Selcuk Journal of Agriculture and Food Sciences SJAFS

http://sjafs.selcuk.edu.tr/sjafs/index

(2022) 36 (1), 31-38

e-ISSN: 2458-8377

DOI:10.15316/SJAFS.2022.006

Research Article

Determination of Yield, Quality and Morphological Characteristics of Different Hybrid Pepper Cultivar Candidates in Konya Ecological Conditions

Necibe KAYAK[1], Ünal KAL[2], Yeşim DAL[2], Önder TÜRKMEN[2], Selcan EROĞLU[1], Banu Çiçek ARI[1], Neslihan ISSI[1], Ömer Burak TANRIVERDI[1], Musa SEYMEN[2,*]

[1] Selcuk University, Institute of Science, Department of Horticulture, Konya, Turkey
[2] Selcuk University, Horticulture Department of Agriculture Faculty, Konya, Turkey

ARTICLE INFO

Article history:
Received date: 15.12.2021
Accepted date: 18.01.2022

Keywords:
Agronomy
Capsicum annuum
F_1 cultivar
Open field
PCA

ABSTRACT

Pepper is an important variety of vegetable that has economic value in human nutrition in Turkey and in the world. Continuous changes in producer and consumer demands also create a competitive environment in pepper breeding. Green pepper cultivation is generally carried out in greenhouse cultivation, and its cultivation has become widespread in open field conditions. In the study, 8 F1 (G12, G11, K42, B25, L9, Z22, G14 and L10) pepper varieties with superior characteristics were used as plant material. Some plant, leaf and fruit characteristics as well as yield and quality parameters were examined. As a result of the principal components analysis (PCA) made using theese measurements and observations, the study was explained variations in 6 components at a high rate of 97.94%. G11 and G12 cultivar candidates are located in the positive region of both components in the Score plot graph drawn from the first two components which means that these two candidates showed the highest performance among those evaluated ones. These cultivar candidates showed superior characteristics in terms of yield, fruit weight, fruit width, TTS, pH, L and b parameters. It is thought that these cultivar candidates can be grown in open land conditions having semi-arid climates such as Konya and will contribute to the country's agriculture production.

1. Introduction

Pepper belongs to the *Solanaceae* family and is a variety of vegetable that is widely consumed in the world and has high economic value. It has been reported that the homeland of pepper, which has been cultivated since the 15th century, is Central and South America (Pickersgill, 1997). According to 2019 data, 38.027.167 tons of pepper was produced in an area of 1.990.926 hectares in the world. In the world pepper production amount, China ranks first with 18.978.027 tons, Mexico ranks second with 3.238.245 tons, and Turkey ranks third with 2.625.669 tons (FAO, 2019). Considering 2020 data of Turkey, 1.291.091 tons of capia (oil-salt paste), 389.957 tons of bell peppers, 838.890 tons of green peppers, 116.967 tons of charliston peppers are produced, and it constitutes 8.4% of our country's vegetable production (TUIK, 2020).

Pepper is used in human nutrition, fresh, cooked, pickled, canned, dried, etc. It is a type of vegetable that is widely consumed in the form of a vegetable, and it has been reported that 100 grams of pepper contains 22 calories, 1 g protein, 0.1 g fat, 4.4 g carbohydrates, 1 g calcium, 1 g phosphorus and 2 g iron. Red, fresh and green peppers are among the vegetables with the highest amount of vitamin C (Sevgican, 1999; Dobón-Suárez et al., 2021).

Biologically, it is known that the flower structure of pepper is hermaphrodite. Although pepper is a self-pollinated species, it is found in foreign pollination at varying rates (3-30%). For this reason, pepper populations with very different characteristics have spread to different parts of Turkey and created rich genetic variation. Within this rich genetic diversity, Bozokalfa et al. (2009) revealed that fruit types and plant characteristics are the main determinants of a genotype that can be integrated into breeding studies.

In addition to the traditional breeding characteristics in the cultivation and consumption of pepper worldwide, market demands and the competition created by this have led producers to use higher yielding and quality varieties (Kartal, 2021). This had a positive effect on the development of pepper breeding. Purpose of pepper

* Corresponding author email: *mseymen@selcuk.edu.tr*

breeding; is to develop hybrid varieties suitable for open and greenhouse conditions, productive, high quality, resistant to diseases and pests, and able to set fruit in cold conditions. In addition, one of the features that breeders and producers emphasize most in pepper breeding is uniformity (Gülcan, 2020).

The aim of agricultural production is to obtain the highest yield by providing the necessary inputs for the plant to reach its yield potential. For this purpose, the use of hybrid varieties in peppers has increased in recent years. In hybrid varieties, significant success has been achieved in the development of demanded varieties and seed production in terms of yield, quality, durability, adaptation, resistance to diseases and pests (Kaloo, 1988; Etienne et al., 2018). The degree of kinship of the parents plays an important role in the F_1 generation being superior to the parents in the pepper hybrid cultivar breeding program. While the heterosis effect is low in hybrids of genetically very close or very distant lines, heterosis is higher in hybrids of lines with medium level of genetic relatedness (Geleta et al., 2004). Heterosis breeding has an important effect on the development of high yielding varieties in pepper.

