METHODS OF HARVESTING OF MIXED CROPS

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Abstract

The mixed crops of grain grains and leguminous crops can promote receiving bigger quantity of production from each hectare of a cultivated area. Now combines which could fully provide high-quality harvesting of the mixed crops completely aren't issued. When using combine harvesters with the classical scheme of the threshing and separating device the way of harvesting of the mixed crops for two passes of the combine is offered. An example of harvesting of the mixed crops is reviewed: triticale – a white lupine.

In rotor combines process of the threshing and separation happens in one body which at the same time threshes and separates the grain. In such solution rather big technological gaps between a rotor and a separation unit are established. Because of repeated impact on harvested material process of the thresh turns out rather effective, and the area of separation several times is more, than in classical scheme. When using combine harvesters with axial rotor on harvesting of the mixed crops, various schemes of modernization of their design are offered that allows making harvesting of crops with different technological properties.

Key words: mixed crops, grain crops, legumes, method of harvesting, combine harvester, threshing-separating device.

INTRODUCTION

Agricultural producers are faced with a problem of receiving bigger quantity of production from each hectare of crops. One of ways of the solution of this task can be the use of the mixed crops. In this case, productivity of each of the cultures entering the mixed crops decreases in relation to their pure crops, but the general exit of production from each hectare can increase.

Cultivation of various mixed crops of grain grains and leguminous cultures is possible. For example, barley – a narrow-leaved lupine, oats – a narrow-leaved lupine, wheat – a narrow-leaved lupine, oats – peas, oats – Vika, triticale – a white lupine, etc. In addition to the direct benefits of such crops may be present and other positive aspects. In the mixed crops of a lupines albus and triticale, we have a natural way of fight against weeds. Such mixed crops aren't littered with weed plants and at the same time we save on herbicides. Given that lupines albus in their biological features metabolizes nitrogen from the air and stores it, it improves the quality of cereal crops. Such crops are good predecessors for any other cultures which are grown up in crop rotations together with them.

One of the most difficult stages of cultivation of grain crops in the mixed crops is their harvesting. It is connected with the fact that it is at the same time necessary to clean cultures with absolutely various technological properties. Legumes easily threshed their grain larger and more susceptible to damage. Conversely, cereal crops require a more "hard" mode of threshing, grain finer and less prone to injury. Readiness for harvesting of mixed crops is determined by degree of a maturity of plants of a lupine when more than 90% of beans at moisture content of seeds grow brown in them 16-18% - (ALDOSHIN, 2015).

Designs of modern combines according to the technological scheme of the threshing and separating device (TSD) can be divided into three main types: classical, rotor and combined. In combines of the classical scheme the threshing and separation of grain harvested material is carried out by a threshing drum and a keyboard straw separator (ALDOSHIN, 2015).

For harvesting of unevenly ripening cultures various designs of threshing mechanism which are carrying out the differentiated thresh have been offered. Heterogeneity of mechanical communications of seeds with a maternal plant demands differential impact on vegetable harvested material at the threshing. The essence of a design of such devices is that at first there is a threshing of more mature grain, and then intensity of a thrashing for less mature increases.

The idea of the two-phase thresh of grain has formed the basis of production of models of two drum combines of the Rostselmash, Krasnoyarsk and Taganrog the of plants for the production of combines in the Russian Federation, firms "John-Deere", "New Hol-

land", "Case". On the basis of a two-phase method also rotor combines have been created subsequently (ALDOSHIN, 2015).

In threshers of a new series of LEXION combines of CLAAS firm the advanced threshing -separating APS device which the firm has for the first time used in MEGA series combines is used. Such device provides acceleration of the movement of grain harvested material thanks to the additional bitter located in front of a threshing drum. APS system increases the speed of the movement of grain harvested material because of what her giving becomes more uniform. At the same time the centrifugal forces operating on grain increase, his separation through lattices of a concave which area is doubled almost, in comparison with one-drum threshing devices improves.

Threshing and separating device with a rotational separator is used in combines of NEW HOLLAND, MASSEY FERGUSON firms and combines of other firms, similar on a class. In new classical combines of the ACTIVA, BETA and CEREA series of MASSEY FERGUSON firm the threshing mechanism of different designs which basis is the 8-bilny threshing drum are applied. For an intensification of process of separation in combines of the CEREA series the advanced design of a concave with the doubled sizes of the separating openings on the last four levels is used.

As it follows from above, combine harvesters suitable for mixed crops harvesting are not available now despite of its need. That is why the main aim of this article is to evaluate the possibilities of its development and to offer its possible design solutions.

