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DETERMINATION OF YIELD AND YIELD COMPONENTS OF POPCORN (*Zea mays* L. everta) GENOTYPES

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Abstract: This research was conducted in Samsun Bafra conditions in 2021, using a total of 19 different genotypes of popcorn, which differ from other corn subspecies in terms of grain size and usage area, and have gained popularity for snacking purposes. The experiment was set up in a randomized complete block design with three replications. The study examined plant height, main stem diameter, leaf number, cob length, cob diameter, cob row number, number of kernels per cob, cob weight, kernel weight, and grain yield of the popcorn genotypes. It was determined that there is a statistically significant relationship between these examined parameters and genotypes. According to the results of the experiment, plant height in popcorn genotypes ranged from 128.33 to 207.00 cm, main stem thickness varied between 11.91 and 20.20 mm, leaf number per plant ranged from 8.33 to 12.33, cob length varied from 11.60 to 20.33 cm, cob diameter ranged from 27.63 to 36.49 mm, cob row number varied between 12.00 and 15.67, and the number of kernels per cob ranged from 405.67 to 772.67. The grain yield values ranged from 183.05 to 482.43 kg/da. The research determined that the average grain yields of populations and lines were higher than the overall average of popcorn cultivars. When considering grain yield and yield parameters, the TBCM-6 line stood out. According to the biplot analysis, it was observed that the P2 and P3 populations, along with the TBCM-3, TBCM-4, TBCM-6, TBCM-23, TBCM-44, and TBCM-62 lines, excelled in terms of yield and yield components.

Keywords: Popcorn, Genotype, Biplot, Yield

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1. Introduction

Maize (*Zea mays* L.), which belongs to the *Maydeae* tribe of the *Gramineae* family, commonly known as the grass family, is a crop that is included in warm climate cereals and can be grown in almost every region of the world (Shaw, 1988; Öner, 2011). In terms of cultivation area, maize ranks second among cereals worldwide, but it holds the first position in terms of yield and production per unit area (Akın, 2022). Maize is one of the economically important cereal crops with versatile usage. Globally, 60% of maize production is used in animal feed, 27% as raw material, 11% in food production, and 4% for other purposes (Anonim, 2016; Mut et al., 2022). In Türkiye, 35% of the produced maize is used for human consumption, 30% for animal feed as silage, and 20% in the feed industry (Gençtan et al., 1995). Maize used for human consumption contributes to approximately 11% of a person's daily caloric needs (Çıldır and Çanakçı, 2006). However, this percentage may vary among developed and developing countries.

Türkiye is one of the countries in the Old World where maize was first cultivated. As a result, various maize cultivars from different subspecies can be found in almost all regions of our country, especially in coastal areas (Sezer and Yanbeyi, 1997; Öner, 2011). Popcorn is one of these subspecies of maize. Popcorn plants differ from other maize subspecies in terms of grain size and usage. Compared to dent, flint, and sweet corn, popcorn has shorter plant height, smaller leaves, cobs (ears), and kernels, and is tougher. The popcorn production area in our country is around 8-10 thousand hectares (Akın, 2022). The Aegean and Mediterranean regions are the main areas for agriculture and production in our country. Approximately half of the popcorn production in our country is in Kahramanmaraş, followed by Adana, Mersin, and Aydın provinces (Öztürk et al., 2019).

In recent years, the increase in production quantity in regions where popcorn farming is practiced has contributed to its growing popularity. One of the main factors that has boosted the popularity of popcorn is its status as a popular snack consumed in cinemas and while watching movies. However, due to the advancements in television technology, online streaming platforms, and other technological innovations, interest in cinema theaters has declined. As a result, the consumption of popcorn in cinemas has decreased while household consumption has increased (Ziegler, 2001). Additionally, popcorn is considered a beneficial dietary product due to its content of vitamins, minerals, high carbohydrates, low calories, low fat, satiating properties, and its ability to absorb stomach acid (Ülger, 1998; Dickerson, 2003; Özkan, 2007).

Popcorn, which is increasingly becoming popular and experiencing a rise in consumption both globally and in our country, has become a financially rewarding product in the market. Therefore, by expanding popcorn farming in ecologically suitable regions, farmers can have a good income opportunity. This study was conducted in Samsun Bafra conditions with the aim of determining the yield and certain yield parameters of specific popcorn genotypes.

2. Materials and Methods

The research was conducted at the Ondokuz Mayıs University Bafra Agricultural Application and Research Center in 2021. The Agricultural Application and Research Center of Ondokuz Mayıs University is located in the Bafra plain, approximately 2 km southwest of the Bafra district, and 42 km west of Samsun province. The soil analysis results of the study area were performed at the Department of Soil Science and Plant Nutrition of Ondokuz Mayıs University Faculty of Agriculture. Soil tests indicated the site had the following conditions: organic matter 2.65%, sandy clay soil, 44.55%, available N (nitrogen), 0.16, available P_2O_5, 118.26 ppm, K, 340 Ca, 15.91 meq/100 g, and soil pH, 7.40. The foundation year's average temperature and total precipitation values were 19.9 °C and 471 mm (Table 1).

