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# Pomological diversity of fig (*Ficus carica* L.) accessions of kermanshah, Iran

**Kyomars Abbasi[1], Isa Arji[2*]**

[1]*Department of Horticulture, Faculty of Agriculture, Islamic Azad University, Karaj, Iran*

[2]*Department of Seed and Plant, Agricultural and Natural Resources Research Center, Kermanshah, Iran*

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**Abstract**

The fig (*Ficus carica* L.) is one of the oldest fruit trees cultivated in Iran. Kermanshah province is located in the west of Iran. It have sub climate that fig grow by farmers and have some genotypes as wild fig. Many specific fig genotypes are much appreciated locally and nationally. Identification of plant germplasms is very important for each country, so this study was focused on fig accessions in farmer orchard of Kermanshah province. Results revealed a large variability within the local fig accessions, so 23 different accessions were distinguished in this work. A total of 28 quantitative and qualitative fruit traits were determined according to the fig descriptors prepared by SPCRI (2008). All quantitative and qualitative fruit traits were not suitable for fig identification. Selecting the most informative variables is very important to facilitate the fig identification. In this study, variable were selected based on Pearson correlation and 11 quantitative and qualitative fruit traits from the initial 28 variables were used for cluster and principal component analysis (PCA). The first four components (PC1-PC4) explained more than 71.72 % of total variability. The first three components PCA was discriminated the sampled accessions in five groups and accounted for about 61.4% of the total variability among the fig accessions. Cluster analysis was performed using these 11 factors and accessions were divided into 5 main clusters. These results reveal that there are a lot of local fig accessions that are very important in genetic pool of fig in Iran.

***Corresponding Author:** Isa Arji ✉ issaarji@gmail.com

## Introduction

Iran is characterized by a wide range of environmental conditions and rich natural biodiversity. The common fig (*Ficus carica* L., 2n = 26) belongs to the family *Moraceae*, with over 1400 species classified into about 40 genera. The genus *Ficus* contains about 700 species, mainly found in the tropics and currently classified into six subgenera (Berg, 2003). The fig (*Ficus carica*) probably originated in Western Asia and spread to the Mediterranean (Tous and Ferguson, 1996). Wild or "nearly wild" figs are reported throughout much of the Middle East and Mediterranean region (De Candolle, 1886). Iran is the fourth largest producer of fig with more than 76,414 tons production in 2010 (FAO, 2012). The fig trees are grown all over the country and mostly located on the marginal lands, in mixture with other fruit trees (mainly olive, grape and Pomegranate), or scattered at the periphery of orchards, and in home gardens.

Kermanshah is one of main places that natural populations of figs are very sparse in it. They are sporadically encountered in the regions of *Quercus* sp. forests in temperate regions of kermanshsh. So there are some genotypes in orchards of fig growers and as wild, so both are important as potential sources of variability; these genotypes can be used to introduce new genes or alleles in the cultivated fig. Fig cultivation is limited to a small number of locations, including Rijave, Golain, and Paveh regions and distributed as individual trees in others regions. Due to the high nutritive value of fig fruit and its favorable effects on human health (Chessa, 1997, Kader, 2001 ,Wang *et al.,* 2003, Solomon *et al.,* 2006, Shukitt-Hale *et al.,* 2007), the fig tree is of great importance throughout the world.

There are several figs genotypes in Kermanshah provinces, these genotypes have not yet been investigated and their identity is unknown. Therefore, it is a crucial necessity for discrimination between these landraces for conservation of plant genetic resources and improvement purposes (Sadder and Ateyyeh, 2006; Rout and Mohapatra, 2008). Varietal discrimination and identification could be achieved either by morphological and/or molecular markers (Saddoud *et al.,* 2008).

Despite the advances in molecular markers in fig characterization (Achtak *et al.,* 2009; Giraldo *et al.*, 2005, 2008; Ikegami *et al.,* 2009; Khadari *et al.,* 2005 Rodrigues *et al.,* 2012, Aka-Kaçar *et al.*, 2003), morphological markers have been used for many years for identification and characterization of genotypes. In fig, several reports demonstrated the usefulness of these markers in documenting variability in their genotypes (Salhi-Hannachi *et al.,* 2006; Saddoud *et al.,* 2008; Padgornik *et al.,* 2010 Gozlekci, 2010, Babazadeh Darjazi, 2011, Mahdavian *et al.,* 2008; Aliskan and Polat 2012). Morphological traits are useful for preliminary evaluation because they facilitate fast and simple evaluation and can be used as a general approach for assessing genetic diversity among morphologically distinguishable accessions. Moreover, morphological markers continue to be the first step for the description and classification of any germplasm as well as useful tools for screening the accessions of any collection (Cantini *et al.,* 1999).

