CHARACTERIZATION OF CAPRIFIG (*Ficus carica* var. *caprificus*) ACCESSIONS SELECTED FROM VARIOUS LOCATIONS IN THE EASTERN MEDITERRANEAN REGION OF TURKEY

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Abstract
The study was conducted to investigate the some morphological and pollinizer characteristics on caprifig accessions selected from five locations (Adana, Hatay, Kahramanmaraş, Mersin, and Osmaniye) in eastern Mediterranean region and six standard cultivars ('Ak İlek', 'Armut İlek', 'Elma İlek', 'Hamza', 'Küçük Konkur', and 'Taşlık') from Aydin location in the Aegean Region of Turkey. A total of 27 characteristics included profichi crops of caprifigs were observed in Adana (12 accessions), Hatay (37 accessions), Kahramanmaraş (17 accessions), Mersin (22 accessions), and Osmaniye (9 accessions) locations and six standard cultivars in 2014 and 2015 years. The average fruit weight per profichi crop of the cultivars (30.33 g) in Aydın location and caprifigs (27.41 g) in Hatay location were the highest compared with the caprifigs selected from Adana (23.14 g), Mersin (19.84), Kahramanmaraş (17.57 g), and Osmaniye (16.10 g) locations. The caprifigs in Mersin location had the darkness fruit skin color. The number of gall flowers was highest in cultivars (634.07), whereas the number of male flowers was found to be highest caprifigs (142.41) in Adana location. The pollen viability of caprifigs ranged between 65.76% (Mersin) and 90.51 (Cultivars). The highest of pollen number per profichi fruit were found caprifigs in Adana (824.188). The cluster analysis showed that Hatay caprifigs and standard cultivars and also Kahramanmaraş and Osmaniye caprifigs were partly similar to each other according to morphological and pollinizer characteristics.

Keywords: Caprifig, morphology, location, pollinizer characteristics.

Introduction

Fig is a functionally gynodioecious genus that includes the hermaphrodite (caprifig) and the female (edible fig) flowers (Beck and Lord 1988). The fig has an interesting and special pollination biology. Fig cultivars are grouped into four types based on their pollination requirement and cropping stages (Flaishman et al. 2008). The caprifig crops are not occur edible fruit. The caprifigs are important as a pollen source both for fruit set in the edible figs and fig breeding. The second and third types contain the two groups of edible figs, Smyrna and San Pedro, require caprification, or the pollination of edible figs with pollen carried from caprifig fruits by *Blastophaga psenes* wasps (Galil and Neeman 1977), to set their main crops of fruit. The fourth type, the common figs, are called 'parthenocarpic' fig because they can occur one or two crops per season with or without caprification. Caprification is a common application in fig-growing areas and has a significant effect on the fruit set and quality parameters of edible figs (Condit, 1947, Ferrara et al. 2016). On the other hand, all of caprifigs are not useful in caprification because of important parameters in their special fruit characteristics. The critical characteristics of the caprifig for profichi crops include fruit size, fruit number per shoot, the time of *Blastophaga* wasps exit from caprifig fruits, ripening period, coinciding with the female flowers in edible figs, amount of gall and male flowers, amount of pollen production, pollen viability and germination ratios, inclusion of the mammoni and mamme crops, and free from disease and pests (Ilgin et al. 2007, Caliskan et al. 2016a). Anatolia is one of the center of origin for figs from where they were transplant to other areas (Condit 1947). The native figs in the country serve as a

rich genetic resource for fig breeding. In addition, Turkey is the world's leading fig-producing and numerous cultivated and wild species of fig, including caprifigs, with considerable diversities of fruit color, form and maturing times are found (Caliskan et al. 2016b). 'Sarılop' and 'Bursa Siyahı' figs are major cultivated cultivars. The cultivars and most local cultivars in Turkey, desire caprification for fruit set. Thus, it has become essential to establish a germplasm evaluation program for caprifigs. The study was conducted to characterize some of the plant, fruit and pollinizer qualities of selected caprifig accessions from different locations, in the eastern Mediterranean region of Turkey.

