DOI: http://dx.doi.org/10.32571/ijct.1265612 E-ISSN: 2602-277X

International Journal of Chemistry and Technology

http://dergipark.org.tr/ijct

Research Article

Evaluation of grain and forage yield and forage quality traits in some hybrid maize genotypes cultivated as second crop under the Eastern Mediterranean conditions

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Received: 16 March 2023; Revised: 26 June 2023; Accepted: 27 June 2023

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Citation: Ertekin, İ.; Konuşkan, Ö.; Atış, İ. *Int. J. Chem. Technol.* **2023**, 7 (1), 113-118.

ABSTRACT

This research was conducted in order to guide researchers by determining grain, forage yield and yield-related traits and forage quality of different parts of the whole plant in some maize cultivars in Eastern Mediterranean ecological conditions. In this study, it was assessed grain and forage yield and fodder quality of four maize cultivars (PR91G98, SY Castaneda, SY Gladius, and SY Tuscani) cultivated under the Estern Mediterranean conditions. To determine forage quality, ear, stem and leaves of the whole plant maize were analyzed separately. To evaluate grain and forage yield, parameters like plant height, stem diameter, hay yield, dry matter yield, green leaf yield, green stem yield, ear weight, green ear yield were investigated while features such as crude protein, crude ash, organic matter, NDF, ADF, digestibility of dry matter, dry matter intake and relative feed value were examined to determine forage quality. The results of this study revealed that ear is very important for forage yield and quality. The greatest hay and grain yield were produced by PR31G98 maize cultivar. It was observed SY Tuscani had higher NDF and ADF values than other maize varieties. With this study, the importance of nutrient content according to silage yield and plant parts in second crop corn cultivation was determined. In addition, research results showed important source data for farmers and researchers regarding forage and grain yield of maize farming and production area is continually increasing.

Keywords: Maize, fodder, quality, cultivar.

Doğu Akdeniz koşullarında ikinci ürün olarak yetiştirilen bazı hibrit mısır genotiplerinde tane ve yem verimi ile yem kalite özelliklerinin değerlendirilmesi

ÖZ

Bu araştırma Doğu Akdeniz ekolojik koşullarında II. ürün koşullarında bazı mısır çeşitlerinin hem silaj olarak hem de tane ürünü olarak değerlendirilmesi ile elde edilen ürünün bitkisel ve kalite özelliklerini belirleyerek çiftçiler ve gelecekteki araştırmalara yardımcı olmak amacıyla yürütülmüştür. Araştırmada ikinci ürün koşullarında 4 mısır genotipinin (PR91G98, SY Castaneda, SY Gladius, ve SY Tuscani) yeşil yem ve tane özellikleri yanında silaj kalitesi değerlendirilmiştir. Araştırma sonuçları, tane ürünü için en iyi mısır çeşidinin PR31G98 olduğunu gösterirken yem kalitesi için ise çeşitler arasında önemli bir fark olmadığını göstermiştir. İncelenen koçan, sap ve yaprağın yem kalitesinde önemli farklılıkların olduğu belirlenmiştir. En yüksek kuru ot ve tane verimi PR31G98 mısır çeşidinden elde edilmiştir. SY Tuscani'nin diğer mısır çeşitlerine göre NDF ve ADF değerlerinin daha yüksek olduğu görülmüştür. Sürekli yeni mısır genotiplerinin geliştirilmesi nedeniyle, yeni çeşitlerin agronomik uygulamalara tepkisinin belirlenmesi önemlidir. Özellikle yeşil yem amacı ile yetiştiricilikte bitkinin içerisindeki koçanın kaliteye etkisinin daha önemli olduğu yapılan çalışmada tespit edilmiştir. Çalışma tane ve silajlık mısır tarımında alternatif bir yaklaşım olan yeşil yem veya taneye bırakmanın sonuçlarını ortaya koyarak Akdeniz iklim kuşağı için uygulamaya yönelik veriler ortaya koymuştur. Araştırma sonuçları, üretim alanları sürekli artan mısır için çiftçilere ve araştırıcılara önemli kaynak veriler ortaya koymaktadır.

