



Formation of a knowledge base in the field of technologies and physical effects for the preparation, storage and use of seed potatoes

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Abstract

Preparation, storage and efficient use of planting stock are the most important operations of end-to-end procurement technologies - transportation of agricultural products for the production of functional products. Among the most significant agricultural products for consumption by the population of many countries of the world are potatoes. This led to many years of research and development by scientists in the field of preparation, storage and efficient use of seed potatoes. However, these problems have not been completely resolved, which, for example, in Russia is largely caused by the destruction of the potato industry during the years of perestroika. In Russia, a significant factor hindering the growth of productivity and quality of potatoes is the low quality of planting stock. Of about 400 varieties of potatoes in the domestic market, about half are foreign breeding. There is an underestimation of the importance of potatoes for the production of functional foods. The authors believe that the most important condition for assessing the state and development trends of innovative research is the formation of a knowledge base in the field of technology and technology for the procurement and use of seed potatoes. A systematic scientific-informational and patent search made it possible to give such an assessment and form a knowledge base in the field of technologies and physical effects for the preparation, storage and use of seed potatoes for the production of high-yielding agricultural products.

Keywords: knowledge base, information and patent search, tubers, preplant planting, seed potatoes, physical effects, potato storage

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INTRODUCTION

Since in Russia potato is one of the most important crops for consumption by the country's population, it is a part of products that ensure food security in Russia, as part of the Petrozavodsk State University jointly with the "Yarmarka" Trading House project "Research and development of an end-to-end technology for the production of functional foods to ensure food safety in the northern territories of the Russian Federation" (project identifier - RFMEFI57717X0264), supported by the Minister Twomey Higher Education and Science of the Russian Federation (Shegelman et al. 2018, Shegelman et al. 2019), serious attention paid to the problems of the domestic potato, as well as innovative solutions in the field of preparation, storage and use of seed potatoes (Shegelman et al. 2018, 2019b).

According to Ignatov A.N. et al. (2019), potato is in fourth place among food crops in the world, and is one

of the main food products of the Russian population. However, the high incidence of potatoes by viral, bacterial, oomycete and fungal diseases seriously affects crop productivity, leading also to economic losses due to culling of seed potatoes and an increase in storage losses. In recent years, there has been an increase in the severity of potato diseases, associated with climatic changes, changes in pathogen populations, a change in cultivated potato varieties and other plant pathogens affected.

As noted in Decree of the Government of Russia dated 05.05.2018 No. 559, potatoes are traditionally the second most important crop product in Russia after cereal crops. The average annual volume of its cultivation in agricultural organizations and peasant

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(farmer) farms is estimated at 6-7 million tons. Russia for potato production is in third place in the world. A distinctive feature of potato growing in Russia remains its focus on the domestic market. The structure of the domestic potato market in agricultural organizations and peasant (farmer) enterprises includes table potatoes - 4-5 million tons, seed potatoes - up to 1 million tons and potatoes for processing - up to 1 million tons.

It was noted in the work written by Bulla R.J. (2011) the importance of potatoes is confirmed by the fact that it is grown as the most important agricultural crop in almost all states of the United States, where annual potato production exceeds 18 million tons, and in the world this volume exceeds 300 million tons.

Experts believe that in order to increase the productivity of domestic potatoes, it is necessary to introduce agricultural enterprises specializing in the production of high-yielding varieties of seed potatoes into practice, it is necessary to adapt the technologies and methods of working with seed potatoes to regional natural-production conditions (Zamotaev et al. 1987, Zazorina 2008).

Specialists pay special attention to taking into account the regional specifics of the conditions of preparation and cultivation, as well as soil and climatic conditions in the justification and selection of effective technologies and varieties of seed potatoes. The research, development, and recommendations given in the Handbooks of Potato Breeders prepared under the guidance of Zamotaev (1987) and Karmanov (1983), as well as in (Rychkov et al. 2007) and others, are devoted to this problem. For the conditions of the North-West of Russia, serious research in works (Evstratova 2003, Matveeva 1997).

Particular attention in the practice of potato growing in (Kvasnuk 2004, Korshunov 2018, Patrikeeva 2010) is given to technologies that provide effective protection of seed potatoes from diseases.

Despite the fact that the problems of preparation, storage and efficient use of seed potatoes have been studied for a long time by Russian scientists, they have not been completely resolved to date. This necessitates the formation of a knowledge base in the field of assessing the state and development trends of technologies and physical effects for the preparation, storage and use of seed potatoes for the innovative development of seed potato growing and the production of high-yielding agricultural products.

LITERATURE REVIEW

Experts note the crucial role of potatoes as one of the main sources of relatively cheap carbohydrates in the diet of the population of Russian regions, as a very common animal feed, and also as agricultural raw materials for the food industry. Moreover, despite the fact that the stable provision of the population with

potatoes depends on the sustainable development of its seed production as the basis of the potato product subcomplex (Safronov 2005), the problems of preparation, storage and efficient use of seed potatoes have not been finally resolved.

