Machines and Equipment for Sowing Grain Crops on Plots of the I and II Stages of Selection Work

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Abstract. The article discusses different options of selection sowing machines developed in the period from 1960 to 2020. The design and basic parameters of the machines are presented. The advantages and disadvantages of some models are outlined. The purpose of the study is to give an overview of technical means of sowing grain crops at the initial stages of breeding work and to outline a list of promising machines for sowing in plots of I-II stages. It is revealed that many engineered machines are being manufactured or undergoing modernization. The created scientific groundwork allows developing new machines and streamlining the operation of existing ones. The presented machines are characterized by a fairly high performance. Many machines are characterized by a wide range of settings for various crops and sowing conditions and greatly facilitate the work of the operator-seeders.

1. Introduction

To strategically ensure food security, the attention of state authorities to the development of plant breeding in the country should be at the highest level. This is reaffirmed by the Resolution of the Government of the Russian Federation No. 996 dated August 25, 2017 on the Federal Scientific and Technical Program for the Development of Agriculture for 2017-2025. At the same time, while increasing the volume of production of domestic breeding machinery, in particular, sowing machinery, it is important to ensure continuous growth of its engineering level and the development of new machines for the mechanization of labor-intensive operations of experimental breeding work.

Until the early 20th century, selection seeders were virtually not manufactured in foreign countries. For sowing in the breeding plots, small working width seeders were used, designed for farms, gardens and orchards and could not meet the requirements of setting up breeding experiments.

In Russia, before the 1990s, breeding and experimental work was carried out by a large number of research institutes, breeding stations, variety plots and educational institutions that amounted over 3000 altogether. Due to the production and economic need to reduce the labor intensity of experimental work and due to the emerged economic feasibility, the development and production of seeding machines for selection was organized in the Soviet Union in the early 1960s. This allowed for the expansion of the scope of work and acceleration of the breeding of new high-yielding varieties. The All-Union Institute of Agricultural Mechanization (VIM) and its experimental design machine-
building plant (MZOK VIM) occupied a special place in the development and production of selection seeders [1-3].

2. Experimental
In the course of the study, an analysis of information from various sources was carried out - R&D reports, literature sources, electronic information resources, advertising brochures of companies, etc.

Various experimental plots are characterized by their purpose, size and other parameters, and it is difficult and sometimes impossible to use a single technology and technical means of seeding. Therefore, plants in nurseries are sown in accordance with agro technical requirements using different methods and machines for plots of different types. When developing machines and seeding technologies, it is necessary to know which machines can be used at each stage of selection work [2, 4].

According to industry standards, OST 46-73-78 "...Parameters of experimental field elements by stages of work" and OST 46-72-78 "...Requirements for sowing, harvesting and type of sowing and harvesting machines", all types of plots are combined into 4 groups in accordance with the four conventional stages of breeding and experimental work. This paper only examines stages I and II [2, 4].

3. Results and discussion
The selection and seed-growing process of creating and multiplying new varieties of grain crops involves sowing seeds in various nurseries, in which up to 30–35 thousand varieties are studied and tested annually.

The type of mobile selection and seed-breeding machines for sowing is mainly determined by the number of options for planting schemes needed by breeders, i.e., the configuration of the experimental plots, the layout of seeds and plants on them, the width of paths and roads. In turn, the type of seeders largely depends on the availability of power units, with which the seeder must be aggregated [2].

For sowing grain, legume and cereal crops at stages I and II of breeding work, rows, inter-plot paths and inter-lane roads are marked using a selection marker, e.g., of the type MS-3-5 mounted on a tractor of drawbar category 0.6 [4].

Stage I of selection and experimental work includes collection, hybrid nurseries, selection nurseries. At this stage of work, one seed at a time is sown at a given interval in the row, care of the crops, harvesting and post-harvest handling of the harvest from a single plant is performed [4].

Stage II includes first-year breeding nurseries (SP-1) and first-year progeny test nurseries of primary seed breeding (P-1). The number of plots at stage II reaches tens of thousands. At this stage of work, sowing of seeds obtained from one inflorescence or plant, care of crops, harvesting and post-harvest processing of the grown crop are carried out [4].

