PRODUCTION EFFECTIVENESS AND FUEL CONSUMPTION OF VARIOUS MOWER TYPES DURING ALFALFA MOWING PROCESS

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Abstract: *The results of fuel consumption and production effectiveness for three types of alfalfa mowers have been shown: self-propelled mower and hay crusher Fortschritt E 302; oscillatory mower with classic cutting apparatus and rotary mower with two drums BRK 1650. The exploitation parameters for each mower were measured simultaneously (moving speed, fuel consumption). The measurements of fuel consumption for all three types of mowers have been done exclusively for mowing, and they have not included fuel consumption for other operations, such as flipping, halts, etc. The production effectiveness is determined by moving speed, swath width and coefficient of the used production working time. The shorted mowing period of the green mass, the greater production effectiveness. The production effectiveness of the tested mowers has been defined applying the chronometric method, i.e. measuring working time of the tested mowing apparatus at certain moving speeds. The aim of this study is to conduct the comparative analysis of various technical performances of the mowing machines, with regards to the fuel consumption and production effectiveness, and identify optimal parameter values for use of tested mowing machines. The comparative results for tests of all three mowing apparatus have shown significant difference at fuel consumption between the self-propelled mower (4.52 l/h), and other two mowers (2.20 l/h for oscillatory mower and 3.32 l/h for rotary mower). The greatest production effectiveness was made by the self-propelled mower-hay crusher with average 1.78 ha/h, and 0.87 usage of coefficient of the used production working time. Oscillatory mower with classic cutting apparatus made the production effectiveness of only 0.72 ha/h on average, whereas the average production effectiveness for rotary mower with two drums was 1.00 ha/h. Coefficient of the used production working time of these two types of tested mowers was the same – 0.84. F test has shown existence of highly significant differences between the tested mowers. The self-propelled mower-hay crusher has consumed more fuel compared to the oscillatory mower with classic cutting apparatus and rotary mower with two* drums. *In this case, the self-propelled mower-hay crusher has shown greater values compared to other two types of the tested mowers. In comparison to the oscillatory mower, that value was 1.6 times higher. Even the rotary mower with two drums was a bit more superior compared to the oscillatory mower with the classic cutting apparatus.*

Kew words: *fuel consumption, production effectiveness, mowing*

INTRODUCTION

The mowing operation is the first technical operation in scope of forage production technology. It has to be performed within an optimal agro-technical timeframe in order to decrease an external factor negative impact. The shorted mowing period of the green mass, the greater production effectiveness of tested mowers. The shorter mowing and drying period of 28 hours (up to 20% of humidity) of alfalfa mowed by the self-propelled mower-hay crusher, had an impact on decrease of jolt leave loss (VUKOVIĆ et al., 2010). Selection of appropriate mower significantly impacts the forage quality preparation. The greatest number of studies about this field was about partial researches, very rarely comparative ones.

The studies on self-propelled mower-hay crusher (TANEVSKI, 1990), indicated that this type of mower averagely consumed around 4.23 *l/h*, whereas the average specific fuel consumption was 2.44 *l/ha*. The average production effectiveness was 1.78 *ha/h*. The

production effectiveness of rotary mower was within range of 1.20 to 2.10 *ha/h* (ZORANOVIĆ et al., 1996).The studies (KOPRIVICA et al., 1996), indicate that the working effectiveness was from 1.35 to 2.13 *ha/h.*

The aim of this study is to conduct the comparative analysis of various technical performances of the mowing machines, with regards to the fuel consumption and production effectiveness, and identify optimal parameter values for use of tested mowing machines.

MATERIALS AND METHODS

The research was done on the following types of mowing machines with respective type of cutting apparatus: self-propelled mower and hay crusher Fortschritt E 302; oscillatory mower with classic cutting apparatus and rotary mower with two drums BRK 1650. The researches for oscillatory and rotary mowers were done on parcels with average yields of 3.3 *t/ha* (without irrigation), whereas the researches for self-propelled mower and hay crusher were done on parcels with average yields of 3.5 *t/ha* (without irrigation).

