ANNOTATION
of the dissertation work
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on the topic "Light chestnut soil phosphate mode and permanent sugar beet productivity with longm term phosphorus fertilizers application" submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D080800 - "Soil Science and agrochemistry"

Relevance of the research topic. The study is driven by the need to scientifically substantiate rational approaches to the application of mineral fertilizers, including phosphorus fertilizers, in the context of modern agriculture in Kazakhstan. Particular importance in this regard is attached to the results of long-term stationary field experiments, which allow for an objective assessment of the impact of fertilizers not only on crop yield and quality, but also on changes in the agrochemical properties of soils, their fertility, and phosphate reserves.

Currently, a significant proportion of Kazakhstan's soils are characterized by low levels of available phosphorus, which limits the productivity of agrophytocenoses. Under these conditions, the use of phosphorus fertilizers is a key factor in increasing crop yields, including those of sugar beet—an important industrial crop in the southeastern region of the country.

In recent years, attention has been increasingly focused on the environmental aspects of mineral fertilizer use. Scientific literature notes the potential for heavy metals to be introduced with phosphorus fertilizers and to accumulate in soil and plants during long-term use. This necessitates a comprehensive assessment of not only the agronomic effectiveness of fertilizers but also their environmental safety.

It should be noted that a number of heavy metals (copper, zinc, iron, etc.) perform important physiological functions and are essential micronutrients for plants and soil microflora. However, when accumulated in excess, they can have a toxic effect on the agroecosystem. Therefore, studying the dynamics of their content during long-term application of phosphorus fertilizers is particularly important.

Thus, this study aims to identify patterns of phosphorus transformation in soil, the efficiency of its use by plants, and to assess the impact of long-term use of phosphorus fertilizers on heavy metal accumulation and ecological state of the soil-plant system. The results obtained are of great importance for the development of scientifically based recommendations for optimising fertilizer application rates and ensuring sustainable and environmentally friendly agricultural production.

Given the high efficiency of phosphorus fertilizers in sugar beet cultivation, as a valuable industrial crop in southeastern Kazakhstan, issues related to increasing productivity, as well as determining the degree of phosphorus utilization by plants from both mineral phosphates and organic soil compounds, are particularly relevant.

Research Aim. The purpose of this dissertation is to investigate the utilization of phosphorus from organic and mineral phosphates in soil and its impact on crop productivity under the long-term and systematic application of phosphorus fertilizers in sugar beet monoculture.

Research objectives:

1. To study the composition of mineral and organic phosphates in light chestnut soil under continuous sugar beet cultivation, as well as their changes with the use of phosphorus fertilizers;

2. To investigate the content and ratio of organic phosphorus compounds in light chestnut soil (labile organic matter, humic and fulvic acids), as well as their changes with the systematic application of phosphorus fertilizers;

3. To determine changes in the content of heavy metals in soil and plants with long-term use of phosphorus fertilizers under continuous sugar beet cultivation;

4. To study the effect of long-term and systematic use of phosphorus fertilizers on the yield and quality indicators of sugar beet under continuous cultivation;

5. To determine the correlation between the content of mineral and organic phosphates (labile organic matter, humic and fulvic acids) in the soil and yield;

6. To calculate the economic and agronomic efficiency of the long-term and systematic application of phosphorus fertilizers in continuous sugar beet cultivation.

Research methods.

The research was conducted from 2017 to 2020 in the Almaty region at the permanent experimental site of the Kazakh Research Institute of Agriculture and Plant Growing. The research object was sugar beet (Beta vulgaris L.), cultivar Avantazh. The experimental design included five treatment variants: (1) control; (2) NK background; (3) NK + P_1; (4) NK + $P_{1.5}$; (5) NPK + 60 t/ha of manure.

Field and laboratory research methods were employed. Agrochemical properties of soil samples were determined using conventional classical methods, including humus content, total NPK content, pH, and other indicators. Total organic phosphate content was determined using the Met method modified by Ginzburg; mineral phosphorus content by the Ginzburg–Lebedev method; available phosphorus by the Machigin method; and the fractional composition of organic phosphorus by the Bowman and Cole method.

Correlation coefficients between the total content of organic phosphates and the fractions of humic and fulvic acids were determined using the methods of Fisher, J. Tukey, and others. Total NPK content was determined by the ashing method according to Ginzburg and Shcheglova, followed by nitrogen determination using the Kjeldahl method, phosphorus by the colorimetric method, and potassium by flame photometry.

The quality parameters of sugar beet (dry matter content, total sugar content, etc.) were determined using conventional methods: dry matter content by the gravimetric drying method, and total sugar content by the Bertrand method.

Main provisions put forward for defense. Proven scientific hypotheses and other conclusions that constitute new knowledge:

1. Changes in the fertility of light-chestnut soil and its phosphate regime with long-term fertilizer application under continuous sugar beet cultivation:

- Agrochemical soil composition;
- Composition of organic and mineral phosphates in soil;

● Quantitative and qualitative composition of organic phosphorus compounds.

