QUALITATIVE ANALYSIS OF WHEAT COMBINE HARVESTER WORK EFFECTS IN RYE HARVEST

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Abstract: *The quality of combine harvester work in the rye harvest is reflected in terms of the amount of realized losses and quality of harvested grain weight. The quality of combine harvester work depends on several factors: the condition of the crop, defining the relevant parameters for combines, technical correctness and staff skills. Quality of work is significantly decrease when key parameters are not well coordinated, resulting in increased losses of rye grain and a high proportion of impurities in harvested mass in the harvester bunker. The aim was to determine the effects of combines ZMAJ 135B and ZMAJ 143 in the rye harvest in the observed area. Work method determines the loss on the header and harvesting device depending on the changes: peripheral winches speed; combine speed, underdrum-drum distance at the entrance and evaluating the quality of harvested weight (content of whole, broken, poorly grains and other particles). Header losses were determined using a wire frame of $1m^2$, located after the passage of the side behind the combine header and harvesting device by setting the appropriate container, during harvester motion, between front and rear wheels at an angle of 10-20^o in regard to the movement direction. The quality of harvested mass was determined by taking samples from the harvester bunker and the determination of the percentage content of healthy (whole), broken grains and impurities was performed later in the laboratory. The applied methodology is standard for this issue and is related to field-testing laboratory and exploitation wheat combine in the single-phase rye grain harvesting. The obtained results allow to point out the advantages and disadvantages of the applied concepts of different wheat combine. Header largest losses were registered in the device combines ZMAJ 143 and were 25.77 kg ha^{-1} (1.18%) and lowest in combine ZMAJ 135B, amounting to 14.76 kg ha^{-1} (0.65%). The highest content of whole rye grain was in combine ZMAJ 135B and amounted to 97.34 in 15^{00}, and the lowest in combine ZMAJ 132 94.59%. Based on these results it was concluded that the ZMAJ 135B harvester worked better than the harvester ZMAJ 143, with lower losses of rye grain on the harvester unit header, and higher content of whole grain with a significantly lower share of impurities in relation to other investigated harvester. The general conclusion of our research is that harvester ZMAJ 135B can be successfully used in rye harvest in a given area and with proper optimization of labor exploitation and operator training can gain full expression.*

***Key words**: harvester combine, harvesting, losses, grain, rye.*

INTRODUCTION

Rye is a farming culture that is important as bread wheat. It contains sufficient amounts of vitamin A, B and E. (OELKE 1990). Rye bread is a tasty, nutritious and long stays fresh. Rye bread is particularly recommended for diabetics. Rey is also excellent as stock food, no matter either the green or in bran, flour or grain. In industry, the grain is used to produce alcohol, starch and vinegar, cellulose, lignin, furfural and a good quality paper and seeds are used in the pharmaceutical industry. Rye is in sixth place in the world by the covered area, behind wheat, maize, rice, barley and oats. The rye was planted on 5200 ha and harvested on

