ABSTRACT

dissertation work of Anna Gennadievna Meshchanova
"Technology for the production of biologically active preparations based on balsam poplar with stimulating activity", submitted for the degree
Doctor of Philosophy (PhD) in the educational program
8D07102- Chemical technology of organic substances

Relevance of the topic . Modern agriculture faces many challenges, including the need to increase crop yields, plant resistance to stress factors and reduce the negative impact of agrochemicals on the environment. In this context, the use of biologically active preparations based on plant raw materials is becoming increasingly relevant. Balsam poplar (Populus bal z amifera L.), known for its unique chemical and biological properties, is a promising source for the creation of such preparations.

One of the key problems of agriculture in Northern Kazakhstan is the impact of unfavorable climatic conditions on the production of grain crops. Spring grain crops are exposed to extreme natural factors. During the period of crop germination, low temperatures may be affected, during tillering and tube formation, drought is observed, and at the following stages, excessive precipitation and the onset of cold weather. In such conditions, there is a risk of lodging of crops and a decrease in yield due to the creation of a favorable environment for the development of infectious diseases.

The use of biostimulants of various natures is considered a promising direction of sustainable agriculture, contributing to increased crop yields without negative impact on the environment. Plants are a valuable source of biologically active substances (BAS), such as vitamins, alkaloids, glycosides, saponins, tannins, polysaccharides (pectins, inulin, fiber, starch), flavonoids, resins, essential and fatty oils, organic acids, phytoncides, pigments and other compounds with a stimulating effect.

To increase the yield of agricultural crops, it is necessary to develop effective, environmentally friendly and economically viable solutions, which is the task of modern agriculture and biotechnology. In this context, the study of the effect of natural biostimulants on the growth and development of plants is of particular importance. The use of biostimulants based on plant extracts is becoming increasingly popular due to their natural origin, the absence of a negative impact on the environment and the possibility of using renewable raw materials.

Plant extracts have long established themselves as effective plant growth stimulants, immunomodulators and means of protection against pathogens. Balsam poplar, due to the high content of biologically active substances - flavonoids, phenolic compounds, tannins and essential oils - has significant potential for use in agriculture. These substances can stimulate plant growth, improve their resistance to adverse conditions and protect against diseases and pests. At the same time, poplar wood processing industry waste remains virtually unused, which is a promising source of affordable raw materials for the production of biostimulants.

The relevance of studying the technologies for the production of preparations based on balsam poplar is determined by the need to find effective, safe and environmentally sustainable solutions for agriculture.

The study of new methods for extracting biologically active substances, such as barothermal, as well as the study of the effect of the obtained preparations based on balsam poplar on the seeds of various agricultural crops, has significant potential for practical implementation in the agricultural sector. The development of technologies using industrial waste corresponds to the principles of sustainable development and reduces the cost of the obtained preparations.

Thus, the research aimed at developing a technology for producing biostimulants based on balsam poplar extracts meets modern requirements of agriculture, biotechnology and ecology, which makes this topic relevant and significant. An important argument in favor of obtaining biologically active substances from poplar is the environmental friendliness of such a solution, since a lot of unused waste (bark, branches, wood, leaves, buds) is generated during logging.

Objects of study:

Vegetative part of balsam poplar (bark, branches, wood, leaves, buds).

The aim of the dissertation is to develop a technology for the production of new herbal preparations based on biologically active substances of Populus balzamifera L., which have growth-stimulating activity.

Research objectives:

1. To conduct a comparative analysis of the qualitative composition of thick substances obtained from poplar buds using extraction and barothermal methods;
2. To conduct a comparative analysis of the qualitative and quantitative composition of the main groups of biologically active substances in extracts obtained from the buds, leaves, catkins, and twigs of balsam poplar;
3. Develop a method for obtaining a dry extract from the vegetative part of balsam poplar;
4. To establish the growth-stimulating activity of balsam poplar preparations (from poplar buds and its vegetative parts) in relation to the seeds of various agricultural crops.

Research methods:

The complex of physical and chemical research methods included: barothermal method of obtaining a thick substance, extraction, various types of chromatography, IR spectroscopy (Varian 660 IR spectrometer), UV spectroscopy (Spectruquant Prove 300, Merck), HPLC-MASS spectrometry (Agilent 1100 Series LC/MSD liquid chromatograph), qualitative reactions to extract components, concentration of extracts on an IR-1LT rotary evaporator.

