є жива мовна практика, постійне спілкування людей у різних сферах діяльності. На думку дослідниці, причиною змінення норм найчастіше є змінення в житті суспільства, а також вплив внутрішніх законів мови [16, с. 3].

Попри певні розбіжності в поглядах як мовознавців, так і лінгвістичних шкіл (української, російської, чеської, польської та ін.), в усіх дефініціях норми наголошено на її суспільному характері. Працівники відділу стилістики та культури мови Інституту української мови НАН України під керівництвом С.Я. Єрмоленко сьогодні активно працюють над вивченням багатоплановості явища літературної норми, установленням критеріїв літературної норми та з'ясуванням відмінностей у змісті понять «мовна норма» й «літературна норма». Зокрема, С.Я. Єрмоленко тлумачить норму як «сукупність мовних засобів, що відповідають системі мови й сприймаються її носіями як зразок суспільного спілкування у певний період розвитку мови і суспільства» [45, с. 438], як певний «конструкт, який витворюється в свідомості людей, належних до однієї комунікативної спільності» [11, с. 66]. Це свідчить про розуміння подвійної природи норми – як явища системного й суспільного, на що свого часу вказував і М.М. Пилинський [31, с. 94].

С.П. Бибик відзначає, що «саме поняття норми передбачає як співвідношення «правильне – неправильне», властиве літературній мові, так і стилістичну диференціацію одиниць мови, закріплених чи то за усною / писемною формою спілкування, чи то за певним функціональним стилем мови, чи то за конкретною стилістичною ситуацією» [1, с. 59]. Г.М. Сюта значну увагу приділяє з'ясуванню впливу індивідуальної мовотворчої практики письменників на становлення літературної мови й літературної норми, який визначає як «структурно-розширювальний або огранювальний, спрямований на удосконалення» [43, с. 54]. Дослідниця вважає, що в сучасній українській лінгвостилістиці норма – «активна метамовна одиниця досліджень, пов'язаних із визначенням дистрибутивних рис слововживання, образотворення, текстотворення в мові поезії та прози певних літературних епох чи течій, соціально й культурно значущих періодів, жанрових спрямувань тощо» [43, с. 56].

О.О. Селіванова визначає мовну норму як «обрані у процесі комунікативної взаємодії з числа варіантів мовної реалізації, уніфіковані, свідомо фіксовані й найбільш поширені традиційні зразки (стандарти) репрезентації системи мови (засоби мови і правила їхнього вживання)» [34, с. 346].

Найповніше, на нашу думку, літературну норму трактує М.М. Пилинський: «Норма літературної мови – це реальний, історично зумовлений і порівняно стабільний мовний факт, що відповідає системі й нормі мови і становить єдину можливість або найкращий для даного конкретного випадку варіант, відібраний суспільством на певному етапі його розвитку із співвідносних фактів загальнонародної (національної) мови в процесі спілкування» [31, с. 94]. На думку М.М. Пилинського, у мовній нормі суспільний характер проявляється ще сильніше, ніж суспільний характер мови взагалі. Норма є об'єднувальним і зміцнювальним елементом літературної мови на всіх етапах її розвитку [18, с. 47]. Вироблення норм сприяє впорядкуванню мовної системи та консолідації національного простору.

Детальну історію розвитку поняття норми подає Н.М. Семенюк [37], уточнюючи тріаду Е. Косеріу «система – норма – мовлення» так: «структура – норма – узус». Розрізнення норми й узусу міститься ще в перших працях Б. Гавранка, згодом (хоча й у трохи різних формулюваннях) у студіях Н.М. Семенюк [37], С.В. Семчинського [38], О.О. Лаптєвої [21] та інших учених. Мовознавці по-різному тлумачать термін «узус». В одних випадках узус ототожнюють з індивідуальним мовленням, а в інших трактують як постійне пристосування мовної системи до потреб носіїв мови. До узусу зараховують мовні норми, які виходять за межі літературної мови, а також окремі нормативні підсистеми у складі літературної мови. Д.І. Ганич та І.С. Олійник у «Словнику лінгвістичних термінів» дають таку дефініцію: «Узус (лат. usus – звичай, правило) прийняте носіями певної мови вживання слів, словоформ, синтаксичних конструкцій тощо» [4, с. 316]. Російський «Лінгвістичний енциклопедичний словник» трактує узус як колективну мовну практику, застерігаючи, що індивідуальні утворення не є узуальними одиницями мови [22]. Отже, узус мови неоднорідний, оскільки залежить від територіального чинника й суспільного становища мовців.

Окреслюючи поняття норми літературної мови, мовознавці Ю.А. Бєльчиков, С.П. Бибик, К.С. Горбачевич, С.Я. Єрмоленко, Г.П. Мацюк, О.Г. Муромцева, С.І. Ожегов, М.М. Пилинський, В.М. Русанівський, Л.В. Струганець, Г.М. Сюта, Н.В. Хруцька, Г.М. Яворська та ін. відзначають одну з найважливіших її рис – історичний характер. Уже у визначенні норми підкреслено її зв'язок із певним синхронним зрізом мови [26, с. 18]. Зміна норм літературної мови тісно пов'язана зі зміною епох, адже діяльність народу – носія мови – також розвивається. М.Д. Гладкий зазначав: «Нормальний хід розвитку кожної мови такий, що старі, давно вживані слова, звороти й конструкції відмирають не враз, а живуть часто сотні літ, помалу гублять своє первісне значення, відмінюють його й стають привичними шаблонами, тими відомими з дитячих літ образами, що полегшують нам процес сприймання нового й заощаджують тим психічну енергію» [5, с. 70]. Вимога стабільності, як доводить Л.В. Струганець, узгоджується з природною мінливістю, яка властива мові як соціальному явищу історичного характеру [41, с. 37]. Цей процес мовознавці Празької лінгвістичної школи назвали «гнучкою стабільністю» [23, с. 381], а українські лінгвісти – С.Я. Єрмоленко [9, с. 227], О.О. Тараненко [44, с. 55], Л.В. Струганець [40, с. 12] та ін., – динамікою мовної норми. Як слушно зазначає Є.А. Карпіловська, мовна норма «змінюється разом із мовою відповідно до нових потреб суспільної практики» [14, с. 43].

У зв'язку з тим, що динамічна теорія норми пропонує враховувати й об'єктивні тенденцій розвитку мови, які не залежать від волі носіїв мови, і цінність успадкованих літературних традицій, вона стала загальнонауково визнаною порівняно недавно. Тривалий час серед мовознавців переважало догматичне уявлення про штучний характер літературних мов і вдавану непорушність їхніх норм [6, с. 78]. Це часто призводило до ототожнення понять «розвиток мови» і «псування мови». Будь-яке мовне новоутворення вважали того часу спотворенням мови, засуджували й забороняли. Однак погоджуємося з Є.А. Карпіловською в тому, що мова є стійкою й рухливою, і норма «не повинна ставати на заваді її розвитку, має змінюватися з часом, відповідати на нові пізнавальні й комунікативні потреби спільноти і задовольняти нові її смаки й уподобання» [14, с. 50].

3. Кодифікація мовної норми

Сьогодні мовознавці погоджуються з тим, що прийняті норми через певні проміжки часу потребують перегляду й переоцінки. Ретроспективною, найбільш експліцитною й об'єктивною формою суспільного прийняття мовних норм, на думку Т.А. Коць, є кодифікація [18, с. 48]. Саме кодифікація відбиває ті явища, які усталилися у процесі мовної практики [40, с. 22; 45, с. 269]. Термін «кодифікація» запропонували мовознавці Празької лінгвістичної школи у 30-х рр. ХХ ст. Кодифікацією також називають систему обов'язкових правил для вживання літературної мови, усвідомлених та прийнятих у конкретний період усім мовним колективом [49, с. 49].

За визначенням Г.П. Мацюк, кодифікація – це «процес, сутність якого розкривається внаслідок мовознавчого пізнання норм літературної мови і практики їхньої реалізації, який у конкретні періоди розвитку літературної мови має теоретичний і практичний вияви й експлікується на описовому, регулятивному етапах та етапі реалізації» [24, с. 41]. С.Я. Єрмоленко також підкреслює, що кодифікація лексичної норми в нормативному словнику «відбиває характер сучасної мовної практики і не може охоплювати лексикон певних історичних зрізів української літературної мови» [10, с. 13]. Таким чином, кодифікація є результатом наукового пізнання закономірностей вияву норми на певному етапі розвитку мови.

С.П. Шевченко слушно зауважує, що норма й кодифікація не тотожні поняття: норма динамічна, змінювана категорія, а кодифікація – статична за своїм характером [49, с. 51]. Вона зберігає та фіксує норму в певний період розвитку мови, сприяє забезпеченню більшої стійкості норм та запобігає напівстихійним і начебто неконтрольованим нею змінам [41, с. 41].

На відмінності норми й кодифікації акцентують і польські мовознавці, які трактують норму не як сукупність правил уживання мовних одиниць (історико-соціологічний аспект), а як один із рівнів внутрішньої структури мови (власне лінгвістичний аспект). Кодифікацію польські лінгвісти розуміють як зовнішній щодо мови факт [19, с. 162]. Мовознавець А. Марковський образно називає кодифікацію «фотографією» норми, зробленою на основі мовних текстів [57]. А.М. Кравчук, продовжуючи образний ряд, альбомами для таких фотокарток вважає граматики та словники, які фіксують норму [19, с. 162].

Як стверджує Л.В. Струганець, мовна норма і її кодифікація у граматиках і словниках перебувають у полярному взаємовідношенні, оскільки кодифікація норми залежить від реальної норми (що повніші знання про літературну норму, то точніша й кодифікація), і навпаки – кодифікована норма також впливає на реальну норму, поступово змінює її й часто досить ефективно [40]. Кодифікація здатна стабілізувати й регулювати функціонування та розвиток літературної норми. А. Єдлічка вважає, що метою кодифікації є розкриття та фіксація синхронної динаміки сучасної літературної норми й тим самим створення умов, за яких кодифікація не була б гальмом природного й суспільно зумовленого розвитку літературної норми [27, с. 38–134]. Я. Фіндра з цього приводу слушно зауважує, що кодифікація – не корсет, який мав би умертвити норму [53, p. 83]. Тому статичний характер кодифікації не перешкоджає їй регулювати вживання мовних засобів вираження і зумовлювати зміни в узусі та нормі.

Суперечність між динамікою норми і статичністю кодифікації намагався подолати М. Докуліл, вимагаючи, щоб кодифікація поряд зі своєю статичністю мала й певну перспективну глибину, тобто в момент свого виникнення вона має кодифікувати певні явища з урахуванням майбутнього розвитку [27]. Окрім того, кодифікація має бути адекватною сучасній для неї нормі. Це є основним принципом, що лежить в основі наукової кодифікації літературної мови. І тому небезпечнішою є не передчасна кодифікація того, що ще не стало нормою, а відмова від визнання прав літературної норми за тими явищами, які фактично вже стали нормою, небезпечна орієнтація на стару норму [13, с. 28–30, 39].

Твердження М.М. Пилинського щодо непослідовності розрізнення норми та кодифікації в українській науковій літературі не втратило своєї актуальності й сьогодні. На його думку, недостатньо вивченим є взаємовідношення цих двох явищ, зокрема вплив кодифікації на норму, умовно кажучи, сила, темпи й межі цього впливу [31, с. 67]. Погоджуємося з Т.П. Мельник, яка вважає, що нормування – це зведення до єдиної системи приписів, які регулюють використання мовних засобів на етапі становлення чи зміни мовних норм, а кодифікація – закріплення цих приписів у нормативних працях, що мають суспільне значення [25, с. 7]. Такими нормативними працями є, насамперед, словники. Слушною є думка Л.С. Паламарчука про те, що «словники – і загальномовні, і спеціальні різної спрямованості, – опрацьовані на засадах сучасної лексикографічної науки, є тим головним інструментом, що зміцнює й закріплює вироблену мовну норму, забезпечує необхідну для кожної мови кодифікацію лексичних засобів усіх категорій» [29, с. 170].

В основі загальномовного нормативного словника лежить розуміння норми як способу мовного вираження, який, по-перше, відображає об'єктивні закономірності мовної системи, а по-друге, отримує суспільне схвалення, що підтверджує слововживання авторитетних письменників [6, с. 78]. Враховуючи це, завдання нормативного словника полягає не тільки в максимально точному й повному тлумаченні значень і відтінків значень усіх слів, уведених до реєстру, але й в оцінці їхніх стилістичних, граматичних та акцентологічних особливостей, а в перекладному словнику – вдалості підібраних перекладних еквівалентів [32, с. 41].

П.Й. Горецький стверджував, що «словник, фіксуючи певні слова й ілюструючи їх прикладами літературного вжитку, тим самим у великій мірі стає словником нормативним» [7, с. 11]. Г.М. Яворська зауважує, що нормативний словник «лише кодифікує наявну літературну норму, що усталилася в мовному вжитку, а не робить нормативним те чи інше конкретне слововживання» [52, с. 13]. Однак вважаємо, що це не завжди так, адже ввівши до реєстру словника діалектизм, вульгаризм, просторіччя тощо й не поставивши при ньому відповідної ремарки, слово буде сприйматися користувачами словника як нормативне.

Укладання словників, що є кодифікаторами мовної норми, – це важка й відповідальна праця, оскільки нормативність – явище відносне: літературна мова є динамічною системою, якій властиві механізми збагачення, поповнення, розвитку [47, с. 168]. Тому укладачі нормативного словника мають розробити чітку систему принципів, що будуть регулювати можливість уведення того чи того слова до реєстру. На цьому свого часу наголошував також Л.С. Паламарчук, вважаючи, що нормативний словник має бути укладений із «дотриманням наукових засад і виробленої для нього наукової концепції» [29, с. 16].

Нормативний словник, зберігаючи культурні мовні традиції, має водночас звільнитися від надуманих догм, які гальмують розвиток мови. На думку К.С. Горбачевича, він має проявляти розумну стриманість, виходити не зі «смакового» пуризму, а зі знання закономірностей розвитку мови, зі спостережень за матеріалами сучасного слововживання [6, с. 86].

Л.В. Струганець стверджує, що словник як кодифікаційна праця певною мірою «запрограмований» на неадекватне відображення реальних мовних норм. Це зумовлено комплексом зовнішніх та внутрішніх недоліків, властивих кодифікації. До зовнішніх недоліків дослідниця відносить типовий для багатьох нормативних описів ригоризм, відсутність вказівок на варіанти й на сфери функціонування варіантів у межах літературної мови, невідповідність кодифікації сучасній нормі, орієнтацію на стару норму, а до внутрішніх – сам факт існування кодифікації [40]. На думку Л.В. Струганець, кодифікаційні праці, насамперед словники, стають зразком для наступних нормативних праць і таким чином на багато років закріплюють функціонування вже неактуальної старої мовної норми. Польський лексикограф Я. Карлович писав, що словник має бути поза будь-якими граматичними чи пуристичними теоріями й об'єктивно представляти весь інвентар мови, на основі якого (але вже поза ним) мовознавці можуть давати свої оцінки щодо мови [57].

Подеколи термін «нормативний словник» ототожнюють із терміном «словник академічного типу» або «академічний словник». Зокрема, Л.В. Щерба під академічним словником розумів нормативний словник, оскільки, якщо б справа була у формальній назві чи виданні, то будь-який словник, виданий в Академії, вважався б академічним [51].

Д.М. Шмельов нормативним вважає словник, який «достатньо послідовно обмежує те, що реально існує в літературній мові певної епохи, й те, що лише спорадично проникає у неї (з діалектів, жаргонів, мови попередніх епох, відомої нам через книги та ін.) як самим реєстром, так і за допомогою відповідних ремарок» [50, с. 45]. Однак найповніше визначення академічного словника, на нашу думку, дає В.Ф. Старко: «Академічний словник – це словник 1) укладений відповідно до вимог науки; 2) який має статус традиційного / канонічного видання серед подібних; 3) що його підготував і видав відповідний відділ академії наук» [39, с. 176]. Дослідник зауважує, що в разі недотримання першої вимоги, словник навряд чи може претендувати на статус канонічного. Якщо порушено лише другу вимогу, то це свідчить про те, що існує інший подібний словник, якому надають перевагу. Третя вимога є факультативною, оскільки словник може бути академічним, навіть якщо його уклали не в академії.

4. Проблема дескриптивної та прескриптивної норм у сучасній лінгвістиці

Розвиток науки про мову у ХХ ст. частково зумовлений протиставленням дескриптивної та прескриптивної лінгвістики, яке відповідає двом різним поглядам на мову: об'єктивному та нормативному. У нашому дослідженні ми оперуємо термінами «дескриптивний» і «прескриптивний» у широкому розумінні. Дескриптивним вважаємо такий метод лінгвістичного опису, який реалізує об'єктивний, безоцінний погляд на мовні факти, а прескриптивним методом – зорієнтований на створення приписів та рекомендацій щодо вживання мовних одиниць.