The results of attempts to mechanize the planting on plots of the I-II stages, both in Russia and abroad, are manifested in a fairly wide list of developed machines. The technology of setting up nurseries provides for a small (for grain crops) row spacing in accordance with the requirements of the breeding experiments methodology, and the currently developed machines allow fitting them into the plots. In Russia, special small-sized power units for selection purposes (self-propelled chassis of the T-16 type and others) have been developed, with which the seeding machinery for the first and, especially, the second stage of selection work can be easily aggregated.

Seeders for stage I are represented by a number of fairly simple mechanisms, mainly driven by manual power, but there are also mechanized models.

Selection hill-drop planter SSG-1 (Figure 1a) is designed for hill-drop seeding of sunflower, soybean, castor oil plant, corn and other intertilled crops [5]. It consists of handles, dropping unit, hopper, seed tube, coulter. The dropping unit is a metering device consisting of two sides attached to handles and made of strip metal. The right handle has an adjustable seed depth limiter. Before sowing, the field is pre-marked with the marker.
The manual planter developed by the Experimental Design Bureau of the Siberian Research Institute of Agriculture (Figure 1b) is designed for manual piece sowing of grain and leguminous crops (wheat, rye, barley, oats, peas, soybeans, etc.) both in virgin (fallow) and non-fallow plots. The planter consists of a body, which includes two 1-meter-high seed tubes spaced 10 cm apart, with funnels and flaps, through which the seeds get into the soil. For controlling the flaps, there is a wire rope drive with a handle. At the base of the body there is a support for adjusting and limiting the depth of planting seeds (2-8 cm) [6].

![Figure 1. Selection hill-drop planter SSG-1 (a); Manual planter developed by SRIA EDB (b).](image)

In 1973-74, All-Russian Research Institute for Legumes and Groat Crops, together with the Central Experimental Design Bureau of the All-Russian Research Institute of Agricultural Mechanization and its experimental design machine-building plant developed a manual selection planter RSS-1 (Figure 2a) for sowing individual seeds in a predefined place of a plot with fixing the sowing place. The RSS-1 planter is designed for sowing individual seeds of grain, leguminous and cereal crops (except for millet) in 1 m-wide plots with the distance between the seeds of 10 cm at a depth of 2-8 cm. Based on the results of state tests conducted in 1974 at the Central Black Earth machine testing station, production was set up at the VIM’s experimental design machine-building plant [1].

Together with the manual planter RSS-1, All-Russian Research Institute for Legumes and Groat Crops, Central Experimental Design Bureau of the All-Russian Research Institute of Agricultural Mechanization and its experimental design machine-building plant developed a self-propelled selection cassette seeder SSK-1 (Figure 2b) for sowing individual seeds in a predefined place of a plot with fixing the sowing location. The seeds are sown automatically from pre-loaded cassettes. Working width – 1.0 m, dual-disc conical coulters, qty – 20 (spaced at 5 cm). Number of cells in the cassette: 500 (25 rows of 20 pieces per row). Planter track width: 1500-1700 mm, working speed: 0.09; 0.18; 0.27 km/h State tests of the prototype of the SSK-1 planter were carried out in 1974 at the Central Black Earth Machine Testing Station, pilot production was organized at VIM’s experimental design machine-building plant [1, 2].
Planters for stage II have a more complex design. This makes it possible to expand their functionality and increase productivity. Many machines are mounted on a self-propelled chassis.

