DETERMINATION OF YIELD AND QUALITY CHARACTERISTICS OF SOME ALFALFA (*Medicago sativa* L.) CULTIVARS IN THE EAST ANATOLIA REGION OF TURKEY AND CORRELATION ANALYSIS BETWEEN THESE PROPERTIES

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Abstract. This study was conducted to determine yield and some quality features of some alfalfa cultivars for three years between 2014 and 2016 in the East Anatolian Region of Turkey and correlation analysis between these properties. In this study, sixteen different alfalfa cultivars (Verdor, Magna-601, Magnum-V, Basbag, Elci, Kayseri, Nimet, Savas, Omerbey, Ozpinar, Alsancak, Gea, Verko, Sunter, Bilensoy-80 and Gozlu-1) were used. Experiments were conducted in the randomized block design with three replications. According to the results of this study significant differences were determined in terms of plant height, green herbage yield, dry herbage yield, crude protein ratio, crude protein yield, acid detergent fiber (ADF), neutral detergent fiber (NDF), digestible dry matter (DDM), dry matter intake (DMI) and relative feed value (RFV) of alfalfa cultivars. In alfalfa cultivars, the highest green plant height, green herbage yield, dry herbage yield, crude protein yield and relative feed value were determined in Gea (54.7 cm, 3591 kg da^{-1}, 1227 kg da^{-1}, 301 kg da^{-1} and 262.1, respectively). The highest crude protein ratio was determined in Magnum-V (25.9%). The least ADF contents were obtained from Gea (18.7%) and the least NDF contents were obtained from Gea, Sunter, Nimet and Ozpinar (27.1%, 27.4%, 27.5% and 27.7%, respectively). The highest digestible dry matter was determined in Gea (74.4%). The highest dry matter intake was obtained from Gea, Sunter, Nimet and Ozpinar (4.53%, 4.52%, 4.48% and 4.45%, respectively). Also, significant correlations were found between the traits studied. As a result, Gea variety with high dry herbage and crude protein yield, low ADF-NDF ratios and high relative feed value was recommended for alfalfa culture in similar ecologies. Outside Gea; it seems that Bilensoy-80, Magna-601, Magnum-V, Omerbey, Sunter, Verdor and Verko cultivars gave results above averages and were remarkable in terms of yield and quality.
Keywords: *crude protein, hay yield, lucerne, relative feed value, Eastern Anatolia Region, ADF, NDF*

Introduction

Alfalfa (*Medicago sativa* L.) is one of the most important forage plants in the world, which has a very broad adaptability to different climatic conditions (Moreira and Fageria, 2010). Alfalfa, due to its superior forage qualities and high yields, is called "Queen of the forages" in Turkey and many countries of the world (Yuksel et al., 2016).

Feeds play a great role in animal nutrition. They provide fiber, minerals, protein and energy (Kamalak and Canobolat, 2010; Kiraz, 2011). Alfalfa, which has high protein

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content, is also a very rich source of nutrients in terms of mineral substances and many vitamins (Geren et al., 2009). Alfalfa hay has significantly high digestibility coefficients for crude fiber, organic matter, crude protein and fat compared to grasses (Sommer et al., 2005).

Alfalfa is the most widely cultivated forage crop in the world and in Turkey. There is still a need to increase alfalfa cultivated lands to make livestock activities more productive and profitable. Increasing alfalfa cultivated lands and use of high-yield and quality alfalfa cultivars with a high adaptation capacity to regional conditions over currently cultivated lands are quite significant issues. Therefore, scientific research should be conducted to identify such high-yield and quality genotypes with high adaptation capacities and research outcomes should be put into practice. With the selection of proper genotypes, farmers and producers will get higher yields per unit area and will have high quality products.

Annual green and dry herbage yields per decare are the most significant yield parameters of alfalfa. Alfalfa herbage quality is designated by crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF). ADF and NDF values represent the compounds constituting cell membrane and low values are desired for roughage quality. Low ADF and NDF values result in high digestible dry matter (DDM), dry matter intake (DMI) and relative feed value (RFV). The ratios of these parameters directly influence roughage quality (Kaplan et al., 2016).

Genotypes have quite diverse nutritional compositions, thus nutritional composition of different species should be investigated (Ulger and Kaplan, 2016). Especially ADF, NDF, crude protein and crude ash contents should be investigated to assess the nutritional composition of feedstuffs (Uke et al., 2017).

To determine these parameters, several studies has carried out in different regions of Turkey (Kusvuran et al., 2005; Demiroglu et al., 2008; Basbag, 2009; Avci et al., 2010; Saruhan and Kusvuran, 2011; Yuksel et al., 2016).

Therefore the present study was conducted to determine yield and quality parameters of sixteen alfalfa cultivars in East Anatolia Region ecological conditions, to reveal the correlation between yield and quality parameters of these cultivars and ultimately to identify the most appropriate cultivar.

Materials and methods

Study area

The study was conducted in the province of Bingol. Bingol province is located in the Eastern Anatolia Region of Turkey. The Bingol province has a surface area of 8253 km^2 and an average elevation of 1150 m. Total area of 8253 km^2 consists of 27.92% forest, 10.25% afforestation area, 7.28% agricultural land, 51.0% pasture, 2.2% meadow and 1.3% other areas. Located in the Upper Euphrates section of the Eastern Anatolia Region, Bingol is located between 41° 20' - 39° 56' east longitudes and 39° 31' - 36° 28' north latitudes (Anonymous, 2018). Bingol land is very mountainous. Steppe vegetation is seen where the forests are destroyed. The most cultivated crops in agricultural land are field crops. In field crops, most wheat and alfalfa cultivation is done.