A total of 19 genotypes were used in the research, consisting of 3 cultivars (Baharcin, SH9201, R997), 5 populations (P1, P2, P3, P4, P5), and 11 lines (TBCM-3, TBCM-4, TBCM-6, TBCM-19, TBCM-23, TBCM-32, TBCM-41, TBCM-44, TBCM-49, TBCM-62, TBCM-109). The trial was established on May 20, 2021, following a randomized complete block design with three replications. The plot length was 5 meters, with 4 rows and a 2-meter gap between blocks. The planting distance was set at 70 cm between rows and 18 cm within rows. The seeding depth was adjusted to 5-6 cm. Based on soil analysis results, 22 kg cultivars of pure nitrogen in the form of ammonium sulfate and 8 kg of phosphorus (P_2O_5) per hectare were applied (Özkan and Ülger, 2011). Harvesting was carried out on October 15 of 2021.

In the study, measurements were taken for plant height (cm), main stem diameter (mm), leaf count (number/plant), cob (ear) length (cm), cob diameter (mm), cob row count, grain count per cob, individual cob weight (g), cob grain weight (g), and grain yield (kg/da) (Öktem, 1996; Sezer and Yanbeyi, 1997; Kara and Kırtok, 2006; İdikut et al., 2009).

The statistical analysis of the data were performed using the JMP statistical software program. Significance testing of the differences between group means was conducted using the Tukey test. Biplot, Pearson correlation, and Cluster analysis were employed to examine the relationships among the investigated traits (JMP, 2019).

Table 1. Climatic data of the region where the research was conducted*

Climate Factors	Month							Total
	Years	May	Jun	July	August	September	October	Average
Rain (mm)	2021	77.4	65.8	8.2	49.3	119.4	169.2	489.3
	Long Years	47.6	47.0	29.8	47.7	61.9	98.8	332.8
Average Temperature (°C)	2021	16.6	20.2	24.9	24.0	18.5	14.7	19.8
	Long Years	15.6	20.2	22.9	23.0	19.6	15.6	19.5
Relative Humidity (%)	2021	71.2	74.5	70.1	74.0	76.2	81.7	
	Long Years	79.42	75.85	74.22	75.36	77.33	79.97	

* Samsun Meteorology Station Climate data (2021-Long years/1981).

3. Results and Discussion

In this study, investigating the yield and yield parameters of certain maize genotypes, the mean values and TUKEY grouping of plant height, main stem thickness, and leaf count are provided in Table 2. The examined parameters of plant height, main stem thickness, and leaf count were found to have statistically significant ($P<0.001$) effects (Table 2).

When examining the maize genotypes in terms of plant height, the tallest plant height of 207.00 cm was observed in the P3 population, while the shortest plant height of 128.33 cm was recorded in the TBCM-19 line. The average plant height of the maize populations was determined to be 193.33 cm, while the average plant height of the lines and cultivars was 163.64 cm and 160.33 cm, respectively. The average plant height of the populations was significantly higher than that of the lines and cultivars (Table 2). Plant height is a parameter that varies depending on environmental factors and genetic characteristics (Sezer and Yanbeyi, 1997; İdikut et al., 2020). It has been noted that the plant height of popcorn is generally shorter compared to sweet corn and dent corn (Ülger, 1998). When examined for main stem diameter, the maize genotypes ranged from 11.91 mm to 20.20 mm. The P2 population had the highest main stem diameter of 20.20 mm, followed by TBCM-4 (20.00 mm) and TBCM-32 (19.97 mm), which were in the same statistical group. The lowest main stem diameter was observed in the R997 variety, measuring 11.91 mm. When genotypes were compared for average main stem diameter, the highest value of 18.53 mm was found in the lines, while the lowest value of 12.93 mm was observed among the cultivars (Table 2).

Table 2. The average values and variance analysis results for plant height, main stem diameter, and leaf number of the maize genotypes are presented

