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COMPARISON OF CEMELE PEPPER WITH BELL PEPPER GENOTYPES (*Capsicum annuum* L. var. *grossum*) WITH RESPECT TO AGRONOMIC AND MORPHOLOGICAL CHARACTERISTICS

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ABSTRACT

This study was conducted in 2014 and 2015 to compare Cemele pepper with other bell peppers (*Capsicum annuum* L. var. *grossum*) genotypes with respect to agronomic and morphological traits. Totally 75 bell pepper genotypes were collected from the centrum and villages of Kırşehir province. For a total of 48 agronomic and morphological characteristics of pepper genotype, the characterization study of IPGRI according to the criteria of the International Union of Plant Protection Preservation (UPOV) were done made. As a result of the principal component analysis, total 11 main component axes were obtained and these axes represented 73.25% of the total variance. Genotypes were divided into 15 groups in dendrogram according to morphological and agronomic characteristics. The mean of the quantitative characteristics of each group was determined and it was determined which group or group was the difference between them. As a result of cluster analysis; D1, D20, D54, D67K, D43 and D39 coded genotypes were determined to be the most distant genotypes in terms of agronomic and morphological degree of relation. To conclude, with the identification of the genotypes of bell peppers in Kırşehir province, it will provide significant advantages in future pepper breeding studies as well as contributing to the formation of pepper database.

Key words: Cemele, pepper, genotype, characterisation, morphological, agronomic

INTRODUCTION

There have been recent positive developments in domestic and national seed production in Turkey. Her qualification rate in domestic hybrid vegetable seed was increased from 10% in 2004 to 60% in 2015 [TARiM 2017]. In order to increase the number of national varieties, the rich genetic resources should be evaluated by means of breeding studies. The main objective of the breeding studies is; disease-resistant, early and high yield, suitable for different types of processing fruit to produce varieties of quality. Hybrid varieties obtained from foreign sources prevent the promotion and use of local populations with superior features.

Pepper which is included in the genus *Capsicum* of *Solanaceae* family and it is a few years' culture plant in temperate climates and in annual tropical climates [Şeniz 1992]. There have been about 30 species grown in tropical and suptropic regions of pepper, whose origin is in Central America and Mexico. Among these, five species (*C. annuum*, *C. frutescens*, *C. baccatum*, *C. pubescens* and *C. chinense*) are cultured and only *C. annuum* species is cultivated economically in the World [Wien 1997].

In 2016, a total of nearly 34.5 million tons of peppers were produced in the world and this amount accounted for 3% of world vegetable production. Tur-

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key withnearly 2.5 million tons of pepper production was situated in 3rd rank after China and Mexico [FAO 2016]. Turkey pepper production in 2017 reached nearly 2.6 million tons, making her pepper producer in the World. Turkey's bell pepper production with 420.9 thousand tons covers her 16.14% of total pepper production [TUIK 2017]. Vegetable cultivation has been carried out in 1906 hectares of the total cultivated area of 281 thousands ha of Kırşehir province. Total pepper production in Kırşehir province was 1.32 thousand tones, and 42.1% of it consisted of 554 tons of bell pepper production [TUIK 2017]. The genotype, whose name is Cemele, is the most cultivated pepper in the province due to high market demand. Cemele pepper, whose name is due to the intensive cultivation in Çayağzı village of Kırşehir with its own bitter taste**,** thin fruit flesh thickness and taste, it is also in demand in the surrounding cities, especially in Kırşehir. Cemele pepper, which is preferred to be used as dried peppers without any market problems, is pleased to find the customer at an average price of two or three times more than other bell peppers.

Local genotypes are also evaluated in direct breeding or indirectly developing new varieties [Inal 2002]. However, this valuable biodiversity is at risk of disappearing for a number of reasons, such as the impacts of industrial agriculture, the orientation of such seeds due to the advantages provided by hybrid varieties, not being kept under protection, and not using suitable propagation methods. A large part of the pepper producers in Kırşehir maintain seed needs from the plants that they selected as seed in the production process. However, the supply of seeds without complying with the rules of isolation can be seen in high rates of cross-pollination with other genotypes in time. Cemele pepper, especially in the genotypes of the deterioration of the uniformity of the genotype, leads to an increase in off-type plant in genotype.

Plant breeding studies are carried out to identify, protect and preserve these genetic resources, which constitute the gene pools necessary for the development of new varieties and the generation of genetic variation [Bliss 1981, Tan 1992]. There have been many characterization studies to determine the current agro-morphological variation between pepper genotypes and to determine the distribution status of this variation [Belletti and Quagliotti 1982, Eshbaugh 1988, Cole et al. 1993, Akıncı and Akıncı 2004, Duman and Düzyaman 2004, Zewdie et al. 2004, Keleş 2007, Binbir and Baş 2010, Bozokalfa and Eşiyok 2010, Sharma et al. 2017, Bicikliski et al. 2018].

In the present study, it was aimed to compare the morphological and agronomic characteristics of Cemele pepper with other bell pepper genotypes which have been significant popularities and economic values in vegetable production of Turkey. In this way, as well as contributing to the formation of the pepper database in Kırşehir, the morphological and agronomic characteristics to be used in filling the property document required for the geographic indication registration of the brand value Kırşehir Cemele bell pepper will be determined.

MATERIAL AND METHODS

The bell pepper genotypes used in this study were obtained from 89 villages of Kırşehir province. There are 4 pieces (Kandil Dolma, 11-B-14, Uras 98 and Doru 16) commercial bell pepper varieties which are common in our country and 7 previously stuffed from Kırşehir province of Aegean Agricultural Research Institute (ETAE) pepper genotype. During the study, agronomic and morphological characterizations of 75 bell pepper genotypes were conducted. In the coding of genotypes, the letter D symbolizing the pepper was used. In the province, the genotypes obtained from the district of Çayağzı where Cemele pepper cultivation was most intense were given the CM code. Çayağzı is a populated place and located in Kırşehir, Turkey. Kırşehir is located (38°49''–39°48'' north latitudes, 33°25''–34°43'' east longitudes) in Turkey's Central Anatolia Region. The determined altitude is 1228 meters by using GPS.