Due to the severity of the problem, the Resolution of the Government of Russia dated 05.05.2018 No. 559 by amending the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2025 approved the subprogram "Development of selection and seed production of potatoes in the Russian Federation". The purpose of this program is to ensure stable growth in production and sales of high-quality seed potatoes of modern competitive domestic varieties based on the use of new high-tech Russian developments and comprehensive scientific and technical projects of a complete innovation cycle.

We believe that the developers of the subprogram quite justifiably and very promptly included in the assessment of the indicators achieved during its implementation the number of:

a) developed technologies for breeding and seed production of potatoes protected by Russian and/or foreign conservation documents;

b) the registered results of intellectual activity.

In Russia, in order to optimize the indicators of commercial quality of seed potatoes, to bring them closer to international standards and to unify them with the main provisions and rules in the field of international trade in seed potatoes, from 01.01.2018 a new interstate standard GOST 33996-2016 "Seed potatoes. Technical conditions and methods for determining quality."

As Koksharova M.K. (2004) wrote, the task of organizing the protection of potatoes from viral diseases and combating them requires the effective use of the achievements of science in the field of seed production, selection and virology. To this end, a wide range of studies will be carried out (Anisimov et al. 2013, Vasilev 2013, Prishchepenko and Zamalieva 2013).

Russian scientists are conducting a scientific search to increase the efficiency of growing seed potatoes using various growth regulators (Artafit, Albit, Polistin, Mival-Agro, Zircon, Ecogel, Epin-Extra), which significantly increase the number of tubers of the seed fraction. In studies, seed potato crops were sprayed twice during the growing season. The effectiveness of such regulators was proved, but it was noted that they had an individual selective character of action on different varieties of potatoes (Nikolaev et al. 2015).

It has been established that the use of low molecular weight chitosan induces resistance to viral infection in plants (Chirkov 2002), however, it is low - not more than 50% efficiency against potato viruses.

In work by Sysoeva M.I., Matveeva E.M., Sherudilo E.G., Markovskaya, E.F. (10.02.2009), it is noted that in the conditions of the Northwestern region of the Russian Federation for potatoes, the potato cyst-forming

nematode *Globodera rostochiensis* Woll is a common, dangerous and highly harmful pest, under the influence of which the yield decreases by 30-60%.

Experts note that in Russia, seed growing in the potato industry was destroyed during the years of perestroika, and only in the last 5-7 years it began to gradually revive. According to the Potato Union, out of about 400 varieties of potatoes in the Russian market, only 52% is in domestic selection. Of the 10 leading varieties that occupy almost 80% of the planting of seed and potato, only 2-3 are domestic. According to A. Krasilnikov, executive director of the Potato Union, large chain stores that came to Russia initially worked on imported products, often had foreign owners and well-established foreign relations. Over the past 10 years, the share of foreign varieties of seed potatoes has increased by 25.9%, while domestic varieties have decreased significantly (Koksharova 2004). At the same time, the growth of yield and quality of potatoes in Russia is restrained by the low quality of planting material, and V. Gorbachev, general director of "Krasny Oktyabr" company (Bryansk region) notes that only imported varieties have been used in the farm for the last ten years - they did not find a good domestic seed potato.

A. Meleshin, deputy director of the Moscow Research Institute of Potato, also notes that the potato varietal base is in decline. Russian scientists have created and continue to create new effective varieties of potatoes, but it is difficult for Russian varieties to get even to the domestic market, not to mention export. As a result, as Tatyana Gubina, deputy chairman of the Potato Union, notes, part of the crop will be obtained from poor-quality seed material that cannot be sold.

All this confirms the view that the innovative development of seed potato production requires the formation of a knowledge base for assessing the status and development trends of research in the field of technologies and physical effects for the preparation, storage and use of seed potatoes, as well as identifying promising patented developments in this field.

MATERIALS AND METHODS

The materials used in this work included the results of systematic patent information searches under the grant "Research and development of end-to-end technology of functional food manufacture for achieving food supply security for north territories of the Russia."

The aim of the study was to analyze the status and development trends of research in the field of preparation, storage and use of seed potatoes, aimed at the innovative development of seed potato growing. To achieve this goal, a detailed patent information search of literary sources and normative documents in the field under consideration was performed.

Terms and definitions used: potato is a perennial plant belonging to the Solanaceae family of Solanum

genus Solanum, cultivated with the aim of obtaining tubers that are used for human nutrition, as raw materials for the processing industry, as well as for animal feed; tuberization - the process of formation, growth and development of tubers; early potato cultivar - a potato cultivar characterized by the formation of a harvest of marketable tubers 60-70 days after planting seed tubers in the soil and having a vegetation period of 80-90 days; tubers shelf life - the ability of tubers to maintain their qualities under normal conditions of storage without significant changes during the storage and/or transportation period; seed potatoes - tubers or any other planting material, except for potato seeds of the botanical species *Solanum tuberosum* L, which, on the basis of regular assessment during growing and sorting, are recognized as suitable for propagation in the established manner.