Необхідність розрізнення дескриптивного та прескриптивного підходів у сучасній теоретичній лінгвістиці, на думку Г.М. Яворської, не викликає сумнівів, хоча оцінка прескриптивності і сьогодні коливається від цілковитого заперечення і проголошення несумісності ролі лінгвіста й мовного нормалізатора до визнання статусу нормативної лінгвістики й переконання, що саме лінгвіст може бути найкомпетентнішим і найефективнішим мовним нормалізатором [52, с. 17–18].

Б. Фаска дескриптивною називає норму, «абсолютно ідентичну можливостям, які надані системою мови» [цит. за 41, с. 37]. Така норма не вилучає жодного варіанта із суми всіх можливих. Як стверджує П.О. Селігей, «описувачі» вважають, що норма має ґрунтуватися винятково на узусі, а мовознавець – лише сторонній спостерігач, споглядальник. Його справа – збирати мовні факти й описувати їх у нейтральний, безоцінний спосіб [36, с. 68]. Дескриптивна норма відображає лексеми, словоформи, й мовні конструкції, які реально вживаються в мові. Вони не завжди відповідають установленим зразкам, адже на них позначаються і стилістичний потенціал, і екстралінгвальні чинники, і постійні внутрішньосистемні пошуки [18, с. 48]. Тобто всі можливості певної мовної системи, які прийняті й репродукуються лінгвосоціумом, становлять дескриптивну норму.

Л.В. Струганець виділяє такі ознаки дескриптивної норми: 1) вона детермінована лише системою мови і її внутрішніми закономірностями; 2) вона еволюціонує у процесі зміни й одночасно зі зміною в системі мови; 3) вона не унеможливлює жодних реальних, реалізованих і тих, які реалізуються, перспектив мовної системи, тобто визначається варіантністю [41, с. 37].

Окрім дескриптивної норми мовознавці також виокремлюють прескриптивну норму, яка є ідеальною, але часто недосяжною. За лінгвістичним словником О.О. Селіванової, прескриптивне мовознавство – це «розділ мовознавства, що вивчає проблеми унормування (кодифікації) мовних форм, їхньої оцінки під кутом зору правильності, естетичності, раціональності тощо» [35, с. 487]. Є.А. Карпіловська також наголошує на прескриптивному характері мовної норми, стверджуючи, що вона «радить мовцям, як краще висловити свою думку, які засоби дібрати для кращого взаєморозуміння» [14, с. 44].

У мовознавстві прескриптивний підхід охоплює проблеми стандартизації вимови, синтаксису, коректного стилістичного використання лексичних засобів тощо. На думку Г.В. Гайович, «прескриптивісти пропагують те, що певні групи мовного колективу розглядають як добрий смак. Якщо ці смаки консервативні, прескриптивне мовознавство може нав'язувати суспільству незмінність мови, якщо радикальні – продукувати неологізми» [3, с. 40]. Таким чином, прескриптивний підхід до вивчення мовних явищ містить рекомендації щодо їх ефективного використання, а прескриптивна норма є сукупністю тенденцій відбору і правил використання мовних засобів [3, с. 42]. Стабільність прескриптивної норми залежить від культурно-історичної ситуації, мовної структури та особливостей генези її літературної форми [18, с. 48]. Якщо літературна традиція, освіта й соціальний статус такої норми у країні є сприятливими, то вона може бути доволі консервативною.

Специфіка прескриптивного лінгвістичного підходу як принципово позначеного оцінним ставленням до мови розкривається в його протиставленні дескриптивній лінгвістиці, зорієнтованій на безоцінну об'єктивність [3, с. 45]. Як стверджує О.М. Пешковський, лінгвіст виступає у двох ролях: спостерігача-науковця та учасника мовного процесу. При цьому лінгвіст «як учасник мовного процесу, як член цієї мовної спільноти розцінює мовні факти нарівні з усіма іншими освіченими людьми» [30, с. 298]. На думку Г.М. Яворської, із цього випливають два суттєвих моменти, хоча й не сформульовані експліцитно. По-перше, хоча в лінгвіста, на відміну від нефахівця, набагато більше спеціальних знань, система норм і цінностей, якою він послуговується під час оцінювання мовних фактів (тобто в ролі нормативіста), є тією ж самою, що й у звичайного носія мови. По-друге, прескриптивний підхід, принаймні щодо літературної норми, реалізується через погляд на мову зсередини, з точки зору носія мови («учасника мовного процесу, члена мовної спільноти») [52, с. 21].

Аналіз дихотомії «прескрипція – дескрипція» підтверджує, що ці два мовні явища не лише конкурують між собою, але і взаємодоповнюють і взаємодіють одне з одним: дескриптивна лінгвістика робить спостереження й об'єктивний опис певного матеріалу, а прескриптивна лінгвістика на основі цього робить узагальнення й виводить правила [3, с. 42]. Підстав різко протиставляти ці явища або вивищувати одне за рахунок іншого немає. Як стверджує П.О. Селігей, «той, хто принципово не дає мовним явищам оцінок (там, де вони потрібні), схоже, прагне уникнути відповідальності за свою позицію» [36, с. 68]. Водночас дослідник наголошує, що кожен мовознавець має право обирати: чи просто описувати узус, фіксуючи закономірності й тенденції (мова якою вона є), чи, крім цього, ще й виробляти рекомендації з метою цей узус змінити (якою мова має бути).

Натомість Г.М. Яворська констатує, що під час опису літературної норми «досліднику надзвичайно важко утриматися від оцінних суджень, зберегти об'єктивний погляд на речі, побудувати виклад за принципом sine ira et studio, без гніву та упередження», тому пропонує два виходи з такої ситуації. Суть першого, на її думку, полягає в утриманні від спроби об'єктивно проаналізувати сучасний стан речей, адже описувати результати певних процесів можна лише після того, як вони деякий час «відстояться». Другий вимагає не лише розгляду фактів, а й створення відповідної теоретичної моделі їхньої інтерпретації, для того «щоб за позірною сваволею проглянули певні закономірності» [52, с. 153–154].

Варто відзначити, що співвідношення дескриптивного та прескриптивного підходів до мови будується таким чином, що дескриптивність логічно не вимагає прескриптивності (вона може існувати окремо), натомість прескриптивність обов'язково передбачає процедуру опису – адже для того, щоб сформулювати норму, потрібно уявити той стан речей, який підлягає нормативному регулюванню [3, с. 42]. Як зазначає Т.А. Коць, прескриптивна норма не завжди встигає відбивати тенденції дескриптивної норми, а дескриптивна норма не завжди відповідає ідеальній прескриптивній нормі [17, с. 190–194].

Погоджуємося з Г.М. Яворською, яка ґрунтовно аналізує поняття дескриптивна та прескриптивна лінгвістика і вважає, що для створення літературних норм важливим є об'єктивний опис мовного матеріалу, який здійснює дескриптивна лінгвістика, та втілення приписів і рекомендацій щодо його використання, що робить прескриптивна лінгвістика [52, с. 299]. Ці принципи реалізуються в нормативному словнику, адже дескриптивний підхід розглядає мову такою, яка вона є (реєстр словника, джерельна база), а прескриптивний – якою вона має бути (рекомендації щодо вживання мовного матеріалу, що реалізуються через систему обмежувальних ремарок у словнику) [52, с. 24]. Але й реєстр не є об'єктивною даністю: він формується залежно від спеціалізації словника, впливів часу, тиску ідеології, лінгвістичної думки та особистих уподобань укладача (укладачів) словника. Тому введення чи вилучення того чи того слова до реєстру теж є проявом формування прескриптивної норми.

5. Висновки

Отже, рефлексії над поняттям мовної норми відбувалися досить активно і тривають сьогодні, оскільки функціонування норми пов'язане з категорією оцінки. За час свого існування поняття «норма» зазнало істотних змін і уточнень щодо змісту та обсягу. На початку XX ст. мовознавці наголошували на системному характері норми і трактували її як складну упорядковану структуру, верхів'я якої займає літературна мова. Цей аспект у розумінні поняття «норма» залишився непорушним до сьогодні. Однак сучасні дослідники визнають подвійну природу норми – як явища системного й суспільного водночас, і тлумачать її як найстійкіший мовний факт, відібраний у процесі суспільної комунікації, який відповідає системі мови й отримав суспільне схвалення та визнання.

Наслідком визнання мовної норми постає її кодифікація в авторитетних виданнях: граматиках, словниках тощо. Кодифікація має низку ознак: системність, об'єктивність, загальнообов'язковість, наддіалектність, перспективність. Кодифікація 20–30-х рр. XX ст., яка стала об'єктом нашої пильної уваги, значно вплинула на подальший розвиток української літературної мови, визначила засади наукового опрацювання її лексичного складу. У цей період дослідники заперечували стихійні норми, а основну увагу зосередили на системних принципах унормування української літературної мови. Такі принципи залишилися актуальними й у наш час.

Найдостовірнішими фіксаторами змін у лексико-семантичній системі мови й кодифікаторами норм літературної мови є загальномовні лексикографічні праці, оскільки саме в них віддзеркалюються рівень розвитку літературних норм, стан суспільної мовосвідомості етносу в той чи інший період. Загальномовні нормативні словники сприяють підвищенню культури особистості й водночас є засобом цілеспрямованої й науково обґрунтованої мовної політики. Користувачі загальномовних словників підвищують культуру власного мовлення, розвивають мовний смак і чуття слова.

У дослідженні здійснено розмежування дескриптивної та прескриптивної норм за такими критеріями: ставлення до мови (оцінне / безоцінне); опис / відбір мовного матеріалу; наявність / відсутність рекомендацій щодо вживання мовного матеріалу. З огляду на це дескриптивною нормою вважаємо систему різнорівневих одиниць, які реально функціонують у мові, а прескриптивною – регульовану за допомогою приписів та рекомендацій, переважно кодифіковану систему мовних одиниць.

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SOCIO-COMMUNICATIVE DIMENSION OF TELEVISION DEVELOPMENT

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Abstract. The purpose of the paper is forming of a certain concept of periodization in television development in the context of social and communication features of broadcasting, which would be based on the following aspects: technological, content and communication. The survey is based on integrated approach to the use of theoretical, empirical, empirical-theoretical, analytical research methods and sectoral methods of social communications. Historical and comparative historical methods have been used to analyze and systematize data on the formation and development of television and its individual broadcasting models (on-line and off-line). Systematization, classification, and grouping were used to identify features and factors of television development in individual models. The comparison method was used to identify common and distinct features of different stages of television broadcasting. The content analysis method was used to systematize data on the development of on-line and off-line models as communicative television technologies. Results of the survey is comprehensively understanding the phenomenon of television development as a space to meet the social and communicative needs of society. Analyzing and understanding the main stages of television development as a communication system will improve the quality of the study of individual issues related to television, as well as help predict the future vectors of development of this communicative phenomenon. The issue is changing the traditional paradigm of television as a communication space influenced by electronic media and internet communication, with convergence and new

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technologies that directly change the content of television space. Practical implications of research are in summarizing the observations on the development of different models of television, as well as television in general, show that the fluctuation of the interest of the viewer and producer to each of them depends on the state of technological development, political and communication tasks. Using the periodization of television development offered by various researchers in the content analysis, we have recorded a new stage of television development, which is related to the impact of Internet communication, which we have designated as the "period of media integration" – eradicating a new technological component (Internet), the emergence of new content and a new format for viewer engagement that extends beyond television communications. The value of research lies in defining and justifying changes in television content that tend to complicate creative, technological and communication influences, and engagement with the viewer changes from watching and mediating reactions to television programs to direct communication and interaction.

1. Introduction

The history of Ukrainian television in the context of world television development in general remains is a poorly understood topic for researchers of the theory and history of social communications and media. Analyzing and comprehending the major stages of television development as a communication system will improve the quality of the study of particular issues related to television, and will help predict the future vectors of development of this communicative phenomenon. This issue becomes important especially in the age of electronic media and the impact of Internet communication, with convergence and new technologies affecting traditional television models.

The source of the study is the history of world and national television. The purpose of our study is due to the need to formulate a certain concept of periodization of television development in the context of social and communication features of broadcasting, taking into account technological, content and communication aspects. According to the purpose of the article we have set the following tasks:

– to study and propose a concept for television development that would meet the requirements of the development of communication technologies;

– to identify the factors that influenced television at each stage of its formation;

– to track the development of the off-line and off-line models in the context of historical technological and communicative changes in society;

– to distinguish the communicative component of interaction with the viewer at each stage of television development;

– to identify further research vectors related to television functioning in general.

The realization of the goal and objectives of the research determine the complex approach to the use of theoretical, empirical, empirical-theoretical, analytical methods of research and sectoral methods of social communications. Historical and comparative historical methods have been used to analyze and systematize data on the formation and development of television and its individual broadcasting models (on-line and off-line). Systematization, classification, and grouping were used to identify features and factors of television development in individual models. The comparison method was used to identify common and distinct features of different stages of television broadcasting. The comparison method was used to identify common and distinct features of different stages of television broadcasting. The content analysis method was used to systematize data on the development of on-line and off-line models as communicative television technologies.

2. Development of two broadcasting models (on-line and off-line)

Television originated from a technical invention, and the main purpose of this discovery for the society was the ability to transmit the image at a distance. People not only receive a new technical device, but also a completely new cultural, social, linguistic paradigm, which over time will change the nature of man and his ability to perceive information. It should be noted that the first development and the first successful experimental attempts were based on the transmission of the signal on-line, that is, the moment of content creation and its reception coincided in real time:

– USA: New York opened the opening of the World's Fair, where US President FD Roosevelt April 30, 1939 [2, p. 9-10];

– United Kingdom: The BBC used off-camera footage to cover sports – tennis, yacht racing, football – but the most important highlight in 1937 was the live broadcast of the coronation of George VI, which is considered to be the greatest achievement of live coverage [2, p. 39];

– Germany: during the 1936 Summer Olympics, live broadcasts were broadcast live for 8 hours a day and were broadcasted via coaxial communication by residents of not only Berlin but also Hamburg, Leipzig, Nuremberg, Munich and Cologne [2, p. 57].

New technological advances and online communication make the model online, with its interactivity appealing to the viewer, albeit more demanding for manufacturers than the project without the feedback shown on the record. The viewer's participation in the formation of television content corresponds to the socio-psychological attitudes of the modern open society, therefore, it is effective in terms of the formation of television content of modern TV channels.

Therefore, the communication characteristic of the model on-line is the possibility of direct interaction with the viewer, this property is provided by the following factors:

– the viewer is a direct participant in the event (story). It is about the role of the witness-witness in the information broadcast, the socialization with the community during telethon, the role of the "virtual judge" in entertaining shows in the form of comments on events witnessed by the viewer through Internet communications;

– Feedback allows you to influence the results of studio projects directly by the viewer (the viewer can participate in surveys, engage in conversation, speak on the subject of the program through Internet communication).

– the time of interaction with the viewer is equal to the time of broadcasting a television product;

– self-identification of a person within the framework of the "I – community" model;

– the reaction to the program as it is viewed gives the television product a new role, creating variant finals in the future.

Open text and real-time overlays for viewers and TVs activate the viewership by forming their own audience for a particular communication channel. Thus, we see that almost all the leading countries in the world have used the opportunities of live television in the formation of unique telecontent. This model is characterized by open real-time overlapping text for viewers and TVs, resulting in increased viewership, script variability, and certain restrictions on genre use, visuals, and message editing. New technological assets and Internet communication make the model on-line thanks to its interactivity promising in the context of the problem of formation of actual telecontent.

In the initial phase of television, the on-line model gave way to an off-line model, enabling editing of messages, reproduction of reality through specific forms of editing and shooting, while at the same time using complex scripted forms, not limited by time and space characteristics. This change in models is evidenced by facts from television history, including Ukrainian history.

The history of Ukrainian electronic television begins with the date of commissioning of the television center on Khreshchatyk, 26. According to I.G. Mashchenko in the Encyclopedia of Electronic Mass Media [4, p. 180], on the day of its first airing, the feature film "The Great Zagreva" was shown, and the very next day the workers of the Kiev TV Center rolled out two studio cameras on Khreshchatyk and broadcasted a military parade and demonstrations on the occasion of the October Revolution. This historical fact testifies that two broadcasting models – live broadcast and prepared screen product – coexisted in Ukrainian television from the very beginning. However, the situation has changed over time.

