YIELD AND QUALITY PERFORMANCES OF ALFALFA (*MEDICAGO SATIVA*) CULTIVARS SOWN AT VARIOUS DATES UNDER SUB-MEDITERRANEAN ECOLOGICAL CONDITIONS

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Abstract. In this study it was aimed to determine the best sowing date and cultivar for the cultivation of alfalfa (*Medicago sativa* L.) in the Southeastern Anatolian Region of Turkey, using a randomized split-block design with three replicates. The study was conducted from 2015 to 2017 using alfalfa cultivars of Kayseri, Magnum V, Gea, and Nimet and these cultivars sowed at three different sowing dates March 10, April 5, and April 30, 2015. The mean plant height of the cultivars was 66.04 cm, mean number of main stems was 10.77 number/plant, mean fresh herbage yield was 50020.1 kg ha^{-1}, mean hay yield was 13509.2 kg ha^{-1}, mean crude protein yield was 2464.0 kg ha^{-1}, mean crude protein rate was 17.88%, mean acid detergent fiber (ADF) rate was 34.01%, and mean neutral detergent fiber (NDF) rate was 39.49%. The highest mean plant height, fresh herbage yield, hay yield, and crude protein yield were observed at first and second sowing times. The results clearly indicate that the first and second sowing dates were the most suitable periods for alfalfa planting in the region studied. Additionally, Magnum V cultivar was the highest cultivator for fresh herbage and hay yield.
Keywords: *alfalfa, sowing dates, varieties, yield, forage quality*

Introduction

Among forage crops, alfalfa (*Medicago sativa*) has the highest forage yield. Alfalfa's herbage is rich in vitamins and high in protein. Because its herbage and hay are quite beneficial and nutritious for farm animals, alfalfa is known as "the queen of forage crops" (Demiroglu et al., 2008).

The seed-sowing dates for alfalfa planting change from region to region. In coastal regions dominated by a Mediterranean climate, winter sowing is common. On the other hand, in regions having a terrestrial climate such as the Central Anatolian and Eastern Anatolian Regions, sowing are generally performed in spring periods. Some regions in which alfalfa is sown in spring might not produce yield in that first year. Nevertheless, the Southeastern Anatolian Region has the ecological conditions that are suitable for harvesting a considerable yield during the sowing year; however, according to Lowe et al. (1972), the main limiting factors affecting cultivar spreading and growth are precipitation and temperature. Thus, temperate and semitropical regions such as the Mediterranean regions alfalfa can harvest up to eight or nine times per year; however, this yield of alfalfa reduce up to two to three times in colder regions. In another study (Eginlioglu et al., 1996) it was reported that the number of sowings, soil fertility, and climate factors also have an effect on alfalfa yield. In that study, it stated that number of harvest for alfalfa can range from 2 to 4 for Eastern Anatolian and Central Anatolian Region, whereas in the coastal regions harvesting of 7 or 8 can be foreseen.

Saruhan and Kusvuran (2011) have reported for several alfalfa cultivars in the Southeastern Anatolian region that the highest fresh herbage yield (48960 kg ha^{-1}) and hay yield (12660 kg ha^{-1}) was produced by the Elci cultivar, while the highest crude

protein rate (22.67%) was obtained from Bilensoy cultivar. Aka and Avcioglu (2003), who investigated the adaptation of seven alfalfa cultivars to the conditions within the Aegean Region, indicated that the height of the main stem varied between 61.56 and 67.50 cm, and that the highest hay yield was obtained from Pioneer-5715 (15730 kg ha^{-1}), whereas it was the lowest for Elci (11780 kg ha^{-1}). In Similar studies on alfalfa cultivars it showed that hay yield of alfalfa was 11020 - 12660 of kg ha^{-1}, 9820 - 17970 of kg ha^{-1} and 12910 - 17810 of kg ha^{-1} (Sengul and Tahtacioglu, 1996).

Moreover, Yılmaz and Albayrak (2016) sowing the some cultivars such as Bilensoy, Verko, Gea, Prosementi or candidate alfalfa cultivars under Isparta conditions found that the highest crude protein rate was produced by candidate cultivars (17.3 7%). In that study it was detected that acid detergent fiber (ADF) and neutral detergent fiber (NDF) rates in Bilensoy cultivar were the lowest (34.50 and 42.20%, respectively). Engin and Mut (2017) conducted at to identify some quality parameters in alfalfa fodder and determine hay yield under Yozgat conditions using alfalfa cultivars of Bilensoy, Kayseri, Verko, Gea, Plato, Victoria, Emiliano, Sunter, Nimet and Basbag during the 2013 and 2015. The mean plant height was the highest in Emiliano cultivar (86.90 cm), whereas it was lowest in Kayseri cultivar (57.50 cm). Authors detected that total hay yield for two year was 21070.0 and 43305.0 kg ha^{-1} for Bilensoy and Sunter, respectively. Again, in that study, the crude protein rate was between 24.20% and 26.10% of percent, and the total protein yield was the highest for Sunter (5906.0 kg ha^{-1}), whereas it was the lowest for Gea (3251.0 kg ha^{-1}).

Alfalfa can be effectively grown for both silage and grain production in Southeastern region of Turkey and thus increasing forage shortage currently encountered will considerably be decreased. The aim of this study was to determine the optimum sowing date for alfalfa under the Southeastern conditions of Turkey, and identify the alfalfa cultivars with the highest quality and yield.

Materials and methods

This research was conducted in researching and application fields of Siirt University Faculty from 2015 through 2017 (*Fig. 1*). As plant material we used four cultivars of alfalfa cultivars such as Gea, Magnum V, Kayseri, Nimet obtained from different research institutes and private seed companies in Turkey. These cultivars sown three different sowing dates (March 10, April 05, and April 30, 2015) are more plant height and more resistant to lodging, and the characters of growing is upright. These cultivars in Turkey have been also recommended for the Southern Marmara, Aegean, Thrace, Black Sea, Southeastern and Eastern Anatolia, Central Anatolia, and Mediterranean regions.