The research methodology provided for the collection, synthesis and analysis of information collected on the basis of the study of patents, scientific and technical literature with the identification of the characteristics of various methods and devices in the field of preparation, storage and effective use of seed potatoes. The technological operations of preparation, storage and use of seed potatoes were considered as elements of end-to-end harvesting technologies - transportation of agricultural products and food production. Particular attention in the research is given to identifying the physical effects used in this process and the patented technical and technological solutions as the basis for identifying promising innovative solutions (Shegelman et al. 2019a).

These materials and methods formed the basis for the formation of a knowledge base characterizing the state and development trends of research in the field of development of technologies for the preparation, storage and use of seed potatoes, as well as for identifying promising patented developments in this field.

RESULTS AND DISCUSSION

To compete in the domestic and foreign seed potato markets, it is necessary to accelerate the introduction of innovative technologies and the promotion of competitive potato varieties (Anisimov and Zebrin 2018).

All this, as in other areas of activity, determines the need to search for patentable solutions. The most important factor for assessing the state and development trends of innovative research, along with the study of scientific and technical literature, is a patent search, which made it possible to give such an assessment in the field of preparation, storage and use of seed potatoes.

Specialists from the All-Russian Research Institute for Plant Protection note that more than 20 viruses are known to infect potato plants, among which the most

harmful viruses are X and Y, which are often present in plants together and reduce tuber yield by 40-60%. They cause general plant inhibition, twisting, wrinkling or spotting (mosaic) of leaves, reduce the yield and quality of tubers and are the main cause of degeneration of potatoes. Since potatoes are propagated vegetatively and most viruses can pass into daughter tubers, the proportion of plants infected with viruses increases as planting material multiplies. In this regard, the named institute patented the invention for a concentrated composition and method of protecting seed potatoes at all stages of seed production from viruses X and Y (Evstigneeva et al. 2015). The objective of the invention is to develop a concentrated composition for the protection of potatoes, stable during long-term storage, with high biological efficiency against viruses X and Y, cost-effective for storage and use, safe for humans and the environment. The problem is solved by creating a concentrated composition based on chitosan with Mm. 30-40 kDa, with a degree of deacetylation of 75-90%, sodium salt of salicylic acid and 6-benzylaminopurine. The concentrated composition and method allow to protect potato plants from the most harmful viruses X and Y, as well as to obtain virus-free potato seed tubers.

A team of authors (Tulinov et al. 2017) patented a special device for spring vernalization of seed potatoes. The device's infrared lamps provide drying and heating of potato tubers, and LED lamps promote enhanced metabolism in the tuber cells, stimulate their germination, then bactericidal lamps disinfect these tubers. According to the authors, the use of a plant for the vernalization of potato tubers using a preparation containing natural phenolic compounds made it possible to obtain a yield increase of 4.3 t / ha. In addition, the dry matter content in tubers increased by 1.4%, starch by 0.5%, vitamin C by 0.7 mg%.

It is known that the processing of potato tubers using physical effects prevents the pollution of agricultural land and allows, without chemical intervention, more efficient use of the capabilities of potato tubers. Among them, methods of presowing stimulating treatment of potato tubers with low-frequency magnetic fields (Titenkova and Makarova 2015). Nizhny Novgorod State University of Engineering and Economics has patented a plant for the pre-planting treatment of potato tubers under the influence of electrophysical factors (Kotin et al. 2019). The purpose of the preventive treatment of potato tubers before planting by the combined action of electrophysical factors is to disinfect from a number of pests, to activate potato tuber cells to accelerate and increase their germination, with the exception of side effects on the physicochemical composition of the grown potatoes. An object of the invention is to eliminate the shortcomings in the use of chemicals, reduce operating costs when implementing the technology of pre-planting processing of potato tubers and using the installation in farms due to the combined effects of such physical

factors as electromagnetic field of ultra-high frequency, corona discharge, ultraviolet rays, ozone and induction heating up.

A number of solutions are patented in the field of micro-tubers. For example, in patent (Seleznev 2019), the acceleration of the processes of formation and growth of potato mini-tubers is ensured by the use of a light flux of combined spectral composition and a fog-forming method of irrigation of cultivated plants, and the increase in yield is achieved by increasing the density of plants per unit area.

A patent of Chechen State University (Sibiryatkin et al. 2018) proposed a method for producing micro-tubers without the use of phytohormones by changing the mineral composition of the nutrient medium and the physical conditions of cultivation. At the same time, potato plants cultivated *in vitro* are cut and placed on a nutrient medium containing macro- and microelements according to the prescription Murashige and Skoog, Fe-chelate, agar-agar, and sucrose. When they reach a height of 5-6 cm under conditions of a laminar box, the developed nutrient medium cooled to 30 ° C is added to the tubes with plants. Then the tubes with plants are placed in complete darkness for 45-60 days at a temperature of 21 -25 ° C. At the end of this period, 98% of plants form 1-2 micro-tubers per shoot. It was experimentally proved that the temperature shock caused by the addition of a warm nutrient medium to the culture vessels with the subsequent placement of plants in the dark stimulates tuberization in them without phytohormones, which reduces the cost of micro-tubers production. This is also facilitated by a decrease in the concentration of ammonia nitrogen in the nutrient medium and an increase in the concentration of sucrose to 80 g / l.

