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# Ethnobotanical and *on Farm* Genetic Surveys of Fig (*Ficus carica* L.) Genetic Resources in Kerkennah Islands

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## ABSTRACT

Fig tree (*Ficus carica* L.) is characterized by a wide genetic diversity in Tunisia although it is considered as a secondary species. In Kerkennah islands, despite several biotic and abiotic stresses, local population has conserved the fig germplasm. This species is very well suited to the harsh environments. In order to enhance *on farm* conservation of fig genetic resources and to have inventory of related traditional knowledge (TK), a global survey was conducted among a wide range of stakeholders and local governmental agencies in Kerkennah archipelago. For this purpose, prospections were done during two successive years covering the totality of the islands. A total of 9 locations and 26 sub-locations were visited. Twenty four farmers were solicited. Surveys have taken into account sex, age of farmers, predominant agricultural activities of farmers, field area, fig cultivated varieties, land management, traditional knowledge, production and its use, source of incomes and marketing of production. Participatory Four Cell Analysis (FCA) allowed the classification of fig cultivars regarding the threat level of loss and the adequate manner of conservation. Results of this study showed that it is imperative to pay particular attention to threatened and rare cultivars. Hence, the importance to conserve such diversified germplasm. *On farm* conservation program is a suitable alternative for such region for preservation of traditional knowledge, cultivars rehabilitation and a sustainable agriculture.

## Introduction

Fig tree, a gynodioecious species (male caprifigs and female trees), with 2n = 26 chromosomes (Storey, 1967), is probably the oldest domesticated crop by more than 10.000 years ago (Kislev et al., 2006). Nowadays, the common fig grows wild in some Mediterranean zones where it has been cultivated for its edible fruits for millennia in close association with olive and grapevine (Zohary and Hopf, 1988). Several studies described genetic resources characterization using morphological parameters (Saddoud et al., 2008; Gaaliche et al., 2001; Baziar et al., 2018). Several molecular markers were used in order to assess genetic diversity such as SSR (Saddoud et al., 2005,

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2007; Perez-Jimenez et al., 2012; Boudchicha et al., 2018), AFLP (Baraket et al., 2009a), ITS (Baraket et al., 2009b) and to evaluate genetic conformity after *in vitro* propagation (Bayoudh et al., 2015). Tunisia, considered as secondary center of diversification or micro-gene-center for several fruit tree species, is still holding significant amount of genetic diversity. Fig area accounts 34000 ha with a production of 27000 tones on 2017 (DGPA, 2017). These fruit tree genetic resources, including fig, represent an excellent heritage conserved through generations together with traditional knowledge (TK). Nowadays, conservation and utilization of genetic resources are well recognized as absolute priority. Their importance has been highlighted in the strategic plan for biodiversity 2011-2020 and the Aichi targets (CBD, 2014). Over the last century, islands biodiversity has become one of the most threatened places of the world. Although many island conservation plans address biodiversity requirements at the species level, few plans address the spatial requirements of the biodiversity processes that underpin the persistence of these species (Lagabrielle et al., 2010). Local fig germplasm is very diversified and represented by numerous autochthonous cultivars such as Bither Akhal, Bither Abiadh, Baghli, Temri, Dchiche Assal, Kahli, Marchini, Mahdoui and Bouong (Saddoud et al., 2007). These cultivars are result of many years of systematic domestication and improvement by unknown numbers of farmers. Due to the increased pressure on agriculture, local cultivars and landraces are the most threatened germplasm (Saad et al. 2001). Furthermore, caprifigs are as important as female trees. Local production of caprifigs is insufficient, that's why price of caprifigs can exceed largely those of edible figs especially in the early period of caprification. The most common caprifig cultivars in the islands are Assafri and Bithri. Conservation of local fig germplasm must take into account the concordance between the period of caprification and the maturity of caprifigs. Several surveys were conducted in order to make inventory and describe fruit genetic resources in Kerkennah Islands and *ex situ* conservation of Kerkennah fig cultivars was undertaken since the last decade in two field genebanks situated in south-west (Rhouma, 1996) and center-east of Tunisia (Mars, 1995). The linkages among *ex situ* and *on farm* conservation strategies is very important as highlighted by Professor Scarascia Mugnozza. The loss of biodiversity could result implications on environmental, socio-economic, political, and ethical management of plant genetic resources (Pagnotta and Noorani 2018). Nowadays, implementation of *on farm* conservation needs identified farming areas, farmers and crop types. *On farm* conservation is targeted to smallholder farmers and areas where technologies are not easily accessible (Joshi and Upadhya 2019). It is worth to valorise PGR in order to ensure their sustainable use. Barberi et al. (2013) have thought that consumers today seem to be convinced by the importance to conserve biodiversity and to appreciate valorization of their own roots and identity while appreciating family farming and local knowledge.

