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Determination of yield and quality characteristics of local alfalfa genotypes cultivated in semi-arid conditions of Türkiye

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ABSTRACT

Alfalfa is a field crop that can produce more protein per hectare than many other field crops. In order to be successful in alfalfa cultivation, varieties that are resistant to winter conditions, diseases and pests and have high yield characteristics should be preferred. In this study, seeds of six local genotypes were collected from farmers cultivating alfalfa in the Muş province of the semi-arid Eastern Anatolia Region. The field trial of this study, in which six local genotypes were compared with four registered varieties, was established in Bingöl province in 2016 with three replications according to the coincidence blocks experimental design. In the study, some yield (green forage and dry matter yields) and quality traits (crude protein ratio, crude protein yield, ADF, NDF, digestible dry matter and relative feed value) of ten genotypes were analyzed for three years (2016, 2017 and 2018). As a result of the research, 68.57 t ha^{-1} green forage yield, 24.07 t ha^{-1} dry matter yield, 23.1% crude protein rate, 5.50 t ha^{-1} crude protein yield, 24.3% ADF rate, 39.0% NDF rate, 70.0% digestible dry matter rate and 172.2 relative feed value were obtained from the genotypes. Sungu-3 and Varto genotypes, together with the registered varieties Elçi, Nimet, Verko and Ömerbey, gave the highest green forage yield, dry matter yield and crude protein yield. While there was no statistically significant difference between the genotypes in terms of crude protein ratio, it was observed that the registered varieties gave better results in terms of ADF, NDF and digestible dry matter ratios and relative feed value. It is foreseen that Sungu-3 and Varto varieties can be preferred and can be used as starting material in the breeding programs to be carried out since they give results close to the registered varieties in terms of yield characteristics.

1. Introduction

Countries such as France, Canada, Spain, and the United States are leading producers of alfalfa hay, contributing to a global export value of around $800 million in 2016. Alfalfa is a highly valued feed for sheep, beef, dairy cattle, horses, and goats worldwide. It can be mixed with grass, grain feeds, or by-products to be used as hay and silage, especially in arid regions. Due to its high-protein content, alfalfa sometimes results in inefficiencies when used alone for grazing, as excess protein is excreted as urea or ammonia Ponnampalam and Holman (2023). The herbage's chemical composition varies by region, with early-flowering alfalfa commonly used in the United States. In contrast, alfalfa is less frequently included in European dairy and beef rations, making it harder to obtain (Clauss et al. 2008).

High-quality green and dry forage is a critical component in the production systems for beef, dairy, and horse industries. Legumes, especially alfalfa (*Medicago sativa*), provide high yields of quality herbage (Collins 2016). Alfalfa is a significant forage crop, extensively grown in temperate and cool subtropical regions worldwide. It produces more digestible energy and protein per hectare than most other crops and is a rich source of vitamin A along with other essential vitamins. These characteristics make alfalfa a valuable protein and mineral source for livestock. Alfalfa grows vigorously and regenerates multiple times after mowing. It can be harvested as hay, made into silage, or used as green chopped grass for grazing. Mature alfalfa plants can reach a height of one meter, with 5-25 stems per crown and roots that penetrate up to five meters deep into the soil. Although it is best suited for hay harvests, alfalfa generally does not persist as long as other legumes in permanent pastures and can cause bloating in livestock. Nevertheless, alfalfa has good seedling viability, excellent drought tolerance, and yields well throughout the summer. To maximize its potential, high-yielding, disease-resistant varieties with strong winter hardiness are needed (Sulc et al. 2017).

Important traits such as yield, quality, disease resistance and abiotic stress tolerance are shaped under the influence of genetic basis (Li and Brummer 2012) and the effect of genetic diversity in alfalfa on yield and quality is very high. Julier et al. (2000) reported that alfalfa cultivars are synthetic genotypes consisting of 8 to 200 parents and therefore have a wide genetic base and genetic diversity in alfalfa has 31-70% effect on alfalfa quality and 57-100% effect on morphological traits and dry matter. Other researchers have also reported that the effect of genetic differences on yield and yield traits and quality in alfalfa is important (Biazzi et al. 2017; Sayed et al. 2022).

In our country, alfalfa cultivation is largely carried out with ground genotypes (Öten and Albayrak 2014) and this study aimed to determine the yield and quality characteristics of local alfalfa genotypes cultivated by regional farmers.

