Implementation of a comprehensive scientific and technical project "Breeding and seed production of new domestic potato varieties of Ural breeding for various purposes" in the Middle Urals

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Abstract. A comprehensive scientific and technical project "Breeding and seed production of new domestic potato varieties of Ural breeding for various purposes" has been implemented on the territory of the Sverdlovsk Region since 2018. Customer: Breeding and seed-growing company "Uralsky Kartofel (Ural potato)". Participants: Federal State Budgetary Institution of Higher Education "Ural State Agrarian University", Ural Research Institute of Agriculture - branch of Federal State Budgetary Scientific Institution "Ural Federal Agrarian Research Center of the Ural branch of the Russian Academy of Sciences", Joint Stock Company Agroindustrial Complex "Belorechenskiy", Federal State Budgetary Institution of Higher Education "Ural State Agrarian University". Based on the use of modern equipment for microclonal reproduction and diagnostics of pathogens using PCR analysis and robotic DNA technologies, the production of original, elite seed material of domestic (Ural) potato varieties has been established. During the period of the project implementation, new competitive potato varieties Terra and Alaska were registered. Laboratory and field studies were carried out and new data were obtained on the development of elements of the growing technology for elite seed potatoes on the basis of LLC BSC "Uralsky Kartofel" and JSC AIC "Belorechenskiy" [5,17]. The directions of further research on the development of technological regulations for seed production and the Ural technology of cultivation of original, elite and reproductive planting material are determined. The work was carried out within the framework of the subprogram "Development of potato breeding and seed production in the Russian Federation".

1. Introduction
The production of high-quality seed material is the most important link in potato growing, capable of providing a significant increase in crop yields. For the fullest realization of seed potential, it is necessary to organize seed production well, the most important tasks of which are accelerated reproduction of new, promising varieties and maintenance of genetically determined traits and properties of all varieties approved for use in production, obtaining high-quality material based on special working methods.

In each state of developed potato growing, there is a seed production system - a group of interconnected production units that meet the country's needs for high-quality varietal seeds and provide for the organization of their production.
In the process of reproduction and production use, the economically useful traits and properties of varieties are deteriorated as a result of mechanical clogging, increase in the prevalence and degree of damage by fungal, bacterial, viral and other diseases and pests. Therefore, the main functions of the potato seed system are variety renewal and variety exchange.

The legal basis for the development of breeding work aimed at obtaining domestic potato planting material is the Decree of the President of the Russian Federation No. 350 dated 11.07.2016 "On measures to implement the State Scientific and Technical Policy in the interests of agricultural development", the Federal Scientific and Practical Program for the Development of Agriculture for 2017-2025, approved by the Decree of the Government of the Russian Federation No. 996 dated 25.08.2017 and the Subprogram "Development of potato breeding and seed production in the Russian Federation" of the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2025, approved by the Decree of the Government of the Russian Federation No. 559 dated 05.05.2018. Scientific analysis shows that the success of potato cultivation is 80% determined by the selection of varieties and the quality of seed material, the introduction of organic and mineral fertilizers, effective protection against pests, diseases, and weeds [3].

Varieties in modern agriculture are an irreplaceable means of production. Each variety has a unique combination of genes that forms a peculiar set of economic and biological indicators, traits and properties of plants grown on an industrial scale for the production of food, technical or feed products. The share of breeding progress in increasing yields is 30-50% [1,4,12-14].

Long-term scientific research by several authors has convincingly proved the effectiveness of improving seed potato from viral infection to increase their yield. The improvement of cultivated varieties, their accelerated reproduction and protection of the material from re-infection based on seed-growing centers in the regions are of particular relevance [3].

In the Sverdlovsk region, the share of acreage under potato varieties of foreign breeding is unacceptably large. In addition to dependence on seed supplies from abroad and the high cost of seed material (about 75-90 thousand rubles per ton, including transportation), a special danger is the possibility of penetration into the country and the subsequent spread of new harmful diseases and pests of potato plants [3,15,16]. Russian breeders annually create, patent, and register in the State Register several new varieties of potato of high quality in a number of parameters superior to foreign varieties [6,11].