The experiment was conducted in 2014 and 2015 by using Experimental Station of Horticulture Department of Agricultural Faculty of Kırşehir Ahi Evran University, Turkey. The average climate data during the study in 2014 and 2015 are given in Table 1. The soil analysis results of the experimental field are given in Table 2. The seeds belonging to the genotypes were planted in peat + perlite (3 : 1) mixture filled in the first year on 18th March 2014, in the second year on 25th March 2015; routine cultivation procedures were applied to the seedlings until they reached the stage

Table 1. The mean meteorological parameters in Kırşehir province during the study

Months	Average temperature (˚C)			Total rainfall (mm)			Average relative humidity (%)		
	2014	2015	Long term	2014	2015	Long term	2014	2015	Long term
May	16.3	15.9	15.3	46.6	39.2	44.8	60.8	57.8	60.7
June	19.9	18.3	19.7	36.0	161.4	33.9	53.6	66.9	54.2
July	25.5	23.1	23.2	13.0	20.6	6.6	38.4	46.3	48.2
August	25.9	24.7	22.9	17.0	11.8	5.0	39.4	47.0	48.4
September	19.8	23.0	18.3	29.8	1.0	12.0	51.2	40.4	52.9

Source: Turkish State Meteorological Service

Table 2. Some chemical and physical characteristics of experimental soil in cultivated area

Physical parameters

Depth (cm)	Distribution of particles (%)			Structure class	Field capacity ($g\ g^{-1}$; %)	Fading point ($g\ g^{-1}$; %)	Volume weight of soil ($g\ cm^{-3}$)
	sand	silt	clay				
0–30	41.7	23.6	34.7	Clay-Loam	30.39	14.13	1.29
30–60	41.8	18.2	40.0	Clay-Loam	32.42	16.85	1.27

Chemical parameters

Depth (cm)	pH	Total salt (%)	EC ($dS\ m^{-1}$)	Lime (%)	Useful nutrients ($kg\ ha^{-1}$)		Organic matter (%)
					P_2O_5	K_2O	
0–30	7.75	0.019	0.556	31.01	48.3	657.2	0.78
30–60	7.46	0.062	1.643	31.16	16.9	281.3	0.69

Source: Ankara Soil, Fertilizer and Water Resources Central Research Center (November, 2013)

of confusion [Vural et al. 2000]. Seedlings that were ready to be planted on the land were planted in the first year on 7th May 2014 and the next year on 10th May 2015 in each plot with 20 plants from the same genotype and at a distance of 70 × 40 cm. The peppers were irrigated with 3-d time intervals by using drip irrigation system. According to soil analysis, 12 kg N, 5 kg P, 15 kg K, 5 kg Ca and 3 kg Mg were applied for each acre cultivated area as suggested by Şalk et al. [2008].

Agronomic and morphological identifications were based on the criteria of feature documents developed by International Association for Plant Genetic Resources Research (IPGRI) and International Union for the Protection of New Plant Varieties (UPOV) were used for pepper [UPOV 1994]. Seedlings, plants, stems, leaves, flowers and fruit parts; a total of 48 properties were evaluated, 8 were qualitative (QL: qualitative characteristic), 32 were quantitative (QN: quantitative characteristic) and 8 were PQ: pseudo-qualitative characteristic. 10 plants in each population were used for characterization. In the current study, mean values of the quantitative properties in the same group were determined in the dendrogram. Fruit length, fruit diameter, fruit thickness of flesh, stalk length and thickness, presence of capsaicin in placenta, dry matter content and soluble solid content were determined in Horticulture Laboratory. Ruler and digital caliper were used in fruit measurements. Soluble solids content (°Brix) was

measured by a digital refractometer (Hanna HI 96801) was used for the water taken from the similar parts of the fruits of each genotype. The dry matter content of each pepper genotype was determined by using oven at 60°C until constant weight obtained [Bozokalfa et al. 2009]. Bitter taste was conducted organoleptically for each genotype in order to determine the presence of capsaicin in the fruit. Also, photographs of fruit samples belonging to each genotype were taken on a millimeter paper.

The current experiment was conducted in randomized block design with three replications. SPSS (Windows version of SPSS, release 17.00) was used for statistical analysis of experimental data. Principal component analysis (PCA) was applied to the data sets and the principal component (PC) axes of the genotypes were obtained [Sneath and Sokal 1973]. PC axes and their variations, cumulative variation rates and factor coefficients were determined (JMP-5.01 software). Then, by applying cluster analysis, dendrograms were formed to present the similarities and differences of genotypes with each other [Duman and Düzyaman 2004]. Means were compared by Duncan Multiple Range Test within SPSS software.

RESULTS

Definition of pepper genotypes have done with some plant chacteristic, such as plant habit, anthocyanin coloration of nodes, hairiness of nodes, glossiness in the leaves, anthocyanin coloration in anthers, color before the physiological maturity, fruit maturity color, stalk cavity, aspect of calyx in the fruit. The frequency percentages have been determined at the same scale value over 90%, among genotypes without any significant variations between them. The frequency percentages of other features were determined to have a wide variability in terms of classification criteria. It was found that these differences were more pronounced especially in fruit properties.

Main component axes, eigenvalues, variance and total variance ratios of the properties examined in the Principal component analysis are given in Table 3. Factors with an eigenvalue greater than 1 were considered to be important in factor analysis because it was desirable to have a factor equal to one of the variables with at least variance of 1.00 [Tabachnick and Fidell 2001]. As a result of the principal component analysis, a total of 11 main component axes related to 48 identification characteristics were obtained.

The eigenvalues of the 11 identified components were found between 1.09 and 8.98. The fifth major component axis explains 51.36% of the total variance. The weight of factor is greater than 0.30 and the weights greater than 0.50 are considered to be very good [Brown 1991, Hair et al. 1998]. In the first group, 21.91% of the total variance is composed of 27 features, while most of these parameters are due to fruit-related characteristics. In addition to the features related to fruit, time of beginning of flowering, peduncle attitude, shortened internode in upper part, plant height, length of blade and shoot length have contributed to the variance. The second factor is predominantly; the correlation coefficients of the properties such as depth of interloculary grooves in fruit, fruit texture of surface and glossiness in leaf were determined to be over 0.5 (Tab. 4).