The method of obtaining a thick substance from poplar buds, which has growth-stimulating activity, by the barothermal method allows, unlike the extraction method, to obtain valuable substances without the use of organic solvents, includes such advantages as product safety, no need to use flammable expensive solvents, fire safety. The method is cost-effective, as it significantly reduces the time of extraction of biologically active substances. A barothermal unit based on a medical autoclave allows obtaining a thick substance on an industrial scale.

The method for obtaining balsam poplar extract (including buds, leaves, bark and branches) with growth-stimulating activity is based on grinding plant materials, extraction with ethanol, filtration and evaporation to obtain a concentrated product.

The effectiveness of the extract is due to the presence of biologically active compounds such as flavonoids, coumarins, saponins, polysaccharides and amino acids, which help stimulate plant growth.

Scientific novelty of the work and theoretical significance of the dissertation:

1. Methods of spectrometric quantitative determination of flavonoids in poplar buds P opulus B alzamifera have been developed. The content of flavonoids in poplar buds has been determined depending on the time of their collection. The highest concentration of flavonoids was recorded in buds collected in March and constituted 10.62% of the dry raw material weight.
2. Optimal conditions for obtaining the maximum yield of thick substance by the barothermal method have been developed: pressure of 1.8 atm, feedstock feed - layer height up to 7 cm, raw material processing time - no more than 2 hours. For the first time, optimized technological block diagrams for obtaining thick substance from balsam poplar buds by the extraction and barothermal method have been compiled. Standardization of the finished product (substance from poplar buds) has been carried out.
3. Optimized schemes for studying the substance have been developed, including barothermal and extraction methods. Extraction of flavonoids from poplar resin is carried out using methylene chloride, and subsequent treatment with ethyl acetate allows for the effective isolation of gibberellins, which have growth-stimulating activity. The concentration of flavonoids isolated by barothermal and extraction methods has been calculated in terms of quercetin: 0.0038 g/ml and 0.0036 g/ml, respectively. The main components of the thick extract and their quantitative content were determined: 2',6'-dihydroxy-4'-methoxychalcone - 2.67%, 3,4-dihydro-2',6'-dihydroxy-4'-methoxychalcone - 2.33%, pinobaxin - 1.91%, chrysin - 0.76%, pinostrobin - 0.04%, pinocembrin - 0.61%, tectochrysin - 0.54% and galangin - 0.18% of the dry material.
4. For the first time, a comparative analysis of extracts from buds, leaves, twigs, catkins and waste from wood processing of balsam poplar was carried out. The qualitative and quantitative composition of the main groups of biologically active substances (flavonoids, tannins, coumarins, saponins, amino acids, polysaccharides) in the studied extracts, as well as in the total extractive substances isolated from them, was determined. For the first time, the optimal duration of extraction for these extracts was established. A comparative analysis of the IR spectra of the obtained extracts was carried out. The content of chlorophylls in the obtained extracts was analyzed.
5. , effective technological parameters have been selected and a technological process and standard for organizing the production of dry extract from plant material Populus Balzamifera *L.* in laboratory conditions have been developed.
6. For the first time, process regulations have been drawn up and an economic

justification for the production of dry extract from Populus Balzamifera *L. has been calculated*. It has been determined that a workshop designed for the production of dry substance from plant raw materials *Populus balsamifera* L. with an estimated capacity of 1792 kg per year will provide a profit of 12,479,933 tenge and will pay for itself within 3.5 years. The Organization Standard ST TOO 110540015567-01-2024, the technological process TP. SE. 000.001 have been developed and an economic justification for the production of dry extract has been carried out.

7. The radioprotective activity of evaporated poplar extract was studied. It was found that thick extract applied to protective screens made from paper has a significant radioprotective effect. When applying poplar extract 0.5 mm thick, the power of penetrating radiation is 78%; when applying poplar extract 1 mm thick - 48%.