According to the randomized split-block trial design with three replications, the whole plot was divided according to the alfalfa cultivars, and subplot parcels were determined by sowing date. There were eight rows in each parcel with 25 cm between them, and the seeds were sown to a depth of 1 - 1.5 cm. Three kilograms of seeds were sown over each 0.1 hectare and fertilized with 150 kg ha^{-1} diammonium phosphate. The parcel was 2 m wide and 5 m long. There were 2 m of distance between each block and 1 m between each parcel. The entire experimental field was 19 m wide and 35 m long, encompassing a total area of 0.0665 ha.
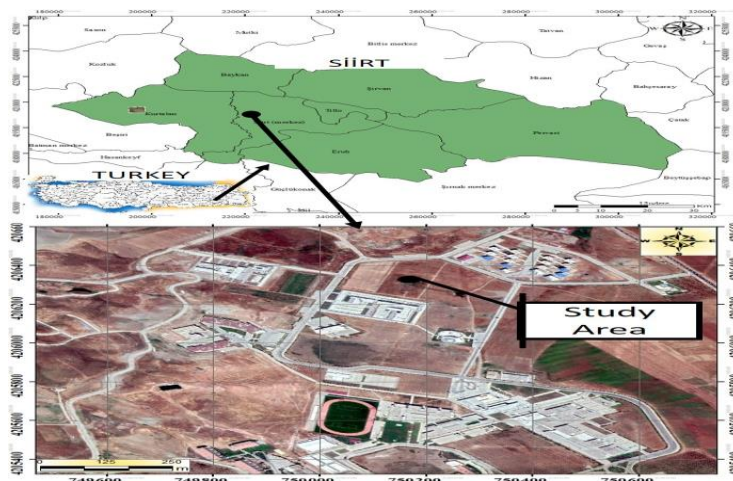
Figure 1. *The location of study area*

Seeds sown in three different sowing dates (March 10, April 05, and April 30, 2015) had the high performance and harvested during 10 - 15% of blooming. 6 rows of plants in the middle of the parcels were harvested after removing one row from the beginning and end of each plot. The processes for pre and post-harvesting were conducted on trial site. Because alfalfa is grown under wet conditions in 2015, five cutting were conducted in the first and second sowing periods, while four cutting were conducted in the third sowing date. In 2016 and 2017, 5 cutting were performed from each sowing period. From each parcel, 0.5 kg samples were randomly collected, air dried under shadow, placed in an oven set to 78 °C for 24 h, and dried until there were no further changes in the sample. At this point, the samples were ground and prepared for analyses.

The characteristics measured in the study were plant height (cm), number of main stems (number/plant), fresh herbage yield (kg ha^{-1}), and hay yield (kg ha^{-1}). In addition, crude protein rate, ADF, and NDF were determined by near infrared analysis using the Near Infrared Reflectance Spectroscopy (NIRS) instrument (Hoy et al., 2002).

The 3-year mean values obtained from the study were used for the analysis of variance with JUMP at 0.05 and 0.01 significance levels (SAS, 1998). The differences among the mean values were compared using Fisher's Least Significant Difference multiple comparison test (Gulumser et al., 2006).

Climate characteristics of the research area

Climate characteristics of the research area are presented in *Table 1*. The Siirt climate has a long-term precipitation (713.10 mm/year), their relative humidity and temperature are 44.73%, and is 16.03 °C, respectively. During this study, the relative humidity was highest in January, and the temperature was generally low. The highest precipitation in 2015 was at 188.00 mm in October 2015, at 162.40 mm in January 2016, and at 126.60 mm in March 2017 (*Table 1*).

As shown in *Table 1,* in the time periods of research, temperatures and relative humidity had higher than the long-term mean climate values. In 2015 and 2017, the total precipitation was 668.00 and 540.80 mm, respectively, which were lower than the long-term average of 713.10 mm; however, in 2016, total precipitation at 731.20 mm, which was higher than the long-term average (*Table 1*). Because region performed in this study are hot and dry, the field was irrigated after each sowing.

Table 1. *Temperature, precipitation and relative humidity values of the research area (Meteorology Regional Directorate, Siirt)*

Months	Temperature (°C)				Precipitation (mm)				Relative humidity (%)			
	LYA	**2015**	**2016**	**2017**	**LYA**	**2015**	**2016**	**2017**	**LYA**	**2015**	**2016**	**2017**
January	2.60	3.86	1.69	2.95	96.80	60.80	162.40	48.80	73.30	73.98	76.04	66.11
February	4.20	6.04	8.06	2.74	97.50	92.00	63.80	26.60	68.50	70.72	68.39	64.49
March	8.30	9.14	10.07	9.54	111.10	125.00	135.60	126.60	60.4	63.19	62.35	64.16
April	13.70	13.72	16.70	14.00	104.70	53.20	66.80	124.60	50.40	55.48	47.45	59.18
May	19.30	20.42	19.90	19.55	62.00	26.80	64.60	74.60	41.50	42.99	48.92	51.62
June	26.00	26.87	26.52	26.94	8.70	3.60	20.40	0.0	24.10	27.79	32.63	29.44
July	30.60	32.09	31.37	32.28	1.60	0.00	2.40	0.0	18.10	19.56	24.48	18.99
August	30.10	31.37	32.28	31.94	0.90	2.40	0.20	0.40	17.20	22.55	20.55	18.99
September	25.10	28.13	24.86	28.31	4.90	1.60	18.80	0.0	24.00	23.14	29.82	19.22
October	17.90	18.54	19.49	18.35	49.10	188.00	40.20	18.40	45.30	59.23	37.10	35.15
November	10.40	10.56	10.33	11.13	81.40	56.80	51.80	73.40	57.10	64.76	49.82	64.44
December	4.80	5.00	3.35	7.95	94.40	57.80	104.2	47.40	56.9	61.75	72.92	65.29
Total/Average	16.08	17.15	17.05	17.14	713.10	668.00	731.20	540.80	44.73	48.76	47.54	46.42

LYA: Long years' average (1960-2017)

Soil properties in the research area

The results of the soil analysis of research area performed by Siirt University Science and Technology Application and Research Center Laboratory are presented in *Table 2*.

