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THE EFFECTS OF CUTTING INTERVALS AND SEEDING RATES ON FORAGE YIELD AND QUALITY OF ALFALFA

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ABSTRACT

Understanding the effects of seeding rate and cutting intervals on dry matter yield and nutritive value may help to optimize of alfalfa production. The objective of this study was to investigate the optimum cutting interval and seeding rate of two cultivars of alfalfa (cv. Alsancak and cv. Nimet). Field experiments were carried out for 3 years in Mediterranean ecological conditions. The treatments were comprised of three cutting programs at 20, 30 and 40 days interval and two seeding rates (15 and 30 kg ha^{-1}). The experiment was designed a split–split plot in a randomized complete block with 3 repetitions. The main plots were cutting intervals, sub-plots were seeding rates and sub –subplots were assigned as alfalfa cultivars. The results of the research showed that all properties inspected were significantly affected from the cutting intervals, the effect of the seeding rate and the cultivars were found to be not significant (except fresh forage yield). While the extended cutting intervals increased the forage yield, it reduced the forage quality. In terms of satisfactory forage yield and quality for similar ecological conditions, 30 days cutting interval and 15 kg ha^{-1} seeding rate have been advisable.

Keywords: Alfalfa, cutting interval, forage yield, quality, seeding rate,

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is one of the most widely used forage crops worldwide for roughage production (Frame et al., 1998). Yield and quality of perennial leguminous forage plants such as alfalfa depends on the cultural practices (sowing time, sowing frequency, harvesting frequency, fertilization, irrigation etc.) and ecological conditions (soil fertility, precipitation, photoperiod, temperature and disease-damaging etc.) (Justes et al., 2002). Knowing the effects of all these factors on alfalfa production and optimizing accordingly is the key to success.

Optimization of the plant density for unit area is a prerequisite for a successful alfalfa production. The results of the research conducted in different regions of the world show that the seeding rates to be used varies from 4 to 40 kg ha^{-1}. Le Gall et al. (1992) stated that about 300-350 plant density in square meter which can be obtained by applying 25 kg seed ha^{-1} in fall and 20 kg seed ha^{-1} in spring cultivation is mandatory for a suitable establishment. On the other hand, Bonciarelli (1987) reported that if the seed bed preparation is well done the seeding rate can be reduced to 15 - 20 kg ha^{-1} but it should be enhanced to 30 - 40 kg seed ha^{-1} in normal conditions. Lloveras et al. (2008) determined that the seeding rate of 10 kg ha^{-1} in alfalfa provides the optimum plant density to provide the sufficient dry matter, and that the different seeding rates used in planting in terms of dry matter yields do not make any significant difference. Therefore, detection of the optimum seeding rate for the own ecological condition is the key of an economic production by reducing the input costs.

As in many other forage plants, the main goal in alfalfa cultivation is to obtain high quality forage with high yield. The yield and quality of herbage are strongly under the influence of growth stage and cutting intervals of the plants which are suitable to several cuttings in a season (Ghandorah et al., 1986; Avice et al., 1997; Kallenbach et al., 2002). Alfalfa can be harvested 8-10 times in a year in Mediterranean climate zone (Avcioglu et al., 2009). While dry matter increase with plant maturity in general, the digestibility and quality of the produced forage are decreased (Ball et al., 2001). Similar results have been reported for alfalfa (Tabacco et al., 2003, Ghandorah et al., 1986). Furthermore, water-soluble carbohydrate reserves of alfalfa also affected from the cutting frequencies that shorten the life span of the alfalfa stands. Constitution of a harvest schedule as a result of determination the optimum cutting interval can also help to plan farm labor, equipment and other maintenance more regularly. As a result, in alfalfa cultivation the higher yield and quality can be obtained only using the proper cultivar and cutting management practices (Tabacco et al., 2003).

The objective of this study is to investigate the effects of seeding rate and cutting interval on forage yield and quality of two alfalfa cultivars under Mediterranean ecological conditions.

MATERIALS AND METHODS

This study was conducted throughout the years 2011 and 2014 in the experimental area of Mustafa Kemal University Agricultural Faculty in Hatay province of Turkey located at 36° 15' N and 36° 30' E. The region has typical Mediterranean climate. Study area had clay soil with pH of 8.22, 23.4 % $CaCO_3$, 6.42 ppm phosphorus, and 1.39 % organic matter at the depth of 30 cm. Figure 1 shows the meteorological data as monthly average temperature and rainfall for the experimental land throughout the growing season. As it is seen in Figure 1, 2011-2012 winter season was extremely rainy whereas the winter season of 2013-2014 and the spring season of 2014 were extremely drought. Almost no precipitation was recorded during the summer times of the study period. The hottest months were in July and August with the average temperature in these months was over 25 °C.

