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Article

Algerian Fig Trees: Botanical and Morphometric Leaf Characterization

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Abstract: Leaf morphology in plants is very important in the evaluation of intraspecific variation. Indeed, the leaves of the fig tree (*Ficus carica* L.) present a great diversity of shape and size. The present study consists of the botanical, morphological, and morphometric characterization of the leaves of 26 local fig tree varieties cultivated in different areas of Bejaia (northeast Algeria). Our results indicate that the morphological parameters of the leaves allowed a good differentiation of the studied cultivars according to the descriptors (UPOV) among varieties and independent of their growing environment. Moreover, the method of morphometric description proposed in this paper allows the differentiation of varieties and the comparison among them in an objective way and by simple mathematical methods. This method demonstrates the existence of a very high percentage of polymorphisms within the studied varieties, but also their classification according to the number of lobes, the depth of the lateral sinuses, and the degree of openness of the angles performed by the main veins of the leaves. The Azougagh variety is characterized by wider angles, and, on the contrary, the Tassahlit variety has the least-open angles. None of the studied varieties presented "entire" leaves. The majority presented leaves with five lobes. The varieties Tilizwith, Tazarzourth, Avarkan, Tamkarkourth, and Inconnu B differed clearly from the rest by showing leaves with seven lobes and deep lateral sinuses. In contrast, the varieties Zarika, Baccor Blanc, Avarkan Lisse, and Avgaiti presented leaves with only three lobes. This is the first work on fig tree characterization using morphometric methods, which are shown to be complementary to the UPOV code and efficient in separating even the closed varieties. It will be interesting to extend these studies to larger scales and areas.

Keywords: *Ficus carica* L.; local accessions; leaf; morphology description; morphometric description

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1. Introduction

The fig tree is one of the oldest fruit trees in the world. It may be the first domesticated plant of the Neolithic revolution, about a thousand years before cereals [1]. The common fig (*Ficus carica* L.) is a typical fruit species of warm climates, widely distributed in the Mediterranean basin where its production is of great economic importance [2]. Algerian fig trees have been cultivated for centuries in Algeria and are known for their high-quality fruits, little is known about their genetic diversity and morphological variability.

In Algeria, according to Chouaki et al. [3], the fig tree is among the three most economically and socially important fruit species (olive, fig, and citrus), constituting more than 10% of the national arboricultural heritage. It adapts to all bioclimatic stages and extends over altitudes ranging from 300 m in the massive mountain of Djurdjura (Kabylia) to an altitude of 800 m [4]. Sometimes, it can grow at higher altitudes than olive trees, from 1000 to 1200 m [5]. It is concentrated in small plantations throughout the country. However, the most prosperous region of Algeria for the cultivation of the fig tree is Kabylia, where most plantations are located [6].

In 2018, the area of fig tree cultivation in Algeria was 39,356 ha [7], while in 1950, it was 80,000 ha [8]. Several factors contributed to this decrease, including the war of national liberation during the period (1954–1962), in addition to the absence of caprific multiplication and new plantations, especially since the 1980s [9]. However, cutting is the only propagation mode that has facilitated exchanges among the different regions [3], although this exchange has led to problems of synonymies and homonymies in the species [10]. According the "Institut Technique de l'arboriculture fruitière" (ITAF, Algeria), there are 37 varieties of figs in Algeria. Condit [10], in 1920, found no less than 43 varieties including 17 caprific trees and 26 edible varieties. This diversity is neglected and exposed to threats of genetic erosion. As result, a part of our heritage, although still poorly known, is lost forever.

