The Main Directions of Improvement of Sowing Disks of Units for Joint Sowing of Two Crops

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Abstract. This article describes the design of an experimental sowing disk for joint sowing of corn and sorghum seeds. The results of laboratory studies are presented and the need to improve the sowing disk and its individual elements is justified. A patent search for sowing machines and sowing disks was carried out in order to analyze and further synthesize the best solutions for the development of new designs of a sowing machine and a sowing disk for joint crops. The necessity of conducting research on further improvement of the disk elements in order to increase its reliability is substantiated.

The dynamic development of the agro-industrial complex and animal husbandry requires an increase in feed production, therefore, a promising direction for the development of feed production is the implementation of mixed crops of several forage crops, in particular corn and sorghum, which not only increase the nutritional value of the feed produced, but also give a significant increase in yield compared to their pure crops. Agronomists have proven the effectiveness of joint showing of corn with sorghum in one row with alternating sides in a row in the ratio (1:3, 1:4) [1].

However, despite the obvious prospects of joint crops, they are practically not implemented in Russia due to the lack of the necessary sowing equipment. The sowing machines of serial pneumatic seeders can sow seeds of only one crop during operation, and they are completely unsuitable for seeding seeds of two crops separately. In this regard, the search for rational schemes and designs of sowing machines for performing simultaneous seeding of seeds of several crops, based on theoretical research in this field, as well as existing designs of sowing machines of pneumatic seeders for dosed accurate seeding of seeds of various crops, has been and remains relevant.

To implement joint sowing of corn and sorghum with alternating seeds in a row (in a ratio of 1:4) Zubrilina E.M. [1] has developed a pneumatic sowing machine (Figure 1a), the design feature of which is a sowing disk with pneumatic cells for sowing sorghum seeds, arranged in groups between the holes for sowing corn seeds (Figure 1b) [2].

The sowing disk is a prefabricated structure and includes the following elements: the main seeding disk 1, the lining of the seeding disk 2, the gasket-washer of the seeding disk 3, the cleaner 4, the connecting screws 5 (Figure 2.) [2,3], while the screws 5 act as a peripheral agitator.

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a) a seeding machine for sowing corn and sorghum seeds [3]  

Figure 1. Pneumatic seeding machine for joint sowing of corn and sorghum seeds

b) sowing disk

Figure 2. Experimental sowing disk for simultaneous sowing of corn and sorghum seeds with alternating seeds in a row in a ratio of 1:4 [2,3]

Since agricultural machinery works in difficult conditions, that the problem of reliability, durability and wear resistance is always relevant [1]. An analysis of laboratory studies of this seeding unit with a disk for simultaneous sowing of corn and sorghum seeds showed a rather low resource and low wear resistance of the cleaner 4 (Figure 2), since the cleaner has a fixed position, and the disks constantly rotate in one direction, the friction process occurs on both sides of the cleaner, and the working bodies of the disk set are in therefore, dry abrasive friction constantly occurs in the dusty area, which leads to a rapid failure of the cleaner and the gasket washers, because the disks and the cleaning gasket are made of steel (GOST 4543-71) with appropriate physico-chemical characteristics.
Therefore, there is a need for additional research and refinement of the sowing disk in order to increase its resource, wear resistance, as well as versatility for joint sowing of various crops, not only corn and sorghum. Therefore, the research of our team is aimed at finding new materials for the manufacture of prefabricated disk elements (for example, cleaning pads) or a new design that allows us to realize the same ratio of 1:4 seeding of two row crops.

To develop new technical solutions, we conducted a patent search for several designs of seeding disks and seeding machines. B.Kh. Akhalaya and co-authors [4,5] developed a design of a pneumatic seeder seeding apparatus for combined sowing of row crops with their placement at different sealing depths (Figure 4). This unit allows us to sow seeds in three ways: combined, dotted and nested and at different sealing depths, which is an economically advantageous technical solution in terms of versatility.

