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DETERMINATION OF FORAGE YIELD AND SILAGE QUALITY OF VARIOUS MAIZE (*Zea mays* L.) CULTIVARS UNDER KAYSERI ECOLOGICAL CONDITIONS

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Abstract
This study investigated the forage yield and silage quality features of some maize (Zea mays L.) cultivars under Kayseri ecological conditions. The field experiment was conducted in 2019 using a randomized block design with three replications, testing 12 maize cultivars (Simpatico, NK Vitorino, Hiva F1, Kerbanis, 9628 HP F1, Kontigos, Sy Antex, Kolosseus, Sy Inove, DKC 7240, Kilowatt, and Sy Dracma) that have different maturity groups. Measured parameters included plant height (2.54-3.16 m), stalk diameter (23.67-27.83 mm), leaf number (11.63-16.07 leaves), ear number (1-1.07 ears), first ear height (84-151 cm), leaf, stalk, and ear ratios (12.5-16.55%, 44.85-58.45%, and 27.27-40.77%, respectively), green herbage yield (6080-9158 kg/da), and dry matter yield (1912-2638 kg/da). Silage quality characteristics included dry matter content (25.24-31.99%), pH (3.67-4.12), Flieg score (97.36-119.50), crude protein ratio (4.45%-6.34%), neutral detergent fiber (41.16%-48.62%), acid detergent fiber (23.52%-32.17%), digestible dry matter (63.84-70.58%), dry matter intake (2.48-2.92%), and relative feed value (123.20-156.72). As a result, DKC 7240 had the highest green herbage yield, while DKC 7240, Kolosseus, and Sy Dracma had the highest dry matter yields. Hiva F1, NK Vitorino, and Simpatico achieved the highest crude protein rate of silage. The highest Flieg scores were recorded for Kerbanis, Kolosseus, Hiva F1, Sy Antex, 9628 HPF1, and Kontigos, and the highest relative feed values were observed in Kerbanis, Sy Antex, Sy Dracma, Simpatico, Kolosseus, NK Vitorino, and Hiva F1.

Keywords: Forage yield, Forage quality, Silage, Zea mays

1. INTRODUCTION

Maize is an annual cross-pollinated plant belonging to the Poaceae family. While maize has a wide range of uses in human nutrition and various industries, a significant proportion of its production over the last 30 years has been allocated to animal feed and globally, 62% of domestic maize production is used for feed purposes (Daşdan, 2018). In countries with well-developed livestock industries—such as Germany, the Netherlands, and the United States—maize silage plays a crucial role in cattle feeding (Tezel, 2018; Daşdan, 2018). Similarly, in Türkiye, the use of maize silage in animal nutrition is becoming increasingly common, and the areas dedicated to silage maize cultivation are expanding. The growing interest in maize as a forage crop and the expansion of its cultivation area can be attributed to several factors: its high dry matter yield per unit area, compatibility with mechanized farming practices, the availability of varieties (from different maturity groups) suited to different ecological conditions, its potential for use as a second crop, its

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suitability for high-quality silage production, and its higher energy content compared to other roughages (Tezel, 2018; Mut et al., 2019). As with other crops, the selection of an appropriate variety plays a critical role in determining yield in maize production. Maize is inherently a warm-season crop that thrives under adequate moisture conditions. The minimum germination temperature is 9-10 °C, and the most suitable growth temperature is between 25-30 °C. It is greatly affected by the environmental conditions between emergence and tasselling, and the climatic conditions during this period are an important factor determining the maturity and harvest date (Kün, 1994: 169s). Maize has cultivars from different maturity groups. Early-maturing varieties reach physiological maturity in approximately 70–75 days, whereas late-maturing varieties require around 140 days (Mut et al., 2019). The maturity period is a critical criterion in variety selection. However, other characteristics—such as high yield potential, genetic structure, ear size, adaptability to local environmental conditions, and resistance to pests—must also be considered (Emeklier et al., 2011). Moreover, there is significant variability in the chemical composition of maize due to genotypic traits and growing conditions (Kızılşimşek et al., 2024). Since not all varieties perform equally well under different environmental conditions, it is essential to conduct regional trials to identify the cultivars best suited to local ecologies. Therefore, the objective of this study was to determine the forage yield and silage quality characteristics of several maize cultivars from different FAO maturity groups.

