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# Harvesting *Lupinus albus* axial rotary combine harvesters

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**Abstract**

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To ensure the agricultural production of the plant protein, it is advisable to cultivate leguminous crops, such as white lupine (*Lupinus albus*), which are rich in plant protein. White lupine is an easily threshed crop. Its seeds are large enough, so the main problem is to avoid seed damage during harvesting. To improve the harvesting technology of white lupine, the authors suggest using grain combine harvesters with axial flow threshing and separating mechanism (TSM). They consider it necessary to modify the design of such combine harvesters to eliminate repeated threshing of a grain (seed) mass and decrease threshing intensity in a threshing separating mechanism. The authors have also provided grounds for technological parameters of a combine harvester – a rotor speed and a concave clearance. The recommended rotor speed should be approximately 350–400 min$^{-1}$ and the concave clearance should be 40 mm.

**Keywords**: axial flow threshing; separation mechanism; grain; seed; damage

*Lupinus albus,* commonly known as the white lupin or field lupine, is a member of the genus Lupinus in the family Fabaceae. In many countries, including in Russia is a very acute problem of the production of plant-based protein, which can be solved by growing and expanding the production of legumes. One of which is *Lupinus albus*. The human need for protein is 100–120 g·day$^{-1}$, and preferably animal protein accounted for 60% of this amount. But in order to get 1 unit of animal protein you need to spend 3–7 units plant (Ahmed 2013).

Protein deficiency in animal feed is 20–25%. This deficit is compensated by exports of soybeans to Russia. *Lupinus albus* has the highest production potential among the cultivated forage species of *Lupinus albus* – 4 to 5 t·ha$^{-1}$, the seeds contain 35–40% protein and 10–12% fat. The cost of cultivation of *Lupinus albus* is 3 to 4 thousand rubles per ton while the price of soybeans on the domestic and world markets 14 to 17 thousand rubbles per ton. In contrast to soybean seeds of *Lupinus albus* do not contain inhibitors of trypsin, so you can use them to feed without heat treatment (Pristavka et al. 2016).

Technical characteristics of axial-rotory the threshing and separating systems in comparison with the threshers which includes drum deck threshing device and walker show us that axial-rotory combines have bandwidth more than 10 kg·s. Unfortunately, the regularity of threshing and grain separation in such systems has not been studied enough. Axial-rotor grind crushed and lose less grain than a threshing machine with straw walkers. (Quick, Wesley 1978; Carrol 1999).

The possibility of harvesting large grains of *Lupinus albus* harvesters with axial rotary threshing and separating device causes particular interest the pecu-

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liarity lies in the fact that the gaps between the rotor and a concave are large, allowing you to work on light modes providing low damage of seed. Herewith, the area of grain separation considerably more than the classic combines harvesters ensuring the allocation of grain from the heap. Recommendations for the use of axial rotory combines, obtained in result of researches, harvesting *Lupinus albus* allows reducing the seeds loss and damage (Aldoshin 2016).

The casing in the threshing and separating parts can rotate in the passing or counter direction with the rotor. The possibility of using the system with a fixed casing is provided by the locking elements

Table 1. Characteristics of MSU with a longitudinally extending rotor

| Parameter | Feature |
|---|---|
| Rotor diameter | 762 mm |
| Rotor drive | hydromechanical |
| Rotor speed MSU | 250–1,000 $min^{-1}$ |
| Concave MSU | rotating |
| Angle of the rotor concave | 360° |
| Frequency of rotation of the concave | > 8 $min^{-1}$ |
| Size of the threshing clearance | 10–50 mm |

## MATERIAL AND METHODS

The processes occurring in the threshing separating devices of the axial rotor type differ from the processes occurring in the classical ones consisting of a bilge drum and a deck.

The aim of the experimental study of cleaning process of *Lupinus albus* axial rotary combine harvesters was obtaining recommendations for their settings. Studies were carried out on a combine harvester RSM-181 "TORUM" (Rostselmash, Russian Federation). The harvester has threshing and separating system with longitudinally mounted rotor. Adjustment of threshing gaps was proceeded by changing the position of threshing concave sections. Technical characteristics of the harvester are presented in Table 1.

