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# A Comparison of the Nutrient Contents and In Vitro Digestibility of Silage Corn Varieties Grown as Main and Secondary Crops

## Ana ve İkinci Ürün Olarak Yetiştirilen Silajlık Mısır Çeşitlerinin Besin Madde İçerikleri ve İn Vitro Sindirilebilirliklerinin Karşılaştırılması

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### ABSTRACT

A study was conducted to determine the dry matter yields as well as the nutrient compositions and in vitro digestibility of nine silage corn varieties grown as main and second crops under Van conditions. In 2020-2021, a study was conducted on 9 corn varieties from different maturation groups during the growing periods of the main crop and the second crop. The main crop was harvested during the transition from milk maturity to dough stage maturity, while the second crop was harvested at the beginning of the milk maturity period. The study determined the crude nutrient (DM, CA, CP, EE, ADF, and NDF) analysis and in vitro dry matter digestibility (IVDMD) of the corn herbage. The Bodega corn variety had the highest DM yield in the main crop, while the KxB6451 corn variety had the highest yield in the second crop. Among the varieties studied, DKC5685 had the lowest DM yield, ADF, and NDF content in the main product. However, it had the highest CP content and IVDMD ($p$ <.05). The KxB8392 silage variety was found to have the highest CP content and digestibility compared to other varieties in the second product ($p$ <.05). It is important to choose the most appropriate early varieties that are suitable for the ecological conditions of the region. The Capuzi variety in the main crop and the KxB8392 variety in the second crop were found to be the most suitable in terms of DM yield, CP, ADF and NDF content, and IVDMD.

**Keywords:** Main and second crop, Silage corn, Variety, In vitro dry matter digestibility

### ÖZ

Van koşullarında ana ve ikinci ürün olarak yetiştirilen silajlık dokuz mısır çeşidinin kuru madde verimleri yanı sıra besin madde kompozisyonları ve in vitro sindirilebilirliklerini belirlemek amacıyla bu çalışma yapılmıştır. 2020-2021 yıllarında ana ürün ve ikinci ürün yetiştirme dönemlerinde yürütülen farklı olgunlaşma gruplarına ait 9 mısır çeşidi yetiştirilmiştir. Hasat, ana ürün olarak yetiştirme koşullarında süt olumdan sarı oluma geçişte, ikinci üründe ise süt olum dönemi başlangıcında yapılmıştır. Hasılların ham besin madde (KM, HK, HP, HY, ADF ve NDF) analizleri ile in vitro kuru madde sindirilebilirlikleri (IVKMS) belirlenmiştir. Ana üründe en yüksek kuru madde verimi Bodega çeşidinde, ikinci üründe ise KxB6451 çeşidinde belirlenmiştir ($p$ <.05). KM verimi, ADF ve NDF içeriği en düşük olan ana ürün varyetesi DKC5685 iken, HP içeriği ve İVKMS bakımından en yüksek varyete olarak belirlenmiştir ($p$ <.05). İkinci üründe ise HP içeriği ve sindirilebilirlik açısından en iyi varyete olarak KxB8392 belirlenmiştir ($p$ <.05). Erkenci çeşitler içerisinden uygun çeşitlerin seçilmesi gerekmektedir. Ana üründe Capuzi varyetesi, ikinci üründe ise KxB8392 varyetesi KM verimi yanında sıra HP, ADF ve NDF içeriği ile IVKMS açısından öne çıkan çeşitler olmuştur

**Anahtar Kelimeler:** Ana ve ikinci ürün, Silajlık mısır, Varyete, İn vitro kuru madde sindirilebilirliği

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## Introduction

The satisfaction of forage requirements is the most important criterion for the efficient maintenance and increase of animal production. The production of roughage, which represents an essential source of nutrition for ruminants in our country, is inadequate in terms of both quality and quantity. Although drying is a common practice in our country for meeting the roughage needs of animals throughout the year, silage production and ensiling have reached desired levels primarily in our western regions. The main reason why silage production in the Eastern Anatolia Region is not reaching the desired level is that corn is not widely grown in the region and some risks exist in producing it. It is known that the most important plant used for making silage is corn, and in places where silage technology is developed, corn is grown without any problems (Güney et al., 2010; Koç & Çalışkan, 2016). Corn silage has a high dry matter (DM) production potential per unit area, and this potential is reliable and sustainable. It is the most preferred fodder plant for silage due to its advantages, such as the possibility of being grown as a second crop, its suitability for mechanization, the lack of need for additives for fermentation and the ease with which it can be ensiled. In addition to these advantages, corn silage is widely used in ruminant rations because it can be easily mixed into total rations, has a high energy value compared to other forage sources, and is a source of insoluble dietary fiber (NDF) in neutral solvents (Buxton & O'Kiely, 2003; Fernandez et al., 2004; Ferraretro et al., 2015). According to the data from TÜİK (2022), corn, which is the third cereal in our country after wheat and barley, is cultivated on 524,792 hectares for silage purposes. The total yield is 28558983 tons and theaverage yield is 5444 kg $da^{-1}$. In the same year, according to TÜİK data, corn for silage is cultivated on 1210.3 ha in Van Province and the average yield is 4963 kg per decare.