8. The growth-stimulating activity of the extract obtained from poplar buds and wood processing industry waste has been studied. The effect of the thick substance of balsam poplar buds on tomato seed germination and seedling growth, the effectiveness of the growth stimulator on northern flax seed productivity, and the effectiveness of the growth stimulator on northern flax seed productivity have been studied. The growth-stimulating activity of the extract from wood processing industry waste has been studied for the first time on wheat seeds. The effect of the extract obtained from wood processing industry waste on physiological and biochemical indices and productivity of soybeans, sugar beets, and cucumbers has been studied.

Technical result

1. *Development of an effective technology for the extraction of biologically active substances*

Optimization of methods for isolating biologically active substances (BAS) from balsam poplar using extraction and barothermal methods.

2. *Reducing production costs*

The use of waste from the wood processing industry as raw materials for obtaining extracts ensures the environmental friendliness and economic efficiency of the technology.

3. *Increasing the efficiency of biostimulants*

Creation of herbal preparations with high growth-stimulating activity, confirmed by testing on seeds of various agricultural crops.

4. *Integrated use of raw materials*

Conducting a comparative analysis of extracts from the vegetative part of the plant (buds, bark, leaves, catkins) for their rational use.

5. *Environmental safety*

Offering a safe way to dispose of wood waste by processing it into useful products, which reduces the burden on the environment.

Practical application of the results

Development of universal phytopreparations based on balsam poplar, intended for wide application in agriculture, with an emphasis on increasing seed germination and productivity of agricultural crops.

The technical result provides a scientifically sound basis for the introduction of developed herbal preparations into agricultural practice and contributes to the expansion of the range of environmentally friendly biostimulants.

The author's personal contribution consists of choosing the direction and setting up the research, theoretical substantiation of the tasks, carrying out experimental work, processing the materials, interpreting and discussing the results obtained.

The main provisions of the dissertation submitted for defense:

1. A comparative analysis of obtaining a thick substance from balsam poplar buds by barothermal and extraction methods, analysis of the qualitative and quantitative content of the main groups of biologically active substances in the obtained substances was carried out. Optimal conditions for obtaining the maximum yield of a thick substance by the barothermal method were established: pressure 1.8 atm, layer height - 7 cm, raw material processing time - 2 hours.
2. Flavonoids contained in poplar resin were isolated by separating thick substances into individual components, with subsequent spectral identification. The main components of the thick extract and their quantitative content were determined: 2',6'-dihydroxy-4'-methoxychalcone - 2.67%, 3,4-dihydro-2',6'-dihydroxy-4'-methoxychalcone - 2.33%, pinobaxin - 1.91%, chrysin - 0.76%, pinostrobin - 0.04%, pinocembrin - 0.61%, tectochrysin - 0.54% and galangin - 0.18% from dry material.
3. A technological process and standard for organizing the production of dry extract from waste from the wood processing industry Populus Balzamifera have been developed.
4. A study was conducted on the growth-stimulating activity of herbal preparations obtained from poplar buds and waste from the wood processing industry.

Approbation of the work. The main provisions of the dissertation were presented at international scientific and practical conferences: "Youth and Science-2022", dedicated to the 85th anniversary of the North Kazakhstan University named after M. Kozybaev (Petropavlovsk, 2022), X International Scientific and Practical Conference "Actual Problems of Mathematics and Natural Sciences", dedicated to the 75th anniversary of Associate Professor R.A. Akberdina (Petropavlovsk-Barnaul-Surgut-Novosibirsk, 2022), IV International Scientific and Practical Internet Conference "Development Issues in the Spheres of Education, Science and Culture: Theory, Practice, Experience" (Nur-Sultan, 2022), VIII International Scientific and Practical Conference "Modern Trends in the Development of Science and the World Community in the Era of Digitalization" (Moscow, 2022), X International Scientific and Practical Conference "Modern Trends in the Development of Science and the World Community in the Era of Digitalization (Moscow, 2022), XLV International Scientific and Practical Conference " Eurasia Science " (Moscow, 2022), International Scientific Conference on Actual Problems of the Chemistry of Natural Compounds Dedicated to the 80th Anniversary of the Academy of Sciences of the Republic of Uzbekistan (Tashkent , 2023), J ubilee International conference “70 YEARS UCTM” (Sofia , 2023), 16 th World Congress on Polyphenols Applications (Malta , 2023).

