Ministry of Education and Science of Ukraine
Sumy National Agrarian University Faculty of Agricultural Technologies and Environmental Management
Department of Biotechnology and Chemistry

Modern biotechnology of agricultural crops

(compulsory EC)

Specialty H1 Agronomy, 201 Agronomy

Educational program Agronomy

Level of higher education Third (PhD)

Sumy – 2025

Developers: **V.M. Kovalenko, Ph.D. in Agricultural Sciences, Associate Professor**

Approved:
Guarantor of the educational program Andriy MELNYK

1. GENERAL INFORMATION ABOUT THE EDUCATIONAL COMPONENT

<table>
<tr><td>1.</td><td>Name of EC</td><td colspan="4">Modern biotechnology of agricultural crops</td></tr>
<tr><td>2</td><td>Faculty/Department</td><td colspan="4">Agrotechnology and Environmental Management/Biotechnology and Chemistry</td></tr>
<tr><td>3</td><td>Status EC</td><td colspan="4">Mandatory</td></tr>
<tr><td>4</td><td>Program/Specialty (programs) that include EC for (to be filled in for mandatory EC)</td><td colspan="4">ONP H1 Agronomy</td></tr>
<tr><td>5.</td><td>The EC may be proposed for (to be filled in for elective ECs)</td><td colspan="4">-</td></tr>
<tr><td>6.</td><td>Semester and duration of study</td><td colspan="4">3 semesters, 13 weeks</td></tr>
<tr><td>7.</td><td>Number of ECTS credits</td><td colspan="4">3.0</td></tr>
<tr><td rowspan="2">8</td><td rowspan="2">Total number of hours and their distribution</td><td colspan="3">Contact work (classes)</td><td>Independent work</td></tr>
<tr><td>Lectures
20</td><td>Practical /seminars 20</td><td>Laboratory</td><td>50</td></tr>
<tr><td>9.</td><td>Language of instruction</td><td colspan="4">State (Ukrainian)</td></tr>
<tr><td>10.</td><td>Teacher/Coordinator of the educational component</td><td colspan="4">Kovalenko Vladislav Mykolayovych</td></tr>
<tr><td>11.</td><td>Contact</td><td colspan="4">Associate Professor of the Department of Biotechnology and Chemistry, Room 13 c (Faculty of Agrotechnology and Environmental Management),
Teacher profile - https://agro.snau.edu.ua/kafedri/kafedra-biotexnologi%d1%97-ta-fitofarmakologi%d1%97/sklad-kafedri/kovalenko-vladislav-mikolajovich/
<u>Consultations:</u>
in person - every Tuesday from 1:00 p.m. to 2:00 p.m.;
online via Zoom, Viber - every Wednesday from 16.00 to 17.00 e-mail: tovagrarne_bz@ukr.net</td></tr>
<tr><td>11.</td><td>General description of the educational component</td><td colspan="4">The discipline "Modern Biotechnology of Agricultural Crops" develops students' professional imagination and deepens their knowledge of modern approaches and technologies used in plant biotechnology. Particular attention is paid to the biological foundations and principles of creating biotechnological processes in agriculture, including the molecular biological, biochemical, and physiological-biological characteristics of agricultural crops, methods of their genetic and cellular engineering, microclonal propagation, and the creation of varieties with specified properties.
The course is aimed at studying the mechanisms of regulation of growth, development, resistance to biotic and abiotic factors, biosynthesis of secondary metabolites and other valuable biologically active substances in plants. The principles of implementation and adaptation of biotechnological developments in agricultural production are considered, including environmental aspects, product quality assessment in accordance with regulatory documents (DSTU, TU U, and others), as well as the prospects for creating effective and waste-free technologies.
As part of their practical training, students acquire skills in working with modern equipment and methods of biotechnological analysis, master the principles of developing technological schemes for the production of biotechnological products of plant origin, focusing on key stages.
production and quality control.</td></tr>
</table>