The development of video tapes and VCRs, initiated in the 1950s in the United States and the early 1960s in the USSR, was the impetus for the increase in the number of pre-recording programs. This made it possible, on the one hand, to delay the demonstration of the program and, on the other, to use editing and shooting capabilities, to improve telematic power. Therefore, technologies for preparing programs for broadcasting, editing, video recording have gradually evolved, and programs that undergo editing and editing remain traditionally a priority in modern TV space. These are pre-prepared texts that meet the requirements of the audience, can combine several events at one time, have complex special effects and editing clutches, the language of these programs using the techniques of directing and shooting approaches cinema.

Thus, the off-line model is a technology of formation of the screen product for which the moment of creation of content and its reception do not coincide in real time, there is an expanded possibility for reproduction of the screen image by means of editing. As a result, there is a great ability to edit not only messages but also video. Most TV journalism genres consider this model: it has a clear, closed and inviolable form of script, and is the result of the process of television reproduction of an event.

The main purpose of the off-line model programs is the one-vector transmission of certain messages, in the communication act with the viewer the feedback is not taken into account or is not dominant. Summarizing, we can say that this model is characterized by the following features:

– the viewer belongs to the role of the observer, the television content is used by him for pleasure, performing informative, integrative or recreational function;

– there is a possibility of feedback (every program or TV channel has an actual address, contact telephones, sites, etc.), but it does not allow to influence the results of programs / projects directly by the viewer (the viewer can write a review or leave a questionnaire for participation in various projects, to speak on the subject of the program through Internet communication, if there are certain conditions for this);

– the interaction with the viewer is probable only after watching the program, it does not coincide with the time of the television broadcast;

– continuing introverted self-actualization of the person with the immersion in their own feelings;

– feedback on viewing a program appears more often as a result of measuring the audience interested in a screen product.

The main difference between producing off-line models is the ability to edit teletext that applies to the script, text strategies, visuals and timeline. Installation becomes the way of life of this model.

So, we see that the development of video tapes and VCRs (50-60's) has given a new impetus to increasing the number of pre-recording programs. The two broadcasting models coexisted from the outset, but differed in capabilities and effects. The off-line model as a technology for forming a screen product for which the moment of content creation and its reception does not coincide in real time, the main purpose is one-vector transmission of certain messages, the communication act with the viewer does not take into account the feedback or it is not dominant. The main difference between off-line programs is the ability to edit teletext that applies to scripts, text strategies, visuals, and timelines. Editing becomes the way of existence of this model and allows to distinguish such editing functions as technical, semantic, dramatic, visual and strategic. For the off-line model audience, there is a certain concept of the audience's expectations of the likely finale.

3. The history of television. The experimental period

The periodization of television development history in the context of complex research has been considered by various scholars. Thus, I. Katsev [3] proposed periodization of domestic television, distinguishing 4 stages and focusing on the creative process: technical experiments (1907-1957); acquisition of own means of expression (1957-1970); the period of rigid censorship (1970-1985) and stagnation (1985-2000). A. Fortunatov [8] distinguished 3 stages, focusing on technical development and communicative aspects: the period of formation (1883 – the end of the 30-ies); TV as an independent phenomenon and a social institute (40-80 years); the period of digitalization and convergence (lasts from the 80's). M. Golyadkin [2] distinguishes 4 stages, which are connected with time, technology development and improvement of genre palette of this type of communication: experimental stage (30-40 years), formation period (50-60 years), TV – as a means of communication (70-80 years) and television content (from the 90s to the present).

As part of this study, the conception of M. Golyadkin as the one that most adequately reflects the development of telecommunications technologies is adopted to periodize the history of television development. Accordingly, each stage has its own constitutional features. For the experimental broadcasting period, the characteristic features are:

– the process of adopting common broadcasting standards;

– the origin of the main types of broadcasting: information (photo newspapers in the USSR, analogs of news, sports events, reports from the scene, etc.); political and public (in Germany invited politicians to the studio); entertaining (cinema, theatrical and musical performances with the participation of famous actors); and even children and youth (Great Britain showed animation films, Germany – youth programs, the USSR – children's performances) [2, p. 9–57];

– live coverage of the event attracts more than 150,000 viewers at the 1936 Olympics in Germany;

– the programs are cultural and educational in nature (most of the broadcasting is occupied by performances, performances by actors, screenings);

– a small number of television sets in the population – from 500 (France) to 15 thousand (Great Britain), the largest number by saturation of radios and TVs before the Second World War was Germany [4, p. 108–113];

– the first audience research and skeptical Attitude to TV. Gallup, a US audience survey, found that in 1939, 87% of the population considered television superfluous, and by the end of 1945, 81% of Americans had never seen television before, although 10 television stations and 6,000 people worked in the country [4, p. 117].

In general, in the first stage of television development, we can outline 3 directions of experimental action related to the following: 1) the development of a technological component (mechanical and electronic television); 2) content development (live broadcasts, speeches, etc.); 3) with interaction with the viewer (audience research and production of receivers in the amateur way – during the era of mechanical television in the territory of the USSR, there were almost 2000 receivers collected in the amateur way). The off-line model is implemented mainly in the form of closed cultural texts. The development of the model on-line is experimental in nature, the technology of live broadcasting is actively developing. The outbreak of World War II hindered the development of television.

4. Television History. Formation Period

The second phase begins after 1945, related to the resumption of broadcasts and the operation of television in general. From 1946 to 1954, television broadcasting was restored in all the leading countries of the world – the period of television broadcasting began, characterized by:

– international influence. Establish links between countries using radio relay frequencies, and set up international television organizations (eg OIPT and Interbay);

– professional staff. Creative workers come from related industries, have philological, theatrical and film education, appear universities, which train specialists;

– the invention of VCRs had a huge impact on the further development of the model off-line: in 1956, the American channel CBS uses a VCR to delay the evening news, and after 4 years of the USSR Central Television for the first time broadcast a concert recorded on the first Soviet-style video recorder [2, p. 21, 99]. The first television films and series appear, but studio cameras are still quite heavy and do not allow mobile movement, so the active development of this model is still ahead;

– development of model capabilities on-line. In addition to broadcasting live reports, there is a dialogue: Triangle (Tallinn, 1965), Business Meetings Club (Perm, 1967), Seven Fair (Polish TV). The telemaster was also set up: On July 24, 1962, more than 180 million Americans and 100 million Europeans saw US President John Kennedy deliver a press conference with the help of Telemachus, with American and European viewers participating [6, p. 12]. Entertainment broadcast attracts the audience for the results: in 1964, in France during the program "Man of the Twentieth Century" viewers, trying to answer the presenter's questions, call and block the telephone network of Paris (at the same time more than 100 thousand people). At the same time, Czech television, with the participation of the viewers, is conducting the song contest for tomorrow [6, p. 12–13]. Live broadcasts are also used in news broadcasts: during the "Relay Relay" program in the mode of "direct inclusion" involved local television studios of the country, and in 1967 its author Yu. Fokin makes a screen list of studios "USSR-67. One hour of life of the Motherland », uniting more than 30 cities of the USSR [4, p. 216, 233]. However, for the USSR during this period, the development of the on-line model became a feature of local television studios, as T. Shalman defines, only "exclusively on regional television. On the central television screen, interaction with the audience was allowed only very limited, only in a few entertainment and educational programs" [9, p. 40];

– growing television audience in the world. The dynamics of the development of telecommunications in the USSR is evidenced by the fact that in 1953 there are three television centers in Moscow, Leningrad and Kiev with 120 thousand television sets, and after 5 years in 3258 centers and 1 million 760 thousand TV sets [11, p. 30];

– study audience and effects of TV. A systematic audience study begins and major research schools are formed to study the impact and effects of television both in the US and Europe. For domestic journalism, this period is connected with the emergence of universities and the development of scientific research in the field of television communication (analysis of television is presented in the first studies by R. Boretsky [1], V. Sappak [7], O. Yurovsky [10] and others).

Thus, in the period of the formation of television, development proceeds in 3 directions: technological components of broadcasting (standardization, influence of space technologies); Content (unique TV genres: TV series, talk shows, etc.) viewer interaction (systematic study of audience and effects of TV, experimental nature is the use of viewer interaction (telephone polling during the broadcast). The model off-line extends the capabilities and genre palette by recording on the VCR. The development of the model on-line associated with international broadcasts and dialogic genres that are widely used in regional broadcasting.

5. History of television. Globalization period

Continuing trends that began in the 50s and 60s, 70-80s is recognized as a global medium of communication. This is evidenced by the joint international conventions and declarations adopted by the Council of Europe and the UN General Assembly: the Council of Europe Declaration on the Freedom of Expression of Views and Information (1982), the Convention on the Principles of the Use by States of Artificial Satellites of the Earth for Direct Television Broadcasting (1982)) and other documents. The characteristic features of this period are:

– development of satellite broadcasting and frequency distribution, experimental developments in high-definition television (HDTV) and stereo-TV;

– segmentation of television space. Parliamentary channels, public service broadcasting, and highly specialized channels appear: CNN (1980), MTV (1981), Eurosport (1989); TV channels broadcasting via satellite; segmented airtime within one TV channel by time; morning, evening or nighttime programs appear, for example, «in the morning» of 1987, «the evening before and after midnight» projects were available at the USSR Central Committee;

– The topic of programs is expanding. Educational cycles appear. For example, BBC-2 in 1971 introduced a new form of correspondence "Open University" with the award of a bachelor's degree [4, p. 244];

– the on-line model extends interaction to intercontinental cooperation; Spectators actively cooperate with television – during a TV quiz on MTV's Wall Dellen High School Cruise Championship in 1983, a record number of telephone responses was received – 80,799 [4, p. 281]. "Direct inclusions" become a new feature of news broadcasting, but television for the first time becomes a place of demonstration of cruelty: during the live broadcast, the Spanish government is taken hostage by hostages, and during the Cairo military parade, «Muslim Brotherhood groups» attacked the President and those present;

– the off-line model continues to refine genre forms: the production of films specifically for television is actively developing. Yes, I.G. Mashchenko noted that in 1985 the release of feature television films (series) at Ukrainian film studios for the first time exceeded the production of tapes for screening in cinemas [4, p. 288]. The Western viewer is in particular demand for Docudrama documentary TV projects, based on documentary material but reproduced by the artistic means of television: court cases, 911 rescue service events, and more. Under the influence of cinematography, it becomes more complex to telematic, and the quality of the video series improves.

– audience research continues: The introduction of pillmetry by the British company AGB (Audits of Great Britain) in 1984 is a new step. This made it possible to take into account every 5 minutes the switching on and switching of channels (the number of which could be up to 97 at a time) and to transmit feedback data by telephone, in the early 90s this system was used throughout Europe [12]. The USSR used only sociological methods of mail analysis, for example, the State Television and Radio of the USSR created a department of letters for recording, studying and analyzing correspondence of viewers and listeners [4, p. 260].

Thus, we see that the recognition of television as a medium of communication is on an international scale, its capabilities are being improved in 3 ways: the technological component is complemented by satellite communication; content expands, market segmentation occurs; engagement with the viewer enhances the audience learning system, introduces pillmetry and ratings. The off-line model complicates the telematic, the tendency to destroy the broadcasting program and receive custom materials, by pre-recording the VCR with a separate viewer. The development of the model on-line during this period is associated with "bridges" and live broadcasts, especially sports competitions such as the Olympics. For the first time, live broadcasts go beyond editorial influence, demonstrating live attacks.

Globalization as a cultural process is contradictory. From one on the other hand, it is positive because it brings people, states, peoples closer, opens up new opportunities for them, modernizes, intellectualizes them life and thoughts. Otherwise, globalization is negative because leads to the universalization of such phenomena as terrorism, extremism, aggressive separatism, man-made catastrophism, nationalism, and in general, all the problems of modern civilization (environmental, energy, demographics). Countries or social organisms fail pressing the new global pyramid – degrading, corrupt and collapsing, actually being under the rule of the class-mafia structures. In this case, globalization complicates human being, brings a person closer to suffering and uncertainty. But, the negative ones the effects of globalization can by no means be absolutized, together with the complications inherent in globalization, it has positives moments. Globalization ensures the integration of peoples and states into one space, which helps them solve their life problems effectively by means of changing human existence. According to the writer and the publicist Mario Vergas Llosa, "Globalization is expanding horizons individual freedom" [12, p. 54]. On the other hand, a person is influenced global processes lose their identity, the foundations of identity.

The direction of globalization as well should be discussed separately formation of a single global information space. It is widely believed that the development of modern IT has given a strong impetus to accelerating the process of borrowing cultural and institutional and on this basis a certain universalization of the forms of the public life. Essentially, this is a widespread introduction of basic ones social values, institutional arrangements and cultural models, that are peculiar to the countries of the West, especially the USA [14]. Currently the leading countries the world and multinationals are making extensive use of new ones opportunities in this field to realize their own political, economic, socio-philosophical interests. Along with this powerful feeds based on the latest technologies, targeting different countries and cultural communities; a powerful, unmanaged flow of carrier information is updated relevant symbols, cultural specimens. As a result of such expansion there is a destruction of traditional sociocultural forms and institutes.

6. History of television. The period of telecast

Individual devices for satellite reception, cable television, segmented markets and the emergence of pay-TV services are leading to TV content and the development of the television industry. The development of digital broadcasting and the construction of new national television networks (a process to which Ukraine is involved), the development of HDTV, satellite communication systems and the integration of Internet communications and television are a hallmark of the period beginning in the 1990s. For this period the characteristic features are:

– legal regulation of TV channels: in the USA in 1996 the Communication Act was replaced by the Communication Act (1934), significant changes were made to the basic and competition provisions in all types of communication (including the Internet); during this period Ukraine adopts a number of laws in the field of telecommunications regulation; the Council of Europe Parliamentary Assembly adopts resolutions on the rights and principles of television journalists' activities;

– increasing the number of commercial TV companies, especially in the post-Soviet space. The example of Ukraine shows the dynamics: 1990 – the first non-state regional television company "Tonis Center" ("Channel 7") in Kharkiv, in 1998 the National Council for Television and Radio Broadcasting registered 516 broadcasting organizations in Ukraine, and in 2005 there are already 1268 broadcasters licensed to broadcast;

– the on-line model in information broadcasting begins to use live broadcasts to wage information wars: the constitutional crisis of power in Russia in 1993, the coverage of the Iraq war (2003), the events of the 2004 Orange Revolution in Ukraine, and others. Democratization on the air of perestroika times was approved through live broadcasting programs. The Reality-Show genre appears in the entertainment broadcast;

– the off-line model remains basic for manufacturers, the complexity of formats continues, the attraction to entertaining broadcasting is observed;

– audience surveys are expanding internationally – in 1991, the London Institute of Communication analyzed evening news in 55 countries on 97 TV channels; research is being conducted in new countries, and in 1997 SOCIS Gallup International began to analyze television audiences in Ukraine as well [4, p. 313, 336].

Thus, in the period of telecasting, the expansion of television capabilities in 3 directions also continues: the technological component is being improved with digital broadcasting and high-definition television (HDTV, HDTV); content continues to expand (Reality-Show genre appears); audience research goes beyond one country, extends to new countries, including Ukraine. The off-line model remains basic to manufacturers and complicates formats (especially in entertainment). Within the on-line model, the Reality-Show genre developed during this period and "information wars" continued.

7. History of television. Media Integration Period

But active development of Internet communication, social networks, new opportunities that get traditional media integrating into the Internet allow us to predict the next stage of television development – this is a certain period of media integration. In our opinion, it is just getting started, so all new influences on Internet content from telecontent, new audience studies that allow more thorough user experience while engaging with content are opening new avenues for further exploration of television and social communication in general.

Analyzing the current state of television development, we see that a new technological component (the Internet) is actively influencing the viewer. This creates a new type of content where the participation and role of the viewer change – from event watcher to active participant (a prime example is the various Life-Show live broadcasts where viewers are involved in the conversation), in addition we see a new type of communication, with the integrating features of television and internet communication in general.

Increasing the number of Internet users and its speed, it is possible to form a new type of media content consumers, as evidenced by the popularity of various video hosting services, the rapid increase in the number of mobile devices that allow to expand the limits of content consumption – without limiting itself to broadcast TV channels on demand (Video on Demand (VOD), live view (on-line). This confirms the validity of a new approach to understanding the interaction between journalists and consumers of information – a conceptualization of journalism based on the identity construct offered by American researcher R.D. Mercy [13]. This is how journalists understand their audience and, as members of that audience, connect with their communities.

Integrated journalism is known to consist of three stages: gathering, editing and disseminating information. However, the influence of the Internet allows the consumer to play his or her role at each stage, thus helping the journalist determine the degree of "relevance" of the story to himself and to the potential audience. All this works to the working hypothesis that interactive television, as a key television communication, contributes to the further development of media culture among viewers, since experience and a certain critical attitude to information are specific to an audience with a certain level of media education. Updating public journalism confirms the relevance of this hypothesis, especially in the context of interactive broadcasting.