2. MATERIALS AND METHODS

The maize cultivars given in Table 1. were used in the experiment. The FAO maturity groups of the cultivars vary between 300 and 750. The research was conducted in 2019 on the land belonging to the Erciyes University Agricultural Research and Application Center located in the central campus of Erciyes University (Talas-Kayseri-Türkiye). The monthly total precipitation (mm) and average temperature (ºC) values for the year 2019 and the long-term average are provided in Figure 1. In the May-August period when the experiment was conducted, a total of 126.9 mm of rainfall was recorded, which was above the long-term average (111 mm). It was observed that in May and June, the monthly average temperature values were above the long-term average, while in July, a temperature of 21.6 ºC was recorded, which is below the long-term average (22.2 ºC). The soil of the experimental area has a sandy-loam texture with a 13.65% clay, 11.25% silt and 74.48% sand ratio, and its organic matter is low (1.54%), EC value is 0.098 mmhos/cm, pH value is 7.24, P_2O_5 content is 6.25 kg/da and lime content is 1.13%.

The research was carried out according to a randomized block design (RCBD) with three replications a total of 12 maize cultivars, from different maturity groups and supplied by various seed companies, were used in the study. Each block consisted of 12 plots with a plot length of 3 meters. A distance of 1 meter was maintained between the blocks. Before planting, a compound fertilizer (15-15-15) was manually applied at a rate of 8 kg/da (N, P_2O_5, and K_2O), incorporated into the soil using a cultivator. Seven rows per plot were opened using a hand marker set to 70 cm row spacing. Manual sowing was carried out on May 5, 2019, placing two seeds every 20 cm in each row. Singling was performed after seedling emergence. Approximately three weeks after singling, weed control was done using hoes, followed by the throat-filling operation. Subsequently, an additional 12 kg/da of nitrogen (in the form of ammonium sulphate) was applied through a drip irrigation system as top dressing. The experimental area was irrigated with a sprinkler system until

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the throat-filling stage and then switched to a drip irrigation system based on the crop's water requirement.

Harvesting was carried out in August, with specific dates shown in Table 1. For morphological and agronomic measurements, 10 plants were randomly selected from each replication to determine plant height (from soil surface to tassel tip), stalk diameter (measured at the first internode above the soil), first ear height (from soil to the node of the first ear), number of leaves per plant, number of ears per plant, and biomass composition (leaf, stalk, and ear components were separated and weighed). Green herbage yield (GHY) was determined by harvesting 20 plants from the inner rows of each plot at the ½-milk line stage. Two of these plants were dried at 65°C to constant weight to determine dry matter (DM) content. Dry matter yield (DMY) was calculated by multiplying DM ratio with green herbage yield per decare.

For silage quality assessment, two randomly selected plants from each replicate were chopped using a stalk shredder, packed in vacuum-sealed bags, and stored in a dark environment at room temperature. After a 60-day fermentation period, the silage was opened. A 150 g sample from each was dried at 65°C to determine the silage DM ratio. Additionally, 40 g of fresh silage was mixed with 360 ml of distilled water, and the pH of the filtrate was measured (Budaklı-Çarpıcı, 2009). Flieg scores were calculated using the formula from Kılıç (1986), as cited by Öten et al. (2016), based on silage DM and pH values. Dried silage samples were ground to pass through a 1 mm sieve. Crude protein (CP) content was estimated by determining total nitrogen via the Kjeldahl method (Bremner and Mulvaney, 1982) and multiplying by the factor 6.25. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents were determined using the Ankom 200 fiber analyzer, following the manufacturer's protocol. Dry matter intake, digestible dry matter and relative feed values in silages were calculated using the following formulas provided to Güney et al. (2016).

Dry matter intake (DMI; % of body weight) = 120 / NDF

Digestible Dry Matter (DDM; % DM) = 88.9 - (0.779 × %ADF),

Relative Feed Value (RFV) = DDM × DMI /1.29

The data obtained from the study were subjected to analysis of variance (ANOVA) using the SPSS software, in accordance with the randomized block design. Duncan's Multiple Range Test was used to determine significant differences between the means.