Anahtar Kelimeler: Mısır, kaba yem, kalite, çeşit.

1. INTRODUCTION

Worldwide, maize (*Zea mays* L.) is a member of family Gramineae (Poiaceae) and is the most important grain and forage crop in our country and all over the world due to its high adaptability and high grain and forage yield.[1,2] Maize is grown in Major ecological zones of the country, making it available to be used as livestock feed.[3,4] While

DOI: http://dx.doi.org/10.32571/ijct.1265612 E-ISSN: 2602-277X

corn has a significant role in human nutrition and agriculture-based industry with its grain, in the last 30 years, a significant part of its production has become an important feeding used in animals and provided source of energy for livestock animals.[5] The sowing area of grain and silage maize has enlarged constantly in the last decade and reached 1.2 million ha in 2020 respectively.[6] The production of maize could have been attributed to a combination of genetic improvement (50 %) and improved crop management practices (50 %).[7] Maize genotypes interact with crop management practices in producing yield, and hence, understanding the dynamics between plant genetics and agronomic management will enhance the occasion to maximize yield potential of a hybrid using a corresponding recommended agricultural management system.[8,9]

One of the major problems to be solved in the development of our country's livestock is to meet the need for high quality, cheap and abundant roughage regularly. Therefore, in order to meet the quality roughage requirement of livestock enterprises, it is essential to improve pastures, to enlarge the production areas of forage crops, to bring cheap and alternative roughage sources to animal production, and to transfer quality roughage production techniques to producers.[10,11] Maize has higher potential yield (t DM/ha/cut) than all the grasses, legumes and crops used as forage material. The proximate and mineral compositions of maize depend on cultural practice of the forage material. It was determined as the ranges of 18-19 and 35-37 % for acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents, respectively in maize forage.[3] Roth and Henrichs[12] conducted experiment on maize silage and they found the ranges of 7.2-10.0, 23.6-33.2 and 41.0-54.1% for crude protein (CP), acid detergent fiber (ADF) and neutral detergent fiber (NDF) contents, respectively and the same was observed by McDonald et al.[13] in maize plant with values of 23.3, 5.7 and 10.0% for crude fiber (CF), ether extract (EE) and ash, respectively and noted these findings. Öner et al.[14] reported crude protein, ADF and NDF ratios of silage maize under Samsun conditions as between 3.85% and 5.85%, 31% and 41% and 49% and 60%, respectively.

The research studies on maize genotypes should be performed to achieve height grain and hay yield quality, which are appropriate for the region in the Eastern Mediterranean conditions. Therefore, the purpose of this study was to assess the grain yield and forage quality responses of maize in the second crops under the Eastern Mediterranean condition.

2. MATERIALS AND METHODS

The experiment was conducted under the Mediterranean condition (in Amik lowland) in the second crop growing seasons in 2020. The soil was clay loam having pH 7.7, low in available phosphorus (7.40 kg ha^{-1}) and organic matter content (1.95%). Some climatic data which occurred in the experimental area during the growth period are given in Table 1. The study was arranged in randomized complete block design with three replications. Maize hybrids were PR91G98, SY Castaneda, SY Gladius, and SY Tuscani. The seeds were sown on June 21, 2020, maintaining 5 m long 4 rows with 70 cm row distance.

Fertilizers were applied as basal during the sowing (350 kg N, P_2O_5 and K_2O ha^{-1} (15-15-15). At V6 stage of maize, 400 kg ha^{-1} urea was applied as top dress (on July 10, 2020). The plots were irrigated once every 10-14 days when consuming nearly half of the available soil water. The control of weed and insect was performed when it was necessary. The regular agronomic practices for the maize crop were carried out according to the recommendations.

