TESTING RESULTS OF MOWER WITH DIFFERENT CUTTING DEVICES IN ALFALFA MOWING

S. BARAĆ, A. VUKOVIĆ, Bojana MILENKOVIĆ, M. BIBERDŽIĆ

University of Priština, Faculty of Agriculture, Lešak , Kopaonička bb, 38232 Lešak, Serbia
Bačka, 33/19, 11080 Zemun,
E-mail adress: sbarac@eunet.rs

Abstract: *Alfalfa is an important legume culture, which plays an important role in ruminant nutrition, as well as quality fodder. Intensive production of alfalfa involves the use of appropriate mechanization, i.e. the mower, keeping in mind that the cutting is the first operation in the preparation technology of forage. Mowing must be done in an optimal agrotechnical term, because it reduces the negative impact of external factors and can be done a variety of mowers. The quality of mower is reflected in terms of height stem cutting cutter bar, the amount of losses caused by cutting and grinding, the total losses, efficiency of work procedures in relation to the structural surface and the resulting effect. Quality of work depends on several factors: state of crops, defining of relevant operation parameters, technical accuracy and staff skills. When the relevant parameters are not well coordinated, quality can significantly decrease, resulting in increased losses and poor quality work. The aim of our study was to determine the technical and technological indicators, quality of work achieved and the effects of four types of mowers in the defined modes. Classical oscillatory mower with fingers, standard design oscillatory two rod mower, drum rotary mower and five discs rotary mower were studied. The test method is derived from test objectives. Tests were done in two phases. In the first phase, there were determined work conditions: biological yield, crop characteristics, the average height of alfalfa, the presence of weeds, the condition of the terrain, climatic conditions, while the second phase determined the effects of work depending on the conditions. It was determined a cutting height, the losses during mowing, operating speed, realised effects. Based on the results of the effects of mower different with cutter bar in mowing alfalfa, it was concluded that the changes defined parameters demonstrated a statistically significant impact on the effects of work in all the mower. The lowest cutting height was recorded at the two rod mowers and was 4.52 cm (6.17 km h^{-1}) and the highest was at the five discs rotary mower with 8.15 (11.35 km h^{-1}). The smallest losses due to the cut height were in conventional mowers and the highest losses were in mowing with the five discs rotary mower and were 2.99% of yield. Total losses were varied in the range of 1.05 to 3.56% of the biological yield.*

Key words**:** *mower,losses, cut height, achieved performance.*

INTRODUCTION

Alfalfa is an important legume culture, which takes an important place in the nutrition of ruminants, as well as quality fodder. It is commonly used to store hay (90% of cases), for silage, for industrial processing and manufacturing of various dehydrated products, less for grazing (DJUKIC, 2005.). It is rich in protein, and crude protein in the leaf represented by 27% and in flower with 32%. Alfalfa can be prepared for the feeding of ruminants in different ways, but in the study area is dominated by the preparation that involves cutting of alfalfa, natural drying, manually or mechanically tumbling and collecting, loading the classical or selfloaded-unloading trailers, transport and storage in various buildings. Intensive production of alfalfa involves the use of appropriate mechanization, or the mower, keeping in mind that the mowing is the first cutting operation in the preparation technology of forage. Mowing must be done in an optimal agrotechnical term, because it reduces the negative impact of external factors, and can be done a variety of mowers. In the ecological conditions of Šumadija county, the most

