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THE PERFORMANCES OF SOME NEW DENT MAIZE (*Zea mays* L.) CULTIVARS GROWN AS MAIN CROP IN A MEDITERRANEAN ENVIRONMENT

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ABSTRACT

The experiment was conducted in the experimental fields of at Alasehir district of Manisa province in western Turkey in 2016 and 2017, aiming to determine the adaptability of new maize cultivars for grain production as main crop under Mediterranean ecological conditions. Kayras, Kalends, Kebeos, Keidas, Inove, Performer, Hydro, Pioneer 2088, Pioneer-31-D-24, Pioneer 2105, LG 30600, LG Indaco, LG 30692, BC 678, C-955 and Valbom were tested. Significant differences were detected among the varieties in terms of plant height, first ear height, number of leaves per plant, stem diameter, ear length, ear diameter, number of kernels per ear, 1000 kernel weight, grain yield and crude protein traits. The average value of plant height of maize cultivars varied between 216.03 and 262.45 cm and first ear height 82.70 and 105.48 cm; number of leaves per plant 11.50 and 14.65; stem diameter between 19.0 and 24.1 mm; ear length between 19.33 and 23.06 cm; ear diameter 38.0 to 52.4 mm; number of kernels per ear 314.05 and 563.11; 1000 kernel weight 295.06 and 406.03 g; grain yield 9020.6 kg ha^{-1} and 12243.0 kg ha^{-1} and crude protein content between 8.72 and 14.24 %. In conclusion, cv. Pioneer-2105 and cv. Performer were found to be superior to other cultivars for yield and 1000 kernel weight traits.

Keywords: Cultivars, grain yield, maize

INTRODUCTION

Maize is a warm season cereal, commonly cultivated in large areas for grain production. Maize has the first rank in world's production cereal crop and it is the most important food source for local populations in middle and south America, Africa and China. Maize is mostly cultivated in many countries for silage production in last thirty years. Being the most important silage crop in the world, because of its properness for ensiling. It produces abundant amounts of green herbage which has high nutrition value and palatability (Kirtok, 1998; Yolcu et al., 2008).

The use of grain maize in industry has gradually increased in recent years compared to other cereals. Due to its given twice more yield than barley and wheat from the unit area and its cultivation technique, harvesting, transportation and storage which are comparable easy. The use of biofuels in recent years has also increased the need for maize plants particularly in subtropical regions of the world like Mediterranean zone (Ozata et al., 2013).

In Turkey, maize is cultivated on an area of 639.084 hectares, with an annual production of 5.9 million tons and the average yield of 9231.9 kg ha^{-1} (TUIK, 2018). The average maize yield per hectare of Turkey is close to the other major countries growing maize such as France (10030.0 kg ha^{-1}), Germany (10680.0 kg ha^{-1}), Austria (10790.0 kg ha^{-1}) and USA (10730.0 kg ha^{-1}) (Kokten and Akcura, 2017). Maize grain production of Turkey is portioned as follow; about 35 % for human nutrient requirement, and 65 % for animal feed (Keskin et al., 2005).

Due to the increasing demand for maize, the private sector and public institutions in Turkey constantly introduce new maize varieties to the market. As of 12.09.2018, there are 277 registered and 57 permitted maize varieties in Turkey (TTSM 2018).

The performance yield and some quality characteristics of different maize cultivars and lines were studied at different climatic and soil conditions in Turkey such as Edirne, Sanliurfa, Aydin, Konya, Adapazari, Kahramanmaras, Izmir, Cankiri, Giresun, Adana, and Bingol, respectively (Babaoglu, 2003; Oktem and Oktem, 2009; Koca and Erekul, 2011; Karasahin and Sade 2012; Oner et al., 2012; Idikut and Kara, 2013; Budak et al., 2014; Kusvuran and Nazli, 2014; Yilmaz and Han, 2016; Demir and Konuskan, 2016; Kokten and Akcura, 2017) and the superior genotypes were proposed to the farmers.