Hybrid cultivar breeding in pepper is one of the issues of economic and strategic importance both at national and international level. Pepper breeding studies in Turkey started in the 1980s and many standard varieties have emerged in the light of these studies (Sürmeli and Erdogan, 1985; İnan, 1988; Sürmeli and Şimşek, 1991; Ekiz and Kemer, 1995). Although the usage rate of hybrid pepper varieties has increased in our country in recent years, the use of varieties developed through selection is still available. Some of the hybrid pepper varieties developed in Turkey are the varieties developed by companies operating in our country but of foreign origin.

Thanks to its high production both in the world and in our country, pepper has an important place in economic terms and also for human nutrition; There is a tendency towards the use of hybrid varieties on the basis of parameters such as yield, quality, environmental compatibility, color and aroma. Although F_1 cultivars have been developed in pepper cultivation, there is still a need for new F_1 cultivars with high adaptability in different ecological conditions. In this study, it was aimed to determine some yield, quality and plant characteristics of 8 F_1 pepper cultivars under Konya ecological conditions.

2. Materials and Methods

The research was carried out between May-August 2021 in Selcuk University Faculty of Agriculture, in the research fıeld. Climatic data of the trial year belonging 2021 were taken from the climate station located in the trial area, and some climate data were recorded during the trial season. When Table 1 is examined, the highest temperature was 40.3 °C in June. The lowest temperature was 4.9 °C in September, and the average temperature was between 17.3-23.8 °C. The highest precipitation occurred in August and September. As a result of the soil analysis, it has a pH 7.8 organic matter 1.2% and a clay-loam structure without salinity problem.

Table 1
Variations of meteorological parameters of region during experimental years

Mon.	Max. Temp (°C)	Min. Temp (°C)	Mean Temp (°C)	Mean wind speed (m s^{-1})	Precipitation (mm)
May	35.9	6.7	18.4	2.4	2.5
June	40.3	11.2	21.6	0.8	1.4
July	36.2	13.1	23.8	2.8	5.8
Aug.	35.2	12.8	23.7	2.4	13.4
Sep.	30.2	4.9	17.3	2.3	14.4

In the experiment, eight hybrid cultivar candidates with having heterosis characteristics, defined by the codes G12, G11, K42, B25, L9, Z22, G14 and L10, developed by the Selko-Agriculture company, which carries out Ar-Ge studies on different vegetable species in Antalya, were used as plant material.

After the drip irrigation pipes were laid on the land cultivated in early spring, seedlings were planted on the row on May 5, 2021. Seedlings were planted in 20 plots of each genotype, with 80 cm row spacing and 50 cm row spacing. Irrigation was done with drip irrigation system at intervals of 5-7 days according to the needs of the plant. When the plants reach a certain height, throat filling process was done and hoeing was done 3 times according to weed growth. 15 days after planting the seedlings, 3.5 kg da^{-1} of MAP (monoammonium phosphate) and 400 ml of humic acid per decare were given by drip irrigation system. The second fertilization was applied on June 11 with the same amount of humic acid and 200 g potasiyum+magnesium (Potasmag). Approximately ten days after the seedling planting, the increase in soil temperature and the "Luna Tranquility" application, which is effective against root rot, was applied with drip irrigation based on the soil temperature rate. Fruits at harvest size in cultivar candidates were harvested separately from each plot. The first harvest was made on July 18, and the trial was terminated at the end of a total of 6 harvests. In order to make measurements and observations on the fruit, 10 fruits representing the genotype were sampled and necessary measurements and observations were made.

In the experiment, the characteristics taken from the plant, leaf and fruit were determined according to the International Union for Conservation of New Plant Varieties (UPOV) feature document. In plants; plant height (cm), internode length (cm), anthocyanin coloration at level of nodes, color intensity at the nodes, hairiness at the nodes, in the leaves; leaf length and width, leaf color values (L, a*, b*) and fruits; yield per plant (g), number of fruits (plant), fruit weight (g), fruit length (cm), fruit width (mm), fruit flesh thickness (mm), fruit stalk length (mm), fruit stalk thickness (mm), TTS, pH, fruit anthocyanin coloration, fruit texture of surface measurements and observations were taken.

In the experiment, the standard deviations of the numerical measurements observed taken from different cultivar candidates were taken and interpreted. Observational parameters were tried to be interpreted as percentages. Yield, quality and plant characteristics were subjected to PCA in the JMP-14 computer package program, and the parameters revealing the important differences between F1 cultivar candidates were determined. With the Loading Plot and Score Plot plots drawn from the PC1 and PC2 components from the analysis, the relationships between the parameters and the distinctions between the genotypes were revealed.