Genotypes		Plant height	Main stem diameter	Leaf number
P1		191.00 ± 2.61 b	13.47 ± 0.12 gh	9.67 ± 0.44 c-f
P2		191.00 ± 0.67 b	20.20 ± 0.21 a	12.33± 0.44 a
P3		207.00 ± 2.00 a	15.45 ± 0.14 e	12.00 ± 0.67 ab
P4		186.67 ±1.11 b	15.59 ± 0.25 e	11.33 ± 0.44 abc
P5		191.00 ± 1.33 b	15.80 ± 0.23 e	11.00 ± 0.67 a-d
Population Ave.		193.33± 5.69	16.10 ± 1.64	11.27 ± 0.95
TBCM-3		175.33 ± 1.11 c	18.56 ± 0.33 bc	10.33 ± 0.44 b-e
TBCM-4		164.67± 1.11 ef	20.00 ± 0.66 a	10.67 ± 0.44 a-d
TBCM-6		163.33 ±0.44 f	19.57 ± 0.11 ab	9.33 ± 0.44 def
TBCM-19		128.33 ±1.11 ı	18.31 ± 0.30 cd	9.33 ± 0.44 def
TBCM-23		188.33 ± 1.11b	15.28 ± 0.08 ef	9.67 ± 0.44 c-f
TBCM-32		172.67 ± 3.78 cd	19.97 ± 0.14 a	9.67 ± 0.44 c-f
TBCM-41		154.67 ± 1.56 g	17.89 ± 0.26 cd	8.33 ± 0.44 f
TBCM-44		183.67 ±2.89 b	18.56 ± 0.19 bc	11.00 ± 0.01 a-d
TBCM-49		143.67 ±2.22 h	18.72 ± 0.29 bc	9.67 ± 0.44 c-f
TBCM-62		153.33 ±1.11 g	19.62 ± 0.19 ab	11.00 ± 0.01 a-d
TBCM-109		172.00 ±1.33 cde	17.32 ± 0.11 d	11.67 ± 0.44 ab
Line Ave.		163.64 ± 13.67	18.53 ± 1.04	10.06 ± 0.80
SH9201		165.00 ± 0.67 def	14.06 ± 0.11 fg	11.00 ± 0.67 a-d
BAHARCİN		164.00 ± 2.00 f	12.82 ± 0.36 hı	8.33± 0.44 f
R997		152.00 ± 1.33 g	11.91 ± 0.55 ı	8.67 ± 0.44 ef
Variety Ave.		160.33 ± 5.56	12.93 ± 0.84	9.33 ± 1.11
Total Average		170.93 ± 15.89	17.01 ± 2.28	10.26 ± 1.07
		Mean Squares	Mean Squares	Mean Squares
Genotypes	18	1152.69**	20.88**	4.32**
Block	2	3.70	0.18	0.37
Error	36	6.22	0.16	0.41
CV		1.46	2.35	6.24

**= There is no difference between the means shown with the same letters in the same column (P<0.01).

Upon examining the analysis of the variance table, it was determined that the variation among genotypes had a highly significant effect on the number of leaves per plant (Table 2). The highest number of leaves per plant, 12.33 piece (leaves/plant), was observed in the P2 population, which was in the same statistical group as several other genotypes. The lowest number of leaves, 8.33 piece (leaves/plant), was found in the TBCM-41 genotypes. When the average number of leaves per plant was considered, it was determined to be 11.27 piece in populations, 10.06 piece in lines, and 9.33 piece in cultivars (Table 2).

In this study investigating the yield and yield parameters of certain corn genotypes, the average values and TUKEY grouping of cob length, cob diameter, number of cob rows, and number of kernels per cob are presented in Table 3. It was determined that these examined parameters had statistically significant effects (P<0.001) (Table 3).

The average cob length of genotypes was determined as 16.66 cm, with a range of 11.60 cm (R997) to 20.33 cm (TBCM-3) (Table 3). When examined in terms of average cob length, genotypes were found to be 17.14 cm in populations, 16.64 cm in lines, and 15.92 cm in cultivars. Several studies have also demonstrated significant differences among genotypes in terms of cob length (Sezer and Yanbeyi, 1997; Kaya and Kuşaksız, 2004; Shafai et al., 2020; Şahin and Kara, 2021). In the conducted studies, it has been determined that cob length varies between 15.7-17.0 cm (Gökmen et al., 2001), 11.5-18.2 cm (Şahin and Kara, 2021), and 16.3-16.9 cm (Shafai et al., 2020), and this research yields similar results. The observed differences in cob length among the research findings can be attributed to variations in environmental conditions where the studies were conducted and the different genotypes used.

When examined for cob diameter, the highest cob diameter of 36.49 mm was observed in the TBCM-23 line, while the lowest cob diameter of 27.63 mm was recorded in the TBCM-49 line. The average highest cob diameter among corn populations was 32.08 mm in lines, while the lowest average cob diameter was 30.36 mm in populations (Table 3). Previous studies by Sade and Çalış (1993), Kahramanoğlu (2009), and Şahin and Kara (2021) reported cob diameter ranges of 24.3-35.5 mm, 29.9-37.6 mm, and 29.3-35.6 mm, respectively. Our study's cob diameter values align with the findings of these researchers.

