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Forage Value of Some Popcorn (*Zea mays* L. *everta)* Genotypes

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In this study, it was aimed to determine forage yield and yield characteristics of some popcorn (*Zea mays* L. *everta*) genotypes and find out the using possibilities of popcorn as a feed material. Study was carried out during the second crop growing season under Sanliurfa, Turkey climatic conditions in 2017. The experiment was designed complete randomized blocks design with three replicates. In the research 13 popcorn new genotypes were used as a crop material. In the study, tassel flowering duration values ranged from 52.0 day to 58.0 day, plant height from 161.23 cm to 210.20 cm, leaf number from 11.16 to 13.90 number ear^{-1}, stem diameter from 21.12 mm to 25.39 mm. Also, another characteristic such as height of fist ear value values were between 74.1 cm and 111.4, biomass yield between 5092.9 kg da^{-1} and 8069.28 kg da^{-1}. Dry matter yield values varied from 1812.28 to 3333.54 kg da^{-1}, harvest index from 17.72% to 41.64%. When the plant height, biomass yield and dry matter yield values evaluated together for forage value of popcorn genotypes it was determined that 5YTR1305, AYCİN R-997, KUM1347 and 235EAD05 popcorn genotypes was found better than others. It was observed that biomass yield in popcorn plant reached 8 tons da^{-1} and dry matter yield over 3 tons da^{-1}. It has been seen that popcorn can be used as a feed source for livestock animals.

Keywords: Popcorn; biomass yield; dry matter yield; harvest index.

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1. INTRODUCTION

Popcorn (*Zea mays* L. *everta*) is an important plant whose economic value is increasing day by day, as it is used in human nutrition as well as in animal feed and industry. Popcorn is the most well-known subtype of corn used in making snack. It is mostly grown in hot and tropical climates. It matures at high temperatures. There are 3-5 cobs on the plant. The grain color can be yellow, white or purple. More yellow and white are preferred.

After the grain matures, water remains in the endosperm and this causes an explosion when the water is exposed to high temperature. Due to the vitamins and minerals, it contains, popcorn is a preferred food item in terms of nutrition. The popcorn plant can be used in animal nutrition as green fodder, dry fodder and silage. Popcorn have been suggested as alternative silage crops [1]. In addition, Lilburn [2] reported that it is a good animal feed due to its nutritious and rich content. The stems and leaves of popcorn are also used in paper making and wickerwork.

Plant height, stem thickness and leaf number in the plant are the features that increase biomass yield and dry matter yield values of popcorn plant.

Kaya and Kuşaksız [3] stated that the height of first ear was found as 102.8 cm and plant height 230.4 cm. Aydın [4] reported that the tassel flowering duration was determined between 66.0. and 73.0 cm. Plant height values were between 217.7 and 280.3 cm, first ear height were between 101.7 and 138.0 cm.

Kuşvuran and Nazlı [5] found that the first ear height in popcorn varied between 98 and 140 cm and plant height between 252 and 280 cm.

İdikut et al. [6] found tassel flowering duration values between 54 and 56 days and plant height as 134 and 181 cm in their study. Önem [7] reported that tassel flowering duration value was between 68.5 and 84.25 day and plant height 176.050 and 236.975 cm.

Yılmaz [8] found that biomass yield values in corn were ranged from 4904 kg da^{-1} to 6244 kg da^{-1}, dry matter yields were between 1481 kg da^{-1} and 2477 kg da^{-1}.

Turan and Yılmaz [9] stated that they obtained biomass yield as 5704.5- 7403.2 kg da^{-1} and dry matteryield as 1483.0-1617.9 kg da^{-1}.

When looking at other studies in corn, it is seen that there are different results. Akdeniz et al. [10] stated that biomass yield was found as 2850.1-7608.5 kg da^{-1}, dry matter yield was between 745.9 and 1465.9 kg da^{-1}. Atasever et al. [11] reported that biomass yields were found as 7293-8510 kg da^{-1} and dry matter yield 2283-2627 kg da^{-1}.

Çarpıcı [12] stated that dry matter yield was 1930.0 kg da^{-1}. Tantekin [13] emphasis that biomass yield found as 5694.85-10820.85 kg da^{-1} and dry matter yield as 1431.00-3006.33 kg da^{-1}.