Table 3. The factors related to the eigenvalue statistics found in the principal component analysis and determined variances

	PC Axes										
Parameters	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
Eigen value	8.98	3.93	3.32	2.60	2.22	2.00	1.67	1.55	1.35	1.30	1.09
Variance (%)	21.91	9.59	8.10	6.34	5.42	4.87	4.09	3.78	3.31	3.17	2.67
Cumulative variance (%)	21.91	31.50	39.60	45.94	51.36	56.23	60.32	64.1	67.41	70.58	73.25

PC – principle components

Table 4. The relationships between investigated traits of genotypes and the groups of factors

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11
Time of maturity	**.891**	.164	-.062	-.067	.065	-.080	.154	.083	-.007	-.110	.095
Time of beginning of flowering	**.804**	-.030	-.050	.085	.038	-.115	.167	.056	.015	-.211	.062
Fruit attitude	**.795**	-.293	-.096	.037	-.150	-.223	.142	-.093	.200	.030	-.054
Ratio length/diameter	**-.780**	.029	-.190	.027	.110	**-.400**	.072	-.010	.023	-.084	.083
Shape in longitudinal section	**-.768**	**-.310**	-.180	.226	.027	.162	.177	.124	.101	.002	.068
Fruit diameter	**.731**	-.004	**.399**	.097	-.059	.183	-.041	.236	-.086	-.094	.023
Capsaicin in placenta	**-.718**	**.305**	.165	.174	-.001	-.151	.042	.103	.038	.075	.158
Peduncle attitude	**.688**	**-.389**	-.074	.158	-.048	-.101	.195	-.015	**.353**	.034	-.103
Shortened internode	**-.615**	**-.392**	**-.302**	.096	-.110	.153	.076	-.240	.076	-.070	-.194
Plant height	**.591**	-.138	.027	.193	.157	**.389**	**.355**	-.053	-.183	-.287	-.028
Leaf length of blade	**-.548**	.037	.139	**-.449**	**.333**	.090	.141	.287	.226	-.204	.100
Length of internode	**.544**	-.059	-.237	**.304**	-.040	.030	**.326**	.077	-.124	**-.315**	.101
Fruit length	**-.519**	-.250	-.002	.089	-.033	**-.376**	.033	**.482**	-.139	-.274	.088
Stalk length	**.426**	**-.390**	.272	**.395**	.144	-.028	-.082	.052	.152	**.354**	-.048
Leaf blistering	**.405**	**-.337**	-.013	-.213	.040	**.366**	-.062	**.400**	-.188	.187	-.072
Depth of interloculary grooves	.221	**.599**	.182	-.206	-.291	-.058	-.014	.096	.208	.020	-.160
Fruit texture of surface	**.502**	**.590**	-.199	.016	**-.324**	-.091	-.070	.153	.084	.058	.143
Leaf glossiness	**.512**	**.513**	.025	-.213	.177	.047	-.189	.062	**-.383**	.079	-.102
Fruit intensity of color (at maturity)	**-.307**	**.497**	.229	-.086	-.245	.134	-.038	-.063	.212	-.087	-.266
Depth of stalk cavity	-.204	**-.450**	.212	**-.362**	**-.371**	-.131	**.312**	-.028	-.130	.175	-.012
Fruit intensity of color (before maturity)	**-.399**	**.429**	**.364**	.256	**-.364**	.075	.233	.120	.024	-.142	-.004
Fruit glossiness	-.067	-.026	**.567**	**.346**	-.253	.172	.084	.002	.292	**.339**	-.003
Thickness of flesh	**.523**	.298	**.552**	.130	.111	-.140	.012	-.037	-.069	.129	.156
Fruit shape of apex	.092	-.180	**.512**	**-.375**	.040	-.235	-.087	-.166	.207	-.028	.154
Length of stem	**.365**	-.238	**.505**	.084	-.136	.103	.251	-.147	-.227	-.058	.228
Sinuation of pericarp at basal part	.007	**.463**	**-.488**	-.025	**-.392**	.256	.171	-.037	-.054	-.021	.154
Sinuation of pericarp at excluding	.065	**.350**	**-.485**	-.078	**-.468**	**.318**	.003	-.145	.027	.030	.059
Stalk thickness	-.241	**.371**	**.467**	.215	**.411**	.011	-.108	-.051	-.099	-.126	-.028
Intensity of anthocyanin coloration	-.014	-.059	**-.394**	.038	**.385**	.240	-.025	-.277	.038	**.344**	**.390**
Number of locules	-.194	.181	**.350**	-.165	.049	.273	.221	-.083	.116	.150	.189
Leaf width of blade	.096	.018	.031	**-.636**	**.349**	.147	**.326**	.243	**.352**	-.153	-.092
Fruit stalk cavity	-.289	.029	.117	**-.594**	-.135	-.209	.163	-.168	**-.398**	.158	.201
Leaf intensity of green color	**-.339**	**.406**	.014	**.458**	.208	.052	.122	-.086	.190	-.131	.000
Soluble solid content	**-.358**	.178	-.098	**.398**	.275	.042	.123	.272	-.211	.202	-.123
Leaf profile in cross section	**.358**	**.300**	**-.372**	-.034	**.446**	-.110	.003	-.066	-.039	.180	-.292
Leaf undulation of margin	-.111	-.224	-.145	-.164	.012	**.578**	-.116	**.328**	.175	.096	.216
Anthocyanin coloration of hypocotyl	-.024	.272	-.176	.142	.232	-.212	**.468**	-.186	.086	.063	**.313**
Amount of dry matter	**-.354**	.228	.096	.064	.024	.103	**.456**	**.334**	-.214	**.360**	-.143
Leaf shape	**.345**	**.301**	-.192	-.253	.197	-.226	**.414**	-.040	.140	.241	-.221
Fruit shape in cross section	.218	-.089	**-.351**	.142	-.276	**-.476**	-.052	**.482**	.098	.229	.160
Stem hairiness of nodes	**.331**	**.341**	-.065	-.016	.194	.021	**-.343**	.174	.200	-.041	**.352**

Physiological maturity time, flowering initiation, fruit attitude are the first three factors that explain the variance the highest. Fruit diameter characteristics for factor 1 were positively high. The length/diameter ratio of fruit, fruit shape in longitudinal section and capsaicin in placenta were determined negatively in the negative direction. In factor 2, depth of interloculary grooves in fruit, texture of fruit surface, glossiness in leaf and intensity of fruit color (before maturity) were positively high, while the fruit depth of stalk cavity was high. Factor 3, fruit glossiness, fruit thickness of flesh, shape of apex and length of stem have positively contributed significantly to variance (Tab. 4).

