Evaluation of the efficiency of row-crop seeders using vacuum and extrabaric seed metering methods

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Abstract. Developed agricultural production is the basis for the economy of any country. Therefore, it is important to develop agricultural technologies, mechanize the cultivation process, provide organizational and information support, etc. Crop production is an important part of agricultural production. Agricultural crops are grown using various cultivation technologies. In each technology, sowing is the most important process, that allows you to predict the volume of future crops and determine profitability of the agricultural production. The article substantiates the fundamental influence of high-quality sowing on the yield of sunflower seeds. The processes of dosing sunflower seeds with pneumatic seeders are described. The advantages of the extrabaric seed dosing system in comparison with the vacuum seed dosing system are identified. The conditions and methods of conducting a field study in the south of Russia are described to assess the quality of sowing sunflower seeds by vacuum and extrabaric dosing systems. The results of a field study of the quality of distribution of seeds and sunflower plants in the soil are analyzed for arid conditions of southern Russia. The quality of arrangement of sunflower plants was analyzed for vacuum and extrabaric dosing systems. The possibility of improving the vacuum and extrabaric dosing systems is described.

1. Introduction

Sunflower is a valuable oilseed crop whose production has been increasing in the Russian Federation and Eastern Europe [1-3]. One of the ways to increase the production of sunflower is high-quality sowing. The high productivity of plants depends on the distribution of the optimal number of seeds in the soil with a rational nutritional area [4-7]. In practice, it is difficult to sow sunflower seeds due to their different shapes (elongated, triangular, oval) and sizes.

Sunflower seeds are sown in a dotted manner with single-seeded seeders. These seeders are equipped with mechanical and pneumatic seeding units. Pneumatic seeding devices are more widespread, since they are more versatile. In turn, pneumatic seeding devices use a vacuum or extrabaric seed metering system.

In a generalized form, the vacuum seed metering system operates as follows (Figure 1). In the housing of the sowing unit, a rotating sowing disc with rounded metering holes is located on the drive shaft. The disc divides the enclosure space into two parts. The seed chamber is located on one side of the sowing disc and the vacuum chamber - on the other one. The air flow in the holes of the seeding disc is created due to the pressure difference in the seed chamber (atmospheric) and vacuum (less than atmospheric), therefore the flow is directed from the seed chamber to the vacuum one. The moving air stream cap-
tures the seeds and presses them against the holes in the seed disc. In this way, seeds are captured in the seed chamber. The sowing disc moves the seeds pressed against the holes to the work area of the extra seed spreader. Their purpose is to leave one seed at each hole of the sowing disc. The spreader operation is necessary when there is more than one seed in the hole. By design, ejectors can be plate, roller, brush, or combined. The sowing disc transports the seeds pressed against the holes to the point where they are dropped into the opener.

![Diagram of seed metering system](image)

**Figure 1.** Vacuum seed metering system

The extrabaric seed metering system operates as follows (Figure 2). The sowing disc forms an internal space for the seed and extrabaric chambers, into which seeds and compressed air are fed, while the compressed air (pressure greater than atmospheric pressure) moves through the metering elements of the seeding disc into the surrounding space (atmospheric pressure). In the sowing disc, metering elements are made in the form of recesses of a certain shape with an opening for air passage. When the seeding disc rotates and compressed air is supplied, the seeds are fixed by the air flow in the metering elements of the seeding disc and are transported to the operating area of the extra seed spreader, which leaves one seed in the metering elements (similar to the vacuum seed metering system). Further, the dosing elements deliver the seeds to the intake device, the seeds from the dosing elements are fed into the seed tube using the air flow. The air stream moves the seed through the seed tube into the opener.

The extrabaric seed metering system has the following advantages: the metering elements act on the seeds during metering better than the holes, the zone of entry into the metering elements is larger, the air flow acts more actively on the seeds when they enter the metering elements, the dominant seed is better retained in the metering element than in the opening of the disc, the seed moves the air stream into the opener.

All these advantages allow the extrabaric system to qualitatively dose seeds at operating speeds of up to 15 km/h, to be universal for sowing seeds of various crops, to use various layouts of working bodies, to vary the size of row spacings in a wide range [8-10].

In this regard, the purpose of the study is to assess the quality of seeding by the methods of vacuum and extrabaric dosing when sowing sunflower seeds.
2. Materials and methods
Evaluation of seeding by the method of vacuum and extrabaric dosing was carried out on the most difficult for piece dosing material sunflower seeds, which have an elongated shape that is very different from a round one, therefore the seeds adhere well to each other, which complicates high-quality dosing.