The production of quality silage corn necessitates choosing a variety with an appropriate maturity index for each region. Research has demonstrated that varieties with disparate maturity indexes exhibit notable discrepancies in quality parameters, even when cultivated in a single trial area and harvested on the same date (Gruber et al., 2006; Zeller et al., 2014). Corn, a warm-season crop, requires a safe frost-free period of at least three months for successful cultivation. In the East Anatolia Region, the short vegetation period, and the late arrival of the last frosts of spring and early arrival of the first frosts of autumn make corn farming difficult. Recently, in provinces such as Van, Ağrı, Erzurum and Kars, where the vegetation period is short, silage corn cultivation has become widespread with the introduction of early maize varieties (Bulut et al, 2008). Corn varieties are evaluated by dividing them into 8 separate groups by the FAO system according to their maturity times. This value varies between FAO-100 and FAO-800. The varieties in the FAO-100 group are the earliest, and those in the FAO-800 group are the latest. On average, the FAO-100 group completes its maturation in 70 to 75 days, the FAO-400 group in 100 to 105 days, and the FAO-800 group in 140 days (Bulut, 2016). However, these are full maturity times, and it is anticipated that these times will be shortened by approximately two weeks at harvest to select the most productive silage corn seed. However, new varieties introduced to the market need to be tested in different ecologies and adaptation studies must be carried out continuously. Based on this assumption, a study was conducted to determine the dry matter yields per decare, as well as the nutrient compositions and in vitro digestibility of nine different silage corn varieties grown as first and second crops under Van ecological conditions. The satisfaction of forage requirements is the most important criterion for the efficient maintenance and increase of animal production. The production of roughage, which represents an essential source of nutrition for ruminants in our country, is inadequate in terms of both quality and quantity. Although drying is a common practice in our country for meeting the roughage needs of animals throughout the year, silage production and ensiling have reached desired levels primarily in our western regions. The main reason why silage production in the Eastern Anatolia Region is not reaching the desired level is that corn is not widely grown in the region and some risks exist in producing it. It is known that the most important plant used for making silage is corn, and in places where silage technology is developed, corn is grown without any problems (Güney et al., 2010; Koç & Çalışkan, 2016). Corn silage has a high dry matter (DM) production potential per unit area, and this potential is reliable and sustainable. It is the most preferred fodder plant for silage due to its advantages, such as the possibility of being grown as a second crop, its suitability for mechanization, the lack of need for additives for fermentation and the ease with which it can be ensiled. In addition to these advantages, corn silage is widely used in ruminant rations because it can be easily mixed into total rations, has a high energy value compared to other forage sources, and is a source of insoluble dietary fiber (NDF) in neutral solvents (Buxton & O'Kiely, 2003; Fernandez et al., 2004; Ferraretro et al., 2015). According to the data from TÜİK (2022), corn, which is the third cereal in our country after wheat and barley, is cultivated on 524,792 hectares for silage purposes. The total yield is 28558983 tons and theaverage yield is 5444 kg $da^{-1}$. In the same year, according to TÜİK data, corn for silage is cultivated on 1210.3 ha in Van Province and the average yield is 4963 kg per decare.

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**Table 1.**

*The climate values and the long-term averages (LTA) of the research area*

| Months | Temperature, °C | | | Precipitation, mm | | | Relative humidity, % | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2020 | 2021 | LTA | 2020 | 2021 | LTA | 2020 | 2021 | LTA |
| January | -2.5 | -0.7 | -2.5 | 43.8 | 13.0 | 33.2 | 74.5 | 67.1 | 66.7 |
| February | -1.7 | 0.8 | -1.5 | 79.9 | 12.9 | 31.5 | 77.1 | 73.3 | 67.2 |
| March | 4.9 | 3.7 | 2.8 | 44.3 | 39.9 | 47.7 | 72.5 | 67.0 | 65.4 |
| April | 8.6 | 11.7 | 8.4 | 51.8 | 5.0 | 57.4 | 65.4 | 48.8 | 59.3 |
| May | 14.5 | 16.7 | 13.4 | 27.8 | 20.2 | 45.3 | 54.0 | 46.4 | 55.1 |
| June | 19.3 | 21.6 | 18.8 | 13.7 | 0.2 | 16.4 | 44.4 | 32.0 | 47.1 |
| July | 23.0 | 24.2 | 22.7 | 17.6 | 4.6 | 6.9 | 46.4 | 38.4 | 42.3 |
| August | 21.6 | 23.5 | 22.9 | 10.0 | 1.4 | 5.3 | 44.5 | 38.0 | 40.5 |
| September | 20.1 | 18.8 | 18.3 | 5.6 | 6.3 | 20.4 | 41.3 | 40.6 | 43.9 |
| October | 13.3 | 12.3 | 12 | 1.8 | 50.2 | 48.2 | 53.0 | 51.0 | 57.3 |
| November | 6.7 | 7.0 | 5.1 | 12.8 | 23.1 | 48.8 | 65.4 | 69.6 | 64.2 |
| December | 1.4 | 1.2 | 0.2 | 27.7 | 29.4 | 45.1 | 71.5 | 67.3 | 67.5 |

## Methods

All animal experiments and procedures were approved as a study not requiring ethical approval by the Local Ethics Committee for Animal Experiments at Van Yüzüncü Yıl University (Decision Number:2004/02-03 Approval Date: 29/02/2024).

### Field Trial

The research was conducted in the trial fields of Van YYÜ Faculty of Agriculture during the first crop (May 5-August 20) and second crop (June 20-October 20, based on the wheat harvest date) growing periods in 2020 and 2021. The average temperature (°C) and total monthly rainfall (mm) values of some climate data measured at the Van Province Metrological Station for the period of the research are given in Table 1. According to the climate information for the period of May-August 2020 and May-August 2021, which covers the period in which the study was conducted, the average temperature was 21.3 °C and 22.2 °C, respectively, and the average of total precipitation for same periods was determined as 13.1 and 13.8 mm, and the average of the years was found to be similar (Anonymous, 2020; 2021).

In the research, Simpatico (FAO 300), K*B 8392 (FAO 400), K*B 6451 (FAO 400), DKC5685 (FAO 500), Bodega (FAO 500), M15G40 (FAO 500), Kerbanis (FAO 550), Capuzi (FAO 600) and Kolesseus (FAO 680) varieties belonging to different maturity groups were used as silage corn. The trial was designed with three replications in a randomized block design with plot lengths of 5 m, 1 m between plots and 2 m between blocks. Sowing was done with a 6-row seeder at 12 cm row spacing and 70 cm row spacing, and fertilization was done with diammonium phosphate and ammonium sulfate fertilizers at a rate of 20 kg of pure nitrogen per decare and 8 kg of pure phosphorus per decare (Çelebi et al., 2010). Sprinkler irrigation was used throughout the growing season to use water efficiently. While the main crop silage corn varieties were harvested at the transition from milking to dough stage maturity (August 20), the second crop silage corn varieties were harvested at the beginning of milking maturity (October 20) due to climatic conditions.