common are rotary mowers and classical oscillatory fingers mowers. The surfaces of lucerne in the Republic of Serbia vary, with a slight decrease in recent years (in 2008. of lucerne was 192 000 ha and in 2010. total of 187 000 ha). In 2010 it has been mown 187 079 ha in Serbia and produced 1.10484 million tons, while the realized yield of 5.8 t ha^{-1} (Statistical Yearbook of Serbia 2011.). Alfalfa cutting issues and the effects of different mower were done by several researchers. According to WENNER et al. (1987.), speed significantly affects the quality of work and losses, and the recommended operating speed of the oscillatory mower of 5-8 km h^{-1}. The losses are realized when mowing reflected primarily in unnecessarily high stubble and high cut off the stems (with alfalfa than 6 cm). On the other hand, the mower in its work more or less performed by chopping the stems due to a number of crossings of the cutting device at the same surface state POTKONJAK et al. (1990.). Finely powdered mass when handling the hay remains in the soil and is also the mass loss. If we bear in mind that the greatest amount of finely powdered mass make parts list containing the greatest amount of nutrients, that special attention must be paid to this type of loss, the same authors point out. When saving alfalfa hay which is trying to use more biological yield of green mass, among other things, to reduce losses. To avoid damaging the cluster, the alfalfa is considered that the optimum cutting height of 6-8 cm, and that should not be below 6 cm ZORANOVIĆ (1995). Recommended operating speed when mowing with conventional mower of 5-8 km h^{-1}, with two blade mower 8-12 km h^{-1}, a rotary mower with a 8-15 km h^{-1}. When examining the oscillatory mowing devices (ZORANOVIĆ et al., 1996.), state that the total losses varied in the range of 0.90-2.29% of the yield and average yield of 1.59%. Stem cutting height ranged from 5.35 to 7.54 cm at rehearsals, approximately 6.42 cm. The same authors state that the working width investigated oscillatory mower decreases with increasing operating speed, while the stem cutting height increases. The optimal moment for cutting of alfalfa was at the time of budding (bud appearance). The wilting coefficient in the first 24 h was increased by more than 100% for the SEVERE treatment compared with alfalfa mowed using a conventional roller-conditioner in alfalfa that was not exposed to precipitation (SUWARNO et al., 1999.) At this stage of development of alfalfa, we get the highest yield and best quality, because the highest protein content of 19% and the lowest crude fiber content of 25.1%, (LUKIC, 2000.). As recommended by WIERSMA et al. (2001.), alfalfa should be cut to a height of 2 inches (5.08 cm) in order to achieve maximum yield and good quality mass. Some authors, in addition to the quality of work as GOTTFRIED (2007, 2008.) and HUBERT (2008.) give emphasis constructive solution mower from the standpoint of simplicity, ease of maintenance, functionality, reliability and productivity. These are very important parameters, but these authors in their works, not to explore and work quality. POTKONJAK et al. (2009.), according to best realize the amount of cutting conventional mowers, as better maintain the set cut-off level, due to the small width compared to other types of mowers. In addition to cutting the amount realized losses when working mower is a key parameter for assessing the quality of work. According to the same authors classical mower has achieved the lowest total mass loss (average 1.27% yield of green matter), then a mower with two knives (average 1.51%). Rotary mowers have achieved higher total losses, with the mower with 6 discs had an average loss of 3.16%, and 14 discs with 2.75%. VUKOVIC (2009.), says that the increase of speed reducing mower devices working width, with an increase in total losses. With the increasing speed of growth of losses due to high taxes, a decrease losses due to attrition. Total losses to the classical oscillator cutter amounted to 1.18% of the yield of alfalfa, the self-propelled mowers losses amounted to 1.52%, a rotary mower at 2.99%, says the same author. The mower type express a significant influence on the drying rate cut weight. Thus, the oscillatory mowers with conventional cutter bar alfalfa drying process lasted 47 hours, with a rotary drum mowers with 55 hours, which significantly affects the reduction of losses (VUKOVIC et al., 2010.). The losses that occur are

reflected as losses due to unnecessarily high cutting height (over 6 cm in alfalfa), and as the losses due to fragmentation of the mass cut as finely powdered mass when handling the hay remains in the grounds. KOPRIVICA et al. (2011.), point out that in the preparation of alfalfa hay in the field as the main problem is the lack of uniformity in the drying of plant mass. Namely because of uneven drying rate of alfalfa, the leaves dry much faster than the stems, causing further manipulation of the machine is operating to its decline, with significant loss of mass quality alfalfa. Oscillatory conventional mower with cutter bar achieve an average production efficiency of only 0.72 ha h^{-1}, while the rotary mower realized average performance of 1.00 ha h^{-1}. Efficiency of work time was the same for the both mowers and was 0.84 (VUKOVIC et al. 2011.).