Table 1. Maize cultivars used in the experiment, FAO groups and harvest dates

No	Maize Cultivars	FAO Groups	Harvest Date	No	Maize Cultivars	FAO Groups	Harvest Date
1	Simpatico (KWS)	300	08.08.2019	7	SY Antex (SYNGENTA)	400	21.08.2019
2	NK Vitorino (SYNGENTA)	600	13.08.2019	8	Kolosseus (KWS)	680	22.08.2019
3	Hiva F1 (BIOTEK)	600	17.08.2019	9	SY Inove (SYNGENTA)	450	22.08.2019
4	Kerbanis (KWS)	550	17.08.2019	10	DKC 7240 (DEKALB)	750	24.08.2019
5	9628HP F1 (BIOTEK)	500	18.08.2019	11	Kilowatt (KWS)	700	24.08.2019
6	Kontigos (KWS)	550	19.08.2019	12	SY Dracma (SYNGENTA)	450	24.08.2019

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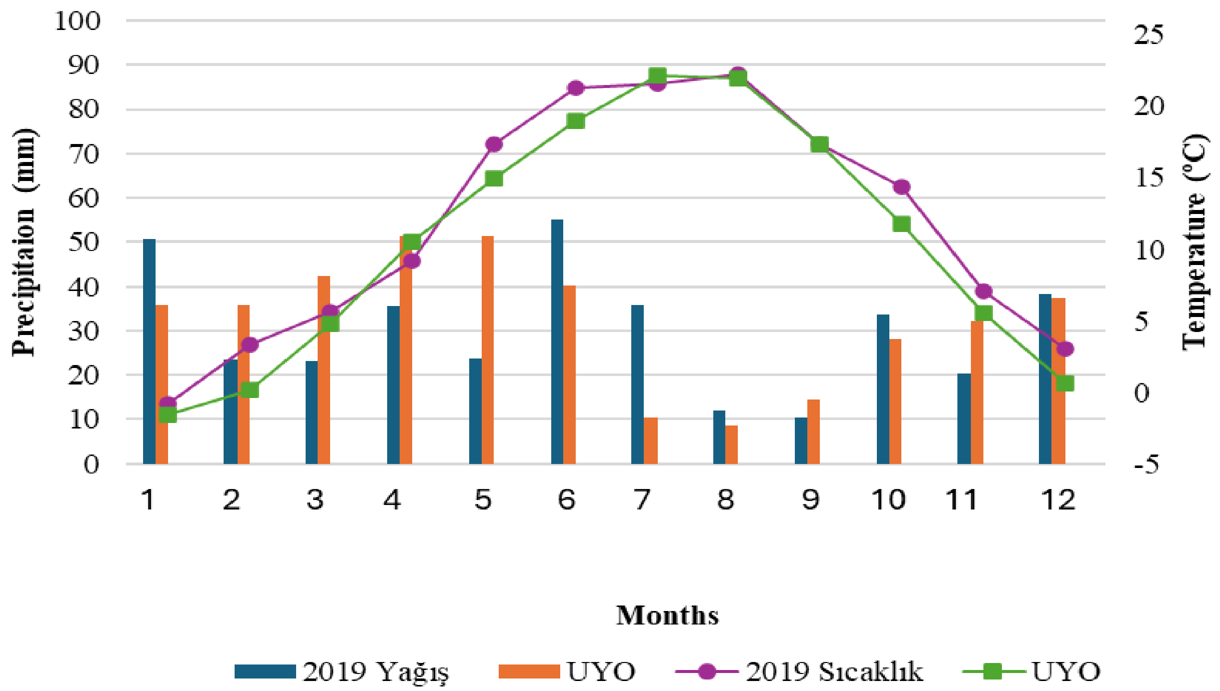

Figure 1. Monthly total precipitation (mm) and average temperature (ºC) values for the year 2019, and the long-term average

