ABSTRACT

of dissertation for the degree of Doctor of Philosophy (PhD)
of Kudasova Darikha Yeradilovna
in the specialty 6D070100 – Biotechnology
on the topic:
"Development of technology for microencapsulation of biologically active ingredients to increase the efficiency of their application"

General description of the work. The dissertation work is devoted to the development of technology for microencapsulation of biologically active ingredients to improve the efficiency of their use in crop growing during sowing.

Relevance of the research topic. Agriculture is one of the leading sectors of the economy of Kazakhstan. The main objectives of the implementing reforms in agriculture in Kazakhstan are to maintain the number of sown areas and their fertility, increase the production of high-quality seeds, increase productivity, improve product quality, efficient use of water resources, reduce the impact of the agro-industrial complex on the environment, ensure food safety.

It is known that in agricultural practice, to obtain guaranteed yields, agents of chemical protection and plant growth regulation are actively used. These include phytohormones and their synthetic analogues, microelements, bactericides, fungicides, acaricides and other biologically active compounds. Such chemicals are used in the treatment of plant seeds at different stages of ontogeny.

Agriculture is now seeing real impacts from the use of agrochemicals on the environment, food safety and human health, some of which are persistent organic pollutants. In recent years, their use has been limited worldwide and balanced agrotechnical measures have been proposed for environmentally and economically safe products that combine, along with improved functional characteristics, the possibility of less use of agrochemicals.

In this regard, it is relevant to reduce the use of protective agents and increase the effectiveness of plant stimulants by encapsulation, their dosed and controlled release, which will positively affect the intensification of crop growing and the rural economy as a whole.

Traditionally, plant stimulants can be applied directly, however, direct addition can lead to an excessive amount of the active agent, which can change the properties of the substance. Direct application of biologically active ingredients, such as growth stimulants, may result in inactivation or degradation, depending on the environment.

The development of active materials with the property of increasing the shelf life is currently one of the urgent problems. The use of a shell made of biodegradable and non-toxic materials is a possible solution to control the stability of active agents during shelf life, as well as to improve their safety and longevity when used on various crops. The use of the microencapsulated form of the active agents may be effective during the period of storage, processing or transport, and once the microcapsules have been applied, the active agents will gradually be released and retain their activity for a longer time compared to non-encapsulated

forms. In addition, in contrast to the usual introduction of the active substance and its distribution throughout the plant body, the use of nanocontainers allows to reduce the dose of the agent used and minimize its side effects. Additionally, it becomes possible to control the release of the substance from the container.

Thus, both plant stimulants and plant protection agents as active agents can be used in the form of microcapsules, since the latter with biodegradable matrices have been found to be an effective method of controlled and sustained release of the active substance used for plant protection, growth or nutrition. The benefits of encapsulation include more efficient operation, greater user safety, and better environmental protection. The key functionality that can be provided by encapsulation is the controlled release of the bioactive agent at the right place at the right time.

Moreover, the control of molecules at this level requires a comprehensive understanding of the structure and dynamic properties of the system to justify the use of active agents in microencapsulated form. The main hypothesis of the work is that an improved understanding of the molecular structure/reactivity relationship in complex microcapsules loaded with biologically active agents can help develop a new composition of microcapsules with specially selected properties for plants, as well as adjust their optimal composition.

In this regard, the research work on the development of technology for microencapsulation of biologically active ingredients in order to increase the efficiency of their application is relevant.

The research purpose: Development of technology for microencapsulation of biologically active ingredients to improve the efficiency of their application in crop growing during sowing.

To achieve the research purpose, the following objectives were set:

- selection of stimulants based on screening studies of their biological and physiological activity;
- choice of method for microencapsulation of stimulants;
- study of the stability, activity, and prolonged action of encapsulated objects, study of the kinetics of the release of the active agent;
- determination of the morphological and physiological characteristics of microcapsules;
- optimization of the composition of microcapsule shells with stimulants included using a system based on biodegradable materials – sodium alginate, calcium chloride and chitosan, and screening tests of microencapsulated and free biologically active substances on seeds and vegetative plants;
- development of a science-based technology for microencapsulation of plant growth stimulants.