2. Materials and Methods

The research was conducted in the experimental fields of Bingöl University's Genç Vocational School in Bingöl province, Türkiye. The Genç district, located in the Eastern Anatolia Region, is at an average altitude of 986 meters (Figure 1).

The study area's long-term climate data (1990-2015) recorded an average temperature of 12.3°C, 918 mm of annual precipitation, and 56.6% humidity. July and August are the hottest and driest months, while winter sees the highest precipitation and humidity levels (Figure 2).

Soil analysis of the research site revealed a sandy-clay-loamy texture, consisting of 59.5% sand, 18.2% clay, and 22.3% silt. The soil had a neutral pH of 7.26, was non-saline (0.34 mS cm^{-1}), and had low levels of calcareous content (3.48%), organic matter (2.1%), phosphorus (51 kg ha^{-1}), and potassium (436 kg ha^{-1}).

Seeds from six local alfalfa genotypes, collected from farmers in Muş province in July 2015, were used. These genotypes were coded as Sungu-1, Sungu-2, Sungu-3, Varto, Ziyaret, and Üçdere. Four registered varieties ("Elçi," "Nimet," "Verko," and "Ömerbey") served as controls (Table 1). In a previous study conducted in Bingöl province (Cacan et al. 2018), it was observed that the adaptation abilities of Elçi, Nimet, Verko and Ömerbey varieties were compatible with the ecology of the region, so these varieties were preferred as controls. The field experiment was established on April 6, 2016, in a randomized complete block design with three replications. Each plot was five meters long, consisting of six rows spaced 20 cm apart, with a seed density of 30 kg ha^{-1}. The experiment area received 40 kg ha^{-1} of nitrogen and 100 kg ha^{-1} of phosphorus fertilizers at planting, and the crops were irrigated. Herbage was harvested three times in 2016 and four times in both 2017 and 2018 at the 10% flowering stage.

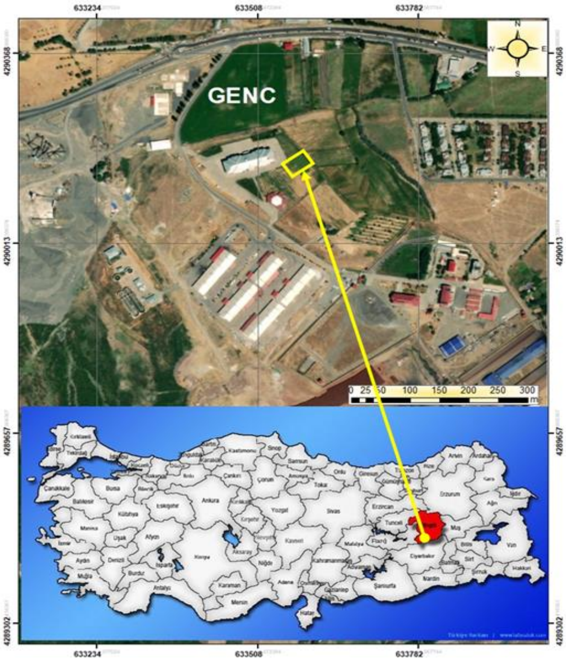

Figure 1. Study area.

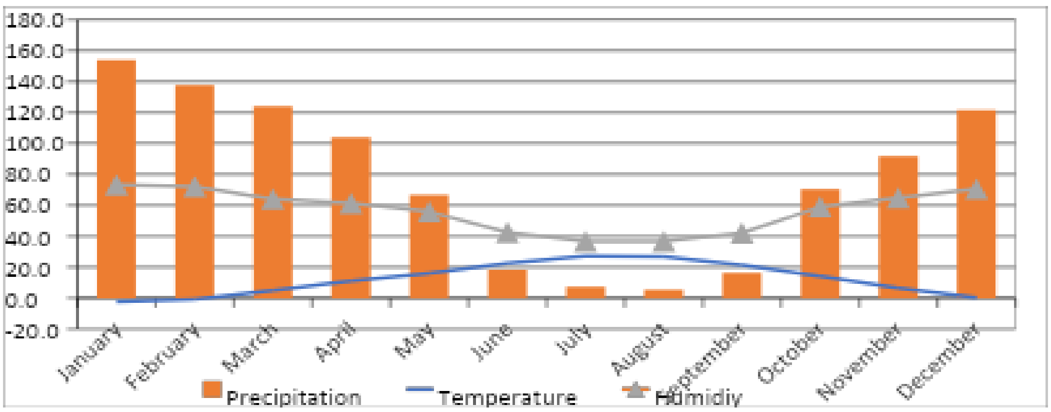

Figure 2. Climate data for study area (TSMS 2024).