These trends are confirmed in the materials of David Poltrak's report "The Outlook for the Broadcast Networks" at the UBS Global Media conference, the American television market is characterized by "interactivity with the viewer": it is fixed that almost 60% viewers while watching television programs "communicated or searched for" information about the same program [14, p. 127].

The new development of real television, on-line broadcasting in various social networks and applications once again bring some interest to the life of a real character in today's world. So researcher Podebonostseva believes that real television is the direct heir to television as such: from a living person who speaks to an audience on the air, moreover, not only through words but also through eyes, gestures, facial expressions, television has been transformed into different formats of real show. These are shows that make a spectacle of the lives of ordinary people. 5-10 years ago, such programs were based on stories, testimonies, confessions of people who wanted to share their personal problems, but today we see that social networks and blogging open up new opportunities for interaction with the producer of audiovisual work (or content). And anyone can become this manufacturer.

Irina Pobedonostseva believes that the real show is one of the TV formats that fully implements the ideology of interactivity, as the audience throws the candidates out of the game and influences its further development [5, p. 167], when viewers begin to rate the contestants, the projects go live, and after a while, in the continuation of the same live broadcast, we find out who is leaving the project – so the on-line model is used.

8. Conclusions

Thus, we see that the socio-communicative dimension of television in Ukraine must be viewed in the context of historiographical and theoretical-methodological studies, in the context of mass-communication processes. The essence of television and its particular problems have often been the focus of many researchers, and it is almost impossible to distinguish the industry or range of issues that remain beyond the reach of scientists. Observance of the objectively chronological sequence of events, phenomena and facts, the use of general methodology and methods of scientific research allows to form a television concept combining 2 models of broadcasting on-line and off-line. The on-line model is characterized by open text and real-time overlapping for viewers and TVs, leading to a more active audience. The off-line model is the technology of forming a screen product for which the moment of content creation and its receiving do not coincide in real time.

The periodization of television development distinguishes 5 stages: experimental broadcasting; becoming; TV as a means of communication; tele-wealth and the current state of development, collectively called the integration period. Each period is characterized by a tendency to develop in 3 general directions: technological, content development and development of interaction with the viewer. The achievements of each period and the improvement of technological aspects (television standards, signal transmission, satellite communications, improvements in technology, video, etc.) influenced the development of on-and-offline broadcasting models. Generalizations of observations on the development of television models indicate that the fluctuation of interest in each of them depends on the state of technological development, political and communication tasks. Television content tends to complicate the creative, technological and communication impact, and interaction with the viewer changes from watching and mediating the reaction to the television program to direct communication and interaction.

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CHAPTER «HISTORY OF ART»

ROMAN MIRACLE-WORKING ICONS OF THE MOTHER OF GOD IN THE ICONIC ART OF UKRAINE

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Abstract. *The purpose of the study* is to examine the origins, iconography and artistic-stylistic features of the world-known miracle-working icons of the Mother of God "Salus Populi Romani" ("Salvation of the Roman People") and "Madonna del Perpetuo Soccorso" ("The Mother of God of Perpetual Help") and their copies that became widespread in the pictorial art of Ukraine in the 17^{th} – 21^{st} centuries. *Methodology*. A complex method of the research in the icon-painting was applied in this study: historical, art history and philosophical-theological approaches (the latter is mandatory because of the liturgical designation of icon-painting as it has clearly established rules and canons). Applying artistic analysis the fact is asserted that the known Roman miracle-working icons of the Mother of God "Salus Populi Romani" and "Madonna del Perpetuo Soccorso" as well as their numerous copies in Ukraine in the 17^{th} – 21^{st} centuries represent separate iconographic types of iconography of the Mother of God and are included in the class of the Blessed Virgin Mary icons. The importance of the study is also predetermined by the concrete scientific task that implies generalization of the materials found in the national and foreign literature. *Research results*. Copies of the known miracle-working Roman icons of the Mother of God have been studied: over 20 icons «Salus Populi Romani" and over 50 icons "Madonna del Perpetuo Soccorso" of the above said historical period. Analysis has been made of the origins of iconography of the known Roman miracle-working icons of the Mother of God and it was determined

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that they represent a separate iconographic type. The icon of the Mother of God “Salus Populi Romani” originates from the iconographic type of Hodigitria, while iconography of the icon of the Mother of God “Madonna del Perpetuo Soccorso” shares common traits with the iconography of Hodigitria and Eleusa. It has been established, that they were popular in the sacral art of Ukraine, especially in Galicia, in the first half of the 20th century. A review of the influence of the church canons on the formation of iconography has been made. We shall note that theological principles laid in the iconography do not contradict, but supplement the well-established rules of canonical iconography elaborated in the 9th – 10 centuries and the national art traditions. *Scientific novelty*. Scientific novelty of the obtained results is that the unique works of icon-painting – miracle-working Roman icons of the Mother of God “Salus Populi Romani” and “Madonna del Perpetuo Soccorso” and their copies in Ukraine were introduced into the science of study of art; methods and technology of creation of these icons based on the knowledge of technology of the ancient and modern icon-painting with application of the ancient egg-tempera techniques (taking into account the author’s experience) have been described. *Recommendations*. The study of iconography and art stylistics of these icons as well as their technologies, symbolism still require deeper studies and new scientific approaches.

1. Introduction

An icon is a work of the sacral art that combines spiritual and material essence. Its close link with the Bible (the Holy Scriptures of the Old and New Testaments) and Liturgy makes it a spiritual beacon, transcendental light that helps a human being communicate with God and receive mercy. In the two thousand years of existence of icon millions of people received various graces and bodily healing. We know about thousands upon thousands instances of miraculous healing scientifically and documentarily confirmed. Such icons are declared miracle-working and receive the church symbol – golden crown. Valuable are not only the world-known Roman miracle-working icons of the Mother of God “Salus Populi Romani” and “Madonna del Perpetuo Soccorso”, but also their numerous copies in Ukraine. They excite interest of the students of sacral art first of all by their unique iconography, art stylistics and by technology of their execution. We shall note, that these icons originate from the iconographic type of the Mother of God Hodigitria pointing at Jesus Christ, and through the many centuries spread from the European continent throughout the whole world and, particularly, to Ukraine. The known copies of the icon of Mother of God “Salus Populi Romani” in Ukraine in the 17th – 21st centuries were the icons of the Mother of God: “Consolation” in Lviv, “Berdychivska”, “Letychivska”, “Kokhavynska”, “Berezhanska” and others, as well as the numbered certified Roman copies of the miracle-working icon “Madonna del Perpetuo Soccorso” in Mostyska, Lviv, Ivano-Frankivsk, Drohobych and in other cities of Galicia. The process of the studies was complicated by the fact that a considerable number of these icons was taken out of the country in the period of World War II, in the first half of the 20th century.

Purpose of the study – to trace history of the known Roman icons, circumstances of their arrival and tradition of their veneration in Ukraine, to prove that these icons represent a brilliant phenomenon of the Ukrainian and the world sacral art.

Object of the study. These are copies of the miracle-working Roman icons of the Mother of God “Salus Populi Romani” and “Madonna del Perpetuo Soccorso” that became widespread in the pictorial art of Ukraine in the 17th – 21st centuries.

Methodology of the study. The following complex of methods was used in the study, namely: historical, comparative, typological, analysis and generalization, descriptive, visual, iconological (the object in the historical process); iconographic (principles and methods of depiction); technological (chemical particularities and physico-chemical processes); documentary (official and informal information in writing and photographs, audio– and video-records, books, manuscripts, etc.); artistic-stylistic (analysis of the style of individual painters, their schools, separate artistic epochs); philosophical (metaphysical, dialectical and Aristotelian methods: substance and phenomenon; content and form; necessity and chance, etc.); theological (influence of the teachings of the church and canons on the formation of the artistic image; theology of the icon); inductive (cognition of separate facts – reasoning from particulars to generals) and deductive method (arriving at partial conclusion proceeding from knowledge of general provisions – reasoning from the general to the special); method of artistic analysis.

Analysis of recent publications. History of the Roman miracle-working icon of the Mother of God “Salus Populi Romani” was studied by the

Ukrainian and foreign scientists: academicians Nicodym Kondakov [26] and Dmytro Stepovyk [48–49], Galina Kolpalova [25], Polish scientists in the 20-volume edition under the editorship of Jan K. Ostrowski [42–43], Kazimierz Kuczman [32], Piotr Krasny [28–30], Marek Walczak [55], Andrzej Betley [2–6], Aneta Gluzinska [19], Aneta Gebuta [18], Rafal Nestorow [38], Tomasz Zaucha [60–61]. Researcher Tadeusz Kukiz [33] gives a brief historical account of the keeping of copies of the Roman icon in Galicia in the 17th – 21st centuries. Other publications that contributed to the research subject were also analyzed. Examination of the scientists' works on the subject of the research showed the bulk of information on the history and iconography of the known miracle-working icon «Salus Populi Romani" and its numerous copies in Ukraine.

History of the Roman miracle-working icon of the Mother of God "Madonna del Perpetuo Soccorso" and its copies was described by the Ukrainian Redemptorist priests, Bishop of the Ukrainian Greek-Catholic Church Vasyl Velichkovsky [54], Reverend Myron Shevchuk [47]; Polish Redemptorist Reverend Bernard Lubenski [34] and Jan Dolbakowski [15]; Italian Redemptorists Reverend Fabriciano Ferrero [17] and Reverend Mario Cattapan [11]; Italian researcher Giovanni Antonio Bruzio [7], Polish scientists in the 20-volume edition under the editorship of Jan K. Ostrowski [42] and others.

2. History and iconography of the icon "Salus Populi Romani"

The famous icon of the Mother of God, bearing the honorary name of «Salus Populi Romani" ("Salvation of the Roman People" is installed in the altar of the Basilica of Saint Mary Major (Basilica di S. Maggiore), which is the largest Roman temple erected in honor of the Mother of God. This icon has also another name – "*Saint Mary* of the Snows" (also "Our Lady of the Snows") which is associated with the ancient church legend according to which the Blessed Virgin Mary appeared in a dream of Pope Liberius of pope Liberius and told him to build a new church on the site where a blanket of snow would appear. Indeed, on the morning of August 5, 352, Pope Liberius and citizens of Rome saw a stretch of land covered with white snow on the Esquiline Hill. This is why the church was also called Santa Maria della Nevi (neve in Italian – «snow»). This icon of the Mother of God became famous for the numerous healings and salvation of the city of Rome and its environs during the terrible wars and epidemics [39, pp. 661–662, fig. p. 161; 56, pp. 93–101]. It is known from the history of the icon that it was brought to Rome in 590 during the reign of Pope Gregory I. The canonical act of coronation of the icon was executed by Pope Gregory XVI on August 15, 1838. At the same time the papal bull «Caelestis Regina» ("Queen of Heaven") was proclaimed. For the second time, the icon was re-coronated by Pope Pius XII on October 11, 1954 and the proclamation of the Bull "Ad Reginam Caeli" ("To the Queen of Heaven") [46]. Dedication to the icon was confirmed by the Popes John Paul II and Benedict XVI, as well as by Pope Francis, who visited the icon the next day after being elected Pope. Its copy was present during World Youth Day in 2000 and 2016.

Scientists attribute creation of the icon «Salus Populi Romani" to the 6th century. Quite possible that it is a copy of the more ancient icon painted by the apostle and evangelist Luke. This is partly confirmed by the fact that the icon was painted on a cypress board brought from the Orient. Another opinion is expressed by art expert Galina Kolpakova, who maintains that the final look of this icon was formed at least before the 8th century, and the outlines were probably touched up on the icon in the 12th (1100) – 13th centuries [25, pp. 253–254]. This icon is described in the second volume of his book "Iconography of the Mother of God" (St. Petersburg, 1915) by academician Nikodim Kondakov. The scientist notes that the Blessed Virgin Mary is depicted in a dark-brown kerchief lined with a golden welting with a lining of dark green color. On the kerchief, above the forehead, there is a golden straight cross. The Most Holy holds the Child Jesus in both arms put together below. The right hand holds the left, gripping it by the wrist [26, p. 171]. The crimson tunic is with narrow sleeves and two paired gold hemming on the wrist with a cross in the middle. The infant Jesus is dressed in the red tunic and ocher-brown himation, covered with gold hatching, enhancing the play of light and shadow of the relief folds of clothing. The Savior blesses with His right hand, holding in the left hand the closed Gospel Book. His head is turned to the Mother [26, pp. 171–172, fig. 77]. The monumental figures of the Mother of God and Child are depicted against the golden-ocher-coloured background. Around the most holy heads there are golden-red nimbi. The typical feature of the nimbus of the Child Jesus is that it does not have a cross inscribed on it, which is canonically motivated in icon painting. The size of this icon is 117 x 79 cm.

3. Copies of the icon "Salus Populi Romani" in Ukraine

Copies of the Roman icon from the Basilica of Saint Mary Major are installed in the altars of many Christian churches of the world and in Ukraine as well. The most known copies are in Lviv, Letychiv, Berdychiv, Kokhavyn, Berezhany and in other temples. The copy of the icon «Salus Populi Romani" in Lviv, better known as "Our Lady of Consolation", dates back to the late 16th century. It was painted on the request of the black pope Francis Borgia in 1570 and transferred to the Society of Jesus in the city of Jaroslaw (Poland). Subsequently, it was transferred to the Church of the Apostles Peter and Paul in Lviv. On November 10, 1630 the icon was ceremoniously brought into the church and placed in the altar, and in 1636 it was decorated with silver gilded framing. Also, special metal mounting covering the painted background of the icon was made for this icon to which numerous offerings (votas) were attached. The great church and secular worshipers came to pray before this miracle-working icon, including the Polish kings Sigismund III Waza (1587–1632), Wladislaw IV (1632–1648), Jan Kazimir (1648–1668), and Jan III Sobieski (1674–1696).

On the order of Pope Pius X on May 28, 1905 the icon "Our Lady of Consolation" was coronated. The act of coronation was performed by the Metropolitan of Lviv Archbishop Yosyp Bilchevsky. In 1945 the icon was taken to Krakow, and in 1974 to Wroclaw (Poland) to St. Clement Church. An interesting historical fact is that on December 13, 1981, after the introduction of the state of emergency in Poland, the icon "Our Lady of Consolation" from Lviv became the protectrix of the "Solidarity" workers. Now its copy is displayed in the Museum of the History of Religion in Lviv [1; 13; 16; 36; 40; 57]. The icon "The Mother of God Berdychivska" (Holy Scapular of the Mother of God or "Scapular"), became famous in the Monastery of the Discalced Carmelites in Berdychiv (Zhytomyr region). From history of the icon it is known that it belonged to the *Tyszkiewicz* family who kept it in the castle chapel. On July 22, 1642 it was transferred to the newly built Church of the Discalced Carmelites' Fathers and placed in the main altar in a silver frame of rococo style produced in the jewelry workshop in Wroclaw. The icon was obscured by the external appearance of the Immaculate Conception of the Blessed Virgin Mary (copy by Bartolomeo Murillo). Above the icon there was the monogram «MARIA» in the rays, supported by angels. On the frieze – a gilded medallion crowned with a crown on top. The altar and the altarpiece were adorned with numerous gifts as well as with the objects left as the evidence of healing of by the Mother of God: prostheses and crutches of cripples, etc. [53, p. 19].

Studying iconography of the icon, it is fair to say that its author did not follow the original. He painted it in the Western style without the linear strictness, golden background and Greek letters, "drawing the faces of modern living people full of life, beauty and passion», but «preserving the typological composition and dimensions of the original" (117x79) [53, pp. 22–23, fig. 31]. It is known also that this icon was famous for its numerous miracles, recorded in the book «Liber de exordia istus conventus, progressu et fundatione, inscriptionibus aliquibus et de miraculis ad imaginem BMW Berdiczouiensem spectantes». The cult of the Mother of God in Her miracle-working icon was spread by the monks of the Order. Five years later, on May 23, 1647, the icon "The Mother of God Berdychivska" was proclaimed as the miracle-working icon by the bishop of Kyiv Stanislav Zaremba of Kalinov (also healed by the Mother of God of Berdychiv) on the basis of documentation about the received mercy and miraculous healing through mediation of the Mother of God [53, p. 24]. The icon was decorated with gold and silver jewellery, and a silver shield as an expression of gratitude for the graces received. Saved from the dangers of war events in the past, coronated three times, it perished with the sanctuary during the Soviet occupation in 1941 [53, p. 21]. A copy of this icon is kept in the National Art Museum of Ukraine (end of the 18th century, linden tree board, two connecting plates, levkas, oil, 71 x 52 x 25) [51, 172, fig. 121]. In artistic– stylistic terms, the face of the Mother of God in this icon is like in the icon, that comes from the Church of the Nativity of the Virgin Mary in the village Mala Buhayivka in Vasylkiv district of Kyiv region (first half of 18th century) [51, 93, fig. 51].