3. RESULTS AND DISCUSSIONS

The results of the variance analysis revealed that the differences among the cultivars in terms of plant height, stalk diameter, number of leaves per plant, first ear height, leaf ratio, stalk ratio, ear ratio, green herbage yield, and dry matter yield were statistically significant at the 1% probability level (Table 2). The highest plant height and stalk diameter values among the silage maize cultivars were obtained from the Kilowatt and Sy Dracma cultivars, measuring 3.16 m and 27.83 mm, respectively. In contrast, the lowest values were recorded in the 9628 HP F1 cultivar, with 2.54 m and 23.67 mm, respectively. Studies conducted under different ecological conditions have reported varying results: Okan (2015) reported plant heights ranging from 266 to 365.33 cm and stalk diameters from 22.03 to 29.03 mm in different maize cultivars under the ecological conditions of Bismil (Diyarbakır); Çaçan and İşikten (2018) recorded values between 248.7–282.7 cm and 19.9–22.6 mm in Bingöl; Öner and Güneş (2019) reported ranges of 309.93–365.20 cm in plant height and 23.44–27.84 mm in stalk diameter in Ordu; Yozgatlı et al. (2019) observed values ranging from 1.92 to 2.93 m and 15.32 to 25.75 mm in Yozgat; and Meşe and Gülümser (2020) found plant heights between 2.95–3.81 m and stalk diameters ranging from 1.48 to 2.84 cm in Bilecik. These variations suggest that plant height and stalk diameter are influenced by both the genetic characteristics of the cultivars and the ecological conditions under which they are grown. When the mean number of leaves in the maize cultivars was examined, the highest value was observed in the DKC7240 cultivar with 16.07 leaves per plant, while the lowest was recorded in the NK Vitorino

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cultivar with 11.63 leaves. The number of ears per plant ranged from 1.00 to 1.07 among the cultivars. Regarding the height of the first ear, the highest value was obtained from the DKC7240 cultivar at 151.07 cm, whereas the lowest was recorded in the 9628 HP F1 cultivar at 84.17 cm. The results for number of leaves per plant and first ear height were similar to those reported by Yılmaz et al. (2020), but lower than those found by Meşe and Gülümser (2020). Yıldız et al. (2017) indicated that the interaction between variety and location was significant, as first ear height differed across the Ödemiş and Kiraz regions. The maize cultivars in the present study had leaf, stalk, and ear ratios ranging between 12.5–16.55%, 44.85–58.45%, and 27.27–40.77%, respectively. One of the important indicators of high-quality maize silage is a high proportion of ear in the total plant biomass (Arslan, 2016). Since the interior of the maize stalk consists of a hard and indigestible spongy material, a high proportion of stalks is generally undesirable (Geren et al., 2003; Arslan, 2016). In high-quality maize silage, higher proportions of ears and leaves/stalks contribute positively to the nutritional value (Arslan, 2016). However, some researchers have reported that following silage fermentation, the stalk softens and develops a smell and aroma that is appealing to animals (Arslan, 2016). The cultivars identified as having high ear and leaf ratios and low stalk ratios were Kerbanis, 9628 HP F1, and Kontigos in the present study. Olgun et al. (2012) found that in different maize varieties grown in Eskişehir, the percentages of leaves, stalks, and ears were 10.6–15.71%, 29.66–47.30%, and 39.51–59.69%, while Çaçan and İşikten (2018) reported these percentages as 15.2–18.1%, 48.1–53.1%, and 30.1–35.1% for maize grown in Bingöl.

When both green herbage and dry matter yields were examined, the highest green herbage and dry matter yields were obtained from the DKC7240 with 9158 kg/da and 2638 kg/da, respectively. In terms of dry matter yield, DKC7240, Kolosseus, and SY Dracma were found to be in the same statistical group. The lowest both green herbage and dry matter yields were obtained from the Simpatico with 6080 kg/da and 1912 kg/da, respectively. In a study conducted under Bilecik conditions, Meşe and Gülümser (2020) reported that the dry matter yields of different silage maize varieties ranged from 2464 to 4251 kg/da in 2019, and from 2505 to 4273 kg/da in 2020. Güney et al. (2010), in their study of various maize varieties with different maturity groups in Erzurum, reported silage yields ranging from 4755 to 7876 kg/da in 2005 and from 4987 to 7310 kg/da in 2006. Olgun et al. (2012) reported green herbage yields of 6698 to 13487 kg/da and dry matter yields of 1826 to 4100 kg/da in Eskişehir. Okan (2015) found green herbage yields ranging from 7945 to 17020 kg/da and dry matter yields between 1704 and 2921 kg/da in Bismil, Diyarbakır. Differences in yield values may be attributed to ecological factors, variations in cultivation practices, and differences in the varieties used (Alagöz and Türk, 2019).

