ARTÍCULO ORIGINAL

Innovative ways of improving mechanization of high-quality seeds

Vías innovadoras para mejorar la mecanización de semillas de alta calidad

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ABSTRACT. This paper shows the survey of the results of quality ratings of grain obtained from drum-type and rotary combine harvesters during the winter wheat harvesting. It has been determined that rotary combine harvesters significantly reduce grain damage. With continuous fractional methods of grain postharvest treatment being used, it is possible to simplify the design of seed cleaning machine and to reduce energy and material resources with less grain damage.

Keywords: drum-type and rotary combine harvesters, grain damage, simplification of seed cleaning machine, reduction of the energy and material resources.

RESUMEN. Este artículo muestra los resultados de las clasificaciones de la calidad del grano obtenidos con combinadas cosechadoras con órganos de corte de tipo tambor y rotatorias durante la cosecha de trigo de invierno. Se ha determinado que las cosechadoras de órgano rotatorio reducen significativamente el daño a los granos. Con los métodos de fraccionamiento ininterrumpido de tratamiento poscosecha del grano, se hace posible simplificar el diseño de las máquinas de limpieza de los granos y reducir la energía y los recursos materiales con menos daño del cereal.

Palabras clave: cosechadoras con órganos de corte de tipo tambor y rotatorias, daño a los granos, simplificación de las máquina de limpieza de semillas, reducción de los gastos de energía y recursos materiales.

INTRODUCTION

A key task of agribusiness is a sustainable growth of grain production. The food security of the state is significantly determined by the total harvest of the grain, which is needed for raising seed funds, for providing people with high-quality food products and animal husbandry with grain forage. In order to successfully boost production of the high-quality grain and seeds it is needed to promptly implement new innovative technological and engineering solutions during the harvesting and postharvest treatment (Lachuga *et al.,* 2009; Tarasenko *et al.,* 2013). The main reason for the decrease in the seed germination is the high level of their damage during the harvesting and post-harvest treatment (Pugachev, 1976; GOSAGROPROM, 1988; Aniskin *et al.,* 1992; Pyanykh & Rodimtsev, 2000). Another reason is the “loads” of the unprocessed grains on the trashing floor that are accumulated because of inefficient production of the grain cleaning machinery. In order to get high-quality food grain it is needed to lower grain damage during the harvest and also to organize continuous processing of the grain heap, which is coming from combine harvester. When the coming from the combine harvester grain heap is stacked to the trashing floor, it is exposed to the weather conditions and microorganisms (Orobinskii, 2006). Moreover it is subjected to additional grain damage for 4…6% during the loading to the grain-loader or throwing over to the grain-thrower. This increases energy and resource spend for the grain production and obtained seeds often do not meet the requirements of GOST (State Standards) (GOST R 52325-2005). For preventing this it is necessary to apply continuous processing of the grain heap especially in the seed-growing farms. This will lessen both the total grain damage and the presence of the most dangerous types of grain damage.

METHODS

In order to impartially appraise the influence of the grain damage on the sowing qualities of seeds, it is necessary to use the following index of damage ***T*пр**, when the all kinds of damages lead to the same situation, where the germ is damaged.

$$T_{np} = G_2 + G_1 \frac{b_1}{b_2} + G_3 \frac{b_3}{b_2} + G_4 \frac{b_4}{b_2} + G_5 \frac{b_5}{b_2} + G_6 \frac{b_6}{b_2} \quad (1)$$

where: ***G1…G6*** are the percentage of the grain with the ejected germ, damaged germ, damaged coat of germ, damaged coat of the germ and endosperm, damaged endosperm, damaged coat of endosperm;

***b*1…*b*6** are the coefficients determined by the formula:

$$b_i = 0{,}01\ (B_7 - B_i) \quad (2)$$

where: ***B*7** is the germination of the undamaged grain,%, ***Bi*** is the germination of the grain with the damages under consideration,%,

The multiyear research results demonstrated that the laboratory germination of the winter wheat averaged: without damages 99%, with damages: of the germ 50,8%, of the endosperm 60,6%, of the germ coat 85,6%, of the germ and endosperm coat 83,4%, of the endosperm coat 94,4%.