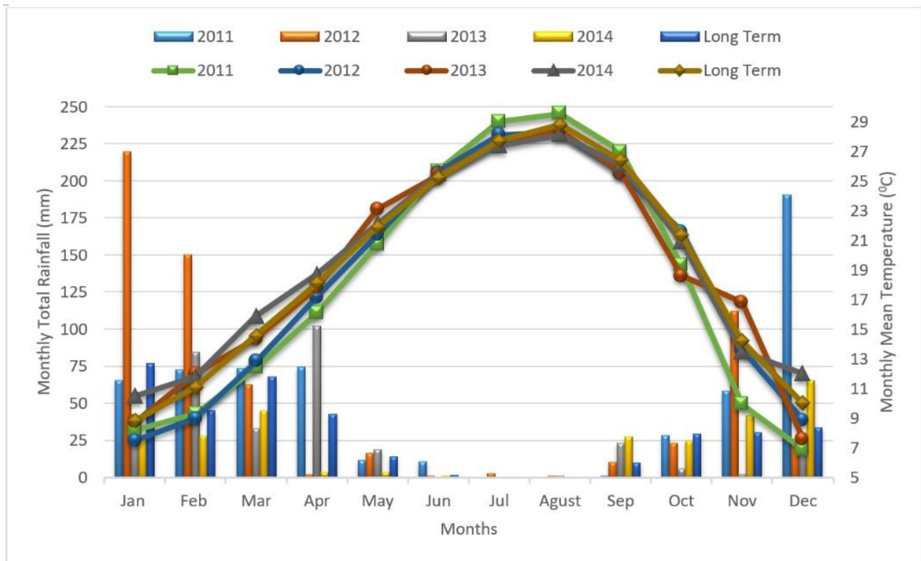

Figure1. Monthly mean air temperature and total rainfall during the study and long term data (means of 20 years)

Two cultivars of alfalfa (cv. Nimet and cv. Alsancak) were cultivated for three years. Nimet (developed and registered by East Mediterranean Agricultural Research Institute) is a cultivar with 90-100 cm length, early growing, erect growth habit, non-dormant (fall dormancy 8) and recommended for Mediterranean and Southeastern Anatolia Regions. The other cultivar Alsancak (developed and registered by Aegean Agricultural Research Institute) is tall, early growing, non-dormant, erect growth habit and also suitable for Mediterranean and Aegean Regions. The experiment was conducted to investigate the productivity and forage quality of alfalfa cultivars at different seeding rates and cutting intervals. The experimental design was a split–split plot in a randomized complete block with 3 replications. The main plots were cutting intervals (20, 30 and 40 days), sub-plots were seeding ratios (15 kg ha^{-1} and 30 kg ha^{-1}) and sub –subplots were assigned as two alfalfa cultivars. Each subplots had 4 rows with 20 cm row spacing and 5 m row length. Before seeding, 50 kg ha^{-1} each of N and P_2O_5 was applied. Sowing was performed manually on 21 November 2011. The plots were irrigated 10 - 14 days interval depending on the climatic conditions and weeds were removed manually.

First cutting of the year was applied at 10% flowering stage for 20 days cutting interval whereas the first cuttings of the other applications (30 and 40 days intervals) were arranged as 10 and 20 days after 10 % flowering. The dates and numbers of the cuttings made in each year are given in Table 1. Cutting and sampling procedures were executed on the remaining 2 rows of 4 m length (0.4 × 4= 1.6 m^2) after the side effect was eliminated. Plants were cut to a stubble height of approximately 5 cm. After measuring fresh forage weights, 500 g green forage sample from each treatment was taken after cutting and then they were dried at 65 °C for dry matter determinations. Dried samples were ground in a mill to pass a 1 mm screen for chemical analysis. Crude protein, NDF and ADF were determined for all samples. Nitrogen concentrations were determined by the Kjeldahl procedure and crude protein concentration was calculated by the formula of N concentration × 6.25. NDF and ADF were analyzed according to the sequential method of Van Soest et al. (1991) by adding α-amylase without sodium sulfite and using the ANKOM filter bag system with A220 fiber analyzer (ANKOM Technology, Fairport, NY).

Data were analyzed by using the software MSTAT-C. The ANOVA was performed by using split-split plot design with the 3 main plot treatments, 2 sub-plot treatments and 2 sub-subplots replicated three times. Treatment mean differences were compared by Duncan Multiple Range Test at P = 0.05 significance level.