The present study is the first inventory aimed at characterizing the genetic diversity and detecting similarities of some fig genotypes grown in different regions of Kermanshah province using pomological descriptors.

## Materials and methods

*Plant material*

The study was conducted on 23 fig (*Ficus carica* L.,) accessions selected from different regions of Kermanshah province include Paveh, Dalaho, Sahneh, Sarpole Zehab, Kermanshah, Salas, and Ravansar during the growing season of 2012. 23 accessions were studied (Table 1). Three trees with at least 10 years old were selected and evaluated from each accession.

**Table 1.** Number, Name and Region of studied fig accessions.

| Number | accession | Region | Number | accession | Region |
|---|---|---|---|---|---|
| 1 | Bavameli | Dallaho | 13 | Zard Talaei | Paveh |
| 2 | Siaveleh Riz | Dallaho | 14 | Siave | Paveh |
| 3 | Lashei | Dallaho | 15 | Zardak Limoei | Paveh |
| 4 | Malekmohammadi | Dallaho | 16 | Rashe Zemestani | Paveh |
| 5 | Shamamleh | Dallaho | 17 | Koeicheh | Paveh |
| 6 | Siaveleh Dorosht | Dallaho | 18 | Daym | Ravansar |
| 7 | Zardleh | Dallaho | 19 | Ghire Vahshi | Ravansar |
| 8 | Sham | Dallaho | 20 | Savze | Salas |
| 9 | Kochleh | Dallaho | 21 | Choarkot | Sarpol |
| 10 | Majifi | Paveh | 22 | Paraei | Kermanshah |
| 11 | Solaimanieh | Paveh | 23 | Golabi | Sahneh |
| 12 | Mamakhaje | Paveh | | | |

*Pomological traits*

A total of 28 quantitative and qualitative fruit traits were determined according to the fig descriptors prepared by SPCRI (2008). Quantitative and qualitative fruit traits were measured on 30 fruits of each tree for each accession. Fruit weight (FW) was measured with a scale sensitive to 0.01g. Fruit length (FL), Fruit diameter (FD), Stalk length (SL), Neck length (NL), Ostiole diameter (OD), Opening Ostiole (OO), and Fruit number per shoot (FN/Sh) were measured by a digital caliper (Guanglu, 0 - 150 mm). 20 qualitative fruit characters are measured on 30 fruits for each tree of each accession based on fig descriptor: Fruit shape (FSH), fruit size (FS), Fruit skin ground colour (FSGC), Fruit skin overcolour (FSOC), Fruit lenticels quantity (FLQ), Fruit lenticels colour (FLC), Fruit lenticels size (FLS), Pulp internal colour (PIC), Fruit cavity (FC), Latex Content (LC), Fruit Skin Firmness (FSF), Amount of Achene (AA), Achene size (AS), Fruit ribs (FR), Fruit skin cracks (FSC), Abscission of the stalk from the twig (AST), Ease of peeling (EP), Crop setting fruit (CSF), Beginning of fruit maturation (BFM) and Abnormal Fruit (AF).

*Data Analysis*

The data collected for each variable were analyzed using SPSS (Version 11.5). In the first step correlation between measured characters were determined by the Pearson correlation. Some characters where had less correlation reduced and selected characters (11 quantitative and qualitative fruit traits) were used for cluster and principal component analysis (PCA) (Giraldo *et al.*, 2010). Scatter plots of the first three principal components were created. The trait greatest amount of variation were determined by the PC scores, where the eigenvalues >1. Only factor loadings equal or greater than 0.5 were considered strong correlation between principal component, quantitative and qualitative traits. Relationships among the genotypes evaluated by using unweighted pair group method with arithmetic mean (UPGMA) cluster analysis based on the similarity matrix developed with the Pearson's coefficients among the 11 PCs selected in this work from the qualitative and quantitative pomological characters.

**Results and discussion**

A total of 28 quantitative and qualitative fruit variables were listed by SPCRI (2008) for Fig descriptor show 22 principal components that explain 100% of the total variability. Giraldo *et al* (2010) applied sequential statistical procedures to select the most discriminant variables in fig (*Ficus carica L.*) from the initial 134 qualitative variables studied. A total of 34 variables was finally selected and broken down in 97 characters that were grouped by principal component analysis in 11 principal components that explain 93.34% of the total variability. In this work as there were poor correlation between selected variables and usually the first three principal components are important. We decide to reduce the variables by the Pearson correlation (Giraldo *et al.*, 2010). A total of 11 variables was finally selected

grouped by principal component analysis in 11 principal components that explain 100% of the total variability but in this work data published for only those by eigenvalues >1. PCA for variable number reduction has been used for Fig (*Ficus Carica* L.,) (Giraldo *et al.,* 2010).