According to the variance analysis, differences among maize cultivars were statistically significant at the 1% probability level in terms of DM, pH, FC, CP, ADF, DDM, and DMI. Differences in NDF and RFV values were significant at the 5% probability level (Table 3). Among the evaluated maize cultivars, the highest dry matter content in silage was obtained from the Kerbanis with 31.99%, while the lowest was recorded for the SY Dracma with 25.24%. In previous studies, dry matter contents in maize silage were reported as 30.2–37.9% by Millner et al. (2005), 28.96–31.49% by Kavut and Soya (2012), and 20.93–32.00% by Güney et al. (2010). In silage maize, harvesting is generally determined according to the milk line stage of the kernel, as there is a relationship between the milk line progression and dry matter content. However, Johnson et al. (2003), in a study conducted with several maize varieties in Washington, reported that in 1996, the dry matter content at the 1/3 and 2/3 milk line stages in kernels of 3845 hybrid maize was 25% and 29.3%,

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respectively. In 1997, the same hybrid showed 25.3% and 31.3% dry matter contents at the respective stages, while the Quanta hybrid had 26.8% and 34%. These findings indicate that, in silage maize, dry matter content at the same milk line stage may vary between varieties, and even within the same variety across different years (Keleş and Çıbık, 2014). One of the most important criteria for determining silage quality is pH measurement, and the pH value of high-quality silage should be around 3.8 and 4.0 (Kızılşimlek et al. 2024). In the present study, the pH values of the silages ranged from 3.67 to 4.12, which falls within the desired range. As shown in Table 3, the effect of cultivar on the pH values of silages from different maize cultivars was statistically significant ($p<0.05$). The lowest pH values (ranging from 3.67 to 3.76) were obtained from the Kontigos, 9628 HP F1, Hiva F1, Kerbanis, SY Antex, and Kolosseus, while the highest pH values were recorded for Simpatico and NK Vitorino with 4.12 and 4.05. The Flieg score, calculated based on the silage's dry matter content and pH, is commonly used as an indicator to assess the fermentation quality of silage (Liu et al., 2024). In this study, the Flieg scores of maize silages varied between 97.36 and 119.50. Hiva F1, Kerbanis,9628 HP F1, Kontigos, Sy Antex and Kolosseus had the highest Flieg scores. Our findings are in accordance with the results of Sarıçiçek et al. (2016). The Flieg score values obtained show that the silages of the cultivars examined in the study are in the excellent quality class (Sokac Cvetnic et al., 2023).

The highest crude protein content was obtained from the Hiva F1 with 6.34%, while Simpatico and NK Vitorino were also in the same statistical group. The lowest crude protein content was observed in the Sy Inove with 4.45%, which was statistically grouped together with Sy Antex, DKC 7240, Kilowatt, and Sy Dracma. Similarly, other studies by Başaran et al. (2017) in Yozgat from 2013 to 2014 and by Güney et al. (2010) in Erzurum between 2005 and 2006 also found important differences in protein content among maize varieties. The protein content obtained in this study was comparable to that reported by Kuşvuran et al. (2015) (4.80–7.02%) and Araujo et al. (2012) (5.29–6.16%), but was lower than the values reported by Başaran et al. (2017) (6.34–9.39%). Digestibility is an important quality measure for roughage, and recently, researchers have been using NDF and ADF to estimate how digestible forages are. NDF is used to estimate feed intake potential, whereas ADF is associated with digestibility (Özkul et al., 2007). Low levels of NDF and ADF in feed indicate higher intake, digestibility, and energy availability, whereas high levels of NDF and ADF are associated with reduced feed intake, lower digestibility, and lower energy content (Atalay et al., 2021). According to Keleş and Çıbık (2014), the ideal NDF and ADF ranges for high-quality corn silage are 38–47% and 22–28%, respectively. In this study, NDF and ADF values among the corn cultivars ranged from 41.16% to 48.62% and from 23.52% to 32.17%, respectively, with significant differences observed between cultivars. In different maize cultivars, digestible dry matter (DDM) ranged from 63.84% to 70.58%, dry matter intake (DMI) from 2.48% to 2.92%, and relative feed value (RFV) from 123.20 to 156.72 (Table 3.14). RFV is an index used to estimate forage quality, calculated based on ADF and NDF values, and an RFV between 103 and 124 is considered second quality, between 125 and 151 is first quality, and above 151 is prime quality (Kılıç and Abdiwali, 2016). In this study, the highest RFV values were obtained from the Kerbanis (156.72), Sy Antex (147.99), Sy Dracma (143.06), Simpatico (138.95), Kolosseus (137.21), NK Vitorino (136.76), and Hiva F1 (136.64) maize cultivars.