The aim of this study was to determine forage yield and yield characteristics of some popcorn genotypes and find out the using possibilities of popcorn as a feed material.

2. MATERIALS AND METHODS

This study was conducted during the second crop growing season under Sanliurfa, Turkey climatic conditions in 2017. The experimental field is located in Harran Plain where the climate varies from arid to semi-arid. Table 1. provides the climatic data obtained from Sanliurfa City Meteorological Station. As can be seen from Table 1. that the weather is hot and dry in the months of June, July and August where maximum temperatures were all above 40°C while the relative humidity was below 50%.

The research area is in Harran Soil Series which has a widespread area in the region. The soils of this series are alluvial base material, flat and deep profile soils. The soil of the research field was clay, slightly alkaline, high in lime and very low in salt contents. Organic matter was low. The research soil has A, B, C horizons and pH ranges between 7.3 and 7.8. Organic matter content was low. Cation Exchange Capacity (CEC) was high and increasing towards the lower layers depending on the clay content (Dinc et al. [15]. Field capacity of the soil was 33.8% on dry basis, permanent wilting point was 22.6% and bulk density was 1.41 g cm^{-3}. Physical and chemical properties of research soil were given in Table 2.

Table 1. Monthly some climatic data during 2017 popcorn growth period in Sanliurfa[†]

Climatic parameters	2017							
	May	June	July	August	September	October	November	December
Av. Temp. (°C)	23.2	29.8	33.0	33.2	26.4	22.1	12.6	5.4
Max. Temp. (°C)	35.0	42.0	43.0	43.0	39.3	33.9	24.4	13.7
Min. Temp (°C)	10.7	18.9	20.9	21.2	14.7	12.3	3.0	-2.2
Av. Humidity (%)	38.3	28.0	25.4	30.6	32.1	35.9	42.9	70.1
Rainfall (kg/m^2)	12.3	0.6	0.2	-	-	22.0	23.3	101.1

[†]Data collected from the Sanliurfa Meteorological Station in 2017 [14]

Table 2. Some chemical properties of research soil in 2017

Deep (cm)	Organic Matter (%)	Total Salt (%)	pH	Lime (%)	P ($kg\ da^{-1}$)	K ($kg\ da^{-1}$)	Fe (ppm)	Zn (ppm)
0-20	1.37	0.098	7.5	22.3	2.8	93.4	1.23	0.67

Thirteen new popcorn genotypes (*Zea mays* L. *everta*) were used as crop material. Since the genotypes used in the research are new genotypes for area, it is aimed to determine the forage yield and yield components of new popcorn genotypes and find out the using possibilities of popcorn as a feed material. Land was ploughed and cultivated then prepared for planting with a single pass of a disk-harrow. The experiment was laid out in a randomized complete block design with three replications. Each plot area was 14 m^2 (5 m x 2.8 m) and consisted of four rows of 5 m in length. The plants were grown 70 cm apart between the rows with 18 cm spacing in each row. The seeds were sown in second part of June at a 50-60 mm depth using a seed drill. At sowing, 80 kg ha^{-1} of pure N, P and K, as a 15-15-15 composed fertilizer, was applied to each plot; this was followed by 160 kg ha^{-1} of pure N as urea when the plants reached 30-40 cm in height.

After sowing, parcels were irrigated by sprinkler irrigation method and germination of seeds was provided. After the emergence of plants, plots were irrigated equally by the furrow irrigation system. Ear and kernel characteristics were measured on randomly selected 25 plants in the center of each plot. Plant height and height of fist ear was measured using a tall ruler. Stem diameter was determined with a digital vernier caliper. All the popcorn plants on the two rows in the middle of each plot were harvested and weighed for determination of biomass yield. Two rows on the outside of each parcel are left as the edge effect.

To determine dry matter yield, in each plot, the wet weight of a randomly selected plant sample was taken and cut to a length of 5-10 cm, dried in a drying cabinet at 70 °C until it stabilized (72 hours) and its dry weight was determined. After determining the dry weight/wet weight ratio, DM yields were calculated by multiplying this ratio by the biomass yield. Throughout the study, no negative factors that could adversely affect the results were observed.