A possible solution to the problem of cleaning *Lupinus albus* is the use of harvesters with axial rotary (explain abbreviation) MSU. Processes in (explain abbreviation) IAS axially rotary type, different from the processes occurring in a drum (classic) IAS. Axial-rotary threshing to a lesser extent, crushed and lose their corn threshers with walkers. They are versatile: with a small alteration can remove different cultures, less moving of working bodies (Kuzmych 2013).

Processes violate and separation of coarse grain heap in axial-rotary MSU are due to the impulse of the impact elements of the rotor in the grain mass, and the velocity of the heap is reduced when you move it to the exit of the device, therefore reducing the amount of grain mass in the threshing space. The stream heap in the working space axially rotary, MSU is moving with a variable angle of inclination to the generatrix of the casing, which depends on the angles of the guides of the lattices of the casing and the working elements of the rotor (strips separator, pests). The angle between the direction of movement of the mass in the working space of IAS and the generatrix of the casing is constantly growing and strives to 900 **unit??** at the outlet of the device. When moving in the working space IAS the flow of grain mass makes about 5 turns and travels about 14 m (for comparison: in drum-MSU way is 0,8–1,2 m) (Alam et al. 2008)

For cleaning *Lupinus albus* it is necessary to perform a number of operations on re-equipment of the combine. It is necessary to remove the pests with a threshing concave. *Lupinus albus* is easy absolutively culture, so demolicious device modernizarea . And remove concave Domracheva device 1 (Fig. 1). Concave becomes smooth, which reduces additional damage. This requires the following sequence of actions: a change from belt to chain, as well as to dismantle concave 1 (Fig. 1) and a tensioning roller 7 (Fig. 2).

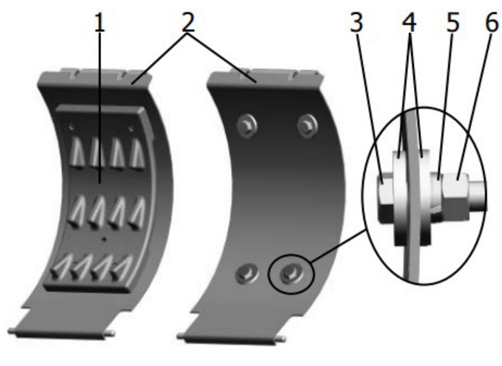


Fig. 1. Dismantling of deck secondary threshing

1 – concave; 2 – cover; 3 – bolt; 4 – washer; 5 – spring washer; 6 – nut

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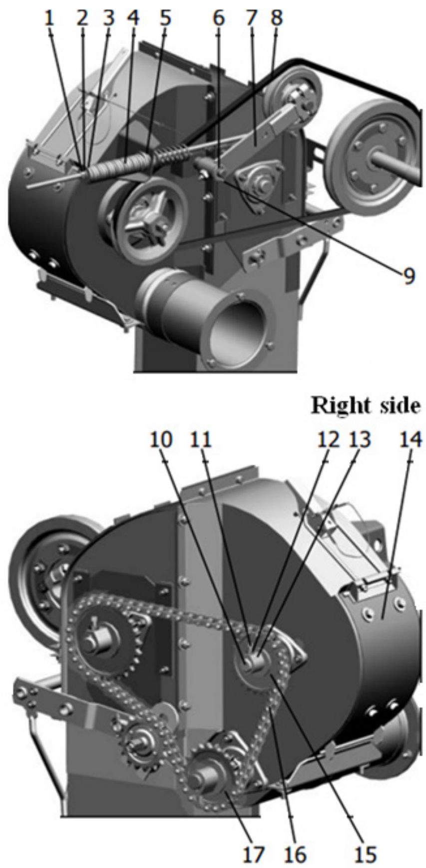


Fig. 2. The change from belt to chain

1,12 – nut; 2,3,6 – washer; 4 – spring; 5 – spherical washer; 7 – roller idler; 8 – strap; 9 – pin; 10 – drive shaft of the secondary threshing; 11 – screw; 13 – key; 14 – cover deck; 15 – sprocket; 16 – chain; 17 – tensioning sprocket

According to Fig. 1, removing the deck 1 on the cover 2 secondary threshing, the holes in the lid to close washers 4 bolts 3, lock washers 5 and nuts 6. For demounting of the tension roller 7 (Fig. 2). Un-screw the nut 1, remove the washers 2 and 3, the spring 4 and the spherical washer 5, pin 9, the washer 6, the belt 8 and the tension roller 7.

