Improvement of the technological process of sowing sunflower seeds with a pneumatic seed planter

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Abstract. The article provides the objectives for the need to study the influence of the shaper on the seed velocity, as well as the influence of the arrangement of its rods on the grain speed at the outlet of the seed flow shaper. The general scheme of the seed flow shaper, its description, 3D model and its arrangement on the seeder are given in the article. It also describes the method of measuring the velocity of seed material. As a result of the study, the dependence of the velocity of sunflower seeds on the distance of the placement of rods, as well as the velocity of grains without a flow shaper, is presented. It was found that as the distance between the axes of the rods increases from 5 to 30 mm, the seed velocity at the outlet from the diffuser increases insignificantly, being in the range of 3.2 – 2.7 m/s. The results of using the seed flow shaper of the proposed design on the seed line of the Amazone DMC Primera pneumatic seed planter for sunflower sowing are also presented. As a result of the assessment of the uniform distribution of plants in rows by seedlings, it was concluded that the quality of seeding improved, the coefficient of variation of intervals between plants was 61.2 and 78.4% with and without the use of a shaper, respectively.

1. Introduction
In recent years, there has been a tendency to increase the acreage under row crops. The most promising crops are sunflower and corn. For their sowing, as a rule, pneumatic precision seeders are used (Figure 1a). But the productivity of such seeders is limited by the width of the gripper and the velocity of movement during sowing. Also, the decrease in the productivity of these seeders is due to a large amount of time for technological maintenance, since an individual sowing machine of complex design with separate boxes for seeds is used for each row.

Achieving high productivity of seeding units is possible by increasing the width of the gripper and increasing the working speed. Also, the use of pneumatic row seeders of sowing systems with centralization (grouping) of dosing elements increases the efficiency of the seeder by reducing labour costs for technological maintenance and also reduces the material consumption of the machine [1]. An example of such machines is the EDX Amazone-Werke seeder (Figure 1b) with a large centralized hopper for seeds and fertilizers. The productivity of such precision seeding planters increases by 50% compared to planters with separate boxes for each seeding machine [2].
Figure 1. Types of seeders: a – Classic precision seeder; b – Precision seeder with centralized dosing system; c – Universal pneumatic centralized seeder

However, due to the limited number of crops sown by this planter, the annual load factor of the unit decreases, which negatively affects the costs of agricultural producers. Therefore, for row crops, especially for sowing corn and sunflower for silage [3], the most promising is the use of wide-reach grain seeders with centralized dosing and pneumatic transportation of seeds to chisel openers (Figure 1c).

Such seeders are optionally equipped with dosing coils for various crops, including corn, sunflower, and legumes [4]. Also, seeders equipped with appropriate chisel openers are suitable for both mulched and direct sowing, as well as for sowing by plowing and can be converted for sowing with a row spacing of 37.5 cm and 75 cm [5].

But at the moment, the use of existing sowing machines of this type without modernization in the sowing system does not allow achieving quality indicators under the agrotechnical requirements of sowing row crops. In this regard, the problem of the quality of sowing row crops with pneumatic grain planters requires more advanced design and technological solutions.

2. Problem Statement
The use of pneumatic seed transporting, with all its advantages, also creates disadvantages associated with rebound and blowing of the seed material, which negatively affect the longitudinal distribution of seeds in the furrow. At a high speed of seed material transporting at the moment when the seeds touch the bottom of the open furrow, an obliquely directed impact on the soil occurs. As a result, the grains bounce off the soil, thereby redistributing along the bottom of the furrow.

To solve these problems, various devices are used, such as a seed guide, an airflow damper, and a flow shaper [6, 7]. But they do not solve the problem of reducing the high speed and redistribution of seeds in the seed duct, but only extinguish the airflow.
3. Research Questions
The Samara State Agrarian University has developed a seed flow shaper (Figure 2) [8] that reduces the speed and regulates the seed flow entering the bottom of the furrow. The shaper includes two sections: an airflow dampener and a seed disperser (Figure 2) [7]. The airflow dampener has the form of a cylindrical mesh pipe the diameter of which is equal to the diameter of the seed duct. The diffuser is a section of the seed duct with circular rods installed diametrically in its transverse planes and evenly distributed in height.