5,197 ha, with a yield of 2.5 t ha^{-1} in Serbia, in 2009. (Statistical Yearbook Of Serbia, 2010). Rye harvest is still performed single-phase harvest methods similar to that of most grain crops. Harvesters which perform cutting, threshing and separating grain from straw and impurities in one pass are used in rye harvest. The optimal time to harvest the rye is period of wax maturity end, bearing in mind the fact that spelled more rash compared to wheat (LAZOVIC et al. 1999). Moisture content for storage is about 14%. The introduction of combine harvesters in the technological process of rye harvesting is to reduce the total losses and quality harvested mass, which also means higher yield of rye in the harvester bunker. Also, energy and labor consumption is the smallest and process of harvesting is the most economical. It is very important to determine total losses and quality of harvested mass in the rye harvest combines, not only in terms of economic calculation and determination of total yield and the effects of the harvester, but also for informing users when harvesters are rented or are engaged in the machinery rings. Losses on the header in the single-phase rye harvest are expressed as free, grain to cut off ears and uncutted parts. All three losses were caused by the work of cutting equipment and winches. Losses that occur in harvesting device are the result of bad adjustment of the parameters of the peripheral drum speed. Considering the problems of single-phase harvesting of rye, it is evident that this problem dealt with a number of researchers in the wider and narrow sense. SCHULER et al. (1975) analyze the losses in the harvest in North Dakota, and concluded that the moisture content has a significant impact on the amount of losses and should be carefully considered. The same authors indicate that the losses on the combine header were about 1%, with over 90% of healthy grain in the harvester bunker. AULD et al. (1986), in northern Idaho, conclude that is possible to have small losses on the header and a high percentage of whole grain in the harvesters bunker (more than 93%) with a well-adjusted combines. OELKE et al. (1990.) recommend less speed and combines good speed winches compliance with the speed of movement for the losses on the header about 1.5%. The top sieve as directed by the same author, should be open 16 to 18 mm, and the bottom 5 - 10 mm for harvested mass with more than 90% of whole grain. The same authors state that harvested losses in threshing machine varied between 1-1.5%. In technology of combining of wheat, according to TADIC (1994), losses are usual collateral and can not be avoided, but with proper combine exploitation there cold be achieved minimum losses. Therefore the author proposes the application of the method of fast loss calculating, which is the most simple and exact, instead of the classic method which is the most complicated and the most expensive. The number of winch revolutions on wheat combines should be adjusted to a moving speed of combines. Losses on drum rotation are 0.1-1.0%, while total losses of threshing engine are 0.15-0.8% of the yield. Optimal working quality in the combining of cereals is being achieved in moisture of 14-16%. From the stand point of fluid dynamics. Clean biomass, separation processes grain losses that ocur can be characterized as a gas/solid multiphase flow with moving boundaries on influence. Physics of this type of flow is very complicated and presents a unique challenge for the development of methods for the characteriyation on these flows (CHAO et al, 1998.). Since MANSOURI and MINAEE (2003) concluded that an increase in cylinder rotational speed from 750 to 950 rpm would double grain breakage, it is recommended that cylinder rotational speed of 800 rpm be chosen. Losses of the combine threshing machine should not be over 0.8% and impurities in threshed mass not over 2%. Introduction of new high performance combines in technology, are represented in low losses and high quality of harvested grains (MALINOVIC et al. 2005)**.** The separation of grain and losses on the header does not exceed the limits (about 1-2%) when the operating speed is not increased STRAKSHAS (2006). By the same authors, well-balanced relevant combine parameters provide a secure state of crop harvest with more than 90% whole grain, with small losses in threshing device of combines. LASHGARI et al (2008), presents a qualitative analysis of damage in harvesting wheat harvest combine John Deere 955 in Karaj. The interaction of speed, velocity, rotation and spacing underdrum-drum exhibited significant influence on grain cracking. The largest grain cracking was 5.47%, with losses in free grains of about 1.5%. As the authors state the most appropriate setting low speed of about 2 km h^{-1}, the rotation of the drum of 800 min^{-1}-900 min^{-1} with the inlet height of 25 mm. BARAC et al. (2008) stated the losses on the harvested device in combine JD satisfactory, wich is not the case with the combine Z142RM. The same authors report that the losses on the header varied in the range of 0.09 - 0.71% and for harvested device from 0.07 to 12.57%. Grain losses during harvesting with JD 1165 Combine harvesters were 1.29%, and the combined losses averaged 0.96%, according to HASANI et al. 2011th.

MATERIAL AND METHODS

Laboratory and field tests of losses in the standard header and the classical performing device (TTO), and the quality of the harvested mass of the two types of combines during harvest of winter rye to the experimental farm, were made in the agro-ecological conditions of Kosovo and Metohija in 2010. godine. Harvesters ZMAJ 143 and ZMAJ 135B were studied. Once we have completed selection of parcel, the biological yield of winter rye on the diagonal of the plot was determined. Also, we found that the crop was upright in the absence of weeds, balanced and did not lay down. The average yield of rye was 2184 kg ha^{-1} for the harvester ZMAJ 135B and 2237 kg ha^{-1}, for the harvester ZMAJ 143, and plant number 440, or 460 per m^2. Losses were determined on the header, harvesting device and quality of harvested mass depending on the peripheral speed winches, linear speed of harvesting, subdrum-drum gap at the entrance to the chamber and drum peripheral speed (with the same volume of air flow, size and setting of the opening sieves). The number of rye grains and ears that have fallen to the ground for self attrition, effects of wind or ice storm on the 1 m^2 (these losses are not incurred during the harvesters walk) are determined before header losses and harvesting device setting and before the rye harvester passing by. Rye grain losses on the header were determined using a 1m^2 wire frame, which was set up after going of the combine behind the header, so do not bother straw and chaff, where they collected all the heads of grain and set aside, and are expressed in kg ha^{-1} and in %. Losses on harvesting device were determined by placing a special tin container, which was made during the combines pass, between the front and rear wheels diagonally or obliquely at an angle of 10-20^0 with respect to the direction of movement so that it drops all the chaff and straw from the harvester (Figure 1).