Test reports have been received based on the results of experimental work to assess the effectiveness of the impact of a natural stimulator of growth, development

and protection of plants from diseases - poplar extract on the process of growing hard wheat Pearl of Siberia, soft wheat Omskaya - 35 in the Karaganda region, Nurinsky district, Zharaspaysky rural district, Zharaspay village.

Based on the results of experimental work to assess the effectiveness of the impact of a natural stimulator of growth, development and protection of plants from diseases - poplar extract on the process of growing soft wheat Novosibirsk, flax in the North Kazakhstan region, G. Musrepov district, Yalta village.

Structure and volume of the dissertation. The dissertation work consists of an introduction, 8 sections, a conclusion, a list of references from 241 titles, contains 220 pages of text, 37 figures and 63 tables.

The introduction substantiates the relevance of the topic. It is noted that the development of technology for obtaining biologically active preparations based on balsam poplar from waste wood of the Willow family will expand the range of growth stimulants. The goal, objectives, object and subject of the study are defined, the scientific novelty, practical significance of the work are revealed, and research methods are presented.

The first section describes the chemical composition of POPULUS BALZAMIFERA L. plants, studies theoretical material on the isolation of biologically active substances from plant raw materials and the use of plant extracts as biostimulants.

Second The section includes a description of the method of spectrometric quantitative determination of flavonoids in the buds of the poplar P opulus B alzamifera. The content of flavonoids in poplar buds was determined depending on the time of collection.

The third section presents the optimal conditions for obtaining the maximum yield of thick substance by the barothermal method. Optimized technological block diagrams for obtaining thick substance from balsam poplar buds by the extraction and barothermal methods are given.

The fourth section presents the results of the study of the qualitative composition of substances obtained from poplar buds using extraction and barothermal methods, and provides the results of the analysis of the composition of the extracts using IR spectrometry and chromatography.

In the fifth section A comparative analysis of extracts from buds, leaves, twigs, catkins and waste from wood processing of balsam poplar is presented. The results of the analysis of the qualitative and quantitative composition of the main groups of biologically active substances (flavonoids, tannins, coumarins, saponins, amino acids, polysaccharides) in the studied types of extracts and the sum of extractive substances isolated from them are presented.

The sixth section presents an analysis of the implementation of the selection of effective technological parameters and the development of a technological scheme for obtaining a dry extract from the plant material Populus Balzamifera in laboratory conditions. Technological regulations are presented and the economic justification for the production of isolation of total dry extract from Populus Balzamifera is calculated.

The seventh section includes a study of the radioprotective activity of evaporated poplar extract. The results are presented that the thick extract applied to protective screens made on the basis of paper has a significant radioprotective effect.

The eighth section presents study of growth-stimulating activity of the extract obtained from poplar buds and waste from the wood processing industry. The effect of the thick substance of balsam poplar buds on the germination of tomato seeds and the growth of seedlings, the effectiveness of the growth stimulator on the seed productivity of northern flax, the effectiveness of the growth stimulator on the seed productivity of northern flax were studied. Studies of the growth-stimulating activity of the extract from waste from the wood processing industry on wheat seeds are presented.

The conclusion presents the main findings based on the results of the experimental studies conducted.

Personal contribution of the author. The personal contribution of the author consists of conducting theoretical and experimental research that substantiates the main provisions submitted for defense, and the author also plays a significant role in generalizing and analyzing the results obtained.

Description of the doctoral candidate's contribution to the preparation of scientific publications. The dissertation candidate is the corresponding author of all scientific articles published based on the results of the research work. Based on the results of the dissertation work, 19 scientific papers were published, including 8 articles, 9 reports at international and national conferences, 2 patents of the Republic of Kazakhstan were received.

The author expresses deep gratitude to the scientific supervisor, Doctor of Chemical Sciences, Professor of the Department of Chemistry and Chemical Technologies of the North Kazakhstan University named after M. Kozybaev, Vladilen Vasilyevich Polyakov and foreign scientific consultant, Doctor of Chemical Sciences, Professor of the Institute of Chemistry and Chemical-Pharmaceutical Technologies of the Altai State University, Barnaul, Natalya Grigoryevna Bazarnova for invaluable support and consultations during dissertation research.