RESULTS AND DISCUSSION

Nowadays national and foreign companies produce combine harvesters with the drum-type system or rotary trashing and separating system. Several foreign companies switched over to the production of the combine harvester only with the rotary trashing and separating system.

Both the rotary and drum-type combine harvesters are used in the Central Black Earth Region of Russia, however drum-type combine harvesters are prevailing at the present time. The damaged grain, which is arriving to the post-harvest treatment in the grain heap, drastically makes it difficult to obtain certified seeds and often high-quality food grain. It has been established that every 10% of the damaged seeds decreases yield capacity of the cereal crops by 1,0…2,5 dt/ha and the higher the level of the damaged seeds, the greater the reduction of the yield capacity. Only due to the high level of the damaged grain annual harvest shortfall makes up 10…15 million tons (Erov *et al*., 2009). The highest damage of the grain exists during the harvesting. Therefore the most important scientific and production task is to find ways of reducing grain damage during the harvesting period. Talking about Central - Black Earth region the drum-type combine harvesters of national and foreign companies are preferably used. More and more rotary combine harvesters both of foreign companies «New Holland», «John Deere», «Case IH», «Massey Fergusson», «Challenger», «Fendt» and of national «Torum 740» are emerging on the fields in the recent years (Truflyak & Trubilin, 2013; Tarasenko, 2013).

The quality of the grain obtained at harvest basically hinges on structural features of the trashing and separating system and its operating mode, namely on amount and level of mechanical effect on the grain during the harvesting period.

The survey results of the quality of the winter wheat grains obtained by drum-type combine harvesters such as John Deere» 9660, «New Holland» CS 660, Polesie GS-12 and rotary combine harvesters such as «New Holland» CR 9080, «John Deere» 9880 and «Torum 740» are shown in table 1 below.

According to the Table 1 the grain heap obtained by rotary combine harvesters contains less crushed and damaged grain.

TABLE 1. Quality of the grain obtained at winter wheat harvest

Combine harvester	Type of the trashing and separating system	Rotor (drum) speed, min^{-1}	Grain content in the heap,% whole grain	crushed grain	grain in a glum	damaged grain	1000-kernel weight, g
John Deere 9880	rotary	700	96,78	0,05	3,03	23,70	38,5
		800	96,57	0,12	2,13	26,70	38,5
John Deere 9660	drum-type	700	97,42	0,85	1,53	25,50	38,5
		800	97,33	1,51	0,91	28,00	38,5
New Holland CR 9080	rotary	600	96,64	0,08	3,21	21,40	37,1
		700	96,80	0,02	3,14	22,00	37,1
		800	96,64	0,03	3,26	23,70	37,1
New Holland CS 660	drum-type	600	96,41	0,81	2,23	26,40	37,1
		700	97,00	0,79	1,24	28,30	37,1
		800	95,98	1,77	1,09	28,40	37,1
TORUM 740	rotary	700	68,48	0,59	30,93	25,39	26,1
		800	70,93	0,74	28,33	27,14	25,2
		900	97,73	0,94	1,33	30,14	25,5
Polesie GS-12	drum-type	820	93,80	3,46	2,74	42,34	25,1

The survey results show that rotary combine harvester «New Holland» CR 9080 causes minimal shattering of grain and grain damage during the winter wheat harvest.

Moreover rotor speed influences on content of the grain in a glum in the grain heap. Necessary rotor speed should be set just according to the level of the grain in a glum. This index is easily monitored in the field conditions. If the grain heap contains a lot of grain in a glum it is necessary to increase rotor speed. In addition to the above the content of the crushed and damaged grain will increase a little.

The sample obtained from rotary combine harvesters at rotor speed 800 min^{-1} practically lacks caryopses with ejected germ.

