



Determining the performance of alfalfa population collected from a narrow agroecological zone of Turkey

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ABSTRACT: *This study was carried out to determine the yield and quality characteristics of some alfalfa village populations cultivated by producers in Bingol province of Turkey. Alfalfa seeds were obtained from 23 different locations in 2015. A three replicated, randomised complete block designed field trial was established in 2016 including these genotypes and four registered varieties. As a result of three year trials, it was determined that the populations obtained from the villages of Servi, Mutluca, Garip, Sarıçiçek-1 and Bağlıisa produced highest green herbage and hay yields. When we compare the quality results, Kumgecit, Küçüktekören and Şenköy-1 populations stands out in terms of crude protein ratio. Highest crude protein yield was obtained from Servi population. In terms of relative feed value, it was observed that the varieties were better qualified than the populations. It is concluded that the populations of Servi, Mutluca, Garip, Sarıçiçek-1 and Bağlıisa can be used in breeding studies especially to obtain genetic progress in yield of alfalfa for feed and bioenergy production. For the genetic improvement of current genotypes with higher crude protein ratio, Kumgecit, Küçüktekören and Şenköy-1 populations can be used as a source. This study showed that, East Anatolia region is not just live-conserving highly diversified species but also covering special intra-species genetic diversity in microclimatic zones of Turkey to be used to improve the global forage and bioenergy crop production.*

Key words: *Medicago sativa L. alfalfa, population, yield, quality, Anatolia.*

Determinação da população de alfafa coletada em uma estreita zona agroecológica da Turquia

RESUMO: *Este estudo foi realizado para determinar as características de rendimento e qualidade de algumas populações de alfafa cultivadas por produtores na província de Bingol, na Turquia. As sementes de alfafa foram obtidas de 23 locais diferentes em 2015. Em 2016, foi estabelecido um ensaio de campo com três repetições, aleatórias e desenvolvido em bloco, incluindo esses genótipos e quatro variedades registradas. Com o resultado de testes de três anos, determinou-se que as populações obtidas nas aldeias de Servi, Mutluca, Garip, Sarıçiçek-1 e Bağlıisa produziam maiores colheitas de forragem verde e feno. Quando comparamos os resultados de qualidade, as populações Kumgecit, Küçüktekören e Şenköy-1 se destacam em termos de proporção de proteína bruta. O maior rendimento de proteína bruta foi obtido da população de Servi. Em termos de valor relativo de ração, observou-se que as variedades eram mais qualificadas do que as populações. Conclui-se que as populações de Servi, Mutluca, Garip, Sarıçiçek-1 e Bağlıisa podem ser utilizadas em estudos de melhoramento, especialmente para obter progresso genético no rendimento de alfafa para produção de ração e bioenergia. Para o aprimoramento genético dos genótipos atuais com maior proporção de proteína bruta, as populações Kumgecit, Küçüktekören e Şenköy-1 podem ser usadas como fonte. Este estudo mostrou que, a região da Anatólia Oriental não é apenas espécies altamente diversificadas conservadoras de vida, mas também abrange diversidade genética intraespécie especial em zonas microclimáticas da Turquia, a ser usada para melhorar a produção global de forragem e bioenergia.*

Palavras-chave: *Medicago sativa alfafa, população, rendimento, qualidade, Anatólia.*

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is a widely cropped legume forage for hay, pasture and silage production throughout the World (LI & BRUMMER, 2012). It provides significant habitat to a wide range of wildlife, including beneficial insects. It improves yields and reduces nitrogen fertilizer needs for subsequent crops. Alfalfa also helps to remediate soil and water contamination (PUTNAM et al., 2001).

Alfalfa also has considerable potential as a feedstock for production of ethanol due to its high biomass production, perennial nature, ability to provide its own nitrogen fertilizer and valuable co-products. Its stems are an excellent feedstock for cellulosic ethanol via fermentation or gasification (MARTIN et al., 2010). The stems has a potential as biomass energy crops especially in temperate regions where their bioconversion potential is high as an energy crop (DIEN et al., 2006). Alfalfa has been considered as

a biofuel feedstock where a system has been proposed to produce electricity from the stems following utilization of the leaves as a livestock feed (SHEAFFER, 2000).

Increasing forage yield is main priority for most alfalfa breeding programs, but yield trends has stagnated over the past two decades (RIDAY & BRUMMER, 2002). Currently, alfalfa breeding relies on recurrent phenotypic selection (LI & BRUMMER, 2012). Alfalfa cultivars are synthetic populations formed from 8 to 200 parents and have a broad genetic base. In the study of JULIER et al. (2000), when intra-cultivar variation was compared with among-cultivars for energy value traits, morphological traits and dry matter yield, variance accounted for 31 to 70% of the genetic variance for leaf-to-stem ratio and quality traits and 57 to 100% for morphological traits and dry matter yield. Researches informed that large intra-cultivar variation for yield-related traits could impart yield stability across environments by competition in alfalfa canopies and cultivar variation could be an additional source of genetic variation in breeding programs for quality traits to achieve a higher genetic gain per breeding cycle (JULIER et al., 2000).

The most cultivated feed crop in Turkey is also alfalfa. Since this species is perennial, well adapted to different conditions, mowable multiple times in a single year vegetation period, good rotation crop, in between with its high hay yield and quality (SOYA et al., 2004; AVCIOGLU et al., 2009).