**Yields Parameters**

During the harvesting period, after removing one row from the edges of each plot as an edge effect, the remaining plants were harvested and weighed, and the green forage yield per decare (kg $da^{-1}$) was determined, taking into account the area of the plot. The plants that were harvested for the green forage yield were dried for 48 hours in a drying oven set at 65 $^{o}C$ and the dry matter content was determined. By multiplying the determined DM rates by the green forage yields, the DM yield per acre was calculated.

**Chemical Analysis**

The chemical analyses were carried out after the corn plants were dried in an oven at 65$^{o}$ C for 48 hours and ground in a mill with a sieve diameter of 1 mm. The dry matter content was determined by drying in an oven at 105 °C for 4 to 6 hours, and the crude ash content was determined by combustion in a muffle furnace at 550 °C for 6 to 8 hours, according to the standards of the AOAC (2000). The ether extract (EE) analysis was conducted using the extraction method (ANKOM XT15) with petroleum ether as the solvent (AOCS 2005). Crude protein (CP) was determined by the Kjeldahl method (AOAC, 2000). NDF and ADF contents were determined with ANKOM 200 Fiber Analyzer (ANKOM, USA) according to the methods Van Soest et al (1991).

***In Vitro* Digestibility**

The *in vitro* dry matter digestibility (IVDMD) was determined by incubating feed samples in filter bags with rumen inoculum and buffer in a 1:4 ratio for 48 hours under anaerobic conditions at 39°C. After incubation, the NDF in the residue was determined using the method described by ANKOM Technology (2002). The rumen fluid was collected from two 2-year-old Simmental breed bulls with an average live weight of 550 kg immediately after slaughter at the abattoir. The fluid was filtered through two layers of sterile cheesecloth and transported to the laboratory within 15 minutes in thermoses at 39°C. The samples were tested in triplicate in each jar using Ankom F57 bags made of nitrogen-free polyester/polyethylene. A and B solutions, which will act as saliva, were prepared to simulate artificial rumen conditions. For this purpose, 1 liter solution A was prepared using 10 g $KH_2PO_4$, 0.5 g $MgSO_4.7H_2O$, 0.5 g NaCl, 0.1 g $CaCl_2.2H_2O$ and 0.5 g urea, and 1 liter solution B was prepared using 15 g $Na_2CO_3$ and 1 g $Na_2S.9H_2O$. The solutions were mixed in such a way that the ratio of A to B was 5 to 1 (pH=6.8). In a Daisy incubator, 2 liters of incubation fluid, consisting of 1600 mL of buffer solution and 400 mL of rumen fluid, were added to each jar, along with $CO_2$. The bags were placed in the incubator with a CO2 tube and were incubated for a period of 48 hours. After incubating for 48 hours, the bags were removed from the jars, washed and then dried in an oven at 105°C for 3 hours and NDF analysis was performed after weighing. The *in vitro* tru digestibility (IVTD) of the feeds on a DM basis was performed using the Ankom Daisy Incubator (Ankom, 2002) and the filter bag technique (Van Soest et al., 1991). The *in vitro* true dry matter digestibility was calculated using the following formula based on NDF.

$$\text{IVDMD}, \% = 100 - ((\text{W3} - (\text{W1} \times \text{C1})) \times 100)/\text{W2}$$

W1: bag tare, W2: dry sample or the amount of nutrients in the dry sample (NDF), W3: the amount of nutrients remaining in the bag at the end of the incubation, C1: blank weight (weight of the empty oven-dried bag after incubation/original bag weight).

**Statistical Analysis**

It was designed as a factorial experiment with a randomized plot design with three replicates. The data obtained from an experiment conducted in a factorial randomized plot design were subjected to analysis of variance using the SAS 9.4 (2014) package program. The Duncan's multiple comparison test and LS-Means were used for the comparison of means (SAS, 2014).

## Results

According to the results of the study, the interaction effects of year, growth period and variety on yield and dry matter content of silage corn are shown in Table 2. The differences between the dry matter yield and content of the corn for silage were found to be significant according to the years, growing periods and varieties ($p$ <.0001). The analysis of variance indicated that there were significant differences in the parameters in each variable within the corn varieties (Table 2) and growing period. Therefore, in addition to the effects of the factors, the effects of the interactions are also important and should be considered together. The DM yield varied among the varieties, and the highest DM yield of 2204 kg $da^{-1}$ and 1203.50 kg $da^{-1}$ was obtained from Bodega and KxB6451 varieties among the varieties sown as main and second crop, respectively ($p \leq .0001$). The DM content of corn varieties sown as the main crop was found to be suitable for quality silage. However, the DM content was found to be significantly lower when grown as the second crop ($p \leq .0001$).

**Table 2.**
*Interaction effects of years, growing period and variety on the yield and dry matter contents of silage corn*

