

ABSTRACT

of the dissertation work by **Beisenbayeva Maussymzhan** on the topic: «Influence of optimization of the watering and mineral nutrition on soybean productivity on common the gray soils of southern Kazakhstan» submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D080800 – Soil Science and Agrochemistry.

Relevance of the Research Topic. By 2050, the global population is projected to increase by approximately 30%, which is considered a critical factor contributing to the worldwide grain deficit. Despite Kazakhstan ranking ninth globally in terms of land area, agricultural lands remain underutilized and inefficiently managed. The southern region of Kazakhstan represents one of the key areas for grain production. According to 2020 statistical data, the sown area of cereals (including rice) and leguminous crops in this region accounted for 304.6 thousand hectares out of the total annual sown area of 847.9 thousand hectares. Soybean (*Glycine max*), as one of the most economically significant crops worldwide, serves multiple purposes: it is widely used as an oilseed crop, as animal feed in livestock and aquaculture, as a major source of high-quality protein for human consumption, and as raw material for biofuel production. Between 1961 and 2007, global soybean production demonstrated a steady annual growth rate of 4.6%, reaching an average of 217.6 million tons during 2005–2007. In 2018/2019, the United States was the global leader with 120.52 million tons of production, whereas by May 2020, Brazil surpassed the United States with approximately 126 million tons. Forecasts indicate that global soybean production will continue to grow at an annual rate of 2.2% and is expected to reach 371.3 million tons by 2030. In Kazakhstan, soybean cultivation was first introduced into agricultural practice in 1975 on an area of 2,670 hectares. In accordance with transformations in the agrarian sector and increasing market demand, the sown area under soybean has expanded to 105–110 thousand hectares in recent years. However, crop productivity remains relatively low, rarely exceeding 2.0 t/ha.

The low yield levels are primarily attributed to non-compliance with agrotechnological cultivation requirements, including inadequate crop rotation practices, limited use of regionally adapted varieties, improper irrigation and fertilization systems, and insufficient weed and pest management. These factors collectively result in significant reductions in yield per hectare.

In the irrigated farming systems of southern Kazakhstan, soybean cultivation has been adopted by individual farms. Nevertheless, due to the agro-climatic conditions of the region—characterized by high air temperatures (40–45 °C) and low relative humidity (13–17%)—during the pod ripening stage, pod shattering and seed loss occur, which reduces harvested yields to as low as 1.0–1.3 t/ha. Consequently, the development of scientifically grounded agrotechnologies for regionally adapted soybean varieties, resilient to the specific climatic conditions of southern soils, represents a priority research direction.

As a leguminous crop, soybean has the capacity to biologically fix atmospheric nitrogen into mineral nitrogen through symbiosis with root nodule bacteria. The application of biological preparations such as Nitragin, along with growth stimulants like Vympel, has been demonstrated to enhance seed germination energy, improve plant resistance to biotic stresses, and facilitate greater uptake of essential nutrients from both inherently low-fertility soils and applied fertilizers. These treatments contribute to the development of a more robust root system and accelerated plant growth, resulting in increased yields. Accordingly, the integration of mineral fertilizers with modern microfertilizers (Orakul) and growth stimulants (Vympel) represents an effective agro-technological measure for enhancing soil fertility, improving crop productivity, and ensuring economic efficiency.

The implementation of mineral fertilizers in combination with Orakul + Vympel not only ensures higher soybean yields but also contributes to the conservation and restoration of soil fertility. Considering the recent decline in soil fertility, including a reduction in humus content of up to 30% in ordinary serosem soils, the relevance and scientific importance of the chosen research topic are clearly justified, highlighting its significance for the advancement of agricultural science and sustainable crop production in Kazakhstan.

Research Aim. Improving Soybean Yield and Product Quality on Ordinary Serosem Soils of Southern Kazakhstan through Optimization of Irrigation Regimes and Mineral Nutrition, Ensuring the Production of a Competitive and Market-Oriented Product.

Research Objectives.

- monitoring the initial soil and climatic conditions of the research site;
- determining the effectiveness of the number of irrigations, optimal timing, and amount of water supplied in accordance with the applied fertilizers during soybean cultivation;
- studying the effect of optimized irrigation technology and applied fertilizers on the dynamics of nutrient elements in ordinary serosem soils;
- assessing the influence of irrigation and fertilizer optimization on soybean growth and development;
- monitoring the impact of irrigation and fertilizer application on soybean yield and product quality;
- calculating the economic efficiency of irrigation and fertilizer use;
- developing an agrotechnological model of soybean cultivation adapted to the natural and climatic conditions of Southern Kazakhstan, based on the research results.