2. The influence of the soil phosphate regime on the yield and quality of sugar beet products under continuous cultivation, as well as changes in the correlations between them:

● Changes in sugar beet yield and quality under the influence of fertilizers;

● Correlations between the soil phosphate regime and sugar beet yield;

● Economic efficiency of long-term and systematic fertilizer application

Description of the main research results. The study was conducted at the Kazakh Research Institute of Agriculture and Plant Growing to examine the effects of long-term and systematic application of phosphorus fertilizers in selected sugar beet fields.

It was determined that the agrochemical properties and phosphate status of light chestnut soils are significantly affected by long-term anthropogenic impact, resulting in a decrease in humus content to 1.65% while maintaining a calcium-rich soil absorption complex.

It was demonstrated that the long-term application of phosphorus fertilizers increases the content of total, mineral, and organic phosphorus in the soil, while also altering their ratios. The increase in the content of available phosphorus and mineral phosphates is directly related to fertilizer application rates, with maximum values observed at a dose of P_{135}.

The results show that organic forms of phosphorus are actively transformed, increasing the role of labile organic matter and fulvic acids in the formation of the soil phosphate status.

It has been established that the long-term use of phosphorus fertilizers does not lead to exceeding the maximum permissible concentrations of heavy metals, which confirms the environmental safety of the soil-plant system.

Phosphorus fertilizers have been shown to have a significant impact on sugar beet productivity: yields reach 492.8–543.1 c/ha, and when combined with organic fertilizers, up to 551.9 c/ha, with an increase in sugar content to 16.3%.

Strong correlations were found between yield and the content of available phosphorus ($R = 0.98–0.99$), as well as phosphorus in labile organic matter ($R = 0.81$).

The economic efficiency of fertilizer application is confirmed by increased yields and high profitability (up to 49.7%), with the maximum efficiency of the P_{135} dose.

Justification of the novelty and importance of the obtained results. The long-term application of phosphorus fertilizers made it possible to establish patterns of change in the phosphate stock structure of light chestnut soils, as well as their impact on the productivity of sugar beet under continuous cultivation. Regression relationships were identified that characterize changes in the quantitative ratios of individual groups of mineral phosphates under the influence of long-term phosphorus fertilizer application.

Optimal phosphorus fertilizer rates are determined based on establishing a phosphate level that ensures a stable sugar beet yield of 450–500 c/ha with a sugar content of no less than 16.0%.

The primary research was conducted in accordance with thematic research plans. The obtained results were annually reported and discussed at scientific meetings and were also presented in the proceedings of the VIII International Scientific and practical conference "Global Science and Innovations: Central Asia 2020" (GSI-VIII) and the III International Scientific and Practical Conference of Young Scientists "The Contribution of Young Scientists to the Development of the Agro-Industrial Complex in the Context of the Fourth Industrial Revolution."

The reliability and validity of the research results are ensured by the clarity of the methodological approaches used in the experimental work, their alignment with the object, subject, purpose, and objectives of the dissertation, and the use of modern methods of analysis and statistical processing.

The results of this dissertation have practical significance and can be used by agricultural producers and farms, contributing to increased production efficiency, sustainable agricultural development, and food security.

The theoretical significance of this work lies in identifying patterns in the transformation of mineral and organic forms of phosphorus in light chestnut soils with long-term application of phosphorus fertilizers, as well as in establishing the relationship between the soil phosphate regime and sugar beet productivity.

The practical significance lies in developing recommendations for optimizing phosphorus fertilizer application rates, ensuring increased yields (up to 420–485 c/ha and higher), improved product quality, and economic efficiency while maintaining environmental safety.

The dissertation materials are used in the educational process at the Kazakh National Agrarian University, in the Department of Soil Science and Agrochemistry, to train students in crop production in the disciplines of "Agrochemistry," "Agrochemical Monitoring and Cartogramming," and "Fertilizer Application Systems."

The research results have been implemented at the farms "Romanenko V.V." and "Vakhitov R.H." in the Eskeldinsky District of the Almaty Region on areas of 9 and 6 hectares, respectively, where sugar beet yields in the range of 420–485 c/ha were obtained.

Compliance with scientific development directions or state programs. This work was completed as part of the 2018–2020 research project "The study of organic phosphorus compounds in soils and transformation of their fractions with systematic fertilizer application under continuous sugar beet cultivation," state registration number AP05133193.

Description of the doctoral student's contribution to the preparation of each publication. The author formulated the goal and objectives of the study, conducted field experiments and laboratory analyses to investigate the effect of long-term phosphorus fertilizer application on soil properties and sugar beet productivity, and processed, analyzed, interpreted, and statistically evaluated the obtained data. The main results of this thesis have been published in seven scientific articles in journals and conference proceedings, including one article in a journal indexed in the Scopus database; 3 scientific articles in 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 3 publications in the proceedings of international scientific conferences.

Volume and structure of the dissertation. The thesis is 145 pages long. The bibliography includes 249 references, and the dissertation contains 19 tables, 10 figures, and appendices.