The research object: amino-fumaric acid derivatives (dimethyl ester of amino-fumaric acid / sample No. 1, Z-isomer of potassium salt of 2-amino-3-methoxycarbonyl acrylic acid / sample No. 2, 1-Methyl-3-methylaminomaleimide / sample No. 3, 1-amino-3-keto-5,5-dimethylcyclohex-1-ene / Sample No. 4, trans diquabis (1-oxo-1,2 dimethoxycarbonyl acetate) of copper (II) / Sample No. 5). Systems based on biopolymers of chitosan, $CaCl_2$, sodium alginate, their

complexes. Seeds of cucumber, corn, wheat, barley were chosen as the main material for screening tests. The basis of the oil phase is soybean oil, purified water Milli-Q.

Scientific novelty of the work: For the first time, a technology for microencapsulation of new plant growth stimulants, amino-fumaric acid derivatives, was developed, in which the developed systems are used for the growth of sowing crops, while:

- morphological and physiological characteristics of microencapsulated forms of stimulants were determined;
- the regulatory properties of new stimulants in microencapsulated form were determined, which ensures environmental safety and improved functional characteristics;
- the effectiveness of the practical application of the technology of microencapsulation of stimulants for the growth of sowing crops was determined;

Thus, microencapsulated stimulants are recommended for production in the form of preparations used for plant growth and development.

Communication with the research plan.

The dissertation was carried out as part of the implementation of the grant of the Ministry of Education and Science of the Republic of Kazakhstan for 2018-2020 on the topic AP05132810 “Scientific and practical foundations of the technology of microencapsulation of biologically active substances and fundamentally new stimulants of plant development in order to intensify agricultural production” (2018-2020).

The degree of reasonableness and reliability of the dissertation:

The results obtained during the research were proven as a result of physicochemical, fluoroscopic, microscopic methods and statistical processing of experimental data. The equipment and materials used in the course of the research comply with the requirements of regulatory and technical documents.

The main provisions for the defense:

1. Evidence-based choice of stimulants based on the results of screening studies of their biological and physiological activity;
2. The method of microencapsulation of stimulants – amino-fumaric acid derivatives using sodium alginate, calcium chloride and chitosan in order to reduce the amount of chemicals used, the dispersion mode and other factors;
3. Optimized conditions for obtaining micro- and nanocapsules of plant growth and development stimulators based on the results of a study of the stability, activity and prolongation of the action of microencapsulated objects, and the kinetics of the release of the active agent;
4. Morphological and physiological characteristics of microencapsulated forms of stimulants;
5. Regulatory properties of the optimized composition of microencapsulated agents, in comparison with free stimulants, recommended for plant growth and development.
6. Efficiency of practical application of the technology of microencapsulation of stimulants for the growth of sowing crops;

7. Science-based technology of microencapsulation of plant growth stimulants.

Approval of the research work. The results of the research work were discussed at the following international conferences: “Topical issues of pharmacology: from drug development to their rational use”, 28-29 May, I Republican Scientific Practical Conference of Pharmacologists with international participation (Bukhara, Uzbekistan, 2020), LXVI International Scientific Conference “Actual scientific research in the modern world”, 26-27 October (Pereyaslav, Ukraine, 2020), scientific achievements. Collectied works of International Scientific Practical Conference, 25 September (Moscow, 2019).

Personal contribution of the author. The processing of the data obtained in the construction of the theoretical basis of tasks, the preparation of instructions and instructions for conducting research, the preparation of drawings of the experiment, as well as in the experimental control work, indicative studies and production experiments, the calculation of economic efficiency were carried out with the direct participation of the author.

Publications on the topic of the dissertation. On the topic of the dissertation, 4 scientific papers were published at international and republican scientific practical conferences, 1 article in a journal included in the international Scopus database with Q1 quartile, 2 articles in publications recommended by the Committee for Control in Education of the Ministry of Education and Science of the Republic of Kazakhstan, 2 articles in the journal included in the RSCI database, and 3 innovative patents were received on the research topic.

Structure and scope of the dissertation. The dissertation consists of introduction, 3 chapters, list of references and appendix, research results on 121 pages of text, 27 figures, 46 tables.