SARUHAN & KUSVURAN, (2011) determined that the yield performance of some alfalfa genotypes in Southeast Anatolia Region conditions of Turkey was at good levels. They determined green grass yield at 35.1-19.0 t/ha, hay yield at 9.4-12.6 t/ha, the ratio of crude protein at 17.9-22.3%. To determine the yield of some alfalfa genotypes in Mediterranean climatic conditions in Turkey, KAVUT et al. (2014) carried out a field trial and obtained 95.2-118.9 t/ha green grass yield, and 20.3-27.1 t/ha hay yield. In the study of OTEN & ALBAYRAK (2018), which examined the quality characteristics of 26 alfalfa genotypes collected from South-West natural flora of Anatolia, the average crude protein ratio was 15.8%, the ADF (acid detergent insoluble fiber) rate was 36.7% and the NDF (neutral detergent insoluble fiber) rate was 47.2%.

In other important grass production zone of Turkey, in East Anatolia, alfalfa is covering 7.392 ha solely in Bingol province, with 292.000 tons production and 39.5 t/ha green grass yield (TURKSTAT, 2019). Alfalfa hay yield differs among regions in Turkey where is 2.5-3.0 t/ha in rainfed, 5.0-25.0 t/ha in irrigated conditions (SOYA et al., 2004; AVCIOGLU et al., 2009). Since the main

source of income in Bingol province of Turkey is animal husbandry, alfalfa cultivation has a long history. Alfalfa cultivation in Bingol is mostly carried out by population seeds.

The purpose of this study was to determine the yield and quality characteristics of some alfalfa populations in Bingol with the aim to utilise them in breeding programmes.

MATERIALS AND METHODS

Research field was located in Bingöl province, Genc subprovince of Turkey. Altitude of the field was 986 m and located at 38.749460 North latitude and 40.536780 East longitude coordinates. In 2015, seeds of local alfalfa populations were obtained from farmers in the villages of Bingol. A total of 23 local genotypes were collected.

The trials was conducted in Bingol University research fields. The research area is located at 38.749460 North latitude and 40.536780 East longitude coordinates (Figure 1). Long term (1990-2015) average temperature is 12.3 °C, precipitation is 917.8 mm and humidity is 56.6% in Bingol. July and August are the months with highest temperature with lowest rainfall and humidity. Most of the precipitation realises in winter period (Table 1).

Long yers (1961-2018) average climatic records obtained from Bingöl Provincial Meteorological Center indicates that average air temperature of the trial location is 12.1 °C and precipitation is 943.3 mm (ANONYMOUS, 2019).

Soil samples obtained from trial field were analysed in University of Bingol Soil Analysis Laboratory. For the evaluation of the analysis results, limit values determined by of SEZEN (1995) was used as base. Soil of research area is sandy-clayey-loam structured (59.5% sand, 18.2% clay, 22.3% loam), has neutral pH ratio (7.26), medium organic matter (2.1%), low phosphorus (51 kg/ha), low potassium (436 kg/ha) and low salt contents (0.34 mS/cm).

For comparison of 23 genotypes, four varieties (Basbag, Bilensoy 80, Savas and Gea) were used as reference.

Field trial was established on date 06.04.2016 with three replications according to randomized block design. The length of each parcel was five meters, each row was consisting of six rows and interrow space was 20 cm. Seeding rate was 30 kg/ha of seed were planted by hand in accordance with TURAN (2019). 40 kg/ha nitrogen and 100 kg/ha phosphorus were applied at sowing. Field trial was carried out under irrigated conditions. Harvests were