The first Russian planter for sowing stage II plots was the manual single-row planter SR-1, developed by Central Experimental Design Bureau of the All-Russian Research Institute of Agricultural Mechanization jointly with the Agricultural Research Institute of the Central Regions of the Non-Black Earth Zone in the early 1960s. The planter was designed for sowing the seeds of grain, legume and cereal crops on plots 1 m long and more. The drill was equipped with two exchangeable coulters: a Suffolk coulter for sowing seeds to a depth of 4 cm and an hoe coulter for sowing to a depth of 8 cm. In addition, there were eight interchangeable plastic seed plates designed for sowing seeds of different crops. After seeding the row, the seeding unit must be cleaned of the remaining seeds. Drill weight: 13 kg [1]. In 1964, state tests of a prototype seeder were carried out at the Volga machine testing station, as a result of which serial production at VIM’s experimental design machine-building plant was started. The seeder was upgraded in 1970. The upgraded seeder was designated SR-1M (Figure 3a) and was pilot-produced at the Siberian Research Institute of Mechanization and Electrification of Agriculture, as well as at other enterprises at the request of breeders and entrepreneurs [1].

The modern analogue of SR-1M seeder is the KLEN-1 batch manual seed drill (figure 3b) developed by the KLEN Small Joint Research and Production Enterprise. The seeder is designed for drill seeding of grain crops, leguminous plants and cereals, as well as grass seeds at plots with the length from 1 to 12 m. (For plots with longer length an additional drive providing seeding up to 30 m is supplied). Seeding depth: up to 6 cm. Weight: 30 kg.

In 1969, All-Russian Research Institute for Legumes and Groat Crops jointly with Central Experimental Design Bureau of the All-Russian Research Institute of Agricultural Mechanization and its experimental design machine-building plant developed a multi-row seed drill SSFK-7 (Picture 4a) mounted on self-propelled chassis T-16M designed for drill seeding of cereals, legumes and cereals, as well as inter-row cultivation for stages II and III of breeding work. Number of coulters: 7 dual-disc or 7 hoe coulters. The seeder was equipped with 6 friction devices with hoppers with a capacity of up to 40 g, which made it possible to sow a separate sample of seeds into each coulter (6 rows in one pass). In addition, the seeder was equipped with one batch seed-feeding device for seeding plots of the III stage (maximum - 7 rows). Production of seeders was organized at VIM’s experimental design machine-building plant in 1971 according to the results of state tests at the Siberian machine testing station [1, 2].

In 1976, All-Russian Research Institute for Legumes and Groat Crops together with the Central Experimental Design Bureau of the All-Russian Research Institute of Agricultural Mechanization developed the SKS-6-10 - a more advanced cassette seeder with interchangeable seed feeding devices to replace the SSFK-7 seeder (Figure 4b). The seeder was equipped with interchangeable seed feeding units of two types: six cone-type autonomous seeding units with a cassette loading device (for stage II)
and one central distribution unit with manual loading from bags (for stage III). The presence of the cassette loading device does not allow installing both seed feeding devices on the chassis together, as in the SSFK-7 seeder. The seeder, equipped with autonomous seeding units, could simultaneously sow different seed samples in each of 6 rows from 1 to 5 m in length. The seeder, equipped with a central distribution unit, was fitted with replaceable heads for 4-10 sleeves (the number of sleeves corresponds to the number of sown rows of the plot) and provided sowing of one seed sample in all rows of plots with a length of 5 to 25 m. The SKS-6-10 seeder was produced at VIM’s experimental design machine-building plant in 1979-1984 [1, 2].

In 1983, taking into account the disadvantages of the seed drill SKS-6-10, a cassette seeder SKS-6A was developed, which has only six autonomous seeding units (for stage II). Designs of gearboxes, cassette feeder, coulter group, as well as containers for cassette blocks of the SKS-6A seeder are similar to the corresponding designs of the SKS-6-10 seeder units. The new seeder introduced a number of improvements in the system of automatics, loading cylinders and seed feeding units. Number of cassettes in one unit: 16, single cassette cell capacity: 500 wheat grains. The seeder passed state tests at the Central Black Earth zone machine testing station and was produced at the VIM’s experimental design machine-building plant from 1984 to 1988 [1, 2].

