ANNOTATION

of the dissertation by Yerish Nurbol Amantayuly entitled
“Technological methods of biologization of the cultivation of spring wheat with the use of elements of exact farming in the conditions of Northern Kazakhstan”,
submitted for the degree of Doctor of Philosophy (PhD) in specialty 6D080100 – Agronomy

1. Relevance of the Research Topic

Currently, approximately 75% of the territory of the Republic of Kazakhstan (RK) is exposed to an increased risk of desertification, while 14% of pastures (more than 15 million ha) have reached an extreme degree of degradation. The total area affected by wind and water erosion amounts to 30.5 million ha, of which 16.5 million ha, or 54.1%, are located in the southern regions. Systematic violations of crop cultivation technologies under production conditions also pose a serious threat to soil resources.

The aggravation of environmental problems and contradictions necessitates further research aimed at optimizing farming systems not only in relation to specific natural conditions but also in accordance with modern production relations. Under these circumstances, the existing zonal farming systems no longer fully meet current agricultural requirements. Therefore, the further development of agriculture in the Republic of Kazakhstan requires a transition to conservation agriculture, including adaptive landscape, precision and biological farming systems, as well as resource-saving technologies. These approaches are intended to contribute to the country’s food security and facilitate the application of the latest advances in alternative agriculture, with the conservation of natural resources as its fundamental principle.

Under current conditions, one of the most pressing problems of agricultural production in Northern Kazakhstan is the decline in chernozem soil fertility due to dehumification, intensification of erosion processes, disruption of the organic matter balance, and a decrease in soil biological activity. According to agrochemical monitoring data, a considerable proportion of agricultural land is characterized by low humus content and a deficiency of available nutrients, which adversely affects the stability of agroecosystems and crop productivity.

At the same time, requirements for the environmental safety of agricultural production, product quality, and the conservation of natural resources are increasing. In this regard, the development of farming biologization technologies based on the use of biologized crop rotations, organic matter from crop residues, green manure crops, and biological products is becoming particularly relevant.

An important approach to increasing the efficiency of agricultural production is the introduction of precision agriculture elements, which make it possible to take into account the spatial heterogeneity of soil fertility, monitor crop condition, and make scientifically substantiated management decisions based on geoinformation technologies and Earth remote sensing data.

Of particular scientific interest is the study of the effects of biologization practices on soil fertility, the structure of microbial communities, the phytosanitary condition of agrocenoses, and spring wheat productivity. Therefore, the development of scientifically substantiated technological approaches to the biologization of spring wheat cultivation using precision agriculture elements is a relevant scientific and practical task for agriculture in Northern Kazakhstan.

2. Purpose of the Dissertation Research

The purpose of the research is to develop and scientifically substantiate technological approaches to the biologization of spring wheat cultivation using precision agriculture elements that ensure the preservation and restoration of chernozem soil fertility, enhancement of the biological activity of agrocenoses, and increased crop productivity under the conditions of Northern Kazakhstan.

3. Object of Research

The object of the research is spring wheat agrocenoses cultivated in biologized crop rotations on the chernozem soils of Northern Kazakhstan with the application of biological products and precision agriculture elements.

4. Subject of Research

The subject of the research is the patterns of changes in the agrophysical, agrochemical, microbiological, and phytosanitary properties of soil, as well as spring wheat productivity, under the influence of technological approaches to farming biologization and precision agriculture elements.

5. Research Objectives

To achieve the stated purpose, the following objectives were established:

- to study the effects of biologized crop rotations on the water regime, nutrient regime, and phytosanitary condition of chernozem soils;
- to assess the effects of biologization practices on organic matter accumulation, crop weed infestation, and the formation of soil fertility;
- to determine the effectiveness of biological products in spring wheat cultivation technology;
- to investigate the structure and biodiversity of the soil bacterial community under different farming biologization technologies;
- to assess the potential use of precision agriculture elements for monitoring soil fertility and crop condition;
- to determine the effects of the studied technological approaches on spring wheat yield, grain quality, and the economic efficiency of cultivation.

6. Scientific Novelty

For the first time under the conditions of Northern Kazakhstan, a comprehensive assessment was carried out of the effects of biologized crop rotations, organic cultivation technology, and precision agriculture elements on the fertility of chernozem soils and spring wheat productivity. The specific features of the formation of soil water and nutrient regimes, the phytosanitary condition of agrocenoses, and the accumulation of the organic mass of crop residues depending on the structure of biologized crop rotations were established.

New data were obtained on the taxonomic composition and biodiversity of bacterial communities in chernozem soils under the application of farming biologization technologies based on sequencing of 16S rRNA gene amplicons. The effectiveness of biological products with different mechanisms of action in spring wheat cultivation under the conditions of Northern Kazakhstan was determined. The feasibility of using agrochemical mapping, Earth remote sensing, and the NDVI and NDRE vegetation indices for monitoring crop condition and soil fertility within an organic farming system was substantiated.

