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DETERMINATION OF GRAIN YIELD AND YIELD COMPONENTS OF SOME MAIZE (*Zea mays* L.) CULTIVARS UNDER KAYSERI CONDITIONS

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Abstract
Maize (Zea mays L) is an important cereal widely used in human and animal nutrition. This study aimed to determine the grain yield, yield components and quality characteristics of some maize cultivars. The study was conducted in Erciyes University Agricultural Research and Application Centre experimental field in 2019, according to the randomized block design with 3 replications. 928 HP F1, DKC 7240, Hiva F1, Kerbanis, Kilowatt, Klosseus, Kontigos, NK Vitorino, Simpatico, Sy Antex, Sy Dracma and Sy Inove maize cultivars were used as material. According to the results of analysis of variance, the differences among the cultivars in terms of ear diameters, ear weight, number of kernels per ear were found statistically significant at 1% level, while the differences in ear length, kernel weight in ear, thousand kernel weight, grain yield and seed protein content were found statistically significant at 5% level. As a result of the research, ear length varied between 18.89 cm (Simpatico) and 21.64 cm (Kilowatt), ear diameters between 44.05 mm (Simpatico) and 53 mm (DKC 7240), number of kernels per ear between 579.5 (Simpatico) and 710.43 (928 HP F1), kernel weight in ear between 164.43 g (Simpatico) and 248.13 g (Kontigos), ear weight between 28. 92 g (Simpatico) and 63.87 g (Klosseus), grain yield between 1174.38 kg/da (Simpatico) and 1772.17 kg/da (Kontigos), 1000-kernel weight between 272.85 g (Simpatico) and 331.91 g (Hiva F1), and seed protein content between 6.02% (Sy Dracma) and 7.71% (Simpatico).

Keywords: Adaptation, grain yield, maize, protein.

1. INTRODUCTION

Maize (*Zea mays* L.) is used as a raw material in the production of products such as alcohol, spirit, oil, semolina, etc. in industry as well as human food and animal feed (Mohammadi et al., 2017; Kılınç et al., 2018). Maize is among the important crops to ensure global food supply and security (Rosegrant et al., 2012; Ahmad et al. 2020). In our country, maize is used in feed, starch, glucose, oil and bioethanol production and is mostly grown in Çukurova, Amik Plain, Central Anatolia and Southeastern Anatolia Regions (TMO 2021). Among cereal crops, maize ranks second in the world in terms of cultivation area and first in production and yield. In Türkiye, it ranks after wheat and barley with 0.59 million hectares of cultivation area and 6.5 million tonnes of production (TUIK 2021). The importance of maize agriculture for our country is increasing day by day due to the main reasons such as the existence of maize production deficit in our country, the width of maize usage

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areas, the fact that the maize-based industry is a developing industry and these industrial products are intermediate raw materials for other sectors, the export potential of maize and maize-based products due to Türkiye's geographical location, the fact that the maize-based industry sector is largely dependent on foreign capital and it is one of the sectors that will provide foreign capital flow to Türkiye (Vartanlı and Emeklier, 2007).

The main studies to be carried out in order to increase maize production are the selection of varieties suitable for the ecological conditions of the region, resistant to environmental factors, the use of quality seed and the dissemination of hybrid varieties in production (Akan and Kılıç 2021). Adaptation trials are of great importance in determining the productive and high quality varieties suitable for the region (Grafakos et al., 2019). In land regions, medium-early varieties (those in the FAO 500 maturity group) or medium-early varieties in the FAO 600 maturity group, whose moisture content decreases rapidly when physiological maturity occurs, are suitable for grain production, and varieties from the FAO 650- 700 maturity group are suitable for silage production (Sade et al., 2007).

Nowadays, as a result of breeding studies, new varieties showing superiority in terms of yield and agricultural characters are being developed. This research was carried out to determine the quality, yield and yield components of some grain maize varieties with different FAO maturity groups and to recommend suitable grain maize varieties for the region.

2. MATERIALS AND METHODS

The climatic data of the place where the experiment was carried out in 2019 are given in Table 1. When the table is examined, the temperature between May and October, which covers the period in which the experiment was carried out, was below the long-term average in July, while it was above the long-term average in the other months. During the vegetation period of the experiment, 171.2 mm precipitation was observed. Precipitation was below the long-term average in May and above the long-term average in all other months. Average relative humidity values were below the long-term average but close to it.