Experiments were conducted over the experimental fields of Bingol University under irrigated conditions for three years (2014-2016). This area is 15 km away from the center of Bingol province with an average elevation of 1092 m. The study area is located between 38.81589^o north latitudes and 40.53866^o east longitudes (*Fig. 1*).

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Figure 1. *Photographs of study area*

Experimental material

This study on the adaptation of alfalfa cultivars is done for the first time in Bingol province. Bingol province is located at the transition point between Southeastern Anatolia Region and Eastern Anatolia Region. Partly cold, partly under the influence of hot climate is located. For this reason, while choosing alfalfa cultivars for adaptation study, it has been taken care to use cultivars belonging to both hot and cold regions. Another reason for the select of these alfalfa cultivars are they are widely grown in Turkey.

A total of sixteen alfalfa cultivars (Verdor, Magna-601, Magnum-V, Basbag, Elci, Kayseri, Nimet, Savas, Omerbey, Ozpinar, Alsancak, Gea, Verko, Sunter, Bilensoy-80 and Gozlu-1) were used as the plant material of the experiments. These varieties were obtained from various institutions and organizations in Turkey.

Treatments

Field experiments were conducted over deep-tilled cultivated and harrowed lands. Experiments were set on 5th of May 2014 in randomized blocks design with 3 replications. Plots were 5 m long. Sowing was performed with the aid of hand marker. Each plot had 6 rows 20 cm apart. Sowing was implemented as to have 3 kg seeds per decare. Before sowing, 4 kg nitrogen (N) and 10 kg phosphorus (P_2O_5) were applied to experimental plots. Sprinklers were used for irrigations. Irrigation intervals were 7-12 days and irrigation duration was 8 h.

Climate data

Climate data for Bingol province were supplied from General Directorate of Meteorology (*Table 1*). Long-term (2000-2015) monthly average temperature was 12.3 °C, total annual precipitation was 917.8 mm and average relative humidity was 56.6%. For the experimental years of 2014, 2015 and 2016 monthly average temperature (13.7 °C, 13.7 °C and 12.8 °C) and relative humidity (51.9%, 52.7% and 56.6%) values were close to long-term averages. However, precipitations of experimental years (757.7 mm, 801.8 mm and 832.5 mm) were lower than the long-term averages. In the months when precipitation was insufficient, irrigation was done every 7-12 days.

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Table 1. *Monthly average climate data of Bingol for 2014-2016 and long years (2000-2015)*

Months	Average temperature (°C)				Total precipitation (mm)				Relative humidity (%)			
	2014	2015	2016	Long years	2014	2015	2016	Long years	2014	2015	2016	Long years
January	-0.4	-1.8	-2.8	-2.5	143.1	148.2	235.1	154.0	71.3	74.7	75.3	73.3
February	2.0	1.9	2.4	-0.9	82.3	115.8	86.3	137.7	57.7	73.8	73.7	72.2
March	8.6	5.4	7.0	4.9	83.5	154.4	125.5	124.1	62.9	65.9	60.4	64.2
April	13.2	10.9	13.9	10.9	41.6	66.7	45.5	103.8	53.3	58.7	48.4	61.2
May	17.2	16.6	16.3	16.2	63.2	21.2	62.2	66.8	52.1	52.0	57.4	55.8
June	22.3	22.9	22.2	22.6	25.9	8.1	34.6	18.4	36.9	37.0	43.6	42.5
July	27.8	27.9	26.9	27.0	4.0	0.0	3.5	7.3	26.3	26.8	33.4	36.7
August	28.0	27.5	28.0	26.8	0.9	0.6	0.0	5.4	24.0	29.7	28.0	36.8
September	21.3	23.4	19.9	21.3	63.7	0.8	29.1	16.4	36.2	30.2	40.3	42.2
October	13.7	14.3	15.2	14.2	87.3	220.9	4.4	70.3	62.3	68.3	43.0	58.9
November	6.3	14.4	6.4	6.5	99.0	18.9	53.7	91.8	64.3	56.4	47.9	64.7
December	4.6	1.3	-2.2	0.2	63.2	46.2	152.6	121.8	75.7	58.6	73.4	70.7
Total/Ave.	**13.7**	**13.7**	**12.8**	**12.3**	**757.7**	**801.8**	**832.5**	**917.8**	**51.9**	**52.7**	**52.1**	**56.6**

Source: General Directorate of Meteorology (Bingol)

Soil structure

Bingol province agricultural soils are generally clay-loam texture, neutral or near neutral in reaction (pH), without salt, low and moderate level calcareous, low organic matter, the amount of phosphorus is insufficient and the amount of potassium is sufficient (Ates and Turan, 2015).

Soil samples were taken from 10 different locations of experimental fields from 0-30 cm depths. Samples were analyzed at Soil-Plant Analyses Laboratory of Bingol University Agricultural Faculty. Analysis results were assessed through the limiting values specified in Sezen (1995) and Karaman (2012). Experimental soils had loamy texture (43.31% saturation). Soils were slightly acidic (pH of 6.37), unsaline (0.0066%), poor in organic matter (1.26%), lime (0.15%) and potassium (24.45 kg da^{-1}) and medium in phosphorus (7.91 kg da^{-1}).