Table 1. Cutting dates and number of cuttings per year

	2012			2013			2014		
	Cutting Interval								
	20 days	**30 days**	**40 days**	**20 days**	**30 days**	**40 days**	**20 days**	**30 days**	**40 days**
1th cutting	10 May	20 May	30 May	8 May	18 May	28 May	29 Apr.	9 May	19 May
2nd cutting	30 May	19 June	9 July	28 May	17 June	7 July	19 May	9 June	30 June
3th cutting	19 June	19 July	18 Aug.	17 June	17 July	16 Aug.	9 June	9 July	6 Aug.
4th cutting	9 July	18 Aug.	27 Sept.	7 July	16 Aug.	29 Sept.	30 June	6 Aug.	15 Sept.
5th cutting	29 July	17 Sept.		27 July	15 Sept.		17 July	5 Sept.	
6th cutting	18 Aug.	17 Oct.		20 Aug.	15 Oct.		6 Aug.	8 Oct.	
7th cutting	7 Sept.			9 Sept.			26 Aug.		
8th cutting	27 Sept.			29 Sept			15 Sept.		
9th cutting	17 Oct			15 Oct.			02 Oct.		

RESULTS AND DISCUSSION

Fresh forage yield

The cultivars effect on fresh forage yield in first year was found to be not significant whereas it was important in the other years. However, the effect of cutting intervals on fresh herbage yield was significant during all experiment years while the seeding rate was only significant in third year. No interaction effects on fresh forage yield were significant in the first year. Only the effect of cutting intervals × seeding rates interaction was significant on fresh forage yield in the second year, while all interaction effects were significant in the third year (Table 2). Fresh forage yields were ranged 91375 kg ha^{-1} to 94273 kg ha^{-1} in term of cutting intervals in the first year. These differences were statistically significant. The highest fresh herbage yield was obtained in 20 days cutting interval in the first year but it was statistically similar with 30 days cutting interval in the first year (Table 2). On the other hand the maximum fresh forage yields of 77967 kg ha^{-1} and 49611 kg ha^{-1} were obtained from 40 days cutting intervals during second and third years, respectively and these values were statistically higher than the yield obtained from the other cutting intervals. Fresh forage yields for 30 days cutting intervals were 68772 and 44675 kg ha^{-1} in the second and third year respectively whereas it was 66420 and 30462 kg ha^{-1} for 20 days cutting intervals for the same years (Table 3). According to the average values over three years, the minimum fresh forage yield of 63718 kg ha^{-1} was determined in 20 days cutting interval while the maximum fresh forage yield of 72985 kg ha^{-1} was determined in 40 days cutting intervals. 30 and 40 days cutting intervals caused an increase in fresh forage yield as compared to 20 days cutting interval. Generally, cuttings applied more frequently led to a decrease in fresh forage yield (Ghandorah et al., 1986; Kallenbach et al., 2002; Ventroni et al., 2010; Ahmad et al., 2016).

The effects of seeding rates on fresh forage yields varied among the years. Fresh forage yields obtained from the seeding rates of 15 kg ha^{-1} (94033 kg ha^{-1}) and 30 kg ha^{-1} (91682 kg ha^{-1}) were statistically similar in the first year. Fresh forage yield of 30 kg ha^{-1} seeding rate (73049 kg ha^{-1}) was higher than obtained in 15 kg ha^{-1} seeding rate (69057 kg ha^{-1}) in the second year, but these values were statistically not different. The higher fresh forage yield was obtained from 15 kg ha^{-1} seeding rate in the third year. The results of variance analysis of three years combined shown that the effects of seeding rates were not significant in terms of fresh forage yield. The main reason for this variability can be explained by the differences in dry matter content of plants at harvest. As a matter of fact, the fact that this variability is not observed in hay yields supports this approach. The same variability was seen between the varieties. These results indicated that hay yields are more reliable while the yield is assessed. Therefore, although the data of the third year is statistically significant, the interactions are not discussed here. When the average of three years is considered, fresh forage yield of cv. Nimet was higher than cv. Alsancak. Annual mean fresh forage yields were 92858 kg ha^{-1}, 71053 kg ha^{-1} and 4152 kg ha^{-1} for first, second and third years respectively. Mean fresh forage yields throughout the first year were higher compared to other years. The yield loss for the second and the third years comparing to the first were 23.5% and 55.2% respectively. It is possible that this loss resulted from cutting practices and unsatisfactory rainfall in 2013 and 2014. Other researchers have also been reported that annual forage yields of alfalfa have changed depending on years (Stanisavljević et al., 2012; Kavut et al., 2014; Ahmad et al., 2016; Yilmaz and Albayrak, 2016; He et al., 2018).