Months	Year and LYM	Precipitation (mm)	Temperature (°C)	Humidity (%)
June	2020	0.4	25.2	67.4
	LYM	32.0	24.8	-
July	2020	0.0	29.5	68.3
	LYM	16.0	27.2	-
August	2020	0.0	29.6	64.7
	LYM	18.2	27.8	-
September	2020	0.0	29.6	65.6
	LYM	41.1	25.7	-

LYM: Long years mean

For hay and dry matter, center two rows of each plot were harvested for about 35 days. The plant heights and stem diameters of ten plants selected randomly were measured before harvest. The plants were cut approximately 5 cm above ground. Three of these sample plants were divided into leaves, stem and ear; all plant fractions were dried in an oven to constant weight at 65°C for their dry matter ratio.

The other three samples were chopped in to 2 3 cm by a shredder (Bosch AXT 25D shredder, Germany) and a 300 g sub-sample taken from the chopped samples was dried in a forced-draft oven to constant weight at 65°C for dry matter (DM) content. The dried samples were ground in a mill to pass a 1 mm screen for chemical analysis.[15] Another 250 g sub-sample taken from the chopped samples was dried at 105°C and used for calculation of dry matter content.

Crude protein, NDF, ADF, and ADL were determined for all samples. Nitrogen concentrations were determined by the Kjeldahl procedure and crude protein concentration was calculated by the formula of N concentration × 6.25. NDF, ADF and ADL were analyzed according to the sequential method of Van Soest *et al.*[16] by adding α-amylase with sodium sulfite and using the ANKOM filter bag system with A220 fiber analyzer (ANKOM Technology, Fairport, NY), and expressed as exclusive residual ash.

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Relative feed value (RFV) computed by using ADF (related dry matter digestibility) and NDF (related intake potential) was used as an index indicating forage quality. Relative feed value (RFV) was identified and formulated by Van Dyke and Anderson [17] as below:

DDM = 88.9 – (0.77×ADF%) DMI= (120/NDF%)

RFV= DDM% × DMI% × 0.775

Where DDM was digestible dry matter as % of dry matter, and DMI was dry matter intake as a % of body weight.

All data were performed for analysis of variance procedures using the JMP, and the TUKEY pairwise test was used to determine the statistical differences among the average values ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

The statistical analysis of the evaluated characteristics for the plant height, stem diameter, hay yield, dry matter yield and grain yield is given in Table 2, and for ear weight, green leaf yield, green steam yield, green ear yield it is presented in Table 3.

Table 2. Plant height (cm), stem diameter (mm), forage yield (kg da^{-1}), dry matter yield (kg da^{-1}) and grain yield (kg da^{-1}) traits of maize varieties1

		Plant height (cm)	Stem diameter (mm)	Hay yield (kg da^{-1})	Dry matter yield (kg da^{-1})	Grain yield (kg da^{-1})
	Genotypes					
Cv.1	SYCastaneda	205.67±0.67^{ab}	17.17±0.17^{ab}	4264.63±73.04	1671.94±104.44	686.35±76.88^{b}
Cv.2	SY Cladius	211.67±1.67^{b}	16.50±0.29^{b}	4427.68±98.23	1882.01±102.86	833.33±46.91^{ab}
Cv.3	PR91G98	208.33±1.45^{ab}	17.83±0.44^{ab}	4499.08±67.65	1661.66±208.53	1006.03±88.84^{a}
Cv.4	SY Tuscani	220.00±1.67^{a}	18.00±0.29^{a}	4358.22±61.51	1653.95±106.66	889.37±22.96^{ab}
	Mean	211.42	17.38	4387.40	1717.39	853.77
	Significance	*	*	ns	ns	*

		Ear weight (g)	Green leaf yield (kg da^{-1})	Green stem yield (kg da^{-1})	Green ear yield (kg da^{-1})
	Genotypes				
Cv.1	SYCastaneda	144.13±16.15	664.00±73.04	1549.52±197.89	2051.148.22
Cv.2	SY Cladius	172.00±12.85	670.22±98.23	1694.60±293.10	2062.86±79.10
Cv.3	PR91G98	176.60±24.64	607.33±67.65	1877.14±235.10	2014.60±286.95
Cv.4	SY Tuscani	186.77±4.82	647.11±61.51	1731.43±99.05	1979.68±117.63
	Mean	169.88	647.17	1713.17	2027.06
	Significance	ns	ns	ns	ns

ns: not significant, *: Significant at statistic level of 5%, a-c Data shown with different superscripts in the same column were different from each other.

