ТЕХНОЛОГИИ, МАШИНЫ И ОБОРУДОВАНИЕ ДЛЯ АГРОПРОМЫШЛЕННОГО КОМПЛЕКСА / TECHNOLOGIES, MACHINES AND EQUIPMENT FOR THE AGRO-INDUSTRIAL COMPLEX

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PROPOSALS FOR THE RECONSTRUCTION OF THE COMBINED HARVESTER OF A TWO-PHASE THRESHING FOR COLLECTION AND SEEDS

Research article

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Abstract

Low quality of commercial and seed soybeans, obtained by combine harvesting and processed on grain-processing production lines, in contrast to crops, is justified by features of physical and mechanical properties of soybean grain: high mass of 1000 seeds (146-180g), the size of the seed with the shape coefficient, close to one (0.847…0.851). These properties contribute to the destructive effect of dynamic loads on soybean threshing and transportation devices of the combine. Agrotechnical assessment of the quality of soybean soy bunker, harvested by combines Acros-595 and T-500 was made. Indicators of contamination of commercial grain (2.3-4.8%), fragmentation (3.3-6.1) and micro-injuries (1.0-2.1%) were identified, which show, that in order to obtain marketable and seed grain of soybeans, their moonlighting on grain cleaning lines is required, accompanied by additional costs and mechanical damage to the grain, increasing the loss of quality grain to waste. It is proposed to change the logistics path in the technology of obtaining seed and marketable soybean grain, reducing the crushing of soybean grain and material costs in harvesters of two-phase threshing. The use of the developed re-equipment at the new T-500 harvester will ensure the creation of a high-performance harvester for harvesting soybean seed crops, reducing fragmentation losses and improving seed quality.

Keywords: soy, yield, combine, quality of grain, sour admixture, fracture, micro-injury, seed.

ПРЕДЛОЖЕНИЯ РЕКОНСТРУКЦИИ СОЕЗЕРНОВОГО КОМБАЙНА ДВУХФАЗНОГО ОБМОЛОТА ДЛЯ УБОРКИ И НА СЕМЕНА

Научная статья

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Аннотация

Низкое качество товарного и семенного зерна сои, получаемого при комбайновой уборке и обработке на зерноочистительных поточных линиях, в отличие от зерновых культур, обосновано особенностью физико-механических свойств зерна сои: высокой массе 1000 семян (146-180г), размерам семени с коэффициентом формы, близким к единице (0,847…0,851). Эти свойства способствуют разрушающему действию динамических нагрузок на зерно сои молотильных и транспортирующих устройств комбайна. Проведена агротехническая оценка качества бункерного зерна сои сорта Сентябринка, убираемого комбайнами Acros-595 и Т-500. Выявлены показатели засоренности товарного зерна (2,3-4,8%), дробления (3,3-6,1) и микроповреждения (1,0-2,1%), которые показывают, что для получения товарного и семенного зерна сои требуется их подработка на зерноочистительных линиях, сопровождаемая дополнительны затратами и механическим повреждением зерна, увеличивающая потери качественного зерна в отходы. Предложено изменение логистического пути в технологии получения семенного и товарного зерна сои, обеспечивающего снижение дробление зерна сои и материальных затрат в комбайнах двухфазного обмолота. Применение разработанного переоборудования на новом комбайне Т-500 обеспечит создание высокопроизводительного комбайна для уборки семенных посевов сои, снижающие потери от дробления и повышающие качества семян.

Ключевые слова: соя, урожайность, комбайн, качество зерна, сорная примесь, дробление, микроповреждение, семена.

Introduction

The Amur region belongs to the main region of Russia for soybean cultivation, where it is planted on an area of 900 thousands or 24.8% of the Russian total. Great attention is paid to improving the structure of sown areas, creation and introduction of new varieties, development of technologies and machines for its production [1], [2], [3].

The climate of the Amur region and the duration of the growing season of soy seeded varieties limit the terms of harvesting, and their non-compliance, usually, leads to a decrease in the quality of marketable grain during harvesting and seed during moonlighting. An important role is given to reducing direct and indirect losses of the soybean crop (the content of crushing and microdamage, up to 10-15% in marketable grain and up to 5-10% in seeds) [4], [5], [6].

The question of more complete preservation of the harvest of soybean grain from mechanical damage is relevant, as a result of which an oil mixture is formed. Its high content (15...20%) leads to a decrease in the marketability of grain by 20-30% and field germination of seeds, forced farming, increase the rate of sowing seeds by 20-30 kg / ha due to their non-conditioned soybean seeds [7], [8], [9].