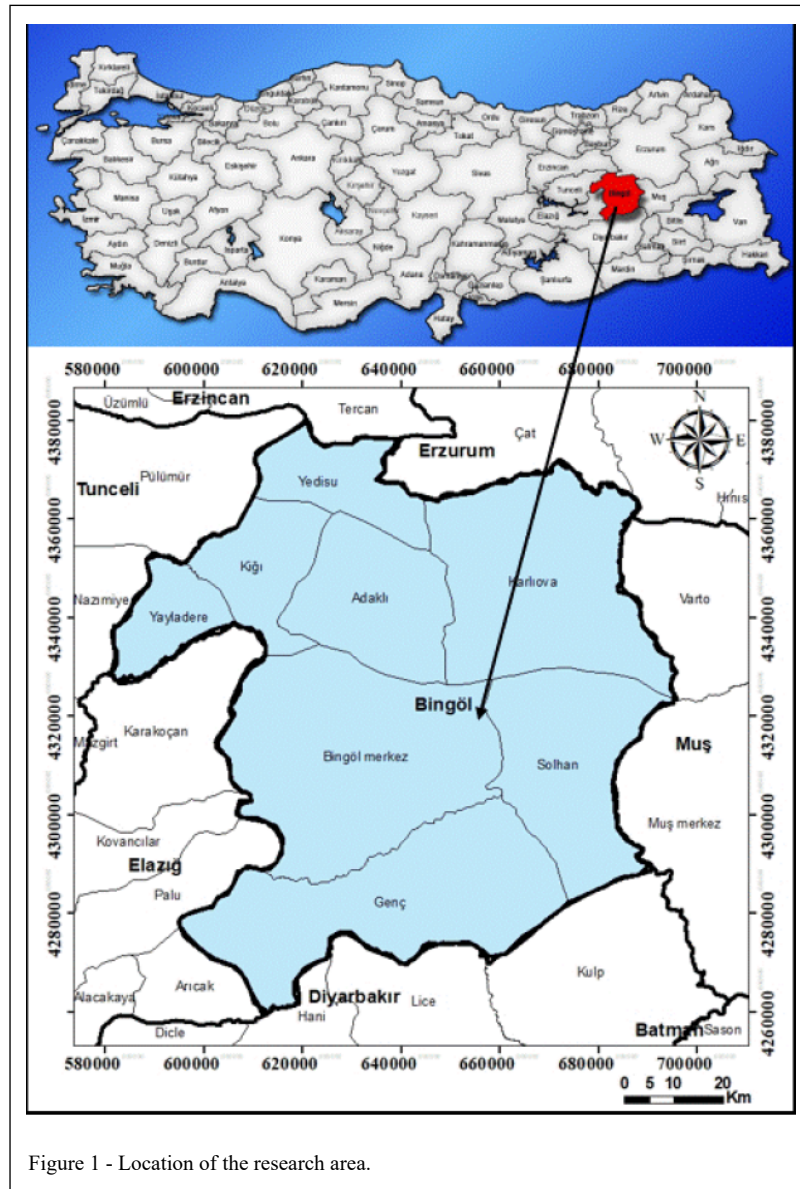


Figure 1 - Location of the research area.

conducted during the 10% flowering period. Parcels were harvested three times in 2016, four times in 2017 and four times in 2018. Green herbage yield was calculated and followingly 500 grams of green herbage sample was dried at 70 °C for 48 hours to measure dry yields in accordance with TURAN, (2019). CP (crude protein), ADF (acid detergent insoluble fiber) and NDF (neutral detergent insoluble fiber) ratios were determined by using grinded hay samples by NIRS (Near Infrared Spectroscopy) instrument. Using the obtained values, the digestible dry matter (DDM) and the relative feed value (RFV) were calculated by using given equations 1 and 2 (MORRISON, 2003).

$$\text{DDM} = 88.9 - (0.779 \times \text{ADF}) \quad (\text{Eq.1})$$

$$\text{RFV} = ((\text{DDM} \times \text{DMI} (120 / \text{NDF})) / 1.29) \quad (\text{Eq.2})$$

In these equations, DDM=Digestable Dry Matter; RFV=Relative Feed Value; DMI=Dry Matter Intake. JUMP 0.5 statistical program was used for variance analysis and Tukey test was used for comparisons.

RESULTS AND DISCUSSION

Green herbage and hay yields

Statistically significant differences ($P < 0.01$) were obtained for green herbage yields and hay yields based on genotypes and trial years which are

Table 1 - Bingol Province Meteorological Data.

Months	-----Average Temperature (°C)-----				-----Total Precipitation (mm)-----				-----Relative Humidity (%)-----			
	2016	2017	2018	LY	2016	2017	2018	LY	2016	2017	2018	LY
January	-2.8	-3.7	2.0	-2.5	235.1	63.9	204.0	154.0	75.3	71.1	72.7	73.3
February	2.4	-2.3	5.2	-0.9	86.3	32.9	74.9	137.7	73.7	61.6	65.8	72.2
March	7	5.9	10.3	4.9	125.5	114.5	72.2	124.1	60.4	64.7	59.1	64.2
April	13.9	10.8	14.4	10.9	45.5	166.4	57.1	103.8	48.4	58.8	44.1	61.2
May	16.3	16.4	16.4	16.2	62.2	92.4	163.0	66.8	57.4	56.2	67.9	55.8
June	22.2	22.6	22.6	22.6	34.6	9.6	33.3	18.4	43.6	39	47.4	42.5
July	26.9	28	27.1	27	3.5	0	4.6	7.3	33.4	28.1	30.6	36.7
August	28	27.6	27.4	26.8	0	2.5	11.7	5.4	28	26	31.1	36.8
September	19.9	23.5	22.6	21.3	29.1	0	11.7	16.4	40.3	26.4	37.0	42.2
October	15.2	13.4	15.9	14.2	4.4	52.8	104.5	70.3	43	48.6	55.6	58.9
November	6.4	7.3	7.9	6.5	53.7	99.5	83.6	91.8	47.9	68.5	72.4	64.7
December	-2.2	3.7	0.75	0.2	152.6	74.6	113.6	121.8	73.4	69.8	71.6	70.7
Total/Ave.	12.8	12.8	14.4	12.3	832.5	709.1	934.2	917.8	52.1	51.6	54.6	56.6

are given in table 2. The majority of the populations yielded higher in terms of green herbage compared to cultivars (Basbag, Bilensoy 80, Savas and Gea). 2016, 2017, 2018 and three years average green herbage yields of average of all genotypes were 51.58, 67.91, 96.39 and 71.96 t/ha, respectively. The highest green herbage average yield (96.39 t/ha) was obtained in the third year of the study. 18 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average green herbage yields. Instead, green herbage yields were highest at Mutluca population in the first year (65.41 t/ha), at Garip population in the second year (81.39 t/ha), at Bagliisa population (109.07 t/ha) in the third year, and at Mutluca population for the average of three years (84.29 t/ha).

2016, 2017, 2018 and three years average hay yields of average of all genotypes were 16.11, 26.31, 30.16 and 24.19 t/ha, respectively. The highest hay yield average (30.16 t/ha) was obtained in the third year of the study. 14 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average hay yields. Instead, hay yields were highest at Arslanbeyli population in the first year (19.44 t/ha), at Servi population in the second year (30.32 t/ha), at Garip population (39.02 t/ha) in the third year, and at Mutluca population for the average of three years (27.82 t/ha).