3. Results and Discussion

In the study, it was observed that the leaf characteristics of eight different F1 pepper cultivar candidates were different from each other (Table 2). When the table was examined, the average leaf length was found to be 77.2 mm. The longest leaf was found to be 86.82 mm from the K42 cultivar candidate. When the leaf width is examined, the average leaf width of the cultivars is 37.29 mm. The highest leaf width was determined as 49.87 mm from the K42 cultivar candidate. The average leaf color L value was found to be 40.24, and the varietal candidate with the brightest value was determined as G12 with 42.59 and and the lowest brightness value was determined as B25 with 38.61 with the lowest brightness. The average leaf color a* value is -13.98, the cultivar candidate with the highest value is G12 with -15.01, and the cultivar candidate with the lowest value is B25 with -12.90. Leaf color b* value average was 21.27, the highest value was determined to belong to the G12 variety candidate with 24.53 and the lowest value was determined to belong to the L10 variety candidate with 18.43. A high value of "L" indicates a high brightness, a negative value of "a*" indicates an excess of green color, a positive increase indicates an increase in redness, a negative increase of "b*" indicates an increase in yellow color, and a positive value of blue indicates an increase in intensity (Bosland, 1993). Başak (2019) determined the averages of leaf length and width (cm) as 6.20-3.63 cm, respectively, in his study. In another study, leaf widths of 8 types and 129 pepper cultivars were determined as narrow in most of the cultivars (47.3%), wide cultivars were mostly block and stuffed types (14%), and very narrow cultivars were hairy/ornamental types (10.9%). has been observed. In another study, 67 pepper genotypes; They found that the leaf width was 2.5 cm and the leaf length was 4.8 cm (Kanal and Balkaya, 2021). The fact that the genotypes in the gene pools have different characteristics indicates the richness of the gene pool. Although the leaf characteristics of the cultivar candidates differ, similar results were obtained in the studies.

When Table 3 was examined, differences were observed between plant heights. The average plant height is 69.08 cm, and it was stated that the cultivar candidate with the longest plant height was K42. When the internode length is examined, the average length is 5.23 cm and the F1 cultivar candidate with the longest internode length was K42 with 6.7 cm. In a study conducted in Samsun with 67 pepper genotypes of *C. baccatum*; The highest plant height values were measured in CB-68 (47.1 cm), CB-85 (47.0 cm), CB-21 (46.7 cm), CB-49 (46.6 cm) and CB-28 (46.6 cm) respectively (Kanal and Balkaya, 2021). Capsicum species show significant differences in terms of plant heights. Padilha et al. (2016) The plant heights of pepper genotypes of *C. annuum* were 23.12- 48.72 cm and Sreenivas et al. (2019) stated that it varies between 37.6-110.6 cm. Başak (2019) determined in his study that the average plant height and internode length were 60.24 and 5.63 cm, respectively. Although the results of the research vary according to the genotypes, they generally support the mentioned literature. Considering the anthocyanin coloration at level of nodes, it was observed that there was coloration in all cultivar candidates. It was determined that the color intensity at the nodes was medium in five cultivar candidates, weak in two, and very low in one. No hairiness at the nodes was observed when looking at all cultivar candidates. Başak (2019) and Mutlu et al. (2009) found the hairiness rates of the nodes to be 98% and 85% weak in their study. The results of the research showed that the hairiness at the nodes produced similar results. Kanal and Balkaya (2021), in their examination in terms of stem anthocyanin coloration; determined that 16.5% of genotypes did not have anthocyanin coloration. It was determined that 34.3% of *C. baccatum* pepper genotypes had low intensity, 32.8% very intense and 16.4% medium intensity anthocyanin coloration. Mutlu et al. (2009) used 185 pepper materials and determined anthocyanin as 1.08% green, 20% light purple, 52.43% purple and 26.49% dark purple at the nodes of the cultivars.

Table 2
Some leaf measurements and observations of different F1 pepper cultivar candidates in Konya ecological conditions

F_1 Variety	Leaf Length (mm)	Leaf Width (mm)	Leaf Color L Value	Leaf Color a* Value	Leaf Color b* Value
G12	84.25±10.20	39.42±4.07	42.59±2.64	-15.01±1.29	24.53±3.78
G11	82.04±8.67	38.45±8.35	41.46±1.29	-14.58±2.52	23.70±0.52
K42	86.82±11.51	49.87±6.46	40.30±1.98	-14.03±1.16	21.47±2.76
B25	78.72±10.83	35.59±5.11	38.61±4.36	-12.90±3.24	19.04±7.56
L9	74.06±14.54	36.27±6.99	39.37±3.17	-13.42±2.43	19.41±4.71
Z22	68.15±7.58	32.72±3.57	40.28±3.53	-14.10±2.21	22.23±4.89
G14	58.61±8.53	27.77±5.73	40.26±1.57	-14.29±1.34	21.29±2.12
L10	85.02±12.39	38.24±2.30	38.99±1.92	-13.50±1.28	18.43±4.02
Average	77.21	37.29	40.24	-13.98	21.27

Table 3
Some plant measurements and observations of different F1 pepper cultivar candidates in Konya ecological conditions.