![Figure 2. Process flow diagram and 3D model of the seed flow shaper: 1 – airflow damper; 2 – cylindrical mesh pipe; 3 – seed diffuser; 4 – hollow cylinder; 5 – round rods.](image)

Since in the diffuser the points of intersection of the axial lines of the round rods with the walls of the shaper form a helical line, all the rods are located one relative to the other at the same angle; therefore, the seeds falling on the rods are reflected by them in different directions along the cross-section of the shaper. The process of distribution of seed material along the longitudinal and cross-section occurs along the entire path of their movement in the pipe of the diffuser. Since the distance between the projections of the center lines of the rods on the cross-section of the diffuser is less than or equal to the diameter of the rods, it is excluded that the seeds fly past the rods without reflection, i.e. all seeds entering the diffuser interact with the rods, change their speed and direction. The seed flow shaper is installed at the entrance to the chisel opener of the pneumatic seeder (Figure 3).

Since the seed velocity and the uniformity of the distribution of the seed material along the furrow depend on the design parameters of the diffuser, the studies have been conducted to determine the effect of the placement of the rods on the value of the seed velocity after the diffuser.
4. **Purpose of the Study**

The study aims to increase the uniformity of seed distribution along the bottom of the furrow by reducing the aftereffect of the airflow and reducing the seed velocity at the outlet of the seed flow shaper. To achieve this, it is necessary to solve the following problem – to determine the regularity of the influence of the distance of the placement of the rods in the diffuser on the speed at the outlet of the shaper.

5. **Research Methods**

To study the effect of the placement of the rods based on the seed velocity, the diffusers were made in the form of a section of the seed pipe with a diameter of 40 mm, in which 7 rods with a diameter of 5 mm were installed. This influence was studied when setting the distance between the axes of the rods in height from 5 to 35 mm with an interval of 5 mm.

The study of the influence of the arrangement of the rods on the grain velocity at the outlet of the seed flow shaper was carried out on a laboratory installation [9] including an air blower, a pipeline stabilizing the airflow, the investigated section of the seed flow shaper. The unit also contains two micromanometers with a Pitot-Prandtl tube and two U-shaped micromanometers for measuring static pressure, which are used to determine the airflow velocity before and after the shaper. This unit also includes a measuring unit for determining the seed velocity. The unit consists of two photo-electrical sensors installed at a distance from each other in the course of the seed movement, the microcontroller and the device for the information output. Each of the sensors consists of an infrared emitter, which is a set of infrared LEDs, and a photo-detector placed opposite each other. The sensor installation distance is 100 mm.

The studies were carried out as follows: after turning on the air blower, the required airflow rate was set at the speed of its rotation. After the air blower, single sunflower seeds were fed to the stabilizing section of the pipeline. At the outlet from the flow shaper, their velocity was recorded by a measuring unit. The
principle of determining the speed was to calculate the time of flight between 2 sensors. The recorded velocity of the seeds was displayed on a digital display board in the unit.

6. Findings
As a result of the experiment, the data were obtained, based on which a graphical dependence of the speed of sunflower seeds on the distance between the rods was constructed (Figure 3). The seed velocity without the flow shaper was 11.4 m/s.

![Graph showing dependence of seed velocity on distance between rods](image)

Figure 4. The dependence of the velocity of sunflower seeds on the distance of the placement of the rods

From the results obtained, it can be seen that as the distance between the axes of the rods increases from 5 to 35 mm, the velocity of the seeds after the diffuser, at the outlet from the flow shaper, increases insignificantly, from 2.7 to 3.5 m/s, but it is remarkably less than the velocity of the seeds without installing the rods.

The decrease in the velocity of the seeds after the diffuser occurs due to their collision with the rods and multiple changes in the trajectory along the way. A slight increase in the velocity of the grains with an increase in the distance between the rods is the result of an increase in the length of the diffuser and as a result of the repeated acceleration of the seeds after their interaction with the rods of the diffuser.

The seed flow shaper, in the form of a damper with a diffuser in which the rods are installed at a distance of 30 mm between the axes, was installed on the seed line of the Amazone DMC Primera pneumatic seed planter when sowing sunflower seeds. As a result of the assessment of the uniform distribution of plants in rows on seedlings, it was found that the use of the shaper helps to improve the quality of seeding. When analysing the crops in the compared areas, it was found that the coefficient of variation of the intervals between plants when sowing with the use of the shaper was 61.2%, but without it - 78.4%.

7. Conclusion
Thus, the use of a flow shaper on a pneumatic seed planter, to improve the technological process of sowing sunflower seeds, helps to increase the uniformity of the distribution of seed material along the bottom of the furrow. As a result of the conducted studies, it was found that the combined use of an airflow damper and a diffuser helped to reduce the seed velocity from 11.4 m/s to 2.7 m/s. Field studies have confirmed an increase in the quality of seed distribution along the row.
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