The soil analysis showed that the soil of research field had a neutral pH, was highly calcareous, non saline, had low organic matter and plant-available phosphorus, and had sufficient potassium, copper and iron but was low in zinc and manganese concentrate (*Table 2*).

Table 2. *Soil analysis results of the research area*

pH	Salt ds/m	Lime (CaCO₃) (%)	Organic matter (%)	P (P₂O₅) kg ha⁻¹	K (K₂O) ppm	Fe ppm	Cu ppm	Zn ppm	Mn ppm	Soil (%)		
										Sand	Clay	Silt
7.21	1.47	16.30	1.96	24.4	620	14.07	5.89	1.13	22.71	36	44	20

Soil analyses were conducted at the Siirt University Science and Technology Application and Research Center Directorate (2015).

Results and discussion

Plant height

The plant height of the alfalfa cultivars sown at different dates under Siirt conditions and the results of their multiple comparison are presented in *Table 3*. The results of the effect of cultivar, sowing date, and sowing date x year interaction for the mean plant height of the alfalfa were significant at $p < 0.05$, while those of year and cultivar x year interaction were significant at $p < 0.01$. Effects of interactions of cultivar x sowing date and the cultivar x sowing date x year were not significant.

When the findings were examined (*Table 3*), the mean plant height of the cultivars in the study ranged from 62.62 to 67.91 cm. The mean plant height were the highest for cultivars of Kayseri (67.91 cm), Gea (67.35 cm), and Magnum V (66.28 cm), whereas Nimet cultivar was the lowest for this characteristics (62.62 cm). The mean plant height according to sowing dates was 66.04 cm. In the first and second sowing dates, plant height was the highest (67.81 and 67.76 cm, respectively). However, it was 62.55 cm in plants from the third sowing date. The mean plant heights in different years were 52.39, 71.96, and 73.77 cm for years of 2015, 2016, and 2017, respectively.

In the current study, varieties investigated were significantly affected form interaction of sowing date x year, showing that there are differences based on sowing dates. Through the years, the height of plants was the lowest at first planting period, but there were a ongoing increase in the following years. Thus, the height of plant was affected form variety x year interaction. For example, Magnum V was the lowest for plant height at first year of trial, but there was a significant increase for plant height in the following years compared with the other cultivars.

***Table 3.** Effect of cultivar and sowing date on plant height (cm)*

Years	Sowing dates	Varieties				
		Kayseri	Magnum V	Gea	Nimet	Variety mean
2015	1st sowing date	60.93	53.03	60.17	60.37	58.63 [B]
	2nd sowing date	48.67	55.23	55.17	55.67	53.69 [B]
	3rd sowing date	44.70	42.40	49.27	43.17	44.88 [C]
	Mean	51.43 [E]	50.22 [E]	54.87 [E]	53.07 [E]	52.40 [B]
2016	1st sowing date	74.27	69.13	70.93	66.40	70.18 [A]
	2nd sowing date	73.93	71.00	72.60	75.47	73.25 [A]
	3rd sowing date	76.60	72.06	70.80	70.33	72.44 [A]
	Mean	74.93 [A-C]	70.73 [C]	71.44 [BC]	70.73 [C]	71.95 [A]
2017	1st sowing date	79.43	75.87	79.30	63.93	74.63 [A]
	2nd sowing date	73.03	87.13	80.20	65.00	76.34 [A]
	3rd sowing date	79.67	70.70	67.73	63.23	70.33 [A]
	Mean	77.37 [AB]	77.90 [A]	75.74 [A-C]	64.05 [D]	73.76 [A]
Mean years	1st sowing date	71.54	66.01	70.13	63.56	67.81 [A]
	2nd sowing date	65.21	71.12	69.32	65.38	67.76 [A]
	3rd sowing date	66.99	61.72	62.60	58.91	62.55 [B]
	Mean of mean	67.91 [A]	66.28 [A]	67.35 [A]	62.62 [B]	66.04
CV (%)		9.50				
LSD$_{variety}$		3.40*				
LSD$_{sowing\ date}$		3.81*				
LSD$_{year}$		3.81**				
LSD$_{variety\ x\ year}$		5.92**				
LSD$_{sowing\ date\ x\ year}$		6.62*				
LSD$_{variety\ x\ sowing\ date}$		ns				
LSD$_{variety\ x\ sowing\ date\ x\ year}$		ns				

The difference between the averages indicated by the same letter in the same group is not statistically significant. *:Significant difference at P < 0.05 level, **:Significant difference at P < 0.01 level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

The results obtained in this study are similar those of plant height taken from another study done in Izmir and Selcuk regions in Turkey (61.56 - 67.50 cm) (Aka and Avcioglu, 1999); however, the plant heights in our study were higher than those observed in the studies done in the Eastern Anatolian Region (54.7) (Cacan et al., 2018), Southeastern Anatolian Region (40.1 - 49.7) (Saruhan and Kusvuran, 2011), Kırşehir (53.91 - 63.47 cm) (Inal, 2015). But our findings for plant height were lower than those from the studies in the Aegean region (Kavut et al., 2014) and Yozgat (Engin and Mut, 2017) at 73.97 - 81.50 and 57.50 - 86.90 cm, respectively.