The dendrogram generated as a result of clustering analysis is given in Figure 1. The mean of the quantitative properties of the genotypes in the groups in the dendrogram determined in 15 main groups are given in Tables 5–6. M group is the highest in terms of plant height (67.2 cm), soluble solid content (6.3 °Brix), fruit stalk length (5.8 cm) and stalk thickness (9.0 mm), O group is the highest in terms of the highest; length of stem (21.5 cm), fruit diameter (88.3 mm), thickness of flesh (5.2 mm). D group is the lowest in terms of length of stem (12.0 cm), length of internode (3.0 cm), plant height (35.4 cm), fruit diameter (22.5 mm) and fruit stalk length (2.2 cm) (Tab. 5–6). The highest dry matter content was determined with 11.7% in group C, which showed characteristic features of Cemele pepper. The amount of soluble solid was 4.7 °Brix in group C.

The common characteristics of the 15 main groups determined in the dendrogram in terms of the 48 agro-morphological features examined and their differences from the other groups are given below:

A group: A group of 13 genotypes was the group closest to C group in terms of similarity of fruit characteristics. The plants in this group were separated from the C group, showing no anthocyanin coloration of hypocotyl, higher fruit diameter (45.2 mm), lanceolate leaves, weak blistering in the leaves and strong concave profile in cross section of the leaf. This group plants have 8.5 cm leaf length and the longest leaf of all.

B group: It was composed of genotypes closest to A and C groups in terms of fruit characteristics. Since the fruit lengths were shorter and their diameters were larger, the length/diameter ratios were 1.8 and lower than the average of all groups. In addition, the dry matter content of this group is the highest with 11.6%. Physiological maturity time is early in groups A and C, while it is medium in group B.

C group: It was a group of pepper genotypes known as Cemele pepper and 15 genotypes found in this group. The fruits of the plants in this group were dark green with an upright posture in terms of color intensity before physiological maturity, trapezoidal shape was longitudinally dominant and fruit tip shape was slightly flattened. All genotypes in the group were mild and slightly hot because they contain capsaicin. It was early in group A in terms of physiological maturity. Group C contained 11.7% the dry matter, this value after the M group the highest dry matter amount. The fruit length/diameter ratio was determined as 2.9 it was the highest ratio after D group (3.6). The average thickness of flesh was 2.3 mm.

D group: Only the CM10 genotype is included in this group and the lowest length of stem (12.0 cm), length of internode (3.0 cm), plant height (35.4 cm) and fruit diameter (22.5 mm) was determined in this group. The CM10 genotype was determined as an independent group because the leaf glossiness was very weak, fruits have anthocyanin coloring, fruit shape of apex was very depressed, fruits have number of locules mainly three.

E group: There were 6 genotypes in the E group; the longest with 8.6 cm and the widest-leaf genotypes with 5.0 cm in this group. The leaves were green color and the flower and fruit attitude was erect and horizontal. Intensity of color (before maturity) of fruits are light green and the dominant shape of its fruits was close to rectangular and square shape. Fruits were weak glossiness and do not contain capsaicin. The time of physiological maturity of the fruits was valid. 11-B-14 variety grown widely in Turkey are included in this group.

F group: Kandil dolma, Doru 16 and Uras 98 commercial varieties were in this group. Fruits were medium green color in before the physiological maturity. Fruit attitude was drooping and shape in longitudinal section was predominantly square. The fruits were medium bright and the fruits did not contain capsaicin and the physiological maturity time was medium. Soluble solid content was the lowest (3.64 °*Brix*) group after G and L groups (3.6 °*Brix*).