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Table 2. Mean values of plant height, stalk diameter, number of leaves per plant, first ear height, leaf ratio, stalk ratio, ear ratio, green herbage yield, and dry matter yield of various maize cultivars

Cultivars	BH (m)	SD (mm)	NPL	FEH (cm)	LR (%)	SR (%)	ER (%)	GHY (kg/da)	DMY (kg/da)
Simpatico	2.88 c*	24.60 bc*	12.93 cd*	106.9 de*	12.62 ef*	46.86de*	40.51 a*	6080 e*	1912 e*
NK Vitorino	2.99 abc	24.58 bc	11.63 e	100.7 e	14.37 b-e	44.85 e	40.77 a	7316 cd	2113 de
Hiva F1	2.67 d	24.65 bc	12.43 d	107.3 de	13.59 c-f	48.00 de	38.33 ab	7087 cd	2232 cd
Kerbanis	2.94 bc	24.54 bc	13.87 b	112.6 cd	15.52 ab	44.98 e	39.50 a	7190 cd	2381 bc
9628HP F1	2.54 d	23.67 c	12.57 d	84.1 f	15.25 abc	45.33 e	39.41 a	6656 de	2186 cd
Kontigos	2.93 c	24.59 bc	12.60 d	109.0 cde	14.99 a-d	47.95 de	37.06 ab	7185 cd	2150 cde
Sy Antex	3.14 a	27.39 a	12.87 cd	117.9 bc	14.65 b-d	49.74 cd	35.61 bc	7504 bcd	2300 cd
Kolosseus	3.03 abc	26.45 ab	13.93 b	123.7 b	12.58 f	48.14 de	39.27 ab	7763 bcd	2579 ab
Sy Inove	3.11 a	26.06 abc	12.90 cd	117.8 bc	13.26 d-f	49.32 cd	37.42 ab	7292 cd	2248 cd
DKC7240	3.12 a	27.40 a	16.07 a	151.0 a	16.55 a	53.95 b	29.50 d	9158 a	2638 a
Kilowatt	3.16 a	26.22 ab	13.33 bc	126.5 b	14.00 b-f	52.72 bc	33.27 c	7497 bcd	2285 cd
Sy Dracma	3.10 ab	27.83 a	13.97 b	125.6 b	14.28 b-f	58.45 a	27.27 d	8325 b	2403 abc
Mean	**2.97**	**25.63**	**13.26**	**115.83**	**14.31**	**47.91**	**36.49**	**7421**	**2286**
Error mean squarre	**0.008**	**1.703**	**0.120**	**28.50**	**0.863**	**4.152**	**3.873**	**209190**	**18822**
F value	**14.17****	**3.45****	**31.55****	**28.31****	**4.904****	**11.95****	**14.75****	**8.60****	**6.312****

**: There is no difference between the means indicated by the same letter in the same column ($p<0.05$)*
***BH:** Plant height; **SD:** Stalk diameter; **NLP:** Number of leaves per plant; **FEH:** First ear height; **LR:** Leaf ratio; **SR:** Stalk ratio; **ER:** Ear ratio; **GHY:** Green herbage yield; **DMY:** Dry matter yield.*

Table 3. Mean values of DM content, pH, Flieg score, CP ratio, ADF, NDF, DDM, DMI and RFV of silages from various maize cultivars.