Number of main stems

According to the mean number of main stems in the alfalfa cultivars sown at different dates and their multiple comparisons (*Table 4*), effect of cultivar, sowing date, and cultivar x sowing date x year on the number of main stems were significant at $p < 0.05$; again, year and cultivar x year were significant at $p < 0.01$. Nonetheless, effect of sowing date x year and cultivar x sowing date were not statistically significant. When these results were examined, we observed that the mean number of main stems in the cultivars ranged between 10.33 and 11.05 number/plant, and the differences in the mean number of main stems in the cultivars were not statistically significant, except for Nimet cultivar (*Table 4*).

Table 4. *Effect of cultivar and sowing date on number of main stem (number/plant)*

Years	Sowing dates	Varieties				
		Kayseri	**Magnum V**	**Gea**	**Nimet**	**Variety mean**
2015	1st sowing date	7.73 mn	6.97 n	9.33 j-l	8.83 k-m	8.21
	2nd sowing date	10.36 h-j	7.83 mn	9.83 i-k	8.63 k-m	9.16
	3rd sowing date	6.83 n	7.10 n	8.16 l-n	8.1 l-n	7.55
	Mean	8.31 d	7.30 e	9.11 d	8.52 d	8.31 B
2016	1st sowing date	11.86 c-g	12.53 a-f	11.33 d-h	11.46 d-h	11.80
	2nd sowing date	12.26 b-f	12.73 a-d	12.06 b-g	10.73 g-j	11.95
	3rd sowing date	11.73 d-h	11.60 d-h	11.60 d-h	11.66 d-h	11.65
	Mean	11.95 a-c	12.28 ab	11.66 bc	11.28 c	11.80 A
2017	1st sowing date	12.63 a-e	12.53 a-f	12.50 a-f	11.20 e-ı	12.21
	2nd sowing date	11.76 d-h	13.93 a	13.36 ab	11.16 f-ı	12.55
	3rd sowing date	13.30 a-c	11.83 d-g	11.26 e-ı	11.20 e-ı	11.90
	Mean	12.56 a	12.76 a	12.37 ab	11.18 c	12.22 A
Mean years	1st sowing date	10.74	10.68	11.05	10.50	10.74 AB
	2nd sowing date	11.46	11.50	11.75	10.17	11.22 A
	3rd sowing date	10.62	10.18	10.34	10.32	10.36 B
	Mean of mean	10.94 A	10.78 AB	11.05 A	10.33 B	10.78
CV (%)		8.30				
LSD$_{variety}$		0.48*				
LSD$_{sowing date}$		0.60*				
LSD$_{year}$		0.60**				
LSD$_{variety x year}$		0.84**				
LSD$_{sowing date x year}$		ns				
LSD$_{variety x sowing date}$		ns				
LSD$_{variety x sowing date x year}$		1.46*				

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at $P < 0.05$ level, **:Significant difference at $P < 0.01$ level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

There were no differences between the first and second sowing dates for number of main stems, except for third sowing date. The highest mean number of main stems was 11.22 number/plant from the second sowing date, and the lowest was 10.36 number/plant observed from the third sowing date. The mean number of main stem in different sowing years was 8.31, 11.80, and 12.22 number/plant, respectively, for years of 2015, 2016, and 2017. The differences in the mean number of main stems in the alfalfa cultivars changed throughout the years, and cultivar x year interaction was significant as statistical. Magnum V cultivar had an increase for numbers of main stems over the years and it was the highest compared to the other cultivars at the end of the year.

The values obtained for the number of main stems were lower than those obtained in the studies performed by Turan et al. (2017), Demiroglu et al. (2008), Kavut et al. (2014), Petkova et al. (2003) and Seker et al. (2003), but higher than those from obtained in the study performed by Inal (2015).

Fresh herbage yield

The difference in mean fresh herbage yield from the alfalfa cultivars sown at different dates and their multiple comparisons indicated that effect of sowing date x year were statistically significant at $p < 0.05$, and sowing date and years were significant at $p < 0.01$. On the other hand, the differences in mean fresh herbage yields for cultivar, cultivar x year, cultivar x sowing date, and cultivar x sowing date x year were not statistically significant (*Table 5*).

Mean fresh herbage yields in different sowing dates ranged between 42948.0 and 54893.3 kg ha^{-1}. There were no differences between the first and second sowing dates whereas, there was a difference in the third sowing date. The mean fresh herbage yield according to year was 36549.1, 55548.0, and 57963.3 kg ha^{-1}, respectively, for 2015, 2016, and 2017. Cultivars had different fresh herbage yields according to different sowing dates, and the ones with lower fresh herbage yields had increasingly higher yields in the following years; however, among the sowing dates used, the second had the highest fresh herbage yield. There were statistically significant differences for year x sowing date (*Table 5*).

The fresh herbage yields detected in this study were lower than the results reported by Demiroglu et al. (2008), Kavut et al. (2014), Avci et al. (2013), Petkova et al. (2003), Aka and Avcioglu (1999), and Seker et al. (2003). However, our findings for fresh herbage yield were higher than the values reported by Turan et al. (2017), Cacan et al. (2018) and Inal (2015), and it was in accordance with findings Saruhan and Kusvuran (2011).

Hay yield

Table 6 illustrates the values for mean hay yield of alfalfa cultivars sown on different dates. These values clearly show that effect of cultivar x sowing date on mean hay yield is statistically significant at $p < 0.05$, and that sowing date and years are statistically significant at $p < 0.01$.

In the present study, the effect of the cultivars, cultivar x year, sowing date x year, and cultivar x sowing date x year on mean hay yield was not statistically significant. While the fresh herbage and hay yield of the cultivars examined in the study (Kayseri, Magnum V and Gea) were higher than the second year; the values of the second year was higher than values of the third year.

