Original paper

THE ENERGY VALUE AND ENERGY YIELDS OF ALFALFA FORAGE DEPENDING ON THE CUTTING TIME IN FORAGE-SEED PRODUCTION SYSTEM

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Abstract

Economic importance of alfalfa (*Medicago sativa L.*) is reflected in the production of high-quality forage, however, the seeds of alfalfa are valuable commodity in the domestic and international markets. In Serbia, the seed is produced in forage-seed mode of exploitation where the second or third growth is used for seed production, and the remaining growths are used for fodder. The aim of this work was to determine the influence of cuttings and time of cutting on total energy value of hay in a model of forage and seed production. The second and third cuts were used as seed cut. In the variant where the second cut was used as seed cut, the first cut was harvested at different times (A_1-early, A_2-medium early, A_3-late and A_4- very late). In the model where the third cut was used for seed, two pre-cuts were used for forage production (A_5). In all the following variants, seed cut was followed by one more cutting (final cut), used for the production of fodder. The highest average total production (from pre-cut and final cut) of NE_L (34606 $MJha^{-1}$) and NE_M (33811 $MJha^{-1}$) was realized in the system of cutting with two pre-cuts. In the variant with single pre-cut, the highest yield was formed in the early system. Later cutting of the first cut causes decline of NE_L production and it was the lowest in the system of very late cutting or 15.1 % less than in the early system and 38% lower than in the system of cutting with two pre-cuts. Delaying of utilization of alfalfa to the later stages of exploitation has contributed to the lower yield of NE_M and in the medium early system and late system and especially in the very late cutting system, where by 22.2 % less was realized than in the early production system. Studies have shown that late cutting of first cut resulted in the reduction of nutritional value expressed in the amount of net energy per unit area.

Key words: *alfalfa, cutting, net energy, yield*

Introduction

Alfalfa is the most important forage legume in Serbia. Its importance is reflected primarily in production of fodder, while the seed production is less important to the national economy. The local seed production satisfies the domestic demand for alfalfa seed, and in some years the alfalfa seed is even exported. In the agro-ecological conditions of Serbia, the alfalfa seed is most commonly produced from the second and sometimes the third growth of alfalfa. Time of cutting and number of pre-cuts significantly influence the yield

of alfalfa seed (Vučković et al., 2004; Karagić, 2004; Karagić et al., 2006; Terzić, 2011). Karagić (2004) and Karagić et al. (2006) and Terzić (2011) have established that by late cutting of the first cut in the average yield of seed from the second growth is higher compared to yields of pre-cut carried out at the beginning of May.

Cutting at certain phase of development significantly influences the yield and quality of alfalfa. Cutting of alfalfa in later development phases ensures higher forage yield and sustainability of alfalfa **(**Undersander et al., 2004**).** The best quality and the highest yield of nutrients are achieved in early phases of alfalfa development - budding stage and before blossoming (Mejakić et al., 1997**).**

In the research of Terzić et al. (2013), in the same dual model of production (hay-seed), the highest average production of NE_L and NE_M in pre-cuts was realized in a harvesting system with two pre-cuts (31981 $MJha^{-1}$ and 31163 $MJha^{-1}$). In the variant with a single pre-cut the highest yield from the first growth was formed in the early system (20988 and 20508 $MJha^{-1}$). Later first cutting led to decrease in production of NE_L and NE_M, with the lowest values recorded in the very late cutting system (18199 and 16017 $MJha^{-1}$).

In addition to the production of hay from pre-cuts, in the dual model of production, the last cut is used for production of hay.

The aim of this study was to examine the total production of the NE_L and NE_M of the final cut and total production of NE_L and NE_M in the seed-forage model of production.

Materials and methods

Study was carried out on experimental field of the Institute for Forage Crops in Kruševac in 2005, 2006 and 2007. The size of the basic plot was 10.5 m^2. Treatments were different time of pre-cut of alfalfa seed crop: A_1- early cut (around May 5th), A_2- medium early cut (around May 15th), A_3- late cut (around May 25th), A_4- very late cut (around June 5th), A_5- cut (A5 I- around May 5th and II - around June 5th). Contrary to the harvest procedure in the A_1 to A_4 systems, where the second cut was used for seed production, in the A_5 harvest procedure the third cut was used for seed production. The final cut was done at the end of October. At the moment of cutting the plants were on average in the early system (A_1) in the stage of budding, in the medium early system (A_2), in the stage of the beginning of flowering, in the late (A_3), in the stage of full flowering and in very late system (A_4) in the stage of post-flowering. In a system with two pre-cuts (A_5), at the time of cutting, plants were in the budding stage and in final cut plants were in various stages of intensive growth. Cutting of growth for forage was done manually at height of about 5 cm. All results related to chemical composition are expressed through absolute dry matter. The quantity of nutrients was calculated based on the chemical composition and yield in absolute dry matter. The total energy value Ne_L and NE_M is calculated as the sum of the energy values of pre-cut in the seed cut and energy value of the last cut. Net energy value of crop residues after harvest of seed was not calculated.