The most important component for providing high yield is to use the better adapted cultivars in any region. Since the maize cultivars may show highly different yield performances depending on the soil and climatic conditions from one region to another, therefore more adaptable cultivars should be selected and cultivated for each particular region. The replacement of low-yielding old varieties with these new genotypes will result in an increase of production per unit area and will contribute to the economy of Turkey. Additionaly, it should be remembered that the cultivars from different origins can provide higher yield than the domestic cultivars (Saruhan et al., 2007; Kusaksiz, 2010).

The objective of this study was to evaluate the grain yield potential and some other yield components of newly introduced maize (*Zea mays* L.) cultivars in Alasehir-Manisa, Turkey.

MATERIALS AND METHODS

The field trials were conducted during the 2016 and 2017, maize was used as a main crop at the experimental area of Alasehir Vocational School in Manisa, Turkey(Western Turkey, latitude 38° 37' N, longitude 28° 52' E, elevation 189 m). The physical and chemical properties of the surface soil (0-20 cm) was as follows: Texture; loamy, pH; 7.55 (mild alkaline), organic matter content; 1.27 % (low) and N, P, K, and $CaCO_3$ contents in the upper 20 cm of soil were 0.06 % (middle), 47.88 ppm (high), 217 ppm (high) and 4.7 % (limy), respectively. The monthly rainfall and mean temperature during the study were summarized in Table 1**.**

Table 1. Average temperature and rainfall in the Alasehir-Manisa in 2016 and 2017 (Anonymous, 2018)

Months	Average Temperature(°C)			Rainfall (mm)		
	Long Years	**2016**	**2017**	**Long Years**	**2016**	**2017**
May	20.5	19.2	19.7	33.2	35.2	34.0
June	25.2	26.3	24.1	15.1	8.2	59.4
July	27.8	27.8	27.6	9.3	0.0	0.0
August	27.1	26.7	26.4	6.5	48.6	0.0
September	22.9	22.1	23.0	10.7	30.2	3.8
Mean	24.7	24.4	24.1	-	-	-
Total	-	-	-	74.8	122.2	97.2

West Anatolia Region, where Alasehir is located is favourable for maize growing in terms of climate and soil characteristics. The Mediterranean climate prevails over the Alasehir plain and its surroundings (Karakuyu and Ozcaglar, 2005). In both experimental years, the average temperature of the growing season was measured close to the average of long years.

The monthly distribution of total precipitation during the trial period varied great in both years the long years average. The highest rainfall in the first year was measured in August (48.6 mm) and the lowest in July (0.0 mm) while the second year highest rainfall in June (59.4 mm) and the lowest rainfall in July and August (0.0 mm).

The field experiment was designed in a Randomized-Complete-Block (RCBD) with three replications. Each plot consisted of four rows, 8 m long, and 0.70 m apart and the seeds were planted 0.20 m apart in the rows. The total area of each plot was 22.4 m^2 and the harvest area of each plot was 9.8 m^2. Sowing dates were 5 May 2016 and 5 May 2017. The previous crop was wheat.

Hybrid maize cultivars as Kayras (Registration date 2013-FAO 630), Kalends (2014-FAO 700), Kebeos (2016-FAO 700), Keidas (2016-FAO 630), Inove (2015-FAO 700), Performer (2015-FAO 700), Hydro (2016-FAO 650), Pioneer 2088 (2016-FAO 650), Pioneer-31-D-24 (2010-FAO 680), Pioneer 2105 (2015-FAO 700), LG 30600 (2016-FAO 690), LG Indaco (2013-FAO 680), LG 30692 (2015-FAO 680), BC 678 (2005-FAO 600), C-955 (1995-FAO 800) and Valbom (2005-FAO 700) were used as the crop material in the experiment (TTSM, 2018). The genetic material of the study was obtained from private seed companies. The full dose of nitrogen (100 kg N ha^{-1}), phosphate (100 kg P_2O_5 ha^{-1}) and potassium (100 kg K_2SO_4 ha^{-1}) were applied at sowing. Additional dose of nitrogen (100 kg N ha^{-1}) was applied at the stage when the crops were 40-50 cm. Seven irrigations were applied each year and weeds were controlled by hoeing. In accordance with Oylukan and Gungor (1975) suggested that the irrigation should generally be applied four times for the vegetation period of maize. Maize needs approximately 601 mm rainfall in a year (Okursoy, 2009). However, the precipitation occurred as 122.7 mm in 2016 and 97.2 mm in 2017 in our study. Hence, seven furrow irrigations were applied each year.