Table 1. Climatic data for 2019 and long years

	2019			Long years average		
Mounts	**Average Temperature (ºC)**	**Average Relative Humidity (%)**	**Rainfall (mm)**	**Average Temperature (ºC)**	**Average Relative Humidity (%)**	**Rainfall (mm)**
January	-0.8	74.8	50.7	-1.6	76.6	35.9
February	3.3	66.7	23.5	0.2	73.7	35.8
March	5.6	59.3	23.1	4.8	67.9	42.4
April	9.2	66.4	35.5	10.5	62.1	51.3
May	**17.4**	**50.2**	**23.7**	**15.0**	**61.0**	**51.5**
June	**21.3**	**55.8**	**55.2**	**19.0**	**55.8**	**40.2**
July	**21.6**	**49.1**	**35.9**	**22.2**	**49.3**	**10.6**
August	**22.3**	**50.3**	**12.1**	**22.0**	**49.1**	**8.7**
September	**17.4**	**51.2**	**10.6**	**17.4**	**53.7**	**14.5**
October	**14.4**	**59.6**	**33.7**	**11.8**	**63.4**	**28.0**
November	7.1	58.8	20.5	5.5	71.4	32.1
December	3.0	78.9	38.4	0.6	77.1	37.5

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Table 2. Soil analysis results of the experiment area

% Clay	% Silt	% Sand	Texture	EC (mmhos/cm)	Organic Matter (%)	P_2O_5	Lime	pH
13.95	11.25	74.48	Sandy loam	0.098	1.54	6.25	1.13	7.24

Soil samples taken from the trial area were analysed in the soil analysis laboratory of Erciyes University, Department of Soil Science and Plant Nutrition. The results of soil analyses for the experimental area are presented in Table 2. According to the results of soil analyses, the experimental area has a sandy loam soil texture (Ülgen and Yurtsever, 1995), neutral soil reaction (Ülgen and Yurtsever, 1995), lime content (Hızalan and Ünal, 1966; Ülgen and Yurtsever, 1974), low in terms of useful phosphorus (Ülgen and Ateşalp, 1972) and salt-free (Richards, 1954) soil structure.
Maize varieties and FAO maturity groups used in the experiment are given in Table 3. In the study, 12 maize varieties belonging to different FAO maturity groups were used.

Table 3. Varieties and FAO maturity groups used in the experiment

Cultivar	FAO Group
9628 hp f1 (biotek)	500
Dkc 7240 (dekalb)	750
Hiva f1 (biotek)	600
Kerbanis (kws)	550
Kilowatt (kws)	700
Kolosseus (kws)	680
Kontigos (kws)	550
Nk vitorino (syngenta)	600
Simpatico (kws)	300
Sy antex (syngenta)	400
Sy dracma (syngenta)	450
Sy inove (syngenta)	450

The experiment was conducted at Yıldırım Beyazıt station of Erciyes University Agricultural Research and Application Centre (ERUTAM) located in the central campus of Erciyes University in 2019. The experiment was carried out according to the randomised block design with three replications. Before sowing, 15-15-15 fertiliser (8 kg P_2O_5 and K_2O) was spread manually and then the soil was mixed with a cultivator. The experiment was sown by hand on 05.05.2019. Sowing was done with 70 cm between rows and 20 cm above rows (İdikut and Kara, 2011). Each plot was 3 metres long and 1 metre space was left between the blocks. After sowing, irrigation was applied with sprinkler irrigation system to facilitate plant emergence. When the plants reached a height of about 30 cm (1 month after sowing), weed control and throat filling were carried out manually. After the throat filling process, drip irrigation system was installed. 12 kg/ha N ammonium sulphate fertiliser was applied as top fertiliser through drip irrigation system. There was no need for weed control again after the throat filling process.

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Harvesting was carried out at the time when black spot was formed on the grains of maize varieties (Wei et al., 2023). In harvesting, 10 ears were harvested randomly by hand after leaving a row from the edges of each plot and 50 cm space from the beginning and end of the plot and the shells were peeled (Erdoğan et al., 2019). The ears were kept in an oven at 65℃ until they reached constant weight and the following measurements were made (Atakul et al., 2017; Kahrıman et al., 2020; Kara and Akman, 2022).

Ear length was determined by measuring ear lengths in cm with the help of a ruler and averaging them.

Ear diameter was measured from the centre point of each peeled ear with the help of callipers and the ear diameter was determined for each variety by taking the averages.

The ear weight was determined by weighing the remaining empty ears after the shells were peeled and the grains were separated on a precision balance and the average ear weight was determined.

The number of grains on the ear was determined by measuring the length of each ear, weighing the grains, counting the grains, averaging them and determining the number of grains on the ear.

Single ear grain weight was determined by weighing the grains obtained from each ear on a precision balance.

Grain yield was determined by converting the grain weights in the harvested parcel to decare and unit area grain yield was determined.