Material and methods

This study was carried out to determine the caprifig accessions collected from Adana, Hatay, Mersin, Osmaniye and Kahramanmaraş provinces located in the eastern Mediterranean region of Turkey, during 2014 and 2015. A total of 22 characteristics included profichi crops of caprifigs were observed in Adana (12 accessions), Hatay (37 accessions), Kahramanmaraş (17 accessions), Mersin (22 accessions), and Osmaniye (9 accessions) locations and six standard cultivars from Aydın province ('Ak İlek', 'Armut İlek', 'Elma İlek', 'Hamza', 'Küçük Konkur' and 'Taşlık'). The characterization of plant material was carried out using the IPGRI (International Plant Genetic Resources Institute) and CIHEAM (International Centre for Advanced Mediterranean Agronomic Studies) descriptors for *F. carica* L. (IPGRI and CIHEAM 2003). A total of 27 morphological characteristics were investigated. The pomological analysis used this study have been described previously by Caliskan and Polat (2012). Fruit weight (FW, g) was investigated with a scale sensitive to 0.01 g (Precisa XB 2200 C, Precisa, UK). Digital calipers (0–150 mm; BTS Tools, Malaysia) were used to determine fruit lengths (FL, mm) and widths (FW, mm), fruit neck lengths (NL, mm) and ostiole widths (OW, mm). Fruit skin colors were evaluated by a colorimeter (Chroma Meter CR-300, Minolta Co., Osaka, Japan). Color parameters were expressed as L*, a*, b*, *C* and *h°* (Francis 1980). Fruit skin color was measured at two opposite locations per fruit. Fruit yields per mamme, profichi and mammoni crops were classified based on fruit numbers per shoot according to the standard fig descriptor. Mature profichi fruits from which *Blastophaga* wasps had not exited and in which anthers had not dehisced and leaves were collected for these examinations. The morphological analyses were conducted on 30 profichi fruits and 30 leaves for each accession. Three replicates, each consisting of 10 fruits or leaves, were performed. Also, 20 profichi fruits were evaluated for estimate pollinizer traits. Pollen viability and germination tests were investigated in ten fruits per accession. The mature profichi fruits were taken to room temperature with dry environment and then split open longitudinally and spread out to dry on aluminum foil on a laboratory bench. After 1 or 2 days, fruits had dried and all anthers had dehisced. The pollens were placed in glass jars (25 ml), then stored at 4 °C in a refrigerator (Storey 1975). Pollen viability was observed using 2,3,5-triphenyl tetrazolium chloride (TTC) staining. Pollen was evenly dusted onto the surface of the TTC solution and held at room temperature for 2 h under daylight. Pollen grains were investigated using a light microscope (x40; Nikon Eclipse E200, Japan). Pollen with bold red color was calculated as viable and colorless as nonviable. In vitro pollen germination was examined using Petri dish method (Eti 1991). Pollens were sown on culture with a clean brush, and incubated under dark conditions at 25 °C for 24 h. The culture medium included 1% agar, 3% sucrose, 100 ppm H_3BO_3, 300 ppm $Ca(NO3)_2$, 200 ppm $MgSO_4$ and 100 ppm KNO_3 at pH 5.0 (Caliskan et al., 2016b). Pollen germination was scored in four random fields of three Petri dishes for each caprifig. A pollen grain was evaluated germinated when the pollen tube length was equal to or greater than the pollen grain width. The numbers of anthers from three replications of 20 flowers per caprifig accession were counted, and after pollen shed, the number of pollen grains was observed using a hemocytometer (Eti, 1990). Pollen production per flower was calculated by multiplying the number of anthers per flower by number of pollen grains per anther. Pollen production per fruit was then investigated by multiplying the number of flowers per fruit by the number of pollen grains per flower. The numbers of male flowers per fruit, numbers of anthers per flower and numbers of gall flowers per profichi fruit that contain *Blastophaga* were also examined for each accession. These investigations were performed using five fruits per accession. The fruits

were stored at -20 °C until investigations. Each profichi fruit was divided into five or six pieces and the numbers of gall flowers that included *Blastophaga* wasps were counted. The numbers of anthers were also evaluated using five male flowers per fruit. Data were analyzed using SAS software (SAS, 2005). Analysis of variance tables were established with Duncan multiple range test at $p<0.05$. To evaluate dissimilarity among locations, cluster analysis was carried out using UPGMA (Unweighted Pair-group Method with Arithmetic Mean).

Results and discussion

Morphological and pollinizer characteristics of caprifig accessions were shown in Table 1. The effects of the locations on the caprifig characteristics except for anther number per flower, shoot length and profichi number per shoot were statistically significant ($p<0.05$). The mean fruit weight, fruit diameter and fruit length values were highest in the standard cultivars of Aydın location (30.33 g, 45.21 mm and 56.12 mm, respectively). The longest fruit neck length was found caprifigs in Osmaniye (13.47 mm) whereas the neck length was the lowest caprifigs in Mersin (9.58 mm). The lowest ostiole width was observed in Mersin location (0.93 mm). Khadivi-Khub and Anjam (2014) estimated that fruit weight varied from 11.52 to 38.12 g, fruit width varied from 18.60 to 34.70 mm, fruit length varied from 25.30 to 55.60 mm and ostiole width varied from 5.80 to 15.00 mm in Iranian caprifigs.