To install a chain transmission is required on the drive shaft secondary threshing 10 to install the key 13, sprocket 15, the nut 12, the screw 11, to put on chain 16 (long 1,352.55 mm and number of units 71) on the sprockets and tighten the chain tensioning sprocket 17.

## RESULTS AND DISCUSSION

The purpose of the experiments was to evaluate the influence of technological parameters of the rotary threshing and separating device on the level of micro- and macro-damage (Abilzhanov et al. 2016; Mašek et al. 2016).

Field experiments were conducted in the conditions of the open joint-stock company "Agrofirma Mtsenskaya", Mtsensk district, Oryol region. Grade remove *Lupinus albus* Dega. Grain moisture of 12.7%. The field relief equal, without bias. In the first series of experiments varied the speed of the rotor with 350 min$^{-1}$ to 750 min$^{-1}$ in increments of 100 min$^{-1}$, with the clearances between the rotor and a concave of 30, 35 and 40 mm with triple replications. In the second series of experiments, we changed the gap from 20 mm to 50 mm with step to 10 mm if the rpm of the rotor 350, 450 and 550 min$^{-1}$ with a triple repetition (Figs 3–6) (Aldoshin 2016).

From Fig. 3 it follows that the grain damage varies with the rotor speed according to the exponential dependence, which is consistent with the studies of other authors (Alam et al. 2008; Rodimtsev et al. 2014; Pristavka et al. 2016)

From Fig 3 it follows that if you change the gap between the rotor and a concave of 30 to 40 mm macro- and micro-damage of grain of *Lupinus albus,* as well as damage, tend to rise. Means further increasing the gap between the rotor and the concave is not advisable. It should be noted that with increasing rotor speeds over 500 min$^{-1}$ there is a sharp increase of grain losses due to its damage. Hence, the rotor speed has a great influence on the quality of threshing of the grain crops. Additionally, when the frequency of rotation of the rotor 550 min$^{-1}$ and the clearance between rotor and concave 40 mm in the hopper of the combine appeared, the husk of the beans *Lupinus albus*.

Of the Figs 4–6 it follows that with the increase of the gap between the rotor and concave, there is a decrease of macro, micro and total damage of grain of *Lupinus albus*. No significant change in damage occurs at lower speeds of rotation of the rotor.

Excessive increase of the gap leads to increasing losses behind the thresher. In addition, there is a more intense blockage of grain in the hopper fragments of not fully threshed beans.

The angle of inclination of the trajectory of the grain mass in the process of its movement from the entrance to the exit of the device is constantly growing closer to 90°. It's consistent with studies of many authors (Kuzmych 2013; Vlăduț 2014; Pristavka et al. 2016) who established that the absolute speed of its movement between the drum beats and the deck plank falls.