Hay yield

Hay yield was significantly influenced by cutting intervals during three years and according to combined analysis results. The effects of seeding rates and cultivars on hay yield were statistically not significant during all experiment years. But according to three years combined analysis the cultivar effect was significant (Table 2). Mean hay yields obtained in the 40 days cutting intervals were higher than others in all experimental years (Table 3). This result was similar to those reported by Kallenbach et al. (2002), who reported that dry hay yield at 42 days cutting interval were higher than hay yield of 28 and 34 days cutting intervals. Ghandorah et al. (1986) reported that, dry matter yield recorded in the 30 and 40 days cutting intervals were similar and dry matter yields of those were higher than dry matter yields obtained in the 20 days cutting interval.

Table 2. Summary of selected *F*-tests for investigated properties in 2012, 2013 and 2014

Source of variation	d.f	Mean Squares					
		Fresh Herbage Yield	**Hay Yield**	**Crude Protein Content**	**NDF Content**	**ADF Content**	**RFV**
				2012			
Replication	2						
Cutting Interval (A)	2	*	**	**	**	**	**
Error	4						
Seeding Rate (B)	1	ns	ns	ns	ns	ns	ns
A×B	2	ns	ns	ns	ns	ns	ns
Error	6						
Cultivar (C)	1	ns	ns	ns	ns	ns	ns
A × C	2	ns	ns	ns	ns	ns	ns
B × C	1	ns	ns	ns	ns	ns	ns
A × B × C	2	ns	ns	ns	ns	ns	ns
Error	12						
CV (%)		6.42	6.54	4.44	3.39	3.67	4.08
				2013			
Replication	2						
Cutting Interval (A)	2	**	**	**	**	**	**
Error	4						
Seeding Rate(B)	1	ns	ns	ns	ns	ns	ns
A×B	2	ns	ns	ns	ns	ns	ns
Error	6						
Cultivar (C)	1	**	ns	ns	ns	ns	ns
A X C	2	*	ns	ns	ns	ns	ns
B X C	1	ns	ns	ns	ns	ns	ns
A X B X C	2	ns	ns	ns	ns	ns	ns
Error	12						
CV(%)		5.48	17.46	2.99	2.23	2.51	2.60
				2014			
Replication	2						
Cutting Interval (A)	2	**	**	**	**	**	**
Error	4						
Seeding Rate (B)	1	**	ns	ns	ns	ns	Ns
A×B	2	*	ns	ns	ns	ns	Ns
Error	6						
Cultivar (C)	1	**	ns	ns	ns	ns	Ns
A X C	2	**	ns	ns	ns	ns	Ns
B X C	1	**	ns	ns	ns	ns	Ns
A X B X C	2	**	ns	ns	ns	ns	ns
Error	12						
CV (%)		3.24	17.26	3.00	2.43	2.28	2.57
				2012- 2013- 2014 Combined			
Replication	2						
Year (A)	2	**	**	*	**	**	**
Error	4						
Cutting Interval (B)	2	**	**	**	**	**	**
A×B	4	**	ns	ns	**	**	*
Error	12						
Seeding Rate (C)	1	ns	ns	ns	ns	ns	ns
A X C	2	**	ns	ns	ns	ns	ns
B X C	2	ns	ns	ns	ns	ns	ns
A X B X C	4	ns	ns	ns	ns	ns	ns
Cultivar (D)	1	**	*	ns	ns	ns	ns
A X D	2	**	ns	ns	ns	ns	ns
B X D	2	**	ns	ns	ns	ns	ns
A X B X D	4	ns	ns	ns	ns	ns	ns
C X D	1	ns	ns	ns	ns	ns	ns
A X C X D	2	**	ns	ns	ns	ns	ns
B X C X D	2	*	ns	ns	ns	ns	ns
A X B X C X D	4	ns	ns	ns	ns	ns	ns
Error	54						
CV (%)		5.88	12.47	3.13	2.83	2.65	3.08

* Indicates F-test significant at P = 0.05, ** Indicates F-test significant at P = 0.01, ns =nonsignificant (P > 0.05).

Table 3. Fresh herbage yield, hay yield, crude protein content, NDF content, ADF content and RFV two cultivars of alfalfa under different cutting intervals and seeding rates.