Cultivars	DM (%)	pH	Flieg score	CP (%)	ADF (%)	NDF (%)	DDM (%)	DMI (%)	RFV
Simpatico	28.65 b-e*	4.12 a*	97.36 d*	5.84 ab*	24.30 c*	47.23 a*	69.97 a*	2.56 b*	138.95 abc*
NK Vitorino	29.26 bcd	4.05 a	101.65 cd	6.03 ab	27.79 abc	45.78 ab	67.25 abc	2.62 b	136.76 abc
Hiva F1	29.72 abc	3.69 cd	116.57 ab	6.34 ab	28.22 abc	45.58 ab	66.92 abc	2.63 b	136.64 abc
Kerbanis	31.99 a	3.74 bcd	119.50 a	5.43 bc	25.17 bc	41.16 b	69.29 ab	2.92 a	156.72 a
9628 HP F1	29.15 bcd	3.73 bcd	114.37 ab	5.50 bc	28.32 abc	46.07 ab	66.84 c	2.61 b	135.49 bc
Kontigos	27.36 cdef	3.67 d	113.05 ab	5.31 bc	30.96 a	48.62 a	64.78 abc	2.47 b	124.24 c
Sy Antex	30.78 ab	3.76 bcd	116.30 ab	4.89 cd	25.48 bc	43.61 ab	69.05 ab	2.76 ab	147.99 ab
Kolosseus	31.94 a	3.77 bcd	118.00 a	5.30 bc	29.55 ab	44.86 ab	65.88 bc	2.68 ab	137.21 abc
Sy Inove	28.83 bcde	3.87 b	108.00 bc	4.45 d	29.55 ab	48.10 a	65.88 bc	2.50 b	127.99 bc
DKC7240	26.44 ef	3.84 bc	104.28 cd	4.96 cd	29.30 ab	48.34 a	66.07 bc	2.48 b	127.40 bc
Kilowatt	26.82 def	3.88 b	103.30 cd	4.50 d	32.17 a	48.27 a	63.84 c	2.49 b	123.20 c
Sy Dracma	25.24 f	3.83 bc	102.28 cd	4.95 cd	23.52 c	45.91 ab	70.58 a	2.62 b	143.06 abc
Mean	**28.85**	**3.83**	**109.56**	**5.29**	**27.86**	**46.13**	**67.20**	**2.61**	**136.30**
Error mean squarre	**1.779**	**0.007**	**23.48**	**0.156**	**6.337**	**6.648**	**3.844**	**0.021**	**113.203**
F value	**7.565****	**8.324****	**7.378****	**6.528****	**3.476****	**1.211***	**3.478****	**2.400****	**2.586***

**: There is no difference between the means indicated by the same letter in the same column ($p<0.05$)*
***DM:** Dry matter content ; pH: pH ; **FS:** Flieg score; **CP:** Crude protein ratio; **ADF:** Acid detergent fiber; **NDF:** Neutral detergent fiber; **DDM:** Digestible dry matter; **DMI:** Dry matter intake; **RFV:** Relative feed value.*

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The PCA analysis output for the parameters examined across different maize cultivars is presented in Table 4. Eleven independent principal components were identified, including four principal component axes with eigenvalues greater than 1. These first four axes accounted for 87.49% of the total variance: PC1 explained 36.70%, PC2 explained 24.15%, PC3 explained 15.72%, and PC4 explained 7.2%. These results indicated that the principal component analysis conducted on the evaluated parameters was interpretable and reliable (Özaktan et al., 2022a; 2022b).

Tablo 4. Eigen values, percent and cum percent, for investigated parameters

Number	Eigenvalue	Percent	Cum Percent
1	7.1458	39.699	39.699
2	4.3461	24.145	63.844
3	2.8300	15.722	79.567
4	1.4253	7.918	87.485
5	0.8608	4.782	92.267
6	0.6649	3.694	95.961
7	0.3641	2.023	97.984
8	0.1706	0.948	98.932
9	0.1348	0.749	99.680
10	0.0483	0.268	99.948
11	0.0093	0.052	100.000