Aware of the importance of *on farm* genetic conservation of fig, several investigations have been conducted in Kerkennah islands since 2004 and later with the Tunisian National Genebank, since 2012, with several collecting missions and surveys. The aim of this study is 1) to make an ethnobotanical survey and 2) to enhance *on farm* conservation of traditional cultivars.

## Materials and Methods

### *Description of the study area*

Kerkennah is a Mediterranean archipelago located a few kilometers from Italian (Lampedusa and Sicilia) and Maltese islands. It is at about 15 miles from Sfax coasts in southern Tunisia with a total agricultural land of about 14500 ha. The archipelago stretches

over 18.000 ha and consists of two main islands. The main one, named "Wide Kerkennah" or "Cherguia", is oriented northeast (Fig. 1). In the South, the second island is "Mellita" or "Gharbia". The archipelago accounts also seven uninhabited small islands fringed the north coast. The highest points in Kerkennah archipelago rarely exceed 13 meters above the sea level. It has a Mediterranean semi-arid climate. The average annual rainfall is about 246 mm. Temperature ranged from 7 to 32°C.

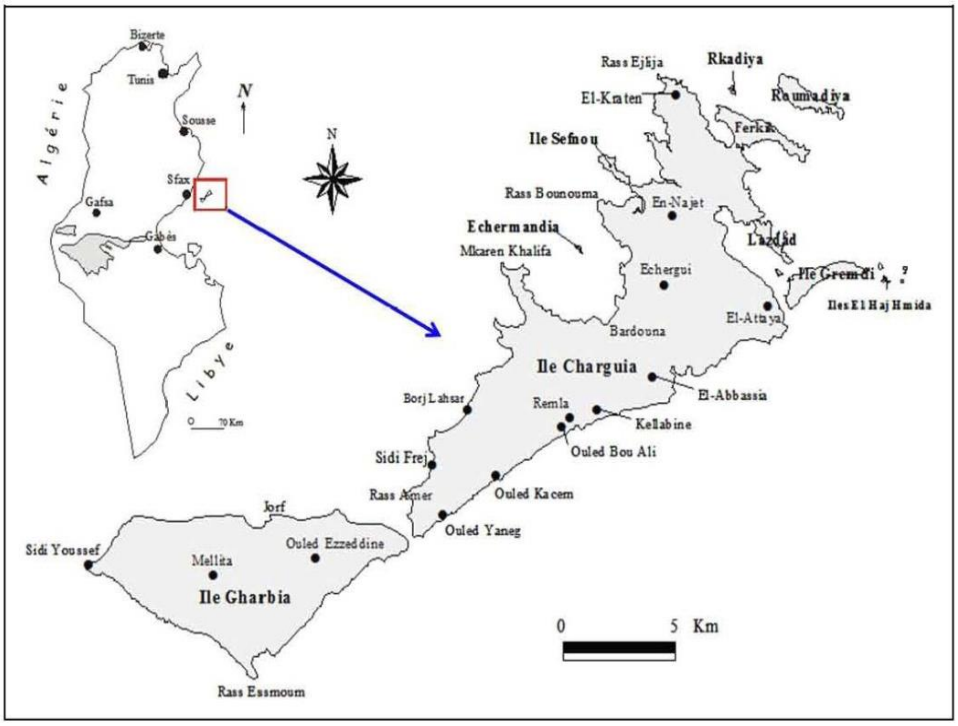


**Fig. 1.** Kerkennah geographical location (Source: Feuilles topographiques au 1/25000, Ministry of Equipment, Tunisia)

### *Ethnobotanical surveys procedure*

The aim of this study was to investigate inventory of local fig genetic resources and to enhance *on farm* conservation of fruit genetic resources. For this purpose, a general survey was conducted in all Kerkennah archipelago including nine villages. We carried out interviews on 24 farms.

The procedure of surveys was:

- Meeting and identification of villages and farmers with the local authorities from the ministry of Agriculture.
- Interview in the villages or the farms of the small scale farmers (one or a group of persons).
- The information gathered was concerned of sex, age and predominant agricultural activities of farmers, field area, fig cultivated varieties, land management, traditional knowledge, production and its use, source of incomes and marketing of production.
- A last meeting was taken place to confirm the information's gathered and to synthetize the results of surveys.

### *Four Cell Analysis 'FCA'*

Considering, inventoried local fig cultivars, the "Four-Cell Analysis" (FCA) was used to understand the fig germplasm distribution in the archipelago. It is a participatory approach that facilitates the distribution of varieties and to identify common, unique and rare plant genetic diversity (Sthapit et al., 2006). Farmers interviewed classified the cultivars regarding the cultivated area, the number of the householders, and the number of varieties and trees per variety.

## Results

Kerkennah islands, located in the south part of Tunisia, may be regarded as one of the most traditional and typical *on farm* conservatories for fig trees. Kerkennah islands are considered as an agro-ecosystem where custodian farmers still conserving autochthonous fig cultivars together with grapevine, olive and some cereals and forage, whose cultivation still adapt to poor soil and severe climate conditions. Custodian farmers are that conserved and maintained agro-biodiversity and the related traditional knowledge during time. They are also recognized in their communities for that.

### *Ethnobotanical study*

Surveys have allowed evidencing agro specificities of the region. The majority of farmers were 40 to 70 years old, with the highest proportion being 60 to 70 years old (Fig. 2). The proportion of men (81.5%) is dominant as compared to women (18.5%) (Fig. 3). The predominant agricultural activities of the farmers are plantation of particularly fruit trees (Fig. 4).