7. Provisions Submitted for Defense

The following principal scientific provisions are submitted for defense:

- biologized crop rotations incorporating legumes and perennial grasses as preceding crops for spring wheat contribute to improved soil moisture availability and the accumulation of available nutrients;
- the utilization of the organic mass of post-harvest crop residues is an important factor in maintaining soil fertility and the biological activity of agrocenoses;
- biologization technologies have a significant effect on the structure of the soil bacterial community, determining the level of its biological activity and ecological stability;
- the application of biological products contributes to increased spring wheat productivity and improvement of the phytosanitary condition of crops;
- the use of precision agriculture elements makes it possible to effectively assess the spatial heterogeneity of soil fertility and crop condition, thereby increasing the efficiency of agrocenosis management;
- the integrated application of biologization practices and precision agriculture elements ensures increased spring wheat yield and enhances the environmental sustainability of farming systems in Northern Kazakhstan.

8. Relationship of the Dissertation Research to Research Projects and State Programs

The dissertation research was carried out within the framework of the budget-funded projects O.0892, “Development of a Precision Agriculture System for Crop Cultivation in Northern Kazakhstan Based on a Comparative Study of Different Cultivation Technologies Using Information Technology Tools, Cultivation Technology Elements, Site-Specific Plant Nutrition, Plant Protection Products, and Machinery for Profitable Production” (State Registration No. 0118RK01276, implementation period: 2018–2020), and O.0969, “Development of Organic Farming Technologies for Crop Cultivation Taking into Account Regional Specificities, Digitalization, and Export” (State Registration No. 0121RK00745, implementation period: 2021–2023).

9. Practical Significance of the Results Obtained

The practical significance of the research lies in the development of recommendations for the application of biologized crop rotations, biological products, and precision agriculture elements in spring wheat cultivation. The implementation of the developed technological solutions will contribute to increasing grain yield and quality, improving the phytosanitary condition of crops, maintaining and restoring soil

fertility, reducing anthropogenic pressure on agricultural landscapes, and increasing the efficiency of land resource use in Northern Kazakhstan.

10. Personal Contribution of the Doctoral Candidate

The personal contribution of the doctoral candidate consists of direct participation in the principal stages of the dissertation research. The author collected, systematized, and analyzed domestic and international scientific sources related to the dissertation topic and participated in the development of the experimental research program and methodology, as well as in specifying the purpose and objectives of the research.

The doctoral candidate directly participated in the field studies conducted in 2019–2022, assessment of the condition of biologized crop rotations, phenological observations of the growth and development of agricultural crops, determination of plant stand density, assessment of crop weed infestation, development of root rot, harmful and beneficial entomofauna, organic mass of crop residues, and yield structure components. The procedures for conducting these observations and recording crop yields are presented in the methodological section of the dissertation.

The author participated in experiments involving pre-sowing treatment of spring wheat seeds with biological products and spraying of plants during the growing season, preparation of materials for laboratory and phytopathological studies, and systematization and analysis of the results obtained.

With the participation of the author, statistical processing of the experimental data was carried out, tabular and graphical materials were prepared, the results were analyzed and scientifically interpreted, and the principal conclusions of the dissertation were formulated.

The doctoral candidate participated in presenting the research results at scientific conferences and seminars, as well as in preparing scientific publications on the dissertation topic.

11. Approbation of the Dissertation Results

The principal scientific provisions and results of the dissertation research were presented, discussed, and positively evaluated at scientific seminars and conferences:

- the principal scientific results of the dissertation research were presented at meetings of the Department of Agronomy of Akhmet Baitursynuly Kostanay Regional University and at the university's annual academic meetings (Kostanay, 2019–2021);
- scientific seminar "Fundamentals of Precision Agriculture" (Astana, January 25, 2019);
- 1st International Forum of Young Scientists (Almaty, February 11, 2019);
- scientific and practical seminar "International Experience in the Application of Innovative Technologies: Direct Seeding and Precision Agriculture Elements" (Zarechny settlement, Kostanay District, September 16, 2019);
- online seminar "Digital Transformation in Agriculture" (Zarechny settlement, Kostanay District, July 9, 2020);
- online seminar "Differentiated Technologies of Precision Agriculture" (Zarechny settlement, Kostanay District, July 23, 2020);
- online seminar "Practical Application of Precision Agriculture Technologies" (Zarechny settlement, Kostanay District, July 30, 2020).

12. Publications

Based on the results of the dissertation research, 5 scientific papers were published, including 1 publication in a journal indexed in the Scopus database, 3 publications in scientific journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan, and 1 publication in the proceedings of an international scientific and practical conference:

13. Scope and Structure of the Dissertation

The dissertation is presented on 135 pages of computer-typed text and consists of an introduction, five chapters of the main body, conclusions, practical recommendations for production, and appendices. The dissertation contains 36 tables and 18 figures. The list of references includes 206 sources.