Experimental seeders for sowing unseeded seeds

E T Farmonov1, A M Arifjanov2, F E Farmonova3

1 Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Republic of Uzbekistan
2 Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Republic of Uzbekistan
3 Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Republic of Uzbekistan

E-mail: Erkinfarmonov2009@mail.ru

Abstract. Information on the use of seeders for sowing seeds of agricultural crops and their converted experimental seeders for sowing unseeded seeds is given in this article. It has been shown that such sowing units do not fully meet the agro technical requirements for sowing unseeded seeds. Most of the research focused on the issues of unloading seeds from the bunker, but did not study the laws of their movement inside the bunker. The authors have proposed a separate two-section hopper for the seeding row of the seeder when sowing unseeded seeds of fodder plants in deserts. Inside the two-section hopper of the proposed seeder, mathematical expressions are set that make it possible to determine the regularity of the movement of unseeded seeds and the time of their fall.

1. Introduction

Arid pastures are the main source of fodder for cattle and sheep breeding in Uzbekistan [1]. Therefore, it is necessary to improve pastures by sowing seeds of pastures crops.

For the purpose of sowing non-seeded seed material, studies were carried out on prototypes equipped with seeders or their sowing apparatus for sowing agricultural crops unsuitable for arid pasture and other conditions [2, 3, 4, 5, 6, 7, 8, 9, 10].

Unseeded seed is usually sown in seed mix mode. Inside the seed hopper, propellers and working parts of the conveyor (rotor, blade, auger, etc.) of various designs are provided for delivering compacted and clogged heaps of seed mixture to the seed window of the hopper. Installation inside a hopper in such large-scale structures is due to the fact that the working parts are subjected to constant mechanical stress due to the forced resistance and the transfer of slightly damaged seeds. As a result, the biological viability of seeds is reduced. Also, due to the small range of seed movement, only a certain part of the seeds enters the seed-unloading window, the rest of the seeds remain in the hopper and the sowing process by unloading the seeds from the hopper stops. Studies have shown that such units do not fully meet the agro technical requirements for sowing unseeded seeds.

A number of researchers have conducted research to improve the sowing apparatus of seeders for sowing unseeded seeds of edible plants [11, 12, 13, 14]. In the course of the study, the issues of unloading seeds from the bunker were studied. However, they did not study the laws of movement of
unseeded seeds in the bunker.

2. Materials and methods
As a result of a critical scientific analysis of the shortcomings of the aforementioned seeders, the authors proposed a hopper for a seeder for sowing unseeded seeds of fodder plants in deserts. The novelty of the proposed seeder is that it has a separate two-section hopper for the seed row (Figure 1) [15].

![Figure 1. Bunker construction scheme](image)

The first rectangular part of bunker I is deployed, the second is of bunker II. Trapezoidal part. 1st hopper, 2nd seed separator, 3rd drum of the separator.

We analyze the regularity of the movement of semen in the bunker seeder. We use the diagram below, to explore the movement of the semen in the first part of the bunker in straight rectangular structure (Figure 2).

![Figure 2. Scheme of the analysis of the movement of seeds in the first part of the bunker of rectangular design.](image)

The upper first part of the hopper is installed at an angle of 900 to the horizontal in the direction of the U axis. Here, in order to improve the downward movement of seeds in the hopper, its walls are made at a greater angle than the angle of friction of seeds against a metal surface relative to the seeder and the drum of the seed separator. Inside the bunker, the gravitational force \( G \), which moves the seeds down, and the resistance forces \( F_1 \) and Archimedes \( F_2 \), interact in the direction opposite to the direction of movement (Fig. 2). If the gravitational force \( G \) of the seed is greater than the sum of the forces \( F_1 \) and Archimedes \( F_2 \), i.e. \( G > F_1 + F_2 \), the seeds move along the hopper from its upper first part down, that is, to its second part.

When deriving the equation of motion of seeds, based on the laws of mechanics [16, 17], we project all forces in the direction of motion.

Take a seed as a solid particle and compose the equation of motion for it as follows:
\[
m \frac{d\theta_0}{dt} = G \cdot F_1 - F_2, \quad (1)
\]

Where: G is the gravity of the seed; \( F_1 \) - resistance force; \( F_2 \) - the strength of Archimedes; \( V_0 \) - seed speed; \( m \) is the mass of the seed.

Summing up the force of gravity and the force of Archimedes, we write:
\[
G - F_2 = (\rho - \rho)gV, \quad (2)
\]
in this: \( \rho \) - seed density; \( V \) - seed size; \( g \) - acceleration of gravity.

We determine the resistance force based on the Stokes model [18]:
\[
F_1 = 3\pi \mu \theta_0 d, \quad (3)
\]
in this: \( \mu \) - dynamic viscosity coefficient of air; \( d \) - seed diameter.