The differences among the genotype means were significant ($P < 0.05$) for plant height and stem diameter. The highest plant height and stem diameter were obtained from SY Tuscani. In terms of plant height and stem diameter, genotypes had statistically similar values to those of Tuscani, PR91G98 and Castenada except for Gladius. Among the varieties, the highest hay yield was 4499 kg da^{-1} in PR91G98 and also Cladius, while the highest dry matter yield was determined as 1882 kg da^{-1}. Grain yield for four genotypes ranged from 1006 kg da^{-1} to 686 kg da^{-1}. The PR91G98 genotype had higher grain yield values than the others. The plant height values and stem diameter determined for the examined maize genotypes were within the values found out in previous studies.[5,18,19] Although the plant traits of maize depend on the genotype, environmental conditions also have a significant effect on the plant traits of maize.

Although the plant height of maize depends on the genotype, the environmental conditions also have a

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significant impact on the plant height of the maize. Güney et al.[20] reported that the average plant height of maize genotypes varied depending on the years and this characteristic was affected by ecological conditions. Silage yields of different silage corn seeds under Hatay conditions were determined as 55.9-69.5 kg ha^{-1} in different maize varieties.[5]

Although the plant parts, crude protein, organic matter, NDF, ADF, DDM, DMI, RFV were not statistically significant for the genotypes, the plant parts were statistically important for all traits (Table 4). Genotype and plant part interactions were statistically significant for NDF, ADF, DDM, DMI, and RFV (Table 4). Crude protein of forages is one of the main criteria for forage quality. Forage quality was significantly influenced by harvest dates,[21] and ADF and NDF concentrations are important forage quality characteristics.[22] These results are in agreement with the work done by Roth and Henrics et al.[12] who reported that crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) contents of maize silage ranged between 7.2-10.0, 23.6-33.2 and 41.0-54.1%, respectively.

Table 3. Means of ratio of plant part, crude protein (CP), crude ash (CA), and organic matter (OM) parameters.

		Ratio of Plant Part (%)	CP (% KM)	CA (% KM)	OM (% KM)
	Genotypes (G)				
Cv.1	SY Castaneda	33.33±5.60	7.11±1.36	6.26±1.59	93.74±1.59
Cv.2	SY Cladius	33.33±6.08	8.02±1.32	6.84±1.63	93.16±1.63
Cv.3	PR91G98	33.33±4.10	6.96±1.20	5.65±1.31	94.35±1.31
Cv.4	SY Tuscani	33.33±4.20	6.62±1.13	5.60±1.32	94.40±1.32
	Mean	33.33	7.18	6.09	93.91
	Significance	ns	ns	ns	ns
	Plant pars (P)				
	Ear	52.49±1.52 ^{a}	7.13±0.14 ^{b}	1.81±0.06 ^{c}	98.19±0.06 ^{a}
	Stem	26.96±1.11 ^{b}	2.94±0.18 ^{c}	4.90±0.32 ^{b}	95.10±0.32 ^{b}
	Leaves	20.55±0.78 ^{c}	11.46±0.40 ^{a}	11.55±0.41 ^{a}	88.45±0.41 ^{c}
	Mean	33.33	7.18	6.09	93.91
	Significance	**	**	**	**
	Significance (GXP)	ns	ns	ns	ns

ns: not significant, **: Significant at statistic level of 1%, a-c Data shown with different superscripts in the same column were different from each other.

Table 4. Means of neutral detergent fiber (NDF), acid detergent fiber (ADF), digestible of dry matter (DDM), dry matter intake (DMI), and relative feed value features.