Table 3. The average values and variance analysis results of cob length, cob diameter, number of rows per cob, and number of grains per cob for different popcorn genotypes are presented

Genotypes		Cob length	Cob diameter	Number of rows per cob	Number of grains per cob
P1		17.50 ± 0.67 bcd	29.80 ± 0.74 efg	13.67 ± 0.44 c-f	608.00 ± 5.33 cd
P2		19.03 ± 0.31 ab	29.49 ± 0.63 fg	14.33 ± 0.44 a-d	772.67 ± 1.11 a
P3		16.50 ± 0.67 c-f	33.50 ± 0.79 bc	15.33 ± 0.44 ab	551.67 ± 27.78 de
P4		17.33 ± 0.62 b-e	29.33 ± 0.25 fg	15.67 ± 0.44 a	684.33 ± 45.11 bc
P5		15.33 ± 0.44 efg	29.67 ± 0.44 fg	13.33 ± 0.44 d-g	516.67 ± 10.22 ef
Population Ave.		17.14 ± 1.16	30.36 ± 1.33	14.47 ± 0.90	626.67 ± 81.47
TBCM-3		20.33 ±0.56 a	30.68 ± 0.14 def	14.00 ± 0.67 b-e	667.67 ± 11.56 bc
TBCM-4		19.00 ± 0.33 ab	32.63 ± 1.08 bcd	14.00 ± 0.01 b-e	706.33 ± 5.11 ab
TBCM-6		17.67 ± 0.56 bc	33.01 ± 0.22 bcd	14.67 ± 0.44 abc	610.33 ± 33.56 cd
TBCM-19		14.87 ± 0.58 fgh	30.62 ± 0.47 def	14.33 ± 0.44 a-d	454.00 ± 5.33 fg
TBCM-23		17.60 ± 0.27 bc	36.49 ± 0.49 a	15.33 ± 0.44 ab	644.33 ± 29.56 bc
TBCM-32		17.93 ± 0.62 bc	31.01 ± 0.91 c-f	12.00 ± 0.01 g	516.00 ± 8.00 ef
TBCM-41		16.83 ± 0.22 c-f	29.35 ± 0.72 fg	12.67 ± 0.44 efg	443.00 ± 8.00 fg
TBCM-44		16.50 ± 0.33 c-f	33.82 ± 0.99 ab	15.00 ± 0.01 ab	498.33 ± 4.44 ef
TBCM-49		13.97 ± 0.38 gh	27.63 ± 0.20 g	12.33 ± 0.44 d-g	415.00 ± 9.33 g
TBCM-62		15.50 ± 0.33 d-g	34.87 ± 0.74 ab	14.00 ± 0.01 a-d	444.33 ± 16.22 fg
TBCM-109		12.87 ± 0.36 hı	32.70 ± 0.54 bcd	14.00 ± 0.02 a-d	444.67 ± 23.56 fg
Line Ave.		16.64 ± 1.76	32.08 ± 2.09	13.85 ± 0.88	531.27 ±91.56
SH9201		18.33 ± 0.44 abc	32.52 ± 0.54 b-e	14.00 ± 0.02 a-d	501.33 ± 7.56 ef
BAHARCİN		17.83 ± 0.78 bc	32.57 ± 0.56 b-e	14.00 ± 0.03 b-e	518.00 ± 9.33 ef
R997		11.60 ± 0.27 ı	29.19 ± 0.97 fg	14.67 ± 0.25 a-d	405.67 ± 9.56 g
Variety Ave.		15.92 ± 2.88	31.42± 1.49	14.22 ± 0.35	475.00 ± 46.22
Total Average		16.66 ± 1.76	31.52 ± 1.98	14.07 ± 0.76	547.49 ± 92.41
		Mean Squares	Mean Squares	Mean Squares	Mean Squares
Genotypes	18	14.52**	15.74**	2.91**	35334.87**
Block	2	0.11	0.56	0.91*	668.44
Error	36	0.46	0.82	0.21	652.55
CV		4.07	2.87	3.26	4.67

**= There is no difference between the means shown with the same letters in the same column (P<0.01).

In the study, the number of rows per cob varied between 12.00 and 15.67 piece, with an average of 14.07 piece rows per cob for the genotypes. The highest number of rows, 15.67 piece, was observed in the P4 population, which was in the same statistical group as several other genotypes. The lowest number of rows, 12.00 piece, was found in the TBCM-32 line. When examining the average number of grains per row, the populations had the highest value of 14.47 piece, followed by cultivars with 14.22 piece, while the lines had the lowest average of 13.85 piece rows per cob (Table 3). It has been reported that the number of rows per cob in the ear is influenced by climate, genetic traits, and cultivation techniques, with genetic factors being the most influential factor (Sezer and Yanbeyi, 1997; İdikut et al., 2020). In this study, significant variations in the number of rows per cob among the genotypes were observed, indicating that these differences are attributed to the genetic makeup of the genotypes and the effect of cob diameter (Kaya and Kuşaksız, 2004; Tekkanat and Soylu, 2005; Kahramanoğlu, 2019).