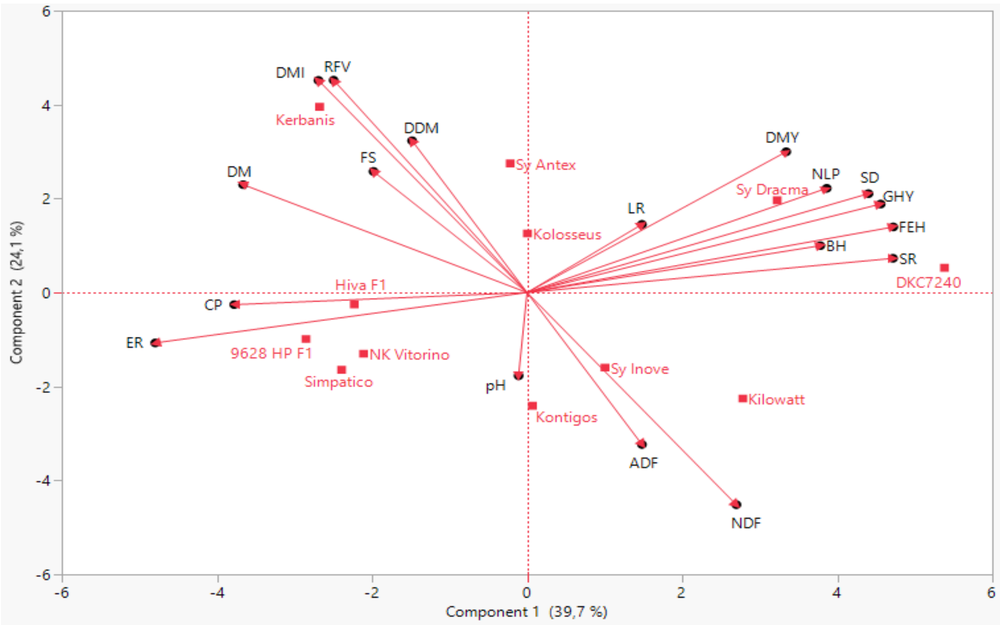

Figure 2. Biplot analysis for the investigated parameters and maize cultivars

***BH:** Plant height; **SD:** Stalk diameter; **NLP:** Number of leaves per plant; **FEH:** First ear height; **LR:** Leaf ratio; **SR:** Stalk ratio; **ER:** Ear ratio; **GHY:** Green herbage yield; **DMY:** Dry matter yield; **DM:** Dry matter content ; pH: pH ; **FS:** Flieg score; **CP:** Crude protein ratio; **ADF:** Acid detergent fiber; **NDF:** Neutral detergent fiber; **DDM:** Digestible dry matter; **DMI:** Dry matter intake; **RFV:** Relative feed value.*

The results of the biplot analysis of the cultivars and the investigated traits are presented in Figure 2. In the biplot, the positions, lengths, and angles between the trait vectors indicate the relationships

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among traits; a smaller angle between vectors implies a close (positive) relationship, whereas a wider angle suggests a distant (negative) relationship (Yan, 2014; Özaktan, 2021). Figure 2 revealed that the traits LR, DMY, NLP, SD, GHY, FEH, BH, and SR—positioned in the positive region of the X-axis—were positively correlated with one another. In particular, SD, FEH, and SR, which had vector lengths and directions similar to that of GHY, exhibited a highly significant positive association. The cultivars DKC7240 and Sy Dracma, which were located in the same region, were superior in terms of the traits represented by these vectors. Similarly, a positive relationship was observed among the DDM, RFV, DMI, FS, and DM traits in the positive region of the Y-axis, with Kerbanis showing the highest values, especially for DMI and RFV, thus distinguishing itself from the other cultivars. In contrast, the traits ER, CP, and pH were most strongly associated with the cultivars Simpatico, 9628 HP F1, NK Vitorino, and Hiva F1, which were clustered in the same region, thereby setting these cultivars apart from others. Notably, a strong negative relationship was observed between NDF and both DMI and RFV, as well as between ER and SR (Figure 2). These findings were consistent with those reported by Kökten et al. (2017) in their study on silage corn.

4. CONCLUSIONS

As a result, DKC 7240 had the highest green herbage yield, while DKC 7240, Kolosseus, and Sy Dracma had the highest dry matter yields in kayseri ecological conditions in 2019. Hiva F1, NK Vitorino, and Simpatico achieved the highest crude protein content in silage. The highest Flieg scores were recorded for Kerbanis, Kolosseus, Hiva F1, Sy Antex, 9628 HPF1, and Kontigos. The highest relative feed values were observed in Kerbanis, Sy Antex, Sy Dracma, Simpatico, Kolosseus, NK Vitorino, and Hiva F1. Nevertheless, to better characterize cultivars performance and stability, multi-year trials across diverse ecological zones of Kayseri are recommended.

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