MATERIAL AND METHODS

The tests were made to four types of mower when mowing alfalfa in exploitation conditions under the environmental conditions of central Serbia (Šumadija county, around Kragujevac, $44^0$00'51''N, $20^0$54'42''E) during June 2011. Classical oscillatory fingers mower, standard design oscillatory two rod mower, drum rotary mower and 5 discs rotary mower were studied. The effects of work depending on the parameters. The test method is derived from test objective. Tests were done in two phases. The first phase was determined by the conditions of work: biological yield, crop characteristics, the average height of alfalfa, the presence of weeds, the condition of the terrain, climate conditions. The yield was determined with 1 m^2 in three replicates per plot diagonal, and then converted to an area of 1 ha. On this basis it was calculated that the average yield of alfalfa hay was 3.5, and 3.8 t ha^{-1} (dry-cropping), which is explained by something unfavorable climatic conditions. The surfaces on which they performed tests were slightly inclined. In the second phase were determined the effects of work depending on the parameters. There were a cutting height, the losses during mowing, operating speed, the recorded effects. Height of cut is determined by the rectangular surface of 1 m^2 with a width equal to grasp mowers in three repetitions, by measuring the amount of residue after cutting the stems (stubble) and determining the mean values from all replicates. Losses incurred in mowing were determined by measuring the surface area of 1m^2 with rectangle frame width tested mowers working width. Total losses are presented as the sum of the losses incurred due to the height of cut and losses arising from the fragmentation of plant mass. Determination of total losses was also performed in three replicates. Speed work is chronometric determined by measuring the paths of length 30 m, and the basic time on the total length of 100 m plots during the headland turning. In addition, measured the actual working width mower and compared with constructive intervention, and on the basis of this relationship is calculated efficiency of work procedures. Lawn mowers are operated in powered by tractors power 29.5 kW.

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

RESULTS AND DISCUSSION

Table number 1 shows the basic data about the state of the tested mowers and alfalfa crops in the plots on which tests are performed.

The data presented in Table 1 indicate that all mowers worked in similar production conditions.

The average yield of alfalfa varied in the range of 3.5 - 4.2 t ha^{-1}, while the average height of the alfalfa plant height was within the range of 48.6-57.8 cm. In all tested mowers were recorded so the presence of weeds.

Table 2 shows the number of high value cuts appliances tested mowers, depending on

the parameters.

Table 1

The characteristics of mowing machines and conditions of research

Parameters	Type of mowing machine			
	Classical	Classical with two rods	Rotary with drums	Rotary with discs
Cutting width (m)	1.6	1.8	1.35	2.0
RPM shaft rotations (min^{-1})	540	540	540	540
Oscilation number (min)	800-1000	800-1000	/	/
Working efficiency (ha h^{-1})	1.25	2.0	1.0	2.5
Working speed (km h^{-1})	4-8	4-8	8-10	to16
Cuting height (cm)	3-9	3-9	4-10	4-10
Power requirement (kW)	18 and upward			25
Transport speed (km h^{-1})	20	20	20	20
Weight (kg)	170	185	325	405
Number of drums/discs	/	/	2	5
Drum rotation (min^{-1})	/	/	2250	3000
Number of blade on the drum	/		3	2
Hight of stem (cm)	52.3	57.8	48.6	54.2
Yield of alfalfa (t ha^{-1})	3.5	3.7	3.8	4.2
Working speed (km h^{-1})	3.74;5.34;8.25	6.17;7.95;9.10	8.40;9.83;10.84	8.97;10.20;11.35

Based on the obtained results shown in Table 2, it is evident that the changes defined parameters exhibited a significant influence on the height of cut in all the mowers.

Table 2

Height of stem cutting

Type of mowing machine	Parameters		Repetition			Average
			n_1	n_2	n_3	
Classical mower	Cuting height	(cm)	5.47	6.20	7.33	6.33
	Working speed	(km h^{-1})	3.74	5.34	8.25	5.78
Classical with two rods	Cuting height	(cm)	4.52	5.19	5.92	5.21
	Working speed	(km h^{-1})	6.17	7.95	9.10	7.74
Rotary drum mower	Cuting height	(cm)	5.18	5.94	6.72	5.95
	Working speed	(km h^{-1})	8.40	9.83	10.84	9.69
5 discs rotary mower	Cuting height	(cm)	6.56	7.32	8.15	7.34
	Working speed	(km h^{-1})	8.97	10.20	11.35	10.17
Statistical analisys	Parameters		LSD 5%		LSD 1%	
	Cuting height		0.623		1.038	
	Working speed		2.189		3.164	

Based on disclosed information can be seen that the lowest cutting height observed in the two rod mowers and was 4.52 cm, the operating speed of 6.17 km h^{-1}, while the highest cutting height was measured with a 5 disks rotary mower with and it was 8.15 cm, the operating speed of 11.35 km h^{-1}.