12.	Purpose of the educational component	The purpose of studying the discipline "Modern Biotechnology of Agricultural Crops" is to provide students with knowledge about modern principles and methods of creating biotechnological products based on agricultural crops, including the construction of biological objects, the cultivation of plant cells and tissues, and the selection of effective biological agents for obtaining valuable compounds. Particular attention is paid to methods of managing biotechnological processes, product quality control, and the application of innovative approaches in the field of agricultural biotechnology. Students acquire knowledge and practical skills for professional activities in the field of agricultural biotechnology, in particular in research involving the use of modern laboratory equipment to study the properties of cell cultures, tissues, plant metabolites, as well as the application of theoretical knowledge for the implementation of biotechnological processes in the production of high-quality and biologically valuable products.
13.	Prerequisites for studying the course, connection with other educational components of the OP	1. The educational component is based on: methods of conducting scientific research, modern aspects of agriculture. 2. The educational component is the basis for the study of selected educational components: Plants in research, Hybridization, mutagenesis, polyploidy, haploidy in plant breeding, and preparation of a dissertation research
14.	Academic integrity policy of academic integrity	**Academic integrity** at SNAU is regulated by a number of regulatory documents, which are posted on the official website of the higher education institution https://snau.edu.ua/viddil-zabezpechennya-yakosti-osviti/zabezpechennya-yakosti-osviti/akademichna-dobrochesnist/. These documents define academic integrity and contain instructions on the procedure to be followed when a participant in the educational process violates academic integrity. Actions such as plagiarism, impersonation, fraud, fabrication, falsification, self-plagiarism, deception, and biased assessment are considered direct violations of academic integrity and will result in severe penalties: − retaking the assessment (test, exam, credit, etc.); − retaking the course; − warning; − reprimand; − expulsion from the university (Article 48 of the Law of Ukraine "On Education"). **Course policy** Students are advised not to miss classes, to dress appropriately, to complete assignments diligently, and to actively participate in the learning process. In case of absence due to illness, a corresponding certificate must be provided. Missed classes must be made up at a time agreed upon in advance with the instructor. The use of other sources with alternative views on certain issues is encouraged in order to foster productive discussion on the problems of the academic discipline. Compliance with the standards of academic integrity is a mandatory requirement. Higher education students must systematically and consistently master the course material. They must actively participate in

		laboratory and practical classes, participate in discussions and case studies, and fully engage in active forms of learning. To obtain a high rating, the following conditions must be met: – do not miss classes, do not be late; – actively participate in the learning process; – complete educational tasks on time; – comprehend, analyze, and understand the educational material; – not to be distracted by extraneous matters during classes; – respect the opinions of other students; – not use gadgets during classes without the teacher's permission; – pay sufficient attention to independent work; – To earn extra points and improve their grade in a subject, students can participate in scientific conferences, prepare scientific articles, etc. The criteria for assessing knowledge for current control are the success in mastering knowledge and acquired skills in lectures and laboratory and practical classes, which includes the ability of a higher education student to master the categorical apparatus, skills of generalized thinking, the logic and completeness of teaching the educational material, activity in practical classes, level of knowledge based on survey results, independent study of topics as a whole or individual questions. The total number of rating points for studying the educational component for the semester is calculated as the sum of points received based on the results of current and final assessments. The maximum number of points for the semester is 100 points. Individual assignments and written work submitted late without a valid reason are graded lower (15% of the total points for a specific class). The inclusiveness of the educational process for people with special needs is applied taking into account their abilities and needs (distance learning in the Moodle system, etc.).
15.	Keywords	Agricultural biotechnology, genetic modification, GM crops/transgenic plants, recombinant DNA, enhancers, molecular markers.