Table 5. *Effect of cultivar and sowing date on fresh herbage yield (kg ha⁻¹)*

Years	Sowing dates	Varieties				
		Kayseri	Magnum V	Gea	Nimet	Variety mean
2015	1st sowing date	46280.0	33360.0	47136.7	44886.7	42915.8 B
	2nd sowing date	40853.3	39040.0	50166.7	49756.7	44954.1 B
	3rd sowing date	21386.7	25353.3	23613.3	16756.7	21777.5 C
	Mean	36173.3	32584.4	40305.5	37133.3	36549.1 B
2016	1st sowing date	51860.0	57033.3	57976.7	55910.0	55695.0 A
	2nd sowing date	54503.3	62783.3	60710.0	60086.7	59520.8 A
	3rd sowing date	55320.0	46850.0	50496.7	53046.7	51428.3 AB
	Mean	53894.4	55555.5	56394.4	56347.8	55548.0 A
2017	1st sowing date	59473.3	57813.3	60683.3	54216.7	58046.7 A
	2nd sowing date	55960.0	67713.3	62176.7	54970.0	60205.0 A
	3rd sowing date	60366.7	52770.0	53670.0	55746.7	55638.3 A
	Mean	58600.0	59432.2	58843.3	54977.8	57963.3 A
Mean years	1st sowing date	52537.8	49402.2	55265.6	51671.1	52219.1 A
	2nd sowing date	50438.9	56512.2	57684.5	54937.8	54893.3 A
	3rd sowing date	45691.1	41657.8	42593.3	41850.0	42948.0 B
	Mean of mean	49555.9	49190.7	51847.8	49486.3	50020.1
CV (%)	14.00					
LSD variety	ns					
LSD sowing date	ns					
LSD year	562.29**					
LSD variety x year	ns					
LSD sowing date x year	973.74*					
LSD variety x sowing date	ns					
LSD variety x sowing date x year	ns					

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at P < 0.05 level, **:Significant difference at P < 0.01 level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

The fresh herbage and hay yield were 37133.3 - 9139.5 kg ha⁻¹ in the first year, in the second year increased to 56347.7 - 15946.0 kg ha⁻¹, then decreased to 54977.7 - 15534.6 kg ha⁻¹ in the final year. This situation is believed to be related to the characteristic differences in cultivars and their different responses to varying ecological conditions.

The mean hay yields of the groups from the different sowing dates ranged from 11932.7 to 14589.1 kg ha⁻¹, with the highest hay yield observed from the second sowing date and the lowest from the third sowing date. Mean hay yields were 8 635.7, 15 557.4, and 16334.7 kg ha⁻¹, respectively, for years of 2015, 2016, and 2017. Considering the three-year values together with the year of the sowing, fresh herbage and hay yield values had an similar increase. However, the hay yield in second sowing date was the highest, indicating that cultivar x sowing date interaction lead to these differences (*Table 6*).

In the present study, the hay yield were higher than that of values reported in the Eastern Anatolian Region (13154.0 and 12270.0 kg ha⁻¹) (Turan et al., 2017; Cacan et

al., 2018) and in Europe, North Africa, and the United States (14200.0 kg ha^{-1}) (Pecetti et al., 2008). However, our findings for hay yield were lower than those observed in the study done in Bornova and Ödemiş in Turkey (Demiroglu et al., 2008), with yields ranging from 18920.0 to 24740.0 kg ha^{-1}.

Table 6. *Effect of cultivar and sowing date on dry herbage yield (kg ha^{-1})*

Years	Sowing dates	Varieties				
		Kayseri	**Magnum V**	**Gea**	**Nimet**	**Variety mean**
2015	1st sowing date	10689.8	8006.5	10614.0	11063.8	10093.5
	2nd sowing date	8469.3	9273.5	11891.7	12081.7	10429.0
	3rd sowing date	5323.1	5991.9	5950.3	4272.9	5384.5
	Mean	8160.7	7757.3	9485.3	9139.5	8635.7^B
2016	1st sowing date	14536.3	15613.5	15696.1	15173.1	15254.7
	2nd sowing date	15155.2	17522.5	17006.4	17240.2	16731.1
	3rd sowing date	15512.2	13401.3	14407.0	15424.7	14686.3
	Mean	15067.9	15512.4	15703.2	15946.0	15557.4^A
2017	1st sowing date	17050.9	15975.5	18058.5	15593.5	16669.6
	2nd sowing date	14471.3	19060.9	17890.5	15005.9	16607.1
	3rd sowing date	16819.0	13232.9	16852.8	16004.4	15727.3
	Mean	16113.7	16089.8	17600.6	15534.6	16334.7^A
Mean years	1st sowing date	14092.3^{A-C}	13198.5^{B-D}	14789.5^{AB}	13943.5^{A-C}	14006.0^A
	2nd sowing date	12698.6^{CD}	15285.6^A	15596.2^A	14776.0^{AB}	14589.1^A
	3rd sowing date	12551.4^{C-E}	10875.3^E	12403.4^{C-E}	11900.7^{DE}	11932.7^B
	Mean of mean	13114.1	13119.8	14263.0	13540.0	13509.2
CV (%)		13.99				
LSD$_{variety}$		ns				
LSD$_{sowing\ date}$		141.12**				
LSD$_{year}$		141.12**				
LSD$_{variety\ x\ year}$		ns				
LSD$_{sowing\ date\ x\ year}$		ns				
LSD$_{variety\ x\ sowing\ date}$		178.32*				
LSD$_{variety\ x\ sowing\ date\ x\ year}$		ns				

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at $P < 0.05$ level, **:Significant difference at $P < 0.01$ level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

Moreover, the hay yields in our study were in accordance with findings of Aka and Avcioglu (2003), in which the adaptations of alfalfa to Aegean Region conditions were examined with hay yield values for seven different alfalfa cultivars ranging from 11780.0 to 15730.0 kg ha^{-1} with those observed in another study done under Erzurum conditions with different alfalfa cultivars (Seker, 2003), which showed the highest hay yield of 13335.0 kg ha^{-1}. Because of that the development of root and storing of spare nutrients in the root region. Thus, it is understood that the development of subsoil parts is given more importance rather than above ground ones. Despite this five cutting were performed in second year of trial and an increase was observed an increase over years (*Tables 3–8*).