Research Methods: Field experiments, laboratory analyses, and statistical methods were employed in this study. The obtained data were subjected to mathematical and statistical processing, which ensured the scientific reliability of the results. Adapted methodologies were applied for agrochemical and agronomic indicators.

In the course of the dissertation research, the following scientifically substantiated propositions and new findings are proposed:

1. Scientific Hypotheses:

- Soybean yield and quality under the conditions of Southern Kazakhstan directly depend on the harmonization of irrigation regimes and mineral nutrition. Correlating the frequency and timing of irrigation with the ontogenetic phases of plant development ensures efficient utilization of water resources.
- The deficiency of nitrogen, phosphorus, and potassium in ordinary sierozem soils can be compensated through the scientifically grounded application of fertilizers, which in turn enhances the intensity of photosynthesis and improves the formation of vegetative biomass.
- Under conditions of limited moisture supply, the application of mineral fertilizers increases soybean resistance to stress factors and improves product quality indicators, including protein and oil content.

2. New Scientific Provisions:

- For the first time, the patterns of the biological response of soybean to irrigation and mineral nutrition under the conditions of ordinary sierozem soils have been comprehensively established.
- The effectiveness of the mutual influence of the optimal irrigation regime and fertilizer application rates for increasing soybean yield has been experimentally proven.
- Soybean productivity elements (plant height, branching intensity, leaf area, duration of flowering and ripening phases) undergo significant changes under the combined influence of moisture and nutrients.
- As a result of the effective application of mineral fertilizers, the agrochemical properties of the soil are improved, the dynamics of nutrient elements (N, P, K) are optimized, which enhances the crop's ability to absorb nutrients.

Scientific Novelty

- For the first time under the conditions of Southern Kazakhstan, optimal irrigation and mineral nutrition regimes for soybean have been substantiated, enabling an increase in both seed yield and quality.
- A technology for integrating water and nutrient regimes has been developed, taking into account the agrochemical properties of sierozem soils and the climatic features of the region.
- Regularities in the influence of various combinations of fertilizers and irrigation regimes on biometric parameters, yield, and seed quality of the soybean variety "Lastochka" have been established.

Key Provisions Submitted for Defense

- 1 Scientifically substantiated irrigation regimes and mineral nutrition systems for soybean cultivation on irrigated lands of Southern Kazakhstan.

- 2 The influence of various combinations of fertilizers and irrigation practices on soybean yield and seed quality.
- 3 Optimal conditions of water supply and mineral nutrition for the “Lastochka” soybean variety.
- 4 The economic efficiency of the proposed agro-technological approaches.

Main Research Results

As a result of optimizing water and nutrient regimes, soybean yield increased by 1.6–1.7 times compared to the control. With pre-sowing seed treatment using the micronutrient fertilizer Orakul and the growth stimulant Vympel, followed by foliar application of these preparations, plant height reached 77.8 cm, the mass of 1000 seeds was 116.0 g, and yield reached 26.0 c/ha.

Practical Significance

The proposed agrotechnological practices allow for increasing the productivity and profitability of soybean cultivation, improving seed quality, and ensuring the rational use of the region’s soil and water resources.

Relevance of the Dissertation Topic to the State Program The dissertation was carried out within the framework of the research project titled “Development and Implementation of New High-Yielding Soybean Varieties with High Quality, Resistant to Stress Factors under Various Regional Conditions of the Country Using Global Diversity”, conducted in 2018–2020 (state registration number №0118PK01208).

Author’s Personal Contribution

The author personally developed the research program and methodology, conducted field and laboratory experiments, performed data analysis, and prepared publications. All conclusions and recommendations are the result of her independent work.

Approbation and Publications

The main research results were presented at international and national conferences:

- XXII International Scientific and Practical Conference “Topical Issues of Environmental Management and Ecology” (2021);
- International Conference “Priorities for Agro-Industrial Development in the Context of Digitalization” (St. Petersburg, 2021);
- International Conference “Scientific Results” (Rome, 2023);
- X Anniversary International Youth Forum “Green Bridge of Generations.”

On the topic of the dissertation, 11 scientific works have been published, including 1 article in a journal indexed in Scopus (Q3).

Volume and Structure of the Dissertation The dissertation is presented in 140 pages of typed text and includes an introduction, 7 chapters, a conclusion, and practical recommendations. The work is illustrated with 22 tables, 19 figures, and appendices. The reference list contains 158 sources, including 11 in foreign languages.