Materials and equipment for seed production in Russia

T E Marinchenko
Rosinformagrotekh, 60, Lesnaya str., Pravdinsky township, Pushkinskiy district, Moscow region, 141261, Russia
E-mail: 9419428@mail.ru

Abstract. Cultivated plants, which form the basis of the human diet, are also used for feeding livestock and poultry and as process raw materials. With the growth of human needs and an increase in the number of factors and the degree of negative impact on plants (changing unstable climate, including drought, decreased fertility, increased resistance of plant pathogens and pests to pesticides, cumulative effects of agrochemical load, etc.), there is a need for further development of research in the field of breeding and seed production. The development of these areas through the introduction of competitive domestic technologies based on the latest scientific achievements is the national interest of the state in the field of food security for the long term. Provision of Russian producers with high-quality domestic seeds of high reproduction for a number of crops is insufficient, which creates a threat to the country's food independence. An important factor in providing agricultural producers with domestic seeds is the development of the material and technical base of breeding and seed production, including state-of-the-art laboratories and equipment for seed preparation, since processing and preparation of seeds are today necessary conditions for improving the quality and competitiveness of domestic seed. The state and problems of the development of plant breeding and seed production, as well as the proportion of seed supply of domestic breeding are discussed. Some domestic projects in the field of seed production are analyzed in order to determine their potential for solving strategic tasks for the development of domestic seed production.

1. Introduction
The Doctrine of Food Security (Decree No. 20 of the President of the Russian Federation “On Approving the Doctrine of Food Security of the Russian Federation” dated 01/21/2020) defines that the national interests of the state in the field of food security for the long term are, among other areas, the development of plant breeding and seed production through introducing competitive domestic technologies based on the latest scientific achievements. This document sets the food safety indicator for seeds of the main agricultural crops of domestic selection at a level of at least 75 % and [1]. According to the results of the end of the year 2019, the indicator of self-sufficiency of seeds in the whole of the Russian Federation amounted to 62.7 %. In absolute terms, on a national scale, the shortage is about 1 million metric tons. As to the amount of seeds sown, the share of Russian selection varies greatly among crops (data are obtained from the Ministry of Agriculture of the Russian Federation); the less than 50 % level is noted for sugar beets (0.6 %), potatoes (9.7 %), sunflower (26.5 %), spring rape (31.7 %), soybeans (41.8 %), vegetables (43.0 %) and corn (45.8 %) [2].

The creation of our own seed material and the domestic production of high-quality seeds of agricultural crops will be promoted by the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2025, under which the subprograms titled “Development of
selection and seed production of potatoes in the Russian Federation” and “Development of selection and seed production of sugar beet in the Russian Federation” will be implemented [3].

An expert discussion of subprograms on the development of: selection and seed production of oilseeds; viticulture, including nursery; nursery and gardening; selection and processing of grain crops; selection and seed production of vegetable crops; selection and seed production of corn; breeding and seed production of industrial crops has been developed and is underway. 45 federal research centers and 30 interdisciplinary research centers have been established. In 2019, the Ministry of Education and Science of Russia opened 286 new laboratories, 100 of them in the field of agricultural sciences, which will increase competitiveness in the world market. Within the framework of the national project titled “Science”, it is planned to update at least 50 % of the instrument inventory. All breeding achievements of scientists will be accompanied by scientific agro-technological support [4, 5].

Modern seed production is represented mainly by the industrial form, i.e. it is concentrated in specialized seed farms or in units of large farms, carried out by industrial methods based on integrated mechanization and automation of all the seed production processes. Therefore, high-intensity systems of automated machines and equipment for crop breeding play a key role in ensuring the production of high-quality seeds [6].

The aim of the study is to study the potential of domestic equipment to ensure the quality characteristics of seeds during their pre-sowing treatment.

2. Materials and methods

The study examined current problems and trends in the development of breeding and seed production in Russia. The material for the study was program and legislative documents that ensure the development of breeding and seed production, scientific publications on the study subject, and data on Russian projects in the field of seed production. The methods used were monographic methods, the comparative and system analysis, the idealization and mental modeling method, as well as the logical approach.

3. Results

Work on improving the existing and developing new equipment and integrated machine systems is performed all over the world. So, Kiattisin Kanjanawanishkul Prarin Chupawa and Thanaphat Nuantoon have designed and constructed an automated sweet pepper seed sorting machine. Sweet pepper seeds are very small, both in dimension and mass, therefore they are very difficult to inspect manually. The machine consists of three main stations: seed feeder, seed inspector using a camera and seed sorter using a vacuum suction system. To transport seeds through each station, the authors designed a circular rotating plate with radial rows of blind holes. This allows all three stations to process a row of seeds in parallel. To identify discolored seeds, images were captured and processed to detect dark areas on the surface of the seeds. Machine accurately sorted 90.9% of input seeds) [7].