F_1 Variety	Plant Height (cm)	Internode Lenght (cm)	Anthocyanin Coloration at Level of Nodes	Color Intensity at the Nodes	Hairiness at the Nodes
G12	66.4±4.97	4.7±0.97	current	medium	absent
G11	73±9.08	5.3±0.83	current	weak	absent
K42	79.4±6.58	6.7±0.97	current	very low	absent
B25	62.8±5.38	5±0.93	current	medium	absent
L9	71.8±3.03	5.2±1.15	current	medium	absent
Z22	62.8±2.58	5±0.61	current	medium	absent
G14	64.4±6.10	5.3±0.90	current	weak	absent
L10	71±2.64	4.7±0.75	current	medium	absent
Average	69.08	5.23	-	-	-

When Table 4 is examined, the average yield per plant is 905.86 g, the highest with 1103.40 g and G11 variety candidate and the lowest with 526.85 g G14 variety candidate. The average number of fruits per plant was determined as 64.22, the highest number of fruits was determined as 86.29 with K42 and the least number of fruits with 42.69 as G14 variety candidate. Average fruit weight was observed as 16.60 g, and it was determined that the cultivar candidate with the heaviest fruit was G11 with 22.52 g. Cherian and Indira (2003), in their study of 25 different *C. chinense* Jacq species, determined the number of fruits per plant as 4.0–63.5 and yield per plant as 12.0–185.0 g. In a study conducted in another Capsicum species, the average fruit width values in *C. baccatum* pepper genotypes were measured between 6.3-26.3 mm (Kanal and Balkaya, 2021). Capsicum species show significant differences in terms of fruit number and yield per plant. In the study conducted with domestic, hybrid and standard pepper varieties; Yield averages per plant varied between 541.4 g/plant (Bozdoğan population) and 203.3 g/plant (Yenipazar population). It has been stated that the hybrid variety gives an average value of 344.4 g/plant (Gülcan, 2020). Padilha et al. (2016) in their studies; the highest fruit number per plant was P138 genotype with an average of 890, and P143 genotype with an average yield per plant of 510. They reported that the genotype with the highest fruit weight emerged as P202 with 17.33 g per fruit. It is seen that there are differences between yield and yield components among the various studies. These differences are thought to be caused by cultivars, ecological factors and growing conditions. When the fruit lengths are examined, the average is 17.17 cm, the variety candidate with the longest fruit length is G14 with 18.3 cm, and the variety candidate with the shortest fruit length is G12 with 16.1 cm. The average fruit width is 16.55 mm, the largest fruit width is L10 with 18.07 mm, and the lowest fruit width is B25 with 15.45 mm. The average fruit flesh thickness was 2.34 mm, and the cultivar candidate with the thickest flesh was determined as Z22 with 2.89 mm. Başak (2019) determined the average fruit length, fruit diameter, and fruit flesh thickness to be 15.97 cm, 15.98 mm, and 1.89 mm, respectively. In the study conducted on 45 chilli pepper genotypes, they found fruit length of 13.92-95.26 mm and fruit diameter of 5.26-15.92 mm (Sreenivas et al., 2019). In his study, Gülcan (2020) determined fruit length of 10.6-13.3 cm, fruit diameter of 18.8-25.1 mm and fruit flesh thickness in the range of 2.2-2.8 mm. Binbir (2010), in their study on 26 different pepper populations and three different standard pepper varieties, found the average fruit length of 12.34 cm, width of 3.5 cm and weight of 42.20 g. Fruit lengths and widths in pepper are directly related to harvest time and genetic structure.

Table 4
Yield and some fruit measurements of different F1 pepper cultivar candidates in Konya ecological conditions

F_1 Variety	Yield per Plant (g)	Number of Fruits (plant)	Fruit Weight (g)	Fruit Length (cm)	Fruit Width (mm)	Fruit Flesh Thickness (mm)
G12	1073.20	74.00	17.68	16.1±0.916	17.096±1.52	2.34±0.47
G11	1103.40	61.40	22.52	16.8±1.12	17.14±1.38	2.04±0.44
K42	1006.14	86.29	13.82	16.3±1.98	15.67±3.32	2.13±0.22
B25	816.47	57.53	15.18	18.2±0.67	15.45±0.81	2.05±0.31
L9	902.93	67.07	15.77	16.5±1.37	16.91±3.08	2.47±0.11
Z22	842.07	55.60	16.47	17.3±0.44	16.64±1.102	2.89±0.38
G14	526.85	42.69	14.60	18.3±1.432	15.5±1.75	2.76±0.49
L10	975.85	69.15	16.78	17.9±2.45	18.07±2.00	2.06±0.18
Average	905.86	64.22	16.60	17.17	16.55	2.34

Table 5
Some fruit measurements and observations of different F_1 pepper cultivar candidates in Konya ecological conditions