An analysis-of-variance (One-Way ANOVA) was performed using Jump 5.0.1. statistical package program to evaluate statistically differences between results. Means of the data obtained from research were compared using Duncan test at $P \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1 Tassel Flowering Duration (Day)

According to variance analysis it was found statistically significant differences ($P \leq 0.01$) among popcorn genotypes on tassel flowering duration. As seen from Table 3. That tassel flowering duration values were ranged from 52.0 day (AYCİN R-997) to 58.0 day (123AYN04). General genotype average of tassel flowering duration was found to be 54.56 day.

Table 3. Tassel flowering, plant height, leaf number and stem diameter values of popcorn genotypes

Genotypes	Tassel flowering** (day)	Plant height** (cm)	Leaf number** (number ear^{-1})	Stem diameter** (mm)
123AYN04	58.00 a†	168.40 de	11.23 de	21.60 b
413MHT05	52.33 b	183.30 bcd	11.53 de	21.12 b
237A1K05	57.67 a	161.23 e	11.73 cde	22.57 ab
4171ED05	56.33 ab	172.93 de	11.93 bcde	22.39 ab
KUM1347	56.67 ab	208.90 a	12.63 b	25.39 a
235EAD05	56.33 ab	177.60 cde	11.16 e	21.16 b
411KTR05	55.67 ab	203.40 ab	11.93 bcde	23.71 ab
5YTR1305	52.67 b	210.20 a	12.66 b	23.92 ab
AYCİN R-997	52.00 b	197.03 abc	11.40 de	23.00 ab
AYCİN R- 427	52.33 b	189.73 abcd	12.10 bcd	24.23 ab
ANTCİN- 98	52.33 b	197.13 abc	13.90 a	22.28 ab
ELACİN	52.67 b	203.56 ab	12.56 bc	22.36 ab
BAHARCİN	54.33 ab	174.86 de	11.90 bcde	22.94 ab
Average	54.56	188.32	12.05	22.82
LSD	4.79	22.01	0.879	3.36

†*There is no statistical difference among values annotated with the same letter according to Duncan test at P≤0.05, **: denotes P≤0.01*

According to the results of other studies conducted on popcorn, different tassel flowering duration values have been reported. According to these results, Oktem and Oktem [16] found the tassel flowering duration to be between 48.5 to 52.8 day, Özkan [17] between 57.6 days and 58.3 days, İdikut et al. [6] between 54.75 days and 66.5 days. Cihangir and Oktem [18] reported that tassel flowering duration values varied from 54.67 days to 63.67 days. In some previous studies, tassel flowering values were stated as between 59 days and 71 days [19], between 54 days and 66 days [20], between 43 days and 63 days [21].

Oktem et al. [22] reported that it ranged between 48 days and 63 days. The results obtained are consistent with the findings of other researchers.

3.2 Plant Height (cm)

The difference among the tested popcorn genotypes was found to be statistically significant in terms of plant height (P≤0.01) at the variance analyses. Plant height values varied from 161.23 cm to 210.20 cm (Table 3). The highest plant height value was obtained from 5YTR1305 genotype whereas the lowest values were seen at 237A1K05 genotype (Fig. 1). Genotype average was found as 188.32 cm. Similar to our findings, Özsoy [23] reported the plant height between 1172.3 cm and 191.6 cm, Cihangir and Oktem [18] between 183.1 cm and 2014.2 cm, Özkan [17] between 184 cm and 200 cm.

Some researchers reported different plant height values in popcorn. Plant height values reported as between 138 cm and 210 cm [19], between 141 cm and 279 cm [21], between 82 cm and 176 cm [24]. İdikut et al. [6] found that it ranged between 134 cm and 181 cm. Marques et al. [25] stated that the plant height is between 197 cm and 216 cm. Plant height changes according to the variety and environmental conditions [18, 22].

3.3 Leaf Number (Number ear^{-1})

In performed variance analyses, differences between popcorn genotypes in term of ear leaf number value was found significant (P≤0.01). Leaf number values ranged from 11.16 to 13.90 number ear^{-1}. It was seen from Table 3 that the highest leaf number value was obtained from ANTCİN-98 genotype whereas the lowest values were seen at 235EAD05 genotype.