		NDF (% KM)	ADF (% KM)	DDM (%)	DMI (%)	RFV
	Genotypes (G)					
Cv.1	SYCastaneda	49.60±7.75	25.30±4.88	69.19±3.80	3.36±0.78	197.82±55.82
Cv.2	SY Cladius	47.92±8.18	24.76±5.05	69.61±3.93	3.77±0.95	225.78±67.65
Cv.3	PR91G98	49.21±6.57	24.17±3.98	70.07±3.10	3.03±0.56	175.11±40.20
Cv.4	SY Tuscani	50.92±7.32	26.23±4.72	68.47±3.67	3.07±0.63	176.60±45.13
	Mean	49.41	25.11	69.34	3.31	193.83
	Significance	ns	ns	ns	ns	ns
	Plant parts (P)					
	Ear	20.10±1.05 ^{c}	7.17±0.45 ^{c}	83.32±0.35 ^{a}	6.16±0.34 ^{a}	398.79±23.44 ^{a}
	Stem	67.83±0.97 ^{a}	38.20±0.74 ^{a}	59.15±0.58 ^{c}	1.77±0.03 ^{b}	81.40±1.97 ^{b}
	Leaves	60.30±0.73 ^{b}	29.98±0.29 ^{b}	65.55±0.23 ^{b}	1.99±0.02 ^{b}	101.30±1.53 ^{b}
	Mean	49.41	25.11	69.34	3.31	193.83
	Significance	**	**	**	**	**
	Significance (GXP)	**	**	**	**	**

ns: not significant, Significant at statistic level of 1%, a-c Data shown with different superscripts in the same column were different from each other.

For the first order of interaction (V×PP), the data in Figure 1 clarified that the NDF was significantly affected by the (V×PP) interaction. The highest NDF was recorded in stems, while the smallest ones were recorded in ears. For the second order interaction (G×PP), data in Figure 2 stated that the ADF was significantly affected by the (V×PP) interaction. The greatest ADF was recorded in stems, while the lowest ones were recorded in ears.

Regarding to the interaction between maize hybrids and parts of the plant, the data in Figure 3 stated that the DDM was significantly affected by the (G×PP) interaction. The maximum DDM was recorded in ears of all genotypes, while the minimum ones were recorded in stems. As can be seen in Figure 4, DMI was significantly affected by the (V×PP) interaction. Regarding the interactions among the maize hybrids and parts of the plant, the data in Figure 5 stated that the RFV was significantly

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influenced by the (V×PP) interaction. According to the results, the RFV of maize variety changed significantly according to parts of the plant. The RFV in ears of Tuscani and Cladius was the same groups and other genotypes were the same group in terms of RFV property, too. The results indicated that the RFV of all maize ear, stem and leaves showed significant differences depending on part of the plants (P<0.05).

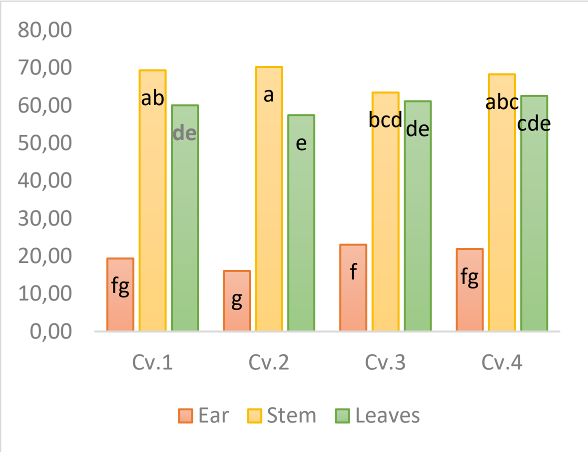

Figure 1. Genotype × part of the plant interaction of NDF

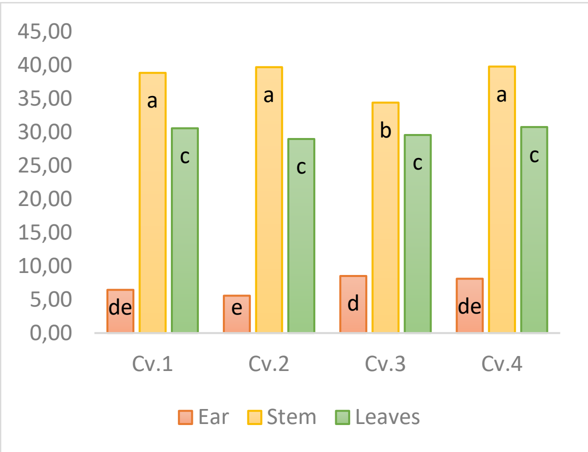

Figure 2. Genotype × part of the plant interaction of ADF.