Cutting height ranged from 5.47 to 7.33 cm for mower with conventional cutter bar (operating speed of 3.74 and 8.25 km h^{-1}). Cutting height was analyzed with a rotary mower with the drums and was within the limits of 5.18 cm (8.40 km h^{-1}), to 6.72 cm (10.84 km h^{-1}).

For all investigated mowers was noticed that increasing speed results the increasing height of cut, and a classic mowers achieved favorable characteristic height of cut as to better maintain the preset cutting height, but the operating speed limited due to construction of cutting device. Cutting height of 6 cm below the cluster can damage alfalfa, and must adjust speed with the height of cut.

The results fit the results of other studies (WENNER et al., 1987.; ZORANOVIĆ et al., 1996., WIERSMA et al., 2001., POTKONJAK et al., 2009.).

By testing the degree of actual significance of differences was determined that change of the preset parameters, or change of pace mower tractor in aggregate had a significant influence on plant height at cutting alfalfa mowing.

One of the most important parameters for assessing the quality of the mower, in addition to cutting height is the height of the actual losses.

Table 3 shows the measured values of losses made by work of cutting devices of tested mowers.

Table 3

Losses during mowers operation

Type of mowing machine	Type of losses[1]	Samples losses (%)			
		Repetition			
		n_1	n_2	n_3	Average
Classical mower	Gvr	0.56	0.78	1.30	0.88
	Gus	0.49	0.42	0.38	0.43
	Gu	**1.05**	**1.20**	**1.68**	**1.31**
Classical with two rods	Gvr	0.84	0.89	1.20	0.98
	Gus	0.33	0.29	0.26	0.29
	Gu	**1.17**	**1.18**	**1.46**	**1.27**
Rotary drum mower	Gvr	0.98	1.51	1.57	1.35
	Gus	2.13	1.67	1.92	1.91
	Gu	**3.11**	**3.18**	**3.49**	**3.26**
5 discs rotary mower	Gvr	1.54	1.75	2.99	2.09
	Gus	0.96	0.78	0.57	0.77
	Gu	**2.50**	**2.53**	**3.56**	**2.86**
Statistical analysis	Parameters	LSD 5%		LSD 1%	
	Losses due to cutting hight	**0.130**		**0.296**	
	Losses due to chopping	**0.189**		**0.268**	
	Total losses	**0.136**		**0.257**	

[1]Gvr- *Losses due to cutting hight*; Gus- -*Losses due to chopping;* Gu- -*Total losses.*

Based on the results shown in Table 3, it is evident that the losses due to the cutting height of mowers with conventional cutter bar observed by repetitions varied in the range of 0.56 to 1.30% (measured lowest values), and losses due to fragmentation in the range of 0.38 to 0.49 %. Total losses are the sum of the losses incurred due to the height of cut due to attrition and amounted to an average of 1.31%, and varied in the range of 1.05-1.68% of yield.

Two rod mower made slightly larger losses incurred due to the height of cut on the classic mower, and they varied in the range of 0.84-1.20%. Losses due to attrition were moving in the range from 0.26 to 0.33% of yield. Total losses amounted to approximately 1.27%, and varied in the range of 1.17 to 1.46% of yield.

Height realized losses in alfalfa mowing was also analyzed when working with a drum rotary mower. Losses caused by the cutting height of mowers were in the range of 0.98-1.57%, while the losses incurred as a result of fragmentation of the mass were in range of 1.92-2.13%. Average total losses amounted to 3.26%, and varied in the range of 3.11 to 3.49% of yield.

In alfalfa mowing with a rotary mower with 5 disks were measured up to the value of losses incurred due to the height of cut and 1.94-2.99%, while the losses incurred as a result of chopping amounted to 0.57-0.96 %. Total losses were within the range of 2.50 to 3.56% of yield (Table 3).

Based on these results, there is a tendency in all the mower with a change to the defined parameters of growth losses due to high cuts, a decrease losses due to fragmentation of the mass.

Testing the level of significance set difference was found to change the defined operating parameters, in the entire mower significantly affect the measured values of losses

(both losses as a result of cutting height, and weight loss due to fragmentation) and total losses.

The results we obtained in our study were in accordance with the results presented by other authors (WENNER et al., 1987., POTKONJAK et al., 1990., POTKONJAK et al., 2009.; VUKOVIC, 2009.;).