The green mass yield was determined based on alfalfa mass measurements taken from a length meter with swath width, calculated per hectare. The exploitation parameters for each mower were measured simultaneously (moving speed, fuel consumption). Mowers' moving speed has been determined by the chronometer method, based on the path driven per time unit. The fuel consumption was measured by the volume method for each probe. The attained parameters were used for determination of average values for each probe. The measurements of fuel consumption for all three types of mowers were done exclusively for mowing, and they did not included fuel consumption for other operations, such as flipping, halts, etc. The production effectiveness was defined applying the chronometric method, i.e. measuring working time of the tested mowers at certain moving speeds.

The attained results were processed by variance analysis method. Significance of differences between treatments was tested by F test, whereas the significance of differences between individual treatments was compared with the lowest significance values (LSD) for probable errors of 0.05 and 0.01.

RESULTS AND DISCUSSION

Fuel consumption (Pg) for the self-propelled mower-hay crusher "Fortschritt" E-302 was within interval of minimal 4.15 up to maximum 4.93 *l/h*, averagely 4.52 *l/h*, (table 1, graph 1). The same mower had the effect (W) of average 2.05 *ha/h*, thus the average specific fuel consumption (Pg/W) for that mower was 2.25 l/ha.

Oscillatory mower with classic cutting apparatus consumed fuel (Pg) of 2.20 *l/h* on average. The minimal fuel consumption was made during the first test and it was 1.86 *l/h*, whereas the maximal consumption was 2.78 *l/h*. The pure effect (W) of that mower was averagely 0.86 *ha/h*, whereas the specific fuel consumption (Pg/W) was averagely 2.62 *l/ha*. The rotary mower with drums consumed fuel (Pg) averagely 3.32 *l/h*, within interval of 2.85 to 3.64 *l/h*. The pure effect (W) was of 1.97 *ha/h* averagely. The average specific fuel consumption (Pg/W) of rotary mower was 2.79 *l/ha*.

F test has indicated existence of highly significant differences between the test mowers. The self-propelled mower-hay crusher had the greatest consumption, and difference between this and other two types of tested mowers was highly significant.

With regards to the pure effect, F test has indicated that the differences for the oscillatory mower were the lowest, i.e. less significant in comparison to the rotary mower, and extremely significantly less in comparison to the self-propelled mower and hay crusher.

There have not been significant differences between self-propelled and rotary mower.

Table 1

Fuel consumption for tested mowers

Type of mower	Parameter	Test				Average
		1	2	3	4	
Self-propelled mower-hay crusher	Pg	4.15	4.37	4.65	4.93	4.52
	W	1.56	1.98	2.23	2.42	2.05
	Psg	2.66	2.20	2.08	2.04	2.25
Oscillatory mower	Pg	1.86	1.95	2.78	-	2.20
	W	0.60	0.81	1.18	-	0.86
	Psg	3.10	2.40	2.36	-	2.62
Rotary mower	Pg	2.85	3.47	3.64	-	3.32
	W	0.98	1.24	1.37	-	1.97
	Psg	2.91	2.80	2.66	-	2.79
Statistic analysis	Parameter	*F* test	*LSD* 0.05		*LSD* 0.01	
	Fuel consumption	13.644**	0.826		1.187	
	Pure effect	4.753*	0.818		1.175	
	Specific fuel consumption	0.318	0.815		1.171	

Pg-fuel consumption *(l/h);* W-pure effect *(ha/h);* Psg-specific fuel consumption (Pg/W), *(l/ha);*

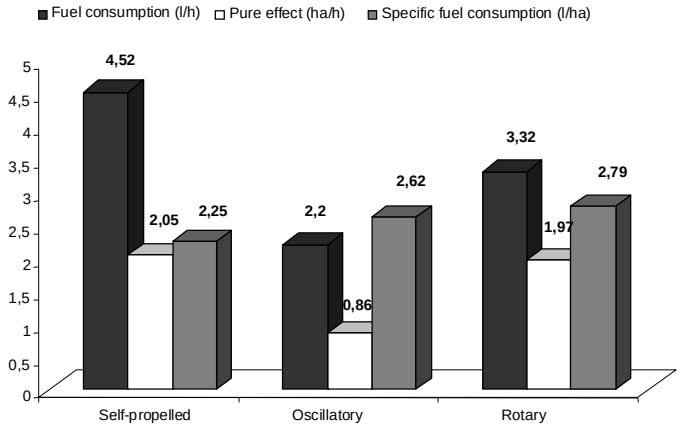

Figure 1: Fuel consumption of the tested mowers

The production effectiveness is determined by three important factors: moving speed (Vt), swath width (Br), as well as the coefficient of the spent production working time (*T*pr). The self-propelled mower-hay crusher had the average production effectiveness (Wpr) of 1.78 *ha/h* (Table 2, figure 2) and the used coefficient of the production working time (*T*pr) of 0,87.