Comparing level of shattering and damage of the grain caused by combine harvesters it is important to note that the higher level of the shattering and damage of the grain cased by rotary combine harvester «John Deere» is brought by feed beater-accelerator and also this level is explained by the grain auger used for delivering grain heap to the cleaning.

The combine harvester «Torum 740» in comparison with the combine harvester «New Holland» CR 9080 boosts shattering and damage of the grain through the increase of amount and level of the mechanical effect on the grain in the crop feed elevator.

The studies demonstrated that the use of the rotary combine harvesters allows significant decrease in the damage of the grain during the harvesting and especially during the seeds harvesting. In comparison with drum-type combine harvester «New Holland» CS 660 the rotary combine harvesters «New Holland» CR 9080, «John Deere» 9880 and «Torum 740» reduce on the average the shattering of the grain in 25,92; 16,85 and 8,68 respectively and the damage of the grain in 1,24; 1,12 and 1,11 times. The results show that change-over to the production of the rotary combine harvesters will reduce damage of the grain during the harvesting. This will allow improving quality of the seeds, to lower seeding rate and to increase yielding capacity.

Influence of the rotor or drum speed ***n*** on the shattering of the grain caused by rotary and drum-type combine harvesters is described by equations (3) and (4) with enough accuracy, where $Д_р$ is the rotary combine harvesters and $Д_б$ is the drum-type combine harvesters:

$$Д_р = -4{,}299 + 251{,}4\cdot10^{-4}\cdot п - 46{,}64\cdot10^{-6}\cdot п^2 + 0{,}287\cdot10^{-7}\cdot п^3 \quad (3)$$

$$Д_б = 3{,}364 - 0{,}2406\cdot10^{-4}\cdot п - 24{,}06\cdot10^{-6}\cdot п^2 + 0{,}2765\cdot10^{-7}\cdot п^3 \quad (4)$$

Damage of the grain caused by rotary $Т_{пр,р}$ and drum-type combine harvesters $Т_{пр,\,б}$ is described by described by equations (5) and (6):

$$Т_{пр,\,р} = 16{,}3 - 43{,}35\cdot10^{-4}\cdot п + 21{,}75\cdot10^{-6}\cdot п^2 \quad (5)$$

$$Т_{пр,\,б} = 20{,}97 + 0{,}1302\cdot10^{-4}\cdot п + 13{,}02\cdot10^{-6}\cdot п^2 \quad (6)$$

The studies demonstrated that the use of the rotary combine harvesters allows significant decrease in the shattering and the damage of the grain during the harvesting. Then during the postharvest treatment of the grain heap on the air-screen grain cleaner for the first cleaning, including its fractionation and separation of the grain of size less than 2,6 mm to the forage fraction, it is possible to exclude from production line air-screen grain cleaner for the final cleaning of the grain heap and also to exclude screening machine. In addition to the above two bucket elevators (for delivering grain and moving it in the screening machine by the grain auger) are excluded from production line. This will allow to reduce amount and level of mechanical effect on the grain and to lessen its damage during the postharvest treatment (Drichina, 2006; Orobinskii, 2012; Tarasenko *et al.*, 2012). Several large weeds left in the grain heap and the unthrashed grain will be separated by air separation machine (Tarasenko *et al.*, 2006). This decreases amount and level of mechanical effect on the grain heap during the postharvest treatment and also lessens shattering and damage of the grain. Moreover energy and material costs for postharvest treatment of the grain heap and for seed preparation are significantly reduced.

Consequently, what is extremely relevant is that the use of the rotary combine harvesters will considerably lessen shattering and damage of the grain during the harvesting period and simplify the design of the seed-cleaning machine including costs of the postharvest seed preparations.

CONCLUSIONS

- It has been determined that rotary combine harvesters significantly reduce grain damage.
- With continuous fractional methods of grain postharvest treatment being used, it is possible to simplify the design of seed cleaning machine and to reduce energy and material resources with less grain damage.

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