Consequently, the creation of seed breeding centers with the participation of breeders (state scientific agricultural producers) seems to be the best way out of this situation. This project is being formed to ensure the transfer of domestic potato growing to a qualitatively new scientific and technological level, ensuring the creation of a domestic potato seed fund to produce competitive agricultural products by Russian producers, as well as the creation of effective technologies for potato production (cultivation) and storage [9].

Considering the great economic and social significance of the industry, the special importance of seed material as a means of potato production, the improvement of the organizational, methodological, and technological foundations of seed production of this crop is of great practical importance for increasing the yield and quality, profitability of growing products.

The breeding of domestic competitive varieties and their improvement accelerated reproduction and protection of the material from re-infection on the basis of seed-growing centers in the regions is of particular relevance [1].

The seed production system includes the following stages (Figure 1)
Figure 1. Scheme of successive stages of potato seed production.

Scientific work is carried out within the framework of the Federal Scientific and Technical Program for the Development of Agriculture of the Russian Federation for 2017-2025 subprogram: "Development of potato breeding and seed production in the Russian Federation on the territory of the Sverdlovsk region", a comprehensive scientific and technical project "Breeding and seed production of new domestic potato varieties of Ural breeding for various purposes" is being implemented on the topic "Development of industrial seed production technology of domestic (Ural) potato varieties based
on virus-free microclonal reproduction technology using modern robotic DNA technologies and PCR analysis" [5].

To solve the problem of industrial potato seed production and development of a system for obtaining virus-free material and providing competitive high-quality planting material for agricultural producers of the Ural Federal District, a Limited Liability Company Breeding and seed-growing company "Uralsky Kartofel" operates in the village of Kochnevo, Beloyarsk CD, Sverdlovsk Region. This project was implemented on the basis of co-financing from the federal, regional budget and investments. The company has most advanced equipment for seed production, including for microclonal propagation, ELISA and PCR analysis.

In 2018, based on the decision of the competition commission of the FSTP "Development of agriculture in the Russian Federation" for 2017-2025, it was decided to support the project "Breeding and seed production of domestic (Ural) potato varieties for various purposes". The project customer was LLC BSC "Uralsky kartofel". The contractors were the FSBEI HE Ural SAU, URFANITS and JSC AIC "Belorechenskiy". The development program is designed up to 2025.

The purpose of the project is to replace imported potato varieties by creating and bringing to the market of the Ural region competitive potato varieties of Russian breeding.

In 2020, 36 tons of potato tubers of the first field generation were obtained for further reproduction. Laboratory and field experiments are conducted in open and protected ground to develop technological regulations for seed production. The microclimate was monitored and the parameters of external factors for the propagation of potato plants in the laboratory and for obtaining mini tubers in protected soil were optimized [5,17].

2. Materials and Methods
The research was carried out in laboratories for clonal micro-reproduction of plants by conducting laboratory experiments in LLC BSC "Uralsky Kartofel" and the FSBEI HE Ural SAU. Field experiments were conducted based on JSC AIC Belorechenskiy, village Kochnevske and the educational and experimental farm of the University village Studencheskoy of the Beloyarsk CD of the Sverdlovsk region.

The object of research was potato varieties of foreign domestic (Ural) breeding, differing in the length of the growing season and the ability to accumulate crops: Impala, Alaska, Terra, Lux, Red Scarlet.

The research materials in the work were the following: regenerating plants, mini-tubers and tubers of elite seed potato. The experiments were carried out in a three- to five-fold repetition according to the methodology of work with tissue culture described in the materials of RAAS No. 6, 2002. The experimental data obtained in the experiments were subjected to mathematical processing by the dispersion method as described by B.P. Dospekhov. During harvesting, the degree of damage to tubers by diseases was determined by the method of the VNIIKH (1995). The quality of potato seed material was determined in accordance with GOST: GOST 11856 - 89. Seed potato [4]. Acceptance and methods of analysis, GOST 29267-91. Seed potato. Improved source material. Acceptance and methods of analysis, GOST 29268 - 91. Seed potato. Improved source material. Technical conditions, GOST 33996-2016 Seed potato. Technical conditions [2,4].

Experimental studies were carried out with the following potato varieties: foreign breeding - Impala, Red Scarlet and domestic (Ural) breeding - Terra, Alaska, Lux.