The number of grains per cob varied between 405.67 and 772.67 piece, averaging 547.49 piece. The lowest values were recorded in the R997 variety with 405.67 piece and the TBCM-49 line with 415.0 piece. It has been reported that the number of grains per cob varies significantly depending on genetic factors and is strongly influenced by ecological conditions (Abendroth et al., 2011; İdikut et al., 2021).

In this study investigating the yield and yield parameters of certain maize genotypes, the average values and TUKEY grouping of cob weight, grain weight per cob, and grain yield are presented in Table 4. It has been determined that these examined yield parameters have statistically significant effects (P<0.001) (Table4).

The cob weights of genotypes ranged from 46.95 g to 133.49 g, with an average cob weight of 94.45 g. The highest cob weight of 133.9 g was observed in the TBCM-3 genotype. The lowest cob weights were recorded in the P4, TBCM-19, TBCM-49, and R997 genotypes, measuring 52.37 g, 46.95 g, 54.05 g, and 57.35 g, respectively, and they were statistically grouped together (Table 4). It was determined that cob weight is influenced by genotype and ecological differences, and similar results were obtained in previous studies (Sezer and Yanbeyi, 1997; Özkaynak and Samancı, 2003; Özkan, 2007; Özsoy, 2017).

Table 4. The average values and variance analysis results for cob weight, grain weight per cob, and grain yield of maize genotypes are presented

Genotypes		Cob weight	Grain weight per cob	Grain yield
P1		85,83 ± 2.10 hı	67.62 ± 0.79 gh	320.99 ± 2.72 f
P2		103.81 ± 3.53 efg	81.58 ± 1.26 de	379.61 ± 13.69 de
P3		107.02 ± 2.00 def	79.79 ± 3.25 ef	298.42 ± 1.10 g
P4		52.37 ± 1.69 j	40.63 ± 1.26 ı	295.37 ± 5.76 g
P5		78.82 ± 2.96 ı	61.78 ± 1.12 h	326.49 ± 0.07 f
Population Ave.		85.57 ± 16.37	66.28 ± 12.06	324.18 ± 23.22
TBCM-3		133.49 ± 1.49 a	104.71 ± 2.34 a	395.59 ± 1.22 cd
TBCM-4		120.40 ± 3.70 bc	94.88 ± 0.71 b	329.53 ± 0.62 f
TBCM-6		112.96 ± 0.99 cde	92.48 ± 0.50 bc	482.43 ± 7.05 a
TBCM-19		46.95 ± 2.91 j	31.34 ± 0.73 j	228.94 ± 0.67 h
TBCM-23		128.55 ± 1.43 ab	103.33 ± 1.15 a	458.01 ± 5.66 b
TBCM-32		94.87 ± 3.16 gh	73.42 ± 2.24 fg	362.61 ± 3.59 e
TBCM-41		81.68 ± 2.35 ı	64.30 ± 1.37 h	232.08 ± 2.08 h
TBCM-44		108.47 ± 3.34 def	71.95 ± 1.87 g	319.97 ± 1.60 f
TBCM-49		54.05 ± 1.24 j	42.33 ± 0.61 ı	280.49 ± 1.23 g
TBCM-62		100.85 ± 0.26 fg	79.16 ± 1.60 ef	404.83 ± 4.41 c
TBCM-109		95.52 ± 2.92 gh	79.87 ± 0.63 e	320.31 ± 1.35 f
Line Ave.		97.98 ±21.46	76.16 ± 17.76	346.80 ± 67.18
SH9201		115.85 ± 1.40 cd	87.58 ± 1.15 cd	460.95 ± 7.41 b
BAHARCİN		115.70 ± 2.99 cd	84.00 ± 0.53 de	225.44 ± 5.16 h
R997		57.35 ± 1.97 j	42.80 ±1.61 ı	183.05 ± 0.63 ı
Variety Ave.		96.30 ± 25.97	74.46± 19.11	289.81 ±114.09
Total Average		94.45 ± 21.74	72.82 ± 16.96	331.85 ± 65.38
		Mean Squares	Mean Squares	Mean Squares
Genotypes	18	2102.42**	1364.93**	21232.52**
Block	2	10.48	0.45	38.79
Error	36	11.73	4.27	43.22
CV		3.59	2.84	2.11

**= There is no difference between the means shown with the same letters in the same column (P<0.01).

When cob grain weights were examined, the highest cob grain weight was observed in the TBCM-3 genotype (104.71 g) and TBCM-23 genotype (103.33 g), while the lowest cob grain weight of 31.34 g was recorded in the TBCM-19 population. The average cob grain weight of the genotypes was determined as 72.82 g (Table 4).