As the year 2016 was the crop establishment year, green herbage and hay yields were lower in this year compared to 2017 and 2018. Under similar arid climatic conditions but in different

provinces in Turkey, SEKER (2003) obtained 53.6 t/ha green herbage and 12.2 t/ha hay yield, TURAN et al. (2017) obtained 37.9 t/ha green herbage and 13.1 t/ha hay yield. Under Mediterranean climatic conditions, DEMIROGLU & AVCIOGLU (2010) obtained 75.4-85.5 t/ha green herbage and 20.5-21.8 t/ha hay yield, GUNDEL et al. (2014) obtained 50.9 t/ha green herbage and 11.3 t/ha hay yield. In a research of JAFARI & RAZBAN (2018), the forage yield and quality of 49 accessions of alfalfa were determined under dryland farming system during 2005-2007 in the Eastern Azerbaijan. Total forage hay yield were 5.43, 4.45 t/ha in years 2 and 3, respectively. 5 Genotypes produced average values of 6.5-8.5 t/ha forage dry matter yield. GOKALP et al. (2017) reported that they obtained 11.8-13.3 t/ha green herbage yield in Tokat, in Turkey.

Crude protein ratios and crude protein yields

Statistically significant differences ($P < 0.01$) were obtained for CP rates based on genotypes, trial years and genotype x year interactions, and for CP yields based on genotypes and trial years which are given in table 3.

2016, 2017, 2018 and three years average CP ratios of average of all genotypes were 24.3, 23.2, 21.6 and 23.0%, respectively. The highest and lowest CP average rates of 24.3% and 21.6% were obtained in the first and third year of the study, respectively. 20 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average CP ratios. Instead, CP ratios were highest

Table 2 - Green herbage and hay yields of alfalfa genotypes.

Genotypes	-----Green herbage yields (t/ha)-----				-----Hay yields (t/ha)-----			
	2016	2017	2018	Mean	2016	2017	2018	Mean**
1 Garip	54.14	81.39	103.71	79.75 ab	17.74	26.70	39.02	27.82 ab
2 Küçüktekören	46.49	64.89	90.18	67.19 bc	14.36	25.19	27.65	22.40 cd
3 Kurudere	51.34	67.31	80.65	66.43 bc	16.29	22.55	30.19	23.01 bcd
4 Kumgeçit	44.76	64.94	95.20	68.30 abc	14.62	27.37	26.80	22.93 bcd
5 Kültür Mah.	43.74	66.62	90.34	66.90 bc	14.31	23.29	27.21	21.60 d
6 Ortaköy	46.02	59.75	79.31	61.69 c	14.30	22.28	27.29	21.29 d
7 Sarıççek-1	47.88	76.08	104.20	76.05 abc	15.04	29.94	34.04	26.34 a-d
8 Sarıççek-2	42.69	62.37	94.72	66.60 bc	13.55	25.93	27.67	22.38 cd
9 Sarıççek-3	48.72	67.63	99.80	72.05 abc	14.85	29.63	29.94	24.81 a-d
10 Yelesen	43.74	56.28	85.65	61.89 c	13.93	26.05	27.31	22.43 cd
11 Çeltiksuyu-1	46.42	62.19	100.02	69.54 abc	14.74	26.28	28.95	23.32 bcd
12 Çeltiksuyu-2	50.29	63.81	89.01	67.70 bc	15.73	23.84	30.41	23.33 bcd
13 Çeltiksuyu-3	50.75	73.93	93.12	72.60 abc	16.70	25.74	33.18	25.21 a-d
14 Meşedali-1	57.45	75.05	100.27	77.59 abc	17.20	26.85	32.39	25.48 a-d
15 Meşedali-2	52.83	69.07	96.06	72.65 abc	15.52	27.74	30.95	24.74 a-d
16 Servi	58.26	78.11	108.68	81.68 ab	18.68	30.32	36.59	28.53 a
17 Çevirme	45.96	64.87	92.99	67.94 bc	14.83	25.64	28.90	23.12 bcd
18 Arslanbeyli	62.17	66.68	98.19	75.68 abc	19.44	25.35	29.64	24.81 a-d
19 Mutluca	65.41	80.08	107.38	84.29 a	19.18	28.43	34.33	27.31 abc
20 Bağlıisa	56.70	73.43	109.07	79.73 ab	18.06	29.01	31.33	26.13 a-d
21 Taşlıçay	46.54	64.23	94.03	68.26 abc	14.93	25.69	28.77	23.13 bcd
22 Şenköy-1	53.44	63.65	106.83	74.64 abc	17.39	28.89	28.38	24.88 a-d
23 Şenköy-2	49.49	66.81	98.85	71.72 abc	15.00	25.48	29.32	23.27 bcd
24 Başbağ	60.78	67.75	95.74	74.76 abc	18.12	25.51	29.51	24.38 a-d
25 Bilensoy 80	60.10	64.63	93.24	72.65 abc	18.15	24.65	27.60	23.47 a-d
26 Gea	57.58	73.02	99.94	76.85 abc	17.98	26.83	32.01	25.61 a-d
27 Savaş	48.95	59.05	95.36	67.79 bc	14.20	25.16	24.92	21.43 d
Mean	51.58 C	67.91 B	96.39 A	71.96	16.11 C	26.31 B	30.16 A	24.19
LSD (0.05)	Year (Y):34.05**, Genotype (G): 16.25**, Y x G : not significant				Year (Y):1.07**, Genotype (G): 5.09**, Y x G : not significant			
	CV: %12.73, ** P<0.01				CV: %11.87, ** P<0.01			

at Bilensoy 80 variety in the first year (25.7%), at Taslicay and Senkoy-1 population in the second year (both 24.8%), at Kumgeçit population (24.0%) in the third year, and at Kumgeçit population for the average of three years (24.2%). Under similar arid climatic conditions in Turkey, ENGIN & MUT (2017) and CACAN et al. (2018) was obtained 25.0% and 23.9-25.9% respectively. BASBAG et al. (2009), collected 11 alfalfa clones from Southeastern and Eastern Regions of Turkey and determined a significant variation in quality properties of alfalfa clones for crude protein (17.3-23.2%). In a study of Basbag et al., (2017), 16 individual plants were selected from the Southeastern Turkey from their natural habitat and clonally propagated in field trials where crude protein content ranged between 17.33 to 24.60 %.