F_1 Variety	Fruit Stalk Length (mm)	Fruit Stalk Thickness (mm)	TTS	pH	Fruit Anthocyanin Coloration	Fruit Texture of Surface
G12	32.17±4.13	4.51±1.08	4.9	5.96	absent	wrinkled
G11	30.54±1.48	3.69±0.43	5	5.52	absent	straight
K42	30.28±2.45	3.59±0.31	4.6	5.68	absent	straight
B25	29.47±5.11	3.70±0.47	4.1	5.62	absent	wrinkled
L9	32.44±1.45	4.46±0.79	5.1	5.79	absent	S. wrinkled
Z22	43.07±11.64	3.80±0.32	4.8	5.92	absent	straight
G14	31.66±4.44	4.33±0.40	4.5	5.42	absent	S. wrinkled
L10	35.23±3.15	3.65±0.43	5.1	5.91	absent	wrinkled
Average	33.11	3.97	4.76	5.73	-	-

When Table 5 is examined, it has been observed that the average fruit stalk length is 33.11 mm, the highest stalk length is Z22 with 43.07 mm and the lowest stalk length is 29.47 mm with B25 variety candidate. The average fruit stalk thickness was 3.97 mm, the highest stalk thickness was obtained from the G12 variety candidate with 4.51 mm and the lowest fruit stalk thickness was obtained from the K42 variety candidate with 3.59 mm. It has been determined that fruit stalk lengths vary between 18.5-71.1 mm in pepper genotypes of *C. baccatum* (Kanal and Balkaya, 2021). Taş (2020) reported that fruit stalk lengths in pepper genotypes of the *C. chinense* species ranged between 19.9-61.9 mm. Başak (2019) found the fruit stalk length as 4.15 cm and stalk thickness as 4.14 mm in their study. In another study, it was reported that the length of the fruit stalk varied between 25.5-32.7 mm (Gülcan, 2020). Ermis et al. (2019) measured the fruit stalk thickness between 2.4-10 mm. Considering the studies, fruit stalk length and fruit stalk thickness are approximately similar. The mean TTS value was 4.76, the highest TTS value was determined as 5.1 in L9 and L10 cultivar candidates, and the lowest TTS value was determined in B25 cultivar candidates with 4.1. Average pH value was 5.73, G12 variety candidate with the highest pH value of 5.96 and G14 variety candidate with the lowest pH value of 5.42. Although the high amount of TTS is a desirable feature especially in the tomato paste industry, this is also true for sharp peppers used for drying and industrial purposes. Başak (2019) found the amount of TTS in the range of 2.7-6.3% in her study. Similarly, Karaağaç and Balkaya (2010) reported that the amounts of TTS varied between 5.0-7.6%. Öntürk (2018) found in his study that the pH values of pepper populations varied between 4.83 and 5.59. Fruit anthocyanin coloration was not observed in any F_1 cultivar candidate. Fruit surface structure was observed as 3 straight, 3 wrinkled and 2 slightly wrinkled in 8 cultivar candidates. Mutlu et al. (2009) reported that most peppers did not have anthocyanin coloration in their study.

Table 6
Principal component analysis of yield, quality and morphological characteristics of different F_1 pepper cultivar candidates under Konya ecological conditions

Items	PC1	PC2	PC3	PC4	PC5	PC6
Eigenvalue	6.41	4.26	3.42	1.81	1.63	1.03
Percentage of variance	33.77	22.46	18.04	9.57	8.62	5.46
Cumulative variance	33.77	56.24	74.28	83.85	92.48	97.94
Eigenvectors						
YL	0.355	0.114	0.142	-0.068	-0.089	-0.139
NF	0.341	-0.079	0.145	0.124	0.264	-0.086
FW	0.153	0.248	-0.049	-0.303	-0.476	0.072
FL	-0.320	-0.115	0.110	-0.097	-0.280	-0.026
FWi	0.149	0.331	0.256	0.027	-0.179	0.276
FFT	-0.221	0.180	-0.265	0.382	0.141	0.059
FSL	-0.092	0.258	0.023	0.556	-0.186	-0.180
FST	-0.094	0.237	-0.139	-0.151	0.538	0.305
TTS	0.183	0.305	0.087	0.155	-0.074	0.541
pH	0.104	0.278	0.267	0.320	0.226	-0.273
FTS	-0.156	0.077	0.290	-0.362	0.383	0.044
PH	0.317	-0.175	0.003	0.108	0.002	0.436
IL	0.167	-0.360	-0.216	0.219	0.067	0.093
CIN	-0.163	0.312	0.309	-0.043	0.066	-0.160
LL	0.327	-0.048	0.252	-0.135	0.007	-0.215
LW	0.347	-0.182	0.079	0.083	0.123	-0.138
L	0.191	0.248	-0.338	-0.172	0.094	-0.156
a	-0.157	-0.243	0.378	0.096	-0.033	0.044
b	0.164	0.215	-0.391	-0.119	-0.016	-0.272