Plant harvesting

Since weeds, disease and harmful were not seen in the research area, no medication was applied. In the study, harvesting was carried out in the period when plants were 10% flowering (Manga et al., 2003).

Plant heights were measured over randomly selected 10 plants of each plot as the height from the soil surface to upper most bud. Average of 10 plants was considered as the plant height. The harvested herbage from each plot was weighed to get green herbage yields. Then, plot herbage yields were converted into yields per decare. From each green herbage harvest, 0.5 kg was dried at 70 °C for 48 h. Dried samples were weighed to get dry herbage yields of the plots. Then, these values were also converted into dry herbage

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yields per decare. Experiments were conducted for 3 years. Two cuts were performed in the first year and five cuts were performed in the second and third year.

Plant analysis

Crude protein, ADF (Acid Detergent Fiber) and NDF (Neutral Detergent Fiber) analyses were performed at laboratories of Dicle University Scientific and Technological Research Center with NIRS (Near Infrared Spectroscopy - Foss Model 6500) analysis device. With ADF and NDF ratios, digestible dry matter (DDM = 88.9-(0.779 × %ADF)), dry matter intake (DMI = 120/%NDF) and relative feed value (RFV = (DDM x DMI)/1.29) was calculated (Morrison, 2003).

Statistical analysis

Experimental data were subjected to ANOVA with JMP statistical software. Means were compared with HSD test. Correlation coefficients were calculated to determine the relationships among investigated traits (Kalayci, 2005).

Results

Green herbage and dry herbage yields (kg da^{-1})

Green herbage and dry herbage yields of sixteen alfalfa cultivars are provided in *Table 2*. The differences in green herbage and dry herbage yields of the cultivars and the years were found to be significant ($P < 0.01$).

Table 2. *Green and dry herbage yields of alfalfa cultivars*

		Green herbage yield (kg da^{-1})				Dry herbage yield (kg da^{-1})			
No	**Cultivar**	**2014**	**2015**	**2016**	**Mean**	**2014**	**2015**	**2016**	**Mean**
1	Alsancak	1502.8	3249.7	3536.3	2762.9 e**	539.8	1153.2	1362.6	1018.5 cd**
2	Basbag	1736.6	3450.0	3382.5	2856.3 de	524.1	1255.0	1340.0	1039.7 b-d
3	Bilensoy-80	1608.9	3778.6	3646.9	3011.5 c-e	550.1	1363.9	1489.0	1134.3 a-c
4	Elci	1518.5	3507.6	3689.1	2905.1 de	542.5	1350.5	1497.3	1130.1 a-c
5	Gea	1712.0	4382.6	4678.4	3591.0 a	572.7	1533.1	1576.2	1227.3 a
6	Gozlu-1	1186.9	3688.9	3330.1	2735.3 e	381.1	1252.3	1138.9	924.1 d
7	Kayseri	1322.0	3911.4	3522.8	2918.7 de	451.8	1390.9	1424.2	1089.0 a-d
8	Magna-601	1712.1	4573.3	4380.7	3555.4 ab	495.9	1633.4	1476.0	1201.8 ab
9	Magnum-V	1468.3	4022.2	4411.0	3300.5 a-d	480.6	1430.1	1472.2	1127.6 a-c
10	Nimet	1717.3	3336.0	4171.8	3075.0 b-e	563.9	1228.2	1371.7	1054.6 b-d
11	Omerbey	1571.5	4273.8	4428.9	3424.7 a-c	538.0	1507.1	1555.5	1200.2 ab
12	Ozpinar	1822.0	3249.5	3669.3	2913.6 de	597.5	1148.8	1439.5	1061.9 a-d
13	Savas	1506.2	3498.9	3722.9	2909.3 de	515.8	1198.1	1273.8	995.9 cd
14	Sunter	1455.4	4125.1	4286.7	3289.1 a-d	506.7	1454.9	1437.1	1132.9 a-c
15	Verdor	1740.1	3831.7	4229.9	3267.2 a-d	544.0	1379.4	1515.0	1146.1 a-c
16	Verko	1698.4	3882.2	3977.9	3186.2 a-e	544.6	1470.7	1454.2	1156.5 a-c
Mean		1579.9 C**	3797.6 A	3941.6 A	3106.4	521.8 C**	1359.4 B	1426.4 A	1102.5
Significant at P < 0.01, CV: 9.76%						**Significant at P < 0.01, CV: 9.14%**			

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The greatest green herbage yield was obtained from Gea cultivar and the cultivars Magna-601, Omerbey, Magnum-V, Sunter, Verdor and Verko were also placed in the same statistical group. The lowest green herbage yield was obtained from Gozlu-1 and Alsancak cultivars. Considering the green herbage yields of the years, the greatest value was obtained in 2015 and 2016 the lowest value was obtained in 2014. Three-year average green herbage yield was calculated as 3106.4 kg da^{-1}.

The greatest dry herbage yield was obtained from Gea cultivar and the cultivars Magna-601, Omerbey, Verko, Verdor, Sunter, Ozpinar, Magnum-V, Kayseri, Elci and Bilensoy-80 were also placed in the same statistical group. The lowest dry herbage yield was obtained from Gozlu-1 cultivar. Considering the dry herbage yields of the years, the greatest value was obtained in 2016 and the lowest value was obtained in 2014. Three-year average dry herbage yield was calculated as 1102.5 kg da^{-1}.

