Innovative grain seeder coulters

A G Zubarev, N P Laryushin and O N Kukharev
FSBEIHE "Penza State Agrarian University", 30 Botanicheskaya St., Penza, 440014, Russia

Abstract. One of the main working bodies of grain seeders is the coulter, the work of which determines the uniform distribution of seeds along the length of the furrow and the depth of their seeding. Of the wide variety of used coulters, the most widespread are double-disc coulters, since they have less traction resistance and better quality indicators of their work. However, as shown by scientific research of foreign and domestic scientists, when the double-disc coulters are working, the quality indicators of their work are not met, as a result of which the yield of the cultivated crop decreases. To eliminate the noted drawbacks during the operation of double-disc coulters in the Penza State Agrarian University, innovative double-disc coulters for a grain seeder have been developed. During the operation of these coulters, in comparison with the serial ones, thanks to the installation of a seed guide, a soil ripper and a seed speed damper on the coulters, the seeds are evenly distributed along the length of the furrow and the depth of their planting.

As a result of the review of modern coulters for sowing grain seeds, it can be noted that double-disc coulters are most suitable for high-quality sowing. To improve the quality indicators of sowing with double-disc coulters, it is necessary to eliminate the disadvantages inherent in them. These include: loosening of the walls and bottom of the furrow, shedding of the furrow during the placement of seeds along its bottom, as well as the uneven flow of seeds and their hitting the rotating discs of the coulter, in addition, the ejection of seeds from the funnel of the coulter body at a speed greater than the forward speed of the seeder, which leads to rolling of seeds along the bottom of the furrow. All this increases the uneven distribution of seeds along the length of the furrow, the depth of their seeding, which leads to a decrease in the quality of sowing of seeds and the depth of their seeding, a decrease in crop yield and an increase in the cost of production. Thus, the work devoted to improving the quality of sowing grain crops using double-disc coulters is of sufficient relevance.

To eliminate these shortcomings, on the basis of the Penza State Agrarian University, a double-disc coulter with a seed guide and a soil cultivator made as a whole (RF patent for invention No. 2640052) and a double-disc coulter with a seed guide, soil cultivator and a seed speed damper (RF patent for invention No. 2692622) have been developed, manufactured and tested in laboratory and in the field on a grain seeder SZ-5.4-06.

A two-disc coulter (RF patent for invention No. 2640052) with a seed guide and a soil cultivator made as a whole includes body 1 (figure 1), two discs 2 installed at an angle to each other on body 1, seed guide 3 and ripper 4 [1].
Figure 1. Scheme of the technological process of sowing seeds of grain crops with an experimental combined coulter: 1 - body; 2 - disk; 3 - seed guide; 4 - ripper; 5 - funnel; 6 - neck; 7 - bell; 8 - the lower bent part of the ripper; 9 - outlet; 10 - hollow curved wedge; 11 - heel; 12 - oblique oval rib; 13 - bracket; 14 - stiffener; 15 - internal scrapers of the coulter; \( v_c \) - the speed of the seeder; \( \omega \) - angular speed of rotation of the coulter discs.

The seed guide 3 and the ripper 4 are made as a closed unit. The seed guide 3 and the ripper 4 are located between the discs 2 of the coulter and are installed at the rear of the coulter and at the same time below the funnel 5 of the neck 6 of the housing 1 of the coulter. The seed guide 3 and the ripper 4 are made of a pipe, for example, of a circular cross-section, while the bell 7 is fixed to the front of the seed guide 3, while the bell 7 is tightly put on the funnel 5 of the neck 6 of the coulter body 1, while the seed guide 3 is directed to side opposite to the movement of the coulter.

The lower part 8 of the ripper 4 is bent back, in the direction opposite to the movement of the coulter, along an arc of a circle, while the lower bent part 8 of the ripper 4 has an outlet 9 located in the transverse-vertical plane directed relative to the longitudinal-vertical plane of symmetry of the coulter.

Curved wedge 10 has two lateral working edges and a heel 11 and an inclined oval rib 12. In this case, the ripper 4 and the seed guide 3 are fixed to the coulter body 1 by means of a bracket 13, reinforced with a stiffener 14, while the bracket 13 is installed at the point of attachment of the internal scrapers 15 of the coulter.

The coulter works as follows. When the coulter moves in the direction of sowing, two discs 2 of the coulter, mounted at an angle to each other on the body 1, cut a furrow in the soil for seeds and fertilizers, while the seeds and fertilizers fall into the funnel 5 of the neck 6 of the body 1 of the coulter, then through the bell 7 enter the seed guide 3 and then into the ripper 4, then from the ripper 4 the seeds and fertilizers enter the furrow with a compacted bottom of the furrow, which is sealed with soil crumbled from the walls of the furrow behind the discs 2 of the coulter.