The eigenvalues obtained by PCA indicate that the first four components provide a good summary of the data. They explained more than 71.72 % of the variability observed was explained by the first four components (PC1-PC4) (Table 1.). The first component (PC1), accounting for 29.84 % of the total variance, is nominated by fruit characters, namely fruit length (FL), Abnormal Fruit (AF), Fruit shape (FSH), Ostiole diameter (OD), and Fruit weight (FW). In the second component (PC2), Fruit ribs (FR), Fruit skin ground colour (FSGC) and Abscission of the stalk from the twig (AST) that explained 19.85 % of the variance. In the third component (PC3), Fruit diameter (FD), and Amount of Achene (AA) were explained 11.72 % of the variance. Finally, the fourth principal components (PC4) belong to the Beginning of fruit maturation (BFM) were accounts 10.32. % of the total variance.

Similar results were reported for Fig (*Ficus Carica* L.) by Saddoud *et al.* (2008) where they shown that the first three axes of the PCA amounted to 81.9% of the total variability for fruit traits. Total variability of 31 shoots, leaf, and fruits traits of 17 Fig (*Ficus Carica* L.) cultivars was reported by the first three PCs (Gaaliche *et al.,* 2012). More than 61.90 % of the variability observed was explained by the first three components by Aljane *et al.,* (2012) for 17 fig accessions based on 16 morphological and chemical characters.

Three-dimensional diagram of the first three principal components (PC) for the 23 fig accessions shown in fig 1. Five group is observed when the accessions are plotted on the first three PCs. Group 1 included 2 accessions (22=Paraei and23= Golabi). The second group included 3accessions (8=Sham, 12=Mamakhaje and 19= Ghire Vahshi). The third group contained 7 accessions (10=Majifi, 18=Daym, 2=Siaveleh Riz, 21=Choarkot, 7=Zardleh, 13=Zard Talaei and 15=Zardak Limoei). The fourth one constituted by 5 accessions (5=Shamamleh, 11=Solaimanieh, 3=Lashei, 4= Malekmohammadi and 20=Savze). The fifth group consisted of 6 accessions (6=Siaveleh Dorosht, 14=Siave, 1- Bavameli, 16=Rashe Zemestani, 9=Kochleh and 17=Koeicheh).

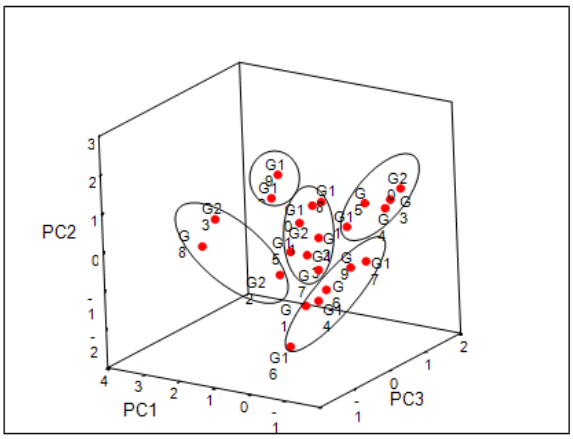


**Fig. 1.** Three-dimensional diagram of the first three principal components (PC) for the 23 fig accessions analyzed in this work.

The first three components PCA was discriminated the sampled accessions in five groups and accounted for about 61.4% of the total variability among the fig accessions, base on fruit qualitative and quantitative characters. Groups are placed as shown in Fig1. This grouping was similar to dendrogram based on all characters (Fig 2) except to accession 8 (Sham) located in group 1. Sham accession has large fruit like Paraei and Golabi accession. A similar grouping is observed when the accessions are plotted on the first three PCs for 35 fig accessions. They conclude four groups distinguished based on the first three components PCA and dendrogram clustering (Giraldo *et al.,* 2010). Our results generally coincide with the results obtained by Gaaliche *et al.*, (2012), Aliskan and Polat 2011. The similar results between the PCA and cluster analysis showed that pomological traits analysis can provide reliable information on the variability in fig tree.