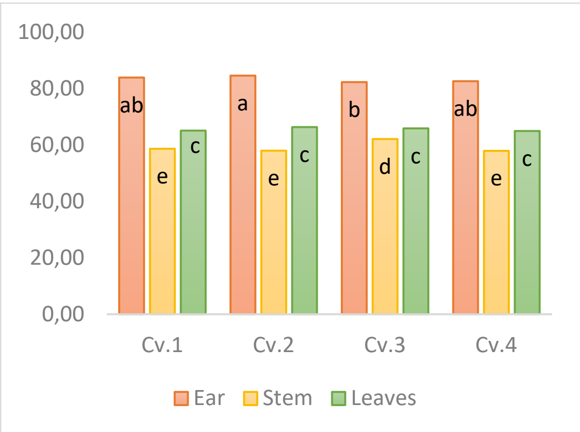

Figure 3. Genotype × part of the plant interaction of DDM.

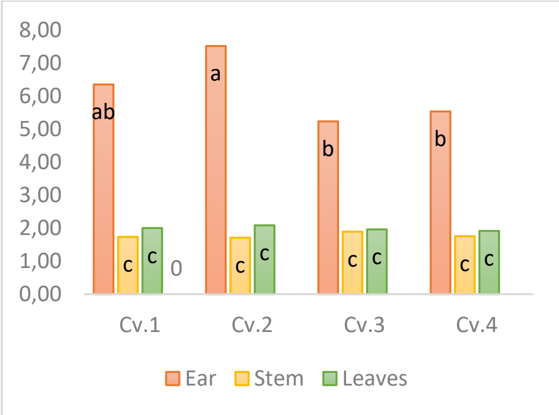

Figure 4. Genotype × part of the plant interaction of DMI.

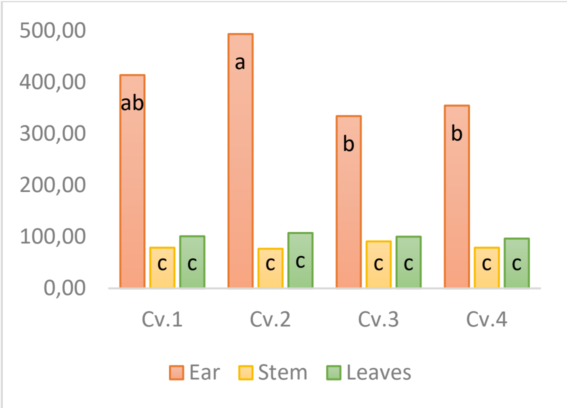

Figure 5. Genotype × part of the plant interaction of RFV.

4. CONCLUSIONS

The new production area and hybrids revealed a significant effect on yield attributes and herbage yield of forage maize. The differences among the four maize genotypes and plant parts were generally signficant in terms of all investigated traits. Especially parts of the plant (ear, stem and leaves) were important in maize cultivars for NDF, ADF, DDM, DMI, RFV. PR91G98 hybrid maize variety resulted in more productivity for parameters. Farmers and maize growers should be encouraged to use part of the plant that performs better adaptability in the specific Hatay ecological conditions. Among the investigated hybrid genotypes for grain yield, PR91G98 hybrid maize variety realized more yield. In conclusion, we deduced that the grain yield, stem diameter and plant height determined for forage yield were more essential than plant parts.

Conflict of interests

I declares that there is no a conflict of interest with any person, institute, company, etc.

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