Innovative seed planter implements for resource-saving sowing technologies

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Abstract. Ensuring a smooth flow of seed with a decrease in the number of injured seeds, a given instability of the total seeding, regardless of the forward speed of the sowing implement with the necessary distribution of seeds along the length and depth of the furrow, all these are the main tasks for modern sowing systems of sowing machines. Thus, we could come to the conclusion that the work devoted to improving the quality indicators of sowing agricultural crops with a seeder by developing a reel-to-reel sowing device with a four-section reel, the grooves of which are formed by the surface of rotation of the torus and are rotated relative to each other along a helical line, at an angle of 45 degrees, as well as a double-disc opener with a seed flow shaper for placing them on the bottom of the furrow is of great importance for the agro-industrial complex of Russia. The article deals with the improving the quality indicators of sowing crops by a planter equipped with reel seeding devices and four-section. the current research also presents and analyses the results of field experiments.

1. Introduction
After analyzing the designs of modern sowing devices and double-disc openers, it should be mentioned that most of them have reel-type sowing devices, which have a housing with a seeding wheel with straight grooves and a valve installed under it, as well as double-disc openers, in which the main elements flanges are used to limit the depth. During the operation of such seeding devices and double-disc openers, the specified stability of the seeding rate is not ensured, the injury rate of the seed increases, as well as destruction of the sides and bottom of the furrow formed by the opener, scattering of seeds along the bottom of the furrow and the closure of the furrow with soil before the seeds enter it, that leads to a decrease in the uniformity of the sowing seeds depth and a decrease in the required uniformity of seeds distribution along the furrow length. The above factors negatively affect the future yield of cultivated crops.

2. Materials and methods
The main methods of laboratory and field research were based on the theory of a multifactor experiment, mathematical statistics and the existing Agricultural Machinery and Technology Testers Association Standards (AMTT AS) 5.6-2018, AMTT AS 1.12-2006, State Standard (SS) 20915-2011, SS 24055-2016, SS 31345-2017 and others. To process the obtained data, the authors used a standard set of applied programs “Statistica 6.0”, “MathCAD”, Simcenter 12, 3D modeling programs, etc.

Figure 1 shows an experimental seed planter with a four-section reel and grooves which are formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of
45 degrees (Russian Federation Patent No. 268149 dated 03/06/2019) which contains a seed box for seeds (1), a figured washer (2) serving to prevent seeds from dropping out of the reel, a square shaft of the sowing device (3), a sectional reel (4) with grooves, a clutch (5) and a spring-loaded valve (6). The grooves of the sectional reel (4) are formed by the surface of the torus rotation. The seed planter with four-section reels with grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees works as follows. From the hopper the seeds fed into the seed box 1. The reel, with grooves formed by the surface of rotation of the torus and are rotated relative to each other along a helical line, at an angle of 45 degrees, due to its rotation, moves the seeds to the spring-loaded valve. The seeds from the valve 6 are dumped into the funnel and passing through the seed pipe fall into the opener with the seed flow former for placing them on the bottom of the furrow.

**Figure 1.** Scheme of the technological process of the seed planter with a four-section reel with grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees: 1 – box for seeds; 2 - figured washer; 3 - square shaft of the sowing device; 4 – reel with the grooves made in the form of a torus; 5 - clutch; 6 - spring-loaded valve; 7 - separating discs; П is the surface of the torus rotation.

**Figure 2.** Scheme of the technological process of sowing seeds of grain crops with an opener with a seed dispenser and a soil ripper: 1 - opener body; 2 - disk; 3 - seed dispenser to the bottom of the furrow; 4 - soil ripper; 5 – seed pipe; 6 - neck; 7 - socket; 8 - rear part of the ripper; 9 - hole for seed exit; 10 - furrow bottom sealant; 11 - heel; 12 - sole; 13 - rib; 14 - fastening the seed dispenser; 15 - rib for rigidity; 16 - cleaners to clean the opener; ν – forward speed of the opener; ω - angular speed of rotation of the opener discs.

Figure 2 shows the technological scheme of operation of a double-disc opener with a seed flow former for placing them on the bottom of the furrow (Russian Federation Patent for invention No.
which includes the opener body (1), discs (2), seed dispenser to the bottom of the furrow (3), soil ripper (4), seed pipe (5), socket (7), rear end of ripper (8), seed outlet (9), furrow bottom compactor (10), heel (11), disc scrapers from sticky soil (16). The technological process of the seed planter operation with the proposed openers with seed flow formers for placing them on the bottom of the furrow is as follows (Figure 2). When moving a double-disc opener with a seed flow former for placing them on the bottom of the furrow in the direction of the sowing planter movement, discs 2 of the opener with a seed flow former for placing them on the bottom of the furrow, cut a furrow for seeds and mineral fertilizers. Seed material, consisting of seeds and mineral fertilizers, enters the seed pipe 5 of the neck 6 of the housing 1 of the opener, then through the socket 7 they enter the seed dispenser 3 and then through the soil ripper 4 fall to the bottom of the furrow.