MATERIALS AND METHODS

Experiments were done with combine harvesters with classic threshing and separating device (TSD). Triticale crop mixed with white lupine *(lupines albus)* was harvested during our experiments. The dependences between triticale threshing losses and the gap between threshing drum and threshing concave were studied at the first part of the experiments. Consequently, micro and macro damages of threshed white lupine grains were observed.

Another part of experiments were done with two phase harvesting. Harvesting was carried out by two passes of the combine. The example of performance of this way of harvesting has been carried out in September, 2014 on skilled fields in educational economy of Kalinin of the Tambov region of the Michurinsk area.

Harvesting of the mixed crops of a white lupine *(lupinus albus)* and triticale has been carried out. At the first pass technological settings corresponded to harvesting of a white lupine. In the bunker collecting grain of a white lupine and partially triticale was carried out. The harvested material threshed for the first pass was stacked in a row. At the second pass of the combine made selection of rows with the threshing at the technological settings corresponding to triticale harvesting. After harvesting of the mixed crops threshing losses and free grain, macrodamages (crushing, crush, a collapse) and microdamages (a jointing, damages of a germ, endosperm, covers, etc.) grains were defined.

RESULTS AND DISCUSSION

Qualitative indicators of performance combine harvesters with classic TSD are shown in Fig. 1 - 3.

From the analysis of the data presented in Fig. 1 - 3 follows that an increase in the gap at the outlet of the threshing drum device for different speeds when harvesting mixed crops triticale thrashing losses increased and the damage of white lupine are reduced on the contrary. This condition does not allow both to perform agro-technical requirements for both the mixed harvested crops (ALDOSHIN, 2016, ALDOSHIN, 2015).

For example, to make triticale harvesting by a combine harvester with the classical the threshing and separating device (TSD) according to agrotechnical requirements it is necessary to set:

• linear speed of scourges of a threshing drum to 30-32 m/s;

• a gap between a threshing drum and a concave at the exit to 2-4 mm.

And respectively for a white lupine:

• linear speed of scourges of a threshing drum to 15 - 18 m/s;

• a gap between a threshing drum and a concave at the exit to 14 - 18 mm.

Now combine harvesters which could fully provide high-quality harvesting of the mixed crops completely aren't issued. Actually we need two combines which are consistently working one after another. In this case the next way of harvesting of the mixed crops for combines with classical threshing mechanisms can be offered.

These designs of threshing mechanism for the differential thresh can't solve a problem of harvesting of the mixed crops of grains and leguminous cultures, for

example, of a lupine and triticale as technological properties of cultures are too various. Therefore, technological settings of threshing mechanism of a combine harvester for harvesting of these cultures have to be various. In addition, after threshing legumes we have to select it completely out of the grain heap (separate out), and only then proceed to the threshing and separating of grain crops, although some of it we already threshed and separated with leguminous. Actually we need two combines which are consistently working one after another. In this case the next way of harvesting of the mixed crops for combines with classical threshing mechanisms can be offered.