Unsatisfactory quality of soybean seeds and marketable grain is associated with low strength of soybean grain of various varieties, destructible under static load 172..215 N, high mass of 1000 seeds (146 – 180g) and the size of the seed with a shape factor, close to one (0.847…0.851). Small area of contact of soybean grain with, operating working organs of threshing separation devices, high specific load on grain when threshing, increases tension in the contact area, causing cracks in the shell and further destruction of the grain [10], [11].

Soybean refers to large-seed crops with low grain shell strength. Grain harvesters with single-drum rolling threshing and separation devices allow crushing of grain 8-10% even when choosing the recommended grinding mode. If errors are made in the choice of mode of operation, the fragmentation reaches up to 20...35% [12]. Installed, what is a two-phase soy harvester, soybean grains are reduced [13], [14], [15].

In the farms of the Amur region use harvesters of various modifications of domestic and foreign production. The load on one combine harvester on soybean harvesting alone is over 400 hectares. The total number of grain harvesters in all districts and districts totals more than 2.400 units, of which up to 600 units are obsolete combines of two-phase threshing «Yenisei-950», «Yenisei-1200» with a service life of up to and over 10 years, therefore, the combine fleet is updated with domestic production technology and mainly «Rostselmash», more than 50% of the total. In 2024, commodity producers planned to purchase 85 pieces of modern grain harvesters, for which state support is provided from the regional budget.

The new T-500 harvester deserves attention, intended for the harvesting of all traditional cereals: cereals, beans, olives, the largest, and smelly. The effective combine T-500, adapted to the most difficult cleaning conditions, with a capacity of up to 30 tons / hour of regular time is able to remove more than 1.300 hectares during the season with minimal losses (0.24%) on soy cleaning.

The threshing system TETRA Processor has a flexible deck with electronic clearance control on all sub drums. Huge area of grounding (3.0 m^2) and separations (total 8.3 m^2) provides an intensive separation process with minimal mechanical damage to the grain, including on the most complex agro phones.

The threshing system TETRA Processor constructed on the use of a drum with a diameter of 800 mm and provides a stable and delicate grind without loss. The width of the device – 1500 mm allows you to achieve harvester performance up to 30 tons / hour.

Effective 2-cascade cleaning system OptiFlow c patented suspension area 5.85 $м^2$. Highly optimized airflow, high drop height and finger grating on the shaking board and additional grating significantly improves the cleaning process. The cleaning system uses two flow turbine 5-section fans, the speed of which is adjusted from the cockpit and displayed on the control panel. Convenient cleaning of the grilles and their configuration is carried out by the operator from the cabin. The universal shape and three times the stiffness of combs allow you to work with minimal losses on all types of crops [16].

Updating the harvester fleet aimed at increasing productivity should correspond to improving the quality of harvested commercial and obtained soybean seed grain.

Purpose comparative agro technical assessment of the quality of bunker grain, soybean harvesters Acros-595 и T-500, identify and propose ways to improve the quality of reducing the crushing of marketable grain and the content of weed impurities to improve the quality of soybean seeds obtained during processing.

Research methods and principles

Studies are conducted during the period of mass harvesting of soybeans. To characterize the site, sheaves are taken from an area of 1m^2 and yield is determined, height of attachment of the lower beans, number of beans per plant, ratio of grain mass to straw and bean leaf mass, humidity of grain, straw and sash. Accordingly, from each sample of bunker grain, the divider allocates two attachments, which are weighed and disassembled into the following fractions: the main grain, sour admixture, crushed grain, micro-damaged grain, and frosted grain. In the full analysis made, soybean is referred to as the main, and all the broken ones along the small parts are referred to as crushed grain.

Weed impurities include organic and mineral impurities, weed seeds. Micro-damaged grain includes grain with a crack, disruption of shell, a broken seed and a crushed grain that has lost its shape. Frostbite include unfulfilled oblong grain of green color. The content of the main grain and all the selected fractions is determined as a percentage of the total weight of the grain in the attachment.

Main results

Studies conducted on the variety september during the period of mass harvesting of soybeans. 27.09.2024, in terms of yield 28.4 c/ha. The height of the plants was 70.9 sm., lower legume attachment height 11.3 sm., average number of beans per plant 9, the ratio of the mass of grain to the mass of straw and leaf beans as 1.0 : 0.6 : 0.4 humidity of grain 12.6%, straw and leaves, respectively 16.4 and 18.7%.

According to, agro technical assessment of the work of harvesters by the height of the cut of plants and losses of soybean grain by harvesters Acros 595 and T-500 in 2024. Cleaning conditions are characterized as good quality, soybean loss per harvest did not exceed 1.0%, the combine – 0.24%.