Table 1. Locations where the local alfalfa genotypes were collected

No	Source location	Province
1	Sungu-1	Muş province
2	Sungu-2	Muş province
3	Sungu-3	Muş province
4	Varto	Varto district of Muş province
5	Ziyaret	Muş province
6	Üçdere	Muş province
7	Elçi	Registered variety
8	Nimet	Registered variety
9	Verko	Registered variety
10	Ömerbey	Registered variety

Green forage yield was calculated by weighing the freshly cut forage from each plot, and dry matter yield was determined by drying a 500-gram green forage sample at 70°C for 48 hours. Crude protein, ADF (acid detergent fiber), and NDF (neutral detergent fiber) contents were measured using Near Infrared Spectroscopy (NIRS). From these values, digestible dry matter (DDM= 88.9 - (0.779 × ADF)) and relative feed value (RFV= ((DDM × DMI (120/NDF)) / 1.29)) were calculated Morrison (2003).

2.1. Statistical analysis

Variance analysis of the collected data was performed using JMP statistical software, and Tukey's test was applied for mean comparisons. To analyze the relationships between genotypes and traits, biplot analysis was carried out using Genstat 12th software (Copyright 2011, VSN International Ltd) (Genstat 2009). Correlation analysis was conducted using JMP software, employing the Roe-wise method.

3. Results and Discussion

The genotypes and year main effects were factors significant (P<0.01) but year x genotypes interaction had no significant effects on the green forage yield (Table 2). Green forage yields of tested alfalfa genotypes were determined lowest (39.52 t ha^{-1}) in the first year and highest in third year (88.15 t ha^{-1}) of the study. Among the genotypes, Sungu-1, Sungu-2, and Üçdere had the lowest yields (47.92-63.24 t ha^{-1}), while Sungu-3, Varto, and the registered varieties exhibited higher yields (68.07-82.72 t ha^{-1}).

Çakmakçı et al. (2004) determined the green forage yield of alfalfa genotypes as 3.87-7.23 t ha^{-1}; Kır and Soya (2008) reported that the average green forage yield of alfalfa genotypes varied between 9.3-13.6 kg ha^{-1} in their research conducted in Bornova conditions. Turan (2010) reported that the average green forage yield of alfalfa varieties varied between 26.0 and 30.5 t ha^{-1} according to the planting times. Kumar and Patel (2013) determined the yield of green forage of alfalfa genotypes as 244.82-343.78 g ha^{-1}. Abdalrady et al. (2017), in a study in which they examined different varieties, found that alfalfa green forage yield was 3.7-4.0 in the first year of experiments, 4.6-6.0 t ha^{-1} in the second year. Mutlu (2019) determined the yield of green forage of alfalfa genotypes as 3.3-4.1 t ha^{-1} in research conducted in the ecological conditions of Ankara. All resources and our experiment showed that alfalfa fresh yield changes depending on genotypic differences and ecological differences between varieties.

Average dry matter yields of tested alfalfa genotypes were determined low (12.09 t ha^{-1}) in the first year and high in second and third years (29.01 t ha^{-1} and 31.12 t ha^{-1}, respectively) in the study. The highest dry matter yields (between 23.00-29.10 t ha^{-1}) were obtained from genotypes of Sungu-3, Varto, Elçi, Nimet, Verko and Ömerbey (Table 2). The genotypes and year main effects were factors significant (P<0.01) but second-order interaction had not significant effects on the green dry matter yield (Table 2).

The green forage yields of the genotypes in the study varied between 47.92 and 82.72 t ha^{-1} and dry matter yields varied between 16.45 and 29.10 t ha^{-1}. In general, the registered varieties (Elçi, Nimet, Verko and Ömerbey) stood out with higher green forage and dry matter yields. However, the results show that “Sungu-3” and “Varto” genotypes are also competitive with the registered varieties in terms of green forage and dry matter yield. Alfalfa genotypes can show great differences in terms of green forage and dry matter yields under different ecological conditions. For example, the dry matter yields of alfalfa genotypes under Aegean Region conditions were reported as 18.92-24.74 t ha^{-1} Demiroğlu et al. (2008), green forage yields of 61.69-84.29 t ha^{-1} and dry matter yields of 21.29-28.53 t ha^{-1} under Bingöl province conditions Çaçan et al. (2020) and dry matter yields were reported to vary between 10.47-15.59 t ha^{-1} under Bursa province conditions Erbeyi et al. (2022). These studies reveal the yield potential of alfalfa genotypes grown in different regions of Türkiye and the effect of regional differences on yield.