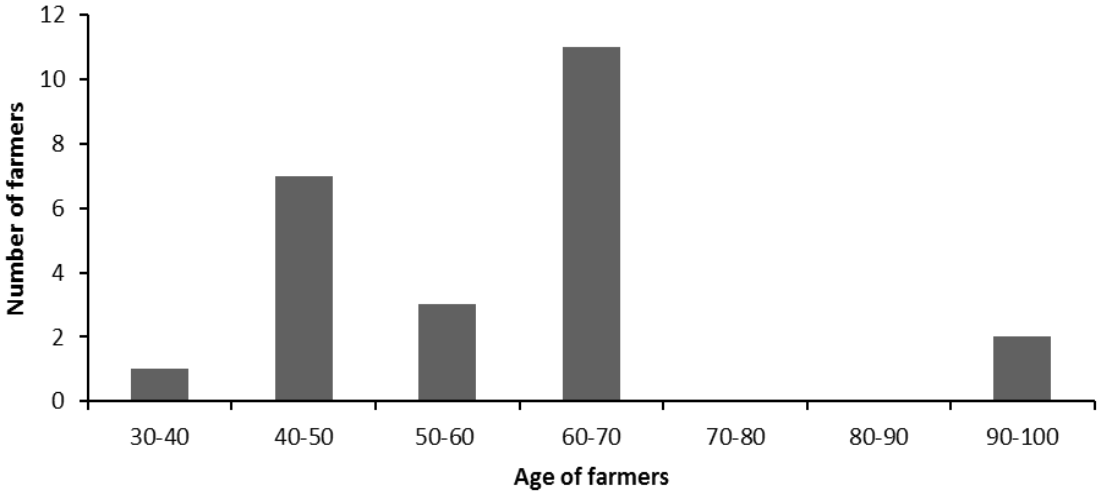


**Fig. 2.** Distribution of farmers regarding to their age in Kerkennah islands

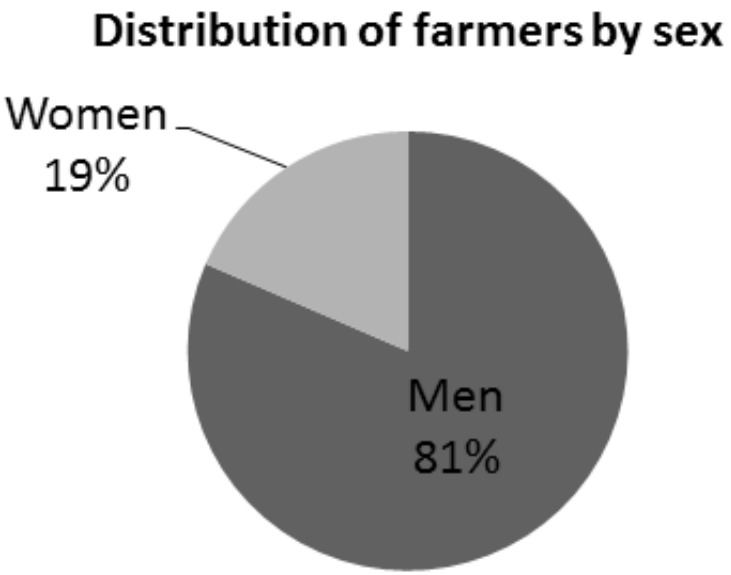


**Fig. 3.** Distribution of farmers regarding to sex in Kerkennah islands

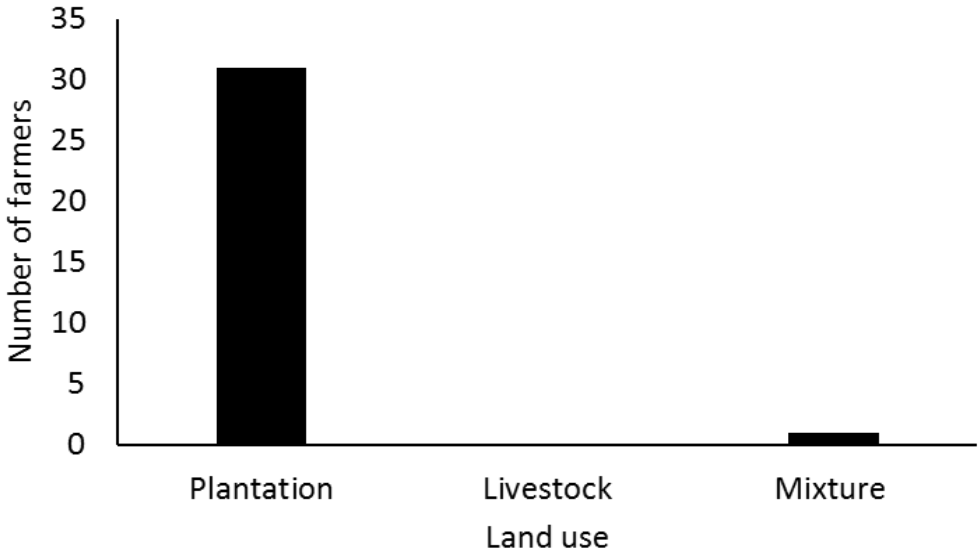


**Fig. 4.** Predominant agricultural activities in Kerkennah islands

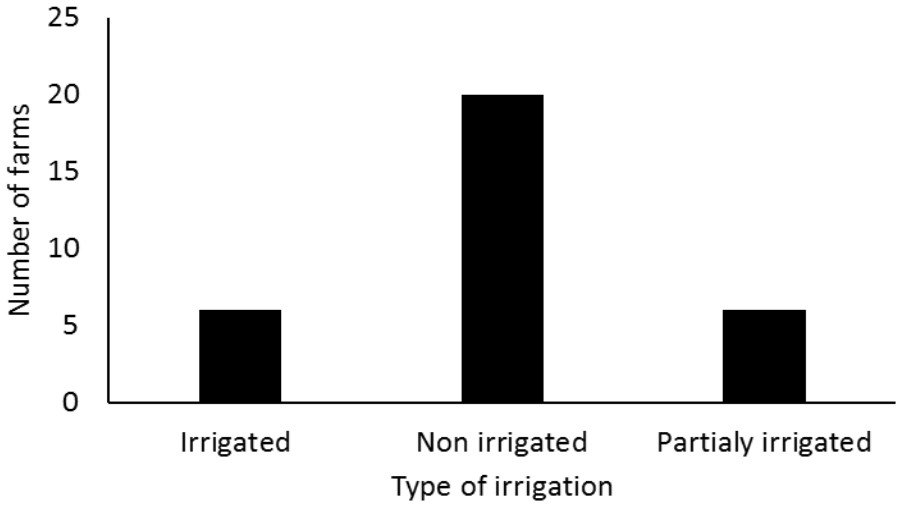


**Fig. 5. Land management for the type of irrigation in Kerkennah islands**

Almost 100% family farmers are the smallholders managing farmland. The cultivated lands are very small and 45% of them are less than 0.2 ha. The cultivated fig ranged from 2 to 11 with a mean of 5.22 cultivar/per field. The total number of cultivars in all islands is about 16. Almost the totality of fields are non-irrigated (Fig. 5). The production is used for both fresh and dried products. For all the farmers interviewed the production of fig is a secondary source of incomes. Thus, the majority of farmers are cultivating and collecting fig as a hobby, since the marketing of production is made 100% at the local level.