Chemical analyses were carried out in the laboratory of the Institute for Forage Crops in Kruševac. The NE_L and NE_M values were calculated ($NE_L=k_1$ x ME, q=ME/UE x 100; $NE_M=k_{mf}$ x ME, q= ME/UE x 100). The calculation used the following digestibility coefficients (Obračević, 1990) CP-80%, SC-53%, DM-46%, NFE-78%. Statistical processing of obtained data was done by variance analysis. Testing of the significance of differences was done by LSD test.

Results and discussion

The paper presents the content of crude protein and crude fiber, energy value of the last cut and total energy value of pre-cut and the final cut in the production model forage-seed production system. Contents of crude protein and crude fibre in the final cut are shown in Table 1.

Table 1. *Contents of crude protein and crude fibre in the final cut (gkg^{-1}DM)*

Cutting term	Year						Average conteint	
	2005		2006		2007			
	Crude proteins	Crude fibre	Crude proteins	Crude fibre	Crude proteins	Crude fibre	Crude proteins	Crude fibre
A_1	203.0	256.7	210.5	276.8	195.1	249.9	202.9	261.1
A_2	214.4	229.9	216.1	285.7	200.3	226.9	210.3	247.5
A_3	219.4	229.4	227.3	252.6	205.5	232.0	217.4	238.0
A_4	222.8	242.9	228.9	234.6	215.7	224.4	222.5	234.0
A_5	221.9	239.5	230.1	232.4	216.4	224.8	222.8	232.2

The content of crude protein in the final cut increases going from A_1 to A_5 system of cutting, while the average content of crude fiber decreases. The results of the final cut in the present study show contradiction in relation to changes in the content of crude protein and crude fiber in the first cut in studies by Mejakić et al. (1997), Undersander et al. (2004) and Terzić et al. (2012) who state that crude protein content in the first cut decreases with the delay in cutting. At the moment of cutting, in the final cut, the plants are in the various stages of intensive growth. Plants from the previous system of cutting, due to earlier cutting of pre-cuts and earlier harvesting of seed production had more time to regenerate in the final cuts. More time for regeneration contributed to the plants from earlier cutting periods (A_1 and A_2) to be developed in relation to the plants from late harvesting of the first cut A_3 and A_4 system, which has influenced the treatments with earlier pre-cuts (A_1 and A_2) to have a lower protein content in the final cut relative to the later harvesting periods (A_3 and A_4).

The energy value of alfalfa last-cut depending on the cutting system is shown in Table 2.

In the last cut, the lowest average values of NE_L (5.61 MJkg^{-1}DM) and NE_M (5.63 MJkg^{-1}DM) were realized in the early system (A_1) of cutting of the first growth. Slightly higher energy value was generated in the very late (A_4) cutting system (5.78 MJkg^{-1}DM and 5.83 MJkg^{-1}DM) as well as in system (A_5) with two pre-cuts (5.79 MJkg^{-1}DM and 5.83 MJkg^{-1}DM). Realized energy value in this study is higher than the value recorded for the first growth in research by Terzić et al. (2013) in the forage-seed model of production, where the energy value of NE_L ranged from 5.40 MJkg^{-1}DM in early cutting to 3.88 MJkg^{-1}DM in very late cutting, and of NE_M 5.28 MJkg^{-1}DM for early system of cutting to 3.41 MJkg^{-1}DM in very late cutting system. In the results stated by Terzić et al. (2013) in the first cut, NE_L and NE_M MJkg^{-1}DM values have declined going from early to late cutting system, while in this research, in case of the last cut, values increased going from early to late system of the first cut.

Table 2. *Contents of NE_L and NE_M of final alfalfa cut (MJ kg^{-1} DM)*

Cutting term	Year						Average content	
	2005		2006		2007			
	NE_L	NE_M	NE_L	NE_M	NE_L	NE_M	NE_L	NE_M
A_1	5.65	5.68	5.51	5.50	5.67	5.71	5.61	5.63
A_2	5.79	5.76	5.54	5.53	5.75	5.82	5.69	5.70
A_3	5.74	5.81	5.74	5.77	5.81	5.88	5.76	5.82
A_4	5.77	5.80	5.75	5.82	5.81	5.87	5.78	5.83
A_5	5.81	5.88	5.70	5.74	5.80	5.87	5.79	5.83

Differences in tendencies between the first and the last cut are the result of harvesting at different stages of development of the first cut. Earlier harvest deadlines of first growth have contributed to the slightly earlier seed harvests, which later, in the final cut, caused, that swaths that have been harvested earlier have a greater number of days to regenerate and plants in the earlier first harvest later are more developed (in the last cut), which caused the plants harvested at earlier periods of the first cut to have lower contents of NE_LMJkg^{-1}DM and NE_M MJkg^{-1}DM compared to plants that are harvested at later periods of the first cuts.