3. Results and Discussion
Our observations of laboratory microclimate have established that (Table 1) the average air temperature fluctuated slightly from 23 to 25 °C and was within the optimal range for growing plants in vitro. The air humidity was maintained by special devices and fluctuated in the optimal range of 60-80%. The light mode was maintained as standard for 16 hours a day using fluorescent lamps. The illumination intensity was 4000 lux.
Table 1. Indicators of microclimate monitoring in the culture hall during in vitro plant cultivation.

| Month   | Load | Average | Humidity | Light |
|---------|------|---------|----------|-------|
| January | 20   | 23-25   | 70-80    | 16    |
| February| 45   | 23-25   | 70-80    | 16    |
| March   | 70   | 24-26   | 60-70    | 16    |
| April   | 100  | 24-26   | 60-70    | 16    |
| May     | 30   | 23-25   | 70-80    | 16    |
| June    | 50   | 23-25   | 70-80    | 16    |
| July    | 80   | 24-26   | 60-70    | 16    |
| August  | 10   | 23-25   | 70-80    | 16    |
| September | 10  | 23-25   | 70-80    | 16    |
| October | 10   | 23-25   | 70-80    | 16    |
| November| 10   | 23-25   | 70-80    | 16    |
| December| 15   | 23-25   | 70-80    | 16    |

Thus, thanks to the special laboratory software, all the microclimate parameters were within optimal limits, which made it possible to fulfill the plan for micro clonal reproduction.

To optimize the parameters of growing micro-plants, studies have been conducted on the effect of various preparations for the sterilization of plant material. Our research has established (Table 2) that when treated with preparations such as potassium permanganate, hydrogen peroxide, soap solution and weak alcohol solution, the complete death of potato regenerating plants occurred.

Table 2. Method of plant material disinfection.

| No. | Treatment method (solution) | Concentration | Number of plants, pcs. | Result after treatment |
|-----|-----------------------------|---------------|-------------------------|-----------------------|
| 1.  | Distilled water (k)         | 100           | 10                      | 100% damaged          |
| 2.  | Water                       | 100           | 10                      | Died                  |
| 3.  | Potassium permanganate      | 10mg/100ml    | 10                      | Died                  |
| 4.  | Hydrogen peroxide           | 10mg/100ml    | 10                      | Died                  |
| 5.  | Soap solution               | 10mg/100ml    | 10                      | Died                  |
| 6.  | Chlorine solution           | 0.1%          | 10                      | 50%                   |
| 7.  | Weak alcohol solution       | 10mg/100ml    | 10                      | Died                  |
| 8.  | Diacid solution             | 0.1%          | 10                      | 10%                   |

The same thing happened when treated with pure and distilled water. It should be noted that when plants were treated with 0.1% chlorine solution, the death of plants was 50%. When treating plant material with 0.1% diacid solution, the death rate was 10%.

Thus, to disinfect plant material and reduce its losses from infection, a 0.1% diacid solution should be used.

Table 3. Effect of the nutrient medium composition on the growth and development of potato plants in vitro.

| Variety | Medium | Cultivation period, days | Plant height | +/- number | Plant |
|---------|--------|--------------------------|--------------|------------|-------|
In the experiment on the effect of the nutrient medium composition on the development of potato plants in vitro, it was found that on the 7th day the number of internodes in regenerating plants varied from 1.4 to 2.5 pcs., and they developed faster on the VNIIKH nutrient medium. The trend of more accelerated growth of potato plants in vitro remained on the 14th day of cultivation under the same external conditions. The final determination of the number of internodes and the height of regenerate plants was carried out on the 21st day after inoculation. It was noted that the height of potato plants in test tubes ranged from 48.6 to 85.3 mm, depending on the variety and the nutrient medium used. It should be noted that the highest plants were regenerators of the Lux variety of the Ural breeding on the VNIIKH medium. The plants of the Impala variety of foreign breeding on the UralNIISH nutrient medium had the lowest index. When using the VNIIKH nutrient medium, there was a tendency for faster growth of potato generant plants of all studied varieties. The number of internodes depended on both the variety and the type of medium. On the VNIIKH medium, the number of internodes was higher by 1.1-2.1 pcs., which is directly proportional to their height. It was higher on the Ural varieties Alaska and Lux also on the VNIIKH medium. Nevertheless, it should be noted that in the UralNIISH medium, the plants were stronger, squat and had a denser structure and a saturated color. To comply with the "principle of the only difference" and the experimental methodology, the external factors - light, heat, humidity during the experiments were identical and were carried out in five-fold repetition, the arrangement of the variants with test tubes was one-tiered systematic.