Substituting expressions (2), (3) into (1) and taking into account that \( m = \rho V \), we write down the mathematical model of the seed movement:
\[
\frac{d\theta_0}{dt} = (\rho - \rho)gV - 3\pi \mu \theta_0 d
\]
or
\[
\rho \cdot V \frac{d\theta_0}{dt} = Vg (\rho - \rho) - 3\pi \mu \theta_0 d. \quad (4)
\]

By entering the following expressions, \( g (\rho - \rho) / \rho_r = A; \quad 3\pi \mu d / \rho_r V = B \), let's write the expression as follows:
\[
\frac{d\theta_0}{dt} = A - B \theta_0 \quad \text{or} \quad \frac{d\theta_0}{B_1 dt} = \frac{A}{B} - \theta_0
\]
\[
B_1 \frac{d\theta_0}{dt} = A_1 - \theta_0; \quad B_1 = \frac{1}{B}; \quad A_1 = \frac{A}{B};
\]
\[
t = B_1 \int \frac{d\theta_0}{A_1 - \theta_0}. \quad (5)
\]

Integrating the last expression (5), we obtain the following relation for time:
\[
t = -B_1 [\ln(A_1 - \theta_0) + C_1] \quad (6)
\]

in this \( C_1 \)-constant of integration:

Based on the obtained results, we will consider the initial conditions of the problem when performing computational work. Background:

\[
t = 0 \quad \theta_0 = \theta_0 = 0.
\]

in this case: \( C_1 = B - \ln A_1 \)

Based on equation (6), we determine the time it takes for the seeds to fall into the second part of the bunker as follows:
\[
t = B_1 \ln \frac{A_1}{A_1 - \theta_0} \quad (7)
\]

Based on this expression, the speed at which the seeds enter the second part of the bin is determined as follows:
\[
\theta_0 = A_1 - A_1 e^{-\frac{t}{B_1}}. \quad (8)
\]

When using the proposed calculation methods (6) and (7), in practice, an “effect” of the added mass arises in the process of joint seed fall. Using [19] to estimate the “effect” of added mass, we determine the rate at which seeds fall together as follows.
\[
\theta = \theta_0 (1 - S_k)^n
\]

where: \( S_k \) - seed concentration; \( S_k = V_0 / V \); \( V \) - shaped hopper capacity; \( V_0 \) - volume occupied by seeds; coefficient determined in the n-experiment.

Based on experiments carried out in the laboratory, the initial parameters of the seeds in the bunker
are determined and the experimental coefficient is determined. This, from the first part of the proposed rectangular design, expressions were obtained to determine the movement of seeds and the time of their fall.

The seed sizes required for the experiment were taken from the table below [20]

| №  | Plant             | Seed size, mm | density km/m³ | Mass of 1000 seeds, g |
|----|------------------|---------------|---------------|-----------------------|
|    |                  | thickness     | width         | length                |                       |
| 1  | Haloxylon (Saxaul)| 1,5-3,8       | 1,6-4,0       |                       | 92-98                 | 2,1-4,9               |
| 2  | Cherkez          | 2,8-4,5       | 8,0-19,0      |                       | 90-94                 | 11,3–15,8             |
| 3  | Chogon           | 1,6-3,8       | 6,0-16,0      |                       | 36-49                 | 12,3–16,1             |
| 4  | Izen-soz soil    | 0,8–2,3       | 1,6 - 3,8     | 1,9- 3,9              | 220 - 250             | 1,4 - 2,3             |
| 5  | Izen- sandy soil | 1,0–2,5       | 1,9 - 4,1     | 1,9- 4,1              | 133 – 150             | 1,5 - 1,8             |

Using Table 1, calculations for the plant seed sizes required for the experiment were performed using expressions (7), (8), (9) (for saxaul, cherkez). In the calculations, the following initial data were taken: seed density $\rho_t = 98$ kg/m$^3$, air density $\rho_t = 985$ kg/m$^3$, dynamic air viscosity $\mu = 18,2 \cdot 10^{-6}$ Pa·s, $V = 0,5 \cdot$ seed volume.

Based on the experiments carried out and the proposed formulas, calculations were performed for the proposed bunker, consisting of two parts. The calculation results are shown in Figure 1 below.

The graph shows that as the concentration of seeds increases, the rate of their fall decreases. The rate of seed drop and their concentration are correlated according to the law of mutual parabola. Here the optimal concentration of seeds is $S_k = 0.75$, and the seed speed is $V = 0.13–0.25$ m/s.

The qualitative analysis of the cast samples' structures has shown that we have not succeeded in detecting a significant difference in the eutectoid amount under various concentration of the modifier. By means of the metallographic studies it has been found that the change in the eutectoid content is not so significant as it was during the influence of different cooling rates on the same bronze. The maximal difference (a decrease from 15 % to 10 %) was detected in case of the sample, which contained 0.75 % of the modifier. At that, the samples with 0.75 and 1.5 % addition of the modifier possessed such vastly branching morphology of eutectoid that it did not allow determining a sphericity coefficient and an average size for them.
3. Conclusion

1. There is no sowing unit that meets the agro-technical requirements for sowing seeds of forage crops. Research on sowing unseeded seeds examined the issues of unloading seeds from the hopper and did not study the laws of their movement inside the hopper.

2. Instead of a large seed hopper, it was decided to create a separate hopper for the seed row.

3. We studied the law of motion of unseeded seeds in a two-section hopper, recommended for the sowing machine for seedlings. At the same time, a law was created that allows determining the time of movement and fall of seeds of forage plants of the desert into the bunker of the seeder. In the course of the study, it was found that the optimal concentration of the seed particle is $S_k = 0.75$, and the speed of its fall is $V = 0.13-0.25 \text{ m/s}$.

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