Reduction of the energy value of alfalfa in the later stages of exploitation is consistent with the results of Obračević (1990), Dinić (1997) and Đorđević et al. (2003). The values obtained in the present study are slightly lower than the values reported by Macgregor (1994) cit. by Glamočić (2002), where the values of NE_L and NE_M in the stage before flowering were 5.96 and 5.89 MJkg^{-1}DM. The values were higher than the values stated by Dinić (1997) where the average values of NE_L and NE_M in alfalfa silage were 5.25 MJkg^{-1} and 5.34 MJkg^{-1}DM in budding stage. Higher values are consequence of harvesting the alfalfa in the final cut in the stage before the bud stage when the leaf and stem ratio is more favourable.

In Table 3 is given the total net energy in MJha^{-1} calculated from pre-cut and final cut together.

Total NE_L energy ranged from 17798 MJha^{-1} (very late period in 2007) to 37380 MJha^{-1} (in the system with two pre-cuts in 2007). In regard to the total production of NE_L and NE_M in MJha^{-1} (Table 3) it can be seen that the highest yield of NE_L was generated in the system (A_5) with two pre-cuts, NE_L (34 606 MJkg^{-1}) and NE_M (33811MJha^{-1}). In the single pre-cut harvesting system, the highest total net energy in MJha^{-1} in milk production was recorded in the system with early harvesting (A_1) of the first growth 25105 MJha^{-1} and 24 637 MJha^{-1} in the production of meat. Postponing of the first cut reduces the yield decreases and the lowest values are recorded in very late (A_4) harvest period.

In earlier harvest periods, lower net energy MJkg^{-1}DM has been realized in the earlier cutting but with higher production of dry matter, which contributed to more MJha^{-1} formed in the total production of NE_L and NE_M per unit area in earlier harvest periods of first cut. Studies have shown that late harvest results in the reduction of yield of net energy per unit area. Later first cut reduces the production of NELMJ$ha^{-1}$and the lowest value is realized in the system of very late (A_4) harvest or 15.1% less than in the early system (A_1) and 38% less than in the system of harvesting with two pre-cuts (A_5).

Table 3. *Total net energy from pre-cut and final cut (MJ ha $^{-1}$)*

Cutting schedule	Year						Average content	
	2005		2006		2007			
	NE_L	NE_M	NE_L	NE_M	NE_L	NE_M	NE_L	NE_M
A_1	27674	27189	24847	24377	22794	22344	25105	24637
A_2	26324	25126	23952	22914	21139	20180	23805	22740
A_3	25323	23430	22303	20727	20668	19277	22765	21145
A_4	24180	21756	21996	19937	17790	15809	21322	19167
A_5	33617	33007	32821	31944	37380	36482	34606	33811
F- test	**	**	**	**	**	**	Level	
LSD	972	925	2415	2339	1241	1182	5%	
	1414	1347	3514	3403	1805	1719	1%	

Delaying the utilization of alfalfa from the early period to the later stages of exploitation has contributed to the formation of lower total yield of NE_MMJha^{-1}in the medium early and late harvesting systems and especially in the very late harvesting system, where 22.2% less is formed than in the early production system and 43% less than in production with two pre-cuts. The highest net energy value is realized in the system with two pre-cuts.

Analyses showed that between the years the highest production was realized in 2005, which was characterized with a lot of rainfall in the summer and the lowest production in 2007, when less rainfall was recorded in summer.

Overall, the total production of NE_L and NE_M, which is given in this paper and the production of NE_L and NE_M in pre-cuts A_1, A_2, A_3, A_4 and A_5 system is reported by Terzić et al. (2013). It can be observed that in the last harvest, the share of production from the last cut is considerably lower than the production of the first cut. Compared with the production in the first cut, the final cut has participated with 15-17% in the total production, and in the system with two pre-cuts, last swath participated with only 8% in the total production of NE_L and NE_M in MJha^{-1}.

Conclusion

Earlier harvesting of the first growth in forage-seed production influenced forming of slightly lower value of NE_L and NE_M MJkg^{-1} DM in final cut.

Later first cut reduces the yield of NE_LMJha^{-1} and the lowest value is realized in the system of very late harvest (A_4).

Delaying of utilization of alfalfa from the early period (A_1) to the later stages of exploitation has contributed to the formation of lower yield of NE_MMJha^{-1} in the medium early (A_2) and late (A_3) harvesting systems and especially in the very late (A_4) harvesting system.

The highest net energy value MJha^{-1} is realized in the system with two pre-cuts (A_5) and seed production in the third cut.

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