Table 1. Morphological and pollinizer characterization of caprifig accessions selected from different locations in the eastern Mediterranean region of Turkey.

Variable	Adana	Hatay	Kmaras	Mersin	Osmaniye	Aydın
FW	23.14 bc	27.41 ab	17.57 cd	19.84 cd	16.08 d	30.33 a
FD	40.70 a	44.32 a	38.95 ab	41.55 a	32.98 b	45.41 a
FL	52.55 ab	54.95 a	41.06 c	40.48 c	45.61 bc	56.12 a
FNL	13.05 ab	12.20 ab	11.66 ab	9.58 b	13.47 a	12.34 ab
OW	1.56 cd	1.90 bc	2.92 a	0.93 d	1.75 cd	2.47 ab
L	57.43 a	49.96b	48.53 b	47.07 b	51.62 ab	52.14 ab
a	-15.45 b	-15.32 b	-13.59 b	-6.80 a	-16.46 b	-16.46 b
b	39.97 a	40.38 a	24.97 c	33.35 b	40.96 a	42.84 a
C	43.72 b	47.65 ab	41.32 bc	36.19 c	47.11 ab	51.21 a
h°	106.69 ab	91.91 bc	110.79 a	80.61 c	94.17 bc	82.76 c
GFN	484.85 bc	521.48 ab	376.31 c	423.88 bc	521.68 ab	634.07 a
MFN	142.41 a	134.03 ab	98.28 b	128.34 ab	116.08 ab	131.01 ab
AN^{ns}	4.42	4.49	4.32	4.21	4.30	4.45
PV	87.20 ab	86.72 ab	84.92 ab	65.76 c	73.06 bc	90.51 a
GP	56.54 a	38.17 bc	44.74 ab	25.22 c	46.43 ab	42.34 ab
PNA	1343 a	1225 a	1417 a	703 b	1068 ab	1414 a
PNFL	5789 a	5236 a	5855 a	3030 b	4723 ab	5827 a
PNFR	824.188 a	708.809 a	543.852 ab	390.296 b	599.557 ab	722.090 a
SL^{ns}	17.73	12.99	12.32	14.82	13.75	13.76
SD	8.24 bc	8.63 b	6.91 c	7.89 bc	8.14 bc	10.08 a
LN	5.53 bc	5.10 bc	6.12 b	5.30 bc	4.73 c	9.88 a
LL	19.11 ab	19.23 ab	12.79 c	19.16 ab	17.82 b	21.23 a
LW	16.20 b	15.59 b	11.03 c	16.57 ab	14.90 b	18.48 a
LA	313.38 b	306.55 b	137.85 c	335.00 ab	287.22 b	396.58 a
PN^{ns}	3.78	3.89	4.01	3.71	3.51	4.82
MN	0.15 b	0.07 b	0.00 b	0.10 b	0.11 b	2.58 a
MAN	0.16 bc	0.22 bc	0.04 c	0.36 b	0.14 bc	1.42 a

FW; fruit weight (g), FD; fruit diameter (mm), FL; fruit length (mm), FNL; fruit neck length (mm), OW; ostiole width (mm), GFN; gall flower number, MFN; male flower number, AN; anther number, PV; pollen viability (%), GP; germination percentage (%), PNA; pollen number per anther; PNFL; pollen number per flower, PNFR; pollen number per fruit, SL; shoot length (cm), SD; shoot diameter (mm), LN; leaf number per shoot; LL; leaf length (cm), LW; leaf width (cm), LA; leaf area (cm^2), PN; profichi number per shoot, MN; mammoni number per shoot, MAN; mamme number per shoot.
^{ns}; non-significant.