InSelect Limited Liability Company has patented a method for growing mini-tubers of healthy potatoes (Nikolaev et al. 2015). The problem solved by the invention is the increase in the number of potatoes mini-tubers in an aeroponic installation under the influence of an organosilicon biostimulator and magnetization of a nutrient solution. According to the method, four times during the growing season of potato plants, the roots are treated with the nutrient solution of the Mival-Agro silicone biostimulator at a concentration of 2.5 g of the drug per 10 l of water, which is simultaneously magnetized. According to the data, the combined use of an organosilicon biostimulator and magnetization of the nutrient solution increases the yield of mini-tubers to 98 pieces from one plant.

Samara Research Institute of Agriculture named after N.M. Tulaykova patented a plant for growing potato minitubers (Milyukhin et al. 2019). The installation consists of a lightweight support frame, planting trays for plant cultivation with frontal plastic doors, a plant lighting unit and a nutrient solution supply system. This feed system consists of a container for a nutrient solution, an

ultrasonic fog generator, polypropylene pipelines connecting a container for a nutrient solution with an ultrasonic fog generator, and the latter with landing trays. Plant nutrition is provided by supplying a nutrient solution in the form of a fine suspension (fog) into the zone of the root system of planting trays, through the operation of an ultrasonic fog generator, through a piping system. The plant is able to maintain a humidity level of up to 100%, depending on the cultivation requirements and the needs of the plants grown.

The Agrochemical + Research and Production Association has patented a nutrient solution to increase the productivity of potato micro-tubers in an aeroponic plant (Ozheredova et al. 2019). The solution contains in 1 liter of water: calcium nitrate (calcium nitrate) - 1 g, monosubstituted potassium phosphate - 0.25 g, magnesium sulfate - 0.25 g, potassium chloride (potassium salt) KCl - 0.125 g and iron chloride - 0, 0125 g. The novelty of the solution lies in the fact that it contains boric acid - 19.63 g, manganese sulfate - 14.00 g, zinc sulfate - 1.41 g, copper sulfate - 1.41 g, microbiological preparation - 5 ml. According to the authors, the use of the solution and its introduction into production will increase the productivity and quality of potato micro-tubers. The volume of production when using the solution is 14960 more micro tubers from one aeroponic installation.

The company SETS, LLC (US) patented a system with a controlled environment and a method for the rapid cultivation of seed potatoes to obtain micro-tubers (Bulla 2011).

A device patented by the Velikiye Luki State Agricultural Academy (utility model patent (Titenkova et al. 2016) reduces energy consumption, increases productivity, increases the germination and growth energy of potato tubers to create a pulsed low-frequency magnetic field and device for heating seed potatoes by using infrared lamps to irradiate seed potato tubers above and below. The objective of the utility model is to create a plant for presowing processing of seed potatoes, characterized by high efficiency with the simplicity of the design, eliminating the possibility of injury, allowing you to adjust the processing performance. The technical result is simplicity of design, reduced energy consumption, increased productivity, increased germination and growth energy of potato tubers. This technical result is achieved by the installation, including a chamber for creating a pulse low-frequency magnetic field and device for heating seed potatoes. On the inner surface of the electromagnetic winding of which there is a reflector with a device for heat treatment placed in it in the form of tubular infrared lamps for irradiation of tubers from above and below, and the conveyor belt is made of non-metallic mesh. The top conveyor belt with seed potatoes moves inside the chamber.

To increase the cold resistance of seed potatoes, the Institute of Biology of the Karelian Scientific Center of the Russian Academy of Sciences proposes germination at a temperature of +18 ... + 23 ° C before planting tubers for 24-27 days, and for 4-6 days, tubers are processed at 2-3 hours daily +5 ... + 6 ° C (Sysoeva et al. 2009).

To increase the keeping quality during the storage period, InSelect LLC proposed the use of complex processing of seed potato tubers before planting with Penncozeb with a consumption rate of 1.2 kg for the active substance per 1 ha, and then using three times the processing of Confidor 0.03 kg / ha during germination plants, during seedlings, active growth in a concentration of 0.04 kg / ha together with Emistim (10 l / t), and the subsequent application of microfertilizer Aquamix in a concentration of 0.1% in combination with Penncozeb with a consumption rate of 1.5 kg / ha during the formation of tubers d (Hapova and Hapov 2018). Experiments have shown that this method increases the yield of varieties Asterix, Dolphin, Naiad by 15%, Vector, Vineta, Riddle, Lark by 18%, Nora by 19%, with an increase in the quality and keeping quality of seed potatoes during storage. The profitability level increased by 49% compared with the control, and amounted to 168%.