Table 4 shows the effects achieved on tested mower depending on the parameters.

Table 4

Realized mowers efficiency

Type of mowing machine	**Parameters*	Repetition		
		n_1	n_2	n_3
Classical mower	Vr (km h^{-1})	3.74	5.34	8.25
	Br (m)	1.53	1.44	1.40
	τ	0.86		
	Wpr (ha h^{-1})	0.49	0.67	0.99
	β	0.95	0.90	0.87
Classical with two rods	Vr (km h^{-1})	6.17	7.95	9.10
	Br (m)	1.62	1.56	1.53
	τ	0.86		
	Wpr (ha h^{-1})	0.86	1.07	1.19
	β	0.90	0.87	0.85
Rotary drum mower	Vr (km h^{-1})	8.40	9.83	10.84
	Br (m)	1.27	1.24	1.22
	τ	0.86		
	Wpr (ha h^{-1})	0.92	1.05	1.14
	β	0.94	0.91	0.90
5 discs rotary mower	Vr (km h^{-1})	8.97	10.20	11.35
	Br (m)	1.84	1.80	1.78
	τ	0.87		
	Wpr (ha h^{-1})	1.44	1.59	1.76
	β	0.92	0.90	0.89

*Vr -*Working speed*; Br -*Working width*; τ -*Working time efficiency coefficient*; Wpr –*Productivity*; β- *Efficiency of work width*

The results presented in Table 4 show that in all tested mowers the increase of operating speed resulted with a reduction in the working procedures in relation to constructive. Thus, in conventional mowers working width was in the range from 1.40 to 1.53 m (constructive 1.6 m), where the efficiency of work procedures was between 0.87-0.95.

The two rod mowers also measured a lower value of work achieved in relation to working width constructive which is 1.8 m. Working width varied in the range of 1.53-1.62 m, the efficiency of work procedures of 0.85-0.90.

Constructive rotary mowers working width is 1.35m with drums, and the work was accomplished working width from 1.22 to 1.27 m, which is the utilization coefficient of 0.90-0.94.

In alfalfa mowing with a rotary mower with 5 disks generated operating procedure was in the range of 1.78-1.84m (actual working width 2 m), where the efficiency of work width varied in the range of 0.89-0.92.

In all tested mowers, there is a tendency to reduce the coefficient of utilization of working width with increasing speed of the mower.

Surface performance of tested mower was in the range of 0.49 ha h^{-1} in the classical regime mowers operating speed of 3.74 km h^{-1}, to 1.76 ha h^{-1}, a rotary mower with 5 disks (operating speed of 11.35 km h^{-1}).

CONCLUSION

Based on the results of the effects of different mower with cutter bar when mowing alfalfa, we can conclude the following:

- Changes to the defined parameters demonstrated the significant influence on the height of cut in the entire mower.
- The lowest cutting height was recorded at the two rod mowers and was 4.52 cm (6.17 km h^{-1}), a maximum height of the rotary mower with 5 disks and amount is 8.15 cm (11.35 km h^{-1}).
- For all investigated mowers noticed that with increasing speed also increased height of cut, and classic mowers achieved favorable characteristic height of cut as to better maintain the preset cutting height, but the operating speed limited due to construction of cutting device.
- The smallest losses due to the height of cut were in conventional mowers and varied in the range from 0.56 to 130% (losses due to fragmentation in the range of 0.38 to 0.49%) and highest in the alfalfa mowing with a 5 discs rotary mower was 1.94-2.99% (losses incurred as a result of fragmentation of mass amounted to 0.57-0.96% of returns).
- Total losses were varied in the range of 1.05% (conventional mower) and 3.56% of the biological yield (5 disks rotary mowers).
- In all tested mowers with the increase of operating speed results to a reduction in the working procedures in relation to constructive. The lowest coefficient of utilization of the working procedures in relation to constructive is measured for two rods mowers and was 0.85, and most for classical mower 0.95.
- Surface performance tested mower was in the range of 0.49 ha h^{-1} (conventional mower, 3.74 km h^{-1}), to 1.76 ha h^{-1}, a 5 disks rotary mower with (11.35 km h^{-1}).
- The general conclusion of our study is that test results show significant differences in the tested mower in the quality of work (cutting height, realized losses) and the resulting effect of the surface, where the test mowers can be used for cutting of alfalfa, with a good education and proper operator adjustment and alignment defined parameters can come to the fore in the study area.