	Fresh Herbage Yield ($kg\ ha^{-1}$)	Hay Yield ($kg\ ha^{-1}$)	Crude Protein Content (%)	NDF Content (%)	ADF Content (%)	RFV
			2012			
Cutting Intervals						
20 days	94273 a$^+$	17701 c$^+$	20.3 a$^+$	40.4 c$^+$	23.0 c$^+$	163.8 a$^+$
30 days	92925 ab	19956 b	18.3 b	45.6 b	25.5 b	141.1 b
40 days	91375 b	22608 a	16.7 c	48.7 a	28.6 a	127.2 c
Seeding Rates						
15 $kg\ ha^{-1}$	94033	20072	18.4	45.0	25.6	143.5
30 $kg\ ha^{-1}$	91682	20105	18.4	44.8	25.5	144.5
Cultivars						
Alsancak	91476	19704	18.2	44.7	25.9	143.9
Nimet	94238	20472	18.6	45.0	25.5	144.2
MEAN (Year)	92858 A*	20088 A*	18.4 B*	44.9 A*	25.7 B*	144.0 C*
			2013			
Cutting Intervals						
20 days	66420 c$^+$	13819 c$^+$	21.4 a$^+$	34.0 c$^+$	25.3 c$^+$	189.7 a$^+$
30 days	68772 b	16217 b	20.3 b	38.1 b	27.7 b	164.6 b
40 days	77967 a	19706 a	19.1 c	40.7 a	29.4 a	150.8 c
Seeding Rates						
15 $kg\ ha^{-1}$	69057	16378	20.1	37.6	27.4	168.3
30 $kg\ ha^{-1}$	73049	16783	20.4	37.6	27.5	168.5
Cultivars						
Alsancak	68060 b	15807	20.2	37.7	27.5	167.6
Nimet	74048 a	17354	20.3	37.4	27.4	169.2
MEAN (Year)	71053 B	16580 B	20.3 A	37.6 C	27.5 A	168.4 A
			2014			
Cutting Intervals						
20 days	30462 c$^+$	7168 c$^+$	22.0 a$^+$	36.6 c$^+$	26.0 c$^+$	174.8 a$^+$
30 days	44675 b	9507 b	20.8 b	42.8 b	27.6 b	146.6 b
40 days	49611 a	13507 a	18.7 c	46.9 c	29.5 a	131.0 c
Seeding Rates						
15 $kg\ ha^{-1}$	42630 a	9794	20.6	41.9	27.7	151.3
30 $kg\ ha^{-1}$	40534 b	10329	20.4	42.2	27.7	150.3
Cultivars						
Alsancak	42595 a	9824	20.4	42.0	27.7	151.2
Nimet	40570 b	10299	20.6	42.1	27.7	150.4
MEAN (Year)	41582 C	10061 C	20.5 A	42.1 B	27.7 A	150.8 B
			Avarage of 3 Years			
Cutting Intervals						
20 days	63718 c$^+$	12892 c$^+$	21.2 a$^+$	37.0 c$^+$	24.8 c$^+$	176.1 a$^+$
30 days	68791 b	15227 b	19.8 b	42.1 b	26.9 b	150.7 b
40 days	72985 a	18607 a	18.2 c	45.4 a	29.2 a	136.4 c
Seeding Rates						
15 $kg\ ha^{-1}$	68574	15415	19.7	41.5	26.9	154.4
30 $kg\ ha^{-1}$	68422	15739	19.8	41.5	27.0	154.4
Cultivars						
Alsancak	67377 b	15112 b	19.6	41.5	27.0	154.2
Nimet	69619 a	16042 a	19.9	41.5	26.9	154.6

+) Values with the different small letter in a column in a year are significantly different according to the LSD test at P<0.05

*) Yearly means shown the different capital letter in a column are significantly different according to the LSD test at P<0.05

Hay yields determined in different cutting intervals can affect from environmental conditions and management factors. Hay yields obtained in the 20 days and 30 days cutting intervals were statistically lower than hay yields of 40 days cutting interval during all years. The maximum hay yields of 22608 $kg\ ha^{-1}$, 19706 $kg\ ha^{-1}$ and 13507 $kg\ ha^{-1}$ were obtained from 40 days cutting intervals during first, second and third years, respectively and these values were statistically higher than obtained in other cutting intervals. The adverse effects of frequent cutting have emerged more clearly, depending on the progress of years. This situation can be explained with decreasing the amount of water soluble carbohydrate reserves (Lloveras et al., 1998). As the average of three years, hay yield of 40 days cutting interval was higher than other cutting intervals (12892, 15227 and 18607 $kg\ ha^{-1}$ for 20, 30 and 40 days cutting intervals respectively).