Quality of the obtained bunker grain of soy variety Sentyabrinka, withdrawal 27.09.2024 in the economy of the Ivanovo municipal district are given in table 1.

Table 1 - The quality of soy bunker grain from T-500 harvesters and Acros-595

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Combine brand	Ugly mix, %	Fracture, %	Micro-damage, %	Frostbite, %	Massa of 1000 seeds, g
T-500	2.3-3.4	4.2-6.1	1.0-2.0	0.7-2.3	160.4
Acros 595	2.4-4.8	3.3-3.6	1.5-2.1	1.3-3.4	161.1

The data in Table 1 show, that the soybean silo grain from the T-500 harvester, depending on the changing modes of operation, contains 0.1-1.4% less weed, than a combine's bunker grain Acros-595. By crushing soybean grain in reverse, the T-500 harvester increases grain crushing by 0.9-2.5% and exceeds the agro technical requirements by 0.2-2.1%, in terms of the amount of micro damage, the compared indicators in harvesters are almost equal. The new T-500, superior in productivity, significantly increases the crushing of soybean grain to 6.1% with high congestion up to 3.4%, affecting the decrease in the credit mass of marketable grain when sold to processing enterprises and will lead to additional fragmentation losses when working for seeds.

Seed quality and seed quality, designed for the elite, reproduction and general crops, determined by GOST R 52325-2005. According to which, key indicators, reduced class of seeds, involvement and contamination of culture. In order to establish the reasons for the unsatisfactory state of the soybean seed material during the sowing period, a detailed analysis of soybean seeds for the content of the seeds of the main crop in the waste (split) and, contamination content was made.

The results of the analysis of different seed batches showed, the main indicators, for which soybean seeds are not suitable for, are the main crop waste (broken grain) and reduced germination due to micro damage. Low quality of seed material forces farms to sharply increase the norms of sowing seeds during sowing; this leads to unproductive use of seeds. In addition, an increase in the rate of sowing when sowing seeds with low quality does not compensate for the improvement in the quality of these seeds, therefore, does not provide in this agricultural technique the increase of the corresponding crop.

Mechanical damage to soybean seeds is the local or general destruction of the grain as a single and complex biological system. According to the degree and types, these destructions are different and reduce field germination and yield (crushed soybean grain does not produce seedlings, micro-damaged – reduces germination by 72%).

A new method of obtaining soybean seeds with a shortened logistical way directly in the combine of two-phase threshing is proposed, which provides for the division of milled grain in quality into two fractions (seed and commodity). The device of the modernized combine harvester and the technology of obtaining air-conditioned seeds of the first fraction in it are protected by RF patents № 2679508, 220380, 2765580 and shown in figure 1. With a two-phase threshing with the first threshing drum with a low level of force on the grain, the most mature biologically complete soybean seeds are ground, separately sorted in the first half of the rack mill and separately collected in the first grain auger, further in a two-section silo of a two-phase mill grain harvester.

Figure 1 shows the sequential numbering of parts and units of the combine.

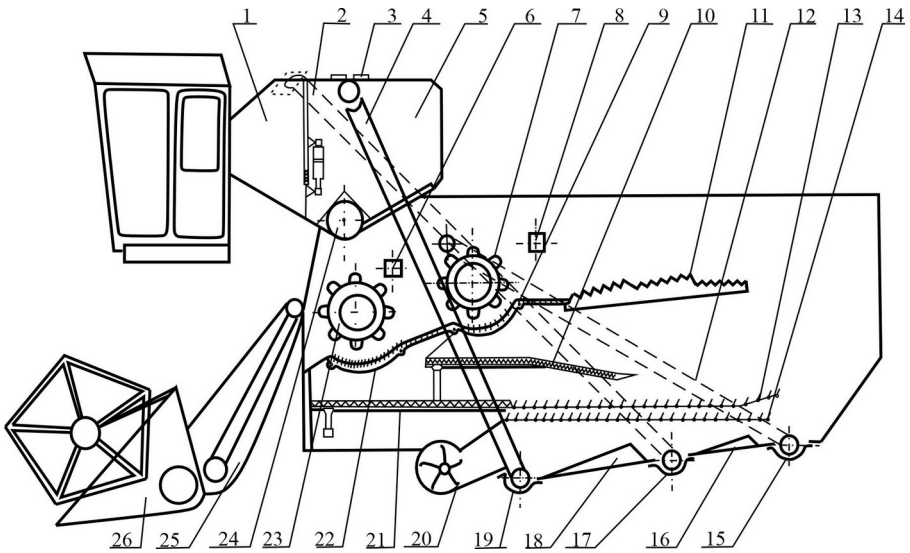

Figure 1 - Scheme of the modernized combine harvester for obtaining full-fledged and high-quality soybean seeds