The grains with 1000 grain weight were mixed, 100 grains were counted 4 times and average 100 grain weight was determined and 1000 grain weight was obtained by multiplying by 10.

Grain protein content was determined by grinding the grains obtained from the plots and the total protein content of the grains was determined using the Kjeldahl method (Kaçar, 1972).

Statistical analysis

The data obtained from the study were subjected to analysis of variance (ANOVA) using JMP Pro 17 statistical package programme and the differences between the means were compared using Tukey multiple comparison test. In addition, biplot analysis and scatter plot analysis were performed on the mean values of the varieties (Chen et al., 2020; Ozaktan et al., 2023).

3. RESULTS AND DISCUSSIONS

According to the variance analysis results of the study in which some traits of maize varieties related to grain yield and yield were determined under Kayseri conditions, the effect of variety on ear diameter, ear weight, number of grains on ear were found statistically significant at 1% level, while the effect of variety on ear length, single ear grain weight, thousand grain weight, grain yield and protein content in grain were found statistically significant at 5% level (Table 4).

The highest ear length was obtained from Kilowatt variety with 21.64 cm and the lowest ear length value was obtained from Simpatico variety with 18.89 cm. All varieties except DKC 7240, Kerbanis and Simpatico were statistically the same and in the highest group. The average ear length was determined as 20.38 cm. Ear length was determined between 10.52-20.53 cm by Sezer et al (2019); 20.5-24.6 cm by Öz and Cengil (2016); 19.76-23 cm by Yılmaz and Han (2016); 16.1-21.3 cm by Şahin and Kara (2021). Our findings are in accordance with the literature.

The highest ear diameter was obtained from DKC 7240 variety as 53.00 mm and the lowest ear diameter was obtained from Simpatico variety as 44.05 mm. The average ear diameter of the varieties was 48.78 mm. Our ear diameter values are in parallel with the literature (Sezer et al

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(2019) 38.89-54.76 mm; Yılmaz and Han (2016) 45.33-48.66 mm; Şahin and Kara (2021) 43.5-53.6 mm).

The highest ear weight was obtained from Kl osseus variety with 63.87 g, while DKC 7240 variety was in the same group statistically. The lowest ear weight value was obtained from Simpatico variety with 28.92 g.

The average number of grains on the ear was 650.03. The highest number of grains on ear value was obtained from 9628 HP F1 variety with 710.43 pieces, while Kerbanis, Klosseus, Kontigos, NK Vitorino, Sy Antex and Sy Inove varieties were in the same group with the highest value. The lowest value was obtained from Hiva F1 variety with 604.20 pieces. Sezer et al (2019) reported 321.55-606.60 pieces/ear; Şahin and Kara (2021) reported 545.6-704.6 pieces/ear.

Table 4. Average values of the examined effects of some corn varieties and are divided into Turkey

Cultivars	Ear length **(cm)**	Ear diameters **(mm)**	Ear weight **(g)**	Number of kernels per ear **(pcs/ear)**	Kernel weight in ear **(g)**	1000 kernel weight **(g)**	Grain yield **(kg/da)**	Seed protein content **(%)**
9628 HP F1	20.81abc	46.98e	33.50ef	710.43a	225.47a	280.93bc	1610.28a	6.63ab
DKC 7240	19.31bc	53.00a	54.67ab	630.47bc	228.98a	300.02abc	1635.40a	6.39ab
Hiva F1	20.79abc	47.96de	34.82ef	604.20c	229.72a	331.91a	1640.64a	7.17ab
Kerbanis	19.56bc	50.44bc	36.97def	699.57ab	236.35a	285.72bc	1688.01a	6.91ab
Kilowatt	21.64a	47.78de	49.97bc	625.47bc	231.83a	300.26abc	1655.75a	6.76ab
Klosseus	19.83abc	52.10ab	63.87a	648.37abc	238.70a	289.43abc	1704.80a	6.53ab
Kontigos	20.63abc	50.62abc	48.87bcd	639.27abc	248.13a	318.15ab	1772.17a	6.73ab
NK Vitorino	21.18ab	46.27ef	37.05def	650.63abc	203.67ab	287.13bc	1454.59ab	6.80ab
Simpatico	18.89c	44.05f	28.92f	579.50c	164.43b	272.85c	1174.38b	7.71a
Sy Antex	20.87abc	48.30cde	40.90c-f	692.23ab	225.22a	281.19bc	1608.50a	6.08b
Sy Dracma	20.19abc	47.74de	37.22def	628.93bc	213.05ab	288.20abc	1521.60ab	6.02b
Sy Inove	20.82abc	50.09bcd	43.12b-e	691.23ab	234.33a	298.45abc	1673.61a	6.21ab
Mean	**20.38**	**48.78**	**42.49**	**650.03**	**223.32**	**294.52**	**1594.98**	**6.66**
F Value								
Cultivar	4.377*	30.269**	18.674**	7.413**	5.281*	3.725*	5.281*	2.504*
Block	2.584	5.102*	1.910	0.176	3.185	1.468	3.185	0.560