2. LEARNING OUTCOMES FOR THE EDUCATIONAL COMPONENT AND THEIR RELATIONSHIP TO THE PROGRAMME LEARNING OUTCOMES

Learning outcomes for the EC:	Program learning outcomes that the EC is aimed at achieving (indicate the number according to the numbering given in the OP)				How RND is assessed
	PRN 1	**PRN 3**	**PRN 5**	**PRN 7**	
DRN 1. The applicant is able to analyze regulatory documents (DSTU, TU U, guidelines) and apply them when developing technological documentation for agricultural biotechnology products purpose,	+			+	Multiple choice test and individual assignment. Presentation, report. Short tests (up to 5 minutes). Careful review and analysis of completed assignments Discussion of selected solutions to the problem. Oral presentations, self-assessment, and peer assessment

justifying rational decisions in relevant technological situations.					
DRN 2. The applicant is able to determine the physical chemical properties of organic compounds that are components of plant cells and other biological agents, and use this data to make informed technological decisions.	+	+			Report with presentation. Short tests (up to 5 min). Group work. Careful checking of assignments. Analysis of professional texts or data. Oral presentations, self-assessment, and peer assessment.
DRN 3. The applicant is able to evaluate the composition and structure of biological agent cells in order to determine optimal conditions for their cultivation and effective use in biotechnological processes.		+	+		Multiple choice test. Presentation, report. Short tests. Group work. Defense of practical work. Observation of applicants. Discussion of selected solutions.
DRN 4. The applicant is able to use knowledge about the properties of biomolecules (proteins, nucleic acids, carbohydrates, lipids) in the technological design of biotechnological processes and product quality control.		+		+	Multiple-choice test and individual assignment. Presentation, report (+ mutual assessment + self-assessment). Short tests (up to 5 minutes). Collaboration among students in a group and ability to work with focus. Careful checking and analysis of completed tasks. Defense of practical work. Discussion of selected ways to solve the problem. Mastering skills and abilities through observation. Observation of applicants in the process of performing tasks
DRN 5. The applicant is able to perform a technical and economic analysis of the feasibility of producing biotechnological products, taking into account market needs, regulatory requirements, and technological resources.	+			+	Multiple choice test. Presentation, report. Short tests. Group work. Careful checking of assignments. Individual conversations. Self-assessment, peer assessment Observation during activities

DRN 6. The applicant is able to combine knowledge of cell biology, the physical and chemical properties of organic compounds, and technical documentation standards documentation to develop effective and safe biotechnological solutions in plant growing.	+	+	+		Multiple multiple selection. Presentation, report. Short tests. Group cooperation. Individual conversations. Defense of practical work. Discussion of solutions. Observation during the task completion process

3. CONTENTS OF THE EDUCATIONAL COMPONENT (ACADEMIC DISCIPLINE PROGRAM)

Topic. List of issues to be covered within the topic	Distribution within the overall budget Time				Recommended reading
	Classroom work			Independent work	
	Lk	Pz	Lab		
	day	day	day	day	
Module 1. Modern biotechnology in agriculture					
Topic 1. Introduction to agricultural biotechnology What is biotechnology and how does it used in agriculture? The main directions of development of modern agrobiotechnology: traditional and molecular approaches	2	2		5	1-20 electronic resources, additional sources, and software
Topic 2. Traditional breeding and its place in modern plant growing History of conventional breeding: methods and achievements Limitations of traditional breeding methods and the need for new technologies.	2	2		5	1-20, Electronic resources, additional sources, and software
Topic 3. Mutagenic selection in crop biotechnology Sources of mutations and methods of their induction: physical and chemical mutagens. Examples of successful mutagenic varieties and their importance for agriculture	2	2		5	1-20, Electronic resources, additional sources, and software
Topic 4. Pure line technology and hybrid seed production Principles of developing inbred lines and F1 hybrids Methods for creating cytoplasmic male sterility sterility (CMS) and its significance	2	2		5	1-20, electronic resources, additional sources, and software
Topic 5. Tissue culture and micropropagation of plants Basics of tissue culture: explants, nutrient media, regeneration Practical application of micropropagation: obtaining virus-free planting material	2	2		5	1-20 electronic resources, additional sources, and software