As a result of laboratory and field studies of the seeder, on the winter wheat variety "Santa", the parameters of a double-disc coulter with a seed guide and a soil cultivator were specified as a whole. The uneven distribution of seeds along the row length with the experimental combined coulter is 26.8%, and with the serial one - 39.5%. The average seeding depth of the experimental seeder and the serial one, respectively, was 51.9 mm, the serial one 53 mm, with an uneven distribution of seeds along the
seeding depth of 24.7% (serial 26.3%), while the number of seeds embedded in a given layer was 84.5 ... 84.9%, and the serial seeder 65.7 ... 68.4%. The traction resistance of the experimental seeder was 1.64 ... 1.95 kN/m [2].

A double-disc coulter with a seed guide, a soil ripper and a seed speed damper (RF patent for invention No. 2692622), contains a housing 1 (figure 2) two discs 2 installed at an angle to each other on housing 1, a seed guide and a ripper, while the guide seeds and a ripper, are made as a whole from a pipe 3 of rectangular section, while the pipe 3 of rectangular section is bent in the direction opposite to the movement of the coulter, while the axis of symmetry of the pipe 3 of rectangular section, while the longitudinal-vertical plane of symmetry of the pipe 3 of rectangular section coincides with the longitudinal - the vertical plane of symmetry of the coulter, while the pipe 3 of rectangular section simultaneously serves as a seed guide and a ripper, while the upper part of the pipe 3 of rectangular section is fixedly connected by a bell 4 to the funnel 5 of the neck 6 of the housing 1 of the coulter, while the pipe 3 of rectangular section in the lower part has a rectangular outlet 7, with the gaps between the discs 2 of the coulter and the side surfaces of the pipe 3 of rectangular section, measured near the cutting edges of the rear part of the discs 2 of the coulter, at least 12 mm on each side of the side surface of the pipe 3 of rectangular section, while below the outlet 7 of the pipe 3 of rectangular section it is installed using welding, curved wedge 8, while the width of the heel 9 of the curved wedge 8 is equal to the width of the rectangular pipe 14 mm, while the middle part of the rectangular pipe 3 is fixed immovably to the coulter body 1 by means of a bracket 10 installed at the place of attachment of the internal scrapers 11 of the coulter discs, while behind the outlet 7 of the rectangular pipe 3, a furrow roller 12 is installed acting as a seed speed damper, while the longitudinal-vertical plane of symmetry of the furrow press roller 12 coincides with the longitudinal vertical plane of symmetry of the rectangular pipe 3, while the furrow press roller 12 consists of a disc 13 with a hub 14 and a rim 15 welded to it, on which it is firmly attached, for example, using glue, tire 16 made of solid rubber, while the furrow press roller 12 is supported by the tire 16 made of solid rubber on the bottom of the furrow formed by the discs 2 of the coulter, while the width of the tire 16 made of solid rubber, while in the hub 14 of the furrow press roller 12 mounted bearing a slip nick made in the form of a sleeve made of antifriction material, while the hub 14 of the furrow press roller 12 is supported through a slide bearing 17 on the axle 18, in this case, the axis 18 of the hub 14 of the furrow press roller 12 has a head on one side, while the furrow press roller 12 has a spring rack 20, while the spring rack 20 is made of alloy spring steel, while the upper part of the spring rack 20 has a fastening part with a longitudinal groove 21 to accommodate the screw connection 22, necessary for attaching the spring rack 20 to the housing 1 of the coulter at the place of attachment of the internal scrapers 11 of the discs 2 of the coulter, while the sleeve 23 is fixed to the bottom of the spring rack 20, while the sleeve 23 is put on the axle 18 of the hub 14 of the furrow press roller 12 and is fixed with it by a locking screw 24, while the axis 18 of the hub 14 of the furrow press roller 12 from axial displacement relative to the hub 14 of the furrow press roller 12 is held by the head 19 of the axle and the end face of the sleeve 23, dressed on the axle 18 the hub 14 of the furrow packer roller 12, in this case, the axial clearance in the mating of the hub 14 of the furrow packer roller 12 with the head 19 of the axle 18 of the hub 14 of the press roller 12 and the end face of the sleeve 23, fitted on the axle 18 of the hub 14 of the furrow press roller 12, is regulated by washers made of antifriction material [3].
Figure 2. Structural and technological diagram of the experimental coulter: 1 - body; 2 - disks; 3 - pipe; 4 - bell; 5 - funnel; 6 - neck; 7 - outlet; 8 - wedge; 9 - wedge heel; 10 - bracket; 11 - scrapers; 12 – furrow roller; 13 - disk; 14 - hub; 15 - rim; 16 - tire; 18 - axle; 20 - rack; 21 - groove; 22 - screw; 23 - bushing; 24 - stopper.