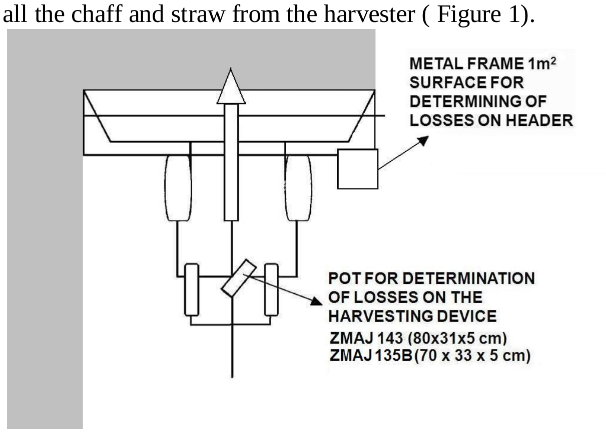

Figure 1: Position the metal frame and container for the determination of losses of the grain rye

Mass collected in the container is treated so that the seeds remain in the pan, and remove the straw and chaff (impurities). Grain in the container are numbered, so that the total number of grains is loss of: sieve, fan and straw walkers, ie. losses on the thresher. Using a special table, based on the number of grains in a bowl and set in the 1000 grains are read by losses in kg ha^{-1}. The quality of harvested weight expressed in percentage content of a healthy (whole), broken and poor grain, and the mechanical impurities, were determined by taking samples from the combine bunkers with the record number of sample and mode of operation. Percentual content of fractions was determined later, in the laboratory.The experiment was carried out on the trails of length of 50 m in three replicates and the sampling regime was noted and the number of combines sample.The research used containers, stopwatch, bags for samples, flagpole, and more. Harvesters were examined in the status quo, with the set they performed owners served as controls. The applied methodology was standard for these issues and concerns of laboratory and field-test of combine issues.

The results are presented in tables, statistically analyzed by analysis of variance and a significance level determined by the difference determined by LSD test.

Specifications of investigated combines are shown in the table No 1.

Table 1

Technical data of exemined combine harvesters

Parameters		Tipe of combine harvesters	
		ZMAJ 135B	ZMAJ 143
Engine power	(kW)	51.5	73.1
Heder engagement width	(m)	3.05	4.20
Drum width	(mm)	790	1000
Drum diameter	(mm)	550	600
Power per header grip	(kW m^{-1})	17.1	17.40
Combine mass	(t)	5.32	7.18
Hopper volume	(m-^{3})	1,8	3.60
Hopper volume/engagement width	(*l* m^{-1})	0.60	0.86
Surface of straw shakers	(m^{-2})	2.6	3.9
Surface of cleaning	(m^{-2})	1.6	2.53
Comprehensive concave angle of the underdrum	^{0}	145	112

RESULTS AND DISCUSSIONS

Table 2 and 3 shows the data on the rye crop on the experimental fields where harvesting is done and also the mode of investigated combine.

Table 2

Basic data about crop

Parameters		
	Crop of the rye	
Sort		Indigenous winter
Grain yields	(kg ha^{-1})	2.184 and 2.237
Plant texture	(m^{2})	440 and 460
Grain and straw moisture	(%)	13.6 and 15.5
The average height of the plants	(cm)	1.24 and 1.36
Ratio of grain: straw	/	1: 1.243 and 1:1.185
Crop condition	/	Vertical without weed

Based on the exposed data it was observed that the examined harvesters in good working conditions, with a yield of 2184 kg ha^{-1} and 2237 kg ha^{-1} and a lot of grain mass was present. Number of plants per m^{-2} was 440, and 460.