The average single ear grain weights of the varieties varied between 164.43 g and 248.13 g. The highest values were obtained from Kontigos, Klosseus, Kerbanis, Sy Inove, Kilowatt, Hiva F1, DKC 7240, 9628 HP F1 and Sy Antex varieties, respectively. The lowest value was obtained from Simpatico variety with 164.43 g. Single ear grain weights were reported to vary between 58.1-206.5 g by Kahrıman et al. (2020); 165.2-266.2 g by Çetin and Soylu (2021); 183.2-329.7 g by Şahin and Kara (2021).

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The highest thousand grain weight was obtained from Hiva F1 variety with 331.91 g, while the lowest value was obtained from Simpatico variety with 272.85 g. The thousand grain weights were reported to vary between 193.15-378.85 g by Sezer et al (2019); 184.6-249.04 g by Yılmaz and Han (2016); 223.6-417.0 g by Şahin and Kara (2021).

The highest grain yield was obtained from Kontigos variety with 1772.17 kg/da, while all varieties except Simpatico were statistically the same and in the highest group. The lowest value was obtained from Simpatico variety with 1174.38 kg/da. The average grain yield of the varieties was 1594.98 kg/ha. Grain yields per decare were reported by Sezer et al (2019) 279.46-1390.60 kg/da; Çetin and Soylu (2021) 997-1603 kg/da; Yılmaz and Han (2016) 655-975 kg/da; Şahin and Kara (2021) 846.3-1180.3 kg/da. When the grain yield values were compared with the literature, similarities and differences were found. These differences may be due to the variety used, ecological conditions and practices.

The highest grain protein ratio was obtained from Simpatico variety with 7.71%, while all other varieties except Sy Antex and Sy Dracma varieties were statistically the same and in the highest group. The lowest values were obtained from Sy Dracma and Sy Antex varieties with 6.02% and 6.08%, respectively. The average grain protein content was determined as 6.66%. Sade et al. (2002) reported that the protein rate in grain varied between 5.8-8.7%; Sezer et al (2019) reported 9.31-13.60%; Ekinci and Duman (2021) reported 7.45-13.66%.