In order to preserve and improve the genetic diversity of our remaining local fig cultivars, the Algerian state has initiated several projects to collect varieties throughout the country, which have been stored in research institute stations (INRA) and technical institutes of fruit trees (ITAFV) in different regions of Algeria. Moreover, several studies based on the morphological characterization of the Algerian varieties were carried out by different authors and botanists [3,4,11–12]. A few authors, such as Boudchicha et al. [13], made the genetic characterization with SSR marker on some local varieties that were kept in Algerian research centers. Fig leaves have a morphology like those of the grapevine leaf (*Vitis vinifera* L.), with the same number of main veins, although in the case of figs, there are no teeth along the edge of the leaf blade. In the case of the grapevine leaf, there is, in addition to the UPOV code [14], an official code of descriptive characteristics developed by the International Organization of Vine and Wine [15]. There are also other complementary characterization methods, such as molecular analysis [16,17], or morphometric methods, such as the reconstruction of the average leaves proposed by Martínez and Grenan [18], whose results are very useful and allowed the description of numerous varieties of vines from different origins [17,19–20]. The simple observation of the average leaves of a variety, reconstructed by this method, allows varieties to be identified in the field by means of a simple subjective visual comparison and, at the same time, allows a statistical comparison, by means of an objective mathematical comparison.

This method has been successfully adapted for the morphometric characterization of olive leaves [21] and is fully adaptable to the characterization of fig leaves, due to their great similarity with those of the vine.

In this context, the objective of our study was to carry out a characterization of some local fig tree cultivars of the Wilaya of Bejaia in the Kabylia region, where most of the most common Algerian varieties are located. For this, we will adapt the method of reconstruction of the average vine leaf to the fig leaf [18]. The leaves will also be described according to the UPOV descriptive character code for fig leaves [22].

2. Materials and Methods

2.1. Plant Material and Study Area

We carried out a survey in the areas known to have an abundance of fig trees. Four different areas with different climatic conditions, soil, and orography were sampled (Tables 1 and 2 and Figure 1). The fourth area is the experimental collection in the ITAFV demonstration farm of Takarietz All, characterized by extensive management and a lack of cultivation practices other than a superficial plowing in the spring with rain-fed irrigation. During the 2018 harvesting season, we collected leaves from the twenty-six varieties. Some varieties were selected for their wide distribution, known as autochthonous, and others were unknown and rare and found only in some orchards (Figure 2). The names of the collected varieties were Avouhvoul, Azougagh, Baccor Blanc, BTA, Chograni, Hafer El Bghal, Khanout, Taghanimt, Taamriwth ITAF, Zarika, and Avgaiti in ITAFV (Takarietz); Avarkan Lisse and Tazarzourth in Timezrit; and the varieties Tassahlit, Tilizwith, Avaaki, and Inconnu B in Kandira. In Beni Maouche, we collected Avarkan, Azanjar, Azegzaw, Inconnu M, Taamriwth, Tahayount, and Achatoui in plot 1 and Tamkarkourth and Abairus in plot 2.

Table 1. Fig tree accessions, distribution areas, and diffusion levels of the different varieties.

Geographic Area	Accession Name	Origin Designation	Diffusion Levels
ITAFV Takarietz	Avouhvoul Azougagh Baccor Blanc BTA Chograni Hafer El Bghal Khanout Taghanimt ITAF Taamriwth ITAF Zarika Avgaiti	Abuhbul Azeggaɣ / / / / / Taɣanimt Taɛemriwt / Abgayti	Fig tree orchard located in the Technical Institute of Fruit Trees and Vines (ITAFV) of the Bejaia Province (Kabylie region in Argelia). This is a germplasm collection with varieties collected from different Algerian regions, most of which are from the Bejaia Province
BeniMaouche—Plot 1	Avarkan Azanjar Azegzaw Taamriwth Tahayount Achatoui	Aberkan Azangar Azegzaw Taɛemriwt Tahayount Aceḥtawi	These are varieties collected from a private farm; they are abundant and present in most regions in the Béjaïa Province
BeniMaouche—Plot 1	Inconnu M	/	Unknown variety found in a single orchard
BeniMaouche—Plot 2	Tamkarkourth Abairus	Tamqerqurt Abɛirus	Tamkarkourth is a very rare variety that was found in two regions with just a few plants, Abairus is also a variety not very abundant in different regions of the province
Timezrit	Avarkan Lisse Tazarzourth	Aberkan Alegɣan Taẓerẓurt	These are varieties that are only found in one single region, in very small numbers, and share characteristics with some varieties from other regions
Kendira	Inconnu B Tassahlit Tilizwith Avaaki	/ Tasaḥlit Tileẓwit Abaɛqi	These are varieties found only in a single orchard that are not identified and in quantities of less than five plants

