Results of Sorting Rice Seeds in an Energy-Saving Electric Sorting Device

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Abstract: This article discusses the design of an energy and resource-saving electric sorting device, its circuit diagram, operating principle, definition of operating modes, designed for sorting rice seeds and obtaining seeds with high quality, similar biological properties, high fertility and potential yield in laboratory and field conditions, in addition informations on experimental studies on the selection of rice seeds, the study of the physical and mechanical properties of selected rice seeds, as well as the results of determining their fertility in laboratory and field conditions. The energy and resource-saving electric sorter can be used in rice seed preparation technological systems, rice clusters and farms.

1 INTRODUCTION

It is known that the quality indicators of seeds prepared for planting, along with other agrotechnical measures, play a very important role in obtaining a bountiful harvest of agricultural crops. After all, the uniform and smooth germination of seedlings, subsequent growth, ripening of the crop and, finally, rice yield directly depend on the quality indicators of seeds prepared for planting. Therefore, improving the quality indicators of rice seeds prepared for planting is one of the urgent tasks today.

The quality of rice seeds can be improved by various methods, including selective breeding. It is known from scientific sources that in order to obtain high-quality seeds of agricultural crops that are close to each other in biological properties, with high fertility and potential yield in laboratory and field conditions, it is necessary to sort them according to all important physical and mechanical properties (Rosaboev, 2015; Tagaev & Akramov, 2024). Sorting crop seeds in an electric field fully meets this requirement. Because the electric field affects the seeds with directed electric field strengths of varying magnitudes, taking into account all their important physical and mechanical properties. As a result, in an electric field, crop seeds are sorted according to all important physical and mechanical properties, namely: weight, geometric dimensions, density, electrical resistance, dielectric absorption and other similar important properties.

2 MATERIALS AND METHODS

Considering the above, as a result of research and design work carried out within the framework of the State Scientific and Technical Program in recent years at the Research Institute of Agricultural Mechanization, an energy and resource-saving electric sorting device was created that improves the quality indicators of agricultural crops, including seeds rice (Patent, 2022a). The essence of an energy- and resource-saving electric sorting device that improves the quality indicators of rice seeds is that the electric field on the surface of the working elements is created in two different conditions, that is, as a result of friction, two dielectric materials appear between the support electrodes, rotating against each other, and opposing coils wound into grooves directed in a two-way spiral toward the dielectric drum. As a result, the seeds are exposed to the total electric field strength, which increases the accuracy of their sorting into seed and technical fractions.

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The figure shows a schematic diagram and working element of an energy- and resource-saving electric sorting device that improves the quality indicators of rice seeds.