Crude protein content

The effect of cultivar x year, cultivar x sowing date, and cultivar x sowing date x year on the mean crude protein rates in the alfalfa cultivars sown at different dates were statistically significant at $p < 0.05$, and also the effect of cultivars and years were significant at $p < 0.01$. On the other hand, the impacts of sowing date and sowing date x year were not statistically significant. Cultivars had a mean crude protein rate of 17.88% with a high value of Magnum V (18.54%) and a low value of Nimet (17.40%).

The mean values for the different years were 16.18, 16.60, and 20.87%, respectively. Mean crude protein rate was the highest for all cultivars in 2017 (*Table 7*). Cultivar x year interaction was statistically significant at $p < 0.05$. In the cultivar x sowing date, the highest mean crude protein rate was 18.57% in first Magnum V sowing date, and the lowest rate one was observed from the third Nimet sowing date at 17.03%.

Table 7. Effect of cultivar and sowing date on crude protein ratio (%)

Years	Sowing dates	Varieties				
		Kayseri	Magnum V	Gea	Nimet	Variety mean
2015	1st sowing date	15.86 f-j	17.17 b-e	16.47 d-h	17.10 b-e	16.65
	2nd sowing date	16.57 c-g	16.40 d-i	15.00 j	15.23 ij	15.80
	3rd sowing date	16.43 d-h	16.53 d-h	16.57 c-g	14.87 j	16.10
	Mean	16.28 CD	16.70 C	16.01 CD	15.73 D	16.18 B
2016	1st sowing date	16.90 c-f	17.54 b-d	17.55 b-d	15.55 g-j	16.89
	2nd sowing date	16.06 e-j	18.21 b	15.39 g-j	16.43 d-h	16.52
	3rd sowing date	16.58 c-g	17.73 bc	15.88 f-j	15.34 h-j	16.39
	Mean	16.51 C	17.83 B	16.27 CD	15.77 D	16.60 B
2017	1st sowing date	20.54 a	21.00 a	20.96 a	20.87 a	20.85
	2nd sowing date	20.96 a	20.89 a	20.80 a	20.32 a	20.74
	3rd sowing date	21.07 a	21.38 a	20.73 a	20.88 a	21.01
	Mean	20.86 A	21.09 A	20.83 A	20.69 A	20.87 A
Mean years	1st sowing date	17.77 DE	18.57 A	18.33 A-D	17.84 C-E	18.13
	2nd sowing date	17.86 B-E	18.50 A-C	17.06 FG	17.33 E-G	17.69
	3rd sowing date	18.03 A-D	18.55 AB	17.73 D-F	17.03 G	17.83
	Mean of mean	17.88 B	18.54 A	17.70 BC	17.40 C	17.88
CV (%)		4.08				
LSD_variety		0.38**				
LSD_sowing date		ns				
LSD_year		0.47**				
LSD_variety x year		0.68*				
LSD_sowing date x year		ns				
LSD_variety x sowing date		0.68*				
LSD_variety x sowing date x year		1.18*				

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at $P < 0.05$ level, **:Significant difference at $P < 0.01$ level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

Under different environmental conditions, different crude protein rates were observed in many studies. The values reported in the literature were from Awad and Bakri (2009) at 19.99 - 26.96%, Geleti et al. (2014) at 18.15 - 19.56%, Katic et al. (2009) at 17.3 - 19.7%, Saruhan and Kusvuran (2011) at 22.67%, Yilmaz and Albayrak (2016) at 17.37%, Zeinab et al. (2013) at 18.5 - 23.0%, Engin and Mut (2017) at 24.2 - 26.1%, Kir and Soya (2008) at 17.86 - 20.26%, Kir (2010) at 22.21 - 23.31%, Saruhan and Kusvuran (2011) at 17.94 - 22.67%, Kavut and Avcioglu (2015) at 19.83 - 20.11%, Inal (2015) at 18.38 - 20.45%, Yuksel et al. (2016) at 15.14 - 19.13%, Cinar and Hatipoglu (2015) at 20.6%, Yilmaz and Albayrak (2016) at 16.23 - 17.53%, Avci et al. (2013) at 18.5 - 19.4%, Turan et al. (2017) at 16.55 - 17.55%, Strbanovic et al. (2017) at 20.00%, Oten et al. (2018) at 18.39%, Walie et al. (2016) at 18.06%, Holman et al. (2016) at 19.50 - 26.50%, Titei et al. (2018) at 23.00%, Mazza et al. (2001) at 19.99 - 21.70%, Toricelli et al. (2001) at 19.99 - 21.70%, Stanacev et al. (2010) at 19.70%, and Scholtz et al. (2009) at 13.90 - 27.80%.

When the values obtained in this study are compared with those above, we see that they are in accordance with some higher and some lower. The differences in crude protein rates were considered to be related to the differences among soil, cultivar, sowing date, and other environmental conditions.

Crude protein yield

Table 8 presents the statistically significant results in mean crude protein yield of the different groups. According to these results, the effect of sowing date x year and cultivar x sowing date on mean crude protein yield were statistically significant at $p < 0.05$, and also the effect of sowing date and year were statistically significant at $p < 0.01$. On the other hand, the effect of cultivar, cultivar x year, and cultivar x sowing date x year were not statistically significant for crude protein yield.

The effect of sowing time on crude protein yield was statistically divided into two groups, first and second sowing time was the highest group, while the third sowing time was the lowest group. When the crude protein yield of the years is examined (*Table 8*). The highest crude protein yield with 3409.7 kg ha^{-1} was obtained in 2017, while the lowest crude protein yield with 1385.7 kg ha^{-1} was obtained in 2015.