Dry herbage yield and averages obtained from the cultivars used in the research are given in *Figure 2*. It is seen that Bilensoy-80, Elci, Gea, Magna-601, Magnum-V, Omerbey, Sunter, Verdor and Verko cultivars gave results above the averages in terms of dry herbage yield.

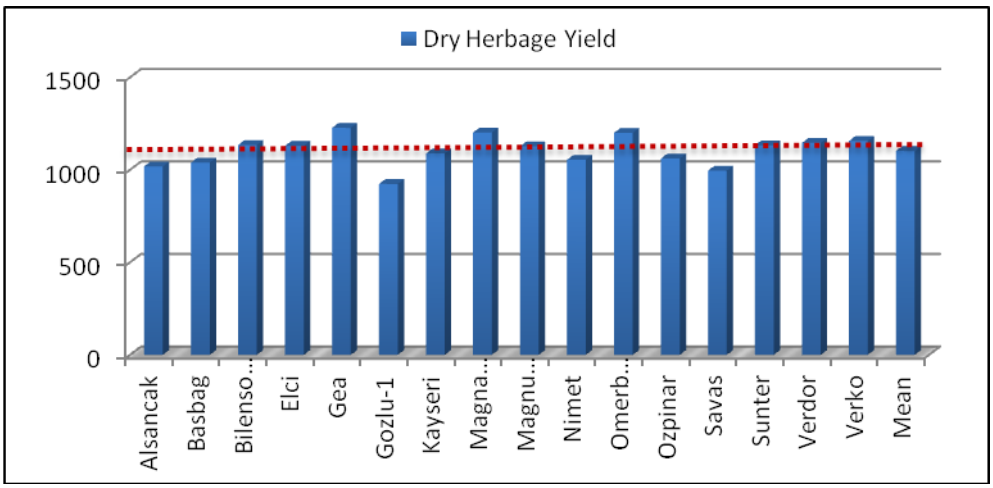

Figure 2. *Dry herbage yield of alfalfa cultivars*

Crude protein ratio (%) and crude protein yields (kg da^{-1})

Crude protein ratios and crude protein yields of sixteen alfalfa cultivars are provided in *Table 3*. While the differences in crude protein ratios of the cultivars were found to be significant at 5% level, the differences in crude protein ratio of the years, crude protein yields and crude protein yield of the years were found to be significant at 1% level.

The greatest crude protein content was obtained from Magnum-V cultivar and the lowest protein content was obtained from Elci and Basbag cultivars. With regard to crude protein contents of the years, the greatest value was observed in 2014 and the lowest value was seen in 2016. Three-year average crude protein content was calculated as 25.0%.

While the greatest crude protein yield was obtained from Gea cultivar and the lowest crude protein yield was obtained from Gozlu-1 cultivar. Considering the crude protein yields of the years, the greatest values were observed in 2016 and 2015 and the lowest

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value was seen in 2014. Three-year average crude protein yield of the cultivars was calculated as 266.2 kg da^{-1}.

Table 3. *Crude protein ratios and yields of different alfalfa cultivars*

		Crude protein ratios (%)				Crude protein yields (kg da^{-1})			
No	**Cultivars**	**2014**	**2015**	**2016**	**Mean**	**2014**	**2015**	**2016**	**Mean**
1	Alsancak	28.2	23.8	21.4	24.5 ab*	152.3	292.1	274.2	239.5 cd**
2	Basbag	26.8	23.1	22.1	24.0 b	140.5	295.7	289.5	241.9 cd
3	Bilensoy-80	29.2	24.2	22.7	25.4 ab	160.9	337.6	328.6	275.7 a-c
4	Elci	26.3	23.2	22.3	23.9 b	142.0	333.3	313.5	262.9 a-c
5	Gea	27.7	25.4	22.5	25.2 ab	158.7	355.0	389.5	301.1 a
6	Gozlu-1	28.4	23.7	22.0	24.7 ab	108.1	252.0	297.1	219.1 d
7	Kayseri	28.7	24.1	22.7	25.2 ab	129.8	323.3	335.3	262.8 a-c
8	Magna-601	27.0	24.6	23.3	25.0 ab	133.9	343.5	401.1	292.8 ab
9	Magnum-V	29.2	24.0	24.5	25.9 a	140.2	360.8	342.7	281.2 a-c
10	Nimet	29.9	23.9	22.8	25.6 ab	168.9	313.2	294.0	258.7 a-d
11	Omerbey	28.9	24.1	23.0	25.4 ab	155.9	358.8	363.3	292.7 ab
12	Ozpinar	28.1	24.0	22.3	24.8 ab	167.4	320.6	275.6	254.5 b-d
13	Savas	27.5	24.1	23.5	25.0 ab	141.4	298.8	288.2	242.8 cd
14	Sunter	28.8	24.3	22.9	25.4 ab	146.1	329.7	353.7	276.5 a-c
15	Verdor	27.1	23.5	23.5	24.7 ab	146.9	357.1	323.3	275.8 a-c
16	Verko	27.9	24.3	22.9	25.0 ab	151.9	333.5	357.1	280.9 a-c
Mean		28.1 A**	24.0 B	22.8 C	25.0	146.6 B**	325.3 A	326.7 A	266.2
*Significant at P < 0.05; **Significant at P < 0.01, CV: 4.42%						**Significant at P < 0.01, CV: 9.96%			

Crude protein yield and averages obtained from the cultivars used in the research are given in *Figure 3*. Bilensoy-80, Gea, Magna-601, Magnum-V, Omerbey, Sunter, Verdor and Verko cultivars gave results above the averages in terms of crude protein yield.