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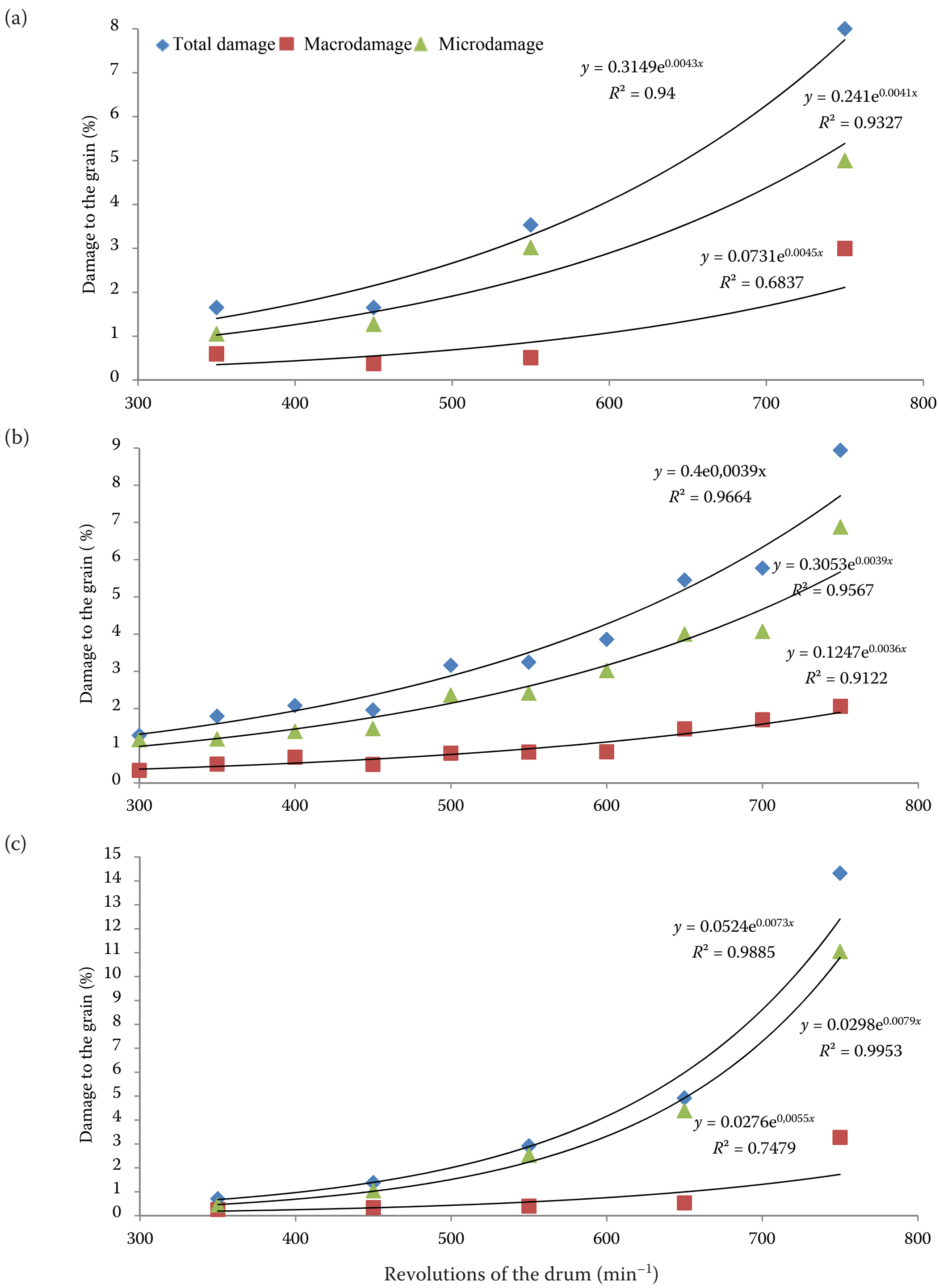


Fig. 3. The dependence of the grain damage on the rotation speed of threshing drum. The gap between the rotor and the deck: (a) 30 mm, (b) 35 mm and (c) 40 mm

## CONCLUSION

Combine harvester with axial-rotary threshing and separating devices can be used effectively for the harvesting of *Lupinus albus*. You need to produce a specific improvement.

Harvesting of *Lupinus albus* combine harvester RSM-181 "TORUM" it is necessary to set the frequency of rotation of the rotor of the threshing device 350–400 min$^{-1}$, and the gap between the rotor and concave 40 mm.