The effects of seeding rates were not significant in terms of hay yields (Table 2, 3). Hay yields for 15 kg ha^{-1} seeding rate were 20072, 16378 and 9794 kg ha^{-1} in first, second and third year, respectively, while hay yields for 30 kg ha^{-1} seeding rate were 20105, 16783 and 10329 kg ha^{-1} for the years 2012, 2013 and 2014, respectively. The three years average hay yields of both seeding rates were very close to each other. This finding is in accordance with that of some previous researchers who found that dry matter production of alfalfa was not affected by seeding rate (Khair, 1997; Lloveras et al., 2008; Abdel-Rahman and Abusuwar, 2012). This finding suggest that 15 kg ha^{-1} seeding rate was suitable for satisfactory hay yield. Sahin and Yilmaz (2008) determined that the average amount of seeds used by the farmers in the planting of alfalfa was 51 kg ha^{-1} in Van-Gurpinar province of Turkey. This situation suggesting that farmers tend to use too much seed in Turkey. Lloveras et al. (2008) suggested that the seeding rate of 10 kg ha^{-1} in alfalfa provides the plant density required to provide sufficient dry matter. Some other researchers reported that a 15-25 kg ha^{-1} seeding ratio was adequate for alfalfa (Le Gall et al., 1992; Bonciarelli, 1987).

Hay yield of both cultivars were statistically similar during three year (Table 2). Together with statistically indifferent, hay yield of cv. Nimet was higher than cv. Alsancak every three years. Hay yields of cv. Nimet were 20472 kg ha^{-1}, 17354 kg ha^{-1} and 10299 kg ha^{-1} for first, second and third years, respectively, while hay yields of cv. Alsancak were 19704 kg ha^{-1}, 15807 kg ha^{-1} and 9824 kg ha^{-1}, respectively (Table 3). According to the averaged values over three years, hay yield of cv. Nimet (16042 kg ha^{-1}) was statistically higher than cv. Alsancak (15122 kg ha^{-1}). Turan et al. (2017) reported that hay yields of alfalfa varied between 7869 kg ha^{-1} – 16201 kg ha^{-1} depending on cultivars in Van, Turkey conditions. Their hay yields were lower than our results for the first and second years. This difference could be due to the variation on the ecological (especially climatic factors) conditions and the planting seasons.

Yearly mean hay yields obtained in the first, second and third years were 20088 kg ha^{-1}, 16580 kg ha^{-1} and 10061 kg ha^{-1}, respectively. Dry matter yields have declined significantly as years progress. Dry matter yield from the first year was higher compared to the others. Hay yield obtained in the first year was 17.5% and 50.0% higher than obtained the second year and the third year, respectively. This reduction is a result of both negative impacts of cutting and inadequate rainfall in the second and third years (Figure 1). Productivity of alfalfa over the year is directly related to the ecological conditions of the location. As a matter of fact, Stanisavljević et al. (2012) obtained higher hay yields in the first year in than the second year under ecological conditions of Nis, but higher yields in the second year from the first year under the ecological conditions of Zajecar. However, they reported that the forage yields gradually decreased in the third and fourth years in both locations. These results support our findings.

Crude protein content

Crude protein contents varied significantly depending on the cutting intervals during 3 years and according to the results of three year combined variance analysis (Table 2). Crude protein contents obtained in 20, 30 and 40 days cutting intervals were 20.3 %, 18.3 % and 16.7% in the first year, 21.4 %, 20.3 % and 19.1% in the second year and 22.0 %, 20.8 % and 18.7 % in the third year, respectively (Table 3). Crude protein contents of 20, 30 and 40 days cutting intervals were 21.2 %, 19.8 % and 18.2 %, respectively as an average of the three years. Crude protein contents obtained in 20 days cutting intervals were higher than the other cutting applications during all experiment years. Crude protein content continuously tended to decrease depending on delayed cutting intervals. Similar results were reported for forage alfalfa cultivars by Ghandorah et al. (1986), Tabacco et al. (2003), Faridullah et al. (2009), Palmonari et al. (2014), Ahmad et al. (2016). Crude protein content decrease depending on advancement in maturity through reducing the leaf ratio and increasing plant cell wall components (Faridullah et al., 2009; Palmonari et al., 2014).

The effects of seeding rates were not significant in terms of crude protein content during 3 years (Table 2). Crude protein contents of 15 kg ha^{-1} seeding rates were 18.4 %, 21.4 % and 20.6 % in the first, second and third years, respectively, while crude protein contents of 30 kg ha^{-1} seeding rates were 18.4 %, 20.4 % and 20.4 %, respectively (Table 2). According to the averaged values over three years, protein contents determined for 15 and 30 kg ha^{-1} seeding rates were 19.7 % and 19.8 %, respectively. Similarly, Lloveras et al. (2008) and Stout (1998) reported that crude protein content of alfalfa was not affected by the seeding rate. The effects of cultivars were not significant in terms of crude protein content during three years (Table 2). Crude protein contents of cv. Alsancak and cv. Nimet were 18.2 % and 18.6 % in the first year, 20.2 % and 20.3 % in the second year and 20.4 % and 20.6 % in the third year, respectively (Table 3). Similar values were also reported in a previous study for crude protein contents of alfalfa (Saruhan and Kusvuran, 2011, Zeinab et al., 2013, Geleti et al., 2014, Kavut and Avcioglu, 2015). It can be said that the two cultivars are quite close to each other in terms of protein content. Similar results for protein content were also reported by Kavut and Avcioglu (2015) and Turan et al. (2017).