### *Traditional knowledge and uses associated with the fig tree*

More than conserving genetic diversity of fruit trees, local population has preserved a large number of best practices. The caprification that needs a special knowledge is one of the most common practices in the islands. This tradition is very old and still used. Farmers used to put caprifgs in the underside of female tree leaves using a quill of palm (Fig. 6).

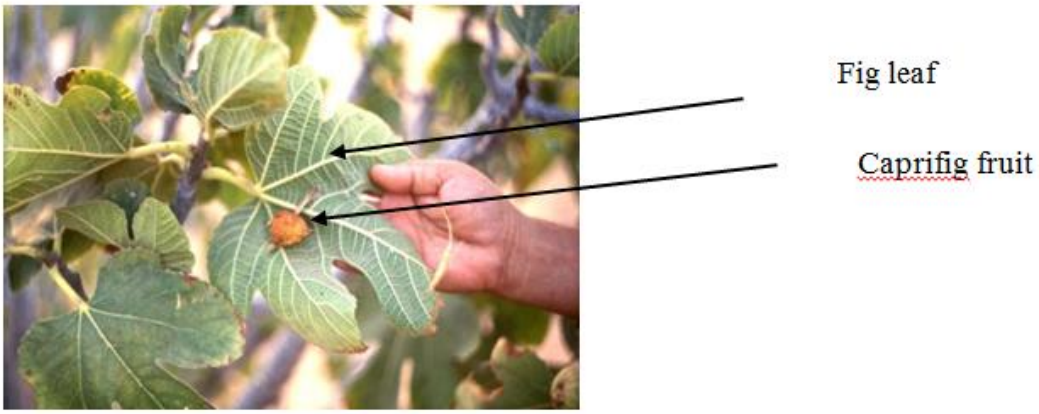


**Fig. 6.** Traditional caprification technique in Kerkennah Island

Thus, the fig wasp (*Blastophaga psenes*) that carry pollen from caprifig fruits can enter easily to syconia (fig fruit) of female trees. Farmers used to place syconia from male fig tree on female fig trees (Smyrna and San Pedro types) at the proper period for pollination. Farmers master the caprifig cultivation that produces three generations of figs ensuring the wasp generations.