When the kernel moisture was about 15% in each cultivar, two rows in the center of each plot were harvested, manually, in between 15-30 September according to cultivar characteristics. Then, the grains were dried under sun until the moisture content decreased below 13%. N content was determined by using Kjeldahl method. The plant height, stem diameter, grain yield and yield components including ear diameter, ear length, number of kernels per ear, and 1000 kernel weight were determined as described by Kokten and Akcura (2017). Grain yield was calculated by multiplying by 10000/plot sizes/m^2.

All data were analyzed statistically by procedures using the MSTAC software package program (Freed et al., 1989). Duncan's test was used for the comparison of the genotype means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Analysis of variance showed that cultivars were significantly different ($P<0.01$) for all traits. Cultivar x year interaction effect was found to be insignificant for first ear height, number of leaves per plant, stem diameter, ear diameter, number of kernels per ear, 1000 kernel weight and grain yield ($P<0.05$) while Cultivar x year interaction effect was significant for plant height, ear length and crude protein content (Table 2, 3, 4).

Table 2. Means of the traits measured in maize cultivars

Maize cultivars	First ear height (cm)	Number of leaves per plant	Stem diameter (mm)	Ear diameter (mm)	Number of kernels per ear
Kayras	85.06 cde	12.15 de	19.0 c	49.7 ab	470.78 abcd
Kalends	105.48 a	11.50 e	22.8 ab	45.4 cd	533.38 ab
Kebeos	82.70 e	13.00 bcd	22.4 abc	44.5 d	455.30 abcde
Keidas	91.81 abcde	12.38 cde	19.8 bc	49.6 ab	563.11 a
Inove	95.20 abcde	12.06 de	22.6 abc	50.0 ab	497.91 abc
Performer	83.70 de	12.58 bcde	22.7 abc	52.4 a	526.00 abc
Hydro	92.30 abcde	13.13 abcd	20.6 abc	47.3 bc	489.60 abc
Pioneer 2088	98.90 ab	13.75 ab	22.0 abc	46.0 cd	428.65 cde
Pioneer 31-D-24	94.85 abcde	13.05 bcd	24.1 a	46.6 cd	528.80 abc
Pioneer 2105	84.76 de	12.23 de	21.0 abc	52.2 a	559.51 ab
LG 30600	98.66 abc	13.60 abc	21.6 abc	49.6 ab	476.66 abcd
LG Indaco	90.20 bcde	12.48 bcde	22.7 abc	47.3 bc	529.03 abc
LG 30692	96.55 abcd	13.13 abcd	20.7 abc	47.6 bc	387.31 def
BC 678	93.88 abcde	12.56 bcde	20.3 abc	38.0 f	454.18 bcde
C 955	104.30 a	14.65 a	20.7 abc	41.4 e	314.05 f
Valbom	99.40 ab	12.30 de	23.0 ab	46.1 cd	359.95 ef
Mean	93.61	12.78	21.6	47.1	473.39
CV (%)	10.04	7.61	13.81	8.07	18.56
F values					
Year	1.18^{NS}	23.76**	110.42**	3.29^{NS}	14.01**
Cultivar	7.04**	10.59**	3.36**	61.44**	12.82**
CultivarxYear	1.56^{NS}	1.15^{NS}	1.42^{NS}	1.11^{NS}	1.48^{NS}

Means followed by different letter(s) are significantly different at the 5% or 1% level of probability.
*, **, indicates significance at 0.05 and 0.01, respectively, NS indicates not significant.