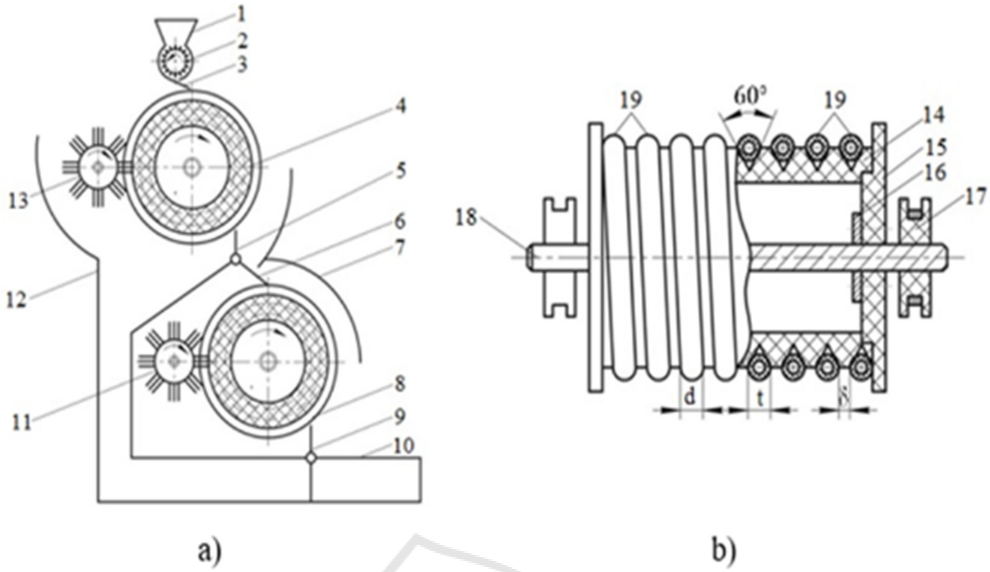

Figure 1: Schematic diagram (a) and working body (b) of an energy and resource-saving electric sorting device that improves the quality indicators of rice seeds:1-loading hopper; 2-provider; 3, 6-pull-out board; 4, 8-working body; 5, 9-dividing plane; 7, 12 - protective walls; 10-reception hopper; 11, 13 - separating brushes; 14- polyethylene pipe; 15-sided discs; 6-flanges; 17 current transmitters; 18-shaft; 19-opposite electrodes.

The working bodies of the energy- and resource-saving electric sorting device, which improves the quality indicators of rice seeds, are made of polyethylene pipe 14, and two-lane helical grooves with a depth angle "γ", width "t1" and distance equal to "δ1", directed towards the surface of the working body located above and surrounded by electrodes of the opposite direction with a diameter d 1 close to the thickness of a rice seed. On the surface of the working body located below, two-lane helical grooves are made with a depth angle "γ", width "t2 " and the distance between them, directed towards "δ2 " and electrodes with the opposite direction c wind diameter d 2 around them, then is close to the width of a rice seed . A polyethylene pipe 14 with double-sided helical grooves is fixed to the shaft 18 using side disks 15 and flanges 16 made of dielectric material. Electrodes of opposite sign 19 are connected to a high voltage source through a current sensor 17.

The operating principle of an energy and resource-saving electric sorting device that improves the quality indicators of rice seeds is as follows. When it is connected to the network using an electric motor and gearbox, feeder 2, working bodies 4 and 8, separating brushes 11 and 13 are rotated. At this time, rice seeds to be sorted are delivered from loading hopper 1 to the surface of working body 4 at the same speed through the feeder 2 and the sliding board 3. The seeds, falling on the surface of the rotating working body 4, are placed between the electrodes 19 in the opposite direction in terms of their thickness. In addition to the force of the electric field, seeds are also affected by centrifugal force, gravity, inertia, reaction forces and friction. Depending on the mutual relationship of the acting forces, depending on their physical and mechanical properties, rice seeds are cut from the surface of the working body 4 at different angles, high-quality seeds fall on the surface of the lower working body 8, and low-quality seeds are cut off when turning at large angles or are separated using brushes 11. Technical fraction 10 enters the receiving hopper.

Rice seeds, cut from the surface of the upper working body 4 and falling onto the surface of the lower working body 8, are placed between electrodes 19 with opposite directions and the sorting process is repeated. Rice seeds, sorted by thickness, width and other important properties, are cut from the surface of the lower working body 8, separated into the seed fraction of the receiving hopper 10, placed in bags and sent for sowing. Seeds adhering to the surface of the working body 8 are cut at large angles or separated with a brush and fall into the technical fraction of the receiving hopper 10. In this sequence, the technological process of sorting rice seeds continues in an energy and resource-saving electric sorting device (Tukhtakuziev & Rasuljonov, 2020; Patent, 2022b; Abdullaev et al., 2023; Tukhtakuziev et al., 2023; Alimova et al., 2024a; Alimova et al., 2024b).

The force of the electric field with great force attracts rice seeds to the surface of the working bodies, which allows, firstly, to increase the accuracy of their separation into seed and technical fractions, and secondly, to increase the efficiency of the device.

3 RESULTS AND DISCUSSION

Good results have been obtained in experimental studies on the selection of rice seeds.

In Table 1, the diameter of the working body of an energy-resource-saving electric sorting device that improves the quality indicators of rice seeds is D = 350 mm, the voltage applied to the electrodes with opposite signs is U = 1500 V, and the number of revolutions of the working body is n = 40; The results of the selection of rice seeds at 50 and 60 min -1 are presented.

As can be seen from the results presented in Table 1, the diameter of the working bodies and the voltage applied to the electrodes in the opposite direction do not change, and with a change in the number of revolutions, the sorted rice seeds are divided into fractions and the mass of 1000 seeds changes.