E.J. Rifna, K. Ratish Ramanan, R. Mahendran studied the effect of well-known novel technologies such as high pressure processing, pulsed electric field, ultrasound, ozone processing, ultraviolet, magnetic field, microwave radiation, non-thermal plasma, electrolyzed oxidizing water, and plasma activated water on germination and growth characteristics of different species of seeds. Of the discussed technologies all, have proven to show enhancement in germination and growth rate) [8].

The strategic goals related to an increase in the rate of economic growth and an increase in the efficiency of economic activity in the agricultural sector cannot be achieved without providing conditions for the sustainable reproduction of the main factors of the production process (material, labor and land resources) while improving their quality characteristics [9].

Therefore, purposeful work is underway to improve existing and develop new equipment and integrated machine systems. E.G. Nurullin have analyzed the main areas of upgrading of the equipment for seed preparation during post-harvest processing of grain crops [10].

In the Russian Federation, scientific institutions are developing for technological support for the production of competitive high-quality seeds the following: integrated solutions for the automation and mechanization of work at all stages of selection and original seed production; methods of high-energy
impact on seed in order to increase their sowing growth and plant development indicators; DNA identification technologies for grain seeds produced and imported on the territory of the Russian Federation; automated machines that implement the principles of non-invasive laser spectroscopy, etc. This will help transform agriculture into a high-tech industry.

For example, the Federal Scientific Agroengineering Center VIM has developed and tested a number of machines for cleaning and preparing seeds. The VIM-1 “Selection” air sorting machine, which practically does not generate dust thanks to the double air purification function, can be used in any premises. It is designed for cleaning and sorting in the air stream of small batches of seeds of cereals, legumes, cereals, oilseeds and grass seeds.

The availability of a special device that evenly distributes incoming material over the entire cross-section of the suction channel ensures high cleaning and seed sorting efficiency.

To thresh inflorescences of cereal and leguminous crops, remove awns from caryopsis of awned varieties of various crops, clean and sort seeds, the MOA-P threshing and cleaning unit has been developed, which can also be used for finish threshing, removing awns and cleaning material harvested by the combine. It includes a frame, a loading chute, an awn separator, an air flow rate adjustment device, an aspiration channel, sediment chambers, a fan, cloth filters, and a control cabinet. It provides replacement of five machines used in breeding production. Tests performed at the P.P. Lukyanenko National Center for Grain, MOA-P unit showed high efficiency of cleaning and sorting seeds, as well as a 1.5-times increase in labor productivity.

The VIM-3 gravity and air grain cleaner is designed for preliminary and basic cleaning of food grains, sorting seeds of various crops out of difficult to separate impurities and obtaining heavy seeds with high rates of germination and germination energy. New ideas of separation using forces of gravity and precision air sorting are implemented. The versatility of the machine allows obtaining seed material of the highest standards for purity and productivity, which increases the yield of grain crops by 4.5 hundredweight / ha.

The VIM-12/25 seed cleaning air sieve machine (Figure 1) designed for preliminary and basic cleaning of food grains, sorting seeds of various crops out of difficult to separate impurities, as well as obtaining heavy seeds with high germination and germination energy, also ensures high-quality cleaning [11].

![Figure 1. VIM-12/25 seed cleaning air sieve machine: 1 – receiving funnel; 2 – gravity column; 3 – air sorting channel; 4 – narrowing partitions; 5 – supporting grid; 6 – outlet pipe; 7, 8 and 9 – I, II and III sections of the air sorting channel; 10 - sedimentary chambers; 11 – fans with electric motors; 12 – dust collector; 13 – conveyor.](image-url)
Smart Grade Company (Voronezh), a manufacturer and developer of hardware and software platform for innovative Sapsan photo separators, has proposed the world's first SE (Micro) desktop photo separator named Sapsan Micro, which is distinguished by its high performance and competitive price. It implements the function of express analysis of the quality of input raw materials based on a neural network.

Photoseparators are needed to remove weed seeds (difficult to separate impurities) from small seeded crops (rapeseed, mustard, millet, coriander, etc., grain, seeds of grain crops, legumes and oilseeds, seeds of vegetable crops), grain with signs of pathology or having a good germination, and also in the field of recyclables. This improves the quality of seeds and grains, and in some cases, the class of wheat. The Sapsan Micro is recommended for small and medium-sized enterprises: seed growers; breeders; mobile and stationary laboratories. The photo separator is distinguished by its power and productivity (up to 650 kg / h on wheat) with a purification quality of 99.99 % using machine vision technologies, artificial intelligence, neural network technologies and sample recognition algorithms.

