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Yield and quality characteristics of alfalfa (*Medicago sativa* L.) cultivars

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A B S T R A C T

The aim of the research was to determine the forage yield and quality of alfalfa (*Medicago sativa* L.) cultivars. As research materials, five alfalfa cultivars were used, including domestic Albatur and Bilensoy in addition to cultivars Gea, Planet and Verko of foreign origin. The investigation was evaluated under Isparta and Kırşehir conditions in the 2015-2017 growing seasons. Plots were established in a randomized complete block design with 4 replicates in both locations. Five cuttings were done during the 2016 and 2017. Average values of all parameters examined are as follows: DMY-2182 kg da^{-1}, CP-20.21%, ADF-33.18%, NDF-41.43%, ADL, 7.97%, TDN-63.06%, RFV-142%. As average of two years, the highest dry matter yield was obtained from cultivar Albatur in both locations. Results of stability analysis, it was found that Albatur the most stable cultivar in terms of dry matter yields.

1. Introduction

Alfalfa (*Medicago sativa* L.) is a high quality forage used worldwide. The superiority of alfalfa lies in its high yield, high protein content and high digestibility. It is considered by researchers as the 'queen of forages' (Dale et al. 2012). Alfalfa is widely grown on 35 million hectares worldwide and is the most important forage in Turkey with 700.000 hectares grown. Since alfalfa is a perennial plant and it is a lot of cutting, the amount of forage obtained is higher than other forage crops.

The climatic and soil conditions of the region in which it is planted directly affect the yield and quality of alfalfa (Albayrak et al. 2018). According to the results obtained from different researches on alfalfa; DMY varied from 873 to 1610 kg/da (Altınok and Karakaya, 2002; Kır, 2010; Albayrak and Türk, 2013). CP varied from 17.28-24.36% (Kavut and Avcıoğlu 2015; Albayrak et al. 2014, Kertikova et al. 2014). ADF contents differed in studies conducted in different ecologies with different alfalfa cultivars (Malushi et al. (2017) 31.40%, Yüksek et al. (2016) 31.33-34.92, Ahmad et al. (2016) 28.74-35.71%). NDF contents were determined 26.70-46.81% depending on different ecological regions and varieties in alfalfa. (Malushi et al. 2017; Sulc et al. 2017; Yüksek et al. 2016).
The aim of the study was to determine of forage yield and quality features of some alfalfa cultivars in Mediterranean and Central Anatolia region conditions.

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2. Materials and Method

The research was conducted during the 2015-2017 growing seasons in Isparta Province (37°45' N, 30°33' E; elevation 1035 m) and Kırşehir Province (39°35' N, 34°44' E; elevation 1089 m). Soil types were clay or clay loam, slightly alkaline (pH, 7.5–7.8), rich in potassium (710–930 kg ha^{-1}), poor to medium in phosphorus (70-75 kg ha^{-1}) and containing 1.5-1.6% organic matter. The climate data of the experiments are given in Table 1.

Albatur, Bilensoy, Gea, Planet and Verko alfalfa (*Medicago sativa* L.) cultivars were used as materials in the research. Each plot was of 8 rows, each 5 m in length. The row spacing was 20 cm. The seeding rates were 20 kg ha. The plots were fertilized in establishment year using DAP (18% N and 46% P) at 100 kg ha. The plots were irrigated once after each harvest. Plots were cut five times each year. The harvest time was based on the 10% flowering stage of alfalfa. The plots were not harvested in the year of establishment (March, 2015). After the harvest, samples were dried at 70 °C for 48 h, and weighed. The crude protein (CP) content was calculated by multiplying the Kjeldahl nitrogen concentration by 6.25 (Kacar and Inal, 2008). The acid detergent fiber (ADF), neutral detergent fiber (NDF) and the acid detergent lignin (ADL) contents and total digestible nutrient (TDN) were determined according to methods from Ankom Technology (Komarek, 1993). The relative feed value (RFV) was estimated according to the following equation adapted from Albayrak and Turk (2013): RFV = [120/NDF]×[88.9 – (0.779 ×ADF)] × [0.775].

The trial was conducted in a randomized complete block design with 4 replications both locations. A split plot design was used for unified analysis of the 2 years (Table 2). The statistical analysis of the yield and quality data was performed using the SAS general linear model procedure (SAS Institute, 1998). The means were compared using LSD test at the 0.05 probability level. For stability analysis in dry matter yield, proc REG process was applied. Average yield (x), regression coefficient (b), regression constant (a), coefficient of variation (CV), coefficient of determination (r2) and deviation from regression (S2d) were used as stability parameters to determine the alfalfa cultivars (Albayrak and Sevimay, 2005).