The average grain yield of the genotypes ranged from 183.05 to 482.43 kg/da, with an overall average of 331.85 kg/da. The highest grain yield of 482.43 kg/da was achieved in the TBCM-6 genotype, followed by SH9201 (460.95 kg/da) and TBCM-23 (458.01 kg/da). The lowest grain yield of 183.05 kg/da was obtained from the R997 genotype. The observed differences among the genotypes in this study can be attributed to variations in individual cob yield, cob grain count, plant population, and grain-to-cob ratio. Previous research has also observed wide variations in grain yield among genotypes, and various studies have reported different ranges of grain yield. Sade and Çalış (1993) reported a range of 198.0-435.0 kg/da, Belen (1999) reported a range of 239.0-642.0 kg/da, Özkaynak and Samancı (2003) reported a range of 141.0-464.0 kg/da, Özkan (2007) reported a range of 204.0-529.0 kg/da, Öztürk et al. (2020) reported a range of 412.0-629.0 kg/da, and Şahin and Kara (2021) reported a range of 317.6-504.0 kg/da (Table 4).

The relationships between the traits and genotypes as a whole are presented in Figure 1 through a biplot graph. In this study, Principal Component 1 accounted for 43.5% of the variation, while Principal Component 2 accounted for 16%, resulting in a total variation of 59.5%. The biplot analysis explains both the relationships between the traits and the relationships between the genotypes. The angle value (0° to 90°) between vectors representing two traits indicates a positive relationship when it becomes narrower and a negative relationship when it becomes wider (90° to 180°). Additionally, the positioning of the genotypes indicates which genotypes have higher values for specific traits. (Yan and Tinker, 2006). Among the examined traits, it is evident that there is a positive and strong relationship based on the angles being less than or equal to 90°. The genotypes P2, P3, TBCM-23, TBCM-44, TBCM-4, TBCM-62, TBCM-6, TBCM-3, and SH9201 exhibited a strong positive relationship among the examined traits in the study (Figure 1).

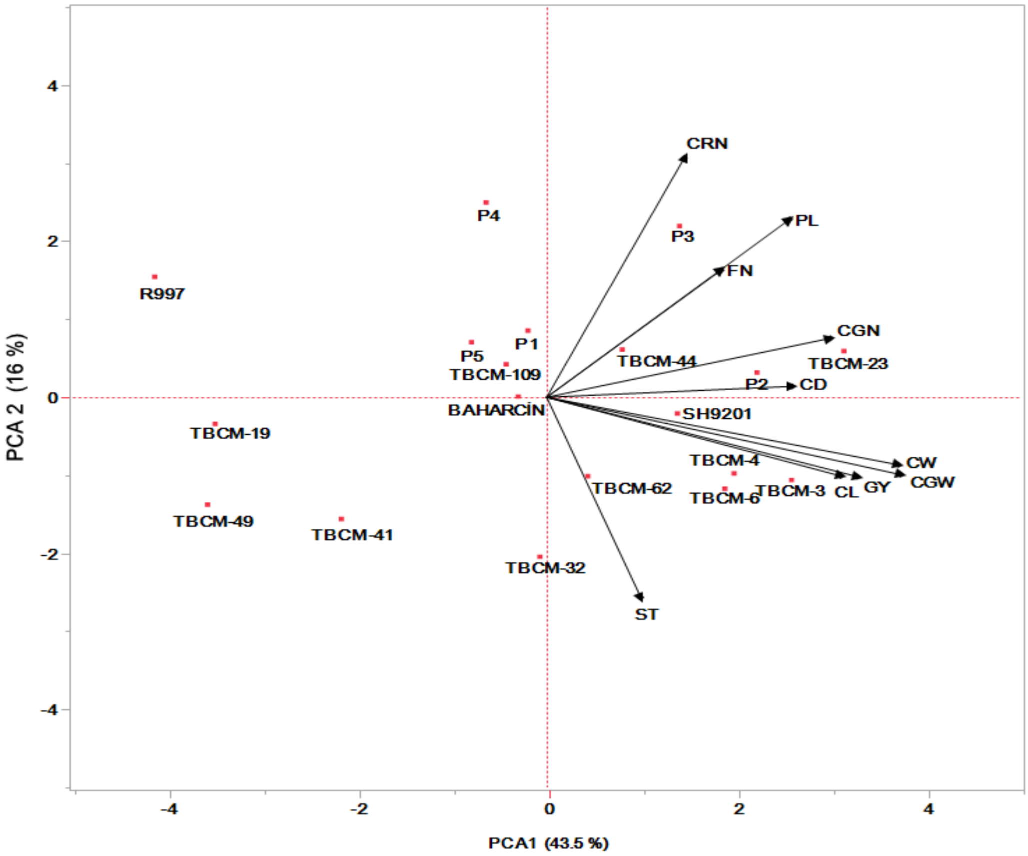

Figure 1. Biplot plot showing relationships between investigated traits and genotypes.