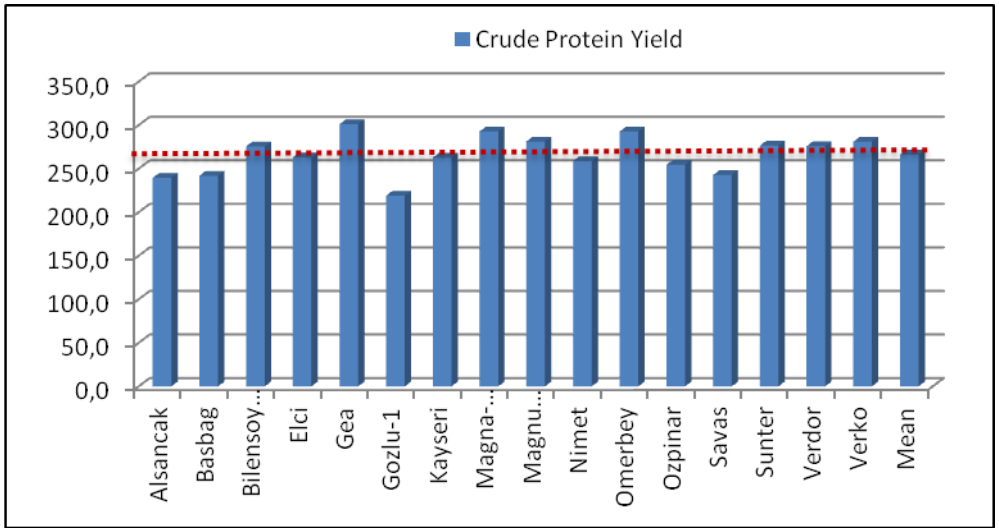

Figure 3. *Crude protein yield of alfalfa cultivars*

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Acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios (%)

Acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios of sixteen alfalfa cultivars are provided in *Table 4*. The differences in ADF and NDF of both the cultivars and the years were found to be significant at 1% level.

Table 4. *ADF and NDF ratios of alfalfa cultivars*

		ADF (%)				NDF (%)			
No	**Cultivars**	**2014**	**2015**	**2016**	**Mean**	**2014**	**2015**	**2016**	**Mean**
1	Alsancak	18.5	19.1	22.2	20.0 a-c**	23.7	28.3	33.8	28.6 ab**
2	Basbag	18.2	22.9	22.7	21.2 a-c	27.9	27.7	34.9	30.2 ab
3	Bilensoy-80	17.9	18.9	22.2	19.7 a-c	25.3	27.8	34.4	29.2 ab
4	Elci	20.0	26.5	22.5	23.0 a	30.7	31.2	34.7	32.2 a
5	Gea	15.8	18.9	21.3	18.7 c	23.6	24.8	32.8	27.1 b
6	Gozlu-1	19.5	20.9	23.2	21.2 a-c	24.7	29.4	35.8	30.0 ab
7	Kayseri	18.9	19.7	21.6	20.1 a-c	23.9	29.4	33.8	29.0 ab
8	Magna-601	19.0	22.7	22.3	21.3 a-c	26.5	28.4	34.1	29.7 ab
9	Magnum-V	19.9	21.1	20.5	20.5 a-c	24.2	29.6	32.5	28.8 ab
10	Nimet	16.5	19.0	21.9	19.1 bc	23.5	25.3	33.7	27.5 b
11	Omerbey	18.2	19.8	22.7	20.2 a-c	24.5	28.0	35.0	29.2 ab
12	Ozpinar	18.5	19.3	21.4	19.7 a-c	23.3	26.7	33.1	27.7 b
13	Savas	18.7	26.1	23.3	22.7 ab	31.4	28.3	36.0	31.9 a
14	Sunter	17.7	17.7	21.4	18.9 bc	22.2	27.0	33.1	27.4 b
15	Verdor	18.7	21.2	20.6	20.2 a-c	25.5	27.9	32.1	28.5 ab
16	Verko	18.3	19.0	21.3	19.5 a-c	24.0	27.5	33.6	28.4 ab
Mean		18.4 C**	20.8 B	21.9 A	20.4	25.3 C**	28.0 B	34.0 A	29.1
Significant at P < 0.01, CV: 11.22%						**Significant at P < 0.01, CV: 8.42%**			

While the lowest ADF ratios were observed in Gea cultivar and the greatest ADF ratios were observed in Elci cultivar. Considering the ADF ratios of the years, the greatest value was observed in 2016 and the lowest value was observed in 2014. Three-year average ADF ratio of the cultivars was calculated as 20.4%.

The lowest NDF ratio was observed in Gea, Nimet, Ozpinar and Sunter cultivars. The greatest NDF ratio was observed in Elci and Savas cultivars. Considering the NDF ratios of the years, the lowest value was observed in 2014 and the greatest value was seen in 2016. Three-year average NDF ratio of the cultivars was calculated as 29.1%.