3. Results

The results of the variance analysis showed that the effects of the cultivars on the dry matter (DM) yield were significant both Isparta and Kırşehir locations (Table 2). Cultivars and years were significant for the CP content. Differences in ADF concentrations occurred between the years only Kırşehir location. Cultivars and years were significant for the NDF content in Isparta. Only differences for NDF were determined between cultivars in Kırşehir.

There was no statistically difference between the ADL contents of cultivars. The effects of cultivars in Isparta location and years in Kırşehir location were found to be statistically significant for TDN. RFV was affected by year and cultivars in both locations (Table 2).

In stability analysis, cultivars Albatur, Gea and Bilensoy had DMY above the general average, while cultivars Planet and Verko showed the lower yield value as the overall average (Table 4). The closest cultivar to the regression line was found as Albatur.

Table 1. Total monthly precipitation and mean temperature of locations during the growing seasons of 2016 and 2017 with long-term averages.

	Precipitation (mm)			Temperature (°C)		
	LT*	2016	2017	LT*	2016	2017
ISPARTA						
March	52.9	70.5	63.4	5.90	6.1	6.4
April	58.8	26.1	38.6	10.6	10.8	11.5
May	46.0	41.8	56.8	15.5	14.7	16.4
June	31.5	92.2	30.2	20.7	20.8	21.7
July	14.5	3.0	12.4	23.5	22.6	24.8
August	10.7	43.4	15.8	22.2	23.7	24.2
September	16.9	20.8	19.4	18.6	17.6	18.9
Total/mean	231.3	297.8	236.6	16.7	16.6	17.7
KIRŞEHİR						
March	37.4	89.0	32.4	5.50	6.9	5.8
April	45.7	26.8	25.6	10.7	8.8	10.7
May	44.1	54.8	45.8	15.4	16.4	16.5
June	36.8	60.4	42.7	19.7	18.9	18.8
July	15.3	16.8	16.7	23.7	22.5	23.7
August	9.8	13.7	5.9	22.6	23.7	23.4
September	29.7	37.2	31.4	17.4	16.5	18.7
Total/mean	218.8	298.7	200.5	16.4	16.2	16.8

LT: long-term (1951–2015).

Table 2. Results of variance analysis and mean squares of dry matter yield (DMY), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), total digestible nutrient (TDN) and relative feed value (RFV) treatments in combined years (2016-2017)

Coefficients of variation	df	DMY	CP	ADF	NDF	ADL	TDN	RFV
ISPARTA								
Block	3	9005	1.52	9.57*	1.58	0.21	5.80*	6.83
Cultivar	4	251392**	7.10**	6.78	8.72**	0.20	4.11	224**
error1	12	10996	1.58	2.12	1.39	0.16	1.23	35.26
year	1	14848	5.69*	8.31	13.09*	0.41	5.04	297*
Year x cultivar	4	3654	0.26	0.94	0.64	0.02	0.57	7.96
error 2	15	13489	1.27	5.97	2.88	0.28	3.62	52.51
KIRŞEHIR								
Block	3	26858	1.30	2.56	0.55	0.04	1.55	5.02
Cultivar	4	23280**	8.77**	3.98	10.69*	0.13	2.41	202**
error1	12	9522	0.98	2.19	2.29	0.20	1.33	31.27
year	1	21060	17.37**	7.26*	4.95	1.09	4.38*	148*
Year x cultivar	4	3171	0.27	0.24	0.14	0.14	0.15	2.85
error 2	15	7776	1.68	0.93	1.65	0.28	0.56	26.19

df = degrees of freedom, *P < 0.05 and **P < 0.01.

4. Discussion

The highest DMY both Isparta and Kırşehir locations were determined Albatur cv. (2468 and, 2351 kg da^{-1}, respectively). DMY yields of other cultivars varied from 2343-1952 kg da^{-1}. Dry matter yield in alfalfa, cultivar (Avcıoğlu et al., 1989; Şengül et al., 1992), leaf / stem ratio (Popovic et al., 2001), climate (Mohammed, 2008), soil characteristics (Demiroğlu et al., 2008), cutting time (Shroyer et al., 1984) etc., are influenced by many factors. DMY in alfalfa are 873-1205 kg da^{-1}in Central Anatolia (Altınok and Karakaya, 2002), 1131-1518 kg da^{-1} in the Black Sea region (Kır, 2010) and 1480-1610 kg da^{-1} in the Mediterranean conditons (Albayrak and Türk, 2013) reported by different researchers. It can be said that the similarities / differences in the results of the research are due to the variety of variations used in these trials and the ecological conditions in which the trials were carried out, especially the total precipitation and temperature differences falling during vegetation and irrigation (Yılmaz and Albayrak, 2016).