| Years (Y) | Growing period (GP) | Variety (V) | Dry matter yield, kg/da | DM, % |
|---|---|---|---|---|
| 2020 | Main crop | Kerbanis | 2128.67±14.44$^{b}$ | 28.67±0.13$^{c}$ |
| | | M15G40 | 2026.00±11.02$^{c}$ | 27.87±0.07$^{de}$ |
| | | Kolosseus | 2020.67±5.81$^{c}$ | 28.00±0.12$^{d}$ |
| | | K*B8392 | 1694.67±13.91$^{gh}$ | 25.80±0.12$^{g}$ |
| | | Simpatico | 1791.33±7.69$^{f}$ | 26.87±0.18$^{f}$ |
| | | Capuzi | 2124.67±11.35$^{b}$ | 29.17±0.15$^{b}$ |
| | | K*B6451 | 1638.33±7.69$^{ı}$ | 25.00±0.12$^{h}$ |
| | | Bodega | 2276.00±30.81$^{a}$ | 30.40±0.35$^{a}$ |
| | | DKC5685 | 1697.00±4.73$^{g}$ | 26.07±0.07$^{g}$ |
| | Second crop | Kerbanis | 1118.33±7.20$^{op}$ | 22.00±0.12$^{lm}$ |
| | | M15G40 | 1149.67±4.81$^{mno}$ | 22.40±0.12$^{kl}$ |
| | | Kolosseus | 994.00±4.00$^{t}$ | 20.27±0.07$^{p}$ |
| | | K*B8392 | 1131.00±5.29$^{nop}$ | 22.00±0.12$^{lm}$ |
| | | Simpatico | 1189.67±5.21$^{k}$ | 23.00±0.12$^{ij}$ |
| | | Capuzi | 1031.33±4.81$^{s}$ | 20.47±0.07$^{op}$ |
| | | K*B6451 | 1227.33±2.40$^{j}$ | 23.47±0.07$^{ı}$ |
| | | Bodega | 1155.00±6.66$^{mn}$ | 22.40±0.12$^{kl}$ |
| | | DKC5685 | 1084.00±5.57$^{r}$ | 21.20±0.12$^{n}$ |
| 2021 | Main crop | Kerbanis | 2141.00±12.53$^{b}$ | 28.53±0.13$^{c}$ |
| | | M15G40 | 1949.67±5.78$^{de}$ | 27.67±0.07$^{de}$ |
| | | Kolosseus | 1962.00±14.11$^{d}$ | 27.53±0.18$^{e}$ |
| | | K*B8392 | 1490.33±7.22$^{i}$ | 23.53±0.18$^{ı}$ |
| | | Simpatico | 1722.33±2.40$^{g}$ | 26.07±0.07$^{g}$ |
| | | Capuzi | 1925.33±28.81$^{e}$ | 26.93±0.35$^{f}$ |
| | | K*B6451 | 1779.67±6.06$^{f}$ | 26.67±0.07$^{f}$ |
| | | Bodega | 2132.00±17.67$^{b}$ | 29.13±0.18$^{b}$ |
| | | DKC5685 | 1661.67±26.30$^{hı}$ | 24.67±0.35$^{h}$ |
| | Second crop | Kerbanis | 1151.33±2.40$^{mno}$ | 22.27±0.07$^{kl}$ |
| | | M15G40 | 1155.67±10.27$^{lmn}$ | 22.27±0.18$^{kl}$ |
| | | Kolosseus | 1022.33±8.95$^{st}$ | 20.73±0.13$^{o}$ |
| | | K*B8392 | 1188.33±10.40$^{kl}$ | 22.47±0.18$^{k}$ |
| | | Simpatico | 1132.33±6.12$^{nop}$ | 21.60±0.12$^{mn}$ |
| | | Capuzi | 1104.00±3.46$^{pr}$ | 21.47±0.06$^{n}$ |
| | | K*B6451 | 1179.67±9.94$^{klm}$ | 22.47±0.18$^{k}$ |
| | | Bodega | 1202.00±8.33$^{jk}$ | 23.13±0.18$^{ıj}$ |
| | | DKC5685 | 1175.33±0.35$^{klm}$ | 22.60±0.20$^{jk}$ |
| P value | Y | | <0.0001 | <0.0001 |
| | GP | | <0.0001 | <0.0001 |
| | V | | <0.0001 | <0.0001 |
| | Y*GP | | <0.0001 | <0.0001 |
| | Y*V | | <0.0001 | <0.0001 |
| | GP*V | | <0.0001 | <0.0001 |
| | Y*GP*V | | <0.0001 | <0.0001 |

$^{a,b,c,d,e,f,g,h,ı,i,j,k,l,m,n,}$: Values within a column with different superscripts differ significantly at $p < .05$ (YxGPxV interactions); DM: Dry matter