The Research Institute of Agriculture of the Komi Republic proposed pre-planting treatment of seed potato tubers in a container filled with a liquid biostimulator (potassium / sodium humate with trace elements with a concentration of 5-5.2 g / l of active substance at a flow rate of 40-50 l of solution per 1 t of potatoes), use a centrifugal tank and carry out processing with constant stirring for 2-3 min. The technical result of the method is to improve the quality of the seed (effect on the tuber at the cellular level, accelerate the process of water metabolism), eliminate damage to the tubers of planting potatoes, simplify the processing method and the possibility of processing tubers of various shapes and sizes. An additional technical result is a reduction in the cost of mineral fertilizers when planting potatoes (by 50% of the norm). Another installation of a similar type was previously patented by this institute (Tulinov and Lobanov 2015).

For potato-producing peasant (farm) farms, the Nizhny Novgorod State Agricultural Academy patented the design of a potato planter (Oshurkov et al. 2020). The problem the design is aimed at combining the functionality of automatic planting of ungrown tubers and semi-automatic planting of grown tubers in one combined potato planter for peasant (farmer) farms and selection seed-growing nurseries, which allows to increase the yield of potatoes, reduce the specific metal consumption of the structure and reduce the term return on investment. This task is achieved due to the fact that the combined potato planter includes a frame with an automatic coupler lock, support wheels, planting devices

of an elevator-chain type with spoons and a casing or without a casing and with cups, which are nourished on the virgin branch of the chain with a feeding top and loading bunkers, the drive of the planting devices, openers and disc furrow closers, and in front of each planting device there are seats for planters, against which are fixed platforms for placement working containers with seed material, with a cup diameter of 110 mm and a height of 50 mm. The technical result provided by the given set of characteristics is to ensure the planting of ungrown and sprouted potato tubers in the automatic and semi-automatic modes with one combined potato planter, which allows to increase the yield of potatoes, reduce the specific metal consumption of the structure and reduce the payback period of investment.

The Chuvash State Agricultural Academy for the cultivation of early potatoes, after a preliminary stage of light germination, proposed to sprout 3-5 mm in size for 15-20 days at a temperature of 12-15 ° C, cover the surface of the tubers with a peat-shell mixture with the addition of hydrogel granules and continue to germinate after drying 10-15 days at a temperature of 15-25 ° C until sprouts appear above the surface of the shell (Semenov et al. 2017). The purpose of the invention is to reduce the duration of maturation of early potatoes after planting. This goal is achieved by the fact that for planting use tubers sprouted in the nutrient shell.

The North Caucasian Research Institute of Mining and Piedmont Agriculture proposes to germinate potato tubers by treating them with a mixture of crushed tubers, molasses, dry distillery stillage and zeolite-containing clay (Bekuzarova et al. 2015). The trace elements and vitamins that make up the enveloping mixture contain various types of antioxidants (vitamins, selenium, amino acids, iodine, rubidium and others), which ensure the resistance of tubers to phytopathogens and viruses. In the initial period of growth, the enveloping tubers film helps to retain moisture and the required amount of nutrients for the full development of plants. The property of zeolite-containing clay beculite - to absorb heavy metals from the soil, provides safe and environmentally friendly conditions for plant growth. Research data showed that in the proposed embodiment, the tubers are not affected by viral diseases, stem nematode, the prevalence of latex late blight is reduced from 25% in the control to 0 in 5 and 6 variants. Moreover, the proposed version of the mixture due to the disposal of plant waste (dry distillery stillage and molasses), a natural source of raw materials (clay beculite) and crushed tubers of the same varieties can reduce their incidence at no additional cost while improving the quality of seed and marketable tubers (with a yield of more 90%) with a crop exceeding 30 t / ha.

Novosibirsk Institute of Organic Chemistry named after N.N. Vorozhtsova and the Siberian Research Institute of Agriculture and Chemicalization of

Agriculture to increase the yield of potatoes by treating seed tubers before storing it, it was proposed to process the potatoes when laying for storage with fir green extract obtained by boiling it with methyl tert-butyl ether and treated with N, N'-tetramethyldiamine methane, extracts of a mixture of Usnea or Cladonia lichens obtained by boiling air-dried raw materials in isopropyl alcohol (Polovinka et al. 2015). The analysis showed the promise of using natural products for the autumn treatment of tubers as phytofungicides-protectants. The potato yield during the processing of seed tubers increased by 28-56% relative to the control.

All-Russian Research Institute of Irrigated Horticulture and Melon Growing has patented a method of potato cultivation (Ermakov et al. 2011), which includes vernalization of seed tubers with biostimulants and inhibitors of pathogens, planting tubers on top of ridges and applying mineral fertilizers, in which mineral fertilizers are applied fractionally with water under drip irrigation in basic proportions in established proportions in series with established proportions phenological phases of potato growth, and onions on turnips and winter rye are used as a precursor.