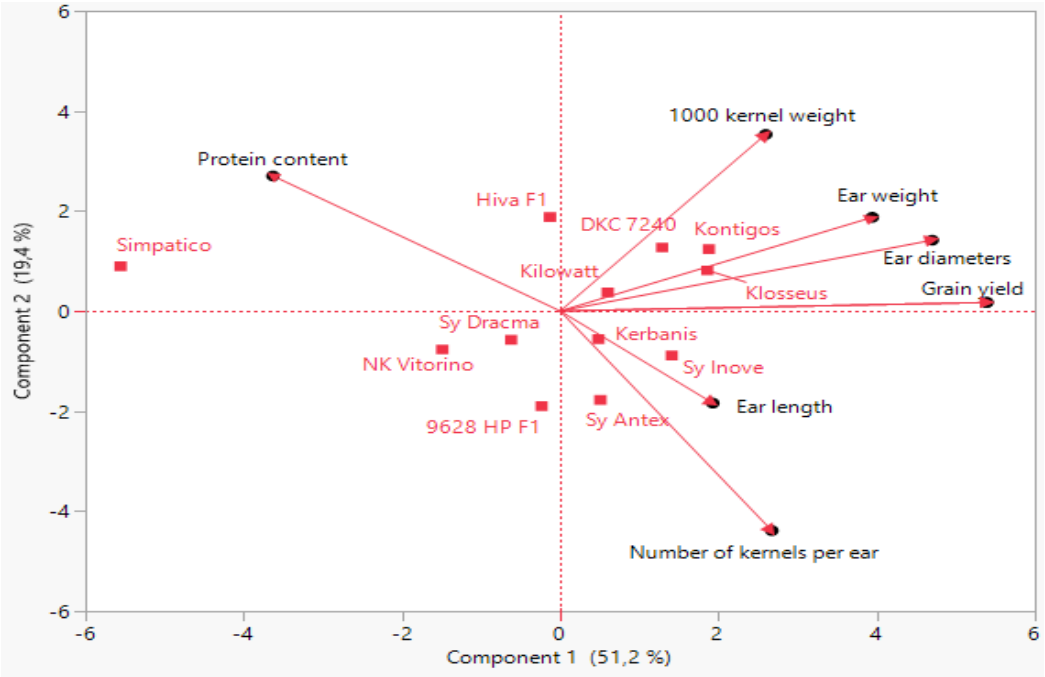

Figure 1. Biplot analysis on varieties and examined parameters

The output of the biplot analysis resulting from all the relationships between the varieties and all the parameters examined is given in figure 1. The scatter plot matrix for an overview of correlations and fit line is given in figure 2. The red circles obtained in the correlations indicate the positive relationship between the parameters, the blue circles indicate the negative relationship and the circle size indicates the degree of relationship. In the biplot analysis, 7 independent principal component

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axes were formed with 3 eigenvalues higher than 1 while PC1 and PC2 defined 70.684% of the total variation, their eigenvalues were recorded as 4.10 and 1.56, respectively. These outputs show that the biplot analysis can be interpreted successfully (Erol et al, 2023; Ozaktan 2021; Ozaktan et al, 2023a; Ozaktan and Doymaz, 2022).When the lengths of the axes obtained in the biplot analysis and the angle between each other were taken into consideration (Ozaktan et al, 2022; Çetin et al, 2023; Ozaktan et al, 2023b), a significant positive relationship was found between ear weight and ear diameters, grain yield. In addition, protein content parameter also showed a negative relationship with other parameters except 1000 kernel weight parameter (Fig. 1 and 2). Kontigos, Klosseus and DKC 7240 maize varieties were in the group with the highest values in terms of 1000 kernel weight, ear weight, ear diameters and grain yield parameters, while Simpatico variety was the leader in terms of seed protein content parameter (Fig. 1).

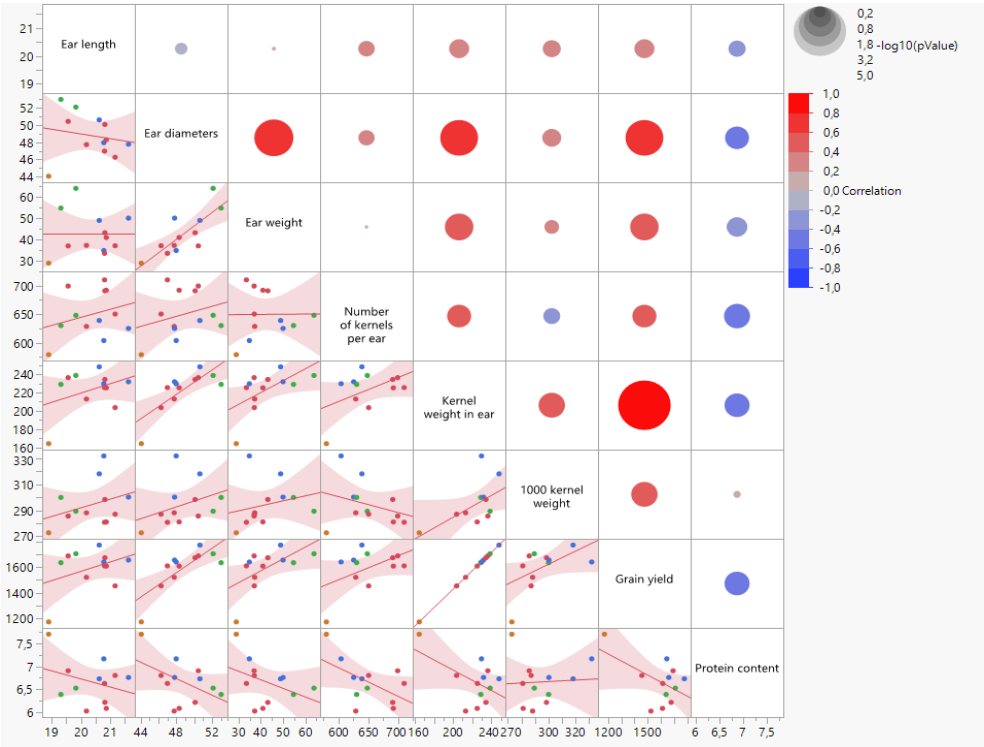

Figure 2. Scatterplot matrix for overview of correlations and fit line

4. CONCLUSIONS

Grain yields of maize varieties with different FAO values grown in Kayseri ecological conditions varied between 1174-1772 kg/ha. Except for Simpatico variety, the other varieties are recommended for Kayseri ecology in terms of grain yield, while Kontigos variety, which has the highest value, can be given the lead.

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