**Table 3.**
*Interaction effects of growing season and variety on nutrient composition of silage corn in 2020 and 2021*

| Years (Y) | Growing period (GP) | Variety (V) | CP, % | CA, % | EE, % | ADF, % | NDF, % |
|---|---|---|---|---|---|---|---|
| 2020 | Main crop | Kerbanis | 5.30±0.20$^{i}$ | 5.69±0.05$^{cde}$ | 1.84±0.04$^{ab}$ | 25.86±0.06$^{gh}$ | 48.15±1.02$^{gh}$ |
| | | M15G40 | 4.71±0.08$^{j}$ | 5.85±0.23$^{c}$ | 1.87±0.35$^{a}$ | 28.82±0.56$^{def}$ | 54.82±0.35$^{bcd}$ |
| | | Kolosseus | 7.20±0.12$^{fg}$ | 6.29±0.03$^{b}$ | 1.85±0.07$^{a}$ | 31.82±0.14$^{ab}$ | 54.49±1.06$^{cd}$ |
| | | K*B8392 | 4.69±0.12$^{j}$ | 6.44±0.05$^{ab}$ | 2.02±0.06$^{a}$ | 24.87±1.01$^{hı}$ | 49.93±0.40$^{fg}$ |
| | | Simpatico | 4.82±0.24j | 5.06±0.06$^{hı}$ | 2.08±0.06$^{a}$ | 32.07±0.47$^{ab}$ | 51.21±1.23$^{ef}$ |
| | | Capuzi | 6.22±0.07$^{ı}$ | 5.03±0.06$^{hı}$ | 2.22±0.22$^{a}$ | 21.40±0.03$^{i}$ | 44.45±1.40$^{ı}$ |
| | | K*B6451 | 4.03±0.06$^{k}$ | 6.59±0.04a | 2.01±0.10$^{a}$ | 32.29±0.68$^{ab}$ | 55.42±0.61$^{bcd}$ |
| | | Bodega | 4.77±0.35$^{j}$ | 4.99±0.12ı | 2.02±0.18$^{a}$ | 25.70±1.35$^{gh}$ | 49.19±0.88$^{fgh}$ |
| | | DKC5685 | 6.85±0.03$^{f}$ | 4.99±0.02$^{ı}$ | 1.90±0.07$^{a}$ | 23.43±1.08$^{ı}$ | 47.66±0.20$^{gh}$ |
| | Second crop | Kerbanis | 7.20±0.17$^{fgh}$ | 5.50±0.06$^{ef}$ | 1.25±0.12$^{c}$ | 29.82±0.29$^{cde}$ | 53.87±0.70$^{d}$ |
| | | M15G40 | 8.70±0.29$^{b}$ | 5.31±0.03$^{fg}$ | 1.76±0.10$^{b}$ | 28.10±0.52$^{ef}$ | 54.54±0.18$^{bcd}$ |
| | | Kolosseus | 8.18±0.01$^{c}$ | 5.27±0.04$^{fgh}$ | 1.72±0.11$^{b}$ | 32.87±0.34$^{a}$ | 56.78±0.35$^{abc}$ |
| | | K*B8392 | 9.58±0.02$^{a}$ | 5.83±0.01$^{c}$ | 1.31±0.05$^{c}$ | 24.30±0.63$^{hı}$ | 47.08±038$^{h}$ |
| | | Simpatico | 6.95±0.12$^{gh}$ | 4.17±0.11$^{i}$ | 1.66±0.06$^{b}$ | 27.53±0.46$^{fg}$ | 49.47±1.07$^{fgh}$ |
| | | Capuzi | 7.53±0.14$^{ef}$ | 5.58±0.11$^{de}$ | 1.61±0.15$^{b}$ | 30.54±0.39$^{bcd}$ | 57.03±0.77$^{ab}$ |
| | | K*B6451 | 8.08±0.02$^{cd}$ | 5.08±0.04$^{ghı}$ | 1.29±0.10$^{c}$ | 29.07±0.62$^{def}$ | 54.79±1.94$^{bcd}$ |
| | | Bodega | 6.88±0.04$^{h}$ | 5.76±0.09$^{cd}$ | 1.55±0.09$^{bc}$ | 31.03±0.97$^{abc}$ | 53.50±0.69$^{de}$ |
| | | DKC5685 | 7.86±0.12$^{de}$ | 5.15±0.06$^{ghı}$ | 1.33±0.14$^{c}$ | 30.57±0.12$^{bcd}$ | 58.40±0.17$^{a}$ |
| 2021 | Main crop | Kerbanis | 5.25±0.15$^{I}$ | 5.69±0.14$^{DEF}$ | 1.88±0.07$^{A}$ | 25.67±0.65$^{I}$ | 48.49±0.73$^{GH}$ |
| | | M15G40 | 4.73±0.14$^{Iİ}$ | 6.20±0.06$^{BC}$ | 1.65±0.14$^{BC}$ | 28.84±0.21$^{G}$ | 55.35±0.30$^{BCD}$ |
| | | Kolosseus | 6.99±0.07$^{FG}$ | 6.38±0.04$^{AB}$ | 1.82±0.02$^{B}$ | 31.85±0.19$^{BC}$ | 54.20±0.83$^{CD}$ |
| | | K*B8392 | 4.61±0.17$^{İJ}$ | 6.55±0.08$^{A}$ | 2.04±0.08$^{A}$ | 25.53±0.27$^{I}$ | 50.09±0.09$^{FG}$ |
| | | Simpatico | 4.73±0.29$^{Iİ}$ | 4.95±0.16$^{H}$ | 2.16±0.18$^{A}$ | 32.14±0.37$^{AB}$ | 51.47±0.89$^{EF}$ |
| | | Capuzi | 6.25±0.13$^{H}$ | 5.03±0.11$^{GH}$ | 2.17±0.14$^{A}$ | 21.77±0.15$^{J}$ | 43.99±0.58$^{I}$ |
| | | K*B6451 | 4.11±0.07J | 6.64±0.10$^{A}$ | 2.04±0.09$^{A}$ | 32.15±0.15$^{AB}$ | 55.26±0.22$^{C}$ |
| | | Bodega | 4.90±0.13$^{Iİ}$ | 5.23±0.13$^{GH}$ | 1.99±0.10$^{A}$ | 25.66±0.37$^{I}$ | 49.75±0.34$^{G}$ |
| | | DKC5685 | 6.66±0.33$^{GH}$ | 5.01±0.09$^{G}$ | 1.98±0.05$^{A}$ | 24.85±0.35$^{Iİ}$ | 47.72±0.32$^{H}$ |
| | Second crop | Kerbanis | 7.32±0.11$^{DE}$ | 5.75±0.16$^{DE}$ | 1.14±0.11$^{E}$ | 29.85±0.13$^{EF}$ | 53.01±0.33$^{DE}$ |
| | | M15G40 | 8.71±0.23$^{B}$ | 5.40±0.12$^{EFG}$ | 1.77±0.06$^{B}$ | 28.04±0.20$^{GH}$ | 53.79±0.78$^{CD}$ |
| | | Kolosseus | 8.43±0.05$^{BC}$ | 5.32±0.10$^{FGH}$ | 1.87±0.13$^{AB}$ | 32.89±0.19$^{A}$ | 57.14±0.32$^{A}$ |
| | | K*B8392 | 9.56±0.12$^{A}$ | 5.88±0.13$^{CD}$ | 1.32±0.07$^{DE}$ | 24.44±0.24$^{İ}$ | 47.04±0.37$^{H}$ |
| | | Simpatico | 6.99±0.06$^{FG}$ | 4.48±0.23$^{I}$ | 1.69±0.11$^{BC}$ | 27.77±024$^{H}$ | 49.65±0.37$^{G}$ |
| | | Capuzi | 7.63±0.10$^{DE}$ | 5.74±0.15$^{DE}$ | 1.78±0.05$^{B}$ | 30.22±0.42$^{DE}$ | 57.09±0.42$^{AB}$ |
| | | K*B6451 | 8.10±0.08$^{CD}$ | 5.41±0.03$^{EFG}$ | 1.27±0.15$^{DE}$ | 28.96±0.20$^{FG}$ | 53.92±1.42$^{CD}$ |
| | | Bodega | 6.87±0.02$^{FG}$ | 5.80±0.17$^{EFG}$ | 1.46±0.13$^{CD}$ | 30.56±0.73$^{DE}$ | 52.65±0.44$^{DE}$ |
| | | DKC5685 | 7.78±0.12$^{DE}$ | 5.27±0.20$^{GH}$ | 1.31±0.07$^{DE}$ | 31.10±0.21$^{CD}$ | 58.29±0.19$^{A}$ |
| P value | Y | | 0.9774 | 0.0018 | 0.9747 | 0.4797 | 0.6764 |
| | GP | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | V | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Y*GP | | 0.4916 | 0.3474 | 0.7682 | 0.4824 | 0.3896 |
| | Y*V | | 0.9968 | 0.9830 | 0.9840 | 0.8481 | 0.9996 |
| | GP*V | | <0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| | Y*GP*V | | 0.9944 | 0.4283 | 0.9352 | 0.9966 | 0.9758 |

CP: Crude protein, EE: Ether extract, CA: Crude ash, ADF: Acid detergent fiber, NDF: Neutral detergent fiber

$^{a,b,c,d,e,f,g,h,ı,I,j}$ Values within a column with different superscripts differ significantly at $p$ <.05 (GPxV interactions in 2020).