Topic 6. Method of embryo rescue in breeding Biological rationale for embryo rescue: technique and environment. Examples of application in hybridization incompatible genotypes (using rice as an example)	2	2		5	1-20, Electronic resources, additional sources, and software
Topic 7. Selection using molecular markers (MAS) Types of molecular markers and principles of their action. Genetic linkage and creation of marker maps to accelerate selection	2	2		5	1-20, electronic resources, additional sources, and software
Topic 8. Fundamentals of genetic engineering in the creation of GM crops. Recombinant DNA technology: main stages from isolation to transformation Comparison of traditional breeding and genetic engineering: advantages and limitations	2	2		5	1-20, electronic resources, additional sources, and software
Topic 9. Methods of plant cell transformation. Biolistic transformation (gene gun) and transformation using Agrobacterium tumefaciens Features of creating transgenic plants: requirements for vectors and markers	2	2		5	1-20 electronic resources, additional sources, and software
Topic 10. Detection of transgenes and assessment of transformation stability Methods of molecular control of transgenic plants (PCR, blot analysis). Issues of regulation, biosafety and commercial production of transgenic crops	2	2		5	1-20, electronic resources, additional sources, and software
Total	**20**	**20**		**50**	

3.1. Topics and lecture plan

No No	Topic	Number hours
1	Topic 1 Introduction to modern a g r i c u l t u r a l biotechnology: objectives, directions, significance	2
2	Topic 2. Traditional breeding and its role in the development of agriculture	2
3	Topic 3. Mutagenic breeding: methods, examples, and effectiveness	2
4	Topic 4. Hybridization and pure line technology in the creation of crop varieties agricultural crops	2
5	Topic 5. Methods of tissue culture and micropropagation of plants	2
6	Topic 6. Embryo rescue: technique, application in complex crosses	2
7	Topic 7. Selection using molecular markers (MAS): principles, stages, examples	2
8	Topic 8. Fundamentals of genetic engineering in plant cultivation: technologies and approaches	2
9	Topic 9. Plant transformation: methods of gene introduction and examples	2
10	Topic 10. Prospects for the use of transgenic crops and the latest trends development	2
	Total	**20**

3.2. Topics for practical classes

No No	Topic	Number hours
1	Topic 1. Analysis of the characteristics of traditional and modern selection of cultivated plants	2
2	Topic 2. Drawing up a plan for a mutagenic breeding experiment	2
3	Topic 3. Calculating hybrid vigor and evaluating the productivity of F1 hybrids	2
4	Topic 4. Practical aspects of micropropagation: selection of medium, regeneration phases.	2
5	Topic 5. Modeling the process of anther culture and obtaining doubled haploids	2
6	Topic 6. Development of a breeding plan using molecular markers.	2
7	Topic 7. Determining the genetic diversity of crops based on marker analysis.	2
8	Topic 8 Analysis of genetic constructs for plant transformation (vectors, promoters, markers)	2
9	Topic 9. Conducting a virtual plant transformation experiment (Agrobacterium vs. biolistics)	2
10	Topic 10. Assessment of the risks and benefits of transgenic crops: bioethics and biosafety	2
	Total	**20**

3.3. Independent work

No No	Topic title and list of questions	Number hours
1	Biological fertilizers	5
2	Biotechnological preparations in complex plant protection	5
3	Cultivation of plant cells and tissues	5
4	Transgenic plants	5
5	Animal reproduction biotechnology. Methods of obtaining transgenic animals	5
6	Production of feed proteins	5
7	Production of essential amino acids	5
8	Production of vitamin preparations	5
9	Biotechnology for livestock waste disposal	5
10	Biotechnology for biogas production	5
	Total	**50**