YL (Yıeld per plant), NF (Number of Fruits), FW (Fruit Weight), FL (Fruit Length), FWi (Fruit Width), (FFT) Fruit Flesh Thickness, (FSL) Fruit Stalk Length, (FST) Fruit Stalk Thickness, FTS (Fruit Texture of Surface), (PH) Plant Height, (IL) Internode Lenght, (CIN) Color Intensity at the Nodes, (LL) Leaf Length, (LW) Leaf Width, (L) Leaf Color L Value, (a) Leaf Color a Value, (b) Leaf Color b* Value

Leaf, plant and fruit characteristics measurements obtained from eight different F_1 pepper cultivar candidates were subjected to PCA in the study (Table 6). As a result of the analysis, 6 independent principal component axes were obtained regarding the 19 identification features examined. These axes represented 97.94% of the total variation. The eigen values of the first 6 components were found to be between 1.03 and 6.41. The fact that the Eigen values are greater than 1 indicates that the weight values of the component are reliable (Mohammadi and Prasanna, 2003; Seymen et al., 2019; Seymen, 2020; Yavuz et al., 2020; Yavuz et al., 2021). In studies, it is reported that it is reported that when more than 25% of total variation explains in the first two components, it could be used for PCA (Mohammadi and Prasanna, 2003; Seymen et al., 2019; Yavuz et al., 2021). It is obvious that the strong explanation of PCA will give important results about the usability of this analysis and the parameters looked at.

As a result of PCA, the first component (PC1) explained 33.77% of the study, while yield per plant, number of fruits, pH, leaf length and leaf width explained positively, in this component, whereas fruit length was the parameters described in the negative direction in this component. The second component (PC2) explained 22.46% of the study; fruit width, TTS and color intensity at the nodes explained positively in this component, whereas internode length explained negatively in this component. The third component (PC3) explained 18.04% of the study; color intensity at the nodes and leaf color a* value was the parameters that explained it positively inthis componentwhereas leaf color L value and leaf color b* value was places in the negative direction of component. The fourth component (PC4) explained 9.57% of the study; fruit flesh thickness, fruit stalk length and pH were positively described in this component whereas fruit weight and fruit texture of surface were negatively described parameters in this component. Fifth component (PC5) explained 8.62% of the study; fruit stalk thickness and fruit texture of surface explained positively in this component, fruit weight negatively explained variable inthis component. The sixth component explained 5.46% of the study; fruit stalk thickness, TTS and plant height were the parameters that explained positively inthis component. In studies on pepper characterization, Zewdie and Zeven (1997) reported that the first six PC factors represented 58% of the total variation, Rivera Martinez et al. (2004) reported that the first three basic components accounted for 72% of the total variation. Keleş (2009) performed PCA analysis in terms of 25 traits that he addressed in his study on the characterization of pepper genotypes, and as a result of the analysis, Keleş (2009) determined that the first three PC axes covered 50% of the cumulative variation. In another study, as a result of PCA, which included 34 morphological features of pepper samples, it was determined that PC with 9 factors explained 85.35% of the total variation (Binbir, 2010). PCA is used as an important and descriptive analysis method for comparing multiple data and defining genetic pools.

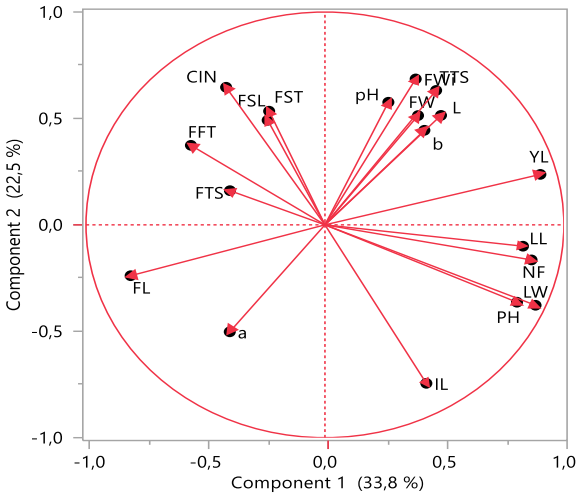

Figure 1
Loading Plot drawn from PC1 and PC2 as a result of the principal component analysis made from the yield, quality and morphological characteristics of different F_1 pepper cultivar candidates in Konya ecological conditions

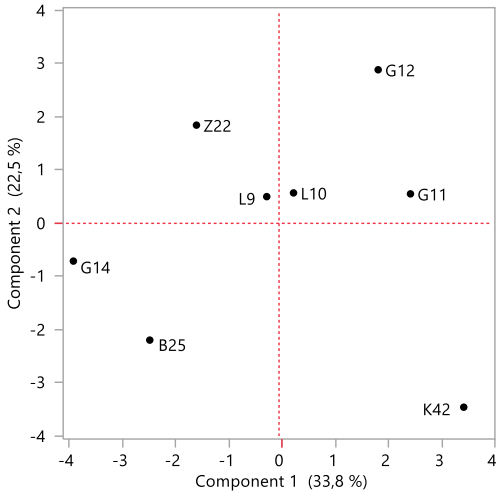

Figure 2
Score Plot plot drawn from PC1 and PC2 as a result of the principal components analysis of yield, quality and morphological characteristics of different F_1 pepper cultivar candidates under Konya ecological conditions