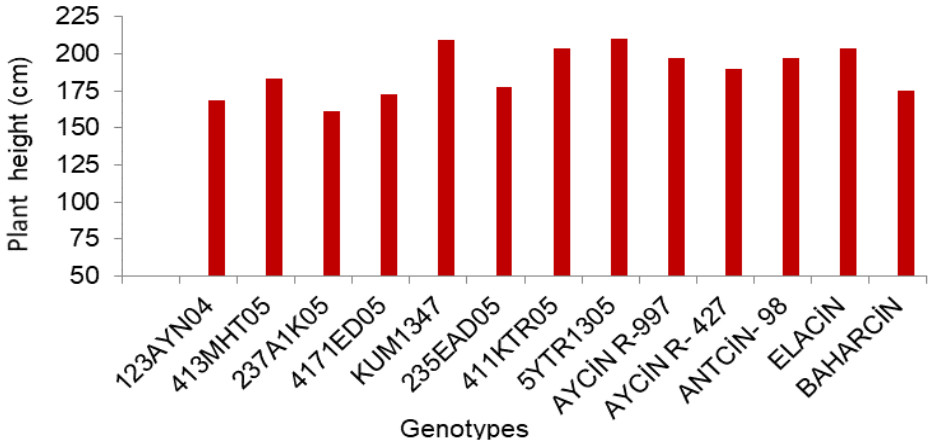

Fig. 1. Plant height values of popcorn genotypes

The general genotype average of leaf number in the plant was found to be 12.05 number ear^{-1}. When we look another study on popcorn, leaf number value was reported as between 13.43 and 15.21 number ear^{-1} [18].

3.4 Stem Diameter (mm)

As seen from Table 3 that differences between popcorn genotypes for stem diameter value was found statistically significant (P≤0.01). It was seen from Table 3 and Fig. 2 that stem diameter values ranged between 21.12 mm (413MHT05) and 25.39 mm (KUM1347). Genotype average was found as 22.82 mm. Similar results were obtained by some researchers [22]. Özkan [17] found that the stem diameter of ear was between 19.1 mm and 21.1 mm, İdikut et al. [26] reported that it ranged between 15.0 mm and 19 mm.

3.5 Height of First Ear (cm)

According to variance analyses differences among tested popcorn genotypes for height of first ear was statistically significant (P≤0.01). Height of first ear value was the highest in 5YTR1305 genotype as 111.4 cm whereas the lowest height of first ear value was seen at 237A1K05 genotype as 74.1 cm (Fig. 3). The average of genotype was found to be 93.87 cm.

Different results have been obtained in other studies. Özkan [17] found height of first ear in popcorn between 102.0 cm and 117.0 cm; İdikut et al. [6] reported height of first ear values between 56.3 cm and 106.1 cm. Özsoy [23] stated that height of first ear was between 74.2 cm and 92.5 cm.

Environmental conditions and genotypes affect height of fist ear [18, 22].

3.6 Biomass Yield (kg da^{-1})

According to variance analysis there was significant difference (P≤0.01) between popcorn genotypes on biomass yield (Table 4). The highest biomass yield was obtained from AYCİN R-427 genotype (8069.28 kg da^{-1}), while the lowest value was found at BAHARCİN genotype (5092.9 kg da^{-1}). The average biomass yield of the genotypes was determined as 6344.5 kg da^{-1} (Fig. 4).

Biomass yield changes according to the variety and environmental conditions.

When we look at the previous studies on corn, it has been reported that the biomass yield was between 4904 kg da^{-1} and 6244 kg da^{-1} [8], between 5704.5 kg da^{-1} and 7403.2 kg da^{-1} [9], between 2850.1 kg da^{-1} and 7608.5 kg da^{-1} [10]. Atasever et al. [11] reported that biomass yield was found to be between 2283 kg da^{-1} and 2627 kg da^{-1}. Biomass yield were reported as between 5694.85 kg da^{-1} and 10820.85 kg da^{-1} by Tantekin [13].