Nimet and Magnum V were in the same statistically significant groups and had the highest mean crude protein yield from their second sowing date and the lowest from the third sowing date, while Gea had the highest crude protein yield from its first and second sowing dates. These results were statistically significant at $p < 0.05$ for cultivar x sowing date.

In current study, year x sowing date interaction was statistically significant and was between 1385.7 and 3409.7 kg ha^{-1}. These values obtained for crude protein yield were higher than those from Inal (2015) at 881.9 - 1129.3 kg ha^{-1}, Turan et al. (2017) at 1348.0 - 2827.0 kg ha^{-1}, Cacan et al. (2018) at 3010.0 kg ha^{-1}, and Kir and Soya (2008) at 372.5 - 522.3 kg ha^{-1} and also these values were lower than those from Hansen and Krueger (1973) at 2700.0 - 3250.0 kg ha^{-1}, Avci et al. (2013) at 4020.0 - 4220.0 kg ha^{-1}, Yilmaz and Albayrak (2016) at 3173.6 - 3837.9 kg ha^{-1}, and Engin and Mut (2017) at 3251.0 - 5906.0 kg ha^{-1}.

Even though the differences in the mean crude protein rate were not statistically significant, there were statistically significant differences in crude protein yields, which can be explained by the differences in hay yields from the cultivars and sowing years (*Table 8*). The correlation between increasing hay yield and crude protein content is also indicated by other researchers (Kir and Soya, 2008).

Table 8. *Effect of cultivar and sowing date on crude protein yield (kg ha⁻¹)*

Years	Sowing dates	Varieties				
		Kayseri	**Magnum V**	**Gea**	**Nimet**	**Variety mean**
2015	1ˢᵗ sowing date	1690.4	1371.9	1740.0	1873.8	1669.0 [D]
	2ⁿᵈ sowing date	1396.8	1507.5	1772.8	1798.2	1619.0 [D]
	3ʳᵈ sowing date	871.3	983.0	983.6	638.5	869.1 [E]
	Mean	1319.5	1287.5	1498.8	1436.8	1385.7 [C]
2016	1ˢᵗ sowing date	2443.0	2730.3	2801.9	2381.6	2589.2 [BC]
	2ⁿᵈ sowing date	2437.1	3219.1	2574.7	2864.7	2773.9 [B]
	3ʳᵈ sowing date	2604.1	2386.8	2358.0	2356.5	2426.3 [C]
	Mean	2494.7	2778.7	2578.2	2534.3	2596.5 [B]
2017	1ˢᵗ sowing date	3502.9	3379.0	3787.6	3253.8	3480.8 [A]
	2ⁿᵈ sowing date	3027.9	3984.4	3714.2	3050.5	3444.3 [A]
	3ʳᵈ sowing date	3542.7	2830.9	3500.5	3341.4	3303.9 [A]
	Mean	3358.0	3398.1	3667.4	3215.2	3409.7 [A]
Mean years	1ˢᵗ sowing date	2545.4 [BC]	2494.0 [BC]	2776.5 [AB]	2503.1 [BC]	2579.7 [A]
	2ⁿᵈ sowing date	2281.0 [CD]	2904.0 [A]	2687.2 [AB]	2571.1 [A-C]	2610.8 [A]
	3ʳᵈ sowing date	2339.3 [CD]	2067.0 [D]	2281.0 [CD]	2112.2 [D]	2200.0 [B]
	Mean of mean	2388.6	2488.3	2581.6	2395.5	2464.0
CV (%)	14.60					
LSD$_{variety}$	ns					
LSD$_{sowing\ date}$	18.79**					
LSD$_{year}$	18.79**					
LSD$_{variety\ x\ year}$	ns					
LSD$_{sowing\ date\ x\ year}$	32.57*					
LSD$_{variety\ x\ sowing\ date}$	33.92*					
LSD$_{variety\ x\ sowing\ date\ x\ year}$	ns					

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at P < 0.05 level, **:Significant difference at P < 0.01 level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

Acid detergent fiber (ADF) rates

According to the ADF rates in this study (*Table 9*), the effect of sowing date, cultivar, year, and cultivar x sowing date on ADF rate were statistically significant at p < 0.05, while cultivar x year and sowing date x year were statistically significant at p < 0.01; nevertheless, the effect of cultivar x sowing date x year were not statistically significant.

The lowest ADF rate at 31.99% was observed in Magnum V cultivar and the highest was observed in Kayseri cultivar (34.78%). When examined in terms of sowing date, the first and second sowing dates were once again in the same statistically significant group and had lower ADF rates compared with third sowing date.

Magnum V had always the lowest ADF rates, although Gea cultivar had the lowest ADF rate in 2017. For this reason cultivar x year interaction was significant (p < 0.05). The effect of cultivar x sowing date indicated that Magnum V's lowest ADF rate was in the second sowing date at 30.58%, and that Kayseri cultivar (35.90%) and Nimet cultivar (36.82) were the highest for ADF rate in the second sowing date and third sowing date, respectively (*Table 9*).