4. TEACHING AND TRAINING METHODS

DRN	**Teaching methods** (work to be carried out by the teacher during classroom sessions, consultations)	**Number of hours**	**Teaching methods** (what types of educational activities should be performed by the student independently)	**Number hours**
DRN 1. Be able to navigate the provisions of regulatory documents that regulate product certification, production certification, technical documentation, and and integrate this knowledge	– **verbal** (lecture, conversation, story, explanation, educational discussion); **-visual**	9	Careful reading of notes and thinking through problematic questions from lectures, solving problems;	9

under time analyzing quality management systems.	(demonstration, illustration, presentation); − **practical** (exercise, experiment, practical work); − by logic of presentation (induction, deduction); − **by level of**		- library attendance the library, working with various literature, taking notes, summarizing; - discussion of educational material with other students without	
DRN 2. Ability apply standards requirements to the organization of technological processes at the enterprise and prepare the relevant documentation in accordance with regulatory provisions.		7		9
DRN 3. Possess knowledge of the structure of cells of biological agents and be able to determine their physical and chemical characteristics in order to optimize cultivation conditions in biotechnological production.	**cognitive activity** (explanatory-illustrative, reproductive, problem-based presentation, partial-search, research); - **interactive teaching methods** (interactive technologies for collective-group and cooperative learning: general circle, microphone, unfinished ideas, brainstorming, case method, small group work, dialogue, synthesis of opinions, joint project, information search, circle of ideas); - **non-traditional teaching methods** (teacher as moderator, game design). Teacher consultations Conducting surveys	6	Teacher participation; - preparation of reports, announcement s, abstracts, presentations; - completion of individual assignments; - working in small groups (developing ideas, preparing presentations); - mutual learning; - use of computers.	9
DRN 4. Be able to determine the physical and chemical characteristics of organic substances such as proteins, nucleic acids, carbohydrates, and lipids, and apply this knowledge for further use in production and research processes.		6		9
DRN 5. Be able to assess the potential of cells in biotechnology, taking into account knowledge of their structure, functioning, and cultivation conditions, as well as the ability to develop proposals for their use in production.		6		9
DRN 6. Calculate the need for a targeted biotechnological product, carry out an economic justification of production, taking into account regulatory requirements and the specifics of technological processes.		6		5
Total		**40**		**50**

5. ASSESSMENT BY EDUCATIONAL COMPONENT

Continuous assessment is used for assessment of the educational component – this is a combination of summative and formative assessment. Continuous assessment is used to establish feedback with students and summative assessment to record grades. It is essential that the assessment method allows for verification of whether the established learning outcomes have been achieved. To this end

, several methods are used simultaneously.

5.1. Summative assessment

Summative assessment summarizes the student's learning activities at a certain point in time, usually at the end of modules (module 1, module 2), certification, and exams. Summative assessment can be described as an assessment at the end of a course that allows you to determine the level of student achievement, summarizing a certain stage of learning.

5.1.1. The following are provided for assessing expected learning outcomes

No	Methods of summative assessment	Points / Share in overall assessment	Date of completion
1.	Multiple choice test and individual assignment. (Module 1. Modern biotechnology Part 1)	20 points / 20%	3rd semester, 5th week
2.	Control test (multiple choice questions)	15 points / 15%	3rd semester, Week 7
3.	Multiple choice test and individual assignment (Module 2. Biotechnology of agricultural crops. Part 2); Preparation of reports, presentations, and presentations.	35 points / 35%	3rd semester, Week 8
4	Individual assignment (type – preparation of an essay and its defense)	30 points / 30%	3rd semester Weeks 9-10