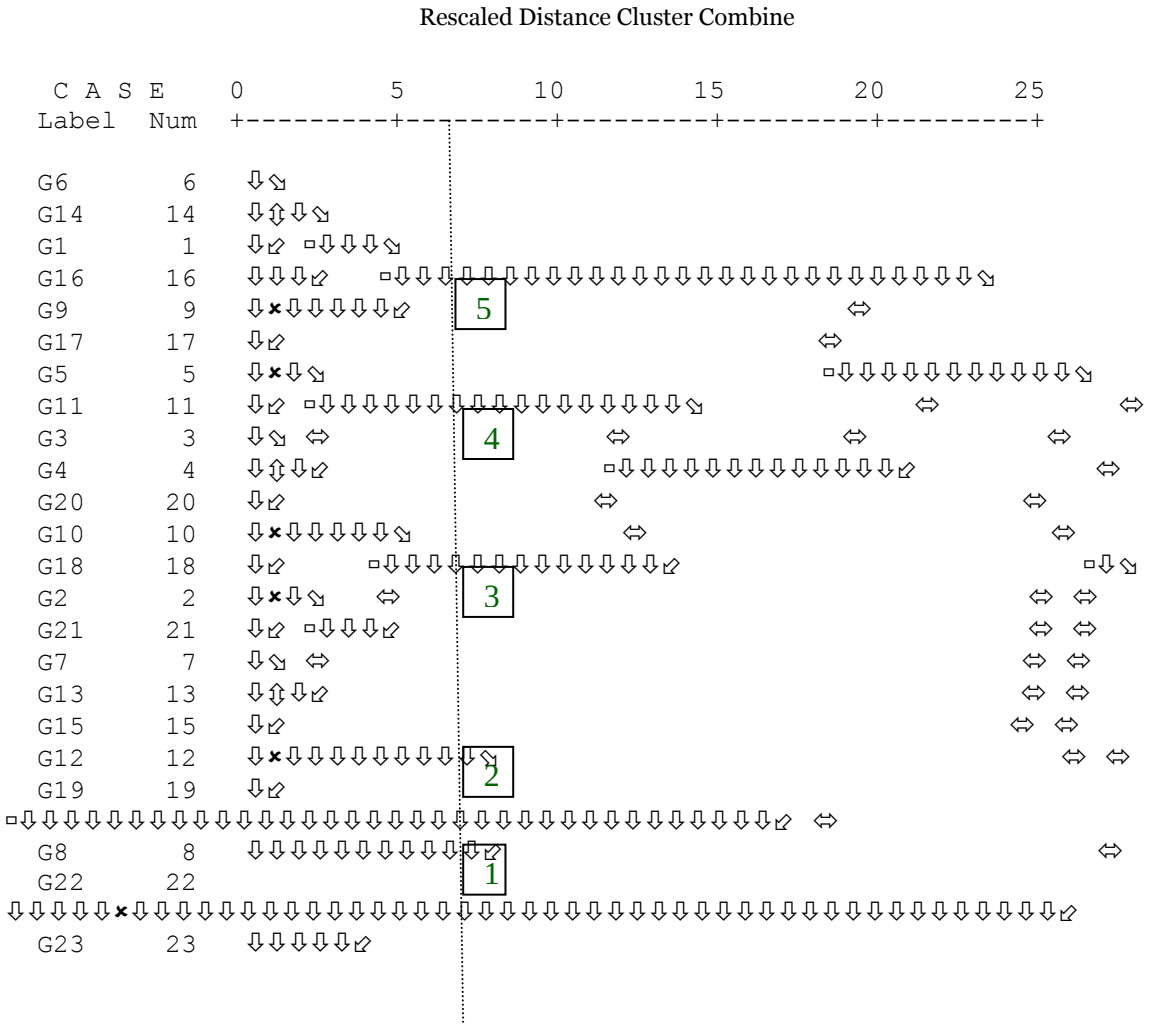


**Fig. 2.** UPGMA dendrogram (based on Ward Method) of 23 fig accessions performed using pomological characters.

The UPGMA dendrogram, obtained based on squared Euclidian distance clustered cultivars into five major groups (Fig 2). Group 1 included 2 accessions (Paraei and Golabi) that were found to have large fruit and higher abnormal fruit. The second group included 3accessions (Sham, Mamakhaje and Ghire Vahshi) they have small to medium fruits with high fruit weight. The third group contained 7 accessions (Majifi, Daym, Siaveleh Riz, Choarkot, Zardleh, Zard Talaei and Zardak Limoei) which are characterized by a medium fruit ribs (FR), and Fruit skin ground colour (FSGC). The fourth one constituted by 5 accessions (Shamamleh, Solaimanieh, Lashei, Malekmohammadi and Savze). These accessions have a high fruit diameter (FD) and Low fruit length (FL). The fifth group consisted of 6 accessions (Siaveleh Dorosht, Siave, Bavameli, Rashe Zemestani, Kochleh and Koeicheh) which are characterized by large ostiole (OD) and easy abscission of the stalk from the twig (AST). Fig accessions are numerous and well adapted to local agro ecological conditions of Kermanshah so, Kermanshah have a source of fig collection that very important for future breeding or cultural programs. Numerous investigations have been performed aimed at identifying the morphological and pomological characteristics of fig (*F. carica* L.) cultivars in Iran (Babazadeh Darjazi, 2011; Safaei, *et al.,* 2008; Mahdavian *et al.,* 2008; Sabet, 1998). They shown there were genetic diversity in fig population in different region of Iran and in this work we are

determined a good genetic diversity of fig population in west of Iran.