Otherwise, women in Kerkennah islands have used to dry the surplus of fresh fig in order to ensure supplementary sources of incomes but also a food source during winter where the island could be isolated due to storms. These fruits are commercialized in local market, and, in many times, the prices are considerably high for both fresh and dried products. Figs, grapes and carobs are the main organically dried fruits in Kerkennah islands using palms (date palm leaves) or leaves of *Pituranthos chloranthus* (Guezzah) as a support for fruit solar drying. Farmers have acquired valuable knowledge for traditional drying figs that can be conserved for two years or more in olive oil. Local inhabitants have been using these products for gastronomy. Dried figs are used for the preparation of several traditional dishes in many ceremonies. Generally, they are used for the preparation of juice highly rich in vitamins that contain dried fig, carob and raisin mixed with fennel. They serve also for the preparation of many sweets. Dried figs have many medicinal properties. They have been recommended to facilitate the intestinal transit, to correct anemia, to reduce hypertension and to increase fertility for both man and women.

## Participatory four-cell Analysis

This approach was used to classify the local fig cultivars together by farmers, development agencies technicians and scientists. Sixteen fig cultivars were considered. Four groups of cultivars were obtained (Fig. 7).

Mahdaoui, Baghli, Bither Abiadh, Bither Akhal, Dchiche Assal and Kethri were considered as common cultivars, and are cultivated in large area and from many householders. *On farm* conservation is the suitable method for this group. A threatened group is compound by cultivars Zidi, Hamri, Bouong and Temri. It is necessary to enhance the cultivation of these cultivars since they are cultivated by only few householders. Also, for Bouang and Temri, it would be wise, for a better conservation, to improve the valorization of their fruits and derived products intended for local consumption. Otherwise, it is worth to pay a special attention to cultivars considered as rare: Jebali, Kettani, Marchini, Mlouki and Badri. These are cultivated in small areas and from few holders. It is necessary to undertake the conservation of these cultivars *ex situ* in fruit trees collection and to develop, simultaneously, a regional program for their rehabilitation.