5.1.2. Assessment criteria

Component	**Unsatisfactory**	**Satisfactory**	**Good**	**Excellent**
Multiple choice test and individual assignment. (**Module 1. Modern biotechnology** Part 1)	*<12 points*	*12-15 points*	*15-18 points*	*18-20 points*
	Requirements for the task have not been met	Most requirements have been fulfilled, but some questions have not been fully answered, and there is no analysis of the material studied	All requirements of the task have been fulfilled	All requirements of the task have been fulfilled, the results have been clearly interpreted the results obtained, made suggestions for improvement and improvement of specific issues, formed their own opinion and vision of a particular problem, demonstrated the ability to critically evaluate various sources of information, thoughtfulness, conclusions made regarding the use of the knowledge gained in professional activities
Preparation of a report or presentation on topic	*<5 points*	*5-7 points*	*7-8 points*	*8-10 points*
	Requirements for the task not met	Most requirements have been fulfilled, but some questions have not been fully addressed, and there is no analysis of the material studied	All requirements of the task have been fulfilled	All requirements of the task have been fulfilled, the results have been clearly interpreted the results obtained, made suggestions for improvement and improvement of specific issues, formed their own opinion and vision of a particular problem, demonstrated the ability to critically evaluate various sources of information, thoughtfulness,

				conclusions were made regarding the use of the knowledge gained in professional activities
Multiple choice test and individual assignment (**Module 2. Biotechnology of agricultural crops,** Part 2); Preparation of reports, announcements, abstracts, presentations, completion of individual assignments.	*<20 points*	*21-25 points*	*26-31 points*	*32-35 points*
	Task requirements not met	Most requirements have been met, but some questions have not been fully answered, and there is no analysis of the material studied	All requirements of the task have been fulfilled	All requirements of the task have been fulfilled, the results have been clearly interpreted, and suggestions for improvement have been made. interpreted the results obtained, made suggestions for improvement and refining specific issues, formed their own opinion and vision of a particular problem, demonstrated the ability to critically evaluate various sources of information, thoughtfulness, conclusions were made regarding the use of the knowledge gained in professional activities
Preparation and presentation of reports	1 *point*	1-3 *points*	3-4 *points*	4-5 *points*
	Requirements for the task not fulfilled	Most requirements have been met, but some questions have not been fully answered, and there is no analysis of the material studied	All requirements of the task have been fulfilled	All requirements of the task have been fulfilled, the results have been clearly interpreted the results obtained, made suggestions for improvement and improvement of specific issues, formed their own opinion and vision of a particular problem, demonstrated the ability to critically evaluate various sources of information, thoughtfulness, conclusions have been made regarding the use of the knowledge gained in professional activities
Individual assignment (topics: sections 3.1, 3.2, 3.3)	<18 *points* <60	18-21 *points* 60-74	22-*26* 75-89	27-30 *points* 90-100
	Lack of understanding of specific subject theories, paradigms, concepts, and principles	Some understanding of specific subject theories, paradigms, concepts, and principles Reproduce knowledge based on directly presented material within the scope of the EC	Understanding of specific theories, paradigms, concepts, and principles, as well as understanding of more specialized areas Reproduce knowledge of the material directly covered within the scope of the EC with some evidence of broader research	A deep understanding of specific theories, paradigms, concepts, and principles, as well as a deep understanding of more specialized areas. Reproduce knowledge gained outside the scope of the material directly the material presented within the scope of the EC Ability to search, analyze, synthesize, generalize, and critically evaluate information

5.2. Formative assessment

Formative assessment is a source of information about the success of learning outcomes for both teachers and learners. Formative assessment is usually conducted during the course of study. The results of learners' assessment tasks help the teacher make decisions about the nature of further learning.