$^{A,B,C,D,E,F,G,H,I,İ,J:}$ Values within a column with different superscripts differ significantly at $p$ <.05 (GPxV interactions in 2021).

The means chemical composition of silage corn according to growing period, variety and year is shown in Table 3 and Figure 1. As shown in Figure 1, corn varieties grown as the main crop have lower levels of CP ($p \leq .0001$), ADF ($p \leq .0176$) and NDF ($p \leq .0001$). The yearxgrowing periodxvariety (YxGPxV) interaction was found to have no significant effect on chemical composition. In contrast, the GPxV dual factor interaction was identified as a key factor. In consideration of the mentioned factors, the varieties that emerge as the most noteworthy in terms of CP are Kolosseus in the main crop and K*B8392 in the secondary crop. The lowest CP content was found in the variety K*B6451 in the main crop and the Bodega variety in the second crop ($p \leq .0001$). Statistically significant differences in ADF and NDF ratios were found among silage corn varieties grown as the main crop and as the second crop ($p \leq .0001$; Table 3). The ADF and NDF ratios in the varieties sown as the main crop were determined to be lower than in the varieties sown as the second crop. The K*B8392 variety exhibited the lowest levels of ADF and NDF contents ($p < .05$, Figure 1).

The mean EE content was determined as 1.97% and 1.51% in the main crop and second crop, respectively. While the highest EE content was obtained from the Capuzi and Simpatico varieties, it was the highest in all varieties sown as main crops. These differences caused significant GP× V interaction.

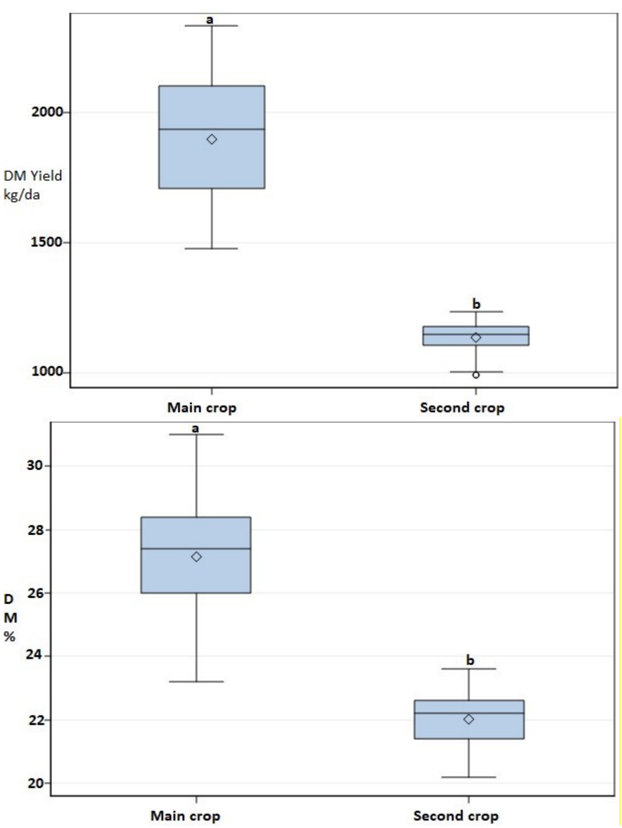


**Figure 1.**
*The average dry matter yield and dry matter content of silage corn varieties sown as main and secondary crops*

Interaction effects of growing season and variety on IVDMD of silage corn are presented in Table 4.

Their interaction GPxV significantly affected IVDMD of corn herbage ($p < .0001$). The IVDMD was higher (53.65% vs. 57.62%) for the corn varieties sown as a second crop, despite the lower ADF and NDF contents of the corn varieties sown as a main crop compared to the same varieties sown as a second crop ($p \leq .0001$; Table 3 and Figure 2). Table 4 shows that DKC5685 corn variety had the highest IVDMD among the corn varieties grown as both main and second crops.

**Table 4.**
*Interaction effects of growing period and variety on the IVDMD of silage corn*

| Factors | Variables | | IVDM, % |
|---|---|---|---|
| Growing period | Main crop | | $53.65\pm0.68^{Y}$ |
| | Second crop | | $57.62\pm0.38^{X}$ |
| Variety | | Kerbanis | $55.26\pm0.70^{C}$ |
| | | M15G40 | $53.55\pm1.25^{D}$ |
| | | Kolosseus | $55.02\pm0.85^{CD}$ |
| | | K*B8392 | $56.27\pm0.84^{BC}$ |
| | | Simpatico | $55.60\pm1.71^{C}$ |
| | | Capuzi | $56.70\pm0.83^{B}$ |
| | | K*B6451 | $50.73\pm1.66^{E}$ |
| | | Bodega | $57.25\pm0.92^{B}$ |
| | | DKC5685 | $60.93\pm0.92^{A}$ |
| Growing Period x Variety | Main crop | Kerbanis | $56.31\pm1.26^{bcde}$ |
| | | M15G40 | $50.01\pm1.59^{f}$ |
| | | Kolosseus | $52.75\pm0.96^{ef}$ |
| | | K*B8392 | $54.40\pm1.25^{de}$ |
| | | Simpatico | $50.52\pm1.69^{f}$ |
| | | Capuzi | $56.66\pm1.28^{bcd}$ |
| | | K*B6451 | $46.10\pm2.21^{g}$ |
| | | Bodega | $56.21\pm1.70^{cde}$ |
| | | DKC5685 | $59.87\pm1.80^{ab}$ |
| | Second crop | Kerbanis | $54.22\pm0.45^{de}$ |
| | | M15G40 | $57.08\pm0.80^{bcd}$ |
| | | Kolosseus | $57.28\pm0.83^{abcd}$ |
| | | K*B8392 | $58.14\pm0.67^{abc}$ |
| | | Simpatico | $60.68\pm1.52^{a}$ |
| | | Capuzi | $56.73\pm1.14^{bcd}$ |
| | | K*B6451 | $55.36\pm0.93^{cde}$ |
| | | Bodega | $58.28\pm0.62^{abc}$ |
| | | DKC5685 | $60.79\pm0.55^{a}$ |
| P value | GP | | <0.0001 |
| | V | | <0.0001 |
| | GP*V | | <0.0001 |

IVDMD: In vitro dry matter digestibility;
X,Y: Values between growing periods with different superscripts differ significantly at $p < .05$.
A,B,C,D,E,: Values among corn varieties with different superscripts differ significantly at $p < .05$.
a,b,c,d,e,f,g,j Values within a column with different superscripts differ significantly at $p < .05$ (GPxV interactions).