To assess the quality of seeding, a field study was carried out in the south of Russia.
Sowing was performed in the optimal agrotechnical period with the same seed material with a row spacing of 0.7 m, Russian seeding machines with vacuum and extrabaric dosing systems at an operating speed of 9 km / h. The seeding depth was similar. For high-quality operation of the vacuum system, a vacuum of 3.8 kPa was required, and the extrabaric system required a pressure of 1.9 kPa. A skid-shaped opener was used for a seeder equipped with a vacuum metering system, and a double-disc opener was used for a seeder with an extrabaric metering system. Sowing was carried out on a field prepared for sowing, on the same day with the introduction of the same starting dose of mineral fertilizers. Dry climatic conditions were observed in the year of the study; precipitation was not observed after sowing. After the emergence of sunflower plants, the distances between the plants were measured (1052 measurements were made for the extrabaric dosing system, and 772 measurements were made for the vacuum dosing system in order to reduce the experimental error) and a data set was compiled.

3. The study of base of data
After processing the data about intervals between plants using the dependencies of mathematical statistics, the results presented in Table 1 were obtained.

Having analyzed the results, we have identified that for the extrabaric dosing system the number of plants in the sowing row was 3.9 pcs/m with the established seeding rate of 4.8 pcs / m and the number of seeds in the soil was 4.8 pcs / m, while 0.9 pcs/m of seeds did not germinate due to the lack of moisture; for the vacuum metering system the number of plants was 4.6 pcs / m with the established seeding rate of 4.2 pcs / m and the number of seeds in the soil was 5.7 pcs / m, while 1.1 pcs/m of seeds did not germinate due to the lack of moisture; the deviation from the established seeding rate for the extrabaric dosing system was 17.9%, and when the seeds remaining in the soil germinate, the value will be zero; for the vacuum dosing system, this indicator is equal to 9.3%, and with the germination of seeds remaining in the soil, the value will increase; the average distance between plants for the extrabaric dosing system was 25.4 cm (at a given 20.8 cm) and when the seeds remaining in the soil

\[ A \rightarrow \text{air flow;} \\
B \rightarrow \text{seed flow from the hopper;} \\
C \rightarrow \text{air flow with seeds to the seed tube;} \\
1 \rightarrow \text{extra seed spreader;} \\
2 \rightarrow \text{bridge breaker.} \]
germinate, the value will be one; for a vacuum dosing system this indicator is 21.8 cm (at a given 23.8 cm), and with the germination of seeds remaining in the soil, the value will increase in the direction of decreasing the average distance between plants; the coefficient of variation of the intervals between plants for the extrabaric dosing system was 58.3%, and for the vacuum dosing system it was 56.9%, which is approximately the same, but with germination of the seeds remaining in the rows, the coefficient of variation will decrease, increasing for the dosing system.

| Table 1. Plant distribution results |
|-----------------------------------|
| Indicator                        | Size | Extrabaric dosing system | Vacuum dosing system |
| Seeding rate                     | pcs / m | 4,8                      | 4,2                  |
| Number of seeds in soil          | pcs / m | 4,8                      | 5,7                  |
| Number of plants per seeding row | pcs / m | 3,9                      | 4,6                  |
| Deviation of the number of plants in the seed row from the seeding rate | % | -17,9                    | +9,3                 |
| Average distance between plants  | cm    | 25,4                     | 21,8                 |
| Standard deviation               | %     | 14,8                     | 12,4                 |
| Average distance between plants error | cm | 0,5                      | 0,4                  |
| Relative experiment error        | %     | 1,8                      | 2,0                  |
| Frequency of intervals of the least value | % | 39,1                    | 36,8                 |
| Frequency of intervals of the optimal value | % | 34,2                    | 33,7                 |
| Frequency of intervals of the largest value | % | 26,7                    | 29,5                 |
| Coefficient of variation of intervals | % | 58,3                    | 56,9                 |

4. Conclusion
The quality of seeding was assessed by the methods of vacuum and extrabaric dosing systems when sowing sunflower seeds with a relative error of no more than 2%. It was found that the extrabaric system doses the seeds more accurately, since the amount of seeds in the soil corresponds to the specified one, and the vacuum system had an overexpenditure of seeds which is 1.5 pcs/m. The frequency of intervals between plants is similar (the difference is not more than 2.8%), but for the extrabaric dosing system, the germination of seeds remaining in the soil will lead to a significant decrease in the frequency of intervals of a larger value, to a small an increase in the frequency of intervals of a smaller value and a significant increase in the frequency of intervals of an optimal value (since the number of seeds in the soil corresponds to 4.8 pcs/m); for the vacuum-intelligent dosing system, germination of seeds remaining in the soil will decrease the frequency of intervals of a larger value, increase the frequency of intervals of a smaller value and increase the frequency of intervals of an optimal value (since the number of seeds in the soil - 5.7 pcs / m - is significantly higher than 4.2 pcs / m). Despite the advantage of the extrabaric dosing system (the frequency of intervals of the optimal value is 34.2%) over the vacuum one (the frequency of intervals of the optimal value is 33.7%), both of them have significant reserves for increasing the frequency of intervals of an optimal value.

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