**Figure 3.** Results of experimental studies of the joint seeding machine [2]

1 – operation of the unit before the intensification of the process; 2 – at $\alpha_{нз}=60^0$; 3 – at $\alpha_{нз}=60^0$ and $\gamma =30^0$; 4 – operation of the unit after intensification; 5 – curve based on the regression equation a) examination of the unit at different values of the main parameters  
1 – without agitator; 2 – factory without antenna; 3 – заводская с усиками; 4 – штифровая  
b) parameters of the quality of the unit's operation with various designs of agitators

**Figure 4.** Seeding apparatus of a pneumatic seed drill for combined seeding of seeds of various crops [4,5]
The authors proposed the design of seeding disks with suction holes and round magnetic pads, on which holes are made in the amount from 1 to 5. Each seeding disk is made of a polymer material, in the suction holes of which metal bushings are embedded (Figure 5) [4,5].

![Figure 5. Seeding disk with suction holes and round magnetic pads](image)

The authors [4,5] justified the choice of a polymer material for the sowing disk by increasing the service life compared to metal, better moisture tolerance and, as a result, corrosion resistance, wear resistance, less injury to seeds, since plastic has a lower coefficient of friction and an economic component from the point of view of manufacture (disk designs are printed on an industrial 3D printer of the Anifrom 950 brand-pro from Total Z).

In our opinion, the idea of using a sowing disk made of a polymer material and with removable pads can be taken as a basis for improving a prefabricated disk for sowing corn and sorghum seeds (Figure 2) in terms of sowing seeds of the main row crop (the seeding rate of which should be 100%).

To improve the process of sowing sorghum seeds in the disk (Figure 2), it is necessary to consider the possibility of replacing the pneumatic-mechanical cell with a more universal design that does not require pneumatics (to get away from the slot disk), but retains the ability to sow small-seeded crops. To find a new technical solution for the disk design, we analyzed the work of B.Kh. Akhalaya [6], who for many years has been one of the main authors of the designs of sowing machines and their elements for the implementation of joint and mixed crops of various crops.

The author [6] proposed the design of a universal sowing disk with through conical cells arranged on it with a uniform pitch (Figure 7).

The seeding disk is made collapsible from two rigidly fixed parts, one of which is made in the form of a round plate 3–4 mm thick with holes around the circumference, and the other in the form of a ring with mounting holes on the side and through conical cells. The use of a sowing disk allows us to sow seeds of different crops, which makes it universal.
Since we are developing the design of a sowing disk for sowing sorghum seeds, which belong to small-seeded crops, we have analyzed the patent [7], the idea of which can be used for sowing small-seeded crops.

**Figure 7.** Sowing disk for sowing small-seeded crops (numbering according to the text) [7]

The sowing disk contains evenly spaced seed cells on its end surface, made in the form of bodies of rotation, the bottom of which is crossed by an annular groove for the ejector. A conical groove 1 is made on the end surface of the sowing disk, in which the cells 2 for seeds are evenly arranged, made in the form of bodies of rotation, the bottom part of which is crossed by an annular groove 3 for the ejector. A chamfer 4 is made along the entire end surface of the disk in each cell 2 on the edge, at an acute angle, for example 45°.

As noted above, the effectiveness of peripheral agitators has already been proven, however, all the designs of units and seeding disks analyzed above do not contain such elements. Therefore, when developing a new disk design, it is necessary to provide for the presence of a peripheral agitator, and this is not about an additional element (such as pin 5 in Figure 2), but about a design that will be made at the same time as the disk, especially if a polymer material is used (Figure 8), as in the Precision Planting seeding machine (USA) and seeders of the ED "Amazone" family [8].

**Figure 8.** Examples of the use of polymer materials in precision seeders
The factors affecting the wear resistance of plastics are temperature, the roughness of the bodies and the nature of their coupling. Many modern types of plastics have greater contact resistance than steel.

Summing up our analytical research, we can outline the following design and technological ways to increase the reliability of the seeding apparatus for joint seeding of two crops and its prefabricated seeding disks: to develop a fundamentally new design of the seeding disk; to select the material of the friction pairs of the disk; to select a wear-resistant polymer material for the manufacture of a cleaner; to reserve less wear-resistant elements [9,10].

References