The production effectiveness of the oscillatory mower with classic cutting apparatus and rotary mower with drums was significantly lower in comparison with the self-propelled mower-hay crusher. In case of oscillatory mower it was only 0.72 *ha/h* on average, whereas it was 1.00 *ha/h* in case of the rotary mower. The coefficient of the used production working time for these two types of tested mowers was the same – 0.84. The width of the working

swath had the greatest impact on high production effectiveness of the self-propelled mower – hay crusher.

Table 2

The production effectiveness of the tested mowers

Type of mower	Parameter	Test				Average
		1	2	3	4	
Self-propelled mower-hay crusher	Vt	4.90	6.14	7.00	9.52	6.89
	Br	4.20	4.10	4.03	3.95	4.07
	*T*pr	0.87				
	Wpr	1.36	1.72	1.94	2.11	1.78
Oscillatory mower	Vt	3.82	5.29	8.17	-	5.76
	Br	1.45	1.41	1.36	-	1.41
	*T*pr	0.84				
	Wpr	0.50	0.68	0.99	-	0.72
Rotary mower	Vt	8.32	9.65	10.21	-	9.40
	Br	1.56	1.48	1.45	-	1.50
	*T*pr	0.84				
	Wpr	0.82	1.04	1.15	-	1.00

Statistic analysis	Parameter	*F* test	*LSD* 0.05	*LSD* 0.01
	Moving speed	3.168	2.198	3.158
	swath width	1299.928**	0.096	0.138
	Production effectivness . (ha/h)	15.205**	0.321	0.461

Vt=moving speed *(km/h);* Br=swath speed *(m);* *T*pr=coefficient of the used production working time; Wpr= production effectiveness *(ha/h);*

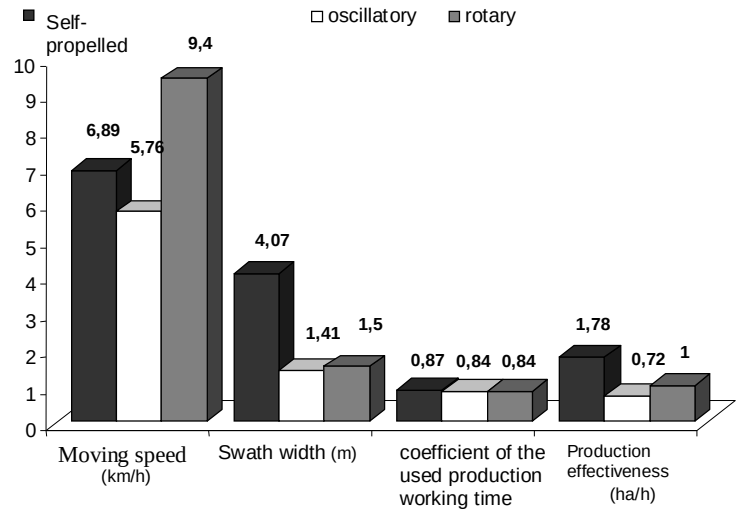

Figure2: Production effectiveness of the tested mowers

F test has shown existence of highly significant differences between the tested mowers. The highest production effectiveness was shown by the self-propelled mower-hay crusher, and it was highly significant, higher than the other two types of the mowers, which

have not shown statistically significant differences.

CONCLUSIONS

The self-propelled mower-hay crusher has consumed more fuel compared to the oscillatory mower with classic cutting apparatus and rotary mower with two drums. This can not be attributed only to the energy spent on mowing working device, but also it was impacted by the total mass (weight) of the tested mower. The comparative results for tests of all three mowing apparatus have shown significant difference at fuel consumption between the self-propelled mower (4.52 l/h), and other two mowers (2.20 l/h for oscillatory mower and 3.32 l/h for rotary mower).

The production effectiveness is one of the most significant parameters for selection of appropriate mowing machine. In this case, the self-propelled mower-hay crusher has shown greater values compared to other two types of the tested mowers. In comparison to the oscillatory mower, that value was 1.6 times higher. Even the rotary mower with two drums was a bit more superior compared to the oscillatory mower with the classic cutting apparatus.

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