The new icon was painted by the artist-restorer Bozena Mucha-Sowinska of Nowa Guta (eastern part of Krakow) on request of the Provincial Father of the order of the Discalced Carmelites in 1991 [53, p. 30, fig. 32]. The base of the icon (size 143 x 93 cm) was waterproof multilayered plywood. And the image itself is made using oil-resin techniques on primed canvas. It should be noted that painting the new icon was connected with some difficulties, namely: there was no color reproduction of the ancient original, although there was collected a great number of the black and white images. In these images the Mother of God is covered with an embroidered revetment and has a crown on her head. Bearing this in mind, of special value became the detailed description of the icon made by Father Bronislaw Jarosinski in 1921–1925 after removal of the miracle-working icon from the altar.

Despite the fact that the artist did not adhere to the original, her copy differs from the Roman original in materials, techniques of execution, composition and size, the icon is successfully complemented by multifigured compositions of the angels around the heads of the Mother of God and Child Jesus, and the eye of the Divine Providence in the triangle (symbol of the Blessed Trinity) above [53, p. 30]. This icon was consecrated by Pope John Paul II on June 9, 1997 in the Church of St. Jadwiga in Krakow in the presence of Archbishop Maryan Jaworski, Metropolitan of Lviv, and a delegation of Berdychiv parishioners. With the permission of the Apostolic Capital, on July 19, 1998, Bishop Jan Purwinsky, the ordinary of Zhytomyr diocese, performed the act of coronation of the icon in Berdychiv [53, p. 6].

The recent history of the miracle-working icon of the Mother of God of Berdychiv ended on July 16, 2006, when the 250th anniversary of the first coronation of the icon by Pope Benedict XVI was celebrated in Berdychiv. That year the district center of Zhytomyr region again became a pilgrimage site for thousands of pilgrims. Since then, many contemporary Ukrainian artists made copies of the miracle-working icon: Andriy Demianchuk (2007), Sergiy Bulko, Igor Oryshchak and Igor Leskiv (joint work, 2008), Vasyl Stefurak (2009) [48, pp. 9, 11]. We learn about the spiritual essence and artistic sophistication of the ancient and new copies of the icon of the Mother of God "Berdychivska" from the works of the Ukrainian scientist, Professor Dmitro Stepovyk [48, pp. 7–11; 49, pp. 153–168].

The Letichev icon of the Mother of God (the Queen of Podillya and Volhynia) is considered as one of the best copies of the Roman icon "Salus Populi Romani". The time creation goes back to the beginning of the 16th century, but the name of its remains unknown. Icon was painted with oil paints on canvas stretched on the board. Its size is 128.5 x 92 cm. It is known that in 1606 the Dominican Fathers brought from Rome to Letychiv a copy of the icon donated by Pope Clement VII. This icon was a rescue and protection against the Tatar invasion, as evidenced by the Letychiv and Kamyanets head Jan Potocki. The Dominican Fathers, rescuing the icon from destruction, moved it to Lviv in 1654. And in 1722 it was returned to Letychiv. Subsequently, on the basis of numerous testimonies of miraculous healings, Pope Pius VI issued his decree in 1778 declaring the icon as miracle-working. The act of coronation of the icon of the Mother of God «Letychivska» was performed on October 4, 1778 by Bishop Stanislaw Rajmund Ezerski [58]. Since then, this miracle-working icon has become a protection for the believers of Podillya. In 1920 the icon was taken to the city of Lublin in Poland. Pope John Paul II instituted the liturgical day (July 6) honoring the icon of the Mother of God «Letychivska» [58].

Valuable was the icon of the Mother of God with the Child, known as "The Mother of God Kochavynska" of the 17th century. It was installed in the parish church of the Assumption of the Virgin Mary in the village Kokhavyn According to the legend, this icon hang on an old oak tree in the Kohavyn forest by the road that passed from the town of Zhydachiv to the town of Ruda (in the summer of 1648 it was seen by Anna Wojankovska) [12, p. 7]. A wooden chapel was built in 1680 in the place of the oak tree and the ancient icon was installed in it. On May 26, 1755, Archbishop Mykolai Ignatius Vyzhitsky proclaimed the icon of the Mother of God of Kochavyin as miracle-working on the basis of all the testimonies and conclusive acts. On June 27 of the same year the icon in the procession was moved from the chapel to the newly built church [23]. In 1894 a new church was erected with the assistance of Father Jan Tropinsky, which was consecrated on August 30, and on September 1 a ceremonious transfer of the icon of the Mother of God took place. Two years later, on September 8, 1896, celebrations were held to mark the 250th anniversary of the proclaiming of this icon as miracle-working. It is known that the icon was decorated with silver covers and silver crowns [41, 70, fig. 78]. On August 15, 1912, with the blessing of Pope Pius X, the act of coronation of the icon of the Mother of God was performed. The crowns for the ceremony were made by the master from Stryi Yozef Yakshcha. The icon was repeatedly restored and repainted, in particular, in 1931 by Henryk Kichna, and in 1966–1967 by Waclaw Szymborski and Anna Szyszko-Bonusz-Szymborska. At that time the icon was in silver covers of the 18th century, decorated with precious stones and golden crowns [41, 70, fig. 74–77]. In 1939 the icon was taken to Poland, and in its place an authentic copy (also taken away in 1944) was installed [23]. After restoration in Krakow in 1974, the ancient icon was transported to the city of Gliwice and installed in the church of St. Bartholomew (its copy is also in the church of the town of Sciechów in Poland). The icon depicts the Blessed Virgin Mary holding the Child Jesus in her left arm and the below inscription in Latin "O MATER DEI ELECTA ESTO NOBIS VIA RECTA" – ("O, Mother of God, you are chosen, You are our straight path" (to God)). This icon (56 x 82 cm) was painted with tempera paints on the oak tree board in the first half of the 17th century. On May 30, 2000 a copy of the miracle-working icon of the Mother of God of Kochavyn was brought from Poland and installed in the Church of the Intercession of the Blessed Virgin, that was taken care of by the Redemptorist fathers (the Order of the Most Holy Redeemer). Another copy, installed in the altar of the new chapel of the monastery of St. Gerard, which has the status of a novitiate house of Lviv province, was consecrated on February 18, 2001. Its author is Orysia Nykolyshyn [20; 21; 23; 37].

In the castle church of the Holy Trinity in Berezhany there is an icon of the Mother of God with the Child ("*Saint Mary* of the Snows"). This icon was brought to Berezhany by nobleman Alexander Sinyawski in the beginning of 17th century as a gift to the town from Pope Paul V, and on November 26, 1831, it was ceremoniously transferred to the Church of the Holy Trinity. Since then, the icon became famous for numerous healing from incurable ailments.

In 2008, Pope Benedict XVI by his decree, renewed the dismissal prayer for the Berezhany miracle-working icon of the Blessed Virgin Mary [50]. This icon is still staying in the Church of the Holy Trinity in Berezhany. It is decorated with metal silver-plated covers in whose background there are engraved relief images of the angels, and placed in a wide frame [38, 99, fig. 135]. One more icon of the Mother of God with the Child (Matka Boska Fraska) was installed in Berezhany in the Saint Nicholas Church and the Monastery of the Bernardine Fathers. It is now installed in Warsaw in the Church of the Bernardine Fathers. The icon was painted in 1904 with oil paints on the canvas by artist Fabianski. In the second half of the 18th century image of the Assumption of the Mother of God was painted with oil paint on the canvas [5, 136, fig. 200–201].

Of interest in artistic terms are copies of the Roman icon, that come from Galicia (17th – first half of the 20th century.). These include the icons of the Mother of God: in the Church of the Assumption of the Blessed Virgin Mary in Buchach [44, 20, fig. 31–34]; in the Church of the Assumption of the Blessed Virgin Mary in Bilyy Kamin (was kept in the main altar till 1741, it had metal silver-plated covers decorated with the engraved floral ornament). Now it is in Lviv National Gallery of Art, the branch in Olesko [32, 15, fig. 27]; icon of the Virgin Mary of the Snows in the parish church of Archangel Michael in Stara Sil [27, 254, fig. 510] (painted with oil paints on wood, the background having an embossed gold-plated ornament, wooden covers gold-plated in the 19th century) [27, 254, fig. 516]; in the Church of St. Catherine in Zymna Voda (now the icon is kept in the parish church in Wroclaw-Ciazyn) (the icon of the Mother of God of Snows is painted with oil on wood in the 17th / 18th centuries, set in wooden gold-plated covers) [4, 271, fig. 461–462]; in the St. Martin Church in Semenivka (painted with oil paints on canvas in the 19th century, in plastic metallic silver-plated shield). It is now in the parish church in Doboszowice, Poland. The upper part of the shield has a semicircular shape, and the framing is decorated with baroque ornaments using floral designs The heads of the Blessed Virgin Mary and the Child are crowned with beautiful silver crowns and engraved radiant nimbi [6, 163, fig. 207]; Another icon of the Mother of God with the Child of this iconographic type was located in the side altar (painted with oil paints on wood, circa 1855, in metal silver-plated covers of the 17th century, by G. Shapiro (?). This icon is now in the parish church of the in Kaminna near Namyslow, Poland) [6, 89, ill. 90]; in Fraza (painted in the 17th century on wood with tempera paints and decorated with metal covers with ancient silver crowns of the 18th century. It was restored in 1904–1905 by Jan Tabinski and completely painted in the early 90's of the 20th century) [2 , 92, fig. 144]; in the Church of Our Lady of the Snows and the monastery of the Capuchin Fathers in Kutkir in the main altar (painted with oil paints on canvas in the 17th century, framed with metal covers with silver-plated crowns) [19, 171–172, fig. 265]; in the church of St. Nicholas in Vyzhnyany on the side altar (first half of the 18th century, restored in 1936), wooden covers made in the first half of the 18th century were placed on the icon [19, 330, fig. 573]; in the church of the Blessed Virgin Mary and the Exaltation of the Holy Cross and the monastery of the Dominican Fathers in Pidkamin there was the icon of the Mother of God with the Child ("The Mother of God of Pidkamin"). It was painted in 1612 with oil paints on canvas by a Lviv painter [28, fig. 271–272].

The icon was mounted in a profiled silver frame decorated with floral ornament, probablyб before coronation (1727), obscured by silver covers with the engraved acanthus leaves and large flowers, onto which numerous offerings were fixed in 1708. On the heads of the Mother of God and the Child there are silver crowns, designed by Jan Matejko and placed on August 14, 1873 [28, 155, 159, 165, fig. 258, 306, 324]. In the church of St. John the Baptist in Sasiv there was the icon of the Mother of God with the Child («Mother of God of the Snows»), now in Zuchlow, Poland. The icon, painted with tempera paints on wood in the 17th century, has silver covers of the 18th century and crowns on the heads [18, 250, fig. 486].

Copies of the icon of the Mother of God "Salus Populi Romani" were in the churches of the Assumption of the Virgin Mary: in Vyshnivchyk in the main altar (painted with oil paints on wood in the 17th century and decorated with silver gold-plated covers) [28, 434, fig. 581]; in Skalat in the side altar, early 17th century (repainted in the beginning of the 20th century. It is decorated with gold-plated wooden covers) [61, 182, fig. 362]; in the Church of the Assumption of the Virgin Mary and the monastery and colleges of the Fathers of the Piarists in Zolochiv (painted with oil paints on canvas in the 19th century) [30, 398, fig. 758]; in the Church of the Assumption of the Virgin Mary and the monastery of the Dominican Fathers in Jezupol in the main altar (painted with oil paints on wood in the first half of the 17th century, silver-plated covers with the engravings in the background and framing were made in 1813. In the bottom of the icon there was the following inscription: "POD TWOJA OBRONE UCIEKAMY SIE" – ("Under Your mercy we come"). On the reverse side there was another illegible inscription of the 19th century, and on the sides – the carved figures of unidentified saints. In 2002–2003 the icon was restored by Agnieszka Lubon) [60, 109–110 , fig. 120]; in the Church of the Betrothel of the Blessed Virgin Mary and St. Joseph (painted in folk style in the 18th century. It is now kept in Wroclaw, in the Benedictines Monastery) [43, 389, fig. 818].

The iconography and artistic and stylistic features of these copies differ from the Roman original, but the established norms of the church canon have been observed in them and they show a high level of mastery of execution. A considerable number of these icons were taken out of the country during World War II.

4. History and iconography of the icon "Madonna del Perpetuo Soccorso"

There is the assumption that the copy of the first icon of the Mother of God of Perpetual Help comes from the Cretan village of Lassithi, and some researchers attributed its authorship to the well-known painter of the early Middle Ages, a Basilian monk S. Lazzaro (868). It is not known exactly what happened with the original ancient miracle-working icon, though according to the local stories it was stolen, and according to recent studies, this icon is in Rome and dates from the 10th – 11th centuries [59, p. 132].

It is known from history that Basilian monks settled on the island of Crete in 961, founded several monasteries and opened their icon-painting school on the island. They spread their works all over the world and brought them to Kievan Rus. Suffice it to say that 112 artists (among all these painters the names of Andriy Rizo and his son Mykolay stand out) painted images of the Mother of God and Saints in the 14th – 15th centuries. In 1453, according to some scholars, the icon of the Mother of Perpetual Help was lost during the conquest of Constantinople by the Ottoman Turks, but a copy of it was saved [47, p. 24]. According to church legends, this icon was delivered to the island of Crete (and remained there in the church of Panagia in the village of Fodele). In 1496, the icon was taken from Crete to Rome, and on March 27, 1499 it was ceremoniously installed in the Church of Saint Mathew that was under care of the Augustinian monks. The icon was remained in this church for over three hundred years (15th – 16th centuries), more precisely till 1798, when the French army under the command of Marshal L. Berthier, destroyed over thirty Roman churches, including the church of Saint Matthew. However, the icon was miraculously rescued and transferred to the monastery of St. Eusebius [15, p. 188–189]. In 1819 the Augustinians moved to the Monastery of the Blessed Virgin in Posterula and placed the icon in the private chapel (oratorium) of the monks, where the icon stayed for almost 50 years, till the time when the Redemptorist fathers bought a small house near the ruins and rebuilt a new shrine in the same place in honor of Christ the Redeemer and Saint Alfonso. Father Michel Marci joined the Redemptorists in 1855 and spoke about the glorious tradition and cult of the Mother of Perpetual Help icon. Through the efforts of the CSsR abbot general, Father Nicholas Mauron, on December 11, 1865 Pope Pius IX ordered to place the icon for public worship in the Church of the Most Holy Redeemer and Saint Alfonso. From that time on, “The Mother of God of Perpetual Help” became the main protectrix of the Redemptorists [9, p. 133]. On January 16, 1866 it was handed over into the hands of Fathers Michel Marci and Ernesto Bresciani in the church of Santa Maria de Posterula, and its presentation for the public worship took place on April 26 after restoration by the famous Polish artist Leopold Nowotny [15, p. 191–192]. On May 5, 1866 Pope Pius IX personally prayed before the miracle-working icon and instructed the Redemptorists to spread her cult throughout the whole world. Shortly afterwards, on June 23, 1867, the icon of the Mother of God of Perpetual Help was solemnly coronated by the Pope's representative Cardinal Roger Matei. On May 23, 1871, Pope Pius IX approved the established Fraternity of the Mother of God of Perpetual Help, and on March 31, 1876, promoted it to the rank of the Archfraternity. The Apostolic Capital has established the liturgical day of veneration of the icon, which is celebrated on June 27. It should be noted that not only the Roman icon itself has the miracle-working power, but also its copies as well – wherever they are located [15, p. 187–194].

A great number the fraternities and Archfraternities, churches, monasteries and individual monastic and secular congregations have been named in honor of the icon of the Mother of God of Perpetual Help. More than thirty monastic institutions have chosen Her as their protectrix and established numerous dioceses throughout the whole world. On December 8, 1942 the people of Haiti chose the Mother of God of Perpetual Help as their Heavenly Protectrix. Popular is the incessant novena that was first introduced in 1922 in St. Louis (USA). On June 30, 1991, Pope John Paul II prayed before the image of the Mother of God of Perpetual Help in the Church of the Most Holy Redeemer and St. Alfonso in Rome [15, p. 194].