Plant height (cm)

Plant height was significantly different among maize cultivars in 2016 and 2017 (Table 3). Inove cultivar had highest plant height (277.70 cm), while lowest plant height (216.90 cm) was recorded in Valbom in 2016 and Keidas, Kalends, C-955 cultivars had highest plant height (256.73, 254.66, 254.60 cm), while lowest plant height (215.16 cm) was recorded in Valbom in 2017. Besides, the combined analysis of variance for 2 years for plant height gave significant F value. Highest plant height values of 262.45 cm, 260.15 cm and 258.96 cm were recorded in Keidas, C-955 and Inove, respectively, while lowest plant height of 216.03 cm was observed in Valbom. Year and cultivar x year interaction effects were found to be significant ($P<0.01$) for plant height. The average plant height (245.40 cm) in 2016 was higher than 2017 (238.60 cm). This could be attributed to air temperatures in the first year, especially the air temperatures in May, June and July, were higher than the second year. Different plant heights were reported by different studies conducted at different ecological areas. Oner et al. (2012), Kusvuran and Nazli (2014) reported plant heights ranged between 244.54-299.83 cm, 252.00-280.00 cm, respectively. Compared with these values it could be said that the maize cultivars studied in our research generally had lower plant heights values. These differences may be due to cultivar and ecological differences. In addition to the climate and soil factors were also affected those results. However, our results were higher than the studies conducted with maize cultivars under Edirne conditions (Babaoglu, 2003), Kahramanmaras (Idikut and Kara, 2013), and Sanliurfa (Oktem and Toprak, 2013), it was indicated that the plant heights ranged between 176.00-238.9 cm, 172.20-220.00 cm, 179.6-225.00 cm, respectively. Plant height values reported by (Karasahin and Sade, 2012), (Demir and Konuskan, 2016), (Kokten and Akcura, 2017) were partly similar to our findings.

Table 3. Means of the traits measured in maize cultivars

Maize cultivars	Plant height (cm)			Ear length (cm)		
	2016	2017	Mean	2016	2017	Mean
Kayras	242.63 bcdefg	233.26 bcd	237.95 bcd	20.56 efg	20.58 cdef	20.57 efg
Kalends	250.06 bcdef	254.66 a	252.36 ab	22.40 abcde	23.33 a	22.86 a
Kebeos	225.73 gh	231.13 bcd	228.43 de	20.93cdefg	22.40 abcd	21.66 abcde
Keidas	268.16 ab	256.73 a	262.45 a	21.90 abcdef	21.30 abcd	21.60 abcde
Inove	277.70 a	240.23 abc	258.96 a	22.83 abc	21.46 abcd	22.15 abc
Performer	228.90 fgh	228.86 bcd	228.88 de	23.23 ab	22.60 abc	22.91 a
Hydro	235.80 defgh	237.86 abc	236.83 bcd	22.66 abcd	22.96 ab	22.81 a
Pioneer 2088	258.20 abcd	245.93 ab	252.06 ab	23.36 a	21.33 abcd	22.35 ab
Pioneer 31-D-24	254.60 abcde	232.40 bcd	243.50 abcd	23.73 a	20.46 def	22.10 abcd
Pioneer 2105	236.50 defgh	226.30 cd	231.40 de	23.50 a	22.63 abc	23.06 a
LG 30600	253.20 abcde	247.73 ab	250.46 abc	21.00 bcdefg	18.80 f	19.90 fg
LG Indaco	242.30 cdefg	245.13 ab	243.71 abcd	19.96 fg	21.36 abcd	20.66 cdefg
LG 30692	236.96 defgh	230.10 bcd	233.53 cd	19.46 g	19.20 ef	19.33 g
BC 678	233.03 efgh	237.46 abc	235.25 bcd	20.70 defg	21.06 bcde	20.88 bcdef
C 955	265.70 abc	254.60 a	260.15 a	20.13 fg	19.20 ef	19.66 fg
Valbom	216.90 h	215.16 d	216.03 e	20.86 cdefg	20.45 def	20.65 defg
Mean	245.40 a	238.60 b	242.00	**21.70 a**	**21.19 b**	21.45
CV (%)	7.33	5.49	6.62	6.72	7.03	6.94
F values						
Year			15.69**			13.20**
Cultivar	13.90**	9.53**	14.84**	12.67**	9.22**	19.59**
CultivarxYear			2.70**			5.42**