The crude protein ratios of alfalfa genotypes were determined 21.1%, 23.7% and 24.3%, in the third, first and second years, respectively. The year main effects were factors significant (P<0.01) but genotype and second-order interaction had no significant effects on the crude protein ratio (Table 3).

The main factor of average crude protein yields of tested alfalfa genotypes had significant (P<0.05) but their interaction not significant, and determined low (2.86 t ha^{-1}) in the first year and high in second and third years (7.07 t ha^{-1} and 6.56 t ha^{-1}, respectively) in the study. The lowest crude protein yields (between 3.85-5.18 t ha^{-1}) were obtained from genotypes of Sungu-1, Sungu-2, Ziyaret and Üçdere (Table 3).

Turan (2010) showed that alfalfa crude protein yields varied between 1.46-1.68 t ha^{-1}, also Abdalrady et al. (2017), showed that the crude protein yield varied between 0.25-0.45 t ha^{-1}. Kebede et al. (2014), found the crude protein yield in Ethiopia to be 0.20-0.22 t ha^{-1}, Perez (2020) found the crude protein yield to be 0.23-0.25 t ha^{-1} in a study conducted under Californian conditions.

Crude protein ratios of the genotypes varied between 22.0% and 23.8% and crude protein yields ranged between 3.85-6.66 t ha^{-1}. While the effect of genotypes on the crude protein ratio was found to be insignificant, in terms of crude protein yield, registered varieties such as Nimet, Verko and Ömerbey stood out by reaching values above 6.0 t ha^{-1}. Sungu-3 and Varto genotypes were also close to these registered varieties. The results of the study show that protein ratio and yield of alfalfa genotypes are affected by environmental conditions and genetic structure. In the literature, it was reported that crude protein ratios ranged between 15.6-25.9% and crude protein yields ranged between 1.33-5.90 t ha^{-1}, and the results of this study are consistent with the existing literature Çaçan et al. (2018) Yılmaz and Albayrak (2016), Engin and Mut (2017).

The average of ADF and NDF ratios of tested alfalfa genotypes main factor and their interaction were significant (Table 4). There are different response years and genotypes on ADF and NDF, hence year x genotypes interaction was significant (Table 4).

ADF and NDF ratios varied between 20.7-27.2% and 32.9-42.9%, respectively. While the registered varieties offered better digestibility with lower ADF (except Nimet) and NDF ratios, local genotypes had higher values in terms of these ratios. This indicates that local genotypes are slightly more woody than registered varieties and feed quality may be slightly lower in terms of these characteristics. In previous studies, the average ADF and NDF ratios of 31.6% to 36.7% and 41.2% to 47.2% Açıkbaş et al. (2017), Öten and Albayrak (2018) in alfalfa genotypes collected from nature and the average ADF and NDF ratios of 20.4% and 29.1% in registered alfalfa varieties Çaçan et al. (2018) support these results. In another study, an average ADF rate of 23.0% and NDF rate of 38.6% were obtained in local alfalfa genotypes Çaçan et al. (2020), which also supports the results of this study.

The main factor and their interaction were significant for DDM and RFV (P<0.01) (Table 5). Average DDM ratios of tested alfalfa genotypes were determined low (69.7 and 69.0%) in the second and third years respectively, and high in first year (71.2%) in the study (Table 5).

RFV values of tested alfalfa genotypes were determined low (167.2 and 165.5) in the first and third years respectively, and high in the second year (184.0) in the study. Genotypes showed different response among the yeasr, hence year x genotypes interaction was significant (Table 5).