2016, 2017, 2018 and three years average CP yields of average of all genotypes were 3.74, 6.39, 6.50 and 5.54 t/ha, respectively. The highest and lowest CP yield averages were obtained in the third and first years of the study, respectively. 23 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average CP yields. Instead, CP yields were highest at Arslanbeyli and Bağlıisa populations in the first year (both 4.42 t/ha), at Sarıççek population in the second year (7.24 t/ha), at Servi population (8.07 t/ha) in the third year, and at Servi population for the average of three years (6.40 t/ha). Under similar arid climatic conditions in Turkey, SENGUL et al. (2003) was obtained 2.46-3.21 t/ha, TURAN et al. (2017) was obtained 1.35-2.83 t/ha and ENGIN &

Table 3 - Crude protein ratios and crude protein yields of alfalfa genotypes.

	Genotypes	-----Crude protein ratios (%)-----				-----Crude protein yields (t/ha)-----			
		2016	2017	2018	Mean	2016	2017	2018	Mean
1	Garip	23.4 a-o	22.5 a-p	19.2 qrs	21.7 e	4.00	6.26	7.53	5.93 ab
2	Küçüktekören	24.9 a-i	23.7 a-n	23.4 a-o	24.0 ab	3.40	6.27	6.48	5.39 ab
3	Kurudere	23.7 a-n	23.3 a-p	21.2 k-s	22.8 a-e	3.82	5.35	6.42	5.20 ab
4	Kumgeçit	25.5 ab	23.2 a-p	24.0 a-m	24.2 a	3.42	6.99	6.44	5.62 ab
5	Kültür Mah.	25.2 a-f	24.4 a-k	20.2 p-s	23.3 a-e	3.51	5.88	5.50	4.96 b
6	Ortaköy	25.2 a-f	22.1 c-r	22.1 e-r	23.2 a-e	3.17	5.63	6.03	4.94 b
7	Sarıçiçek-1	23.8 a-n	21.8 h-r	21.7 i-s	22.4 b-e	3.28	7.12	7.39	5.93 ab
8	Sarıçiçek-2	23.1 a-p	22.5 a-p	21.1 l-s	22.2 de	3.06	5.98	5.81	4.95 b
9	Sarıçiçek-3	24.4 a-k	23.7 a-n	20.6 n-s	22.9 a-e	3.51	7.24	6.16	5.64 ab
10	Yelesen	24.3 a-l	22.4 b-q	22.5 a-p	23.1 a-e	3.19	6.34	6.14	5.22 ab
11	Çeltiksuyu-1	24.3 a-m	23.7 a-n	20.3 o-s	22.8 a-e	3.49	6.37	5.90	5.26 ab
12	Çeltiksuyu-2	25.4 abc	23.0 a-p	21.1 m-s	23.1 a-e	3.62	6.03	6.41	5.35 ab
13	Çeltiksuyu-3	22.9 a-p	23.1 a-p	21.0 m-s	22.4 cde	3.86	5.92	6.99	5.59 ab
14	Meşedali-1	23.8 a-m	23.2 a-p	21.8 h-r	22.9 a-e	3.96	6.38	7.06	5.80 ab
15	Meşedali-2	23.0 a-p	22.4 b-q	22.6 a-p	22.7 a-e	3.48	6.40	6.98	5.62 ab
16	Servi	23.4 a-p	21.7 i-s	22.2 c-r	22.4 b-e	4.05	7.08	8.07	6.40 a
17	Çevirme	22.9 a-p	22.9 a-p	22.1 d-r	22.6 a-e	3.40	5.87	6.39	5.22 ab
18	Arslanbeyli	23.1 a-p	22.8 a-p	23.3 a-p	23.1 a-e	4.42	5.83	6.92	5.72 ab
19	Mutluca	25.0 a-h	22.7 a-p	19.0 rs	22.2 de	4.35	7.09	6.50	5.98 ab
20	Bağliisa	24.2 a-m	24.4 a-k	18.5 s	22.4 b-e	4.42	7.04	5.80	5.75 ab
21	Taşlıçay	25.2 a-g	24.8 a-i	21.5 j-s	23.8 a-d	3.69	6.47	6.18	5.45 ab
22	Şenköy-1	23.9 a-m	24.8 a-i	23.4 a-p	24.0 ab	4.31	6.89	6.63	5.94 ab
23	Şenköy-2	25.4 a-d	22.7 a-p	22.7 a-p	23.6 a-d	3.41	6.44	6.66	5.50 ab
24	Başbağ	24.8 a-i	23.6 a-n	21.4 j-s	23.3 a-e	4.29	6.32	6.30	5.63 ab
25	Bilensoy 80	25.7 a	23.4 a-p	22.5 a-p	23.9 abc	4.25	6.35	6.22	5.61 ab
26	Gea	25.3 a-e	23.5 a-o	22.0 g-r	23.6 a-e	4.23	6.78	7.04	6.01 ab
27	Savaş	24.6 a-j	23.1 a-p	22.0 f-r	23.3 a-e	3.29	6.20	5.49	4.99 b
	Mean	24.3 A	23.2 B	21.6 C	23.0	3.74 B	6.39 A	6.50 A	5.54
	LSD (0.05)	Year (Y):0.34**, Genotype (G): 1.64**, Y x G : 3.24**				Year (Y): 0.25**, Genotype (G): 1.22**, Y x G : not significant			
		CV(%): 4.00, ** P<0.01				CV:%12.36, ** P<0.01			

MUT (2017) 4.29 t/ha CP yields. These CP rate and yield values are in accordance with our results.