The variation between genotypes increases as the vectors move away from the origin, while the variation decreases as the vectors get closer to the origin. In the study, low variation was determined between P1, P5, TBCM-109 and Baharcin genotypes. Since it has the shortest vector, the number of leaves was determined as the least distinguishing feature (Mut et al., 2017). "Cob row number" parameter showed high variation with P3 genotype, while "plant height" and "leaf number" showed variation with TBCM-44 genotype. While " number of grains on the cob" and "cob diameter" traits were associated with P2 and TBCM-23 genotypes, SH9201 genotype showed significance in terms of "cob diameter", "cob weight", "grain weight per cob", "grain yield" and "cob length". TBCM-3, TBCM-4, TBCM-6 and TBCM-62 genotypes "main stem diameter", "cob weight", "grain weight per cob", "grain yield" and "cob length" " parameters (Mut et al., 2017).

4. Conclusion

The growth of the cinema and film industries has led to an increased demand for snacks, which in turn has prompted an increase in the production of the most popular snack, popcorn. As the consumption quantity has increased, our efforts to improve the quality characteristics and increase the yield of the product have gained momentum. This study was conducted to determine the yield and some yield components of popcorn genotypes grown under Samsun Bafra conditions, and significant results were obtained in terms of the examined parameters. In terms of grain yield, the TBCM-6 genotype had the highest yield of 482.43 kg/da. The biplot analysis revealed that the P2 and P3 populations, as well as the TBCM-3, TBCM-4, TBCM-6, TBCM-23, TBCM-44, and TBCM-62 lines, stood out in terms of yield and yield components.

Author Contributions

The percentage of the author(s) contributions is presented below. All authors reviewed and approved the final version of the manuscript.

	F.A.	E.Ö.	H.A.	İ.S.
C	25	25	25	25
D	25	25	25	25
S			50	50
DCP	50	25	25	
DAI	25	20	25	30
L	50	50		
W	25	25	25	25
CR			40	60
SR	50	50		
PM	40	20	20	20
FA		30	30	40

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because there was no study on animals or humans.

References

Abendroth LJ, Elmore RW, Boyer MJ, Marlay SK. 2011. Corn growth and development. Iowa State University, Ames, US, pp: 50.

Akin CO. 2022. Effects of Different sowing densities on yield and quality characteristics of popcorn (Zea Mays Everta L.) varieties in Tokat Kazova conditions. MSc Thesis, Gazi Osmanpaşa University, Institute of Science, Tokat, Türkiye, pp: 34.

Anonymous 2016. T.C. General Directorate of Turkish Grain Board, Grain Report, Ankara, Türkiye, pp: 9-107.

Belen S. 1999. A research on the determination of yield and some other characteristics of hybrid and population corn maize (Zea mays everta Sturt.) in Tokat-Kazova conditions, MSc Thesis, Gazi Osmanpaşa University, Institute of Science, Tokat, Türkiye, pp: 48.

Çıldır O, Çanakçı M. 2006. An investigation of the effects of catalyst and alcohol amounts on the fuel properties of biodiesel from various vegetable oils. J Gazi Univ Fac Eng Architect, 21(2): 367-372.

Dickerson GW. 2003. Nutritional analysis of New Mexico blue corn and dent corn kernels. College of Agriculture and Home Economics, New Mexico State University. Cooperative Extension Service Guide H- 233, Las Cruces, US.

Gençtan T, Retirees Y, Çölkesen M, Başer İ. 1995. Hot climate cereals consumption projections and production targets. Türkiye Agricultural Engineering IV. Technical Congress, May 10-12, 1995, Ankara, Türkiye.

Gökmen S. Sencar Ö, Sakin MA. 2001. Response of popcorn (Zea mays L. everta) to nitrogen rates and plant densities. Turk J Agric For, 25: 15-23.

İdikut L, Atalay AI, Kara SN, Kamalak A. 2009. Effect of hybrid on starch, protein and yields of maize grain. J Anim Vet Adv, 8(10): 1945-1947.

İdikut L, Önem M, Zulkadir G. 2021. Determination of quality criteria of local popcorn (Zea mays everta L.) populations grown in Sumbas district conditions. Kahramanmaraş Sutcu Imam Univ J Agri Nature, 24(1): 122-129.

İdikut L, Zulkadir G, Polat C, Çiftçi S, Önem AB. 2020. The effect of different location and sowing times on the quality criteria of cowpea. Turkish J Agri Food Sci Tech, 8(12): 2507-2511.

JMP 2019. JMP User Guide, Release 7 Copyright© 2019, SAS Institute Inc., Cary, NC.

Kahramanoğlu Y. 2019. Determination of yield and some morphological characteristics of some pop corn genotypes (Zea mays L. Everta) under harran plain. MSc Thesis, Harran University, Institute of Science, Şanlıurfa, Türkiye, pp: 86.