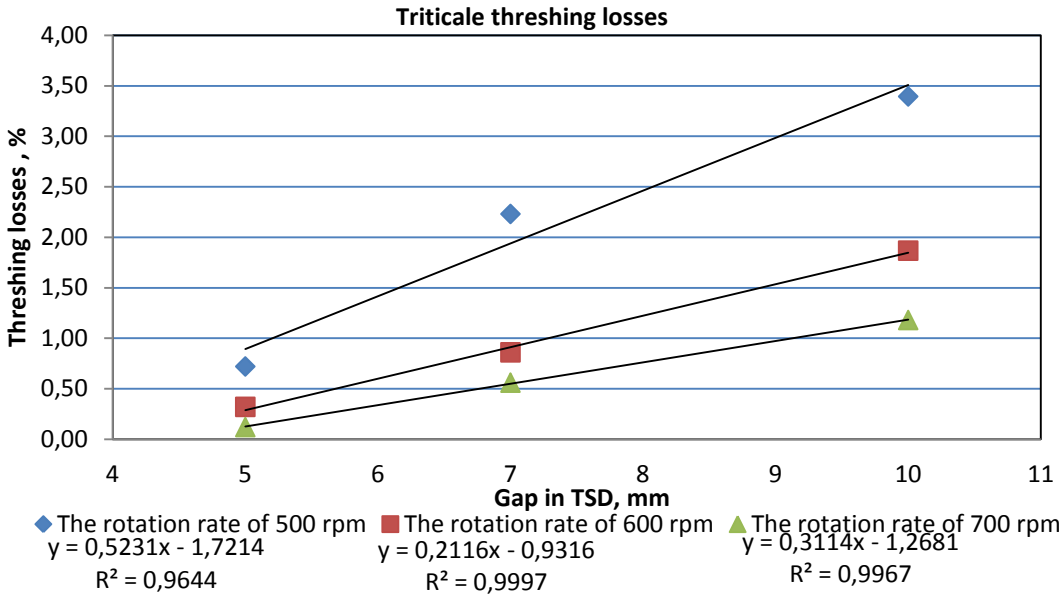

Fig. 1. – Dependence of triticale thrashing losses on the gap at the outlet of the threshing and separating device for different speeds when harvesting mixed crops

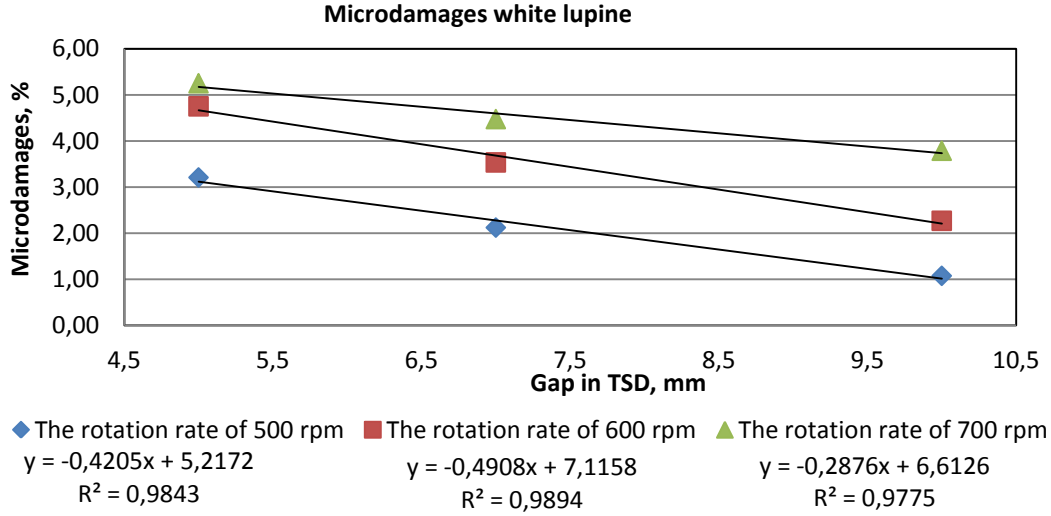

Fig. 2. – Dependence of microdamages of a white lupine *(lupinusalbus)* on a gap at the exit of the threshing and separating device for different speeds of a drum when harvesting of the mixed crops

During two phases threshing, at the first pass threshing losses of white lupine was absent, damages have made 3%. Triticale – not threshed 65%, damages were absent. At the second pass white lupine grain in the threshed harvested material wasn't. Triticale threshing losses have made 0.5%, triticale grain damages – 1.5%. This conformed to agro technical requirements of harvesting of grain grains and leguminous cultures. When harvesting of the mixed crops of such cultures for one pass there is no opportunity to receive losses

and grain damage at the level of agro technical requirements.

In rotor combines, the process of threshing and separation happens in one body which at the same time threshes and separates grain (SRIVASTAVA ET AL., 1993; STOUT AND CHEZE, 1999). Due to intensity of process of separation in rotor working bodies the minimum losses of grain even are provided at high productivity of cultures, at the increased moisture content and at the presence of weeds.