The lightness (L) caprifig fruit skin colors were measured in Adana location (57.43). The highest a* value was detected in Mersin location (-6.80). The lowest b* values was found in Kahramanmaraş location (24.97). Caliskan and Polat (2012) indicated that lowest L*, C and h° values are correlated with darkest fig skin colors. The darkness fruit skin colors were measured caprifigs in Mersin location with the lowest chroma (*C*) and hue (*h°*) values (36.19, and 80.61, respectively). However, most of the caprifigs had the green skin colors. Some researchers showed that the fruit skin colors of caprifigs are mainly green (Condit 1955, Khadivi-Khub and Anjam 2014). The number of the gale flowers per profichi varied from 376.31 (Kahramanmaraş) and 634.07 (Aydın). The number of male flowers per profichi was highest in Adana location (142.41) while it was lowest in Kahramanmaraş location (98.28). Khadivi-Khub and Anjam (2014) displayed that the number of *Blastophaga* in profichi fruits ranged between 4.0 and 267.0 in Iranian caprifigs. Previous reports showed that when the pollen viability was over 50% (Gaaliche et al. 2013) and pollen germination was over 30% (Dokuzoguz 1953), the pollen can be considered functional. Pollen viability ranged between 65.76 (Mersin) and 90.51% (Aydın) and pollen germination ranged between 25.22 (Mersin) and 56.54% (Adana). The pollen numbers per anther, per flower and per fruit were the highest Aydın, Adana and Hatay locations (1414, 5827, 722.090; 1343, 5789, 824.188; and 1225, 5236, 708.809, respectively).
Shoot diameter was ranged from 6.91 (Kahramanmaraş) to 10.08 mm (Aydın). Leaf number per shoot, leaf length, leaf width, leaf area values of caprifigs were the highest in Aydın location (9.88, 21.23 cm, 18.48 cm and 396.58 cm^2). The highest mammoni number per shoot was found in Aydın location (2.58) whereas mammoni number per shoot was not observed in Osmaniye location. Mamme number per shoot was ranged between 1.42 (Aydın) and 0.04 (Kahramanmaraş).
The UPGMA dendrogram based on morphological and pollinizer variables measured 96 caprifig accessions selected from six locations were presented in Figure 1. The six locations can be divided into two main groups. The subgroup A included the locations of Adana, Hatay and Aydın. The caprifig accessions in Hatay and Aydın locations were showed very similar to each other depend on morphological characteristics such as fruit size, fruit neck length, pollen numbers. The caprifigs selected from Kahramanmaraş, Osmaniye and Mersin locations were classified in the group B. Kahramanmaraş and Osmaniye with similar fruit size, fruit skin color, pollen viability and germination and shoot length values were in the same subgroup.

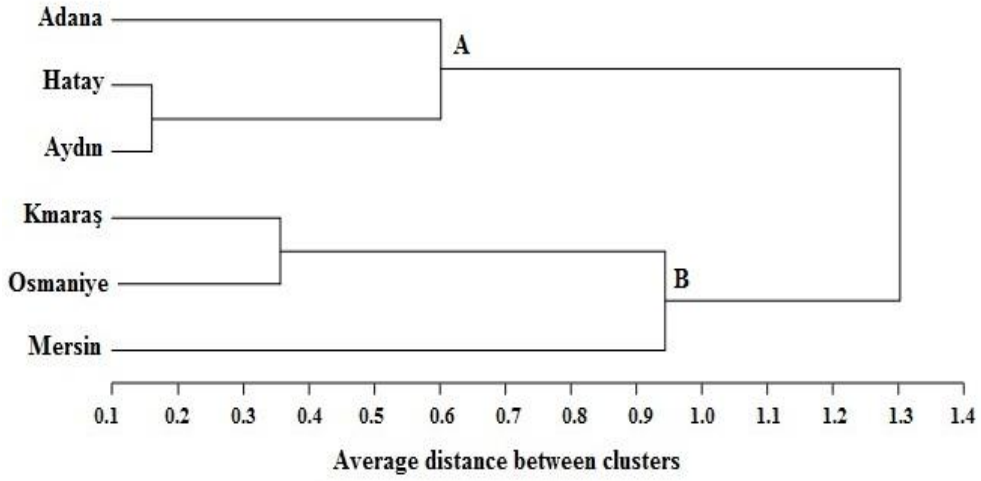


Figure 1. UPGMA dendrogram by using morphological parameters in the caprifig locations

Conclusions

Caprification is very critical for the edible fig culture. Unfortunately, there has been a few study into the genetic resources possible for caprifig germplasm. Further, the morphological and pollinizer parameters of caprifig accessions have not been characterized in detail. The study showed great variation in morphological parameters of caprifig accessions from different locations, eastern Mediterranean region of Turkey. According to these results, the caprifig accessions of Adana, Hatay,

Kahramanmaraş, Mersin and Osmaniye locations found in the eastern Mediterranean region of Turkey can be commonly used for caprification.

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