No	**Elements of formative assessment**	**Date**
1	Short tests (up to 5 minutes)	Weekly, at the end of practical class
2	Cooperation among students in the group and ability to work with focus	Weekly, throughout the semester
3	Careful review and analysis of completed assignments	Weekly, throughout the semester
4	Individual discussions about the results of completed assignments	Weekly, throughout semester
5	Defense of practical work	Weekly, throughout the semester
6	Analysis of professional texts or data	Weekly, throughout the semester
7	Discussion of selected ways to solve the problem	Weekly, throughout semester
8	Oral presentations, self-assessment, and peer assessment	Weeks 2-10
9	Mastering observation skills and abilities	Weekly, throughout semester
10	Observing applicants while they perform tasks	Weekly, throughout the semester

Grading scale: national and ECTS

Total points for all types of educational activities	**ECTS grade**	**National scale grade for credit**
90	**A**	pass
82	**B**	
75	**C**	
69-74	**D**	
60-68	**E**	
35-59	**FX**	Not counted, with the possibility of retaking
1-34	**F**	Not credited with mandatory retaking of the course

6. LEARNING RESOURCES (LITERATURE

6.1. Main sources

6.1.1. Textbooks, manuals

1. . Agronomy: textbook for the third (educational and scientific level of higher education in the specialty N1 "Agronomy" / A. V. Melnyk, Yu. I. Danko, Yu. G. Mishchenko et al.: edited by A. V. Melnyk, Yu. I. Danko. - Odessa: Oldi+, 2025. - 550 p. - (Series "To help graduate students").
2. Andriyanova, Mariya, Aslanli Aslanli, Nataliya Basova, et al. *ORGANOPHOSPHORUS NEUROTOXINS*. Publishing Center RIOR, 2020. http://dx.doi.org/10.29039/02026-5.
3. Bykov O. A., Kostenko O. O. Biotechnology in potato breeding. – Kharkiv: KhNAU, 2021. – 228 p.
4. Bradshaw J. E. (Ed.). Advances in Potato Chemistry and Technology. – 3rd ed. – Cambridge: Academic Press, 2021. – 600 p.
5. http://croptechnology.unl.edu/download.cgi
6. Zhang C., Liu J., Zhang Y. et al. Developing CRISPR/Cas9-mediated gene editing for modifying starch quality

in potatoes // BMC Plant Biology. – 2020. – Vol. 20. – Art. 512. DOI: 10.1186/s12870-020-02709-3.
7. Gnatyuk A. M. Morphological features of fruits and seeds of Colchicum species of the natural flora of Ukraine // PLANTA+. Science, practice, and education: materials of the IV scientific and practical conference with international participation, dedicated to the 20th anniversary of the Department of Pharmacognosy and Botany of the Bogomolets National Medical University (Kyiv, February 20, 2023). – Kyiv, 2023. – Vol. 1. – P. 193–197.