Crude protein content of 2012 (18.4 %) was lower than obtained 2013 (20.3 %) and 2014 (20.5 %) (Table3). Depending on the progress of years, the increase of protein ratio may be due to the fact that after the mid-summer, the harvests were made in earlier plant growth stage due to the weakening of the plant growth. As similar to our findings, differences among years in crude protein contents of alfalfa were reported by some previous researchers (Kir and Soya, 2008; Yilmaz and Albayrak, 2017). Forage protein content was negatively related to forage yield due to available N distributing in a greater volume of plant tissue (Garcia del Moral et al., 1995). As a matter of fact, lower crude protein contents were determined in 2012 when the highest yield was achieved.

NDF content

While only the effects of cutting intervals on NDF contents were statistically significant, the effects of other experimental factors and their interactions were statistically not significant (Table 2). NDF contents tended to increase due to the extended cutting intervals and mean NDF content of each cutting interval significantly differed. The minimum NDF contents were determined in 20 days cutting interval during 3 years while the maximum NDF contents were determined in 40 days cutting intervals. NDF contents recorded in 20, 30 and 40 days cutting intervals were 40.4 %, 45.6 % and 48.7 % in the first year, 34.0 %, 38.1 % and 40.7 % in the second year and 36.6 %, 42.8 % and 46.9 % in the third year, respectively (Table 3). NDF content determined at 20 days cutting intervals was lower than other cutting intervals when the average of three years is considered. In parallel with our findings, previous studies reported that NDF contents of alfalfa ranged between 35% and 45 % depending on cutting intervals and NDF contents increased due to prolonged cutting intervals (Kallenbach et al., 2002; Tabacco et al., 2003; Ahmad et al., 2016; Min, 2016; Grev et al., 2017). Palmonari et al. (2014) found that NDF content didn't significantly affected from delayed harvesting date, but significantly reduced NDF digestibility. This indicated that a decrease in forage quality due to advanced maturity, although there is no numerically significant change in NDF content. Also, Filya (2004) stated that the nutritional value of NDF components decreased depending on the lignin accumulation with plant maturity. NDF contents were statistically similar determined for seeding rates of 15 kg ha^{-1} and 30 kg ha^{-1} in 2012, 2013, 2014 and average of years (Table 2). NDF contents obtained in seeding rates of 15 kg ha^{-1} and 30 kg ha^{-1} were 45.0 % and 44.8 % in the first year, 37.6 % and 37.6 % in the second year and 41.9 % and 42.2 % in the third year, respectively (Table 2). NDF contents of cv. Alsancak and cv. Nimet were 44.7 % and 45.0 % in the first year, 37.7 % and 37.4 % in the second year and 42.0 % and 42.1 % in the third year, respectively (Table 3), but differences between NDF content of cultivars were statistically not significant (Table 2). Some previous researchers reported that the contents of NDF in alfalfa hay varied between 33% and 46% (Kallenbach et al., 2002; Yolcu et al., 2008; Kavut and Avcioglu, 2015; Min, 2016; Yilmaz and Albayrak, 2016; Grev et al., 2017). The findings in our current study are close to the values reported by previous researchers. Mean NDF content of 2013 was lower than NDF contents of 2012 and 2014. Similar results were reported by other researchers who founded that NDF contents varied depending on the years (Kallenbach et al., 2002; Kavut and Avcioglu, 2015).