The studied cultivars differed significantly in crude protein content. Cultivars Albatur, Gea and Bilensoy had higher crude protein contents than cultivars Planet and Verko in both locations (Table 3). In present study, CP contents of cultivars varied from 21.79 to 18.22 %. In studies conducted in different ecologies, crude protein ratios have been reported to change in alfalfa (Kavut and Avcıoğlu (2015) 19.83-20.11%, Albayrak et al. (2014) 18.69%, Kertikova et al. (2014) 17.28-24.36%, Öten (2014) 17.52%, Aioanei and Pop (2013) 16.02-17.01% Cinar (2012) 20.60%). Our findings are generally similar to those of the above mentioned researchers. Nevertheless, it should be kept in mind that the varieties and ecological factors as well as the changes in the harvest time, were effective factors in the change of the crude protein content of alfalfa (Albayrak et al., 2018).

In both locations, the ADF contents of alfalfa cultivars varied from 31.72 to 34.22 5 and there was not found statistically difference between them. ADF contents differed in studies conducted in different ecologies with different alfalfa cultivars (Malushi et al. (2017) 31.40%, Yüksek et al. (2016) 31.33-34.92, Ahmad et al. (2016) 28.74-35.71%, Min (2016) 27.70% -35.2, Jafrarian et al. (2016) 30.60-33.70%, Karayılanlı and Ayhan (2016) 35.34%). It has been stated that there are significant differences between the ADF contents in alfalfa and this may have an effect on the genetic factors as well as the cutting time (Katic et al. 2008).

Cultivars Albatur and Gea had lower NDF contents than cultivars Bilensoy, Planet and Verko in both locations (Table 3). In present study, NDF contents of cultivars varied from 40.06 to 43.22 %. NDF contents were determined 26.70-46.81% depending on different ecological regions and varieties in alfalfa. (Malushi et al. 2017; Sulc et al. 2017; Yüksek et al. 2016; Ahmad et al. 2016). The average NDF contents obtained in our study were higher than the results reported by some researchers and lower than others. Our research findings are generally similar to the results of the researchers mentioned above. In addition to this, it is stated that the varieties and ecological factors used in alfalfa are the most effective factors in changing the NDF ratio of the herbage in the changes in harvest time (Rimi et al. 2012).

ADL content of alfalfa cultivars in both locations was found between 8.14-7.76% (Table 3). Results for

ADL content of alfalfa hay, were within the range found in the literature from 4.0 to 7.40% (Malushi et al. 2017; Sulch et al. 2017; Boziskovic et al. 2014;

Table 3. Dry matter yield (DMY), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), total digestible nutrient (TDN) and relative feed value (RFV) of alfalfa cultivars (average of 2years).

	DMY (kg da^{-1})	CP (%)	ADF (%)	NDF (%)	ADL (%)	TDN (%)	RFV (%)
ISPARTA							
Albatur	2468 a	21.79 a	31.72	40.06 b	7.76	64.19	149 ab
Gea	2343 b	21.26 ab	32.02	39.81 b	8.04	63.96	150 a
Bilensoy	2255 b	21.01 ab	33.16	41.09 a	8.09	63.07	143 bc
Planet	2084 c	20.17 bc	33.05	41.96 a	7.80	63.16	140 c
Verko	2043 c	19.40 c	33.99	42.06 a	8.05	62.42	138 c
CV %	5.19	5.45	7.45	4.14	6.68	3.01	5.03
KIRŞEHİR							
Albatur	2351 a	20.99 a	32.55	40.43 c	7.79	63.55	146 a
Gea	2119 c	20.03 ab	33.18	40.91 bc	8.14	63.06	144 ab
Bilensoy	2233 b	20.04 ab	33.73	42.40 ab	8.06	62.63	138 bc
Planet	1952 d	19.15 bc	34.16	43.22 a	8.04	62.30	134 c
Verko	1972 d	18.22 c	34.22	42.37 ab	7.95	62.25	136 c
CV %	4.15	6.59	2.87	3.07	6.60	1.20	3.67

Means in the same columns are not significantly different at the P = 0.05 level, CV% = coefficient of variation,

Kertikova et al. 2004). The average ADL rates obtained in our study were higher than the results reported by some researchers and lower than others. Ecological differences and cultivars can cause the difference.