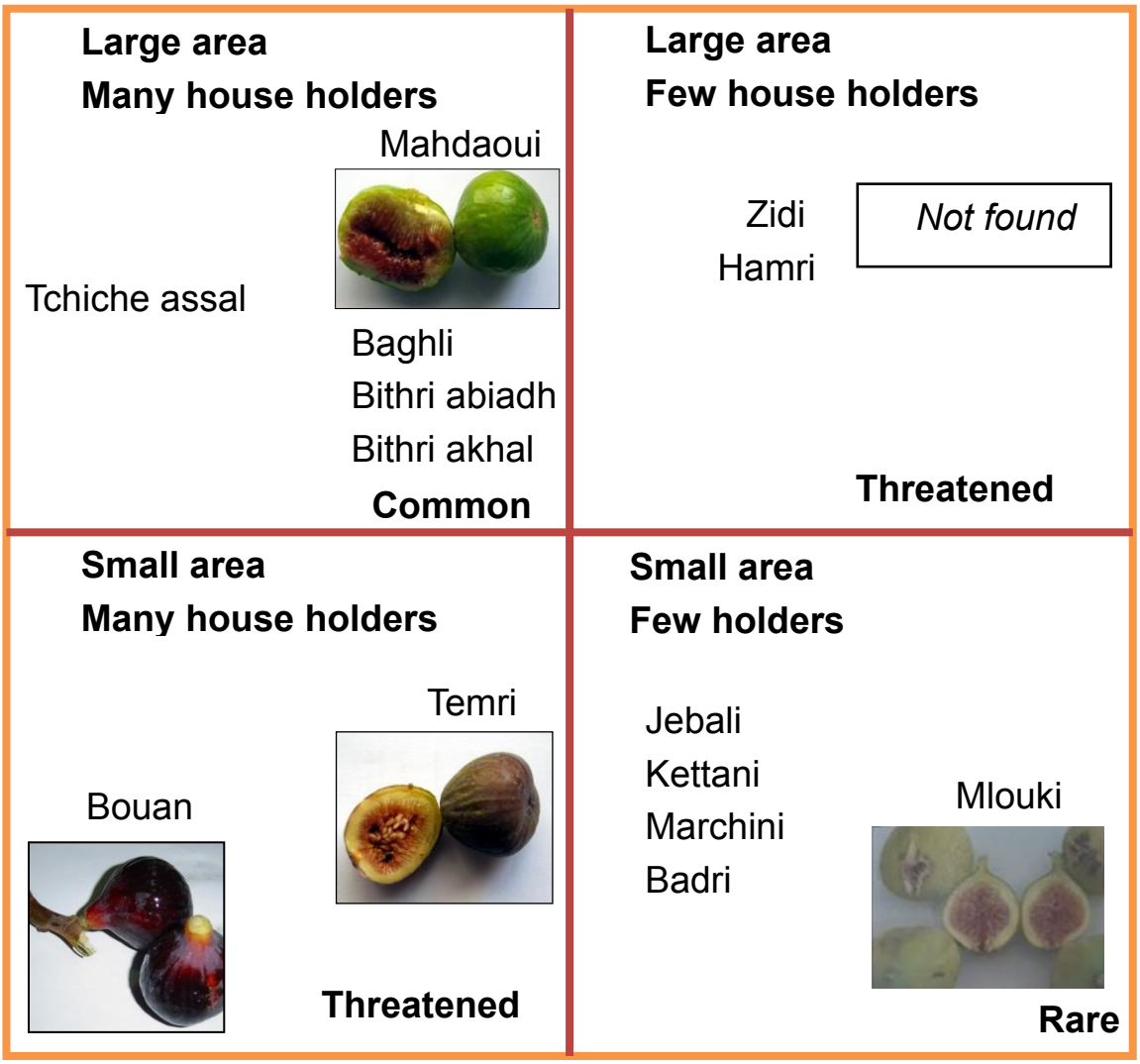


**Fig. 7.** Classification of local fig cultivars according to their distribution following FCA in Kerkennah Island

## Discussion

The islands, for their geographical isolation, are richer in genetic resources than other continental areas with the same size. Genetic diversity is larger in small islands far from the cost, where it is possible to find landraces and wild endemism with new ethnobotanical information (Hammer et al., 1999; Laghetti et al., 2000). The Tunisian islands are a reservoir of plant biodiversity for the country (Médail et al., 2020). Kerkennah is onto these islands, regarding its geographical isolation to the land, lack of industrial activities, and a reduced touristic activity could be candidate territories for conserving highly adapted eoctypes. Many studies were interested to investigate the flora diversity (Médail et al., 2015, Médail et al., 2020). Furthermore, it could be considered as a model for *on farm* conservation of fruit genetic resources. It has preserved a traditional agriculture and special attention to fig cultivation. Such agro-ecosystem can hold highly adapted ecotypes and landraces (Hammer and Laghetti 2006). In spite of climate conditions, low quality of soils and scarce water resources, farmers in the Kerkennah islands are convinced of the importance of the conservation of their local heritage of biodiversity. Herodotus, at the 5$^{th}$ century described Kerkennah formerly named Cyrannis. The archipelago was covered with olive groves and vineyards and constituted a

port for boats from the East (Fehri, 2000). Kerkennah islands have an ancient agricultural tradition as reported in ancient writings. Louis André (1961) even speculated that the Carthaginians were behind the introduction of olive cultivation in Kerkennah islands. Insular communities have been persuaded of the quality and flavor of their local fruits. The development of agro-ecological technologies and systems which emphasize the conservation and regeneration of biodiversity, soil, water and other resources is urgently needed to meet the growing array of socioeconomic and environmental challenges. Although, cultivars were preserved *ex situ*, *on farm* conservation offers a dynamic process, where genotypes are constantly under the action of human and natural selections (Barberi et al., 2013).