The icon of the Mother of God of Perpetual Help is painted with tempera paints on walnut tree wood (from other sources we learn that the icon was painted on cedar tree wood) [59, p. 133]. Its dimensions are 53 × 41.5 cm. Iconographically it is attributed to the Lamenting Virgin (Mary Dolorosa), as well as to Eleusa of Consolation [15, p. 187].

The icon also clearly shows characteristic elements of Hodigitria (She who points the Way). This is the hand of Mary pointing to Jesus Christ, who said about Himself, “I am the way, the truth, and the life!” (John 14:6). Such combination of both types of iconography is of dogmatic importance because it clearly reveals the history of Salvation through artistic means.

Also expressive is the look of the Mother of God, turned to each one of us personally, with the request and encouragement not to be indifferent to the cause of the Atonement and personal destiny. Against the golden background, the symbol of the Kingdom of God, there dominate two large figures of the Blessed Virgin Mary and the Child Jesus. The Blessed Virgin holds Jesus in her left arm and points to Her Son with her right hand simultaneously holding both hands of Jesus. The figure of the Child is slightly bent toward His Mother, but the head is turned to the left and toward Archangel Gabriel, holding a cross and four nails, attributes of the future torture of the Savior. The head of the Mother of God is slightly bent toward the Child with the face full of kindness and gentleness, sadness and thoughts. The face is finely modeled, the nose is elongated, delicate, the mouth is small, lips closed, the eyes are large, olive in color, looking at each of us. However, the way of depicting the holy faces is not traditionally oriental. Here we can visually observe the realistic interpretation of depicting faces and oriental iconography in the construction of the composition.

The Mother of God is dressed in a red dress with golden borders around Her neck and on the sleeves. The red color of the dress symbolizes the hidden martyrdom of Mary, in confirmation of Simeon's words that the sword would pierce Her soul. This prophecy came true during the Passions of Christ. The head and shoulders are covered with the cape-kerchief of blue color that symbolizes Virginity as well as Her earthly birth, and the green lining of it is the symbol of the Spirit of God, faith and life. Golden hatches symbolize God's Energy. Above Mary's kerchief above Her forehead there are two stars. It should be noted that two identical stars are observed on many Byzantine icons of the type of Odigitria, but in a different arrangement – one star on the head and the other on the shoulder. In this case, these stars are special. One star is octactinal with a ninth ray directed at the viewer in the center. It is larger than the star, which is located slightly below. The second, X-shaped, has a triple branching at all the four ends. Five rays come out from this star, except for the central one: one pointing upwards, one pointing to the left and one to the right, and two pointing downwards. They are directed toward Jesus, confirming the Savior's First (Passion) and Second (Glorious) Coming. This star is a symbol of the Incarnation, the Birth of the Savior and the Motherhood of Mary, Queen of Heaven and Earth. The Star is a reminder of the name of Mary, because in Hebrew (מירים – Miriam) etymologically means «Lady» and «The Star of the Sea» [15, p. 188]. This is why the kerchief of Mary is of blue or blue-green color. Around the heads of Mary and Jesus there are decorative engraved nimbi. Floral motives prevail in the Mother of God dress, namely – lily flowers, that signify spiritual and bodily purity. In the Child Jesus' nimbus we see the pained cross.

The Child Jesus is portrayed in full figure, he huddles to His Mother, holding her palm with both hands. Dressed in a green tunic (which is the symbol of the Spirit of God who gives and supports life), with the red belt put on, the symbol of martyrdom –the shed blood for the redemption of the sins of humanity. The brown cape (hemation) thrown on the right shoulder of the Savior symbolizes courage. All the garments are covered with multiple golden hatching (graphic strokes) that symbolize God's Energy, Strength and Power. Although the figure of Jesus the Child is bent in the arms of His mother, His head (with the wide open forehead and thick curly brown hair) is turned to the left, looking at Archangel Gabriel, who holds the cross and nails, the tools of the torture and death – but Redemption as well. The bodily movements of Jesus are also emphasized by the movement of the legs (the left leg is crossed over the right leg, whose bare foot looks from under the cape). An interesting element in the icon is the sandal falling off from the right foot of Jesus [59, p.133]. The scientist Yakiv Krekhovetsky describes this characteristic detail as «an exclusively human feature of the composition» [31, p. 79–84].

The icon has a golden background that emphasizes the royal dignity of Jesus and Mary. Even more evidently is emphasized dignity of the precious crown on Their heads. A characteristic feature is the introduction of angels with the symbolism of the Passion of Christ. The Child Jesus turns His head toward one of them, as if to confirm the purpose of His mission on the Earth. The heads of Jesus and Mary are surrounded with golden nimbi with floral ornaments, executed by the punctuation technique characteristic of the Cretan school of icon painting. The nimbus of the Mother of God is formed by the stylized lilies that symbolize the Holiness and Virginity, and the nimbus of Jesus has a painted Cross characteristic of the iconography of the Son of God. Two archangels, Michael and Gabriel, are dressed in red (crimson) tunics, and Archangel Michael has also a green cloak. The composition is complemented with the red letters indicating the specific figures. At the highest level, on both sides of the head of the Mother of God, we see the Greek letters MP ΘY, which is an abbreviation of the name of the Mother of God (Meter Theou), located at the top of the icon above Her nimbus: on the left side is MP (abbreviated from Μήτηρ) and on the right side is ΘY (abbreviated from Θεού). On the Child's face level – IC XC: Jesus Christ (in Greek Ἰησοῦς Χριστός, literally Jesus the Messiah). Above the Heads of the Archangels: O AP Γ ('ο' Αρχάγγελος Γαβριήλ) – Archangel Gabriel; O AP M ('ο 'Αρχάγγελος Μιχαήλ) – Archangel Michael [15, p. 189].

This icon has very clear and bright colors, as if painted quite recently. The Polish artist Leopold Nowotny worked on its restoration in 1866 [59, p. 134]. Comparing the various descriptive sources and scientific reports on the studies of the icon of the Mother of God of Perpetual Help, it is worth to present the results of the study of 1994 according to which the researchers came to the assumption that the age of wood on which the icon was painted, goes back to the early 14th century, while the paintwork was not as old and dates back to the early 18th century, the paintwork was copied on the reverse side without preserving the original [15, p. 190–191]. However, new studies of the icon show that the icon has a more ancient origin [59, p. 132].

Yakiv Krekhovetsky attributes this iconographic type of the icon of the Mother of God of the Passion to the 13th – 14th centuries. He also suggests that it appeared «probably, for the first time in Serbia: in Lesnovo and Konce» [31, p. 83]. And «in Rome and in the West, in Ukraine and in some other Eastern Churches, the icon of the Mother of God of Perpetual Help is quite popular» [31, p. 83]. Describing the Ukrainian copies of this icon, Professor D. Stepovyk points out that the Ukrainian artists remove completely the expression of sorrow, even some tragic sensation that always accompanies icon-painting of Mary in the Balkan countries, from the faces of Jesus and Mary. The Ukrainian Perpetual Help is serious, deep in thoughts, but not sad or sorrowful. She seems to know that after the Passion of her Son, there will be a great victory over the tortures and death. And such interpretation comes closer to the Gospel text and, therefore, to the truth [49, p. 171–172]. This type of icon was endorsed by the highest ecclesiastical authority and commissioned to be spread worldwide [21].

5. Copies of the icon "Madonna del Perpetuo Soccorso"

Over three thousand identical numbered and certified copies of the original icon of the Mother of God of Perpetual Help were created in Rome in the second half of the 19th century, many of which were brought to Ukraine, including Galicia. One of such icons, an identical numbered certified copy produced on the order in Rome, is in Mostyska. It was painted in 1882 and consecrated by Pope Leo XIII. In 1883 this icon in Mostyska was the object of a special cult [33, p. 287–289]. On September 6, 2001, the icon was re-coronated and consecrated on June 27, 2001 by Pope John Paul II in Lviv, and the Saint Catherine Church was proclaimed as the Sanctuary of the Mother of God of Perpetual Help.

Similar icon was installed in the altar of the Roman Catholic Church of the Mother of God of the Blessed Thunder Candle, and later – in the chapel of the Theological Seminary in Lviv. It was painted by the Roman artist Giovanni Burchardt on December 6, 1900, No. 2396. The icon was consecrated by Pope Leo XIII [22]. Authenticity of this image with the original is confirmed by the inscription in Latin on the reverse side of the icon [22]. On September 26, 1999, this icon was returned to the chapel of the Higher Theological Seminary of Lviv Archdiocese (Lviv-Bryukhovychi) [33, p. 233–235]. On June 26, 2001, Pope John Paul II prayed before the icon in Lviv [22].

Copies of the certified icons are installed in Roman Catholic churches: in the Convent of Discalced Carmelite Sisters in the Church of the Mother of God of Perpetual Help and Saint Joseph in Lviv (painted with tempera paints on wood in Rome as a «certified copy» No. 713 of the archetype in the local church of the Redemptorists. The icon was supplied with the appropriate certificate on the reverse side dated November 15, 1880, signed by Father Mikolaj Mauron, General of the Redemptorists, consecrated by Pope Leo XIII [29, p. 147]. Now it is installed in the church of Carmelite Sisters in the Polish city of Kalisz [29, p. 138]; in the church of the same name in Levandivka, in the main altar [8, p. 219–221]; in the chapel of the same name in Zboyisky, 1932–1933 [10, p. 146]. It was consecrated by Archbishop Boleslaw Twardowski on October 20, 1935 (today, the altar of this church contains the icon painted with oil paints on wood by Sister Dominika Sobolewska of Krakow. On June 26, 2001, it was consecrated by Pope John Paul II in Lviv); in Saint Bartholomew Church in Drohobych (painted on wood with tempera colors, 52.5 × 42.5 cm, has a golden background and engraving on the nimbi. Its authenticity with the original is confirmed by the certificate signed by Father Matthius Raus, the superior general of the Redemptorists, on June 15, 1908 No. 3296. The author – Giovanni Burchard).

Also copies of this icon are also found in the Roman Catholic churches: the Cathedral Church of the Assumption of the Blessed Virgin Mary in Lviv [10, p. 154] (painted on wood with tempera and oil paints, has a gold-plated background and the engraved ornament in the form of uniform of even rays emerging from the central part of the nimbus around the head of the Mother of God. The sizes are close to the original Roman icon, approximately 50 × 40 cm); in the Church of the Mother of God of Perpetual Help in Bilky Koroliwski (now Nyzhnya Bilka (now Lower Squirrel), now in Walaw, near Przemysl (the icon is painted on metal with oil paints and set in the gold-plated frame); in Saint Stanislaw's Church in Zalishchyky; in the Church of the Assumption of the Blessed Virgin Mary in Zolochiv; in the Ave Maria Church in Ivano-Frankivsk (consecrated by Pope Pius X in 1946), now in the Church of the Assumption of the Blessed Virgin Mary in Polanica Zdroju in Poland; in the Church of the Immaculate Conception of the Blessed Virgin Mary and Saints Andrew and Stanislaw in Ivano-Frankivsk, now at the Church of Saint Mauritius in Wroclaw; in the Church of the Nativity of the Blessed Virgin Mary in Stryi (painted on wood with tempera paints, with gold-plated background and engraving, as well as golden crowns on the head of the Blessed Virgin and Child Jesus, 60 × 46 cm); in the Church of the Mother of God of Perpetual Help in Ternopil (painted in tempera-oil technique on cedar tree wood, has the certificate of authenticity and No. 2485. This icon was brought from France by the Sisters of the Congregation of St. Joseph in 1904. The author – Giovanni Burkhard, Rome 1901); in the Church of the Assumption of the Blessed Virgin Mary in Truskavets (painted on metal with oil paints, 55 × 40 cm. The second icon, placed in the sanctuary (executed on wood with tempera paints and covered with oil varnish, 40 × 30 cm); in the churches of: Immaculate Conception of the Virgin Mary in Lopatyn; Mother of God of Perpetual Help in Shybalyn; Saint Apostles Peter and Paul in Yavoriv; Exaltation of the Holy Cross in Berezdivtsi; Birth of St. John the Baptist in Lypnyky; Holy Trinity in Medenychi; The Mother of God of Perpetual Help in the village Sokoliv; Saint Nicholas in the village Pnikut of Mostyska district, Lviv region; Decapitation of St. John the Baptist in Sambir; the Mother of God of Perpetual Help in Trybukhivtsi; The Assumption of the Blessed Virgin Mary in Turka; single-nave church of Saint Joseph in Tshchents built in Neo-Gothic style in 1924-1928; chapel in the village Ushnya in Zolochiv district of Lviv region; in Boryslav, Truskavets (painted on metal with oil paints); church of St. Michael the Archangel in Malekhiv (painted in 2008 with egg tempera on the oak tree wood (99 × 78 cm), gold-plated background with gold leaf, the nimbi carved with engraved floral ornament. The icon has an oval form, and its feature is a decorative framing carved in the same wood. In this frame is painted the cross motif that forms a compositional unity with a painted image. The authors of this icon are Lviv artists Lev and Andriy Demianchuks, father and son (Leo did the carving an, Andriy did icon painting).

Copies of this icon are found in the Greek Catholic churches of: St. Anne (painted with oil paints on canvas in the second half of the 19th – early 20th centuries. On the reverse side of the icon there is the certificate, attested on February 22, 1932 with the signature of the General Superior of the of the Comgregation of the Most Holy Redeemer Patrick Murray and blessing of Pope Pius XI [45, p. 31–33]; in the Church of the Nativity of the Blessed Virgin Mary in Lviv-Sikhiv (painted with egg tempera on the oak tree wood. The background is gilded with gold leaf, and the nimbi are carved and engraved with floral ornament of the lily flowers motif. Pope John Paul II consecrated it during his visit to Lviv. the authors – Lev and Andriy Demianchuks), in the Church of the Entry of the Mother of God into the Temple, Lviv-Sikhiv (painted in 2008 with egg tempera on the oak tree wood, dimension 87 x 74.5 cm. The background is gilded with gold leaf, and the nimbi are carved and engraved with floral ornament. The painting has a decorative framing. The authors are Lev and Andriy Demianchuks); in the Church of the Holy Priest Martyr Yosafat: one is set in the main altar, the other a separate stand under glass. In the early 1920's, this icon was given to the Redemptorists of the Eastern Rite in Ukraine. It was damaged by bullets during World War II [52]; in the chapel of the monastery of St. Alfonso, in Lviv-Holosko (painted with tempera paints on wood, has gilded nimbi around the head of the Mother of God and the Child Jesus, the author – Redemptorist brother Lev Stefanovych); in the chapel of St. Panteleimon in the village Bohorodchany, Stryi deanery (painted with oil paints); in the Church of the Mother of Perpetual Help in Ivano-Frankivsk; in the Church of St. Peter and Paul in the town of Novoyavorivsk (painted with egg tempera on the oak tree wood, 2009). The background is gilded with gold leaf and the nimbi are carved and engraved with floral ornament. In the lower part of this icon there isset the coat of arms of the Congregation of the Fathers

Redemptorists. The autors – Lev and Andriy Demianchuks); in the Church of the Nativity of the Blessed Virgin Mary in the village Solonka (painted with oil paints on canvas, 120 × 90 cm. The author – M. Chizhevych, 2000; in the church and monastery under the same name (Danyla Halytskoho boulevard, Ternopil, 55 × 45 cm, without frame (the author – Petro Rak; 1966); in the Church of the Mother of God of Perpetual Help, Lviv: a large icon, set in the main altar of the church, executed in the technique of relief carving technique and painted in tones of the original icon, and an icon on the tetrapod in a carved frame-mounting (painted with tempera paints based on egg emulsion, on the oak tree wood, has a gilded background and the engraved ornament. The autors – Lev and Andrii Demianchuks; in the Church of the Transfiguration of Our Lord in Lviv; in Romanove Selo of Zbarazh district, in the monastery of the Fathers Redemptorists of Saint Alphonso. The author – Father Orest Kozak, Studite, 2015); in the Church of the Immaculate Conception in the monastery of the Fathers of Redemptorists of Saint Clement; in the church of Saint Joseph the Betrothed (painted with oil paints on pine tree boards in the post-war period, 145 × 85 cm, has a gilded background with the carved floral ornamental motifs). In the Ukrainian Autocephalous Orthodox Church: in the Cathedral of the Assumption of the Blessed Virgin in Lviv; in Romanove Selo of Zbarazh district and in the Church of Saint Volodymyr of the Ukrainian Autocephalous Orthodox in the town of Nadvirna, Ivano-Frankivsk region, etc.