Table 2. Green forage and dry matter yields of tested alfalfa genotypes

	Green forage yield (t ha^{-1})				Dry matter yield (t ha^{-1})			
Genotypes	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**
Sungu-1	19.18	63.60	60.97	47.92 d	5.98	20.02	23.35	16.45 c
Sungu-2	31.49	72.41	74.01	59.30 cd	10.41	25.79	28.84	21.68 bc
Sungu-3	31.04	86.80	86.37	68.07 abc	10.99	29.29	33.21	24.50 ab
Varto	37.22	83.53	84.41	68.39 abc	10.11	28.67	36.66	25.15 ab
Ziyaret	41.40	73.14	76.78	63.77 bc	12.84	26.19	28.90	22.65 bc
Üçdere	37.45	73.99	78.28	63.24 bcd	11.42	28.03	29.55	23.00 ab
Elçi	53.86	73.08	106.21	77.72 ab	15.16	32.93	28.72	25.61 ab
Nimet	52.12	86.02	110.02	82.72 a	17.14	33.43	36.74	29.10 a
Verko	44.72	88.11	99.14	77.32 ab	13.25	31.91	33.68	26.28 ab
Ömerbey	46.76	79.70	105.35	77.27 ab	13.62	33.80	31.52	26.31 ab
Mean	39.52 C	78.04 B	88.15 A	68.57	12.09 B	29.01 A	31.12 A	24.07
LSD (0.05)	Year (Y): 608.4**, Genotype (G): 15.19**, Y x G: non significant				Year (Y): 2.506**, Genotype (G): 6.257**, Y x G: non significant			
	CV: 14.29%, **P≤0.01				CV: 16.76%, **P≤0.01			

Table 3. Crude protein ratio and crude protein yields of alfalfa genotypes

	Crude protein ratio (%)				Crude protein yield (t ha^{-1})			
Genotypes	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**
Sungu-1	24.0	25.2	21.0	23.4	1.44	5.06	5.05	3.85 c
Sungu-2	24.8	23.0	22.5	23.4	2.58	5.91	6.46	4.99 bc
Sungu-3	24.5	24.4	22.1	23.7	2.67	7.10	7.37	5.71 ab
Varto	23.9	22.4	19.7	22.0	2.45	6.36	7.15	5.32 ab
Ziyaret	24.1	23.3	21.0	22.8	3.13	6.11	6.07	5.10 bc
Üçdere	23.6	24.4	20.2	22.7	2.71	6.85	5.97	5.18 bc
Elçi	22.4	23.3	22.4	22.7	3.39	7.70	6.42	5.84 ab
Nimet	23.0	26.7	19.2	22.9	3.95	8.95	7.07	6.66 a
Verko	23.9	26.3	21.2	23.8	3.18	8.39	7.16	6.24 ab
Ömerbey	22.8	24.4	22.1	23.1	3.13	8.23	6.89	6.08 ab
Mean	23.7 A	24.3 A	21.1 B	23.1	2.86 B	7.07 A	6.56 A	5.50
LSD (0.05)	Year (Y): 1.06**, Genotype (G): non significant, Y x G: non significant				Year (Y): 57.32**, Genotype (G): 143.14**, Y x G: no significant			
	CV: 7.41%, **P≤0.01				CV: 16.79%, **P≤0.01			

Table 4. Acid detergent fiber and neutral detergent fiber ratios of alfalfa genotypes

	ADF (%)				NDF (%)			
Genotypes	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**
Sungu-1	22.6 abc	27.9 ab	26.1 abc	25.5 AB	40.5 ab	44.9 a	39.7 ab	41.7 A
Sungu-2	23.6 abc	29.4 a	24.6 abc	25.8 AB	40.9 ab	46.1 a	40.0 ab	42.3 A
Sungu-3	23.8 abc	26.8 abc	25.2 abc	25.3 AB	41.2 ab	43.2 a	39.8 ab	41.4 A
Varto	24.2 abc	29.4 a	28.1 ab	27.2 A	42.0 ab	44.2 a	42.0 ab	42.7 A
Ziyaret	23.7 abc	29.2 a	26.2 abc	26.4 AB	42.3 a	44.1 a	42.2 a	42.9 A
Üçdere	20.4 abc	26.1 abc	25.6 abc	24.0 ABC	38.0 abc	40.2 ab	38.9 abc	39.0 AB
Elçi	21.8 abc	21.7 abc	23.2 abc	22.3 ABC	37.1 a-d	31.3 b-e	35.8 a-e	34.8 BC
Nimet	23.1 abc	18.1 c	28.4 ab	23.2 ABC	39.5 abc	27.1 de	41.6 ab	36.1 BC
Verko	21.0 abc	17.8 c	23.2 abc	20.7 C	37.3 a-d	25.8 e	35.4 a-e	32.9 C
Ömerbey	22.5 abc	19.9 bc	24.5 abc	22.3 BC	39.9 ab	28.8 cde	38.8 abc	35.9 BC
Mean	22.7 B	24.6 A	25.5 A	24.3	39.9 A	37.6 B	39.4 AB	39.0
LSD (0.05)	Year (Y): 1.75**, Genotype (G): 4.37**, Y x G: 9.08**				Year (Y): 2.08*, Genotype (G): 5.20**, Y x G: 10.79**			
	CV: 11.62%, **$P \leq 0.01$				CV: 8.60%, *$P \leq 0.05$, **$P \leq 0.01$			