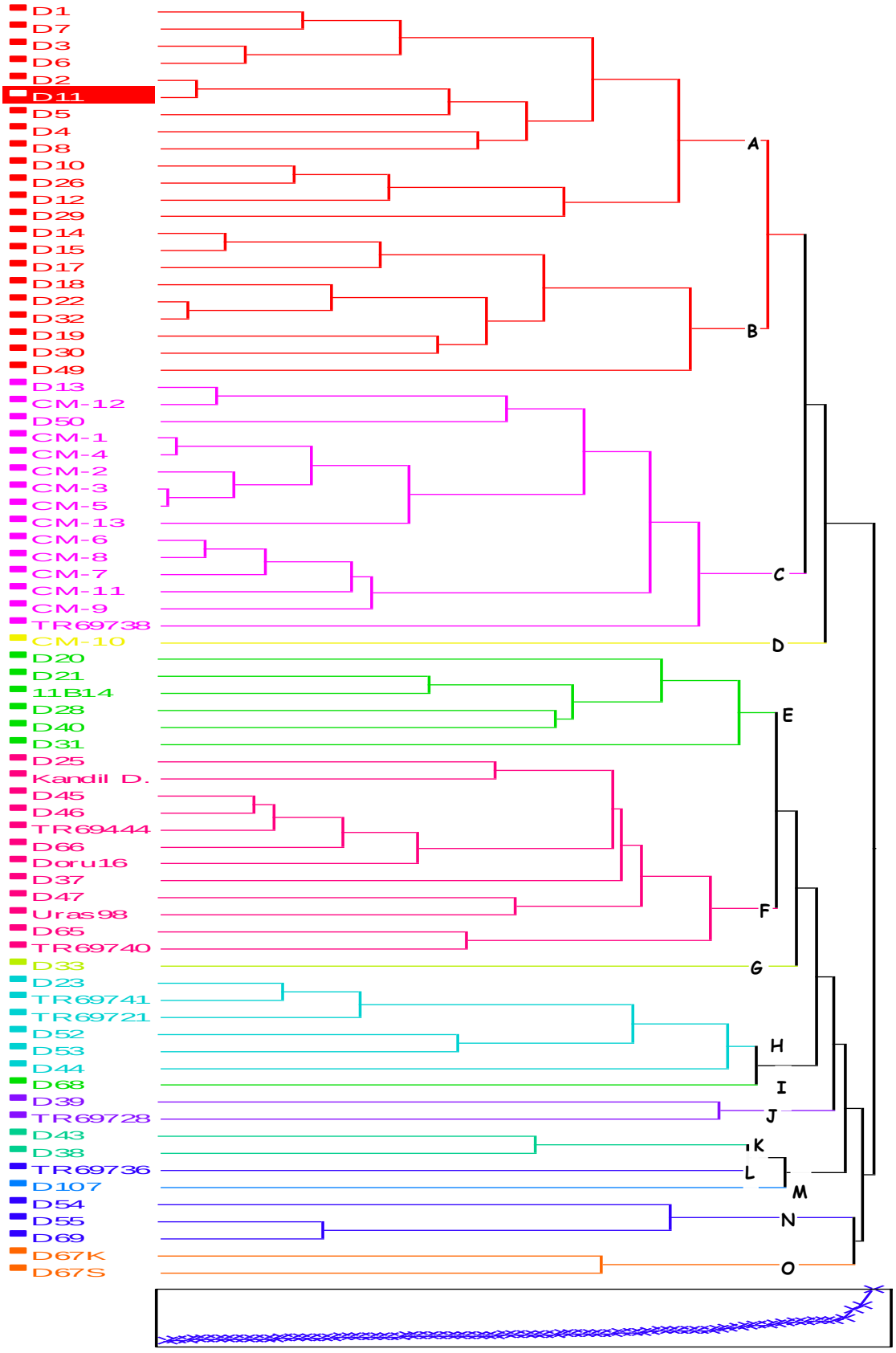

Fig. 1. Dendrogram obtained from cluster analysis

Table 5. Mean values of some quantitative properties of bell pepper genotypes as a result of cluster analysis

Groups	Length of stem (cm)	Length of internode (cm)	Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Fruit stalk length (cm)	Fruit stalk thickness (mm)
A	14.5 ±2.31^{def}	4.0 ±0.64^{g}	41.9 ±3.91^{ef}	8.5 ±1.11^{a}	4.2 ±0.50^{bcd}	3.1 ±0.80^{cde}	7.1 ±0.93^{bc}
B	13.1 ±2.31^{def}	4.4 ±0.80^{efg}	45.5 ±3.78^{de}	8.1 ±0.66^{ab}	4.5 ±0.49^{abc}	3.2 ±0.53^{cde}	6.4 ±0.70^{cdef}
C	12.3 ±3.61^{ef}	4.1 ±1.02^{fg}	40.2 ±6.15^{f}	7.9 ±0.86^{ab}	4.1 ±0.41^{cde}	3.2 ±0.90^{cde}	6.9 ±0.90^{bcde}
D	12.0 ±1.78^{f}	3.0 ±0.16^{h}	35.4 ±1.69^{g}	8.3 ±0.68^{a}	4.2 ±0.38^{bcd}	2.2 ±0.35^{e}	7.1 ±0.51^{bcd}
E	13.2 ±2.24^{def}	4.9 ±0.98^{def}	49.4 ±5.05^{bcd}	8.6 ±0.96^{a}	5.0 ±0.56^{a}	3.2 ±0.71^{cde}	5.9 ±0.96^{defg}
F	15.1 ±2.52^{cd}	4.8 ±0.85^{defg}	46.2 ±4.12^{de}	6.9 ±1.03^{cd}	4.1 ±0.51^{cde}	4.1 ±0.83^{bc}	5.8 ±0.91^{efg}
G	17.2 ±1.25^{bc}	4.2 ±0.43^{fg}	47.4 ±2.96^{cd}	7.3 ±0.43^{bc}	4.7 ±0.41^{ab}	3.2 ±0.28^{cde}	5.1 ±0.91^{gh}
H	13.8 ±2.53^{def}	5.2 ±0.72^{cde}	42.6 ±3.22^{ef}	7.3 ±0.95^{bc}	4.3 ±0.51^{bcd}	4.3 ±1.17^{b}	5.3 ±0.82^{fg}
I	14.9 ±1.56^{cde}	6.9 ±0.71^{a}	53.2 ±2.58^{b}	5.5 ±0.07^{e}	3.6 ±0.13^{e}	3.1 ±0.33^{cde}	6.4 ±0.72^{cdef}
J	13.3 ±1.79^{def}	5.2 ±1.56^{cde}	45.4 ±2.21^{de}	6.8 ±0.98^{cd}	4.0 ±0.63^{cde}	3.1 ±0.82^{cde}	4.9 ±0.74^{gh}
K	18.8 ±1.55^{b}	5.6 ±0.93^{bcd}	51.2 ±8.79^{bc}	6.9 ±0.66^{cd}	4.1 ±0.44^{cde}	3.7 ±0.50^{bcd}	6.4 ±0.75^{cdef}
L	18.0 ±1.54^{b}	5.9 ±0.98^{bc}	49.3 ±2.86^{bcd}	6.6 ±0.59^{cd}	4.0 ±0.39^{cde}	2.5 ±0.86^{e}	4.1 ±0.30^{h}
M	13.3 ±1.35^{def}	6.4 ±0.41^{ab}	67.2 ±1.92^{a}	6.3 ±0.26^{d}	3.9 ±0.27^{de}	5.8 ±0.24^{a}	9.0 ±0.43^{a}
N	14.8 ±1.09^{cde}	4.9 ±0.90^{def}	48.4 ±5.02^{cd}	6.6 ±0.95^{cd}	4.3 ±0.96^{bcd}	3.0 ±0.65^{de}	7.9 ±1.01^{b}
O	21.5 ±1.78^{a}	5.4 ±0.73^{cd}	51.9 ±1.88^{bc}	7.4 ±0.76^{bc}	4.3 ±0.41^{bcd}	5.3 ±1.07^{a}	7.6 ±0.43^{b}
Mean	14.1 ±3.15	4.6 ±1.05	44.8 ±6.40	7.7 ±1.15	4.3 ±0.57	3.5 ±1.01	6.4 ±1.18