Table 3

Basic data about combine harvester working regime

Type harvest combines			
Parameters		*ZMAJ 135B*	*ZMAJ 143*
Winch perifer rotation	($m\ s^{-1}$)	0.65; 1.32; 1.60	0.81; 1.26; 1.75
Position of the winch in a horizontal plan	/	Middle	Middle
Drum perifer rotation	($m\ s^{-1}$)	26.60; 29.42; 33.0	27.54; 29.85; 33.15
Fan revolution	(rpm)	670	700
Sieve seting: extension, upper, lower	(mm)	15; 11; 5	16; 12; 5
Directors	/	G. S. S	G. S. S
Mass flow of the grain	($kg\ s^{-1}$)	3.35; 3.68	4.19; 4.57
Working speed	($m\ s^{-1}$)	0.45; 0,76; 0,92	0.57; 0,83; 1.10
Space underdrum-drum at the entrance	(mm)	12; 16; 20	12; 16; 20

In table 4 are presented data on the measured losses of rye grain on the header and harvesting device combines ZMAJ 135B, dependent on the defined parameters and modes of working speed on the examined experiments. Based on the results of research, it is evident that the defined parameters changes, or the regime change of working speed and peripheral speed of winch showed a significant effect on the value of realized losses on the header of the tested combine.

Table 4

Rye grain losses at combine header and harvesting device of combine ZMAJ 135B

Experiment	Grain moisture (%)	Perifery speed of winch ($m\ s^{-1}$)	v_1= 0.45 kg ha^{-1}	v_1 %	v_2= 0.76 kg ha^{-1}	v_2 %	v_3= 0.92 kg ha^{-1}	v_3 %	LSD 5%	LSD 1%
			Rye grain losses at combine header tested (medium) – Working speed Combine of the tested ($m\ s^{-1}$) – The grain losses							
The first	13.6	0.65	15.10	0.69	15.94	0.73	17.47	0.80	0.159	0.292
		1.32	17.25	0.79	17.69	0.81	18.78	0.86		
		1.60	19.87	0.91	20.75	0.95	21.84	1.00		
The second	15.5	0.65	14.76	0.66	16.55	0.74	17.45	0.78	0.214	0.356
		1.32	16.78	0.75	19.10	0.85	19.24	0.86		
		1.60	19.46	0.87	21.48	0.96	21.70	0.97		
			Rye grain losses at combine threshing device tested (medium) – Space under drum-drum at the entrance to treshing device (mm) – Grain losses							
Experiment	Grain moisture (%)	Drum perifer rotation ($m\ s^{-1}$)	h_1=12 kg ha^{-1}	h_1 %	h_2=16 kg ha^{-1}	h_2 %	h_3= 20 kg ha^{-1}	h_3 %	LSD 5%	LSD 1%
The first	13.6	26.60	16.38	0.75	11.58	0.53	11.14	0.51	0.168	0.231
		29.42	12.23	0.56	12.89	0.59	11.57	0.53		
		33.00	20.31	0.93	14.63	0.67	13.10	0.60		
The second	15.5	26.60	10.10	0.46	10.29	0.46	10.00	0.45	0.343	0.470
		29.42	11.79	0.54	11.63	0.52	11.41	0.51		
		33.00	13.87	0.62	12.97	0.58	12.30	0.55		

Based on the data exposed, it is observed that the biggest losses on the header at the first trial were at a speed of combine of 0.92 m s^{-1} - winch peripheral speed 1.60 m s^{-1} (control) and amounted to 21.84 kg ha^{-1} (1%) and the smallest at the speed of combine of 0.45 m s^{-1} - peripheral speed of winches from 0.65 m s^{-1} and were 15.10 kg ha^{-1} (0.69%). In the second experiment, the greatest losses of rye grain were on combine header ZMAJ 135 B were also highest in the control and speed combine of 0.92 m s^{-1} and the peripheral winches speed from 1.60 m s^{-1} and amounted to 21.70 kg ha^{-1} (0.97 %), while the smallest losses in the amount of