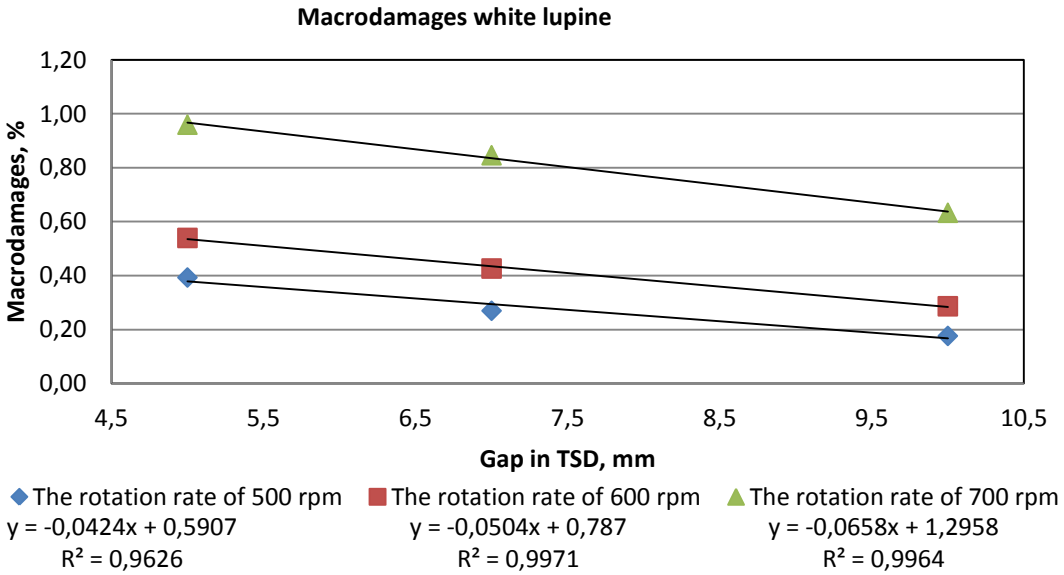

Fig. 3. – Dependence of macro damages of a white lupine *(lupinusalbus)* on a gap at the exit of the threshing and separating device for different speeds of a drum when harvesting of the mixed crops

On the basis of rotor combines various options of harvesting of the mixed crops can be also realized. For example it is possible to use a consecutive combination of axial and rotor threshing mechanisms with tangential feeding of the harvested material (Fig. 4).

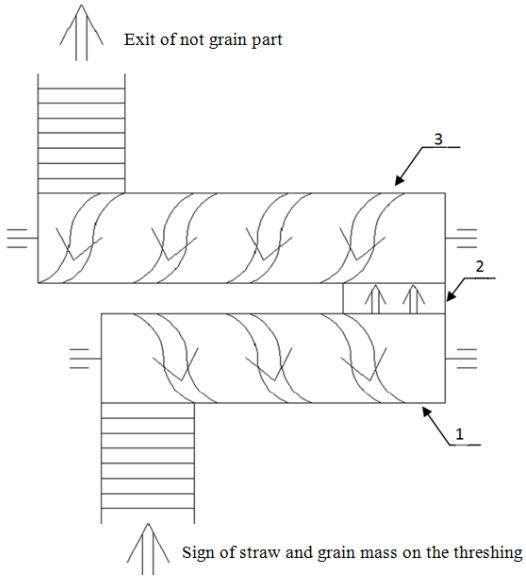

Fig. 4. – A consecutive combination of two axial rotor threshing mechanisms with tangential feeding of harvested material for harvesting of the mixed crops

The combined device works as follows. The conveyor of an inclined chamber, tangential gives the processed harvested material to a rotor of the first threshing-separating device 1 which is adjusted on a "soft" operating mode where grain of easily threshing bean culture not only threshing completely but also is completely separated at the movement of harvested material on a screw trajectory. Full release of grain of bean culture is provided with the big area of the threshing and separation in the first device 1. At the same time part of cereal grain is also threshed and separated.

The remained harvested material is tangentially transmitted through the sending device 2, in the second threshing - separating device 3 which works in the "rigid" mode that provides full threshing of the remained cereal material. Considerable length of a screw trajectory of the movement of the processed harvested material in threshing space, at continuous intensive shock influence promotes full release of grain according to agro technical requirements.

Other option of use of axial threshing mechanisms on harvesting of the mixed crops can be realized due to its division into two parts, each of which provides the threshing and separation of one of cultures. The threshing mechanism with the body divided into two

parts is offered. Each of parts of a body has a possibility of rotation (Fig. 5) different from each other.

The device works as follows. Processed harvested material of the feeder enters the lead-area of threshing mechanism. Under the influence of the rotor blades and the guide casing (1) it acquires spiral motion. At the same time the considerable part of bean culture is threshed. At the same time process of separation of free grain of bean culture through openings of conic part of a casing in a zone "A" begins that reduces grain damage. The remained grain is threshed by scourges (4) rotors of the first zone. Full release of free grain of bean culture through openings of a casing of a zone "A" happens at shock influence of the separating levels of the rotor (5). As the direction of rotation of a rotor and a casing of the first zone coincide that and intensity of shock influence is insignificant that excludes damage of grains of bean culture. Besides gaps between a rotor and a threshing concave are increased, i.e. correspond to the modes of harvesting of leguminous cultures. Speed of blow of scourges of a rotor to the threshed harvested material decreases by size corresponding to the speed of rotation of a threshing concave. Such technological parameters for the first part of threshing mechanism provide agro technical admissible requirements for harvesting of leguminous cultures, and also the partial thresh and separation of grain culture grains.