The differences between the averages shown in different letters $p < 0.01$ is significant

Table 6. Mean values of some quantitative properties of bell pepper genotypes as a result of cluster analysis

Groups	Fruit length (cm)	Fruit diameter (mm)	Fruit length/ diameter	Thickness of flesh (mm)	Soluble solids content (°*Brix*)	Amount of dry matter (%)
A	9.3 ±1.25bc	45.2 ±6.09^{efg}	2.1 ±0.49^{c}	2.3 ±0.42^{def}	4.6 ±0.65^{bc}	10.8 ±2.28^{abc}
B	8.4 ±1.28^{bcdef}	47.5 ±4.91^{ef}	1.8 ±0.36^{cd}	2.2 ±0.38^{def}	4.5 ±0.83^{bcd}	11.6 ±1.51^{a}
C	8.9 ±0.97^{bcd}	32.7 ±8.05^{ı}	2.9 ±0.65^{b}	2.3 ±0.32^{de}	4.7 ±0.62^{bc}	11.7 ±1.19^{a}
D	8.1 ±0.49^{cdefg}	22.5 ±1.98^{j}	3.6 ±0.42^{a}	2.2 ±0.36^{def}	4.9 ±0.03^{b}	8.1 ±0.34^{de}
E	8.3 ±1.75^{cdef}	50.1 ±9.59^{e}	1.8 ±0.63^{cd}	2.4 ±0.46^{de}	3.7 ±0.48^{de}	10.0 ±2.26^{abcd}
F	7.4 ±1.21^{efg}	49.6 ±6.32^{e}	1.5 ±0.34^{def}	2.5 ±0.56^{de}	3.6 ±0.34^{e}	9.4 ±1.29 ^{bcd}
G	8.7 ±0.37^{bcde}	40.5 ±4.23^{gh}	2.2 ±0.24^{c}	2.2 ±0.28^{def}	3.6 ±0.05^{e}	11.8 ±0.60^{a}
H	8.2 ±1.57^{cdef}	48.7 ±6.30^{ef}	1.7 ±0.43^{cde}	2.5 ±0.66^{de}	4.4 ±0.50^{bcde}	10.4 ±2.07^{abc}
I	7.6 ±0.56^{defg}	70.9 ±3.29^{b}	1.1 ±0.11f^{g}	3.3 ±0.31^{c}	4.0 ±0.04^{cde}	11.4 ±0.17^{ab}
J	11.1 ±2.63^{a}	50.9 ±3.23^{e}	2.2 ±0.53^{c}	2.0 ±0.51^{ef}	4.3 ±0.71^{bcde}	7.2 ±0.85^{e}
K	6.9 ±0.76^{g}	42.4 ±3.30^{fg}	1.6 ±0.23^{de}	2.2 ±0.62^{def}	4.6 ±0.77^{bc}	10.0 ±0.66^{abcd}
L	7.7 ±0.83^{defg}	35.8 ±5.82^{hı}	2.2 ±0.45^{c}	1.7 ±0.25^{f}	3.6 ±0.02^{e}	9.2 ±0.43^{bcde}
M	7.3 ±0.42^{fg}	57.6 ±4.34^{d}	1.3 ±0.11^{efg}	2.7 ±0.31^{d}	6.3 ±0.08^{a}	11.2 ±0.36^{ab}
N	5.2 ±1.45^{h}	64.0 ±13.15^{c}	0.9 ±0.44^{g}	4.3 ±0.59^{b}	4.0 ±0.56^{cde}	8.8 ±2.21^{cde}
O	9.7 ±1.01^{b}	88.3 ±5.83^{a}	1.1 ±0.15^{fg}	5.2 ±0.51^{a}	3.8 ±0.55^{de}	9.8 ±0.76^{abcd}
Mean	8.4 ±1.65	46.4 ±12.95	2.0 ±0.75	2.5 ±0.76	4.3 ±0.79	10.5 ±1.98

The differences between the averages shown in different letters $p < 0.01$ is significant

G group: Only D33 genotype was present in this group. The amount of dry matter in the groups was the highest with 11.80% and the amount of soluble solid content was minimum with 3.6 °*Brix*. The plant habit was upright the only group in all groups. Fruit attitude was horizontal, intensity of color (before maturity) was dark green color, fruit shape in longitudinal section was rectangular, intensity of color (at maturity) was dark red, the fruits were strong glossiness, did not contain capsaicin and flowering was late, maturity was medium.

H group: The fruit attitude was drooping, fruit shape in longitudinal section was square.

The shape in cross section (at level of placenta) was circular in this group while the other groups were angular. The fruit texture of surface was slightly wrinkled and intensity of fruit color (before maturity) was medium green. Flowering and maturity were late.

I group: Only D68 genotype was present in this group. The longest length of internode was in this group with 6.9 cm. Fruit attitude was drooping, intensity of fruit color (before maturity) was very dark green and intensity of fruit color (at maturity) was dark red. Fruit stalk cavity was absent. Depth of fruit interloculary grooves was deep and fruit glossiness is strong. Fruits were very hot and the most hot pepper genotype in all groups was D68. Time of beginning of flowering and maturity were late.

J group: D39 and TR69728 genotypes were in this group. Intensity of fruit color (at maturity) was light yellow in only this group. Shape in longitudinal section of fruit was rectangular. Time of fruit maturity was medium-late and did not contain capsaicin. Dry matter content was the lowest (7.2%) and the fruit length was the highest (11.1 cm) group.

K group: It was the group with two genotypes (D43, D38). The stem length was the highest in this group (18.8 cm) after the O group. Intensity of fruit color (at maturity) was light green, flower and fruit attitude was drooping. Flowering and maturity were medium-late.

L group: Only TR69736 genotype was present in this group. It was the highest plant (18 cm) after the O and K groups. In all groups; the lowest fruit thickness of flesh (1.7 mm), the lowest soluble solid content (3.6 °*Brix*), the shortest fruit stalk length (2.5 cm) and the thinnest fruit stalk thickness (4.1 mm) were determined in this group.