Kerkennah islands have preserved genetic resources diversity given their isolation from the main land and involvement of generations and families in agricultural activities. The particular mode to appropriate lands called "Rogbia" is another characteristic influencing the property features in the Kerkennah Islands. Traditionally, in Kerkennah the land may belong to a person and the trees to another person (Rhouma et al., 2005). Fig (*F. carica* L.), is one of the most cultivated and spread fruit crops along the islands (Mars and El Hamrouni, 2000).

Farmers in Kerkennah have preserved large genetic base of fig cultivars. All the types of fig (common, Smyrna and San Pedro) are still present in the archipelago. Minangouin (1961) was impressed by the fig variety Asli, highly appreciated for its fine fruits, very sweet taste and earliness, but the grain is very small and skin very resistant. This variety was inventoried in our survey. Itis named Tchiche Assal very appreciated and typical of the island. It was also repertoried by Saddoud et al. (2007).

Underutilized traditional crops such as local fig cultivars and others species are essential for food security of smallholder farmers (Nilsen et al., 2015). This large diversity is a considered as resilience against many biotic and abiotic stresses. The value of ancient orchards as mentioned by Calabrese and Tartaglini (2012) is not only related to the level of biodiversity which hold but to the sustainable management of the natural resources using low environmental impact farming practices.

Many disasters have occurred because of the narrow genetic base of crops, which offers little resistance to certain biotic and abiotic stresses (Lebot, 1992). One strategy for conserving biodiversity of fruit trees and the related traditional knowledge is the implementation of PDO (Protected Denomination of Origin) or other labels as IG (Geographical Indication) (JORT, 1999). This allows valorization, sustainable use and conservation of both genetic resources and traditional knowledge of farmers. Some fig cultivars of Kerkennah such as Baghli, Dchiche Assal and Mahdoui are particularly indicated for the implementation of a label. It is very advantageous to promote fig conservation in Kerkennah islands by the establishment of origin indication.

The effectiveness of existing protection of farmer's intellectual property tools continue to be discussed at international level (FAO, 2017). Indigenous and local communities consider and appreciate traditional knowledge as a part of their cultural identities. Maintaining and preserving the traditional knowledge can give rise to development of local technologies, to ensuring a sustainable development and maintaining their intellectual and cultural identity (WIPO, 2005). Furthermore, *in situ* conservation, is to be undertaken as a complementary approach of the *ex situ* conservation. It permits to maintain the evolutionary potential of species and populations (Frankel, 1970, 1981; Ledig, 1992). As a consequence, further efforts are needed to promote *on farm* conservation and valorization of local fig germplasm in the

islands. It is imperative to promote both *on farm* and *ex situ* conservation for Jebali, Kettani, Marchini, Mlouki and Badri since they are classified as rare based on FCA. National Gene Bank of Tunisia is collaborating with NGOs and local governmental agencies to establish a participative approach for a sustainable agriculture in the islands.

## Conclusion

This work has allowed inventorying the cultivars of the fig tree in the Kerkennah islands as well as the related local knowledge. After interviewing with farmers and local authorities, we assume that despite the low field area, the small stakeholder's success to preserve large genetic diversity of fig. It was possible to classify threatened varieties with the use of the participatory four cells classification. It is worth to promote a sustainable development system integrating socio-economic parameters and valorization of genetic and cultural resources of fig. However, special attention has to be paid to threatened and rare cultivars. Both *on farm* and *ex situ* conservations are crucial to conserve this heritage from genetic erosion and later extinction.

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## Conflict of interest statement

The authors declare no conflict of interest.

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