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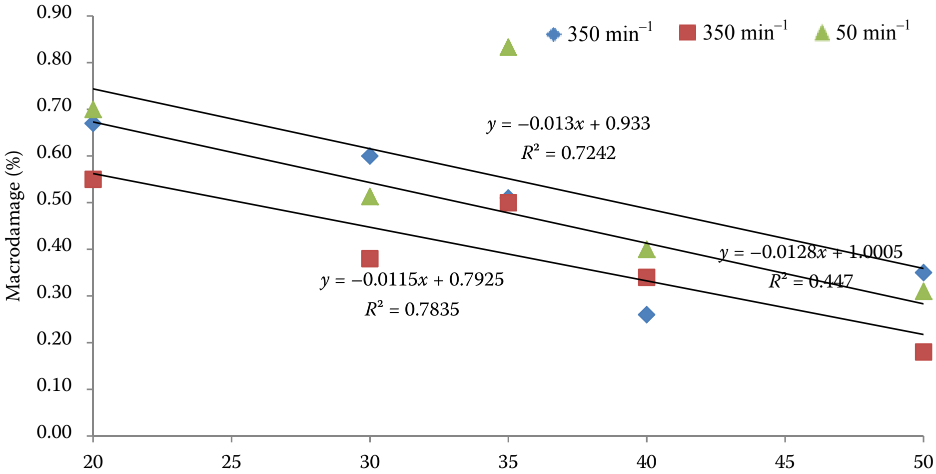


Fig. 4. Dependence of macrodamage the wheat from the gap between the rotor and the deck

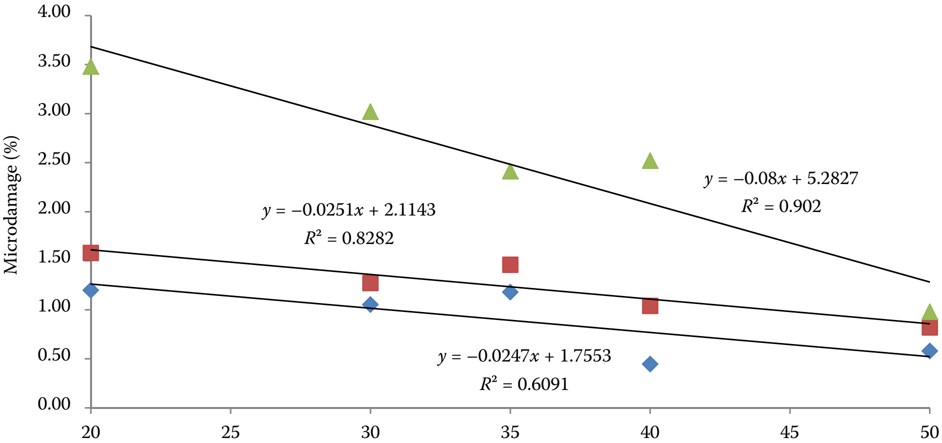


Fig. 5. Dependence of microdamage grain from the gap between the rotor and concave

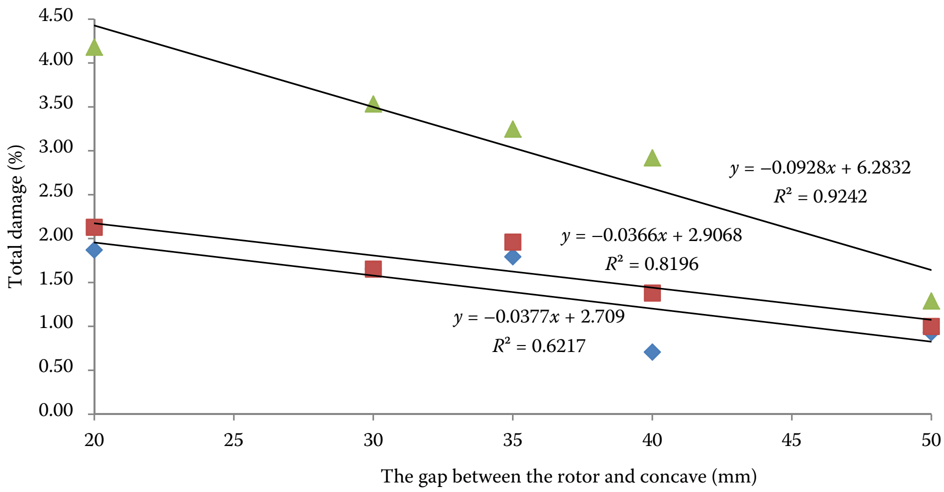


Fig. 6. Dependence of the total damage to the grain from the gap between the rotor and concave

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