National Research Tomsk State University has patented a method that allows you to control the dynamics of tuberization with an increase in the yield of environmentally friendly healthy seed potatoes while minimizing the costs of hormonal preparations. (Golovatskaya et al. 2018) in which, in the process of adaptation to a liquid nutrient medium, the root system of regenerated plants is treated with a biologically active substance - a solution of low concentration brassinosteroids is cultivated under hydroponic conditions at a light flux intensity of $350 \pm 50 \mu\text{mol} / \text{m}^2 \text{ s}$. The purpose of the claimed invention is to regulate the release of high-quality environmentally friendly healthy seed material of potatoes at low labor and financial costs. The problem solved by the invention is the development of an economical way to increase plant productivity by adjusting the timing and increasing the yield of healed potato seed material in hydroponic conditions. The essence of the invention consists in the selection of the type of brassinosteroids, effective concentrations and light exposure to control the timing of tuberization and the size of the tubers. A method for increasing the tuberization and productivity of potato plants under hydroponic conditions, like analogues, involves treating plants with a solution of biologically active substances. In contrast to the prototype, in the process of adaptation to a liquid nutrient medium, the root system of regenerated plants is once treated with a weakly concentrated solution of brassinolide or 24-epibrassinolide, or 28-homobrassinolide, or the Epin-Extra preparation and cultivated under hydroponic conditions when illuminated with a light flux of $350 \pm 50 \mu\text{mol} / \text{m}^2 \text{ s}$. The biological product is based on phytohormone, which refers to steroids -

epibrassinolide. Epibrassinolide is an artificially derived similarity to the phytohormone brassinolide.

Samara Research Institute of Agriculture named after N.M. Tulaykova patented a biotechnological function plant for the production of seed potatoes (Milekhin et al. 2018). This installation is equipped with a unit for lighting plants and a nutrient solution supply system. At the same time, the planting landing tray is made of chemically stable plastic in the form of a closed reservoir, in the upper part of which low-pressure nozzles performing circular spraying are made. Plant nutrition is provided by supplying a nutrient solution of mineral elements to the zone of the plant root system, due to the finely dispersed spraying of the nutrient solution with low-pressure nozzles installed in the upper part of the landing tray between the rows of landing holes. The plant is able to maintain a humidity level of up to 100% depending on the cultivation requirements and the needs of cultivated plants.

Institute of Chemical Physics N.N. Semenova together with the state farm "Zhdanovsky" to reduce losses during storage of seed and ware potatoes patented method (Kuchumov et al. 1994), according to which the potatoes are contained in bulk with the established parameters of the height of the placer. During the treatment, transitional and main periods of storage, cyclical ventilation of potato placers with air with established parameters of the air flow rate, its temperature and humidity is carried out.

All-Russian Research Institute of Potato named after A.G. Lorha patented a method for cultivating tubers (Masyuk et al. 2019). The method is characterized by the fact that they carry out the planting of pre-sprouted, planted and treated growth activators of Jerusalem artichoke tubers and potatoes. Tubers are planted along the bluegrass-planted field end-to-end with straight, continuous, alternating lines up to 50 m long in 2 rows of Jerusalem artichoke and in 2 rows of potatoes with row-spacing between pairs of rows of the same culture 30 cm and row-spacings between crops of 60 cm. Then the plants are grown, inter-row processing and harvesting. The method is favorable for growing super-super elite, super elite and planting material of high reproductions for potatoes and Jerusalem artichoke. Additional effect: with a general increase in potato productivity by 1.7-1.8 times, it becomes possible to use potato tops for livestock feed, since getting into the feed together with Jerusalem artichoke and bluegrass tops in a ratio of 1: 100 to 1: 300 concentration corned beef, harmful to animals is reduced by an order of magnitude and does not threaten their health. In addition to the harvest of potato tubers, up to 50 t / ha of Jerusalem artichoke tubers are harvested from the same area, which can be eaten, fodder or sent for processing (obtaining inulin, fructose, ethyl alcohol). According to the authors, Jerusalem artichoke plants reliably protect potatoes throughout the growing season, protecting them from

flying Colorado beetles and aphids, and the specific microflora of Jerusalem artichoke free the soil from various types of pathogenic fungi (Abashkin et al. 2015).

To accelerate the energy of germination and germination of tubers and increase the yield of potatoes, offers to use physical effects are expanding.

The Scientific Research, Design and Engineering Institute of the Agro-Industrial Complex of the Komi Republic patented a device (Triandafilov and Fedyuk 2011) for presowing treatment of seed potato tubers that contains a biostimulator in the form of a highly dispersed mass, which has adhesive ability and high nutritional value from an aqueous suspension of peat treated by means of an electro-hydraulic effect.

Ryazan State Agricultural Academy. P.A. Kostychev for the production of elite seed potatoes is proposed to influence the potato planting material with a stream of optical radiation in the red region of the spectrum. At the same time, it was proposed to carry out this effect with incoherent light with established parameters of radiation powers, wavelength range, and radiation dose (Savina et al. 2006).