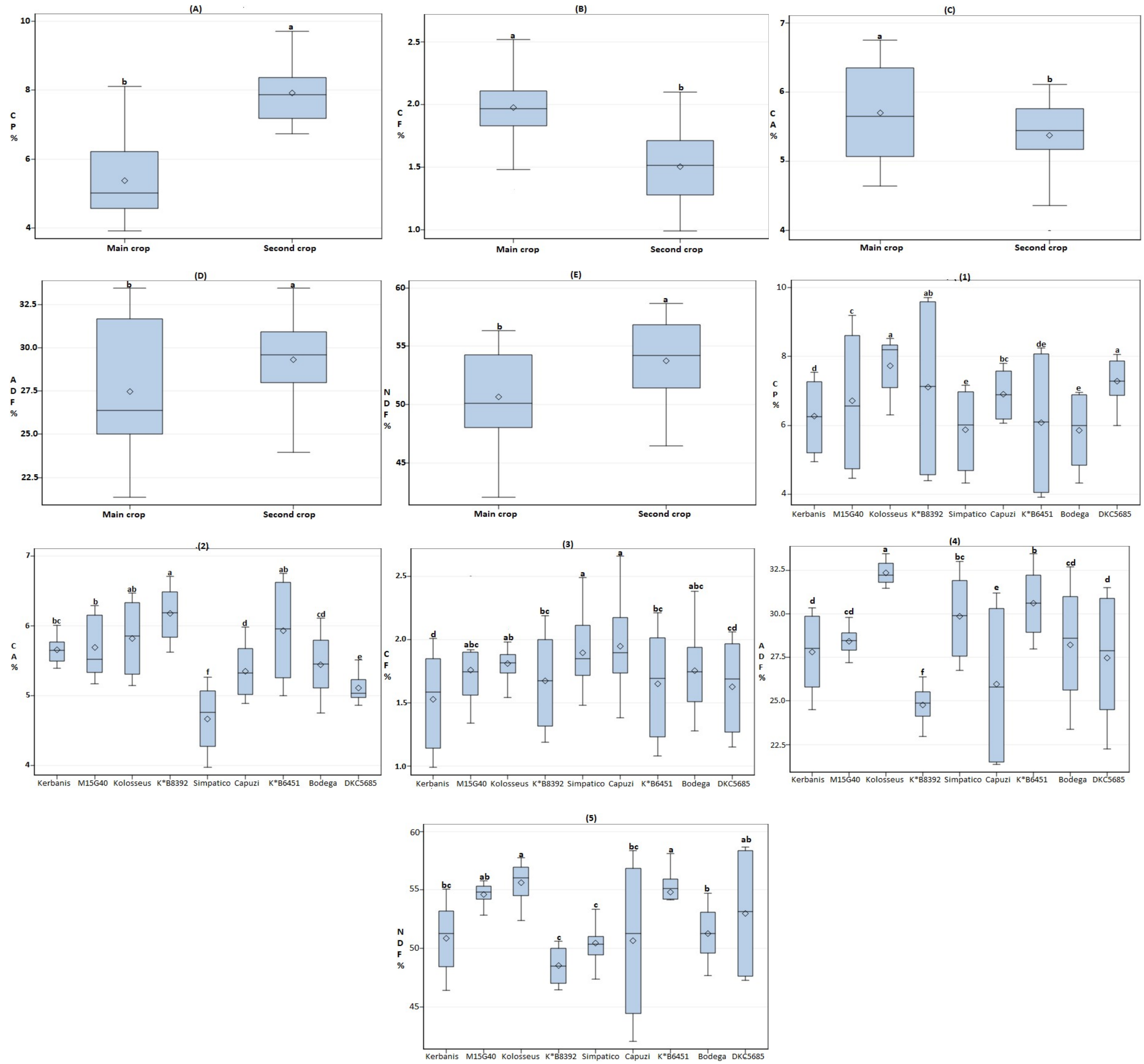


**Figure 2.**

*Changes in nutrient contents for growing periods (A, B, C, D, E) and varieties (1, 2, 3, 4, 5). a, b, c, d: Values within each graph with different superscripts differ significantly at p <.05.*

## Discussion

The DM yield was higher in the main crop compared to the second crop. Given that second-crop corn is typically sown in our region at the end of June and the beginning of July, immediately following the wheat harvest, the interval between planting and harvesting is relatively brief. In the main crop, the first place in the order of importance is yield, while in the second crop, earliness comes first and yield comes second. The primary objective of second crop cultivation is to achieve an optimal level of both earliness and yield in a single variety, with a focus on harvesting that variety prior to the onset of autumnal rainfall. When evaluated in the context of the study, the varieties Bodega, sown as the main crop, and K*B6451 corn variety, sown as the second crop, exhibited the highest DM yield value. The study found that the sowing times had an impact on the dry matter yield of the varieties. İptaş et al. (1997) evaluated 13 silage corn varieties under Tokat's ecological conditions during the crop growing season. The lowest DM yield for the main crop was found to be 2002.30 kg da-1 (P-3163), while the highest yield was reported as 2634.90 kg da-1 (K. Yıldız).

Bulut et al. (2008) examined 17 different silage corn varieties under Erzurum ecological conditions. The DM ratios of the varieties ranged from 23% to 29%, and the DM yields ranged from 802 to 2136 kg da-1. Previous research has shown that there are notable variations in DM yield among different types of corn. It has been suggested that genetic structure and various environmental factors play a significant role in determining dry matter yield (Öztürk and Akkaya, 1996; Turan and Yılmaz, 2000).