ADF and NDF ratios

Statistically significant differences (P<0.01) were obtained for ADF based on genotypes, trial years and genotype x year interactions, and for NDF rates based on genotypes and genotype x year interactions which are given in table 4.

2016, 2017, 2018 and three years average ADF ratios of average of all genotypes were 21.8, 23.6, 23.6 and 23.0%, respectively. ADF ratio averages were same and high for second and third year compared to first year of trials. 21 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average ADF ratios. ADF ratios were

lowest(indicator of high quality) at Saricicek-3 population in the first year (18.7%), at Gea variety in the second year (18.7%), at Kumgecit population (20.7%) in the third year, and at Kumgecit population for the average of three years (20.8%).

2016, 2017, 2018 and three years average NDF ratios of average of all genotypes were 39.0, 37.9, 38.8 and 38.6%, respectively. 14 of 27 genotypes were ranked low(indicator of high quality) and positioned in the same statistical group according to three years average NDF ratios. NDF ratios were lowest at Bagliisa population in the first year (35.9%), at Bilensoy 80 and Geavarieties in the second year (both 27.5%), at Savas variety (34.8%) in the third year, and at Gea variety for the average of three years (33.3%). KARAKOY & SARAC (2018) reported ADF rate

Table 4 - Acid detergent fiber (ADF) and neutral detergent fiber (NDF) ratios of alfalfa genotypes.

Genotypes	-----ADF (%)-----				-----NDF (%)-----			
	2016	2017	2018	Mean	2016	2017	2018	Mean
1 Garip	22.4 b-m	24.7 a-j	25.5 a-f	24.2 abc	39.0 a-e	41.5 a-d	41.3 a-d	40.6 ab
2 Küçüktekören	23.1 a-m	25.8 a-e	23.8 a-l	24.2 ab	40.8 a-e	44.4 abc	38.0 a-f	41.1 a
3 Kurudere	25.2 a-g	23.9 a-l	25.1 a-h	24.7 a	43.8 abc	40.2 a-e	37.9 a-f	40.6 ab
4 Kumgeçit	20.1 h-m	21.6 c-m	20.7 f-m	20.8 f	36.7 a-f	33.8 c-f	34.3 b-f	34.9 bcd
5 Kültür Mah.	20.2 h-m	23.6 a-m	25.0 a-h	22.9 a-f	36.2 a-f	37.4 a-f	40.7 a-e	38.1 a-d
6 Ortaköy	24.7 a-i	23.2 a-m	22.2 b-m	23.4 a-e	42.9 abc	37.8 a-f	39.6 a-e	40.1 abc
7 Sarıççek-1	24.3 a-k	23.5 a-m	22.1 c-m	23.3 a-f	46.1 a	36.9 a-f	35.7 a-f	39.6 abc
8 Sarıççek-2	23.6 a-m	23.2 a-m	22.9 a-m	23.2 a-f	40.6 a-e	41.1 a-e	39.7 a-e	40.5 ab
9 Sarıççek-3	18.7 m	23.4 a-m	21.6 c-m	21.3 def	37.3 a-f	38.0 a-f	37.2 a-f	37.5 a-d
10 Yelesen	22.2 b-m	23.3 a-m	22.9 a-m	22.8 a-f	39.3 a-e	40.0 a-e	37.1 a-f	38.8 a-d
11 Çeltiksuyu-1	22.4 b-m	25.2 a-g	23.4 a-m	23.7 a-d	40.2 a-e	36.9 a-f	37.3 a-f	38.1 a-d
12 Çeltiksuyu-2	22.9 a-m	21.9 c-m	21.7 c-m	22.2 b-f	39.9 a-e	34.2 b-f	37.1 a-f	37.1 a-d
13 Çeltiksuyu-3	20.7 f-m	27.2 ab	24.2 a-k	24.0 abc	37.2 a-f	40.1 a-e	45.6 ab	41.0 a
14 Meşedali-1	21.1 d-m	24.8 a-i	23.4 a-m	23.1 a-f	38.2 a-f	41.2 a-d	36.8 a-f	38.7 a-d
15 Meşedali-2	20.8 e-m	23.6 a-m	25.0 a-h	23.2 a-f	37.6 a-f	42.1 a-d	40.2 a-e	40.0 abc
16 Servi	24.0 a-l	24.4 a-k	25.8 a-e	24.7 a	40.8 a-e	41.0 a-d	38.8 a-f	40.2 ab
17 Çevirme	22.6 a-m	23.4 a-m	22.8 a-m	22.9 a-f	40.2 a-e	41.2 a-d	41.9 a-d	41.1 a
18 Arslanbeyli	19.8 i-m	25.4 a-f	24.0 a-l	23.1 a-f	36.2 a-f	40.3 a-e	37.3 a-f	37.9 a-d
19 Mutluca	20.2 g-m	25.1 a-h	26.4 abc	23.9 abc	37.2 a-f	37.8 a-f	43.7 abc	39.6 abc
20 Bağlıisa	19.7 j-m	26.1 a-d	26.4 abc	24.1 abc	35.9 a-f	41.3 a-e	45.9 a	41.0 a
21 Taşlıçay	19.7 klm	23.2 a-m	24.3 a-k	22.4 a-f	36.9 a-f	39.0 a-e	39.4 a-e	38.4 a-d
22 Şenköy-1	21.0 e-m	27.5 a	24.4 a-k	24.3 ab	38.0 a-f	43.0 abc	38.5 a-f	39.9 abc
23 Şenköy-2	21.6 c-m	24.7 a-i	21.8 c-m	22.7 a-f	38.1 a-f	38.2 a-f	35.3 a-f	37.2 a-d
24 Başbağ	21.8 c-m	20.3 g-h	23.0 a-m	21.7 c-f	38.1 a-f	29.4 ef	40.2 a-e	35.9 a-d
25 Bilensoy 80	20.6 f-m	19.2 lm	23.0 a-m	20.9 ef	37.7 a-f	27.5 f	38.0 a-f	34.4 cd
26 Gea	20.7 f-m	18.7 m	23.2 a-m	20.9 ef	36.8 a-f	27.5 f	35.7 a-f	33.3 d
27 Savaş	24.6 a-k	21.1 d-m	22.6 a-m	22.8 a-f	41.7 a-e	31.4 def	34.8 a-f	36.0 a-d
Mean	21.8 B	23.6 A	23.6 A	23.0	39.0	37.9	38.8	38.6
LSD (0.05)	Year (Y):0.53**, Genotype (G): 2.53**, Y x G : 5.01**				Year (Y): not significant, Genotype (G): 5.76**, Y x G : 11.42**			
	CV(%): 6.20, **P<0.01				CV:%8.42, **P<0.01			