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Note: 1 – section of the seed grain silo of the second fraction, 2 – second grain elevator for moving the seed grain of the second fraction, 3 – distributive screw, 4 – elevator displacement seed grains first fraction, 5 – section bunker for seed grains first faction, 6 – intermediate biter, 7 – second hammering drum, 8 – fail-safe biter, 9 – sub drum second threshing floor drum, 10 – additional concussion plank, 11 – keyboard straw shaker, 12 – elevator submissions unrefined colossal parts on

hammered, 13 – upper sieve resolved stan, 14 – lower sieve resolved stan, 15 – colossal sneak, 16- second scaffolding plank, 17 – horizontally second grain sneak in the crusty the gutter, 18 – first scaffolding plank, 19 – horizontally grain sneak with brushing framing outside edges screw in the crusty the gutter, 20 – fan, 21 – staff concussion plank, 22 – sub drum the first threshing floor drum, 23 – the first hammering drum, 24 – unloaded sneak, 25 – inclined camera, 26 – reaper

In the first half of the mill, a small pile of soybeans is separated, coming from the main concussive board of the combine, after threshing and separation of seeds with the first threshing drum. To reduce the crushing of soybean grain during threshing, the rotation frequency of the first threshing drum is reduced to 280 min^{-1}. To prevent mixing of low-crushing seed grain, a small pile of soy has been milled after grinding with the first threshing drum and hammered with the second threshing drum under more severe conditions, coming from the first and second drums on the rack of the combine, cleaned and collected separately in the bunker.

Table 2 - Qualitative indicators of the seed and commodity fraction, received in the modernized combine harvester «Yenisei-1200» at soybean harvesting

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Indicators	I seed faction	II commodity faction
Seed release, % of harvester	61.4±2.39	38.6±1.21
Cleaning of seeds, %	99.8±0.36	95.43±2.64
Fragmentation of seeds, %	3.4±0.13	5.8±0.29
Micro-damage, %	0.9±0.02	1.3±0.03
Massa of 1000 seeds, g	174.1±6.23	153.2±5.36

The first seed faction, from the bunker of the modernized combine of two-phase threshing, when harvesting soybeans in a similar variety of Sentyabrinka, low content of organic weed contaminant 0.2% and does not require additional cleaning on the grain cleaning line. Fragmentation and micro-damage of components 3.4 и 0.9% in the first seed fraction meet the agro technical requirement for harvesters, used in the cleaning of soybeans. Soybean grains of the first fraction on 13.7% higher by mass of 1000 seeds this shows, that the first fraction includes the most matured easily ground soybean grain with high field germination and biological yield. The developed technology for obtaining the seed fraction directly in the harvester of two-phase threshing during the harvest of soybeans in comparison with the existing traditional technology for preparing soybean seeds reduces the losses from crushing and micro damage and does not require additional cleaning and processing.

Changing the logistics path in the technology of obtaining seed and marketable soybean grain, reducing the crushing of soybean grain and material costs in a converted combine of two-phase threshing, the use of the developed conversion equipment at the new T-500 combine harvester will ensure the creation of a high-performance harvester for harvesting soybeans for seeds that reduce crushing losses and improve the quality of the emitted seeds.

Conclusion

The increased content in marketable grain and seeds of crushing and microdamage is the main indicator of a decrease in the marketability of grain and the sowing qualities of soybean seeds.

The use of the new high-performance combine harvester T-500 with a perfect grinding system and separation at soybean harvesting without re-equipment does not allow obtaining high-quality marketable grain and soybean seeds due to high clogging and crushing of bunker grain, post-harvest work required.

Changing the logistics path in the technology of obtaining seed and marketable soybean grain on the basis of the reconstruction of the combine of two-phase threshing T-500, will ensure the preservation of the grown crop from crushing and microdamage and the receipt of quality soybean seeds.

Конфликт интересов

Не указан.

Рецензия

Все статьи проходят рецензирование. Но рецензент или автор статьи предпочли не публиковать рецензию к этой статье в открытом доступе. Рецензия может быть предоставлена компетентным органам по запросу.

Conflict of Interest

None declared.

Review

All articles are peer-reviewed. But the reviewer or the author of the article chose not to publish a review of this article in the public domain. The review can be provided to the competent authorities upon request.

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