Except for the ITAFV collection, for the varieties from other areas, these are generally isolated plantations and in association with olive trees, in private orchards, which are mostly disappearing.

Table 2. Geographic locations of study areas.

Study Areas	Location	Longitude (E)	Latitude (N)	Altitude (m)
Beni Maouche—Plot 1	Trouna Village (lamrahna)	4°45′16.69″	36°30′40.04″	900 m
Beni Maouche—Plot 2	Trouna Village	4°46′9.14″	36°31′7.47″	800 m
Timezrit	Melloulit Village	4°47′29.49″	36°36′5.68″	710 m
Kendira	Bir Iwahranene Village	4°59′3.47″	36°32′32.06″	920 m
ITAFV Takarietz	ITAFV Takarietz	4°40′5.78″	36°34′44.60″	100 m

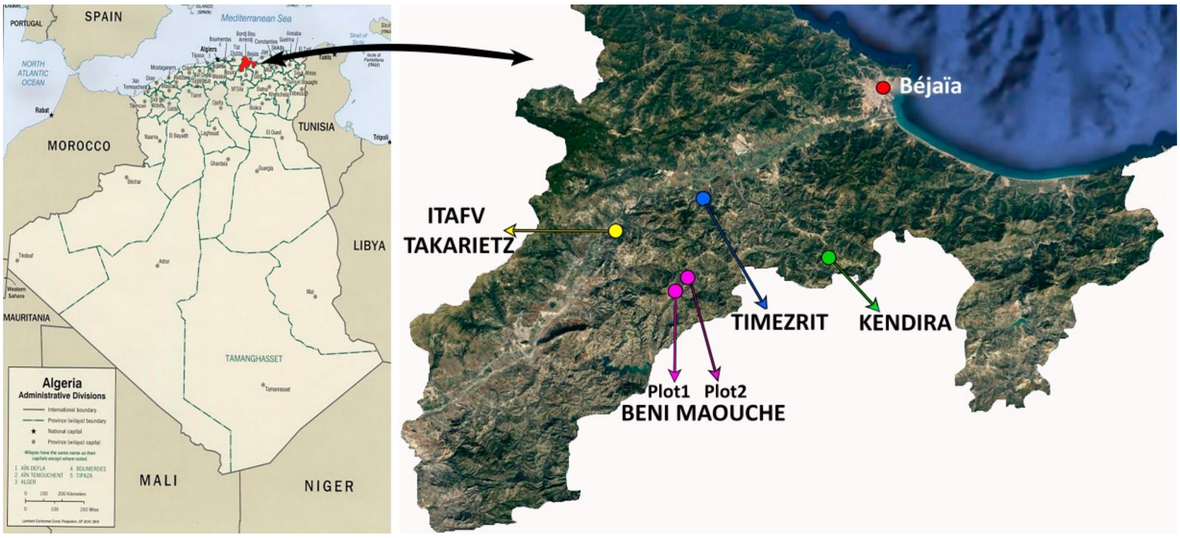

Figure 1. Geographical locations of the plots of land.