In 1989, SN-6AK, a mounted cassette drawbar seeder for category 0.6 tractor with autonomous seeding units was developed (Figure 5a). This was due to the fact that the seeders mounted on the self-propelled chassis were practically not dismantled and the self-propelled chassis could not be used for other works. The category 0.6 tractor-mounted drawbar seeders would always be removed from the

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**Figure 3.** Upgraded manual single-row planter SR-1M (a); KLEN-1 batch manual seed drill (b).

**Figure 4.** Cultivating seed drill SSFK-7 (a); SKS-6-10 cassette seeder with interchangeable seed feeding devices (b).

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tractor at the end of sowing works, and the tractor could be used for other works. The seeder had six autonomous cone seed feeding devices and a cassette feeder. The prototype of the seeder underwent state tests in 1991 in the testing department of Informagrotech and a pilot batch was recommended for production.

After a long break, FNAC VIM resumed work on the creation of new selection seeders in cooperation with Wintersteiger AG (Austria). In 2017-2018, a prototype of self-propelled selective seeder SSS-2-6 was developed and produced (Figure 5b). Bearing frame and sowing machine drive are mounted on the self-propelled chassis VTZ-30 SSh to adapt units of Rowseed S seeder by "Wintersteiger AG" - 6 autonomous cone seed feeding units and cassette feeder. The installed seed feeding unit is capable of simultaneously sowing different seed samples in each of 6 rows of 1 to 5 meters in length. The cassette loading device is computer controlled. The control unit with the Global Seed Control (GSC) system allows to adjust plot and seed feeding unit parameters. The system controls the power supply to the electric motors of the seed cartridge feeder during sowing and alerts the operator with an audible signal if the cartridges are empty.

In May 2018, the SSS-2-6 self-propelled selection seeder underwent field tests at ISA, a FNAC VIM branch, after which its modification SSS-6 was developed with an electric drive for the seed feeding units from a stepper motor. The program control unit ensures the operation of the electric drive, depending on the signals of the optical sensors of the distance traveled, installed on the front wheels of the chassis.

Numerous experiments have established high efficiency of grain crops sowing technology by ears as compared with seed sowing. According to modern breeders, the method of seeding by ears ensures maximum purity of variety. The mixing factor was no more present, which manifested significantly in the nursery seed sowing technology during selection and threshing, the scope of genotypes study and testing has increased. The methodology of operations to prepare ears for sowing and a number of requirements for seeding with ears are already known and described [7, 8].

The design of the new seed drill developed at FNAC VIM for seeding with ears is presented by the principal diagram of the seed drill section. The seeder should be equipped with a tape-cassette seed feeding unit with a tape drive mechanism, a feed reel and a tape take-up device. Main seeder parameters: mounted seeder; aggregated with drawbar category 0.9/1.4 tractors; number of coulters - 4; coulters spacing - 45 cm; ear placement depth - 5-8 cm; approved distance between ears in a row: 30-35 cm; number of service personnel - 1 or 2 sowing operators.

Figure 5. SN-6AK, Mounted cassette seeder for drawbar category 0.6 tractor with autonomous seeding units (a); Self-propelled selective seeder SSS-2-6 (b).
4. Conclusion
When developing and improving sowing machines, it is necessary to take into account that at the initial stages of breeding work the proportion of operations using manual labor where the introduction of new means of mechanization can have a significant economic effect is still high.

Given the relatively low demand for breeding seeding machines, compared with production machines, the versatility of seeding machines should be increased to meet the demand for them both in the breeding business and in peasant and farm holdings.

The following machines should be noted as basic machines for sowing crops in the plots of the initial stages of breeding work and as prototypes for the development of improved and new sowing machines: for stage I - manual selection planter RSS-1, self-propelled selection cassette seeder SSK-1; for stage II - KLEN-1 single-row batch manual seed drill, SKS-6A cassette selection seeder mounted on self-propelled chassis, SN-6AK mounted cassette seeder for drawbar category 0.6 tractor with autonomous seed feeding units, SSS-6 self-propelled selection seeder.

The experience of operation of seed drills shows the usefulness of conducting comparative tests at the country's machine-testing stations of domestic samples of machines, compared with their foreign counterparts.

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