Digestible dry matter (%) and dry matter intake (%)

Digestible dry matter (DDM) and dry matter intake (DMI) ratios of different alfalfa cultivars are provided in *Table 5*. The differences in DDM and DMI of both the cultivars and the years were found to be significant at 1% level.

The greatest DDM ratios were observed in Gea cultivar and the lowest DDM ratios were observed in Elci cultivar. Considering the DDM ratios of the years, the greatest value was observed in 2014 and the lowest value was seen in 2016. Three-year average DDM ratio of the cultivars was calculated as 73.0%.

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The greatest DMI ratios were observed in Gea, Sunter, Ozpinar and Nimet cultivars. The lowest DMI ratio was observed in Elci and Savas cultivars. Considering the DMI ratios of the years, the greatest value was observed in 2014 and the lowest value was seen in 2016. Three-year average DMI ratio of the cultivars was calculated as 4.23%.

Table 5. *DDM and DMI values of alfalfa cultivars*

		DDM (%)				DMI (%)			
No	**Cultivars**	**2014**	**2015**	**2016**	**Mean**	**2014**	**2015**	**2016**	**Mean**
1	Alsancak	74.5	74.0	71.6	73.4 a-c**	5.16	4.30	3.56	4.34 ab**
2	Basbag	74.7	71.1	71.2	72.4 a-c	4.31	4.33	3.45	4.03 ab
3	Bilensoy-80	74.9	74.2	71.6	73.6 a-c	4.75	4.35	3.49	4.20 ab
4	Elci	73.3	68.2	71.4	71.0 c	4.18	3.84	3.46	3.83 b
5	Gea	76.6	74.2	72.3	74.4 a	5.08	4.86	3.66	4.53 a
6	Gozlu-1	73.7	72.7	70.8	72.4 a-c	4.87	4.08	3.37	4.11 ab
7	Kayseri	74.1	73.5	72.1	73.2 a-c	5.04	4.09	3.56	4.23 ab
8	Magna-601	74.1	71.2	71.6	72.3 a-c	4.53	4.23	3.53	4.09 ab
9	Magnum-V	73.4	72.5	72.9	72.9 a-c	4.97	4.05	3.69	4.24 ab
10	Nimet	76.0	74.1	71.9	74.0 ab	5.12	4.76	3.56	4.48 a
11	Omerbey	74.7	73.5	71.2	73.2 a-c	4.92	4.29	3.43	4.21 ab
12	Ozpinar	74.5	73.9	72.2	73.5 a-c	5.21	4.50	3.64	4.45 a
13	Savas	74.4	68.6	70.8	71.2 bc	3.86	4.30	3.34	3.83 b
14	Sunter	75.1	75.1	72.2	74.1 ab	5.44	4.50	3.63	4.52 a
15	Verdor	74.3	72.4	72.8	73.2 a-c	4.75	4.29	3.76	4.27 ab
16	Verko	74.7	74.1	72.3	73.7 a-c	5.04	4.36	3.58	4.33 ab
Mean		74.6 A**	72.7 B	71.8 C	73.0	4.83 A**	4.32 B	3.54 C	4.23
Significant at P < 0.01, CV: 2.44%						**Significant at P < 0.01, CV: 8.82%**			

Relative feed value and plant heights (cm)

Relative feed values (RFV) and plant heights of different alfalfa cultivars are provided in *Table 6*. The differences in RFV and plant heights of both the cultivars and the years were found to be significant at 1% level.

The greatest RFV was observed in Gea cultivar and the lowest RFV was observed in Elci and Savas cultivars. Considering the RFV of the years, the greatest value was observed in 2014 and the lowest value was seen in 2016. Three-year average RFV of the cultivars was calculated as 240.1.

The greatest plant height was observed in Gea cultivar and the lowest value was observed in Savas cultivar. Considering the average plant heights of the year, the greatest value was observed in 2016 and the least value was seen in 2014. Three-year average plant height was calculated as 50.6 cm.

Relative feed values and averages obtained from the cultivars used in the research are given in *Figure 4*. Alsancak, Gea, Kayseri, Nimet, Ozpinar, Sunter, Verdor and Verko cultivars gave results above the averages in terms of relative feed value.

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Table 6. *RFV and plant heights of alfalfa cultivars*