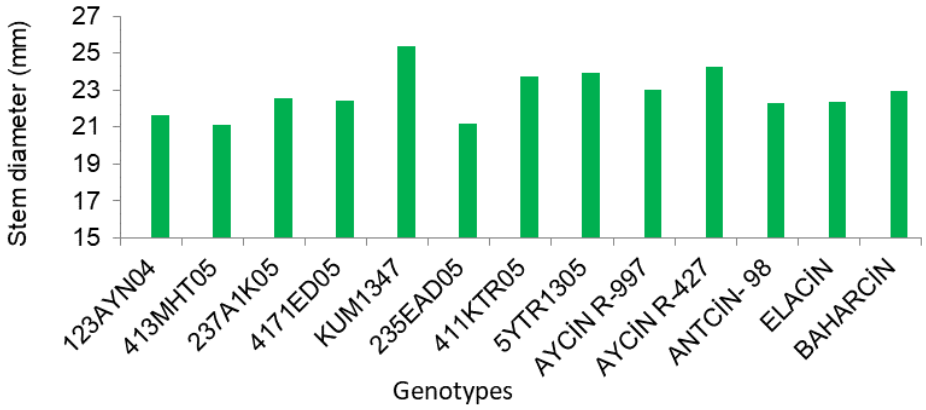

Fig. 2. Stem diameter values of popcorn genotypes

Table 4. Height of fist ear, biomass yield, dry matter yield and harvest index values of popcorn genotypes

Genotypes	Height of fist ear** (cm)	Biomass yield** (kg da-1)	Dry matter yield** (kg da^{-1})	Harvest index** (%)
123AYN04	74.86 e[†]	7288.81 abc	2666.29 abc	17.72 d
413MHT05	92.46 bcd	5344.24 c	2129.76 bc	30.16 abcd
237A1K05	74.10 e	5344.24 c	1812.28 c	30.18 abcd
4171ED05	81.50 de	6270.23 abc	2434.01 bc	23.20 cd
KUM1347	101.70 abc	7130.07 abc	2764.72 ab	30.82 abcd
235EAD05	85.66 cde	7606.29 ab	2804.40 ab	18.63 d
411KTR05	107.66 ab	6733.22 abc	2817.63 ab	34.48 abc
5YTR1305	111.43 a	6005.66 abc	2553.06 abc	36.74 ab
AYCİN R-997	103.30 ab	6032.12 abc	2222.36 bc	32.67 abc
AYCİN R- 427	101.60 abc	8069.28 a	3333.54 a	18.82 d
ANTCİN- 98	101.20 abc	5688.18 bc	2248.81 bc	26.72 bcd
ELACİN	103.46 ab	5873.38 abc	2195.90 bc	41.64 a
BAHARCİN	81.43 de	5092.90 c	1878.42 c	33.11 abc
Average	93.87	6344.50	2443.16	28.83
LSD	16.20	2223.49	802.09	13.38

[†]*There is no statistical difference among values annotated with the same letter according to Duncan test at P≤0.05, ** : denotes P≤0.01*

3.7 Dry Matter Yield (kg da $^{-1}$)

According to variance analysis differences among tested popcorn genotypes for dry matter yield was found significant at 0.01 level. Dry matter yield values and Duncan groups were given Table 4. Dry matter yield values ranged from 1812.28 kg da^{-1} to 3333.54 kg da^{-1} (Table 4).

It was seen from Fig. 5 that the highest dry matter yield value was obtained from AYCİN R-427 whereas the lowest values were seen at 237A1K05 genotype. Mean grain yield value was found as 2443.16 kg da^{-1}.

Dry matter yield in corn is affected by varieties, environmental conditions and growing conditions such as plant density, sowing date, fertilizer amount and type, irrigation amount and methods. Climatic and environmental conditions effect dry matter yield [16].

In previous studies conducted with corn, Yılmaz [8] stated that dry matter yield ranged from 1481 kg da^{-1} to 2477 kg da^{-1}. Turan and Yılmaz [9] emphasized that dry matter yield ranged from 1483.0 kg da^{-1} to 1617.9 kg da^{-1}, Akdeniz et al. [10] stated that dry matter yield was between 745.9 kg da^{-1} and 1465.9 kg da^{-1}.