ADF content

ADF contents were significantly influenced by cutting intervals during all experiment years (Table 2). ADF contents recorded in 20, 30 and 40 days cutting intervals were 23.0 %, 25.5 % and 28.6 % in the first year, 25.3 %, 27.7 % and 29.4 % in the second year and 26.0 %, 27.6 % and 29.5 % in the third year, 24.8 %, 26.9 % and 29.2 as average of three years, respectively (Table 3). ADF content of the cutting interval was significantly differed from each other and ADF contents tended to decrease with delayed harvesting time. The similar results were reported for alfalfa by Kallenbach et al. (2002), Tabacco et al. (2003), Ahmad et al. (2016), Min (2016). The effects of both seeding rates and cultivars were not significant in terms of ADF content during 3 years (Table 1). ADF contents of 15 kg ha^{-1} seeding rates were 25.6 %, 27.4 % and 27.7 % in the first, second and third years, respectively, while crude protein contents of 30 kg ha^{-1} seeding rates were 25.5 %, 27.5 % and 27.7 %, respectively (Table 3). Consistent with our findings, Stout (1998) reported that ADF content of alfalfa was not affected by the seeding rate. ADF contents of cultivars were very close to each other in every three years. Yolcu et al. (2008) reported that ADF contents of 12 alfalfa cultivars ranged between 21.82 % and 42.76 %. The main reason for this large variation can be the usage of a large number of cultivars with different genetic structures. This indicates that the ADF value of the varieties used (cv. Alsancak and cv. Nimet) is quite reasonable. Mean ADF content of 2012 was lower than ADF contents of 2013 and 2014. As similar to our findings, differences among the years in view of ADF contents of alfalfa hay were reported by Yilmaz and Albayrak (2016).

Relative feed value

Relative feed value (RFV) calculated by using ADF (related dry matter digestibility) and NDF (related intake potential) is an index indicating forage quality (Rohweder et al., 1978). Therefore, RFV showed a case in parallel with NDF and ADF contents, due to calculated by using them, but there is an inverse relationship between RFV with ADF and NDF. RFV was significantly varied depending on cutting intervals during 3 years (Table 2). RFV were significantly decreased depending on prolonged cutting intervals (Table 3). RFV calculated in 20, 30 and 40 days cutting intervals were 163.8, 141.1 and 127.2 in the first year, 189.7, 164.6 and 150.8 in the second year and 174.8, 146.6 and 131.0 in the third year, 176.1, 150.7 and 136.4 as average of three years, respectively (Table 3). RFV obtained in 20 days cutting intervals were higher than other cutting intervals during all experiment years. RFV continuously tended to decrease depending on delayed cutting intervals. Similar results were reported for alfalfa by Min (2016). RFV obtained in 20 days cutting intervals were in the good, supreme and premium classes depending on standard assigned by United States Department of Agriculture for 2012, 2013 and 2014, respectively (USDA, 2018) while RFV obtained in 40 days cutting intervals were in the utility, good and fair classes. This indicates that the increase in yield obtained at delayed cutting times leads to serious losses in forage quality. For this reason, evaluating any forage on yield only can lead to misleading results.

The effects of seeding rates were not significant in terms of RFV (Table 1, 2). RFV of 15 kg ha^{-1} seeding rates were 143.5, 168.3 and 151.3 in the first, second and third years, respectively, while RFV of 30 kg ha^{-1} seeding rates were 144.5, 168.5 and 150.3 respectively (Table 3). The effects of cultivars were not significant in terms of RFV during all experiment years (Table 2). RFV of cv. Alsancak and cv. Nimet were 143.9 and 144.2 in the first year, 167.6 and 169.2 in the second year and 151.2 and 150.4 in the third year, respectively (Table 3). Also, three years average values were parallel with separated years. Yolcu et al. (2008) reported that RFV of alfalfa cultivars ranged between 117.43 and 185.03. Our values are within the limits determined by the researchers. According to USDA hay quality standards, it can be said that, the two alfalfa cultivars used are in the good class in terms of RFV value (USDA, 2018). However, it can be said that alfalfa hay can be produced in higher quality classes provided that the cutting intervals are adjusted well. Mean RFV of 2013 (168.4) was higher than obtained 2012 (144.0) and 2014 (150.8) (Table 3). This indicates that the ecological conditions during the year may have an impact on forage quality.

CONCLUSION

The results of the research showed that mowing at 40 days intervals resulted in increased yield, but serious forage quality losses were also observed in the prolonged cutting intervals. Despite the production of forage at high quality, cutting at intervals of 20 days resulted in insufficient forage yield. The results of the research indicated that the life span of alfalfa stand can shorten due to the inability to accumulate sufficient quantities of water-soluble carbohydrates in case of very frequent cutting intervals after the second year. For this reason it may be advisable for similar conditions to cutting at intervals of 30 days that both more satisfactory yields are obtained and the quality is acceptable. It was concluded that seeding rates did not have a significant effect on the forage yield and forage quality of alfalfa, so seeding rate of 15 kg ha^{-1} was advisable. Two cultivars of alfalfa used exhibited similar characteristics in terms of forage quality. According to the averaged values over three years, yield of cv. Nimet was higher than cv. Alsancak. Therefore, cv. Nimet could be preferred in Mediterranean climate conditions.

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