In a zone "B" the casing has opposite rotation concerning a rotor. At the expense of it the speed of blow of scourges (6) and the separating levels of the rotor (7) on the threshed harvested material increases at a size corresponding to the speed of rotation of a concave. At the same time gaps between scourges and levels of a rotor and the separating concave are reduced. Such technological parameters of axial TSD provide complete threshing and separation of grain cereal crops. The remained part of straw is brought out of the device through straw separator part (8) of the device.

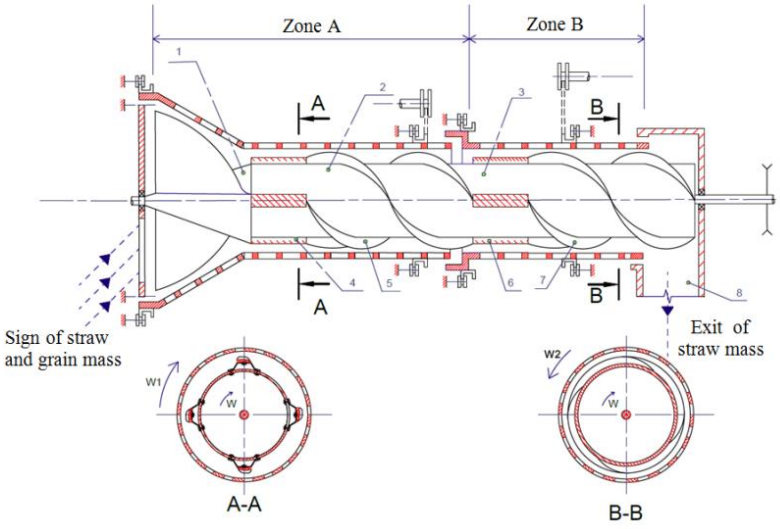

Fig. 5. – Axial threshing mechanism for harvesting of the mixed crops with separately rotating parts of a body

Also for harvesting of the mixed crops of grain crops the axial threshing mechanism having a two-section rotor (Fig. 6) can be offered. It consists of a two-part rotor with a tangential lead-in part. Each of parts of a rotor includes the threshing and separating parts. The separating casing clasps a rotor on all his extent. Section "A" of a rotor has the low speed of rotation corresponding to the threshing of leguminous culture. The threshing part provides the threshing of leguminous culture and the separating part its separation.

The section "B" of a rotor has the increased rotation speed corresponding to threshing of cereal crop. At the expense of it there is a hauling of a layer of the threshed harvested material that improves grain separation process. At the same time the threshing part of section "B" of a rotor provides the final thresh of cereal crop, and the separating part its full allocation.

The device works as follows. Harvested material, lead-through part of the housing (1), is captured pests threshing part (2) of the section "A" of the rotor and threshed in a "soft" mode, typical of legumes. At the same time the threshed vegetable harvested material receives spiral three-dimensional motion between a rotor and a concave (4). After release of grains from beans in the separating part of a rotor (3) there is their final allocation through openings of a concave (4).

The rotor section "A" at the expense of the drive (7) has the low speed of rotation corresponding to the threshing of leguminous crop.

The remained grain harvested material, moving, gets to an area of coverage of section "B" of a rotor. The full thresh and separation of cereal crop is provided at the expense of the increased speed, the movement of scourges (5) and the separating levels of rotors (6) located on section "B". The rotor section "B" also has the independent drive (8). After threshing and separation of grain grains of cultures crop is derived from the device through of the housing (9).