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

	DDM (%)				RFV			
Genotypes	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**2018**	**Mean**
Sungu-1	71.3 abc	67.2 bc	68.6 abc	69.0 BC	164.5 cd	139.4 d	165.6 cd	156.5 C
Sungu-2	70.5 abc	66.0 c	69.8 abc	68.8 BC	161.3 cd	133.7 d	164.3 cd	153.1 C
Sungu-3	70.4 abc	68.0 abc	69.2 abc	69.2 BC	159.0 cd	147.3 d	162.2 cd	156.2 C
Varto	70.1 abc	66.0 c	67.0 bc	67.7 C	156.7 cd	139.2 d	150.2 d	148.7 C
Ziyaret	70.4 abc	66.1 c	68.5 abc	68.4 BC	154.9 cd	139.9 d	150.9 d	148.6 C
Üçdere	73.0 abc	68.5 abc	69.0 abc	70.2 ABC	180.1 bcd	159.2 cd	165.9 cd	168.4 BC
Elçi	71.9 abc	72.0 abc	70.8 abc	71.6 AB	180.5 bcd	214.9 abc	186.1 bcd	193.8 AB
Nimet	70.9 abc	74.8 a	66.8 bc	70.8 ABC	167.7 cd	257.4 a	151.9 d	192.3 AB
Verko	72.5 abc	75.1 a	70.9 abc	72.8 A	180.7 bcd	271.2 a	188.3 bcd	213.4 A
Ömerbey	71.4	73.4 ab	69.8 abc	71.6 AB	167.0 cd	237.9 ab	169.4 cd	191.5 AB
Mean	71.2 A	69.7 B	69.0 B	70.0	167.2 B	184.0 A	165.5 B	172.2
LSD (0.05)	Year (Y): 1.36**, Genotype (G): 3.41**, Y x G: 7.07**				Year (Y): 11.88**, Genotype (G): 29.66**, Y x G: 61.57**			
	CV: 3.14%, **$P \leq 0.01$				CV: 11.10%, **$P \leq 0.01$			

It was observed that the registered varieties gave higher values in terms of DDM and RFV compared to other genotypes and among the registered varieties, especially Verko and Elçi varieties attracted attention with their high DDM (71.6% and 72.8%) and RFV (193.8, and 213.4) values. Although local genotypes were lower in these values, some genotypes still presented results approaching the average values. These findings indicate that registered varieties offer a significant advantage in improving forage quality, but local genotypes also have significant potential under certain conditions. It has been observed that similar DDM and RFV results were obtained from previous studies conducted under regional conditions Çaçan and Arslan (2021), Keskin et al. (2021), Kalkanlı and Başbağ (2022).

Each of the genotypes showing values close to registered varieties in terms of yield or quality are actually variety candidates. Since the Eastern Anatolia Region is a region with a forage deficit, it is of great importance to evaluate promising genotypes in breeding studies. In addition, genotypes that have adapted to the ecological conditions of the region and have high genetic diversity may be more advantageous than registered varieties in some aspects, especially in terms of cold stress, resistance to diseases and pests or adaptation to the region. However, when we compare the genotypes with registered varieties, they may show variability in terms of yield and quality. With this variability, it should not be forgotten that genotypes are important genetic resources for breeding programs.

3.1. Biplot analysis

Biplot analysis showed that PC-1, which accounted for 72.25% of variation, and was associated with genotypes. PC-2, which accounted for 20.22% of the variation, and was related to traits (Figure 3). The alfalfa genotypes situated at the centre of each sector represent the genotype or genotypes that exhibit the highest performance in that sector and its associated traits.