Using PC1 and PC2 components, a loading plot was created to examine the interrelationship between plant, leaf and fruit characteristics (Figure 1). It has been reported that if the angle between the vectors in the figure is <90°, there is a positive relationship, if it is >90°, there is a negative relationship, and if the angle between the vectors is 90°, there is no significant relationship (Yan and Kang, 2002; Yavuz et al., 2020; Seymen, 2021). When the figure is examined, a strong positive correlation was found between the parameters FW, FWi, TTS, pH, L and b*. In addition, there was a strong positive correlation between FST, FSL, CIN, FFT, and FTS, while these parameters were negatively correlated with IL.

A score plot was created for the evaluation of eight different F_1 pepper cultivar candidates using PC1 and

PC2 components (Figure 2). Considering the positive region of both components, G11, G12 and L10 cultivar candidates showed significant results in terms of yield and quality. G11 and G12 cultivar candidates YL, FWi, FW, pH, L, and b* parameters were the parameters that obtained high values and differentiated G11 and G12 cultivar candidates from the other groups.

4. Conclusion

The differences in yield, fruit, leaf and plant characteristics of eight different F1 pepper cultivar candidates were evaluated in Konya ecological conditions. As a result of PCA, the study was explained at a high rate of 97.94% in 6 components. G11 and G12 cultivar candidates located in the positive region of both components in the Score plot graph drawn from the first two components that explained the study the most were determined as superior cultivar candidates. These F1 cultivar candidates showed superior characteristics in terms of yield, fruit weight, fruit width, TTS, pH, L and b* parameters. It is thought that these F1 cultivar candidates can be grown in open land conditions in regions such as Konya with semi-arid climates and will contribute to the country's agriculture production.

5. References

Başak H (2019). Kırşehir yerel sivri biber (*Capsicum annuum* L. var. *longum*) populasyonlarının agronomik ve morfolojik karakterizasyonu. *KSÜ Tarım ve Doğa Bilimleri Dergisi*, 22 (2), 202-216.

Binbir S (2010). Bazı Yerel Biber (*Capsicum annuum* L.) Populasyonlarında Karakterizasyon Çalışmaları. *Adnan Menderes Üniversitesi* Fen Bilimler Enstitüsü.

Bosland P (1993). Breeding for quality in Capsicum. *Capsicum and Eggplant Newsletter*, 12, 25-31.

Bozokalfa MK, Esiyok D, Turhan K (2009). Patterns of phenotypic variation in a germplasm collection of pepper (*Capsicum annuum* L.) from Turkey. *Spanish Journal of Agricultural Research* (1), 83-95.

Cherian E, Indira P (2003). Variability in Capsicum chinense Jacq. Germplasm. *Capsicum Eggplant Nwsl*, 23, 45-50.

Dobón-Suárez A, Giménez MJ, Castillo S, García-Pastor ME, Zapata PJ (2021). Influence of the Phenological Stage and Harvest Date on the Bioactive Compounds Content of Green Pepper Fruit. *Molecules*, *26*(11), 3099.

Etienne H, Breton D, Breitler JC, Bertrand B, Déchamp E, Awada R, Ducos JP (2018). Coffee somatic embryogenesis: How did research, experience gained and innovations promote the commercial propagation of elite clones from the two cultivated species?. *Frontiers in Plant Science*, *9*, 1630.

Ekiz H, Kemer M (1995). Breeding of Demre pepper. *EUCARPIA: IXth meeting on genetics and breeding on Capsicum and eggplant*.

Ermiş S, Yılmaz K, Özden YŞ (2019). Standart Tohumluk Kaydı Denemelerine Giren Biber (*Capsicum Annuum* L.) Çeşitlerinde Ölçülebilir Morfolojik Karakterlerin Belirlenmesi. *9. Ulusal Sebze Tarımı Sempozyumu*.

FAO (2019). Food and Agriculture Organization, FAO. [Date of access: 08.12.2021].

Geleta SB, Brinsfield RB, Ron Mulford F, Womack HE, Briand CH, O'Keefe JA (2004). Managing phosphorus for yield and quality of sweet corn grown on high phosphorus soils of Maryland's eastern shore. *Canadian journal of plant science*, 84 (3), 713-718.

Gülcan H (2020). Yerli, Standart ve Hibrit Biberlerde (*Capsicum annuum* L.) Bazı Verim ve Kalite Özelliklerinin İncelenmesi. *Aydın Adnan Menderes Üniversitesi*, Fen Bilimleri Enstitüsü.

İnan Y (1988). Çarliston Biber Islahı. *TAGEM Sonuç Raporu, Yalova*, 15.

Kaloo D (1988). Vegetable Breeding Vol. II.

Kanal A, Balkaya A (2021). *Capsicum baccatum* türüne ait biber popülasyonunun karakterizasyonu ve morfolojik varyasyon düzeyinin belirlenmesi. *Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi*, 26 (2), 278-291.

