The influence of the moisture content of the heap at the moment of threshing and the influence of width of the sieve holes on the content of grains with film

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Abstract. Our own research and analysis of the literature cited in the work have identified a number of different factors that affect the quality of the harvested grain. The paper provides an assessment of the influence of such indicators as the physical and mechanical properties of the harvested crop, the design features of the threshing-separating devices, the relative humidity of the processed heap, the size of the openings of the screens of the separating device. Studies carried out for machines with various types of threshing and separating devices have shown the advantage of rotary machines. The heap obtained on them with minimal contamination contains 2.2 times less crushed grain and 1.5 times more grain with the film. The sowing qualities of seeds, both germination energy and laboratory germination, are higher than those of seeds obtained from combine harvesters with a classic threshing-separating device. Investigations of the distribution of the components of the grain heap coming from the combine harvesters were carried out at five different moisture levels of grain on sieves with a hole width of 2.0 to 3.2 mm. The experimental results showed that the relative humidity of the grain does not significantly affect the distribution of the grain heap. At the same time, studies have shown that the bulk of the heap entering post-harvest processing in a grain cleaning machine is allocated on sieves with a hole diameter of 2.4–3.0 mm. The largest amount of whole grain is allocated on sieves 2.4–3.0 mm. With an increase in the grain moisture content of the initial heap from 14.1 to 18.9% and the size of the sieve openings from 2.0 to 3.2 mm, an increase in the amount of grain with the film is observed. The results presented can be used in organizing the activities and substantiating the design and technological schemes for post-harvest grain cleaning.

1. Introduction
The national security of the Russian Federation directly depends on its food independence. Agriculture, which is based on grain production, ensures the sovereignty of our state in this area. Increasing the production of seeds and food grains is the main task of the country's agro-industrial complex [1, 2]. The priority direction of the development of the agro-industrial complex is the widespread use of advanced technologies and technical means, taking into account the soil and climatic characteristics of various regions and specific farms [3–5]. Taking into account the preservation of sown areas, an increase in the volume of grain obtained is possible due to a decrease in losses at all stages of its production and an increase in yield. The main factor affecting the yield of
crops grown is the quality of the seed. The quality indicators of seeds in accordance with the current GOST for wheat are shown in Table 1.

At the present stage, grain harvesters of domestic and foreign production are still the main means for harvesting cultivated crops [6, 7]. The dominant means for cleaning seed and food grains are grain cleaning machines installed in the technological lines of grain cleaning units and grain drying complexes used in agricultural enterprises of the agro-industrial complex of the Russian Federation [8–11].

The quality of the grain obtained during harvesting depends on a number of factors: the physical and mechanical properties of the harvested crop, the design features of the threshing-separating device (TSD) and its operating modes [12–15]. The results of studies on the qualitative composition of the grain heap obtained from grain harvesters with different types of TSDs are presented in Table 2.

### Table 1. Varietal and sowing qualities of wheat seeds.

| Seed category | Varietal purity, %, not less | Damage to sowing by smut, %, not more | Purity of seeds, %, not less | Content of seeds of other plants, pcs/kg, no more | Impurities, % no more | Germination, %, not less |
|---------------|----------------------------|---------------------------------|-----------------|--------------------------------|-----------------|-------------------|
| OS            | 99.7                       | 0/0                             | 99.0            | 8                              | 3               | 0                 | 0                 | 92               |
| ES            | 99.7                       | 0.1/0                           | 99.0            | 10                             | 5               | 0                 | 0.01              | 92               |
| RS            | 98.0                       | 0.3/0.1                         | 98.0            | 40                             | 20              | 0.002             | 0.03              | 92               |
| RSm           | 95.0                       | 0.5/0.3                         | 97.0            | 200                            | 70              | 0.002             | 0.05              | 87               |

Table 2. Qualitative composition of the grain heap coming from combine harvesters with various types of TSDs.

| Indicators                                         | TSD type |
|----------------------------------------------------|----------|
| Rotation frequency of drum/rotor, rpm               | 980      |
| Components of the grain heap:                       |          |
| Whole grain, %                                     | 92.64    | 96.44 |
| Crushed grain, %                                   | 5.98     | 2.76  |
| Grain in film, %                                   | 0.94     | 0.64  |
| Weeds, %                                           | 0.19     | 0.16  |
| Germination energy:                                 |          |
| Laboratory germination, %                           | 72.6     | 76.8  |
| Undamaged (manual threshing), %                    | 100      | 100   |
| Damaged (combine threshing), %                     | 92.6     | 94.6  |

The data of experimental studies presented in Table 2 show that the grain heap obtained from combine harvesters with a rotary threshing and separating device at a drum rotation frequency of 980 rpm has the best quality indicators. It contains more whole grain, 2.2 times less crushed grain and 1.5 times more grain in the film. In addition, it has minimal debris. The sowing qualities of seeds, both germination energy and laboratory germination, are higher than those of seeds obtained from combine harvesters with a classic threshing-separating device. To determine the effect of grain moisture at the
time of threshing and the size of the holes of the sieves installed in grain cleaning machines for post-
harvest processing of grain included in the processing lines of grain cleaning units on the grain content
in the film, special studies were carried out.