14.76 kg ha^{-1} (0.66 %) were during the peripheral speed of winch 0.65 m s^{-1} and the speed of combine of 0.45 m s^{-1} (Table 4). Testing level achieved significance difference was determined to change the preset parameters, or change the speed of combine and peripheral winches speed affect significantly the level of realized losses on the combine header ZMAJ 135B. Results of combine ZMAJ 135B harvesting device losses, are showing that changes the size gap at the entrance between the underdrum and drum in interaction with changing the peripheral speed of the drum showed significant influence on the measured losses of grain rye to combine exercising device tested. Results of combine ZMAJ 135B harvesting device losses (Table 4), show that at the first trial the biggest losses recorded in the underdrum-drum space of 12 mm, the peripheral drum speed of 33.00 m s^{-1} (control) and amount to 20.31 kg ha^{-1} (0.93% of biological yield) and the smallest at a distance underdrum-drum of 20 mm, the peripheral drum speed of 26.60 m s^{-1} and the amount of 16.38 kg ha^{-1} (0.75% of biological yield). Smallest losses in the carrying out of this device combines the second experimental field, were measured at underdrum-drum space at the entrance of 20 mm and is 0.45% of biological yield and 10.00 kg ha^{-1}, the peripheral drum speed of 26.60 m s^{-1} (control), and the highest at a distance underdrum-drum at the entrance of 12 mm and amounted to 13.87 kg ha^{-1}, or 0.62% of biological yield, the peripheral drum speed of 33.00 m s^{-1}.

On the basis of testing the significance level of setting differences on the amount of rye grain losses in combine ZMAJ 135B harvesting device, we found that the interaction changes the spacing uderdrum-drum at the entrance, as well as drum peripheral velocity changes significantly affect the amount of realized harvesting device losses.

The results are similar to other authors (SCHULER et al., 1975.; AULD et al., 1986.; OELKE et al., 1990.; TADIC, 1994.; MALINOVIC et al., 2005.; STRAKSHAS, 2006. and BARAC, 2008.).

Different values of the measured loss on the header and combine ZMAJ 135B harvesting device with the same parameters defined in another experimental field in the first, primarily to explain the different grain moisture content.

Table 5

Rye grain losses at combine header and harvesting device of combine ZMAJ 143

Experiment	Rye grain losses at combine header tested (medium)									
	Grain moisture (%)	Perifery speed of winch (m s^{-1})	Working speed Combine of the tested (m s^{-1})						LSD	
			v_1= 0.57		v_2= 0.83		v_3= 1.10			
			Grain losses							
			kg ha^{-1}	%	kg ha^{-1}	%	kg ha^{-1}	%	5%	1%
The first	13.6	0.81	18.78	0.86	20.10	0.92	20.97	0.96	0.135	0.282
		1.26	21.40	0.98	21.84	1.00	24.46	1.12		
		1.75	24.24	1.11	24.00	1.10	25.77	1.18		
The second	15.5	0.81	17.45	0.78	19.24	0.86	19.01	0.85	0.189	0.293
		1.26	19.46	0.87	20.58	0.92	21.70	0.97		
		1.75	22.37	1.00	23.26	1.04	25.73	1.15		
Rye grain losses at combine threshing device tested (medium)										
Experiment	Grain moisture (%)	Drum perifer rotation (m s^{-1})	Space under drum-drum at the entrance to treshing device (mm)						LSD	
			h_1= 12		h_2= 16		h_3= 20			
			Grain losses							
			kg ha^{-1}	%	kg ha^{-1}	%	kg ha^{-1}	%	5%	1%
The first	13.6	26.60	20.31	0.93	19.44	0.89	18.13	0.83	0.198	0.263
		29.42	20.75	0.95	19.87	0.91	18.78	0.86		
		33.00	24.46	1.12	20.75	0.95	19.87	0.91		
The second	15.5	26.60	18.34	0.82	17.67	0.79	15.88	0.71	0.167	0.199
		29.42	19.46	0.87	18.12	0.81	16.11	0.72		
		33.00	24.61	1.10	16.78	0.75	17.45	0.78		

In Table 5 are presented data on the measured losses of rye grain on the header and combines ZMAJ 143 harvesting device, dependent on the defined parameters and modes of working speed of the examined experiments.

According to the results shown in Table 5, we note that the interaction between the regime change of working speed and peripheral winches speed significantly affected the value of realized losses on the combine ZMAJ 143 header. So the biggest losses of rye grain on the header of the combine on the first trial were at a speed of combine of 1.10 m s^{-1} and the peripheral winches speed of 1.75 m s^{-1} (control) and amounted to 25.77 kg ha^{-1} (1.18%) and the lowest in the peripheral winch speed of 0.81 m s^{-1} with the speed of the harvester of 0.57 m s^{-1} and amounted to 18.78 kg ha^{-1} (0.86% of biological yield). At the second trial reported a similar effect changes the defined parameters on the amount of losses on rye on the header of combines ZMAJ 143. The largest losses of rye grain were in the control and speed of the harvester 1.10 m s^{-1}, peripheral winches speed of 1.75 m s^{-1} and amounted to 25.73 kg ha^{-1} (1.15% of biological yield), while the smallest losses amount of 17.45 kg ha^{-1} (0.78%) were the peripheral winch speed of 0.81 m s^{-1} and the combine speed of 0.57 m s^{-1}.