6.2. Additional literature

8. Vyganyailo, G. V., Lyubychenko, V. O. Regulation in biotechnological processes using genetically modified organisms / scientific supervisor V. M. Kovalenko // Materials All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Students' Day (November 17–21, 2025, Sumy). – Sumy: Sumy National Agrarian University, 2025. – P. 40.
9. Gorpinchenko O. M., Bilovodska M. B. The effectiveness of drip irrigation of potatoes at different soil moisture levels / scientific supervisor V. M. Kovalenko // Materials of the All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Students' Day. – Sumy: SNAU, 2025. – P. 41.
10. Dubovyk V. I. Biotechnological evaluation of kefir starter culture / scientific supervisor V. M. Kovalenko // Materials of the All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Student Day. – Sumy: SNAU, 2025. – P. 42.
11. Zakorko V. S., Borysenko I. B. Assessment of the effectiveness of further generational reproduction of potatoes obtained from *in vitro* meristem culture / scientific supervisor V. M. Kovalenko // Materials of the All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Students' Day. – Sumy: SNAU, 2025. – P. 43.
12. Kalach, A. V. Organization of biotechnological quality control of products at PJSC "Okhtyrsky Brewery" / scientific supervisor O. G. Shvets // Materials of the All-Ukrainian Scientific conference of students and graduate students dedicated to International Students' Day. – Sumy: SNAU, 2025. – P. 45.
13. Polyvany A. D., Bilovodska M. B. Adaptive potential of potato varieties under conditions of abiotic stress in the North-Eastern Forest-Steppe of Ukraine / scientific supervisor V. M. Kovalenko // Materials of the All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Students' Day. – Sumy: SNAU, 2025. – P. 47.
14. Serdyuk P. V. Potato productivity under conditions of the North-Eastern Forest-Steppe of Ukraine / scientific supervisor V. M. Kovalenko // Materials of the All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Students' Day. – Sumy: SNAU, 2025. – P. 48.
15. Shevich A. S., Bilovodska M. B. Increasing the potential of dietary potato varieties in the conditions of the North-Eastern Forest-Steppe of Ukraine / scientific supervisor V. M. Kovalenko // Materials of the All-Ukrainian Scientific Conference of Students and Postgraduates dedicated to International Students' Day. – Sumy: SNAU, 2025. – P. 49.
16. Kalenka S. M., Novytska N. V., Zhemoida V. L., et al. Seed production and methods for determining the quality of agricultural crops: textbook / edited by S. M. Kalenka. – Vinnytsia: FOP Danyluk, 2011. – 320 p.
17. Bielyk Y., Savosko V., Lykholat Y., Heilmeier H., Grygoryuk I. Macronutrients and heavy metals contents in the leaves of trees from the devastated lands at Kryvyi Rih District (Central Ukraine) // *E3S Web of Conferences*. – 2020. – Vol. 166. – Art. 01011. – DOI: 10.1051/e3sconf/202016601011.
18. Martínez-Huitle C. A., Rodrigo M. A., Sirés I., Scialdone O. A critical review on latest innovations and future challenges of electrochemical technology for the abatement of organics in water // *Applied Catalysis B: Environment and Energy*. – 2023. – Vol. 328. – Art. 122430. – DOI: 10.1016/j.apcatb.2023.122430.
19. Dyachok V., Kochubei V., Huhlych S. Production of biofuel based on the transformations of greenhouse gases // *Environmental Problems*. – 2025. – Vol. 10, no. 2. – P. 97–103. – DOI: 10.23939/ep2025.02.097.
20. Linares Arroyo G., Abascal A., Degen T. et al. Monitoring, trends, and impacts of pollution // *Nature Reviews Earth & Environment*. – 2024. – Vol. 5. – P. 417–430. – DOI: 10.1038/s43017-024-00555-9.

Electronic resources

21. Adams F. *International Causes of Hunger and Malnutrition: Food Insecurity and the Global Economy* [Electronic resource]. – 1st ed. – London : Routledge, 2025. – 198 p. – DOI: 10.4324/9781003539636.
22. Afzal, A., Ijaz, M., Rafique, M. 2021. New selection techniques to detect sources of resistance against stripe rust in wheat. Plant Protection 5,197-203.
23. Afzal, A., Syed, S., Khizar, M., Iqbal, J., Ashraf, S., Altaf, A., Mehmood, B., and Khan, M.R., 2023. Advancement of Crop Productivity via CRISPR-Nanoparticle Interface. Pakistan Journal of Biotechnology 20, 269-274.
24. Halder, K., Chaudhuri, A., Abdin, M.Z., Majee, M., Datta, A., 2022. RNA interference for improving disease resistance in plants and its relevance in this clustered regularly interspaced short palindromic repeats-dominated era in terms of dsRNA-based biopesticides. Frontiers in Plant Science, 13, 885128.
25. Santra, H.K., Banerjee, D., 2020. Natural products as fungicide and their role in crop protection. Natural Bioactive Products in Sustainable Agriculture 131-219

6.3. Excel software.

Word text editor. Microsoft Office Power Point.

Electronic database with the Agrobase program. Web version: https://agrobaseapp.com/ Greenval program. Web version:https://greenval.org/about

Electronic database with the ViralZone program. Web version:https://viralzone.expasy.org/