The coulter works as follows. When the coulter moves, the discs 2 cut a furrow, while the seeds enter through the neck 6 into the funnel 5 and then into the rectangular pipe 3, which acts as a seed guide and soil cultivator with compaction of the bottom of the furrow and then through the hole of the rectangular pipe 3 enter the furrow, hitting directly into the furrow roller 12, which acts as a damper for the speed of seeds, while the seeds are distributed evenly along the length of the furrow and the depth of their placement with their simultaneous compaction at the bottom of the furrow. All this affects the increase in crop yields and a decrease in its cost.

As part of the research program, wheat of the spring variety "Arhat" was sown with a SZ-5.4-06 seeder with serial coulters and an experimental seeder equipped with double-disc coulters with seed guides, soil cultivators and furrow press rollers acting as seed speed absorbers, which showed that the number seeds planted in a layer from 4 to 6 cm by a SZ-5.4-06 seeder with experimental double-disc coulters with seed guides, soil looseners and furrow press rollers acting as seed speed absorbers (91.4 ... 91.5%) higher than the indicators of the basic seeder (77.8 ... 78.3%). The optimal value of the unit speed V can be considered the range of values from 7.3 ... 11.3 km / h. As a result, it was found that the increase in the yield of seeds of spring wheat variety "Arhat" when sowing with a seeder with developed double-disc coulters with seed guides, soil cultivators and furrow press rollers acting as seed speed absorbers was 13%. The uneven distribution of seeds along the row length with the experimental combined coulter is 25.6%, and with the serial one - 39.5%. The average seeding depth of the experimental and serial seeder, respectively, was 48 mm (serial - 53 mm) with an uneven distribution of seeds along the seeding depth of 23.6% (serial 26.3%), while the number of seeds planted in a given layer was 91.4 ... 91.5%, and the serial seeders 65.7... 68.4%. The traction resistance of the experimental seeder was 1.64 ... 1.95 kN / m [4].

Analysing the results of studies of a double-disc coulter with a seed guide and a soil cultivator made as a whole (RF patent for invention No. 2640052) and a double-disc coulter with a seed guide, soil
cultivator and a seed speed damper (RF patent for invention No. 2692622), we can conclude that high-quality the performance of the double disc opener with the seed speed damper is better. Coulters of this type are currently installed on SZ-5,4-06 seeders and are being prepared for introduction into serial production at Agrokomplekt LLC, Kamenka, Penza region.

Acknowledgments
This work was prepared with the support of the Federal State Budgetary Institution "Russian Foundation for Basic Research" (Contract No. 19-38-90158 / 19).

References
[1] Voloshin I V, Laryushin N P, Kuvaitev V N, Shumaev V V and Vanin D V 2017 The design of the combined opener for sowing grain crops Volga Region Farmland 2 56-61
[2] Laryushin N P, Voloshin I V and Shumaev V V 2016 Analysis of the results of studies of seeding by depth with openers of grain seeders Proc. of the Int. Sci.-Practical Conf on Energy-Efficient and Resource-Saving Technologies and Systems ed. P V Senin et al (Saransk) pp 309-14
[3] Zubarev A G, Laryushin N P and Shukov A V 2019 Development of working bodies for a grain seeder for sowing using resource-saving technologies Science in the Central Russia 3 (39) 78-83
[4] Zubarev A G and Laryushin N P 2020 Results of research of the opener of a grain seeder with a seed speed damper Modern High Technologies 8 38-43
[5] Laryushin N P, Zubarev A G, Shumaev V V, Vanin D V and Kiryukhin T A Pat. of the Russian Federation 2692622, IPC A01C 7/20 Soshnik No. 2018146243 No. 2018146243 appl. 24.12.2018, publ. 25.06.2019 applicant and patentee FGBOU VPO Penza GAU
[6] Laryushin N P and Shumaev V V 2015 Technology and Means of Mechanization of Sowing Agricultural Crops with a Combined Coulter for Multilevel Fertilization and Seed Distribution. Theory, Design, Calculation (Penza: RIO PGSKhA) 179 pp
[7] Laryushin N P and Zubarev A G 2019 Soshniki grain seeding machines for resource-saving technologies Proc. of the XIV Int. Sci. and Practical Conf. on Agroindustrial Complex: State, Problems, Prospects pp 65-68