In particular, if the number of revolutions of the working body is n=40 min -1, the mass of 1000 grains of rice containing 74.6% rice seeds, divided into the seed fraction, will be 31.24 grams, which is 3.07 grams more than control, then the number of revolutions of the working body n = 60 min -1, the mass of 1000 grains of rice with 93.6% seeds divided into the seed fraction was 29.26 grams, which increased by 1.09 grams compared to the control. That is, with an increase in the number of revolutions of the working parts of the energy and resource-saving electric sorting device, which increases the quality indicators of rice seeds, the separation of sorted rice seeds into a seed fraction was observed. increases, and the mass of 1000 seeds decreases.

A different picture was observed in the technical faction. With an increase in the number of revolutions of the working bodies, the number of rice seeds separated into the technical fraction and the mass of 1000 seeds in it decreased. In particular, at the number of revolutions of the working bodies n=40 min -1, the mass of 1000 grains of 25.4% barley seeds, divided into a technical fraction, is 19.15 grams, which is reduced by 9.59 grams compared to the control, the number of revolutions of the worker organ n= 60 min -1, the weight of 1000 grains of 6.4% rice seeds, divided into the technical fraction, was 12.23 grams, which decreased by 15.94 grams compared to the control. With an increase in the number of revolutions of the working bodies, the number of seeds separated into the technical fraction, and a decrease in the mass of 1000 seeds in it, low-quality and light rice seeds are mixed into the seed fraction.

Table 1: Results of sorting rice seeds at different speeds of the working body.

№	The number of revolutions of the working body and the name of the fractions	Share-large separation, %	Weight of 1000 seeds, g	Control the difference is in the baton	
				G	%
1	P = 40 min $^{-1}$ Control After sorting: - seed fraction -technical faction	100.0 74.6 25.4	28.17 31.24 19.15	- +3.07 -9.59	- +10.80 -33.9
2	P = 50 min $^{-1}$ Control After sorting: - seed fraction -technical faction	 100.0 84.5 14.5	 28.17 30.92 14.09	 - +2.75 -14.08	 - +9.76 -49.98
3	P = 60 min $^{-1}$ Control After sorting: - seed fraction -faction of technicians	 100.0 93.6 6.4	 28.17 29.26 12.23	 - +1.09 -15.94	 - +3.87 -56.59

Table 2: The result of sorting rice seeds in a pilot copy of an energy and resource-saving electric sorting device.

№	Voltage value and faction name	Fractionation, %	Weight of 1000 seeds, g	Difference compared to control	
				G	%
1	*U* =1000 V Control After sorting: - seed fraction -technical faction	 100.0 90.79 9.21	 27.78 29.18 13.95	 - + 1.4 - 13.83	 - +5.04 - 49.78
2	*U* = 1 50 0 V Control After sorting: - seed fraction -technical faction	 100.0 80.92 19.08	 27.78 30.43 17.06	 - +2.65 - 10.72	 - + 9.54 - 38.59
3	*U* = 2000 V Control After sorting: - seed fraction -technical fraction	 100.0 68.37 31.63	 27.78 31.90 19.42	 - +4.12 - 8.36	 - +14.83 -30.09

Based on the analysis of the results obtained, we can come to the following conclusion: from the point of view of manufacturability, the diameter of the working bodies D= 350 mm, the magnitude of the voltage applied to the electrodes in the opposite direction is the most optimal operating mode for the precise separation of rice seeds into seed and technical fractions in energy and a resource-saving electric sorting device. Achieved at U = 1500 V and an equal number of revolutions of the working body. up to n = 50 min -1. In this mode, the weight of 1000 grains of 84.5% of rice seeds, divided into the seed fraction, was 30.92 grams, which increased by 2.75 grams compared to the control.

Table 2 presents the results of sorting rice seeds in a pilot version of an energy- and resource-saving electric sorter. Experimental studies: diameter of the working parts of the electrosorting device D = 350 mm, speed n = 50 min, electric field strength E = 6·105 V/m and voltage applied to the electrodes with the opposite direction U = 1000, carried out at 1500 and 2000 V.

From the results presented in Table 2, it is clear that with a change in the voltage applied to the opposite electrodes, there is a division of rice seeds into fractions and a change in the mass of 1000 seeds. Specifically, if the magnitude of the voltage applied to the electrodes in the opposite direction is U = 1000 V, the weight of 1000 grains of 90.79% rice seeds divided into the seed fraction will be 29.18 grams, which is increased by 1.4 grams. Compared to the control, at U = 2000 At equal V, the weight of 1000 grains of rice with 68.37% seeds divided into the seed fraction was 31.90 grams, which increased by 4.12 grams compared to the control.