3. Results and Discussion

In order to clarify the parameters of the new working bodies of the seed planter, laboratory and field experiments were carried out in the fields of LLC “Agrofirma Biokor-S” of the Penza region in 2019-2021 using a seed planter consisting of an MTZ-81 tractor and a SZ-5.4-0.6 seed planter equipped with specially designed reel sowing implements with four-section reels and grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees, as well as double-disc openers with seed flow shapers for placing them on the bottom of the furrow for sowing grain crops (Figure 3) according to the methods of AMTT AS 5.6-2018 “Tests of agricultural machinery. Sowing and planting machines. Indicators of application”. General requirements and agri-technical assessment were examined in the framework of SS 31345-2017.

Observing the effect of the sowing planter speed on the uneven distribution of seeds along the length of the furrow, the speed of the sowing unit with a seeder equipped with developed reel seeding devices and four-section reels where grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees, as well as double-disc openers with seed flow shapers for placing them on the bottom of the furrow for sowing crops (Figure 3), according to previously adopted methods, was in the range of 1.47 \( \ldots \) 3.68 m/s. Carrying out laboratory and field studies, the significant effect of the forward speed in the sowing planter on the uneven distribution of seeds along the length of the furrow was noted. Based on the results of the current research, it was necessary to draw a graphical dependence of the uneven distribution of seeds along the length of the furrow \((v, \%)\) from the seeding planter forward speed (Figure 4).

![Figure 3](image-url)

Figure 3. General view of the seeding unit consisting of the MTZ-81 tractor and the SZ-5.4-06 seed planter equipped with the developed reel seeding devices, with four-section reels and grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees, as well as double-disc openers with seed flow formers for placing them on the bottom of the furrow for sowing grain crops.

Having considered the graph of the correlation between the uneven distribution of seeds along the furrow length on the forward speed of the sowing unit, it could be concluded that it is necessary to use...
a grain seeder with the developed reel seeding devices, with four-section reels and grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees, as well as double-disc openers with seed flow shapers for placing them on the bottom of the furrow, for sowing seeds of grain crops in the speed range of 7.6 ... 9.9 km/h, since at this speed there is a minimum uneven distribution of seeds along the length of the furrow (Figure 4).

**Figure 4.** Graphs of the dependence of the uneven distribution of seeds along the length of the furrow on the speed of the seeding unit

4. Conclusion
The final assessment of field experiments of the sowing unit was determined by the yield of the crops. Laboratory and field researches of a seed planter equipped with the reel-to-reel seeding devices and four-section reels where grooves formed by the surface of rotation of the torus and rotated relative to each other along a helical line, at an angle of 45 degrees, as well as double-disc openers with seed flow shapers for placing them on the bottom of the furrow, when sowing grain crops (for example, the seeds of spring barley variety "Belgorodsky 100"). According to the results of laboratory and field experiments, it was found that the smallest value of the uneven distribution of seeds along the length of the row is \(v = 22\%\), at a speed of the unit from 7.6 to 9.9 km/h. On average, the yield of the grain part of the seeds of spring barley varieties "Belgorodsky 100" increased by 13\% when using the current seed planter. The annual economic effect with an annual load of 120 hours amounted to 484192.5 rubles per a seed planter SZ-5.4-06M.

References
[1] Shumaev V, Kulikova J, Orehov A and Polikanov A 2020 Investigation of the grain seeder opener operation for environmental friendly technologies of crops production *Scientific papers-series A-agronomy* Vol. 63 1 527–532
[2] Ovtov V 2021 Construction and Design Parameters of the Reducer-Variator *Journal of Engineering Science and Technology Review* 3 202–204
[3] Laryushin N, Pivovarov V, Kukharev O and Vershinin Y 2019 Complex of machines for onion production using resource-saving technologies *Vegetables of Russia* 6 141
[4] Aksenov A and Sibirev A 2020 Technical support of vegetable growing in countries of the Eurasian Economic Union *AMA, Agricultural Mechanization in Asia, Africa and Latin America* 3 12–18.
[5] Hevko R, Tkachenko I and Synii S 2016 Development of design and investigation of operation processes of small-scale root crop and potato harvesters *INMATEH – Agricultural Engineering* 49 (2) 53
[6] Kalabushev A, Larushin N and Zubarev A 2020 Scientific results on justification the parameters of a combine u-shaped furrow-opener *Scientific papers-series A-agronomy* Vol. 63 1 80–85
[7] Shevchenko A and Begunov M 2013 Theoretical studies of the traction resistance of the keeled opener *Omsk Scientific Bulletin* 3 (123) 135
[8] Finch-Sawage W and Bassel G 2016 Seed vigour and crop establishment extending performance beyond adaptation *Journal of Experimental Botany* 67 567