There are many differences in chemical composition and digestibility values between silage corn varieties in terms of main and second crops (Grant and Ferraretto, 2018; Velho et al. 2020). In the study, the DM content of the main crop corn varieties was found to be 27.14% and was determined to be within the desired level. However, the average DM content of the second crop corn varieties was 22.01%. In this case, the DM content of second-product corn varieties is insufficient for successful silage fermentation. Therefore, further investigation is required in the field of withering insecond-crop silage corn production in the region, as well as irrigation planning, specifically the cessation of irrigation or the development of novel varieties exhibiting an earlier growth period. Bulut et al. (2008), Ozturk et al. (2008), Ergül (2008), and Taş et al. (2016) found that the DM ratio of maize varieties grown for silage ranged from 23 to 29%, 27.3 to 28.4%, 24.4 to 32.1%, and 28.15 to 29.91%, respectively. The DM ratio should be in the range 25-40% for silage to be considered high quality (Klamem et al., 2005, Panyasak & Tumwasorn, 2015). A DM content in excess of 40% is an indication of high cellulose content. It is well known that this situation can lead to a decrease in the digestibility and palatability of the feed. Furthermore, a high DM content can also be a challenge when compacting silage and increase the likelihood of spoilage. It has been stated that the varying DM ratios of different corn varieties are due to genetic factors as well as harvesting the corn plant at different times (Nazli et al. 2019).

The chemical composition of silage corn content showed a significant difference between growing periods and varieties. In second crop conditions, the CP, NDF, and ADF levels are elevated (Geren et al., 2003; Çarpıcı, 2016). The crude protein ratio of various silage corn varieties under different ecological conditions is as follows: 7.09-9.53% in Yozgat (Yozgatlı et al., 2019), 7.63-9.32% in Ordu (Öner & Güneş, 2019), 6.16-8.61% in İzmir (Yıldız et al., 2017), and 5.18-6.28% in Konya during the main crop season. Although the CP ratio varies depending on genetic differences, it can also be affected by ecological conditions and factors such as sowing time, harvest time, irrigation and fertilization (Burgu & Mut, 2023).

The ADF and NDF ratios in the varieties sown as the main crop were determined to be higher than in the varieties sown as the second crop. This is because it has an excess of grains, which reduces the concentration of fiber fractions when sown as a main crop. The ADF and NDF rates of the different corn varieties ranged from 21.77% to 32.87% and 44.45% to 58.40%, respectively. Loucka et al. (2018) reported that the ADF rate in corn varieties should be 30% to make quality silage. According to Kördikanlıoğlu and Gülümser (2021), the ADF and NDF ratios of silage corn varieties grown as a second crop under Bilecik conditions ranged from 31.52% to 47.56% and from 47.13% to 69.91%, respectively. Alagöz and Türk (2020) reported that the meantime, silage corn varieties grown as a main crop under Isparta conditions had an average ADF ratio of 39.68% and an average NDF ratio 56.53%, respectively. In Ordu province, 13 different varieties of silage corn were used as the main crop, with an average ADF and NDF content of 28.29% and 53.73%, respectively (Öner & Güneş, 2019).

It was determined that growing period, variety, and GPxV interactions were statistically significant regarding IVDMD of resulting herbages. The IVDMD was determined to be higher in corn varieties sown as second crops. The IVDMD coefficients obtained in this study (53.55 to 60.93%) were comparable to those reported by Caetano et al. (2011), who determined them in nine different corn varieties (58.56 to 63.94%). The disparate responses observed in the varieties sown as the main and second crops may be attributed to the discrepancies in climatic conditions, such as temperature and the number of days with favorable conditions for growth, between the spring and summer seasons. These conditions influence the growth and development of each variety. It is important to note that the results observed in this study are related to the harvest period. In particular, the later harvesting of the varieties sown as the main crop resulted in starch maturation and decreased digestibility due to increased crystallization (Peyrat et al., 2016). Paziani et al. (2009) examined the agronomic characteristics of corn varieties for silage production. They observed that the digestibility of the maize plant is primarily determined by the digestibility of the stalk and kernel-related parameters.The primary factor influencing the optimal timing of the first and second corn crops is the differing rates of vegetative growth. The first crop reaches the optimal harvest stage for silage—the dough maturity stage—in a shorter period of time than the second crop. However, the same varieties remain in the beginning of the milk ripening stage when sown as a second crop. Opsi et al. (2013) conducted an evaluation to assess the effect of planting dates and maturity at harvest on in IVDMD in silage corn varieties. Their findings revealed that IVDMD varies considerably across varieties, sowing dates and maturity at harvest. The means IVDMD across the evaluated corn varieties ranged between 76.80% and 81.10%.

## Conclusion and Recommendations

The results of this study indicate that corn varieties grown as main crops produce more silage and feed than corn varieties grown as second crops. Furthermore, significant differences were observed among varieties and cultivation methods in terms of chemical composition and in vitro digestibility of the herbage. Significant contributions are made to forage production, especially by utilizing the agricultural land left fallow during the summer period after grain production.

In order to be successful in growing both main and second crop silage corn, it is necessary to identify the varieties that are suitable for this ecology. In this way, the producers who are going to produce silage maize will be able to provide data that they will use for the evaluation of the varieties. Although it was found that many of the varieties used in the study could be grown successfully in the regional ecology, they differed in yield and quality characteristics. In conclusion, considering the maturity periods of the varieties for silage and the need for early harvesting, it can be said that early varieties that produce tassel and cob silk as soon as possible can be grown as a second crop in Van's ecological conditions. In addition, it was found that the corn varieties K*B8392 can be grown as a second crop for silage, CP content and in vitro true digestibility, if the sowing time can be shifted one week earlier, taking into account climate changes. Considering the CP content and in vitro dry matter digestibility as the main crop for silage, it was found that the maize variety DKC5685 would be the most suitable in the ecological conditions of Van. Therefore, it is necessary to identify early maturing corn varieties for Van province, which has high altitude and a short cultivation period, and to continue these studies regularly. In terms of DM yield, the Bodega, Kerbanis, and Capuzi varieties were identified as the main crop, while the KxB8392 variety was identified as the second crop.

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