ACKNOWLEDGEMENT

The investigation published in this paper is a part of the project "Improvement of biotechnological processes in the function of the rational use of energy, increase productivity and quality of agricultural products" financed by the Ministry of Education and Science of the Republic of Serbia, grant No TR-31051.

BIBLIOGRAFY

1. ĐUKIĆ D. (2005): Stanje i perspective lucerke u Evropi i u našoj zemlji. Zbornik radova. Naučni institut za ratarstvo i povrtarstvo. Novi Sad. No. 41, pp. 155-169.
2. GOTTFRIED E. (2007): Mit Power oder nur Easy. Profi, *Magazin für professionalle Agrartechnik*, 1:16-21.
3. GOTTFRIED E. (2008): Zum Fürchten. Profi, Magazin für professionalle Agrartechnik, 1:30-33.
4. HUBERT W. (2008): Leicht geschnitten. Profi, Magazin für professionalle Agrartechnik, 1: 26-28.
5. KOPRIVICA R., VELJKOVIĆ BILJANA, STANIMIROVIĆ N., RADIVOJEVIĆ D. (2011): Organizaciono tehnološka rešenja u pripremanju kvalitetnog sena lucerke samohodnim kosačicama gnječilicama. Međunarodni naučni simpozijum agronoma "Agrosym Jahorina 2011". Poljoprivredni fakultet, Istočno Sarajevo. Zbornik radova, pp. 603 – 610.
6. LUKIĆ D. (2000): Lucerka. Monografija. Naučni institut za ratarstvo i povrtarstvo, 450. Novi Sad.
7. POTKONJAK V., ZORANOVIĆ M. (1990): Kvalitet rada i snaga za pogon rotacionih kosačica sa 4, 5 i 6 diskova. In proc. Zbornik radova XVII naučnog skupa "Poljoprivredna tehnika".

Opatija. pp 73-78.
8. POTKONJAK V, ZORANOVIĆ, M, ANĐELKOVIĆ S.(2009): Eksploatacione karakteristike različitih tipova kosačica pri košenju lucerke. Savremena poljoprivredna tehnika. Novi Sad. Vol.35. No1-2, pp. 73-78.
9. STATISTICAL YEARBOOK OF SERBIA (2011.): Satistical office of the republic of Serbia.Belgrade.
10. SUWARNO, K. M. WITTENBERG AND W. P. MCCAUGHEY (1999): Comparative characteristics during wilting for alfalfa conditioned by maceration or by a conventional roller-conditioner. Canadian Journal of Animal science.pp. 509-517.
11. VUKOVIĆ, A. (2009): Eksploatacione karatkteristike samohodne kosačice-gnječilice u poređenju sa traktorskom klasičnom i rotacionom kosačicom.Magistarska teza. Poljoprivredni fakultet Priština, Zubin Potok. pp.48.
12. VUKOVIĆ, A., STANIMIROVIĆ, N., BARAĆ, S. (2010): The influence of different type of mowers on alfa/alfa drying speed. Biotechnology in Animal Husbandry Vol. 26, (spec.issuce), Belgrade. pp. 561-566.
13. VUKOVIĆ, A., BARAĆ, S., MILENKOVIĆ BOJANA (2011): Production effectiveness and fuel consumption of various mower types during alfalfa mowing process. Research Journal of Agricultural Science,Vol. 43(1), pp.345 - 349.
14. WENNER, H.L., KOL, I. (1987): Landtechnik Bauwesen, Teil B,Verfahrestechniken. BLV Verlagsgesellschaft, München.Germany.
15. WIERSMA D., WIEDERHOLT R. (2001.): Alfalfa cutting height to maximize forafe yield and quality. Proceedings 2001. University of Wisconsin, USA, http://ww.uwex.edu/ces/forage/wfc/proceedings2001/alfalfa_cutt.
16. ZORANOVIĆ M. (1995): Analiza tehničko-eksploatacionih parametara kosačica. Magistarska teza. Poljoprivredni fakultet, Novi Sad, pp. 132.
17. ZORANOVIĆ M., POTKONJAK V. (1996): Eksploatacione karakteristike kosačica pri košenju lucerke, Savremena poljoprivredna tehnika, Novi Sad. Vol. 22, br 5, pp. 266-272.