The TDN refers to the nutrients that are available for livestock. This variable is related to the ADF concentration of the forage. As ADF increases, TDN declines. As a result, animals are unable to utilize the nutrients that are present in the forage (Albayrak et al., 2011). In present study, the alfalfa cultivars had TDN content in the range of 64.19 to 62.25 % (Table 3). Forages with an RFV of over 151, 150–125, 124–103, 102–87, 86–75, and less than 75 are categorized as prime, premium, good, fair, poor, and rejected, respectively (Albayrak and Türk, 2013). Based on the average of the 2 years and locations, the alfalfa cultivars had relative feed values ranging from 150-134 and, thus, may be categorized as premium quality.

In order for a variety to be stable, it is reported that the regression coefficient (b) should be close to 1, the regression constant (a) should be positive, the coefficient of determination (r2) should be high, coefficient of variation (CV) and the deviation from the regression (S2d) should be low (Albayrak and Sevimay, 2005). DMY of cultivar Albatur is high and b value is close to 1 (Table 4).

Table 4. Values related to stability parameters of alfalfa cultivars for total dry matter yield

Cultivars	X mean	b	a	r^2	CV	S^2d
Albatur	2410	1.03	158.13	0.89	1.22	867
Gea	2230	1.84	-1796.17	0.90	2.28	2592
Bilensoy	2244	0.27	1661.59	0.48	1.07	572
Planet	2017	1.22	-654.60	0.98	0.76	235
Verko	2008	0.63	631.19	0.99	0.08	2.51

5. Conclusion

According to present study results; cultivar Albatur had the highest dry matter yields 2468 and 2351 kg da in Isparta and Kırşehir respectively. The lowest dry matter yield was obtained from Planet and Verko cultivars in both locations. Albatur, Gea and Bilensoy had higher CP contents than Planet and Verko. Albatur and Gea had the lowest NDF contents.

ADF, ADL and TDN values of cultivars were found to be similar to each other. All cultivars were in premium group in terms of RFV value. According to the results of the stability analysis, Albatur was found to be the most stable cultivar in terms of dry matter yield.

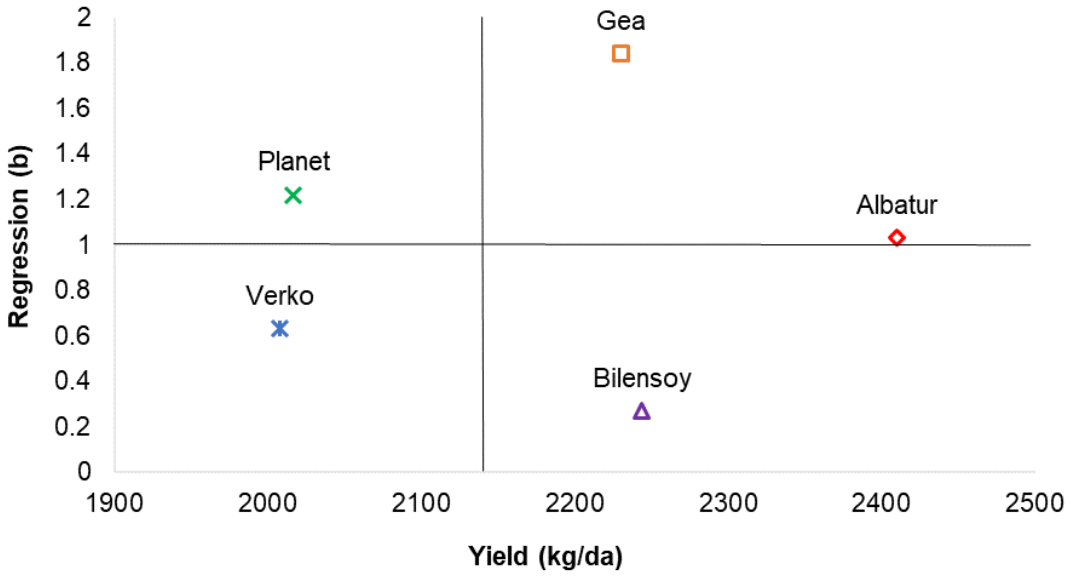

Figure 1. Stability statues of alfalfa cultivars according to DMY and regression coefficient.

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