By testing of achieved difference significance level was determined to change the preset parameters, or change the speed of combine and peripheral winches speed affect significantly the level of realized combine ZMAJ 143 header losses.

Analyse of the rye loss on combine ZMAJ 143 harvesting device (Table 5), shows a significant effect of variation of defined parameters on losses. The largest losses of combine ZMAJ 143 harvesting device on the first experimental field were recorded in the control at a distance underdrum-drum of 12 mm (peripheral drum speed of 33.00 m s^{-1}) and the amount 24.46 kg ha^{-1} (1.12% of biological yield), and the lowest in the peripheral drum speed of 26.60 m s^{-1} and spacing underdrum-drum of 20 mm and the amount of 18.13 kg ha^{-1} or 0.83%. During tests on the second experimental field, the smallest losses in harvesting device were measured at underdrum-drum space at the entrance of 20 mm and 0.71% of the amount of biological yield, and 15.88 ha^{-1} (peripheral drum speed 26.60 m s^{-1}, while the highest losses of rye in this combines harvesting device and the measured distance underdrum-drum at the entrance of 12 mm - 24.61 kg ha^{-1}, or 1.10% of biological yield, with the drum peripheral speed of 33.00 m s^{-1} (control).

Change of the spacing size between the underdrum and drum at the entrance to the harvesting device to interact with the change of peripheral drum speed significantly affected the value of rye grain losses in combines ZMAJ 143 harvesting device.

The research results of this work are similar to the results of (TADIC, 1994.; MALINOVIC ET AL., 2005; STRAKSHAS, 2006.; LASHGAR ET AL., 2008.; HASANI ET AL., 2011.).

Different values of the measured loss of the header and combines ZMAJ 143 harvesting device for the same parameters defined in another experimental field in the first, explain the different grain moisture content.

Correction changes the relevant parameters that we have made in relation to the control (setup by the owner of harvesters) have enabled significant reduction in the amount of rye grain losses on the header and both investigated combines harvesting devices.

The quality of harvested mass taken from the examined harvesters' bunkers for both years is shown in Table 6.

Based on the results of the investigated combines harvested mass quality research for similar defined parameters, we can see that the combine ZMAJ 135 B separation devices doing better compared to the harvester ZMAJ 143. The highest average content of whole grain weight was recorded in harvested mass of ZMAJ 135B combines with working speed regime of 0.92 m s^{-1} - 97.32% (15^{00}) and the smallest in harvested mass of combine ZMAJ 143 - 94.59% (9^{00}), combines the operating speed of 0.57 m s^{-1}. When the damaged grain in question, we note that the working elements of combine ZMAJ 135B made less damage to rye grain as a minimum content of damaged grains was noted in harvested mass of combine harvesters and amounted to 0.27% (15^{00}), which can not be said for working elements of combine ZMAJ 143 because the weight of the harvested mass recorded the most damaged grain and 0.91% (9^{00}).

Table 6

Quality of threshed grain from hopper of exemined combine harvesters

Combines	Working speed of combines ($m\ s^{-1}$) and time sampling	Treshed grain structure (average values for both experiments) (%)					Total
		Whole Grain	Damaged	Broken	Plain	Mechanical admixtures	
~~ZMAJ 135B~~	0.45 (9^{00})	96.31	0.42	1.61	0.86	0.80	100
	0.76 (12^{00})	96.62	0.44	1.28	0.84	0.82	100
	0.92 (15^{00})	97.34	0.27	0.91	0.87	0.63	100
ZMAJ 143	0.57 (9^{00})	94.59	0.91	1.97	1.00	1.53	100
	083 (12^{00})	94.90	0.79	1.92	1.10	1.29	100
	1.10 (15^{00})	95.10	0.60	1.76	1.21	1.33	100