Means followed by different letter(s) are significantly different at the 5% or 1% level of probability.
*, **, indicates significance at 0.05 and 0.01, respectively, NS indicates not significant

First ear height (cm)

The combined analysis of variance for 2 years for the first ear height gave significant F value (Table 2). Highest first ear height value of 105.48 cm and 104.30 cm were recorded in Kalends and C-955, as the lowest first ear height of 82.70 cm was observed in Kebeos. First ear heights obtained from our study were found lower than the results of Oktem and Oktem (2009), Karasahin and Sade (2012), Oner et al. (2012), Kusvuran and Nazli (2014), but higher than the results of Idikut and Kara (2013).

Number of leaves per plant

The F values (Table 2) indicated that the number of leaves per plant were significantly effected in all cultivars in 2016 and 2017. C- 955 had the maximum number of leaves (14.65) per plant, while the minimum number of leaves (11.50) per plant were taken from Kalends. Year effect was found to be significant (P<0.01) for number of leaves per plant. Average number of leaves per plant (13.07 cm) in 2016 was higher than 2017(12.49 cm). This could be attributed to air temperatures in the first year, especially in May, June and July, were higher than the second year. Variation among genotypes for number of leaves per plant could be also attributed to the genetic potential and intrinsic ability of different cultivars to access growth resources and their expression in terms of yield (Allard, 1999). These findings were in agreement with those of Babaoglu (2003) and Oktem and Toprak (2013).

Stem diameter (mm)

The combined analysis of variance for 2 years for stem diameter gave significant F value (Table 2). Highest stem diameter value of 24.1 mm was recorded in Pioneer 31-D-24, while lowest stem diameter of 19.00 mm was observed in Kayras. Year effect was found to be significant (P<0.01) for stem diameter. Average number of stem diameter (23.6 mm) in 2016 was higher than 2017 (23.3 mm). This could be related to air temperatures in the first year, especially in May, June were higher than the second year. Variation among genotypes for stem diameter could be also reflected to the genetic background and intrinsic ability of different cultivars to access growth resources and their expression in terms of yield (Allard, 1999). Babaoglu (2003), Idikut and Kara (2013) reported 17.0-22.6 mm and 21.0-24.0 mm stem diameter, respectively. Our results were similar to their results. Stem diameter values obtained from our study were found lower than the results of Kokten and Akcura (2017).

Ear length (cm)

Ear lenght was significantly different among maize cultivars in 2016 and 2017 (Table 3). Pioneer 31-D-24, Pioneer 2105, Pioneer 2088 had highest ear length (23.73 cm, 23.50 cm, 23.36 cm), while lowest ear length (19.46 cm) was recorded in LG 30692 in 2016 and Kalends had highest ear length (23.33 cm), while lowest ear length (18.80 cm) was recorded in LG 30600 in 2017. Besides, the combined analysis of variance for 2 years for ear length gave significant F value. Highest ear length value of 23.06 cm, 22.91 cm and 22.81 cm were recorded in Pioneer 2105, Performer and Hydro cultivars, respectively, while lowest ear length of 19.33 cm was observed in LG 30692 cultivar. Year and cultivar x year interaction effect were significant (P<0.01) for ear length. The average of ear length (21.70 cm) in 2016 was higher than 2017 (21.19 cm). The monthly distribution of total rainfall during the trial period varied great in both years the long years average. The highest rainfall in the first year was measured in August (48.6 mm) and the lowest in July (0.0 mm) while the second year highest rainfall in June (59.4 mm) and the lowest rainfall in July and August (0.0 mm). It has been found that ears m^{-2} is reduced by water stress early in vegetative growth, with longer periods of water stress resulting in a fewer ears (Pandey et al., 2000). During silking and just prior to silking unfavorable conditions can cause ear development to be halted and ear abortion (Andrade et al. 1999). This could have a negative effect on both ears m^{-2} and kernel number. The average temperature and the rainfall values in 2016 could be provided the humidity and triggered the pollination and the fertilization. Suitable conditions might have caused the first year ear lengths to be taller. These differences among the maize cultivars might be due to the genetic potential, the environmental factors and the nutrient uptake capacities of the cultivars as similar results reported by previous authors Oktem and Toprak (2013); Kusvuran and Nazli (2014); Yilmaz and Han (2016); Caglar et al. (2017).