*Correlation within traits*

The correlations of the qualitative and quantitative pomological characters were evaluated with Pearson correlation analysis. Significant Pearson correlation was found. Relationships between all pomological characters were expressed in a correlation matrix (Table 2). These correlations are important for the agro industrial profitability. The highest positive significant correlation (0.821) was between fruit length and abnormal fruit. So accessions with very large fruit had the highest abnormal fruit (group 1). There was a significant negative correlation between Ostiole diameter and abnormal fruit and poor or negative relation with all other mentioned traits. Fruit shape had the significant correlation with fruit length. Fruit weight have the positive correlation with fruit length, fruit diameter, fruit shape, abnormal fruit, the Beginning of fruit maturation (BFM), and abscission of the stalk from the twig (AST). This correlation can be explained by the great relationship of these characters. These could be as fruits with larger in size would also have higher length, diameter. The correlation within fruit length (FL) and achene amount (AA) was significant negative. So longer fruit had some problem with pollination. There was positive significant correlation between fruit diameter (FD) and fruit ribs (FR). Achene amount (AA) had the positive correlation with Ostiole diameter (OD) and negative correlation with abnormal fruit.

**Table 2.** Factor loadings for each trait on the component analysis of PCA analysis.

| | PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|---|
| Eigenvalues | 3.283 | 2.183 | 1.289 | 1.135 |
| % of Variance | 29.843 | 19.847 | 11.716 | 10.320 |
| Cumulative % | 29.843 | 49.690 | 61.406 | 71.726 |
| Character* | | Eigen value | | |
| FSh | **.705** | -.051 | -.197 | .460 |
| FL | **.877** | -.057 | -.083 | -.132 |
| FD | -.007 | -.514 | **.736** | -.048 |
| FW | **.504** | .336 | .332 | -.068 |
| OD | **-.674** | -.244 | -.057 | .294 |
| FSGC | .267 | **.658** | .083 | .443 |
| AA | -.461 | .310 | **.626** | .246 |
| FR | .198 | **-.809** | .233 | .140 |
| AST | .342 | **.585** | .319 | .074 |
| BFM | -.417 | .431 | .049 | **-.635** |
| AF | **.834** | -.173 | .173 | -.358 |

*See Pomological Traits in Material and Methods

**Table 3.** Correlation matrix between measured fruit characteristics.

| | FSh | FL | FD | FW | OD | FSGC | AA | FR | AST | BFM | AF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FSh | 1 | | | | | | | | | | |
| FL | 0.573** | 1 | | | | | | | | | |
| FD | -0.081 | -0.063 | 1 | | | | | | | | |
| FW | 0.263 | 0.357 | 0.116 | 1 | | | | | | | |
| OD | -0.289 | -0.403 | 0.129 | -0.344 | 1 | | | | | | |
| FSGC | 0.300 | 0.083 | -0.160 | 0.359 | -0.228 | 1 | | | | | |
| AA | -0.311 | -0.423* | 0.156 | -0.078 | 0.222 | 0.096 | 1 | | | | |
| FR | 0.176 | 0.142 | 0.461* | -0.134 | 0.000 | -0.386 | -0.159 | 1 | | | |
| AST | 0.109 | 0.284 | -0.203 | 0.224 | -0.336 | 0.348 | 0.277 | -0.214 | 1 | | |
| BFM | -0.436* | -0.282 | -0.084 | 0.014 | 0.067 | -0.021 | 0.170 | -0.439* | 0.011 | 1 | |
| AF | 0.361 | 0.821** | 0.217 | 0.293 | -0.603** | -0.022 | -0.347 | 0.233 | 0.234 | -0.231 | 1 |

**Conclusion**

As a result of this present study, we conclude that the pomological characteristic is an adequate tool for identification of fig accessions. Variable reduction based on data correlation is a use full toll for better managing of fig (*Ficus Carica* L.) identification. These results reveal that there is a lot of local fig accession that could contribute to further studies.

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