between 42.66-44.19% and NDF rate between 51.38-53.78% in Sivas province of Turkey, in accordance with our study. BASBAG et al. (2009), collected 11 alfalfa clones from Southeastern and Eastern Regions of Turkey and determined a significant variation in quality properties of alfalfa clones for ADF (16.8-33.3%) and NDF (20.3-35.2%). In a study of Basbag et al., (2017), 16 individual plants were selected from the Southeastern Turkey from their natural habitat and clonally propagated in field trials where ADF values ranged from 20.52 to 37.71 % and NDF values were between 22.16 and 41.22 %.

DDM and RFV values

It was found that there were statistically significant ($P<0.01$) differences among genotypes

and average of years in terms of digestible dry matter ratios and relative feed values, but there was no statistically significant difference among years in terms of relative feed value. DDM and RFV values of alfalfa genotypes examined in the study are given in table 5.

2016, 2017, 2018 and three years average DDM of average of all genotypes were 71.9, 70.5, 70.5 and 71.0%, respectively. DDM averages were higher in the first year compared to second and third year of trials. 17 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average DDM values. DDM values were highest at Sarıççek-3 population in the first year (74.3%), at Gea variety in the second year (74.3%), at Kumgeçit population (72.8%) in the third

Table 5 - Digestible dry matter (DDM, %) and relative feed value (RFV) of alfalfa genotypes.

Populations	-----DDM (%)-----				-----RFV-----			
	2016	2017	2018	Mean	2016	2017	2018	Mean
1 Garip	71.5 a-l	69.7 d-m	69.0 h-m	70.1 def	172.1 cde	156.1 de	157.1 cde	161.8 e
2 Küçüktekören	70.9 a-m	68.8 i-m	70.3 b-m	70.0 ef	161.9 cde	144.1 de	172.6 cde	159.6 e
3 Kurudere	69.3 g-m	70.3 b-m	69.4 f-m	69.6 f	147.8 de	164.0 cde	170.4 cde	160.8 e
4 Kumgeçit	73.2 a-f	72.1 a-k	72.8 a-h	72.7 a	186.8 b-e	199.0 a-e	199.4 a-d	195.1 abc
5 Kültür Mah.	73.2 a-f	70.5 a-m	69.5 f-m	71.0 a-f	188.4 b-e	176.2 b-e	159.9 cde	174.8 b-e
6 Ortaköy	69.6 e-m	70.8 a-m	71.6 a-l	70.7 b-f	152.3 de	175.2 b-e	170.6 cde	166.0 cde
7 Sarıççek-1	70.0 c-m	70.6 a-m	71.7 a-k	70.8 a-f	141.3 de	178.5 b-e	187.3 b-e	169.0 cde
8 Sarıççek-2	70.5 a-m	70.9 a-m	71.0 a-m	70.8 a-f	162.2 cde	161.9 cde	167.8 cde	164.0 de
9 Sarıççek-3	74.3 a	70.6 a-m	72.1 a-k	72.3 abc	186.4 b-e	174.2 b-e	182.5 b-e	181.0 a-e
10 Yelesen	71.6 a-l	70.8 a-m	71.0 a-m	71.1 a-f	170.5 cde	165.7 cde	180.7 b-e	172.3 cde
11 Çeltiksuyu-1	71.4 a-l	69.3 g-m	70.7 a-m	70.5 c-f	165.6 cde	175.0 b-e	179.4 b-e	173.4 b-e
12 Çeltiksuyu-2	71.1 a-m	71.8 a-k	72.0 a-k	71.6 a-e	165.7 cde	195.5 a-e	183.6 b-e	181.6 a-e
13 Çeltiksuyu-3	72.8 a-h	67.7 lm	70.1 c-m	70.2 def	182.4 b-e	157.1 cde	143.8 de	161.1 e
14 Meşedali-1	72.5 a-j	69.6 e-m	70.7 a-m	70.9 a-f	178.4 b-e	157.3 cde	180.7 b-e	172.1 cde
15 Meşedali-2	72.7 a-i	70.5 a-m	69.4 f-m	70.9 a-f	179.8 b-e	156.5 cde	161.1 cde	165.8 cde
16 Servi	70.2 b-m	69.9 c-m	68.8 i-m	69.6 f	160.2 cde	159.1 cde	167.8 cde	162.4 de
17 Çevirme	71.3 a-m	70.6 a-m	71.2 a-m	71.0 a-f	165.2 cde	161.1 cde	158.2 cde	161.5 e
18 Arslanbeyli	73.5 a-e	69.1 h-m	70.2 b-m	70.9 a-f	189.5 b-e	160.2 cde	175.8 b-e	175.1 b-e
19 Mutluca	73.1 a-g	69.4 f-m	68.3 klm	70.3 def	183.0 b-e	170.9 cde	146.0 de	166.6 cde
20 Bağlıisa	73.6 a-d	68.6 j-m	68.3 klm	70.1 def	190.7 b-e	154.5 de	138.5 e	161.2 e
21 Taşlıçay	73.6 abc	70.8 a-m	70.0 c-m	71.5 a-f	185.9 b-e	170.0 cde	165.8 cde	173.9 b-e
22 Şenköy-1	72.5 a-i	67.5 m	69.9 c-m	70.0 ef	178.6 b-e	146.2 de	170.5 cde	165.1 de
23 Şenköy-2	72.0 a-k	69.6 e-m	71.9 a-k	71.2 a-f	177.3 b-e	169.8 cde	189.7 b-e	178.9 a-e
24 Başbağ	71.9 a-k	73.1 a-g	71.0 a-m	72.0 a-d	175.8 b-e	232.5 ab	166.8 cde	191.7 a-d
25 Bilensoy 80	72.9 a-h	74.0 ab	71.0 a-m	72.6 ab	181.2 b-e	251.0 a	174.4 b-e	202.2 ab
26 Gea	72.8 a-h	74.3 a	70.9 a-m	72.6 ab	184.9 b-e	253.7 a	185.9 b-e	208.1 a
27 Savaş	69.8 c-m	72.5 a-j	71.3 a-m	71.2 a-f	159.4 cde	215.4 abc	190.5 b-e	188.4 a-e
Mean	71.9 A	70.5 B	70.5 B	71.0	173.1	177.1	171.4	173.8
LSD (0.05)	Year (Y):0.41*, Genotype (G): 1.97*, Y x G : 3.90*				Year (Y): not significant, Genotype (G): 29.9**, Y x G : 59.2**			
	CV(%): 1.56, ** P≤0.01				CV:%69.69, **P≤0.01			