Ear diameter (mm)

The combined analysis of variance for 2 years for ear diameter gave significant F value (Table 2). Highest ear diameter value of 52.4 mm and 52.2 mm were recorded in Performer and Pioneer 2105 cultivars, while lowest first ear diameter of 38.0 mm was observed in BC 678. Stress during vegetative growth has an effect on kernel number due to the fact that the size of the ear and number of ovules formed are determined during this stage (Abendroth et al., 2011). Pre-anthesis drought stress reduced the kernel row number and the number of kernels per row thus reducing the kernel number as well (Moser et al., 2006). Variation among genotypes for ear diameter could be related to the genetic background of cultivars. Similar results have been recorded by Babaoglu (2003); Karasahin and Sade (2012); Oktem and Toprak (2013); Kusvuran and Nazli (2014); Budak et al. (2014); Yilmaz and Han (2016); Kokten and Akcura (2017).

Number of kernels per ear

The combined analysis of variance for 2 years for number of kernels per ear gave significant F value (Table 2). Keidas had the maximum (563.11) number of kernels per ear while the minimum number of kernels per ear (314.05) per plant were taken from C-955. Year effect was found to be significant ($P<0.01$) for number of kernels per ear. The average number of kernels per ear (492.14) in 2016 was higher than 2017 (454.63). Number of kernels per ear are the yield component that varies the most with water stress. It has been found that yield reductions from water stress were mostly due to reduced kernel numbers and kernel weight with kernel number having the greatest correlation with yield reduction (Pandey et al., 2000; Moser et al., 2006). Reductions in kernel numbers are highest when stress occurs during silking and early grain fill stages (Eck, 1986). Number of kernels per ear are a direct result of number of rows and kernels per row. Number of rows is strongly related to the genetics of the hybrid and is only effected by serious environmental stresses. Once silks appear from the ear shoot, the plant is considered to be in the silking stage which is the first of the reproductive stages. This stage is the most sensitive period for the crop to water and heat stress due to the fact that the number of kernels per ear is determined. At this stage, both pollination and fertilization occur and silks on the primary ear must be present during pollen shed. Pollen shed is a critical factor and ultimately determines whether or not potential ovules will be fertilized (Abendroth et al., 2011). This could be attributed air temperatures (in June, July, and August) and rainfall (in August and September) in the first year were higher than the second year. Suitable weather conditions were occurred in 2016 for pollination and fertilization. Similar results (327.3-571.3 number of kernels per ear) have been recorded by Kokten and Akcura (2017).

1000 kernel weight (g)

The combined analysis of variance for 2 years for 1000 kernel weight gave significant F value (Table 4). The highest 1000 kernel weight value of 406.03 g and 401.33 g were recorded in Pioneer 2105 and Performer, while the lowest 1000 kernel weight of 295.06 g and 298.36 g were observed in Valbom and C-955. Similar result has been recorded by Oner et al. (2012); Karasahin and Sade (2012); Caglar et al. (2017); Kokten and Akcura (2017). Moser et al. (2006) reported low 1000-kernel weights due to pre-anthesis drought stress. It was concluded that this reduction in kernel weight was due to the reduced capacity of assimilate production and storage during grain filling. It has been observed stress before pollination may lead to failure of ear development and a reduced kernel number stress immediately after pollination reduces kernel number as well (Harder et al., 1982). Stress occurring after 2 or 3 weeks after pollination no longer affects the number of kernels per ear but rather reduces kernel weight (Eck, 1986).