The graph illustrated that the Elci, Omerbey and Verko genotypes were situated within the first sector. Among these genotypes, the Verko genotype exhibited the highest mean for RFV, DDM and CPR. The Nimet genotype exhibited the highest mean for DMY, GFY and CPY in the second sector, while Ziyaret and Varto genotypes were located in the third sector, and Varto genotype demonstrated the highest mean for ADF and NDF. In the fourth sector, the Ucdere, Sungu-1, Sungu-2 and Sungu-3 genotypes were included; however, they did not exhibit any distinctive characteristics regarding the examined traits. The observed lower averages of these genotypes compared to the other genotypes for the examined traits resulted in their absence from the biplot image, as they did not stand out for any of the traits. A positive correlation was identified between the traits in

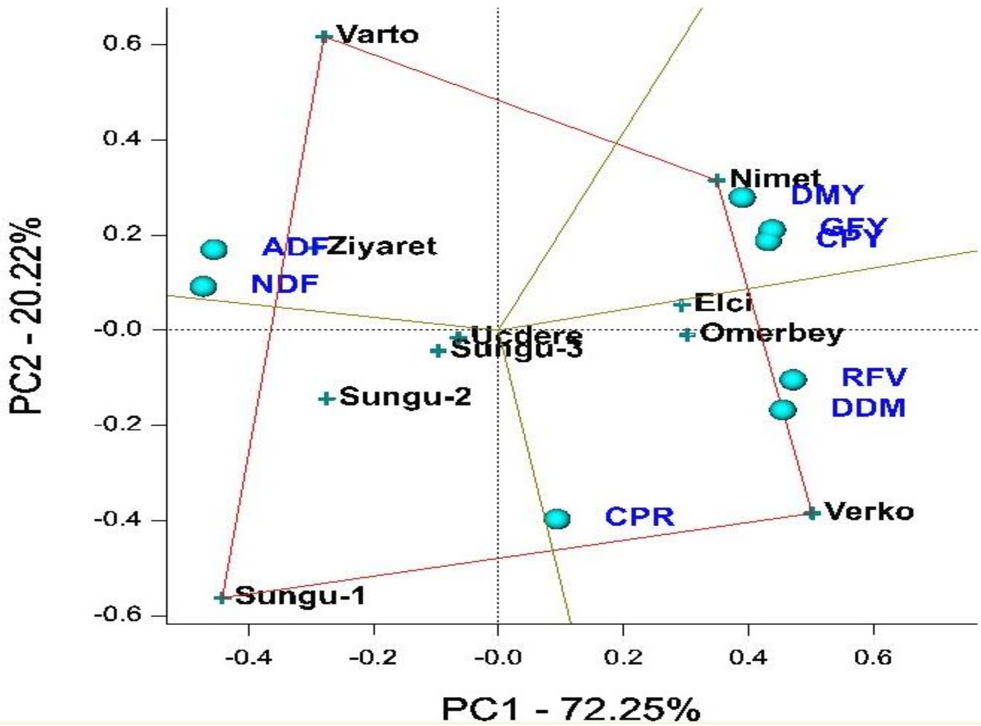

Figure 3. Polygon views of biplot analysis based on performance scaling for examined traits in the 'which-won-where' pattern of genotypes and traits. Abbreviations: GFY; Green forage yield, DMY; Dry matter yield, CPR; Crude protein ratio, CPY; Crude protein yield, ADF; Acid detergent fiber, NDF; Neutral detergent fiber, DDM; Digestible dry matter, RFV; Relative forage value.

the same sectors. Conversely, a negative correlation was observed between the traits on the right and the traits on the left of the coordinate plane (Figure 2).

3.2. Correlation analysis with heat-map method obtained from scatterplot matrix

The correlation graph indicates that there is a significant relationship between the traits in question when the regression coefficient (R) value approaches ±1.00. Conversely, as the value moves away from ±1, the strength of the relationship between the traits in question decreases.

Accordingly, the heat-map graph obtained demonstrated a positive and significant relationship between GFY and DMY (R= 0.97, $P \leq 0.01$), CPY and GFY (R= 0.97, $P \leq 0.01$), and DMY (R= 0.98, $P \leq 0.01$). Additionally, a positive and significant relationship was observed between DDM and GFY (R= 0.66, $P \leq 0.01$) and CPY (R= 0.64, $P \leq 0.01$). Furthermore, a positive and significant relationship was observed between RFV and GFY (R= 0.75, $P \leq 0.05$) and DDM (R= 0.97, $P \leq 0.01$). However, a negative and significant relationship was identified between ADF and GFY (R= -0.66, $P \leq 0.05$) and CPY (R= -0.64, $P \leq 0.05$), as well as between NDF and GFY (R= -0.75, $P \leq 0.05$) and CPY (R= -0.71, $P \leq 0.01$). A direct negative relationship was identified between DDM and ADF (R= -1.00, $P \leq 0.01$). A negative and high (almost direct) relationship was determined between DDM and NDF (R= -0.98, $P \leq 0.01$), RFV and ADF (R= -0.98, $P \leq 0.01$), and NDF (R= -0.99, $P \leq 0.01$) (Figure 4).