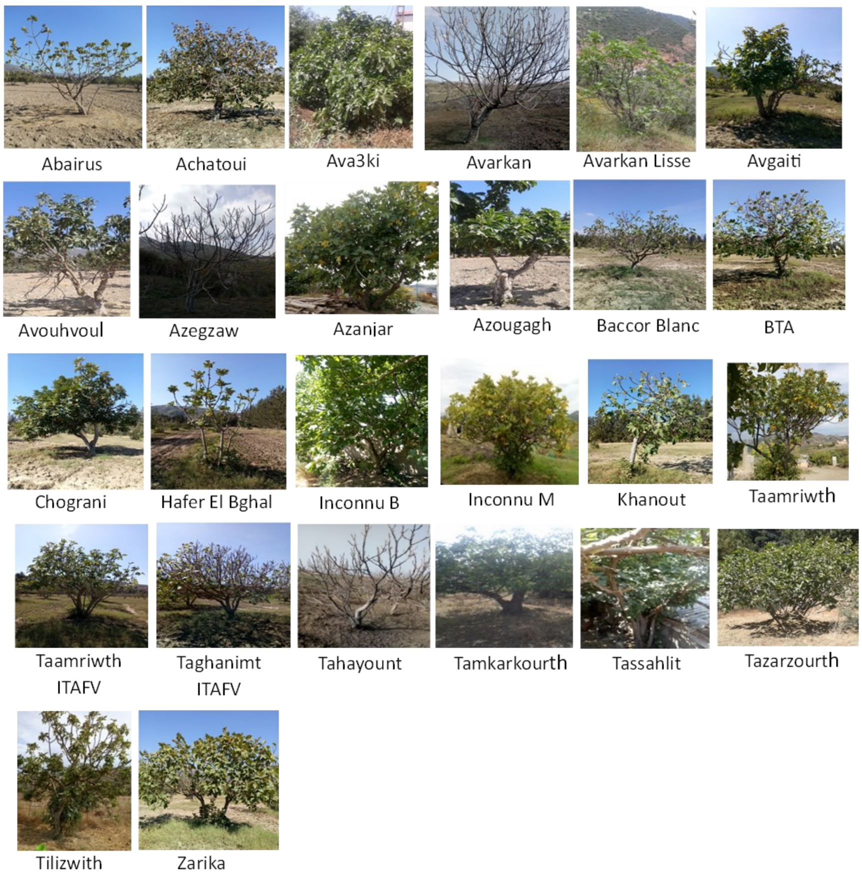

Figure 2. Images of the studied fig trees.

2.2. Sampling and Methods

2.2.1. Sampling

In accordance with the UPOV Code (27): FICUS_CAR *Ficus carica* (International Union for the Protection of New Varieties of Plants of Figs, UPOV [22], we chose five healthy plants, vigorous and free of parasites or diseases, which had not undergone any treatment.

The fully developed leaves located on the middle third of a well-developed year-round twig were collected during the period of July and August, considering the polymorphism of the leaves of the species *F. carica*, and the measurements were carried out on leaves belonging to the dominant foliar type. The samples consisted of 11 leaves following the Martinez and Grenan [18] method (Figure 3); however, according to UPOV [22], a minimum of two leaves per plant is sufficient for characterization. The samples were chosen at random from each variety, at a rate of two leaves from each of the four plants and three leaves from the fifth plant.