		RFV				Plant heights (cm)			
No	**Cultivars**	**2014**	**2015**	**2016**	**Mean**	**2014**	**2015**	**2016**	**Mean**
1	Alsancak	297.6	246.0	197.6	247.1 ab**	38.2	54.4	57.9	50.1 a-c**
2	Basbag	249.6	238.6	190.6	226.3 bc	39.3	46.7	55.9	47.3 cd
3	Bilensoy-80	276.1	250.1	193.9	240.0 a-c	42.3	53.3	58.4	51.3 a-c
4	Elci	237.0	203.7	191.5	210.7 c	43.7	52.1	58.3	51.4 a-c
5	Gea	301.5	279.7	205.0	262.1 a	41.7	59.8	62.7	54.7 a
6	Gozlu-1	278.4	229.9	185.6	231.3 a-c	43.7	51.9	59.8	51.8 a-c
7	Kayseri	289.8	233.1	198.9	240.6 a-c	43.2	57.5	61.4	54.0 ab
8	Magna-601	260.1	233.3	195.9	229.8 a-c	43.2	51.9	57.5	50.8 a-c
9	Magnum-V	282.6	227.6	208.7	239.6 a-c	47.2	45.5	52.4	48.4 c
10	Nimet	301.7	273.6	198.5	257.9 ab	38.8	53.1	52.5	48.1 c
11	Omerbey	285.1	244.6	189.6	239.8 a-c	40.8	49.4	56.5	48.9 bc
12	Ozpinar	300.3	257.3	204.3	254.0 ab	42.5	52.4	57.9	50.9 a-c
13	Savas	222.5	229.0	183.2	211.6 c	36.2	39.1	50.4	41.9 d
14	Sunter	316.4	261.5	203.1	260.3 ab	43.1	57.1	62.4	54.2 ab
15	Verdor	273.6	240.9	212.3	242.3 a-c	45.3	55.1	58.4	52.9 a-c
16	Verko	291.6	250.7	200.5	247.6 ab	42.6	55.0	61.0	52.9 a-c
Mean		279.0 A**	243.7 B	197.4 C	240.1	42.0 C**	52.1 B	57.7 A	50.6
Significant at P < 0.01, CV: 8.96%						**Significant at P < 0.01, CV: 6.77%**			

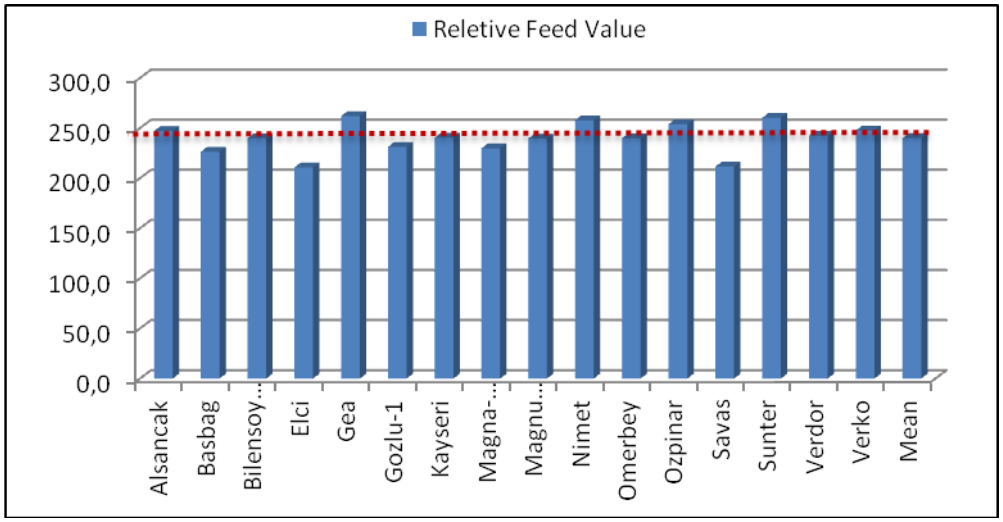

Figure 4. *Relative feed value of alfalfa cultivars*

Correlations among investigated traits

Correlation coefficients among investigated traits of sixteen alfalfa cultivars are provided in *Table 7*. Plant height had highly significant positive correlations with green herbage yield, dry herbage yield, crude protein yield, ADF and NDF ratio and had highly significant negative correlations with crude protein ratio, DDM, DMI and RFV.

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Table 7. *Correlations coefficients among investigated traits*[+]

	GHY	DHY	CPR	CPY	ADF	NDF	DDM	DMI	RFV
PH	0.774**	0.794**	-0.751**	0.758**	0.318**	0.595**	-0.318**	-0.609**	-0.606**
GHY		0.972**	-0.805**	0.947**	0.409**	0.575**	-0.409**	-0.620**	-0.634**
DHY			-0.831**	0.945**	0.434**	0.592**	-0.434**	-0.632**	-0.649**
CPR				-0.771**	-0.515**	-0.809**	0.515**	0.827**	0.837**
CPY					0.402**	0.521**	-0.402**	-0.563**	-0.581**
ADF						0.508**	-1.000**	-0.496**	-0.618**
NDF							-0.508**	-0.986**	-0.977**
DDM								0.496**	0.618**
DMI									0.989**

+ Correlations coefficients for 2014, 2015 and 2016, **significant at $P < 0.01$
PH = Plant Height, GHY = Green Herbage Yield, DHY = Dry Herbage Yield, CPR = Crude Protein Ratio, CPY = Crude Protein Yield, ADF = Acid Detergent Fiber, NDF = Neutral Detergent Fiber, DDM=Digestible Dry Matter, DMI=Dry Matter Intake, RFV=Relative Feed Value

Green herbage yield had highly significant positive correlations with dry herbage yield, crude protein yield, ADF and NDF, and had significant negative correlations with crude protein ratio, DDM, DMI and RFV. Dry herbage yield had highly significant positive correlations with crude protein yield, ADF and NDF, and had highly significant negative correlations with crude protein ratio, DDM, DMI and RFV. Crude protein ratio had highly significant positive correlations with DDM, DMI and RFV, and had highly significant negative correlations with crude protein yield, ADF and NDF. Crude protein yield had highly significant positive correlations with ADF and NDF, and had highly significant negative correlations with DDM, DMI and RFV.