2. Materials and methods
The research was carried out during the harvesting of winter wheat “Severodonetskaya Yubileinaya”
in the fields of LLC NPKF “Agrotech-Garant Berezovsky”. In accordance with the current
GOST 12036-85, the composition of the grain heap was determined, the selection of samples with a
moisture content of 14% was carried out in three replicates of 0.5 kg each. The moisture content of the
grain at the time of threshing was determined with a Wile-65 moisture meter. To determine the
fractional composition of the heap coming from the combine harvesters for post-harvest processing, a
laboratory sieve classifier UI-ERL-2-1 was used, equipped with a set of sieves with longitudinal holes,
the size of which varied from 2.0 to 3.2 mm. The fractions of grain material isolated during separation
on sieves were weighed on a JW-1 electronic balance with an accuracy of 0.01 g. Three weighed
portions weighing 45.0–50.0 g were isolated from each sample, foil and weeds. The qualitative
indicators of the components that make up the grain heap obtained from the combine harvesters are
presented in Table 3.

Table 3. Distribution of the components of the grain heap coming from the combine harvesters at
different humidity levels.

| Moisture content of the initial heap, % | Width of sieve holes, mm | Distribution of grain heap components on sieves, % | Whole grain, % | Grain with film, % |
|---------------------------------------|--------------------------|-----------------------------------------------|----------------|------------------|
| 14.1                                  | 2.0 2.4                  | 88.84                                         | 0              |
|                                       | 2.2 3.1                  | 95.92                                         | 0.2            |
|                                       | 2.4 9.1                  | 97.55                                         | 0.7            |
|                                       | 2.6 30.3                 | 97.6                                          | 0.85           |
|                                       | 2.8 25.2                 | 98.03                                         | 0.95           |
|                                       | 3.0 26.2                 | 95.5                                          | 2.85           |
|                                       | 3.2 3.7                  | 87.74                                         | 8.2            |
|                                       | 2.0 2.4                  | 89.22                                         | 0              |
|                                       | 2.2 3.0                  | 96.37                                         | 0.35           |
|                                       | 2.4 7.7                  | 97.6                                          | 0.6            |
| 15.5                                  | 2.6 35.8                 | 97.7                                          | 0.6            |
|                                       | 2.8 24.6                 | 98.1                                          | 0.9            |
|                                       | 3.0 22.9                 | 95.4                                          | 3.1            |
|                                       | 3.2 3.6                  | 88.04                                         | 8.61           |
|                                       | 2.0 3.0                  | 89.27                                         | 0.12           |
|                                       | 2.2 3.2                  | 95.99                                         | 0.3            |
|                                       | 2.4 8.0                  | 97.35                                         | 0.6            |
| 17.5                                  | 2.6 37.8                 | 97.8                                          | 0.65           |
|                                       | 2.8 25.3                 | 97.95                                         | 0.95           |
|                                       | 3.0 19.1                 | 95.45                                         | 3.2            |
|                                       | 3.2 3.6                  | 88.08                                         | 10.02          |
|                                       | 2.0 2.7                  | 89.45                                         | 0.1            |
|                                       | 2.2 4.2                  | 94.69                                         | 0.35           |
|                                       | 2.4 13.1                 | 97.2                                          | 0.55           |
| 18.9                                  | 2.6 40.5                 | 97.85                                         | 0.7            |
|                                       | 2.8 22.5                 | 98.08                                         | 0.9            |
|                                       | 3.0 15.0                 | 96.44                                         | 2.76           |
|                                       | 3.2 2.0                  | 87.98                                         | 10.14          |
3. Results

From the experimental data presented in Table 3, it can be seen that the bulk of the heap entering the post-harvest processing in the grain cleaning machine is allocated on sieves with a hole size of 2.4–3.0 mm. The largest amount of whole grain is allocated on sieves 2.4–3.0 mm. With an increase in the grain moisture content of the initial heap from 14.1 to 18.9% and the size of the sieve openings from 2.0 to 3.2 mm, an increase in the amount of grain released in the film is observed. For instance, with a grain moisture content of 14.1%, the maximum value of the allocated grain in the film is noted on a 3.2 mm sieve and equals 8.2%, and at a moisture content of 18.9%, 10.14% is allocated on the same sieves.

In the course of processing the results of the studies carried out, with the elimination of insignificant factors, it was found that the combined effect of the moisture content of the original heap and the sizes of the sieve holes on the grain distribution in the film is approximated with sufficient accuracy by the following equation:

\[
C_u = 68.77 - 58.15b - 0.14W_u + 11.63b^2 + 0.22bW_u - 0.01W_u^2
\]

\[
R = 0.94
\]

4. Conclusions

The research results presented in Table 3, on the combined effect of the initial moisture content of the heap and the size of the holes of the sieves used in grain cleaning machines, show that the size of the holes of the sieves has a significant effect on the distribution of the grain heap, that is, the size of the holes of the sieves, but not the moisture content of the original heap.

The heap obtained from combine harvesters with an axial-rotor threshing-separating device has the best quality indicators.

Based on the results of the studies carried out, the materials presented in the tables, we can say with confidence that in order to obtain high-quality seeds, it is necessary to significantly reduce the level of damage at all stages of production, both during harvesting and during post-harvest processing.

To reduce damage to seed material and improve the quality of the grain heap on farms, especially in seed production, it is necessary to use rotary combine harvesters.

Post-harvest processing of the grain heap coming from the combine with the presence of collapsed, crushed seeds, seeds with the film and weeds should be carried out in-line without placing it on the current with wide use in technological lines of fractional grain cleaners.

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