In the technical fraction, with an increase in the voltage applied to the electrodes in the opposite direction, an increase in the delamination of rice seeds into it and an increase in the mass of 1000 seeds were observed. In particular, with a voltage applied to the electrodes equal to U = 1000 V, the mass of 1000 grains of 9.21 percent rice seeds, divided into a technical fraction, is 13.95 grams, which is reduced by 13.83 grams compared to the control., at U =2000 V. The weight of 1000 grains of 31.63% rice seeds, divided into the technical fraction, was 19.42 grams, which decreased by 8.36 grams compared to the control.

U = 1500 V to electrodes in the opposite direction. in an experimental copy of an energy- and resource-saving electric sorting device. With this strain size, the weight of 1000 rice seeds, divided into a seed fraction of 80.92%, was 30.43 grams, which increased by 2.65 grams compared to the control.

Experimental study on rice seed sorting found that since the original seeds contain various impurities, as well as broken and very small seeds, we propose to sort these seeds after pneumatic or mechanical sorting using energy and resource-saving electrical equipment. sorter.

In table Figure 3 presents the results of a study of the mass of 1000 rice seeds sorted in the original and prototype of an energy- and resource-saving electric sorting device.

From the results presented in Table 3, it is clear that the mass of 1000 seeds of the first initial rice with mass, standard deviation σ = 0,81 grams and coefficient of variation V = 2.92 %, m = 27.78 grams, after sorting in In a prototype of an electric sorting device, the seed mass of 1000 fractionated rice seeds at σ = 0.36 grams and V = 1.18 % was m = 30.43 grams, compared to the control Δ m = 2.65 grams increased.

Table 3: Results of the study of the mass of 1000 rice seeds.

Seeds and faction name	Weight of 1000 seeds, g	Standard deviation σ , g	Coefficient of variation - enti V , %
Rice seeds: - control - seed fraction	 27.78 30.43	 0.81 0.36	 2.92 1.18

Analysis of the results presented in Table 3 shows that in a prototype of an energy- and resource-saving electric sorting device, when sorting rice seeds, with an increase in weight by 1000 seeds, seeds of similar weight are obtained. This is clearly visible from the coefficients of variation in the mass of 1000 rice seeds in the control and seed fractions. The value of the coefficient of variation decreased by 2.5 times compared to the control in the variant with division into the seed fraction.

Thus, as the weight of rice grains increases when sorted in an energy and resource-saving electric sorter, they become closer to each other.

In table 4 presents the results of a study of the geometric dimensions of rice seeds sorted in the original and prototype of an energy- and resource-saving electric sorting device.

From the results presented in Table 4, it is clear that there were some changes in the geometric dimensions of rice seeds when they were sorted in an energy- and resource-saving electric separator.

The geometric dimensions of rice seeds - length, width and thickness - in the control variant and after sorting in an energy- and resource-saving electric separator are equal to a = 8.59 mm, b = 3.68 mm and c = 2.09 mm . device, in the version with the separation of seeds into fractions a = 8.76 mm, b = 3.69 mm and c = 2.24 mm.

Table 4: Results of a study of the geometric dimensions of rice seeds.

Seeds and faction name	Geometric dimensions a, b, c, mm	Medium square σ, mm	Variation coefficients V, %
Rice seed: - Control	 8.59 3.68 2.09	 0.61 0.25 0.31	 7.09 6.92 14.64
- seed faction	8.76 3.69 2.24	0.58 0.22 0.11	6.59 5.88 4.72

Analysis of the results presented in Table 4 shows that when sorting rice seeds in an energy- and resource-saving electric sorting device, the geometric dimension's increase, and the geometric dimensions of the seeds come closer to each other. Thus, it was noticed that the coefficients of variation in the geometric dimensions of seeds divided into the seed fraction were reduced compared to the control.

Table 5 presents the results of a study of the sphericity coefficient of rice seeds sorted in a primary and energy- and resource-saving electric sorting device.

Table 5: Results of the study of the coefficient of sphericity of rice seeds.