ADF had highly significant positive correlations with NDF, and had highly significant negative correlations with DDM, DMI and RFV. NDF had highly significant negative correlations with DDM, DMI and RFV. DDM had highly significant positive correlations with DMI and RFV and there were highly significant correlations between DMI and RFV.

Discussion

Precipitation and temperature may result in significant differences in yields of the years (Luo et al., 2016). Regional climate, soil conditions, plant genetics, sowing time and cultural practices significantly influence dry matter yield and green herbage yields (Seydosoglu, 2014). Green herbage yields were reported as between 931-11843 kg da^{-1} (Seker, 2003; Kusvuran et al., 2005; Kir and Soya, 2006) and dry herbage yields were reported as 225-3287 kg da^{-1} (Sengul et al., 2003; Seker, 2003; Kusvuran et al., 2005; Kir and Soya, 2006; Demiroglu et al., 2008; Avci et al., 2010; Saruhan and Kusvuran, 2011) for alfalfa genotypes. Green and dry herbage yields varied based on number of cuts, ecological conditions, genetics structure and thus different values were reported in different studies.

Ball et al. (2001) indicated that variations dry matter and protein contents mostly resulted from genetic differences and that these parameters commonly varied based on leaf and shoot ratios, ripening period, temperature and fertilization practices. Crude protein ratios were reported as between 15.95-28.09% (Sengul et al., 2003; Kir and

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Soya, 2006; Basbag et al., 2009; Canbolat and Karaman, 2009; Avci et al., 2010; Kiraz, 2011; Saruhan and Kusvuran, 2011; Cacan et al., 2015). Crude protein yields were reported as between 34-321 kg da^{-1} (Sengul et al., 2003; Kir and Soya, 2006). Present crude protein ratios and crude protein yields were slightly higher than those earlier findings. Higher crude protein ratios are due to differences in the varieties used. The difference in crude protein yields is due to differences in hay yields of alfalfa varieties. With regard to crude protein content, all cultivars were placed in the best quality group (Rohweder et al., 1978).

ADF and NDF ratios are significant quality indicators of forage crops (Aydin et al., 2010) and such ratios should be low in quality forage since they obstruct the digestibility and consequently decrease the quality of forage. Since high ADF and NDF ratios have negative effects on feed intake and digestibility, the feeds with ideal ADF and NDF values are usually preferred (Kiraz, 2011). ADF ratios of some alfalfa clones were reported as between 16.8-41.0%, NDF ratios as between 20.3-49.0% (Basbag et al., 2009; Canbolat and Karaman, 2009; Avci et al., 2010; Kiraz, 2011; Cacan et al., 2015), DDM ratios as between 56.9.0-75.8%, DMI ratios as between 2.46-5.90% (Basbag et al., 2009; Canbolat and Karaman, 2009; Avci et al., 2010; Kiraz, 2011; Cacan et al., 2015) and RFV as between 127.0-347 (Basbag et al., 2009; Canbolat and Karaman, 2009; Kiraz, 2011; Cacan et al., 2015). With regard to ADF and NDF ratios, all cultivars were placed in the best quality group (Rohweder et al., 1978).

As the plant ages, the proportion of ADF and NDF compounds forming the cell wall also increases (Uke et al., 2017). Therefore, the rates of ADF and NDF are steadily increasing in 2015 and 2016. This situation, directly affects the DDM, DMI and RFV rates, which tend to be lower as years go by. Also, according to the quality standards reported by Lacefield (1988), in terms of crude protein (above 19%), ADF (below 31%), NDF (below 40%), DDM (above 65%), DMI (above 3%) and RFV (above 151) values, alfalfa cultivars appear to be in group “prime”.

In previous studies, plant heights were reported as between 49.7-86.8 cm (Seker, 2003; Kusvuran et al., 2005; Kir and Soya, 2006; Demiroglu et al., 2008; Basbag, 2009; Yesil and Sengul 2009; Saruhan and Kusvuran, 2011). Since Bingol province has a colder ecology, present findings were slightly lower than those earlier findings. As the years progress, the height of the plant seems to increase. This situation parallels directly with the increase of herb yields over the years.

Conclusion

The results revealed that the greatest plant height, green herbage and dry herbage yield was obtained from Gea cultivar, the greatest crude protein ratio was obtained from Magnum-V cultivar, the greatest crude protein yield from Gea cultivar, the lowest ADF ratio from Gea cultivar, the lowest NDF ratio from Gea, Nimet, Ozpinar and Sunter cultivars, the greatest DDM from Gea cultivar, the greatest DMI from Gea, Nimet, Ozpinar and Sunter cultivars and the greatest RFV from Gea cultivar.

The most important yield parameter in alfalfa cultivation is dry herbage yield. Therefore, the cultivars with high dry herbage yields should be selected in cultural practices. It is also critical that the herbage should also have a high protein yield, low ADF and NDF ratios and high digestibility. Considering all these values, Gea cultivar with high dry herbage and crude protein yield, low ADF-NDF ratios and high relative feed value was recommended for alfalfa culture. Outside Gea; it seems that Bilensoy-

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80, Magna-601, Magnum-V, Omerbey, Sunter, Verdor and Verko cultivars gave results above averages and were remarkable in terms of yield and quality.

In addition, significant correlations were found between yield and quality attributes in the study. As the years progress, the dry herbage yield and crude protein yield obtained from alfalfa cultivars is increasing and the relative feed value is decreasing as it is inversely proportional to this.

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