The Federal Scientific Center for Biological Systems and Agrotechnologies of the Russian Academy of Sciences has patented a method for preplant treatment of seed potato tubers (Mushinsky et al. 2019). The method involves the use of Fe iron nanoparticles with a size of 80 nm and silicon oxide nanoparticles of SiO₂ with a size of 25 nm and their optimum concentration of Fe NPs 16×10^{-4} mol / L and SiO₂ NPs 6×10^{-3} mol / L in a mixture with stabilized electrochemically activated aqueous catholyte with a pH of 8-9 and Eh = -400 ... -500 mV in a vacuum medium at a pressure of 650-680 mm Hg with simultaneous stirring in a drum with a rotation speed of 10 rpm for 5 minutes, while the stabilizer using an amino acid from the group of polar uncharged amino acids, which is glycine, in an amount of 0.01 wt. % The method eliminates the duration of pre-planting light germination - vernalization for 15-20 days and extends the applicability of the method of growing potatoes in factorial laboratory conditions. The method is environmentally friendly and can increase the maximum potential of the variety by increasing the polarity of the tuber and improving the technology of potato cultivation, which predetermine the increase in both the quality of the variety and the yield by 30-40% (Anisimov et al. 2016).

The All-Russian Scientific Research Institute of Irrigated Agriculture and a group of authors patented a method (Melikhov et al. 2004) that improves the presowing treatment of seed potato tubers by the light method for 20-25 days at a temperature of 12-14 ° C. Improvement is achieved due to the fact that after germination, a layer of a solution of the natural mineral bischofite is applied in finely dispersed manner on their surface with intensive mixing. At the same time, the density, temperature 80-95 ° C, atomization pressure

and droplet sizes established in accordance with the patent are regulated. The same institute patented a method, in which when storing seed potatoes, the tubers are dried after harvesting with outside air with the set ventilation rate and duration, and after holding the tubers with cyclic ventilation, an aqueous solution of aminoacetic acid is used to moisten acids, tubers are cooled, and for 10-12 days before unloading from the storage, the potatoes are heated with the established temperature regimes.

The All-Russian Scientific Research Institute of Irrigated Agriculture also patented a method (Melikhov et al. 2011) that allows to realize the genetic potential of a variety in terms of productivity, to maintain high seed quality by replicating early ripe potato varieties in summer plantings.

An increase in yield due to the quality of planting potatoes while reducing fertilizer consumption by creating equal favorable initial conditions for the development of tubers provides a method patented by the Federal Scientific Agroengineering Center (Eryomin et al. 2018), in which the wells are squeezed out, organomineral fertilizers are introduced into the hole for planting material, and the fertilizer layer between the wells are shifted to the next well. The hole builder is made in the form of a removable rim mounted on the support drive wheel with hole holders made in the form of a truncated cone with a diameter of a smaller base larger than the diameter of the planting potato and a height equal to the depth of landing.

The analysis also examined technical solutions of the Mountain State Agrarian University using method (Basiev et al. 2015) for breeding seed potatoes of selection samples by placing sprouts by soaking acutifolia maple (*Acer platanoides* L.) in the juice and enveloping it with clay saturated with mineral fertilizers; Among the Flowers company (Shmakov et al. 1998), in which seed tubers are germinated in containers made of translucent film, the non-woven covering material made of polypropylene is used as the material for their manufacture: a team of authors for growing pre-basal healthy seed potatoes and other agricultural products in a multi-tiered plant (Selmen et al. 2005); a team of authors (Chernikov et al. 1995), according to which microbiological and entomopathogenic preparations are used for potato cultivation for preplant planting.

To increase the yield of potatoes, the team of authors patented a method (Rychkov et al. 2001), in which seed tubers are treated with a growth and yield stimulant, sodium carbonate peroxyolate.

The Tver State Agricultural Academy patented a method of cultivating seed potatoes prepared by air-thermal heating before sprouting (Usanova and Kozlov 2015), the environmental safety of which is ensured by planting tubers on a smooth surface of the soil after deep cultivation with simultaneous treatment of tubers and the bottom of the furrow with 5% Fitosporin solution -M by

spraying with a nozzle, and protection from pests is carried out once with Fitoverm-M solution. The problem solved by this invention is to develop an environmentally friendly method of cultivating potatoes and identifying adapted to it a variety of potatoes in the non-chernozem zone of the Russian Federation.

A new technological solution has been proposed by the Far East Scientific Research Institute of Agriculture for the accelerated creation of virus-free sprout culture IN VITRO of new potato varieties, according to which sortotypic tubers are selected before germination, and mini-sprouts with virus-free tubers are used as explants. The latter are sterilized in a mixture of ethyl alcohol and hydrogen peroxide, and then they are cultured in a nutrient medium according to a given temperature (Ermakov et al. 2011).