6. Icon painting technology

The ancient painting techniques used scientific knowledge and experience of the best masters, passed on from generation to generation. This knowledge created a solid theoretical and practical basis for the icon-painting technology, and the well-preserved works of the past centuries confirm this convincingly [14, p. 17]. The icon-painting uses the ancient technique based on egg emulsion. This is a unique phenomenon in which bonding takes place of the molecules of water and flax-seed oil with the aid of the egg yolk with formation of the emulsion. Pigments are added to this emulsion thus producing the egg-tempera paints. Painting is made applying the washing techniques when thin layers of paint are applied to the icon, as applying thick layers leads to the formation of cracks. This technique was widely used in the 13th century, and the icon-painters used earth pigments, supplementing the array of colors with new elements and discovering new properties of the already existing. The three main colors should be considered as the principal colors: red, blue and yellow. Mixing these colors produces purple, orange, green colors. In painting technology, this method of applying paint on the paint is called "scumbling". The technology of types of painting was described in detail by professor of St. Petersburg Academy of Arts Dmitro Kiplik in hise book "Technique of painting" [24, p. 131].

The professional approach to the creation of icons was elaborated by Lviv masters Lev and Andriy Demianchuks on the basis of many years of experience. This approach is based on the knowledge of technology of the ancient and modern icon-painting using the ancient egg-tempera technique. In particular, this is the case with the icons of the Mother of God «Salus Populi Romani" (Figure 1) and "Madonna del Perpetuo Soccorso" (Figure 2) [49, p. 167–168, 245–254; 480].

Figure 1. Icon of the Mother of God "Salus Populi Romani", Lev and Andrii Demianchuks, 2007

Figure 2. Icon of the Mother of God "Madonna del Perpetuo Soccorso", Church of St. Michael the Archangel in Malekhiv, 2008 p. (99 × 78 см.), Lev and Andrii Demianchuks

The process of creation of these icons has its own peculiarities, but in general it is similar to the process of creation of other icons. The icon has a certain a number of consecutive layers. The first layer (the base of the icon) is a solid wooden board, preferably some hardwood; the second layer – linen canvas glued to the board; the third layer – primer, levkas, prepared with powder chalk, glue and oil varnish, onto which the drawing was transferred; the fourth layer – several layers of alcohol varnish and polishing, carving of the nimbi and the background of the icon; the fifth layer – several layers of oil varnish and the gilding process; the sixth layer – icon painting using natural colors – pigments prepared on natural egg emulsion; the seventh layer – flax-seed oil varnish or lacquering, that protects the icon from external impacts. Thus, the entire work on the icon was divided into a series of sequential actions: selection and primary treatment of wood; woodworking; carving the frame of the icon; frame lacquering; canvas gluing; coating with levkas; creation and transfer of the drawing; application of alcohol varnish and polishing; carving of the nimbi and the background of the icon; application of alcohol varnish and polishing; application of oil varnish; preliminary washing; gilding the icon; painting with egg tempera based on pigments; fixation with varnish.

7. Conclusions

Based on the review of scientific works of the national and foreign scientists, a critical analysis has been made of the materials covering information about the history of origin, iconography, stylistics and artistic particulars of the icons of the Mother of God "Salus Populi Romani" and "Madonna del Perpetuo Soccorso" and their copies in Ukraine in 17th – 21st centuries.

As a part of the research, copies of the icon of the Mother of God "Salus Populi Romani" in Ukraine have been studied: "Consolation" in Lviv, "Berdychivska", "Letychivska", "Kochavinska", "Berezhanska" and others, as well as the numbered certified Roman copies of the miracle-working icon "Madonna del Perpetuo Soccorso": in Mostyska, Lviv, Ivano-Frankivsk, Drohobych and other cities of Galicia.

It has been established that the iconographic type of the Roman icons of the Mother of God is descends from Hodigitria (She who points the Way), but it has distinctive peculiarities. Their copies became widespread throughout the world over the centuries, particularly in the European and Ukrainian homes and churches. The iconography and artistic stylistics of these icons have a distinct Oriental origin, but they also show rather noticeable influence of the Western painting, particularly, of the Italian masters of the Proto-Renaissance.

Analyzing the ancient methods and techniques of depiction of the Roman copies of the icon of the Mother of God, it will be fair to say that the best and the most advantageous are the techniques using the ancient egg-tempera emulsion.

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LUMINOUS PICTURES AS A FORM OF THE CONTEMPORARY VISUAL ART

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Abstract. The article analyses luminous pictures as a form of contemporary visual art. The emergence of light sources (LEDs) with a fundamentally new way of generating luminous flux has directly influenced not only the theory and practice of functional and decorative lighting, but also visual arts, extending their expressive capabilities. Today, the introduction of LEDs has brought artificial lighting beyond the need of energy saving, creating necessary conditions for widespread use of light not only for utilitarian purposes, but also as a powerful tool of influencing the aesthetics of the environment. Therefore, the analysis of modern forms of using light as an artistic tool will help to reveal the peculiarities of the obtained aesthetic consequences which are the result of increased expressiveness of the image. The aforementioned aspects have actualized the study of luminous pictures as a form of contemporary visual art in order to identify the technological features of their construction and to classify the main visual techniques for creating the pictorial component of such works. Taking into account gaining the most adequate impression of the light environment and light objects is possible in the immediate environment, in the framework of the study the author created a series of works (luminous pictures) in order to exper-imentally outline the peculiarities of visual aesthetics of the result of the application of various artistic techniques in combination with interior lighting. The technology of indoor LED lighting has been used for the production of luminous pictures. This was determined by the following specific features of its use: invisibility of light sources for user's direct visual perception, which promotes the interpretation of illumination as an integral component of the picture image; uniform scattering of light by the surface used for drawing the image. In the course of the study a number of scholarly problems have been solved. The place of luminous pictures in the framework of

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the main classification vectors of contemporary visual arts has been defined. Accordingly, it has been established that luminous pictures belong to the spatial and temporal visual arts, and such visual arts as painting, graphics, collage and various types of reliefs form the basis of luminous pictures. Depending on the spatial form of the embodiment, luminous pictures can be planar or embossed. Besides, the conceptual grounds for the study of light paintings have been defined, namely, the concept of a layer-by-layer perception of light envelopes of various qualities and different light transmittance, which, when using the internal illumination of an image formed with several layers of light-scattering and translucent sheet-plastic, can become the basis for the creation of multi-layer luminous objects. The author has elaborated several variants of design of luminous pictures with such technological features as: the case which consists of back and front parts, and the front part, from the aesthetic point of view, performs the function of the passe partout for the picture; LEDs are used as light sources that can be located either around the perimeter or across the entire back panel; the inner surface of the case must be white in order to ensure uniform lighting; the power supply unit is located mainly at the bottom of the structure. As a result, these design proposals are registered as a utility model patent PU 135975. The series of copyrighted works experimentally established, classified and characterized the basic visual techniques of creating a depictive component of different types of luminous pictures, e.g. painting in combination with lighting, black-and-white graphics combined with lighting, multilayered pictures combined with lighting. Further re-searches in this direction should focus on determining the compositional and imaginative features of integrating luminous pictures into interior design, as well as exploring their aesthetic consistency with other components of the interior.

1. Introduction

A peculiar illustration of the emotional impact that the combination of light and image can produce to the viewer may be the description of Salvador Dali's childhood impression of his autobiographical work: "…It was a kind of optical theatre, which provided me with the greatest measure of illusion. I have never been able to determine or reconstruct in my mind exactly what it was like… one saw everything as if at the bottom of and through a very limpid and stereoscopic water… The pictures themselves were edged and dotted with colored holes lighted from behind and were transformed one into another in an incomprehensible way that could be compared only to the metamorphoses of the so-called ‘hypnagogic’ images which appear to us in the state of ‘half-slumber’” [4, p. 34–35].

If we turn to the question of the importance of exploring the expressive abilities of light and its influence on the development of contemporary art, according to I.O. Kuznetsova [12, p. 143–144]: “the art of Modern and Contemporary periods solves the problems of depicting time and light”. Alongside, M.I. Yakovlev, describing a series of experiments related to the visual perception of compositional elements and their consistency, mentions the nature of illumination as the first of the given conditions [19, p. 94, 95, 97]. Therefore, the study of modern forms of the use of light as an artistic tool which is used to enhance the expressiveness of the image, will help to identify the peculiarities of the gained aesthetic consequences.

One of the hallmarks of contemporary art is the application of categories of novelty and topicality as criteria for evaluating the importance of works. They are applied in relation to the imagery and topic of the work, as well as to the artistic technique. This fact brings the artists' creative experiments closer to the experimental methods of scientific cognition. Thus, the emergence of light sources (LEDs) with a fundamentally new way of generating luminous flux influences not only the theory and practice of functional and decorative lighting of the environment, but also has direct impact on the visual art, expanding its expressive capabilities.

The aforementioned aspects **actualize** the study of luminous pictures as a form of contemporary visual art with the **aim** of identification of the technological features of their construction and classification of the basic visual techniques of creating the pictorial component of such works. To achieve this goal, it is necessary to solve the following **research problems**: to determine the place of luminous pictures and conceptual bases of their research within the contemporary visual arts, to develop a design of luminous pictures and to create a series of luminous pictures using various visual techniques for the experimental determination of visual result variants.

Today, the introduction of the most energy-efficient LED light sources [18] has brought artificial lighting beyond the limits of energy saving, creating the right conditions for widespread use of light not only in utilitarian purposes but also as a powerful means of influencing the aesthetics of the environment. Therefore, taking into account such advantages of LEDs as miniature sizes, safe operating voltage (12 V) and the purity of the color of radiation, they are used as light sources for the illumination of luminous pictures.

Previously, depending on the technological features of the installation, the author identified such types of LED lighting as “indoor”, “exterior” and “hidden” [9, p. 45]. For the production of luminous pictures, the technology of indoor LED illumination is used, due to its following peculiarities: invisibility of light sources for direct visual perception by the user, which promotes the interpretation of illumination as an integral component of the picture; uniform scattering of light by the surface used for drawing the image.

Basing on the fact that obtaining the most adequate impression of the light environment and light objects is possible in the immediate environment, within the study, the author created a number of works (light frames) for the experimental establishment of visual features of the aesthetic result. the use of various fine art techniques in combination with indoor lighting. One part of the luminous pictures (Pics. 1, 5-7), given as examples, was first exhibited in 2016 at the personal exhibition “Touch of Light” and published in the author's catalogue [10], the other (Figure 8-11). is published for the first time.

At the present stage of light design development, its main characteristic is focusing on the qualitative values of lighting. Light design, having combined existing ideas in the fields of psychology of perception and stage lighting, is no longer limited to purely quantitative aspects [6, p. 13–23]. For instance, in the theater, the issues of lighting levels and lighting uniformity are not of great importance, and providing the conditions for the visibility of the stage or any technical equipment is not primary purpose of lighting. Its main purpose is to create illusions and to form different perception of subjects and moods, time of day, changes in the weather, by means of light. Therefore, stage lighting served as an example for determining methods and tools for creating decorative light effects of architectural lighting [17, p. 24]. Accordingly, the basic technological techniques and specific aspects of stage lighting, as described by V.S. Barkov [3], were employed as the basis for the creation of a technique for combining images with lighting within some types of luminous pictures.

2. The place of luminous pictures in the paradigm of the contemporary visual arts

The study of luminous pictures as a form of contemporary visual art requires, first of all, determining their place among the main classification areas of contemporary visual arts. To denote the entire set of arts, within which luminous pictures should be classified, the cultural concept of "visual arts" has been employed [15, p. 36–38]. Such arts use artistic organization of visual perception as sign material.

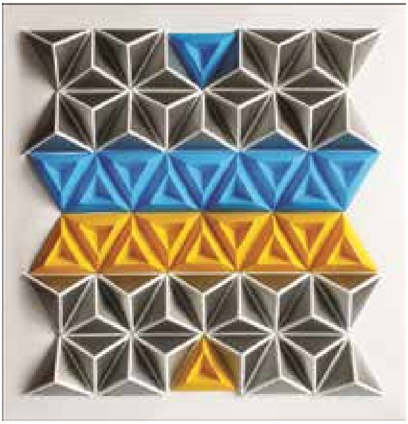
Modern variants of the species division of the visual arts complement each other, so the performed analysis is based on several classifications. Its basis was the most popular typology in the field of art, grounded on the space-time principle. Analyzing the material existence of the art form according to this principle, they distinguish between the spatial arts (construct their images in space, without changing or developing in time), temporal (images are developed in time, not in real space) and spatial and temporal or synthetic (their images have both length and duration, materiality and dynamism) [1, p. 347–350]. Luminous pictures belong to the spatial and temporal arts. This is determined by the material form of luminous pictures embodiment, which determines their perception in space, and by the dynamics of interior illumination, owing to which this perception changes over time. Static illuminated luminous pictures are also spatial and temporal, as they have two states: with inner illumination on they are visually perceived as a light object; with inner illumination off they are perceived as a usual picture.

Having tangible form and created for perception in the real space, all kinds of fine arts are spatial, in particular, painting, graphics, collage and various types of reliefs that make up the pictorial basis of light paintings. Images in the visual arts are created on a plane (the image is produced on a flat surface) or in space (the image has a certain volume or occupies a certain volume) [8, p. 176–179]. Therefore, depending on the spatial form of the embodiment, luminous pictures can be either planar (Figure 5-11) or relief (Figure 1).

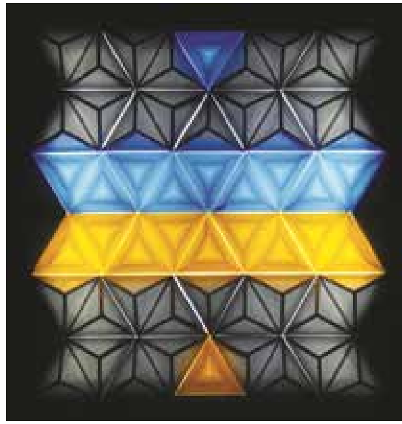
The scheme in Figure 2 shows a graphical generalization of a particular place of luminous pictures within the framework of the main classification directions of contemporary visual arts.

3. Conceptual base of the research

The idea of light is formed at crossroads of scientific, religious, philosophical and aesthetic vectors of knowledge [14, p. 3]. Taking into account that the religious and mystical beliefs can be considered as the expression of stable stereotypes of human thinking [2, p. 11], the interpretation of the notion of light contained in religious legends and myths can be used as



a)



b)

Figure 1. An example of the author's relief luminous picture: a) with inner illumination off; b) with inner illumination on

a basis for creating the concept of luminous picture as an artistic form. For this purpose, "The Zohar" (splendor [2, pp. 148–149]), the most filled with symbolism of the light among othr religious and mystical books, was selected among the texts known from the course of religious studies.

Comments on this book are almost entirely based on explanations of the various levels of cognition of the Creator's light. The universe is described as divided into a number of components of spiritual objects (Partzufim and Sephirot) [13, p. 289] which, by a certain hierarchy, form concentric coats around the Creator. The light emitted by the Creator is a colorless substance, which is impossible to be perceived by a human. Only passing through the Sephirot as through the filters, Creator's light can be perceived by people in a certain color and intensity, which depend on soul level of the subject perceiving this light [13, p. 170–171].

The transfer of the above mentioned concept of the spiritual essence of light into the plane of artistic design underlies the concept of layered perception of light shells of different qualities and different light transmittance. It can become the basis for the development of modern understanding of both light space and light objects, being employed similarly to the option of modeling a computer image using independent layers

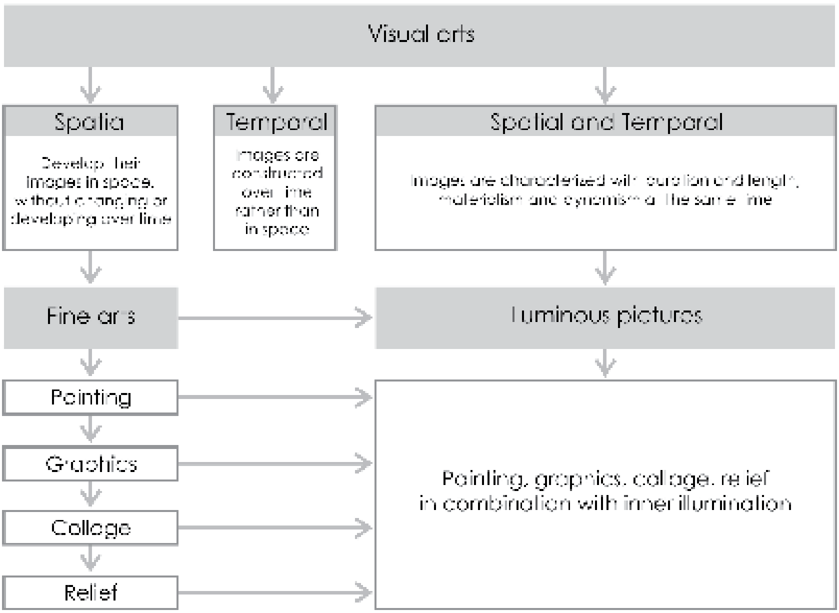


Figure 2. The place of luminous pictures within the framework of the main classification directions of contemporary visual arts

which is inherent in modern graphics editors (Adobe Photoshop, Adobe Illustrator, CorelDRAW). In computer graphics, each of these layers can be adjusted and modified, given a degree of transparency, combined differently with one another. In many ways, this is due to the fact that the computer screen is a light object and the layers of the computer image are virtual. At the material level, the described concept can be embodied in luminous pictures, since the use of inner illumination of an image formed with several layers of sheet plastic of different light transmittance allows to create complex multilayer light objects.