Kara B, Kırtok Y. 2006. Determination of grain yield, nitrogen uptake and utilization efficiency of corn at different plant density and nitrogen doses in Çukurova conditions. Çukurova Unive J Fac Agri, 21(2): 23-32.

Kaya Ç, Kuşaksız T. 2004. Determination of yield and some yield components of maize (Zea mays L.) cultivars sown at different planting times. Anadolu J AARI, 22(2): 48-58.

Mut Z, Erbaş Köse Ö, Akay H. 2017. Determination of grain yield and quality traits of some bread wheat (Triticum aestivum L.) varieties. Anatolian J Agri Sci, 32: 85-95

Mut Z, Kardeş YM, Erbaş Köse ÖD. 2022. Determining the grain yield and nutritional composition of maize cultivars in different growing groups. Turkish J Field Crops, 27(1): 158-166.

Öktem A. 1996. In the conditions of the Harran Plain, II. The effect of phosphorus applied at different doses on yield and yield components in 10 maize genotypes (Zea mays L.) that can be grown as a crop. PhD Thesis, Çukurova University, Graduate School of Natural and Applied Sciences, Adana, Türkiye, pp: 151.

Öner F. 2011. Determination of agronomical and technological characteristics of local corn (Zea Mays L.) genotypes in the Black Sea Region of Turkey. PhD Thesis, Ondokuz Mayıs University, Graduate School of Natural and Applied Sciences, Samsun, Türkiye, pp: 239.

Özkan A. 2007. The effects of different nitrogen dose applications in Çukurova conditions on grain yield, agricultural characteristics and some quality characteristics of two popcorn (Zea mays everta Sturt.) cultivars. PhD Thesis, Çukurova University, Institute of Science, Adana, Türkiye, pp: 125.

Özkan A, Ülger AC. 2011. The Effects of different nitrogen dose applications on the agricultural properties of two popcorn (Zea mays L. everta Sturt) cultivars under Çukurova ecological conditions. Yuzuncu Yıl Univ J Agri Sci, 21(3): 198-208.

Özkaynak E, Samancı B. 2003. Comparison of popcorn (Zea mays everta Sturt.) lines and their testcrosses for yield and yield-related traits. J Akdeniz Univ Fac Agri, 16(1): 35-42.

Özsoy A. 2017. The Effect of different sowing frequencies on yield and quality traits of some popcorn (Zea mays everta L.) varieties in Tokat Kazova conditions. MSc Thesis, Gazi Osmanpaşa University, Institute of Science and Technology, Tokat, Türkiye, pp: 34.

Öztürk A, Özata E, Erdal Ş, Pamukçu M. 2019. Use and future of special corn types in Turkey. J Int Mediterranean Res Inst, 2(1): 75-90.

Öztürk A, Erdal Ş, Pamukcu M, Özata E, Coşkuner Y. 2020. Performances of popcorn hybrids in three geographical regions of Turkey based on yield and quality traits. Int J Life Sci Biotechnol, 3(1): 27-40.

Sade B. Calis A. 1993. The effects of different plant densities on yield and yield components of gin corn populations (Zea mays L. Everta) grown as second crop in virtuous ecological conditions. J Selcuk Univ Fac Agri, 3(5): 34-45.

Sezer S, Yanbeyi S. 1997. The effects of plant density and nitrogen fertilizer on grain yield, yield components and some plant characteristics in cinnamon (Zea mays L. everta) cultivated on Çarşamba plain. Türkiye 2nd Field Crops Congress, September 22-25, 1997, Samsun, Türkiye, pp: 128-133.

Shafai S, Kanth, RH, Alie BA, Saad AA. 2020. Effect of plant spacing and date of sowing on yield and yield attributes of popcorn (Zea mays everta) under rainfed conditions of valley. Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Jammu Kashmir, India.

Shaw RH. 1988. Climate requirement. Corn and Corn Improv, 18: 609-638.

Şahin M, Kara B. 2021. Grain yield and ear characteristics of popcorn populations with different seed colors. Turkish J Sci Eng, 3(1): 1-4.

Tekkanat A, Soylu S. 2005. Determination of important agricultural characteristics of popcorn varieties. Selcuk Univ J Fac Agri, 19(37): 41-50.

Ülger AC. 1998. Effects of different nitrogen doses and row spacing on grain yield and some agricultural characteristics in popcorn (Zea mays everta Sturt.). Çukurova Univ J Fac Agri, 13(1): 155-164.

Yan W, Tinker NA. 2006. Biplot analysis of multienvironment trial data: Principles and applications. Can J Plant Sci, 86: 623-645. DOI: 10.4141/P05169.

Ziegler KE. 2001. Specialty Corn, Popcorn, Ed: Halluer A.R. CRC Press, New York, US, pp: 206.