Thus, the rate of growth and development of potato regenerating plants depends on the composition of the nutrient medium, the presence of certain vitamins and phytohormones in it, as well as the genetic characteristics of the variety used for micro clonal reproduction.

Scientific studies on the productivity of potato varieties grown from mini tubers when receiving the first field generation (Figure 2) found that the yield of foreign varieties of Impala and Red Scarlet was 24.0 and 26.6 t/ha, respectively. Ural varieties Terra, Lux and Alaska showed a level of productivity from 19.3 to 26.5 t/ha. It is necessary to answer that the Ural variety Alaska was practically not inferior to the control (Red Scarlet) in terms of yield and surpassed this indicator in the Impala variety.

| Variety       | 7th day | 14th day | 21st day | on the 21st day, mm | of internodes for 21 days to St, pcs | height for 21 days to St, mm |
|---------------|---------|----------|----------|---------------------|-------------------------------------|-----------------------------|
| Impala        | Ms (St) | UralNIISH |         |                     |                                     |                             |
|               |         |           | 5.0      | 48.6                |                                     |                             |
|               |         | MS        | 2.7      | 63.4                | 1.1                                 | +14.8                       |
| Alaska        | Ms (St) | UralNIISH |         |                     |                                     |                             |
|               |         |           | 4.9      | 53.7                |                                     |                             |
|               |         | MS        | 3.5      | 74.8                | 1.2                                 | +21.1                       |
| Terra         | Ms (St) | UralNIISH |         |                     |                                     |                             |
|               |         |           | 5.3      | 65.8                |                                     |                             |
|               |         | MS        | 3.7      | 81.4                | 1.3                                 | +15.6                       |
| Lux           | Ms (St) | UralNIISH |         |                     |                                     |                             |
|               |         |           | 5.6      | 58.7                |                                     |                             |
|               |         | MS        | 3.4      | 85.3                | 2.1                                 | +26.6                       |
| LSD_{0.05} for variety | 1.0       | 15.0                |                      |                                     |                             |
| LSD_{0.05} for medium   | 1.1       | 15.3                |                      |                                     |                             |
Thus, the yield of potato of the first field generation depends on the genetic characteristics of the variety and weather conditions during the years of the experiment.

![Figure 2. Yield of seed potato by varieties, t/ha, LSD$_{0.05}$ = 1.56 t/ha.](image)

**4. Conclusions**

Based on scientific research on the improvement and development of elements of industrial seed technology based on the use of modern equipment for 2018-2020, for the first time in the Urals, data were obtained for the development of technological regulations for obtaining high-quality planting material in the conditions of the northern region. Robotization was used for the first time in PCR analysis of samples for viral and bacterial infection.

Based on the conducted field experiments on the study of varieties of domestic and foreign breeding and industrial technologies to produce seed potatoes from mini-tubers, it was found that the yield of seed tubers of potato from mini-tubers in 2020 varied for varieties from 19.3 to 26.6 t/ha. Moreover, the highest yield was obtained from the Alaska and Red Scarlet varieties, which amounted to 26.5-26.6 t/ha, respectively. The Ural variety Lux had an intermediate position, and the Terra variety showed the lowest result. The research continues.

When studying the production of mini tubers from plants in vitro, technology elements have been developed that allow increasing the yield coefficient by 1.5-2 times. It was found that in the production of mini-tubers, the best indicator are those micro-plants that were planted at the end of the slow growth phase and mini-tubers that increase the yield of standard products. A new substrate has been studied — mineral wool for the production of mini-tubers in protected soil. It is noted that when using it, the weight of the mini tubers decreases, but the quality of the resulting material meets the GOST requirements.

As a result of work in the FSBEI HE Ural SAU, highly qualified personnel have been trained and work in the LLC BSC Uralsky Kartofel. On the basis of the enterprise, 3 graduate students work and 15 students undergo training and production practices. The scientific support of the project is underway. As a result of the program, it is planned to create two new potato varieties and seed production regulations based on modern methods of microclonal reproduction, a modern system of
machines and robotic DNA technologies. Starting from 2023, LLC BSC Uralsky Kartofel plans to annually produce and sell at least 100 tons of elite potato seeds.

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