Seeds and faction name	Sphericity coefficient	Standard deviation σ, mm	Coefficient of variation V, %
Rice seed: - Control	 0.43	 0.03	 7.13
- seed faction	0.43	0.03	7.04

Table 6: The result of determining the germination of rice seeds in laboratory conditions.

Seeds and faction name	Fertilizer application in laboratory conditions, %	Standard deviation σ, mm	Coefficient of variation V, %
Rice seed: - Control	 0.43	 0.03	 7.13
- seed faction	0.43	0.03	7.04

From the results presented in Table 5, it can be seen that the sphericity coefficients did not change when sorting rice seeds in an energy and resource-saving electric sorter. We can come to the following conclusion: rice seeds are sorted according to all their sizes, length, width and thickness in an energy and resource saving electric sorting device. Consequently, the sphericity coefficient of seeds divided into the seed fraction after sorting does not change compared to the control.

In table 6 presents the results of determining the germination of rice seeds sorted in laboratory conditions using an initial and energy and resource-saving electric sorting device.

From the results presented in Table 6, it is clear that after sorting rice seeds in an energy and resource-saving electric sorter, in the version with separation into the seed fraction, the accuracy in laboratory conditions was higher than in control. The purity of rice seeds in laboratory conditions was 91.25% for the control variant, and 94.0% for the seed fraction, which is 3.75% higher than the control.

Analysis of the results presented in Table 6 shows that when sorting rice seeds in an energy- and resource-saving electric separator, not only the quality in the laboratory increases, but also the quality of the seeds separated into seed fractions in the laboratory. conditions are close to each other. This is also evidenced by the coefficients of variation in the quality of rice seeds, divided into control and seed fractions, in laboratory conditions.

Thus, sorting rice seeds in an energy- and resource-saving electric sorter not only produces seeds with high fertility in vitro, but also seeds with similar fertility in vitro. Table 7 presents the results of determining the germination of rice seeds sorted under field conditions in the original and energy- and resource-saving electric sorting device.

Table 7: The result of determining the germination of rice seeds in laboratory conditions.

Seeds and faction name	Fertilizer application in laboratory conditions, %	Standard deviation σ, mm	Coefficient of variation V, %
Rice seed: - Control	61.50	1.00	1.63
- seed faction	72.50	3.11	4.29

Table 7, it is clear that sorting rice seeds in an energy and resource-saving electric sorter allows not only to obtain seeds with high fertility in laboratory conditions, but also in field conditions. Fertilization of rice seeds under field conditions was 61.5% in the control, 72.5% in the seed fraction after sorting, which was 11.0% higher than the control.

From the results presented in Table 7, it is also clear that sorting rice seeds in an energy- and resource-saving electric sorting device not only increases their field fertility, but also makes it possible to obtain seeds with similar field fertility. This is evidenced by the coefficients of variation in the germination of rice seeds in the control variant and those allocated to the seed fraction under field conditions.

Thus, sorting rice seeds in an energy- and resource-saving electric sorting device produces seeds with high and similar field fertility.

Analysis of the results presented in Tables 6 and 7 shows that sorting rice seeds in an energy- and resource-saving electric sorter makes it possible to obtain seeds with high and close germination in laboratory and field conditions.

A study of the physical and mechanical properties of rice seeds sorted in an energy- and resource-saving electric separator showed that not only in weight, but also in density, geometric dimensions and biological properties, they are close to each other, have high fertility and potential yield. in laboratory and field conditions. It can be concluded that sorting rice seeds in an energy and resource-saving electric sorter creates the basis for growing a rich harvest from them.

Further research and development should be aimed at developing a prototype energy- and resource-saving electric sorter, as well as experimental studies on seed sorting of other crops.

4 CONCLUSIONS

1. The use of devices used in practice based on the pneumomechanical method of sorting rice seeds does not allow obtaining seeds of the required level, since they are sorted according to one important characteristic.
2. Creation of an electric field between electrodes of the opposite direction on the surface of the upper and lower working bodies of an energy- and resource-saving electric sorting device due to the attraction of rice seeds to it by a large electric field force, high-quality rice seeds with similar biological properties, laboratory and providing good seeds with high fertility and potential yield in field conditions.
3. It is necessary to carry out further research work to improve a prototype of an energy- and resource-saving electric sorting device, as well as to conduct experimental studies on sorting seeds of other agricultural crops.

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