Table 4. Means of the traits measured in maize cultivars

Maize cultivars	**1000 Kernel weight (g)**	**Grain yield (kg ha^{-1})**	**Crude protein content (%)**		
			2016	**2017**	**Mean**
Kayras	383.24 abcd	10856.1 abcd	11.33 bc	8.21 de	9.77 bc
Kalends	364.68 bcde	10939.6 abcd	10.93 bc	8.52 bcd	9.72 bc
Kebeos	355.26 def	10578.6 abcd	10.43 c	7.01 g	8.72 c
Keidas	362.60 cde	10945.1 abcd	11.19 bc	7.75 ef	9.47 bc
Inove	395.86 ab	10886.6 abcd	11.08 bc	7.71 ef	9.40 bc
Performer	401.33 a	12127.8 a	11.61 bc	8.16 de	9.88 bc
Hydro	359.45 def	11614.5 ab	11.14 bc	8.11 de	9.62 bc
Pioneer 2088	379.56 abcd	9776.0 bcd	11.54 bc	8.41 cd	9.97 b
Pioneer 31-D-24	363.15 cde	11695.3 ab	11.16 bc	9.23 b	10.20 b
Pioneer 2105	406.03 a	12243.0 a	14.40 a	12.81 a	13.60 a
LG 30600	348.75 ef	10743.1 abcd	12.58 ab	7.29 fg	9.94 bc
LG-Indaco	339.88 ef	11276.8 abc	10.66 c	8.30 cde	9.48 bc
LG 30692	390.35 abc	10418.3 abcd	11.66 bc	8.76 bcd	10.21 b
BC 678	334.40 f	9245.1 cd	10.59 c	8.99 bc	9.79 bc
C 955	298.36 g	9020.6 d	11.30 bc	8.20 de	9.75 bc
Valbom	295.06 g	9782.1 bcd	15.21 a	13.28 a	14.24 a
Mean	361.12	10759.3	11.68 a	8.79 b	10.24
CV (%)	9.44	13.05	12.73	19.61	21.09
F values					
Year	2.82 ^{NS}	6.42*			519.16**
Cultivar	39.23**	4.78**	8.10**	189.89**	34.55**
CultivarxYear	0.99 ^{NS}	1.34 ^{NS}			3.33**

Means followed by different letter(s) are significantly different at the 5% or 1% level of probability
*, **, indicates significance at 0.05 and 0.01, respectively, NS indicates not significant

Grain yield (kg ha^{-1})

The combined analysis of variance for 2 years for grain yield gave significant F value (Table 4). Highest grain yield value of (12243.0 kg ha^{-1}) and (12127.8 kg ha^{-1}) were recorded in Pioneer 2105 and Performer, while lowest grain yield of (9020.6 kg ha^{-1}) was observed in C-955. Year effect was significant ($P<0.05$) for grain yield. Average of grain yield (11029.2 kg ha^{-1}) in 2016 was found higher than 2017 (10489.4 kg ha^{-1}). The differences in grain yield among cultivars can be result from variety characteristics, genetic traits, root length, nutrient uptake, maturity periods of cultivars, climatic factors and agricultural practices (Kokten and Akcura, 2017). Similar results have been recorded by Koca et al. (2010); Oner et al. (2012); Oktem and Toprak (2013); Yilmaz and Han (2016). Our results were lower than in the studies conducted with maize cultivars under Sanliurfa conditions (Oktem and Oktem, 2009), Konya (Karasahin and Sade, 2012), and Cankiri (Kusvuran and Nazli, 2014), it was reported that the grain yields ranged between (8110.0 kg ha^{-1}-16360.0 kg ha^{-1}), (18080.0 kg ha^{-1}), and (14020.0 kg ha^{-1}- 18610.0 kg ha^{-1}), respectively. It was concluded that the differences among the mentioned researchers findings are due to the differences among the crop materials used in the research and the applied agronomic processes.