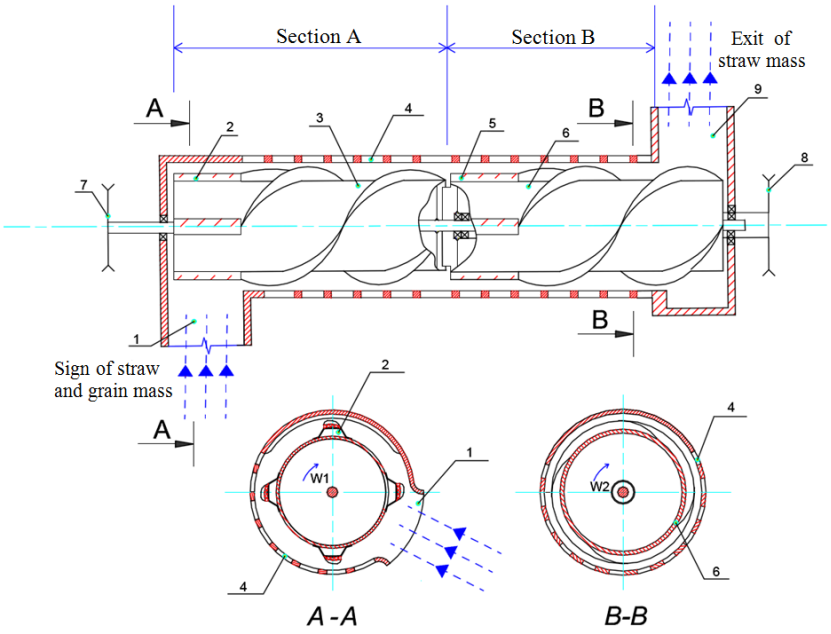

Fig. 6. – Axial threshing mechanism for harvesting of the mixed crops consisted from two sections of rotor

CONCLUSIONS

1. For harvesting of the mixed crops of grain and leguminous crops the combine harvesters with the classical threshing-separating system it is possible to use by the way based on two passes of a combine. At the first pass, harvested material is mown with the thresh, at technological settings of the leguminous crops corresponding to harvesting, then the lots is stacked in a row and at the second pass carry out selection of a row with the final thresh of harvested material at technological adjustments corresponding to harvesting grain crops.

2. On the basis of rotor combines, various options of harvesting of the mixed crops can be also realized. It is possible to use a consecutive combination of axial threshing mechanisms with tangential feeding of harvested material.

3. Advanced designs of axial and rotor threshing mechanisms with separately rotating parts of a concave or from a two section rotor can be also applied to harvest of the mixed crops.

REFERENCES

1. ALDOSHIN, N. V.: Justification of technological parameters of combines on harvesting of a lupinusalbus/ N. V. Aldoshin, A.A.. Zolotov, A.S. Tsygutkin, In, D. Suleev, A.E. Kuznetsov, N. A. Aladyev, Mull Bakhaa // Achievements of science and technology of agrarian and industrial complex, – ISSN. 0235-2451, No. 1, T. 29, 2015: p. 64 - 66.
2. ALDOSHIN, N. V.: Definition of damages of grain of a lupinusalbus while harvesting / N. V. Aldoshin, A.A. Zolotov, A.S. Tsygutkin, V.D. Suleev, A.E. Kuznetsov, N. A. Aladyev, Mull Bakhaa // Tractors and agricultural cars, ISSN 0235-8573, No. 2, 2015: p. 26-29.
3. ALDOSHIN, N. V.:Harvesting of mixed crops of cereals by stripper header / N. V. Aldoshin, A.A. Zolotov, A.S. Tsygutkin, N. A. Lylin, MallaaBakhaa // the Bulletin of federal public educational institution of higher education "The Moscow state agroengineering university of V.P. Goryachkin". No. 1 (71). 2016: p. 7-13.
4. ALDOSHIN, N. V.: Technical ensuring quality of the mechanized works: Monograph / N. V. Aldoshin, R. N. Didmanidze. M.: RGAU publishing house – MSHA, 2015: p. 188.
5. ALDOSHIN, N. V.: A comparative assessment of combines on harvesting of a lupinusalbus / N. V. Aldoshin // the Rural machine operator, ISSN 0131-7393, No. 11, 2015: p. 10-13.
6. ALDOSHIN, N. V.: Mechanization of harvesting of the mixed crops of grain crops / N. V. Aldoshin, A.A. Zolotov, A.S. Tsy-

gutkin, MallaaBakhaa // Tractors and agricultural cars, ISSN 0235-8573, No. 10, 2015: p. 41-45.

7. SRIVASTAVA, A. K., GOERING, C. E., ROHRBACH, R. P.: Engineering Principles of Agricultural Machines, ASAE Textbook No. 6, ASAE 2950 Niles Road, St Joseph, Michigan 49085-9659, USA, 1993, ISBN 0-929355-33-4, pp.601.
8. STOUT, B. A., CHEZE, B: CIGR Handbook of Agricultural Engineering, Volume III – Plant Production Engineering. ASAE 2950 Niles Road, St Joseph, Michigan 49085-9659, USA, 1999, ISBN 1-892769-02-6, pp.632.

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