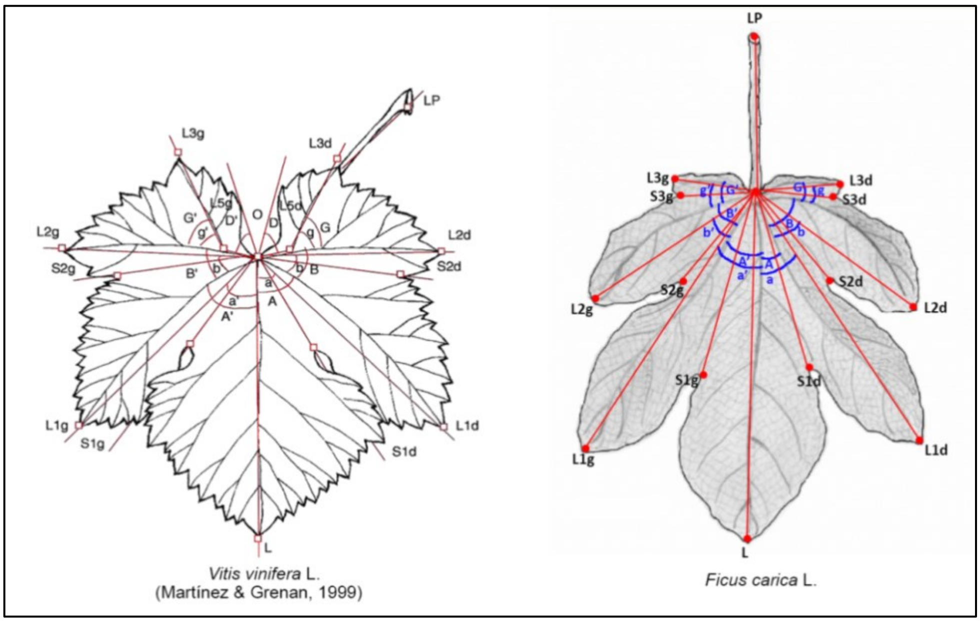

Figure 3. Parameters measured in each of the 11 leaves per variety (adaptation of the method of Martinez and Grenan (1999) [18] to the fig tree). LP: petiole length; L: linear distance between the petiolar point and the central vein end; L1: linear distance between the petiolar point and the end of the first right (L1d) and left (L1g) lateral veins; L2: linear distance between the petiolar point and the end of the second right (L2d) and left (L2g) lateral veins; L3: linear distance between the starting point of the first secondary vein belonging to the second lateral vein and the end of the right (L3d) and left (L3g) secondary vein; L5d: linear distance between the petiolar point and the starting point of L3d; L5g: linear distance between the petiolar point and the starting point of L3g; S1: linear distance between the petiolar point and the bottom (toward the petiolar point) of the right (S1d) and left (S1g) lateral upper sinuses; S2: linear distance between the petiolar point and the bottom (toward the petiolar point) of the right (S2d) and left (S2g) first lower lateral sinuses; S3: linear distance between the petiolar point and the bottom (toward the petiolar point) of the right (S3d) and left (S3g) second lower lateral sinuses; A: angle between the central vein and the first right lateral vein; A′: angle between the central vein and the first left lateral vein; a: angle between the central vein and L1d; a′: angle between the central vein and L1g; B: angle between the first and the second right lateral veins; B′: angle between the first and the second left lateral veins; b: angle between the first right lateral vein and L2d; b′: angle between the first left lateral vein and L2g; G: angle between the second right lateral vein and the first secondary vein of this; G′: angle between the second left lateral vein and the first secondary vein of this; g: angle between the second right lateral vein and L3d; g′: angle between the second left lateral vein and L3g; D: angle between L5d and the tangent of the leaf right side from the petiolar point; D′: the angle between L5g and the tangent of the leaf left side from the petiolar point.

2.2.2. Morphometric Parameters

Following the method of Martínez and Grenan [18], the IT3 program (IT3: Image Tool 3.00 version 2016) adapted to the fig tree was used to measure the quantitative base variables (vein length and angle) required to construct an 'average leaf' for each cultivar (Figure 3). Character ratios were then calculated using this quantitative data (Table 3).

2.2.3. UPOV Parameters for Fig Trees

On the selected leaves of each of the varieties, the UPOV foliar parameters were measured for fig trees, shown in Table 3.

Table 3. Relationships between different leaf variables measured.