M group: Only D107 genotype was present in this group. It has the highest plant height (67.2 cm), the highest amount of soluble solid content (6.3 °*Brix*), the highest fruit stalk length (5.8 cm) and the stalk thickness (9.0 mm). The flower and fruit attitude were drooping, intensity of fruit color (before maturity) was light green. Intensity of anthocyanin coloration of nodes are strong, intensity of leaf color was dark green. Fruit shape in longitudinal section was moderately triangular. There was no fruit stalk cavity. Fruit shape of apex was moderately acute and the time of maturity is late.

N group: The group with three genotypes is named as tomato pepper because of the fact that the fruit shape in longitudinal section was oblate. It had the shortest fruit length (5.2 cm) and the highest fruit diameter (64.0 mm) after O and I groups. Leaf glossiness was medium. Fruit color (before maturity) was medium green, fruit texture of surface was strongly wrinkled. Intensity of fruit color (at maturity) was dark red and depth of interloculary grooves was deep. Leaf profile in cross section was flat, time of fruit maturity was late together with O group.

O group: It consisted of peppers called “Block” or “California Wonder” types. Intensity of fruit color (at maturity) was red (D67K) and yellow (D67S). Highest; stem length (21.5 cm), fruit diameter (88.3 mm), fruit thickness of flesh (5.2 mm) and fruit stalk length (5.3 cm) were determined in this group. Shortened internode (in upper part) had not only in the N and O group. It was the only group with no anthocyanin coloration in the anthers. Before the physiological maturity the fruits were dark green in color, while yellow and red in maturity. Fruit shape in longitudinal section was square, sinuation of pericarp at basal part and excluding basal part are absent or very weak. Fruit shape of apex was depressed, flowering and maturity were very late.

According to cluster analysis, the degree of distant was 2.36 in CM3-CM5, CM1-CM4, D22-D32 and D2-D11 coded genotypes, showing the most similarity; 23.11 in D1-D20, D20-D54, D54-D67K, D20-D43, D20-D39 and D1-CM10 genotypes, showing the most heterogenity in agronomic and morphological traits. Cross-breeding between genotypes identified as distant relatives increases the chances of achieving high positive heterosis rate in breeding studies.

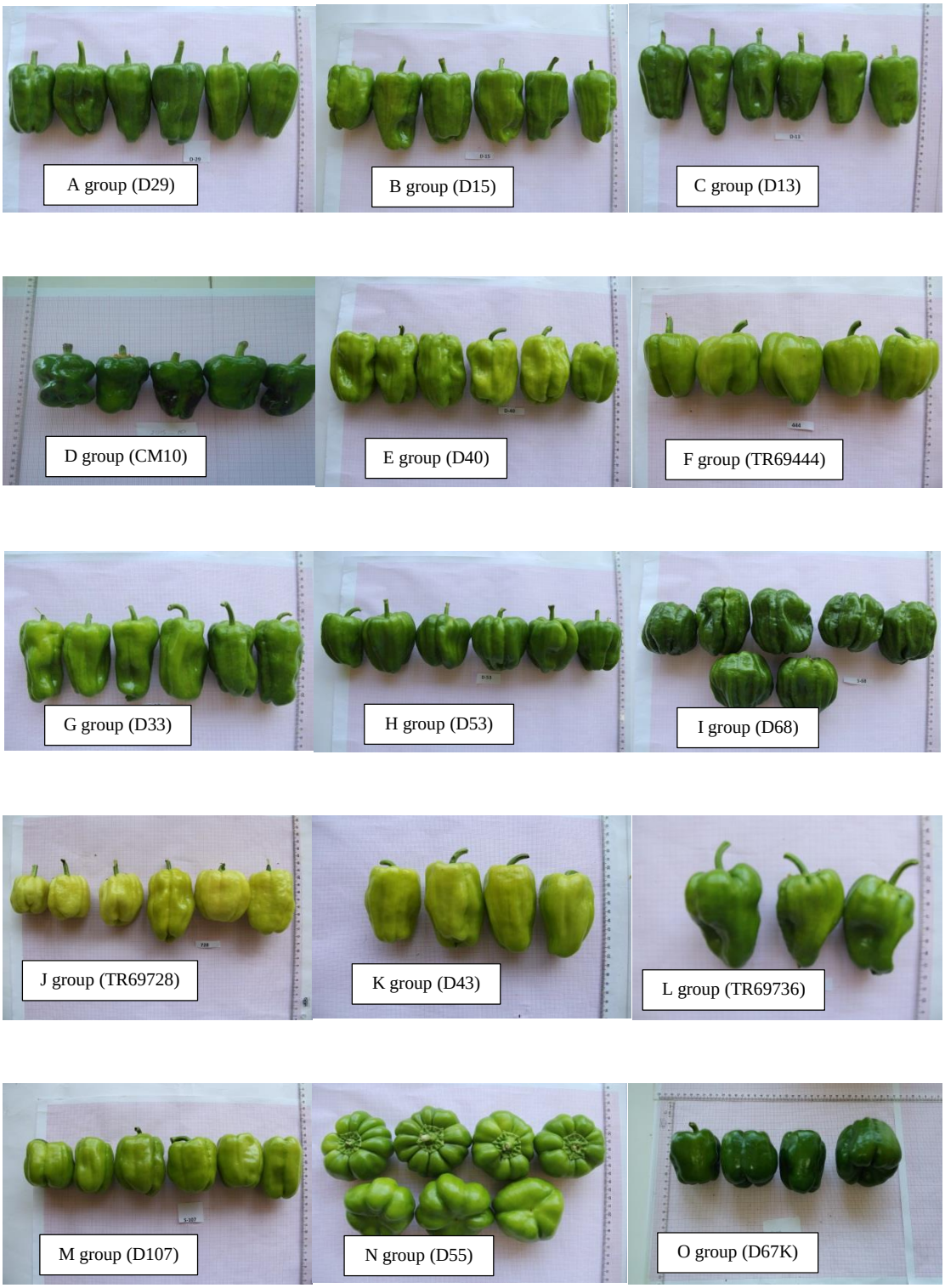

Fig. 2. Genotypes representing 15 groups formed by cluster analysis

Fruit samples of each genotype were drawn on millimeter paper and the fruit picture catalog of the bell pepper genotypes was created. In Figure 2, only 15 fruit images are given due to the high number of genotypes (75 number), as a result of the cluster analysis.