Karaağaç O, Balkaya A (2010). Bafra Kırmızı Biber Populasyonları (*Capsicum annuum* L. var. *conoides* (Mill.) Irish) Tanımlanması Ve Mevcut Varyasyonun Değerlendirilmesi. *Anadolu Tarım Bilimleri Dergisi*, 25 (1), 10-20.

Kartal G (2021). Bazı yerel biber tiplerinden elde edilenmelezlerin morfolojik özelliklerinin ve domates lekeli solgunluk virüsüne (TSWV) dayanıklılığının belirlenmesi. Yüksek Lisans Tezi.

Keleş D (2009). Farklı biber genotiplerinin karakterizasyonu ve düşük sıcaklığa tolerans. *Çukurova Üniversitesi*, Fen Bilimleri Enstitüsü.

Mohammadi SA, Prasanna B (2003). Analysis of genetic diversity in crop plants—salient statistical tools and considerations. *Crop science*, 43 (4), 1235-1248.

Mutlu S, Haytaoğlu MA, İçer AK (2009). Ulusal Gen Bankasi Biber (*Capsicum Annum* L.) Materyalinde Morfolojik Karakterizasyon. *ANADOLU Ege Tarımsal Araştırma Enstitüsü Dergisi*, 19 (1), 63-91.

Öntürk G (2018). Hatay biberi köy popülasyonlarında bitki, çiçek, meyve özelliklerinin belirlenmesi ve teksel bitki seleksiyonu ile farklı hatların oluşturulması. *Hatay Mustafa Kemal Üniversitesi,* Fen Bilimleri Enstitüsü.

Padilha HKM, Valgas RA, Barbieri RL (2016). Agronomic evaluation and morphological characterization of chili peppers (*Capsicum annuum*

, *Solanaceae*) from Brazil. *Australian Journal of Basic and Applied Sciences*, 10 (13), 63-70.

Pickersgill B (1997). Genetic resources and breeding of *Capsicum spp*, *Euphytica*, 96 (1), 129-133.

Rivera Martinez A, Terren Poves L, Rodriguez Bao J, Andres-Ares J, Fernandez Paz J (2004). Characterization of local pepper lines from Northwest Spain.

Sevgican A (1999). Örtüaltı Sebzeciliği. Cilt IE Ü. Ziraat Fakültesi Yayınları No: 528, İzmir.

Seymen M (2020). Seed Yield and Characteristics in a Half-Diallel Pumpkin Population. *Selcuk Journal of Agriculture and Food Sciences*, *34*(3), 200-206.

Seymen M (2021). How does the flooding stress occurring in different harvest times affect the morpho-physiological and biochemical characteristics of spinach?. *Scientia Horticulturae*, *275*, 109713.

Seymen M, Yavuz D, Dursun A, Kurtar ES, Türkmen Ö (2019). Identification of drought-tolerant pumpkin (*Cucurbita pepo* L.) genotypes associated with certain fruit characteristics, seed yield, and quality. *Agricultural Water Management*, *221*, 150-159.

Sreenivas M, Sharangi AB, Banerjee S, Bhattacharya T, Maurya PK, Chattopadhyay A (2019). Characterization and evaluation of indigenous and exotic genotypes for identification of spice chilli lines. *International Journal of Chemical Studies 2*, 7 (2), 1830-1837.

Sürmeli N, Erdogan S (1985). Yağlık (Salçalık) biber ıslahı. *Bahçe Dergisi*, 14 (1-2), 31-35.

Sürmeli N, Şimşek G (1991). Çorbacı Biberi Islahı. *Bahçe 20 (1-2): 3*, 8.

Taş K (2020). *Capsicum chinense* türüne ait biber genotiplerinin morfolojik ve moleküler karakterizasyonu. *Ondokuz Mayıs Üniversitesi*.

TUIK (2020). Türkiye İstatistik Kurumu. [Date of access: 08.12.2021].

Yan W, Kang MS (2002). *GGE biplot analysis: A graphical tool for breeders, geneticists, and agronomists*. CRC press.Zewdie, Y. ve Zeven, A., 1997, Variation in Yugoslavian hot pepper (*Capsicum annuum* L.) accessions, *Euphytica*, 97 (1), 81-89

Yavuz D, Seymen M, Süheri S, Yavuz N, Türkmen Ö, Kurtar ES (2020). How do rootstocks of citron watermelon (*Citrullus lanatus var. citroides*) affect the yield and quality of watermelon under deficit irrigation?. *Agricultural Water Management*, *241*, 106351.

Yavuz D, Seymen M, Yavuz N, Çoklar H, Ercan M (2021). Effects of water stress applied at various phenological stages on yield, quality, and water use efficiency of melon. *Agricultural Water Management*, *246*, 106673.

Zewdie Y, Zeven, AC (1997). Variation in Yugoslavian hot pepper (*Capsicum annuum* L.) accessions. *Euphytica*, *97*(1), 81-89.