Grain yield is determined by the growth and development of the maize plant, the amount of photosynthesis during the growing season, and how efficiently the photosynthate is partitioned into grain. Yield can also be considered to be the result of the interaction of genotype, management, and environmental factors. The most important environmental factors are solar radiation, water and temperature. These factors cannot be controlled by the grower and vary with growing season. Management practices such as tillage, irrigation, nutrient supply, and pest management strive to maximize economic yield, but responses to these practices vary across environments. (Kun, 1985; Oner et al., 2012; Milander, 2015). Environmental effects have been shown to have effects on grain yield and thus yield components as well. Water and temperature have specifically been shown to affect yield through yield components. Available N is not considered to be an environmental factor but it is related as it moves with water in the soil and the plant. Both water stress and temperature have been shown to have interactions with N fertilizer rates. Environment varies across growing seasons and thus causes yield components to vary due to multiple and interactive environmental factors. Novacek et al. (2013) found that yield and yield components vary across years with different rainfall amount and distributions, and temperatures. It has been found that weather patterns within the growing season are more reflective of maize grain yield than averages across the season (Hu and Buyanovsky, 2003).

Temperature has also been found to have an effect on grain yield and its components. Heat stress has been shown to lengthen the time gap between anthesis and silking. Heat stress prior or during this period can reduce yield. Heat stress applied by Cicchino et al. (2010) in two periods one in the late vegetative stages prior to tasseling and one in the period between tasseling and silking and found that yield and kernel number always decreased on the heat stress plants with no clear effect on kernel weight. Temperature also affects grain fill of maize as it has an effect on the rate and duration of kernel growth and final kernel weight. Extreme temperatures of 15°C and 35°C during grain fill have been found to be similarly detrimental to kernel growth and reduce kernel weight. These effects were more severe during early grain fill then during late grain fill (Jones et al., 1984).

Crude protein content (%)

Crude protein content was significantly different among maize cultivars in 2016 and 2017 (Table 4). Valbom and Pioneer 2105 had highest crude protein content (15.21 %, and 14.40 %), while lowest crude protein content (10.43 %) was recorded in Kebeos in 2016. Valbom and Pioneer 2105 had highest crude protein content (13.28 % and 12.81 %), while lowest crude protein content (7.01 %) was recorded in Kebeos in 2017. Besides, the combined analysis of variance for 2 years for crude protein content gave significant F value. Highest crude protein content, of 14.24 % and 13.60 % were recorded in Valbom and Pioneer 2105, while lowest crude protein content of 8.72 % was observed in Kebeos. Similar result was also reported by Koca et al. (2010); Koca and Erekul (2011). Year and cultivar x year interaction effect were significant ($P<0.01$) for crude protein content. Average of crude protein content (11.68 %) in 2016 was found to be higher than 2017(8.79 %). This variation may be due to the different genetic capacity of the genotypes tested (Allard, 1999). Mayer et al. (2016)) evaluated four maize genotypes (flint, popcorn, temperate semi-dent, and temperate × tropical semi-dent) with distinctive endosperm types were grown at heated and non-heated temperature regimes during the early or late stages of the effective grain-filling period. They reported that heat stress during early and late stages decreased both protein and starch contents of kernels.

CONCLUSIONS

Based on the results of the experiment, it could be concluded that significant differences of various traits were found among the maize cultivars tested.

Maize cultivars of Pioneer 2105 and Performer were found to be suitable for grain yield and 1000 kernel weight for growing conditions of Manisa province of Turkey.

Although the study was carried out under limited ecological conditions of Manisa, the results may be applied to similar climatic zones and cv. Pioneer 2105 and cv. Performer could be recommended to the similar locations.

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