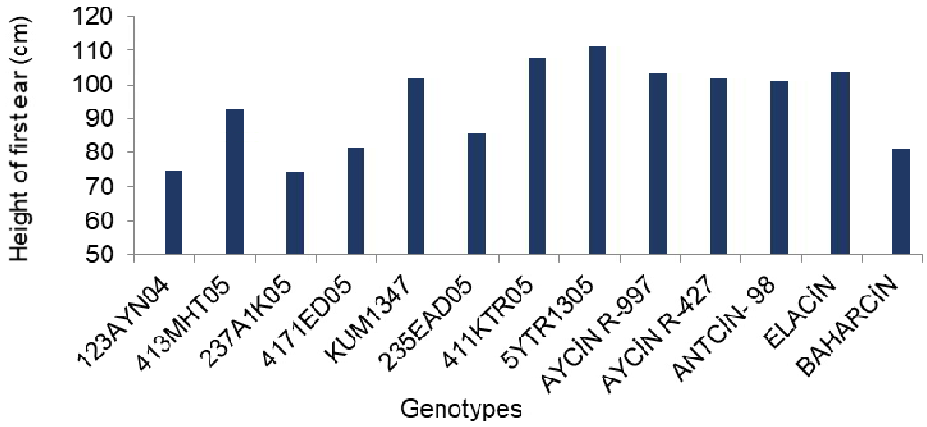

Fig. 3. Height of first ear values of popcorn genotypes

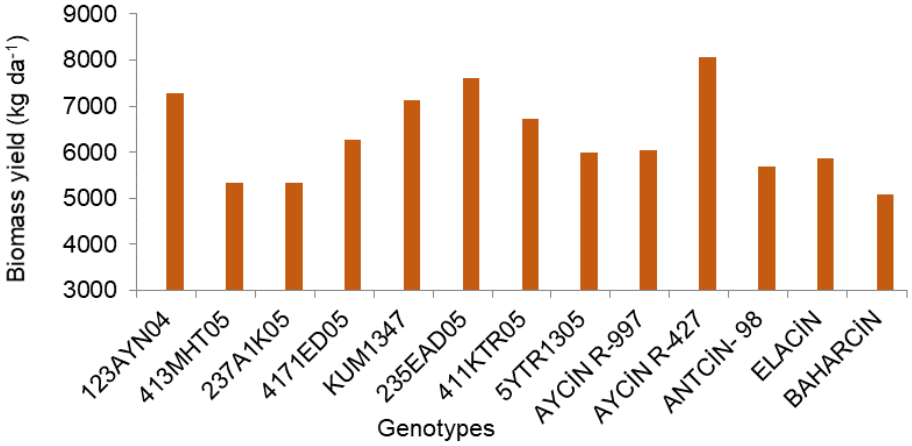

Fig. 4. Biomass yield values of popcorn genotypes

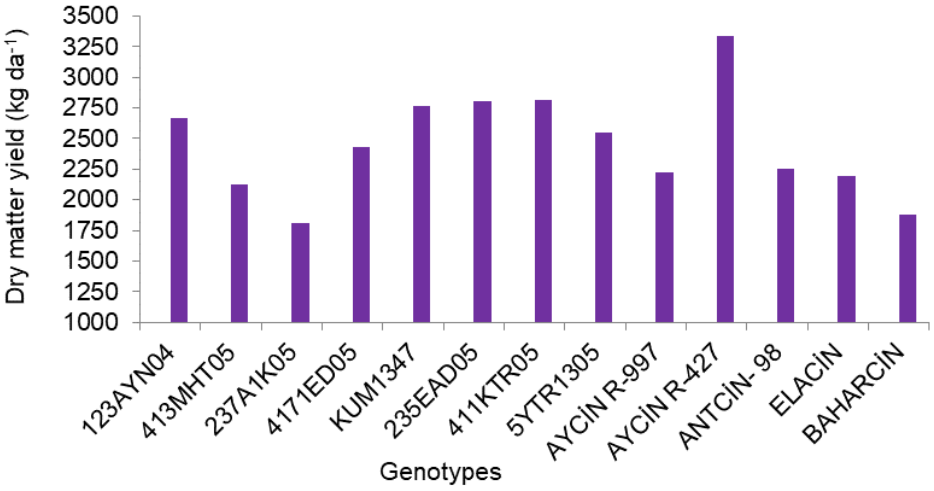

Fig. 5. Dry grass yield values of popcorn genotypes

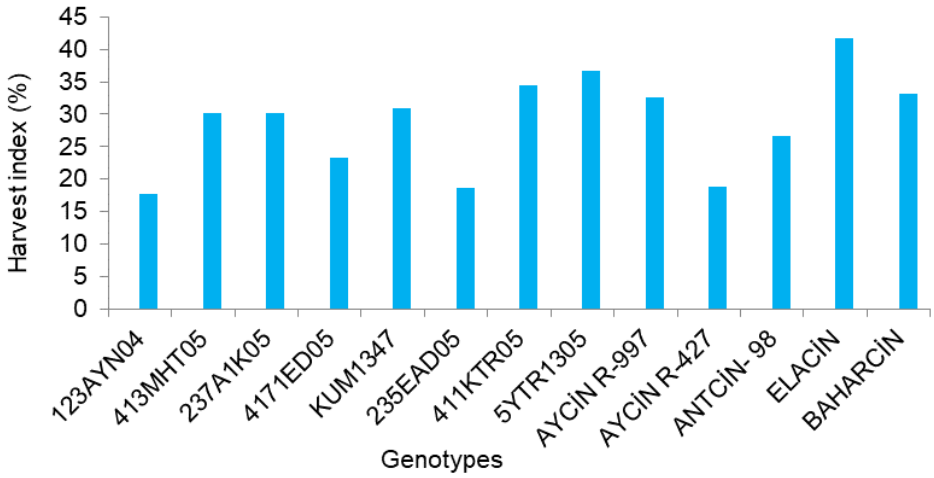

Fig. 6. Harvest index values of popcorn genotypes

In different studies, dry matter yields were reported between 897 kg da^{-1} and 2048 kg da^{-1} [27], between 1884.0 kg da^{-1} and 2130.0 kg da^{-1} [28]. Dry matter yields were stated between 2193.4 kg da^{-1} and 2657.5 kg da^{-1} [29].

Dry matter yields were reported by some other researchers as between 1243.7 kg da^{-1} and 1725.8 kg da^{-1} [30].

Researchers stated that dry matter yields were between 2283 kg da^{-1} and 2627 kg da^{-1} [11], between 1431.0 kg da^{-1} and 3006.3 kg da^{-1} [13].

3.8 Harvest Index (%)

According to the results of variance analysis, a statistically significant difference was found between popcorn genotypes in terms of harvest index compared at 1% (Table 4). It was seen clearly from Fig. 6 that harvest index value was the highest in ELACİN genotype as 41.64 % whereas the lowest harvest index value was seen at 123AYN04 genotype as 17.72%. Average of genotypes was found as 28.83%. Harvest index values changes according to the variety and environmental conditions [31, 32].

4. CONCLUSIONS

As a result, tassel flowering duration values ranged from 52.0 day to 58.0 day, plant height from 161.23 cm to 210.20 cm, leaf number from 11.16 to 13.90 number ear-1, stem diameter from 21.12 mm to 25.39 mm. Also, another characteristic such as height of fist ear value values were between 74.1 cm and 111.4, biomass yield between 5092.9 kg da^{-1} and 8069.28 kg da^{-1}. Dry matter yield values varied from 1812.28 to 3333.54 kg da^{-1}, harvest index from 17.72% to 41.64%.

At the light of research results, when the plant height, biomass yield and dry matter yield values evaluated together for forage value of popcorn genotypes it was determined that 5YTR1305, AYCİN R-997, KUM1347 and 235EAD05 popcorn genotypes was found better than others.

It was observed that biomass yield in popcorn plant reached 8 tons da^{-1} and dry matter yield over 3 tons da^{-1}. It has been seen that popcorn can be used as a feed source for livestock animals.

5. ACKNOWLEDGEMENTS

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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