DISCUSSION

As a result of the main component analysis, 11 main component axes related to 48 identification characteristics were obtained and these axes represented 73.25% of the total variance. Aklilu et al. [2016] studied on 49 pepper genotypes and obtained 5 main component axes explaining 75% of the total variance. Ballina-Gomez et al. [2013] conducted the characterization study of 47 morphological features in 18 pepper genotypes and identified 12 main component axes, explaining 94% of the variance. Similar results were reported with pepper genotypes in our country. Bozokalfa and Eşiyok [2010] conducted characterization study with 67 pepper genotypes and identified 77.6% variability in 11 groups in the first year of the experiment, and 71.52% variability in 10 groups in the second year. Binbir [2010] did characterization study on 54 characteristics of 26 pepper genotype and determined that the principal component analysis of 85.35% of the total multiple variation was composed of 9 axes.

The fact that 25% and more of the total variation can be explained by the first 2 or 3 axes in the principal component analysis. The explanation of 2/3 of the principal component axes total variation shows that the cluster analysis is reliable [Mohammadi and Prasanna 2003, Özdamar 2004]. Duman and Düzyaman [2004] reported that in 25 different peppers genotypes by examined in terms of 15 phenotypic features, the first four axes explained 81.77% of the cumulative variance. They found that 29.54% of the variance of the first PC axis was fruit-related characteristics (fruit weight, diameter, thickness of flesh, dry matter rate and number of fruits per plant). Ballina-Gomez et al. [2013] stated that the first axis explained 22% of the total variance and 57% of the fourth axis. Aklilu et al. [2016] reported that the first axis explained 30.5% of the variance, Zewdie and Zeven [1997] reported that 58% of the total variance was represented in the first six component axes.

Although the total variance was determined as high as 73.25%, the cumulative variation in the first three component axes remained at 39.6%. As the reason for this, it is thought to be effective; Cemele pepper was similar to 38 identified genotypes due to the used materials collected only from Kırşehir province, except for four commercial types. Correlation coefficients of fruit-related properties were found to be high in the study. In the first group, 14 of the 27 characteristics, which accounted for 21.91% of the total variance, consisted of fruit-related agro-morphological features. Many researchers who support our findings have reported that a large part of the determined variation is due to fruit-related characteristics [Duman and Düzyaman 2004, Mutlu et al. 2009, Bozokalfa and Eşiyok 2010].

Bianchi et al. [2016] reported that only the fruit diameter feature had a relative contribution of 20.19% in the total variance determine the genetic variation in 30 peppers genotypes. It is thought that the variation in fruit properties can be influenced more by the fruit characteristics of the seed production which is done without observing the isolation distance.

Thin thickness of flesh in both dried and fresh consumed bell peppers is a desired quality feature. In the study, the thickness of flesh of 75 pepper genotypes ranged from 1.54 mm to 5.29 mm and the mean thickness of flesh was determined as 2.50 mm. In accordance with our findings; Binbir [2010] studied on 29 pepper genotype and found out 1.83 to 6 mm flesh thickness (3.34 mm in average). Keleş [2007] determined thickness of flesh in 82 pieces of bell pepper genotype as 1.8 mm to 7.2 mm (3.1 mm in average). Due to the thin thickness of flesh as used a dry pepper Cemele genotypes were found together in the group C fruit thickness of flesh between 2.05 and 2.85 mm, while the average thickness of flesh of 2.34 mm was determined. Compared to the previous study findings, it was determined that most of the genotypes of Kırşehir bell pepper had a thin thickness of flesh which can be considered as dried.

In the grouped dendrogram in terms of 48 agro-morphological features, genotypes in groups A, B,

C and D were grouped as Cemele type peppers in surveys but they were clustered in four different groups due to differences in some characteristics. The most striking point in the groups is that all genotypes obtained from Çayağzı town (except for CM10 genotype) were in group C. Although the genotypes in groups A and B were similar to Cemele pepper characteristics, they were clustered in different groups due to differences in some characteristics of fruits. It is estimated that this situation may be caused by the heterogeneity of genotypes seen with the effect of cross-pollination in the land conditions which the producer has supplied his own seed. It is known that the rate of cross-pollination in pepper can be between 7 to 90% [Allard 1999]. Also, in collection of genotypes collected from Çayağzı District in the group C, as the manufacturer of the region stated, production of the region; ecology, topography and soil structure can be effective on fruit characteristics and quality. In order to determine the accuracy of this estimation, it is necessary to determine the soil characteristics of Çayağzı town are analyzed and their ecological conditions are different from other aquaculture regions.

In the C group where the genotypes showing the typical characteristics of Cemele pepper were found collectively, CM3-CM5 and CM1-CM5 genotype pairs were determined very close to each other in terms of similarity; CM6-D13, CM1-CM13 and CM6-CM9 genotype pairs were determined as the most remote genotypes. This result, if the measure was not taken (protection of pure lines), it is considered as a pre-sign that the purity of genotypes may be impaired in time.

In the study, it was seen that the group A, B and D groups that had agri-morphological features and group C which collects characteristic Cemele pepper genotypes were clearly separated from other groups in dendrogram. It is not correct to express precisely that a genotype differs from the existing varieties without molecular characterization with the results obtained from morphological characterization alone. However, the dendrogram in Figure 1 clearly distinguishes two main groups, all the commercial varieties used in the experiment are in the second group. Cemele pepper genotypes can be taken into breeding program and increase the chance of being a kind of candidate pepper. The present dendrogram gave the opportunity to see the genetical dimensions or kinship, giving cues for breeding studies.

CONCLUSION

The current study was conducted to compare Cemele pepper with other bell pepper genotypes collected from Kırşehir province with respect to their agronomic and morphological traits. At the end of study, we found out that Cemele pepper showed similar performance as other commercial bell pepper genotypes with respect to yield and morphology. We created a pepper database and collected gene pools for advanced pepper breeding studies. Also, the morphological identification data may using for registration of geographical sign of Cemele pepper which has a great potential for vegetable cultivation. Breeding studies for different purposes can be carried out with the created pepper gene pool. To conclude, when compared to the other cultivating bell pepper genotypes, Cemele pepper has potential for bell pepper production.

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