The basis is multi-criteria sorting of the product: the original product is sorted by its main physical and optical properties, such as color and shades of color (dullness and gloss, transparency, turbidity), shape, size, weight, internal content, and structure. High quality sorting is achieved when the content of impurities in the starting material is 1 to 3 %; high efficiency is maintained with a clogging of 5-10 %. After initial cleaning, the feedstock automatically returns to the feed hopper through the return channel and is subjected to reprocessing. This allows obtaining the maximum sorting quality and at the same time reducing product losses, which is especially important for quality seed variety producers. The device is equipped with high-speed cameras manufactured by Smart Grade LLC. A fluorescent separator allows removing defects from a good product that are similar in color and spectral characteristics in the infrared range in terms of fluorescence; excitation is performed with UV radiation.

The rated productivity of the apparatus is up to 0.65 MT / h (for wheat with an initial clogging of raw materials of less than 2 %), has 12 and more pneumatic valves, a working width of the tray of 60 mm and more, an air flow of 150-250 L / min; the power consumption is 0.3 kW; overall dimensions are 950x570x900 mm; the weight is 130 kg; the service life is 9 years.

The intelligent separation algorithm is based on the principles of machine learning. At the first stage of training, the feedstock is divided into classes according to various criteria (color, shape, composition, etc.): good and defective. Then, a certain number of fractions of the material of each class is passed through the photo separator manually or using a vibratory feeder. The algorithm “remembers” parameters of reference fractions, after which one can start automatic sorting. One of the modifications of the separator allows sorting rice seeds and rice grits at the same time [11].

The development of an optoelectronic express seed analyzer using fiber-optic Bragg gratings is interesting. The basis of his work is the principle of separation of seeds according to their spectral characteristics, which is based on the principles of photonics obtained both in the light stream reflected from the protective shell and in the light stream passing through the seed.

The advantage of using Bragg gratings is a narrow spectral range of reflection of the light flux, i.e. high accuracy of spectral analysis. A line of new optoelectronic systems for express analysis has been developed. The designs of the proposed devices are modular, mobile, energy efficient, accurate, fast, easy to operate and environmentally friendly, which allows them to perform express analysis of seeds with high speed and quality [12].

The KST-0.3 + SL-0, ZhSK-0.3 FSBIU FNATS VIM equipment is intended for transportation and drying of selection seeds in primary seed production. It provides an up to 1.4-time increase in handling productivity with the exception of manual labor, improving the quality of seeds due to the uniformity of drying, reducing the cost of the harvesting and transport process, post-harvest processing and storage of seeds by 25 % [13].

4. Discussion

In the Russian Federation, the contribution of selection to increasing yields in recent decades is estimated at 30–70 %. The optimistic scenario of the Long-Term Strategy for the Development of Russia's Grain...
Complex until 2035 provides for an increase in grain production to 150.3 million metric tons annually [14].

To achieve these goals, along with increasing the use of fertilizers, returning unused land into circulation, breeding new promising varieties, improving cultivation technologies and other factors, an important role is played by the improvement of technical equipment for pre-sowing seed treatment. The quality of processing, along with the productivity and energy intensity of the pre-sowing treatment process, depends mainly on technology and the perfection of technical means.

The analysis of individual domestic developments in the field of seed production showed that the level of technical development, the amount of scientific research in this area provides sufficient potential to ensure the quality characteristics of seeds for automation and mechanization of work at all stages of selection and original seed production.

5. Conclusion

Within the framework of the tasks set by strategic documents, the pre-dominant way to ensure food security is the introduction of new equipment for seed preparation, which increases the yield and germination of seeds and ensures a high yield.

Today, the government provides a wide range of measures aimed at supporting crop production, stimulating domestic demand, producing new types of products and equipment, promoting high-tech engineering products for export, etc.

Domestic developments have appeared that compete with foreign peers. They are aimed at improving the efficiency of crop production, including seed production, which is currently experiencing a high degree of import dependence. Current technologies for processing and preparing seeds are one of the necessary conditions for improving the quality and competitiveness of seeds, as well as increasing crop yields. Many domestic developments have shown high versatility and ambiguity of the tasks to be performed and should be applied to a greater extent by domestic agricultural producers. This will ensure the rapid development of domestic selection and industrial seed production.

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