4. Design and technology solution of luminous pictures

Grounding on the above mentioned concepts, several design variants of luminous pictures have been elaborated. As a result, these project proposals are registered as a utility model patent PU 135975 [11].

Picture 3 demonstrates one of the variants of the luminous picture construction [11, p. 5], that consists of the case (1), which houses the image (2), the light source (3), the control system (4), the power supply (5). The case is made of two parts: the rear (6) and the front (7). The front part (7) consists of a layer of non-translucent material with cutouts (8) and is connected to the rear part (6) with a frame (9). The rear (6) consists of a box (11) and a cover (12) that are bolted together (13). The image (2) is flat, it consists of several parts and is made with application. LEDs located around the perimeter of the back of the case (6) are used as light sources (3). The power supply unit (5) is connected to the standard power supply using a standard connector (10).

Besides, the ratio of the thickness of the luminous picture case to the height and length of its front and rear parts are chosen so that the picture is visually perceived as planar (flat). The front part of the case is made of a layer of non-translucent material with a cutout, which, from an aesthetic point of view, performs the function of a passe partout to the image of the picture and can be a component of the entire composition. The utilitarian function of the layer of non-translucent material in the case front is to ensure the uniformity of the illumination of the image by masking luminance difference that can be observed on those areas of the image which are close to near light sources provided that LEDs are placed around the perimeter of the structure. Assembling of the front and rear of the case can be done either with a frame or with glue.

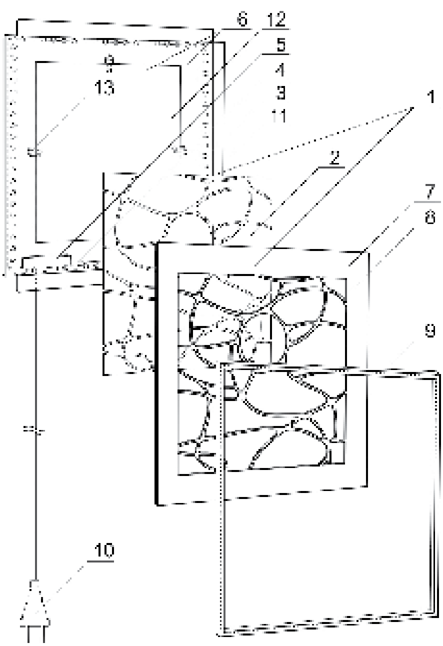


Figure 3. An example of a luminous picture, designed by the author

An image of the light picture may consist of separate thin layers of light-scattering or translucent plastic, and its front may be either flat or embossed, as well as either single-piece, or parted. The image is created by means of paints, applications from light-scattering and translucent films or plastic, and collage. Luminous pictures are integrated into environment similar to conventional paintings, being hung on the wall, or embedded in the surface of enclosing structures of the room.

The number of light sources for installation should correspond to the artistic design. Color range, statics or dynamics, rhythm and rate of change of inner illumination are determined by the general composition of the picture and are coordinated with the subject matter and mood of the image. LEDs can be positioned either around the perimeter or throughout the case rear. Luminous pictures in Figure 1, 5-11 have perimeter option of LEDs layout. The inner surface of the case must be white for better light diffusion and uniformity of illumination. The power supply unit is preferably located at the bottom of the structure.

Figure 1, 5-11 present the author's rectangular-shaped luminous pictures as examples. However, luminous pictures cases, and, accordingly, the image format, can be of any simple geometric shape. In Picture 4 several variants of luminous pictures of different case shape (1) and the format of the image (2), according to [11, p. 8], are demonstrated. In this case, several luminous pictures can be combined into a single structure circuit (15), with a common connection to the power supply (16).

5. Painting combined with lighting

In the early XX century, V.V. Kandinsky, comparing music to painting, specified that music had time as an element of duration, but painting, being deprived of this means, can bring the whole content of a work to the viewer's consciousness at any moment [7, p. 32]. Today, it can be stated that, in addition to the benefits of painting outlined by Kandinsky, this kind of art has obtained time as an expressive means. With the help of a predefined dynamic interior lighting scenario, one can reproduce a number of possible color choices of any static image in one picture. Consequently, modern technological opportunities allow to combine a series of paintings with changes of color relations between elements of a composition within a single work.

The interpretation of light is one of the fundamental problems of the fine arts [14, p. 4]. However, light theory is especially significant in the work of the Impressionists, whose dominant purpose was to reflect changes in the

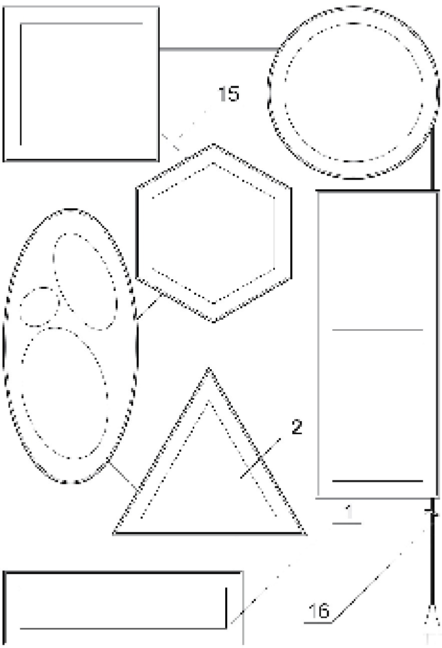


Figure 4. Possible variants of shapes for luminous pictures cases

visual perception of the environment through the inherent dynamics of natural light.

Daylight is constantly changing depending on the state of the atmosphere surrounding the Earth, the seasons, the time of day [3, p. 48]. Claude Monet's fascination with the transmission of the air environment became the basis for the creation of "a new picturesque language and a unique method of working in series [16, p. 131]". In particular, his series of works, in which the same motif is represented at different times of the day, in different seasons or at different weather include *Poplars* (1890-1892) [5, p. 16] and *Rouen Cathedral* (1892-1893). While working on the *Poplars* series, it took Monet about seven minutes to complete each painting, before the lighting changed. Working on a series of *Rouen Cathedral*, which included about 30 paintings, the artist made at least 14 sketches a day, trying to capture the nuances of lighting, characteristic of a very short period of time [16, p. 82–90].

At present, the goal that required Monet to create numerous pictures of an object at different times and in different lighting conditions can be achieved in a single work by combining painting with dynamic interior lighting using white and RGB LEDs. As V.V. Kandinsky wrote in one of his theoretical works, "Ultimately, we come to join potentials of different kinds of art [7, p. 32–33]", and a successive development, change and movement of light brings it closer to music [3, p. 5].

When painting with oil paints, artists widely use white pigment in order to obtain different saturation of tints. The ratio of white pigment to the main spectral color characterizes its saturation. Exactly the same results are achieved by adding white light to color illumination. By adding red, green and blue (RGB) rays, adjusting the luminous flux from zero to apparent power, one can derive not only all the colors of the spectrum, but also purple shades, such as those obtained by mixing blue and red lighting. The main task of color lighting is to enrich the palette of the artist, so all the main color ratios of light rays must be consistent with the entire design of a particular painting. Light and painting should complement each other [3, p. 46–52].

In case of using white light with color temperature of 3000-5000 K in combination with RGB for inner illumination of the picture, turning on only white light produces the color ratios of the image elements characteristic of normal daylight. Turning on additional RGB lighting in different proportions of its components (red, green, blue) changes the color of the picture, affecting the color ratios of the image elements, much like changing the color temperature of natural lighting in the morning, evening or night affects the color ratio of real objects.

Picture 5 is an example of the author's luminous picture made with the use of white and RGB inner illumination.

Stained glass paints are most suitable for creating luminous pictures owing to their transparency and broad color palette. Separate colors are quite easy to mix with each other, forming new shades. Applying stained-glass paints on the white scattering surface forms an image that, under normal general lighting, without inner illumination, is perceived as a con-

a) b)

Figure 5. Author's luminous picture "Whole personality" with: a) white inner illumination; b) white inner illumination with RGB rays in different proportions

ventional picture. The texture of brushstrokes combines the characteristic properties of the texture of watercolor and oil paints ones: transparency and saturation of watercolor and voluminosity which is inherent in oil paints strokes. However, stained-glass paints strokes have clear boundaries and do not mix smoothly, as in watercolor, and the tonal nuance is achieved not by bleaching, as in oil-painting, but by increasing the level of paint transparency. Therefore, pointillism is the most appropriate when forming images with complex tonal renditions for making voluminous effect, as well as for creating realistic images.

As a technique of painting, pointillism was first used by Seurat. His experiments with split point strokes of contrasting colors resulted into creation of this new pictorial method [16, p. 73]. From 1884, Seurat and Signac began to jointly develop the theory of "divisionalism". Modern scholars use the term "divisionalism" for theory, and "pointillism" for technique" [5, p. 26–27].

A separate direction in the creation of luminous pictures is the combination of conventional painting within the same color range with white and monochromatic lighting. With this approach, the white-lighted picture shows all the available color shades. Due to the gradual dynamics of adding monochromatic illumination to white, these nuances are generalized to a single up-going color, which shows maximum saturation when the white light is finally switched off and only monochromatic (monochrome) is turned on. In Picture 6 examples of author's luminous pictures of this type are demonstrated.

6. Black-and-white graphics in combination with illumination

Coating plastic with black, non-translucent paint in combination with interior lighting, you can create silhouette graphic works of high emotional expressiveness. At the same time, the color gamut of lighting and the dynamics of color change is chosen according to the topical and semantic charge of the image in order to enhance its emotional impact on the perceived subject. An example of the author's luminous picture of this type is shown in Figure 7.

A separate technique for such luminous pictures is application of the image on two or more layers of sheet plastic of different light transmittance. In this case, a black and white graphic image, which is visible when the inner illumination is off, is applied to the outer layer of white light-scattering plastic. The inner layer of translucent plastic contains a color image

а)

б)

Figure 6. Examples of the author's luminous pictures made with the use of white inner illumination in combination with that of one of the basic colors: a) "Greenness"; b) "Redness"

that becomes visible only when the inner illumination is on. The color of the light can be either white (Figure 8-9) or white in combination with RGB (for a possible change in color). Figure 8-9 is an example of the author's luminous picture with the above described properties.

7. Multilayered pictures combined with illumination

Turning to the practice of creating decorative effects in stage lighting [3, p. 89, 97], it is possible to single out an interesting technique of illumination with the scattered light behind the curtain with a multilayered application of paper or thin fabric, which allows to create soft transitions of shadows and half shadows of different density and transparency. Similar to this technique, the use of applications with many layers of the same or different light transmittance to create an image in luminous pictures,

Figure 7. Author's luminous picture "A Flower" with: a) inner illumination off; b-g) several intermediate stages of dynamic inner illumination

provides numerous opportunities for using the best effects of the composition elements. Such luminous pictures may have different variants of embodiment: luminous pictures made with several layers of white light-scattering plastic; luminous pictures composed of several outer layers of white light-diffusing plastic in combination with the inner layers of translucent plastic of other colors, which become visible only when the inner illumination is switched on.

a)

b)

Figure 8. The author’s luminous picture “Apples” with:
a) inner illumination off; b) inner illumination on

Picture 10 presents variants of the author's luminous pictures, where the image was created by means of applying many layers of white light-scattering plastic 0.3 mm thick. As seen in Figure 10a, when the inner illumination is off, such an image looks as a white superficial relief. Tonal gradations become articulated only when the inner illumination of the picture is switched on (Figure 10b).

The higher the luminous flux of inner illumination is, the bigger number of tone gradations can be used to create the image. The above examples contain on average about 10 tonal gradations, which are sufficient for graphical processing of both the shape of simple geometric figures and for the tonal nuancing of a portrait (Figure 10c).

Ornamental compositions make a separate direction of luminous pictures of this type. Figure 11 demonstrates an example of the author’s luminous picture from the series “Nanoembroidery” which employs an ornamental motif of the Ukrainian cross stitch. Such luminous embroidery can have various embodiments: pictures that look like an embroidery pattern when the illumination is off, and the ornament that imitates embroidery appears when the illumination is on; pictures with visible ornamental on or off; in both variants, the color may change when using white lighting in combination with RGB light.


a)


b)

Figure 9. The author's luminous picture "Chrysanthemums" with: a) inner il-lumination off; b) inner illumination on

8. Conclusions

Summing up, in the process of studying luminous pictures as a form of contemporary visual art, the following research problems have been solved:

1. The place of luminous pictures within the classification paradigm of modern visual arts has been determined. Accordingly, it is established that luminous pictures belong to the spatial and temporal visual arts, and such visual arts as painting, graphics, collage and various types of reliefs form their figurative basis. Depending on the spatial form of the embodiment, luminous pictures may be planar or embossed.

2. The conceptual bases of luminous pictures studies have been defined, namely the concept of layered perception of light envelopes of different qualities and dif-ferent light transmittance, which when used with inner illumination of the image, formed from several layers of light scattering and light-transparent sheet plastic, can become the basis for creation complex multi-layered light objects.

3. A number of luminous pictures designs has been elaborated. They feature the following: the case consisting of rear and front parts, and the latter,

a)

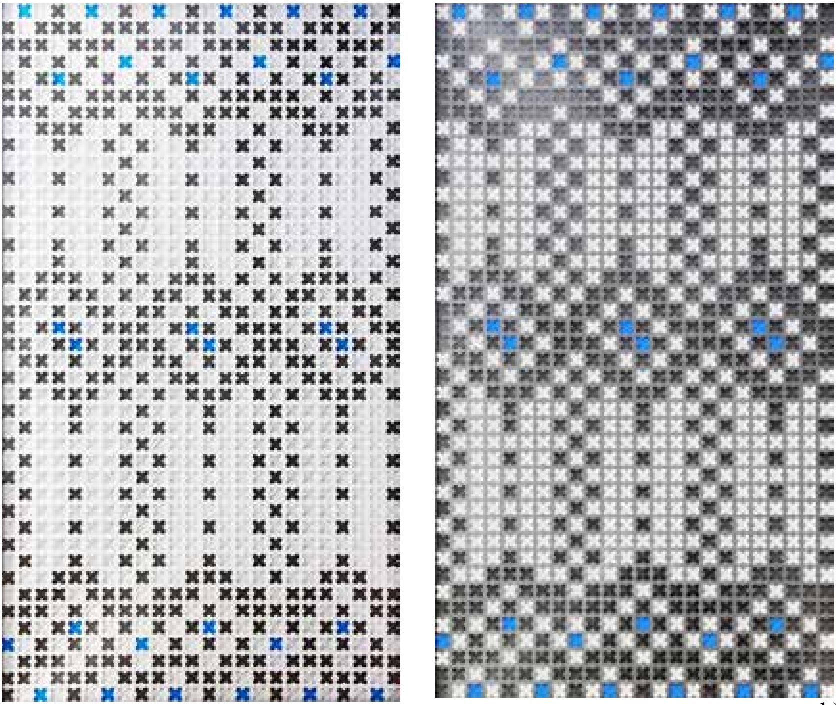
b)

c)

Figure 10. Examples of the author's multilayered luminous pictures created with application technique: a) "Geometric sketch" with inner illumination off; b) "Geometric sketch" with inner illumination on; c) "Self portrait" with inner illumination on

from the aes-thetic point of view, performs the function of the passe partout to the picture; LEDs are used as light sources, which can be located either around the perimeter or throughout the entire rear plane; the inner surface of the case must be white to ensure uniform lighting; the power supply unit is preferably located at the bottom of the structure. As a result, these project proposals are registered in the form of a patent for utility model PU 135975.

4. A series of the author's works has experimentally established, classified and characterized the main visual techniques of creating an image component of different types of luminous pictures, namely: painting in combination with lighting, black and white graphics in combination with lighting, multi-layered paintings combined with lighting.



a) b)

Figure 11. The author's luminous picture "Nanoembroidery № 3" with: a) in-ner illumination off; b) inner illumination on

Further researches in this area should be focused on identifying the compositional and artistic features of integrating luminous pictures into interior design, as well as investigating their aesthetic consistency with other components of the environment.

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