The highest content of broken grains were measured in the harvested rye mass from the ZMAJ 143 harvester bunker in 9^{00} and stood at 1.97%, while the working elements of combine ZMAJ 135B significantly lower breaking rye grain with similar defined parameters, so that the weight of the harvested mass recorded and minimum content of broken grains in the amount of 0.91% in 15^{00}. Poor grain content during the tests varied in the range of 0.84 - 0.87% as it was in the combine ZMAJ 135B harvested mass, or from 1.00 to 1.21% in combine ZMAJ 143 harvested mass. When the presence of mechanical impurities in the rye harvested mass issue, we note that a minimum of mechanical elements, was in rye harvested mass from the ZMAJ 135B harvester bunker and to 0.63% during 15^{00}, which can not be said for the harvester ZMAJ 143 because the weight of harvested rye from the bunker of the harvester registered the highest mechanical impurities in an amount of 1.53% in 9^{00} (Table 6).

The average values obtained during the investigation and exploitation of combines in rye harvest are shown in Table 7.

Table 7

Average values of exploitational parameters for working of combine

Parameters		Combine harvester	
		ZMAJ 135B	ZMAJ 143
Engagement width		3.05	4.20
Average working speed	($m\ s^{-1}$)	0.96	0.96
Used time quotient	(-)	0,73	0,75
Colected proceeds	($t\ ha^{-1}$)	2.14	2.19
Acreage output	($ha\ h^{-1}$)	0.76	1.06
Mass output	($t\ h^{-1}$)	1.63	2.32
Mechanical work warrant	($kWh\ ha^{-1}$)	67.76	68.96
Mechanical work warrant	($kWh\ t^{-1}$)	31.66	31.49

Looking at the results of average values have been shown by investigated combine, we can conclude that we obtained expected values during the exploitation of the examined harvesters. Comparing the average data from the west European countries and America, we can see that tested parameters ($h\ ha^{-1}$, $t\ h^{-1}$), in terms of performance are significantly smaller. The reason for this lies mainly to the varietal and locational characteristics. Coefficient of utilization of time to combine both slightly lower than expected. The specified value is explained by the dense mass of rye grain, which has often led to combine congestion. Because of significant differences in performance as a result of different operating speeds of combines, harvesters ZMAJ 143 showed a higher consumption of machine work and higher productivity in relation to the harvester ZMAJ 135B (67.76: 68.96).

CONCLUSIONS

Based on the results of the combines ZMAJ 135B and ZMAJ 143 effects in the rye harvest, we can conclude the following:

- The parameters of the examined harvesters are significantly affected by losses on the header, harvesting device and the quality of harvested mass;
- The largest losses of rye grain on header have been recorded in combine ZMAJ 143 on the first experimental field of 25.77 kg ha^{-1} (1.18%) and the lowest in combine ZMAJ 135B, also in the second experiment, amounting to 14.76 kg ha^{-1} (0.66%);
- The biggest losses on rye grain threshing device in the amount of 24.61 kg ha^{-1} (1.10%) were measured in combine ZMAJ 143 on the second experimental field, and the lowest in combine ZMAJ 135B also on the second trial and the amount of 10.00 kg ha^{-1} (0.45%);
- The highest content of whole rye grain in harvested mass was in combine ZMAJ 135B and amounted to 97.34% in 15^{00}, and the lowest in combine ZMAJ 143 and amounted to 94.59% in 9^{00};
- Combine ZMAJ 135B made less damage to grain during rye threshing, and has recorded the least broken grains in the amount of 0.91% in 15^{00}, while the highest content of broken grains recorded in rye harvested mass from the combines bunker of ZMAJ 143 in 9^{00} and amounted to 1.97%;
- Impact of the investigated combines defined parameter regime on the values of measured rye grain losses and quality of harvested mass was assessed as very significant;
- Comparing the average data from Western Europe and America, we can see that the conditions of Kosovo and Metohija efficiency parameters (h ha^{-1}, t h^{-1}), are significantly smaller and the reason is the variety and location specificities;
- The correction of the relevant parameters changes that we have made in relation to the control (setup by the owner of harvesters) have enabled significant reduction in the amount of rye grain losses on the header and harvesting device of both investigated combines;
- Combine ZMAJ 135B (in operation for 4 years), worked better than the harvester ZMAJ 143 (the exploitation of about two decades) so, with proper optimization of labor, and operator education can fulfill exectations and be used successfully in the single-phase rye harvesting in the studied area.

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