Table 9. *Effect of cultivar and sowing date on ADF (%)*

Years	Sowing dates	Varieties				
		Kayseri	**Magnum V**	**Gea**	**Nimet**	**Variety mean**
2015	1st sowing date	33.81	33.69	31.66	36.78	33.98 BC
	2nd sowing date	37.24	29.71	35.64	34.60	34.30 B
	3rd sowing date	36.71	32.78	35.14	38.82	35.86 A
	Mean	35.92 A	32.06 DE	34.15 BC	36.73 A	34.71 A
2016	1st sowing date	33.07	33.40	30.60	35.27	33.08 B-D
	2nd sowing date	37.30	30.00	34.83	34.27	34.10 B
	3rd sowing date	36.10	32.53	35.00	38.67	35.57 A
	Mean	35.49 AB	31.98 E	33.48 CD	36.07 A	34.25 A
2017	1st sowing date	33.53	32.46	31.53	32.80	32.58 D
	2nd sowing date	33.17	32.04	32.51	33.28	32.75 CD
	3rd sowing date	32.13	31.26	33.59	32.97	32.49 D
	Mean	32.94 C-E	31.92 E	32.54 DE	33.02 C-E	32.61 B
Mean years	1st sowing date	33.47 DE	33.18 FG	31.26 FG	34.95 BC	33.21 B
	2nd sowing date	35.90 AB	30.58 G	34.33 CD	34.05 CD	33.72 B
	3rd sowing date	34.98 BC	32.19 EF	34.58 B-D	36.82 A	34.64 A
	Mean of mean	34.78 A	31.98 C	33.39 B	35.27 A	33.86
CV (%)	4.49					
LSD variety	0.82**					
LSD sowing date	0.72**					
LSD year	0.72**					
LSD variety x year	1.43*					
LSD sowing date x year	1.23*					
LSD variety x sowing date	1.43**					
LSD variety x sowing date x year	ns					

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at P < 0.05 level, **:Significant difference at P < 0.01 level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

The ADF values obtained in this study were higher than those of Geleti et al. (2014) at 21.49 - 26.19%, Engin and Mut (2017) at 27.5 - 29.7%, Toricelli et al. (2001) at 28.89 - 32.29%, Markovic et al. (2008) at 16.3%, and Kanani et al. (2006) at 26.50%. In several similar studies, the ADF rates ranged from 35.16 to 36.03% (Kir, 2010) and from 31.97 to 41.5% (Gungor et al., 2008), which were higher than those from our study; however, the results of our study were in accordance with values reported by Cacan et al. (2015) at 31.86% and Yilmaz and Albayrak (2016) at 34.50%.

Neutral detergent fiber (NDF) rates

When the NDF rates were examined by cultivars and sowing dates, the effect of cultivar, year, and cultivar x sowing date were statistically significant at p < 0.01; whereas it were not statistically significant for sowing date, sowing date x year, cultivar x year, and cultivar x sowing date x year for NDF rates (*Table 10*).

***Table 10.** Effect of cultivar and sowing date on NDF (%)*

Years	Sowing dates	Varieties				
		Kayseri	**Magnum V**	**Gea**	**Nimet**	**Variety mean**
2015	1st sowing date	40.47	39.23	38.14	42.05	39.97
	2nd sowing date	43.27	37.57	42.06	41.22	41.03
	3rd sowing date	39.23	39.63	42.91	44.40	41.54
	Mean	40.99	38.81	41.04	42.55	40.85 [A]
2016	1st sowing date	38.58	38.33	39.50	42.27	39.67
	2nd sowing date	41.33	37.03	43.33	41.63	40.83
	3rd sowing date	37.57	38.87	41.13	43.77	40.33
	Mean	39.16	38.08	41.32	42.56	40.28 [A]
2017	1st sowing date	37.38	36.00	36.37	37.57	36.83
	2nd sowing date	36.87	35.79	36.51	37.60	36.69
	3rd sowing date	36.04	35.09	38.48	37.62	36.81
	Mean	36.76	35.63	37.12	37.59	36.78 [B]
Mean years	1st sowing date	38.81 [CD]	37.85 [DE]	38.00 [DE]	40.63 [AB]	38.82
	2nd sowing date	40.49 [B]	36.80 [E]	40.63 [AB]	40.15 [BC]	39.52
	3rd sowing date	37.61 [DE]	37.86 [DE]	40.84 [AB]	41.93 [A]	39.56
	Mean of mean	38.97 [C]	37.50 [D]	39.82 [B]	40.9 [A]	39.30
CV (%)	3.84					
LSD$_{variety}$	0.82**					
LSD$_{sowing\ date}$	ns					
LSD$_{year}$	0.70**					
LSD$_{variety\ x\ year}$	ns					
LSD$_{sowing\ date\ x\ year}$	ns					
LSD$_{variety\ x\ sowing\ date}$	1.41**					
LSD$_{variety\ x\ sowing\ date\ x\ year}$	ns					

The difference between the averages indicated by the same letter in the same group is not statistically significant, *:Significant difference at $P < 0.05$ level, **:Significant difference at $P < 0.01$ level, CV: variation coefficient, LSD: least significant difference, NS: non-significant.

Considering the different NDF rates in different cultivars, Magnum V had the lowest at 37.51%, while Nimet had the highest at 40.90%. In terms of sowing dates, there are two different statistically significant groups, and the lowest NDF rate was in the first sowing date group, while other sowing dates are in another group together. The NDF rates were 40.85, 40.28, and 36.78%, respectively, for years of 2015, 2016, and 2017. The cultivar x sowing date group values ranged between 36.80 and 42.93%. The NDF values obtained in this study were higher than those of Kanani et al. (2006) at 34.20%, lower than those of Kir (2010) at 42.68 - 44.13% and Yilmaz and Albayrak (2016) at 42.20%, and comparable to those of Engin and Mut (2017) at 40.0 - 42.9% and Geleti et al. (2014) at 36.86 - 43.53%.

The ADF and NDF rates can be altered by environmental conditions, soil, sowing date, and cultivar.

Conclusion

Throughout this study, domestic and foreign alfalfa cultivars obtained from various sources were sown in Siirt city of Turkey and the effect of sowing date and type of the cultivar over yield and other properties related to its agricultural value were investigated. Our results showed that the highest crude protein rate and yield, and the lowest ADF and NDF rates were founded in Magnum V cultivar. According to the sowing date mean values, the plant height, number of main stems, fresh herbage, and hay yields were higher from the first and second sowing dates on 10 March 2015 and 5 April 2015, respectively. Taken together, the most suitable dates to sow alfalfa in Siirt city of Turkey were the dates of 10 March and 5 April. Our results also showed that the Magnum V alfalfa cultivar is the best option for the production of herbage and high-quality hay.

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