year, and at Kumgeçit population for the average of three years (72.7%).

2016, 2017, 2018 and three years average RFV of average of all genotypes were 173.1, 177.1, 171.4 and 173.8, respectively. 8 of 27 genotypes were yielded high and positioned in the same statistical group according to three years average RFV values. RFV values were highest at Bağlıisa population in the first year (190.7), at Gea variety in the second year (253.7), at Kumgeçit population (199.4) in the third year, and at Gea variety for the average of three years (208). In a study of BASBAG et al., (2017), 16 individual plants were selected from the Southeastern Turkey from their natural habitat and clonally propagated in field trials where relative feed value ranged from 134.3 to 306.1.

The obtained DDM rates were similar to the findings of CACAN et al. (2018) (71.0-74.4%). On the other hand, our RFV values were higher than GUNDEL et al. (2014) and ENGIN & MUT (2018), and lower than CACAN et al. (2018). BASBAG et al. (2009), collected 11 alfalfa clones from Southeastern and Eastern Regions of Turkey and determined a significant variation in quality properties of alfalfa clones for DDM (63.0-75.8%). Since the relative feed value is calculated from the ADF and NDF ratios, the difference between these two values changes the relative feed value significantly. In general, the alfalfa plant has an excellent RFV quality grade (170-180 RFV) when it contains 21-22% CP, less than 28% ADF and less than 35% NDF (BOMAN, 2017). When these characteristics are considered together, herbage

quality of alfalfa genotypes that we examined in the study are in excellent grade.

CONCLUSION

The natural variation in wild germplasm is very wide and could be detected and transferred in breeding programs and this variation has been reported earlier in Turkish alfalfa germplasm (SAKIROGLU et al. 2011). The region that genotypes collected in our study is in the Fertile Crescent and also in the intersection of Vavilov's two centers of origins, Transcaucasia and Mediterranean. The region has been noted to be one of the centers of diversity for alfalfa (SMALL, 2011; SAKIROGLU & BRUMMER 2013). Germplasm collected showed a desirable characters for improving yield and quality of alfalfa. Our results indicated that the collection and utilization of wild alfalfa germplasm is crucial for increasing its adaptation. In terms of both green herbage and hay yield, Servi, Mutluca, Garip, Sariçiçek-1, Bagliisa village populations were found superior to registered varieties. When we compare the quality results, Kumgecit, Küçüktekören and Şenköy-1 populations stands out in terms of crude protein ratio. Highest crude protein yield was obtained from Servi population. In terms of relative feed value, it was observed that the varieties were better qualified than the populations. It is concluded that the populations of Servi, Mutluca, Garip, Sariçiçek-1 and Bagliisa can be used in breeding studies especially to obtain genetic progress in yield of alfalfa for feed and bioenergy production. For the genetic improvement of current genotypes with higher crude protein ratio, Kumgecit, Küçüktekören and Şenköy-1 populations can be used as a source.

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DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

AUTHORS' CONTRIBUTIONS

All authors contributed equally for the conception and writing of the manuscript. All authors critically revised the manuscript and approved of the final version.

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