4. Conclusions

The genotypes "Sungu-3" and "Varto" and registered varieties "Elçi", "Nimet", "Verko" and "Ömerbey" were superior to the other genotypes due to the highest green forage yield (between 68.07-77.72 t ha^{-1}), dry matter yield (24.50-29.10 t ha^{-1}) and crude protein yield (5.32-6.66 t ha^{-1}). Both ADF and NDF values of all local genotypes were in the high group compared to registered varieties as most were in the low group. DDM and RFV values of local genotypes were in the low group. Elçi, Verko and Ömerbey registered varieties were in the high group for DDM. All registered varieties were in the high group for RFV.

Since Sungu-3 and Varto genotypes are close to registered varieties in terms of yield, these genotypes have the potential to provide a great advantage for farmers, especially if they want to engage in low-input agricultural production activities. Since these genotypes are well adapted to the regional climatic conditions, they stand out in terms of disease resistance, adaptation to different soil conditions and drought resistance.

In changing agricultural production conditions due to climate change, local genotypes are important genetic resources and have great potential in terms of yield and quality. While even the use of local genotypes in their current form provides advantages in terms of low input and adaptation, it is of great importance to include these local genotypes that show superior characteristics in terms of yield or quality in breeding studies. If these materials are included in breeding studies, both local genetic resources will be utilized and farmers will have the opportunity to gain new varieties with good performance.

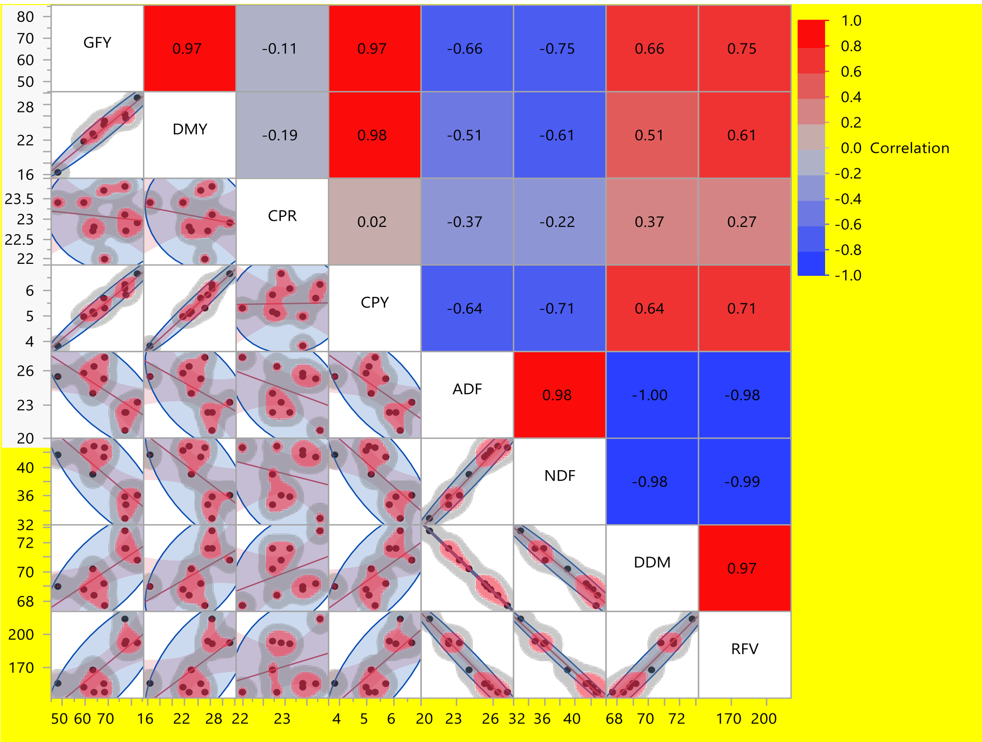

Figure 4. The correlations are estimated with the Roe-wise method. Abbreviations: GFY; Green forage yield, DMY; Dry matter yield, CPR; Crude protein ratio, CPY; Crude protein yield, ADF; Acid detergent fiber, NDF; Neutral detergent fiber, DDM; Digestible dry matter, RFV; Relative forage value.

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