The analysis showed insufficient attention to the issues of enrichment of potatoes and other agricultural raw materials. For example, according to Italian scientists cited in the patent for the invention (Tsanirato 2013), 225 million people in the world suffer from iodine deficiency disorders, and in potatoes grown in Italy, the average iodine content is less than 1 microgram per 100 g wet weight. In the said patent, options are proposed for enriching potatoes with iodine by applying a composition to plants, which includes a solution of a compound of iodine, phosphorus pentoxide and potassium oxide. Enriched potatoes have an iodine content of at least 25 µg per 100 g of potatoes. As a result, the potato is enriched with iodine even after cooking and after storage, unaltered organoleptic properties are preserved in the products.

The AgroNIR firm has patented a method for cultivating potatoes (Starovoirov et al. 2006) and a method for propagating seed potatoes (Oves et al. 2008). Firm "AgroNIR" together with V.I. Starovoirov patented a method for storing seed potatoes, which reduces losses during storage and improves its quality (Chulkov et al. 2010). According to this method, in the treatment and main periods when storing potatoes, it is ozonized once a month at a certain concentration of ozone and a certain period of time, special regimes are also set for potatoes during storage.

Thus, we can state that the following directions of development of research in the field of preparation, storage and use of seed potatoes include:

- elaboration of new compositions and methods for protecting seed potatoes at all stages of seed production from viruses;
- elaboration of new compositions and methods for increasing the efficiency of the production of micro-tubers;
- elaboration of innovative methods for the quick cultivation and planting of seed potatoes;

- elaboration of methods and devices for the vernalization of seed potatoes, including the use of biostimulants and inhibitors of pathogens;
- use of physical effects to improve technological processes for the production of elite seed potatoes, as well as for its pre-sowing processing and storage;
- enrichment of potatoes, in particular iodine, to obtain further enriched food products;
- improvement of potato storage methods.

CONCLUSION

Despite the fact that the problems of preparation, storage and efficient use of seed potatoes have been studied for a long time by domestic scientists, they have not been completely resolved by now, which necessitates the formation of a knowledge base for analyzing the state and development trends of research in the field of preparation, storage and use of seed potatoes and identifying areas and patented technological and technical solutions aimed at the innovative development of seed potato growing. There is an underestimation of the importance of potatoes for the production of functional foods.

The most important factors for assessing the status and development trends of innovative research is a systematic scientific information and patent search, which allows such an assessment of the status and development trends of methods and devices for the efficient implementation of technological operations for the preparation, storage and use of seed potatoes, to identify patented solutions, to identify universities, scientific organizations and developers conducting research and development in the field of potato intensification.

The synthesis of new patentable solutions in the field of preparation, storage and efficient use of seed potatoes in Russia is actively engaged in by scientists from domestic universities and research institutes (Velikoluksky State Agricultural Academy, All-Russian Research Institute for Plant Protection, All-Russian Research Institute for Irrigated Vegetable and Melon Farming, Far Eastern Scientific Research Institute of Agriculture, Institute of Biology Karelskog Scientific Center of the Russian Academy of Sciences, N.N.Semenov Institute of Chemical Physics, K.A. Timiryazev Moscow Agricultural Academy, Nizhny

Novgorod State Agricultural Academy, Komi Scientific Research Institute of Agriculture, Nizhny Novgorod State University, N.N. Vorozhtsova, Ryazan State Agricultural Academy named after P.A. Kostychev, All-Russian Research Institute of Potato named after A.G. Lorha, Samara Research Institute of Agriculture. N.M. Tulaykova, Siberian Research Institute of Agriculture and Chemicalization, Tver State Agricultural Academy, Chuvash State Agricultural Academy, Federal Scientific Center for Biological Systems and Agricultural Technologies of the Russian Academy of Sciences), manufacturing enterprises and individual authors.

Among the areas of patenting the results of scientific research can be identified: methods and devices for the protection of seed potatoes at all stages of seed production, for pre-planting, vernalization, increasing yield and quality while reducing fertilizer consumption, planting ungrown and sprouted tubers, quick cultivation of seed potatoes, processes cultivation, increase its productivity, increase the germination and growth energy of potato tubers, increase cold resistance, improve storage quality, the use of biostimulants and inhibitors of pathogens, potato recovery.

The analysis allowed us to note insufficient attention to potato enrichment during cultivation, in particular iodine enrichment, because, for example, enriched with a solution of the compound of iodine, phosphorus pentoxide and potassium oxide contains iodine at least 25 µg per 100 g of potato, and when using enriched in this way potatoes even after cooking and storage in the products in it retained unchanged organoleptic properties.

Among the directions of development of research in the field of preparation, storage and use of seed potatoes were identified: the development of new compositions and methods for protecting seed potatoes at all stages of seed production from viruses; development of innovative methods for the rapid cultivation and planting of seed potatoes; the development of methods and devices for the vernalization of seed potatoes, including the use of biostimulants and inhibitors of pathogens; the use of physical effects to improve technological processes for the production of elite seed potatoes, as well as for its pre-sowing processing and storage; enrichment of potatoes, in particular iodine to obtain further enriched food products; improvement of potato storage methods.

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