Relationship	Formula *
Rel. 1	Lp/L
Rel. 2	L1d/L
Rel. 3	L1g /L
Rel. 4	L2d/L
Rel. 5	L2g/L
Rel. 6	S1d/L1d
Rel. 7	S1g/L1g
Rel. 8	S2d/L2d
Rel. 9	S2g/L2g
Rel. 10	A + B + G
Rel. 11	A′ + B′ + G′
Rel. 12	S3d/L3d
Rel. 13	S3g/L3g
Rel. 14	(S1d + S2d)/(L1d + L2d)
Rel. 15	(S1g + S2g)/(L1g + L2g)

* See Figure 2.

2.3. Statistical Analysis

Principal component analysis (PCA) was performed on the quantitative ampelographic data, considering the ratios described above. All calculations were made using SAS system v.9.1 software (SAS Institute, Cary, NC, USA).

3. Results

3.1. The Results of the UPOV Descriptor Code for Fig Leaves

Table 4 shows the results of the UPOV descriptor code for fig leaves. The variation in leaf characteristics showed great variability for all varieties characterized regardless of the geographic origin within the study area; leaf characteristics include leaf shape, leaf shape of central lobe, leaf ratio of length of central lobe to length of blade, shape of leaf base, leaf blade length, and presence/absence of basal lateral lobes on petiole sinus. The number of lobes is one of the most important characteristics of the fig leaf description in the UPOV code, varying between three and five in this case. According to this parameter, the varieties under study were grouped as follows: Baccor Blanc, Avgaiti, Avarkan Lisse, and Zarika showed leaves with three large lobes (Table 4). The varieties Azanjar, Inconnu M, Chograni, Taghanimt ITAF, Achatoui, Tassahlit, Avaaki, Abairus, Azegzaw, Taamriwth, Tahayount, Avouhvoul, BTA, Hafer El Bghel, Khanout, Taamriwth ITAF, and Azougagh presented leaves with five large, pronounced lobes (Table 4). Although Tamkarkourth, Tazarzourth, Avarkan, Inconnu B, and Tilizwith were catalogued as varieties showing leaves with five large, prominent lobes, the highest level of expression for this characteristic (Code UPOV 17), these leaves should really be considered as presenting seven lobes. The UPOV code also includes the parameter "presence or absence of basal lateral lobes on petiole sinus” (code UPOV 23) that allows differentiating subgroups within the group of varieties with five lobes. When the notation is “presence”, there is another UPOV parameter known as “size of lateral basal lobes on petiole sinus” (code UPOV 24), which allows differentiation among varieties, according to three levels of expression (small, medium, and large). Regarding the five varieties mentioned above, we observed that all showed basal lateral lobes on petiole sinus, the size of these lateral lobes being small for Tazarzourth; medium for Tamkarkourth, Inconnu B, and Tilizwith; and large for Avarkan.

The characterization of the remaining parameters (Table 4 and Figure 4) revealed variability in the shape of the central lobe (code UPOV 19) and the shape of the leaf base (code UPOV 21). The center lobe comes in five different shapes: narrow rhombic (nine varieties: Abairus, Avgaiti, Azegzaw, Baccor Blanc, BTA, InconnuM, Taamriwth, Taamriwth ITAF, and Zarika), lyrate (six varieties: Avarkan, Azougagh, Hafer El Bghel, InconnuB, Tazarzourth, and Tilizwith), spatulate (five varieties: Avaaki, Chograni, Khanout, Tahayount, and Tassahlit), broad rhombic (four varieties: Achatoui, Avarkan Lisse, Taghanimt, and Azanjar), and just two varieties whose shape is linear (Avouhvoul and Tamkarkourth). Regarding the shape of the leaf base, we observed four forms: The moderate calcarate shape was the most common with ten varieties (Avaaki, Abairus, Azanjar, BTA, Hafer El Bghel, Inconnu M, Khanout, Taamriwth, Taamriwth ITAF, and Tahayount), followed by the cordate shape (Avarkan Lisse, Avouhvoul, Azagzaw, Baccor Blanc, Chograni, and Taghanimt), the strong calcarate shape with six varieties (Avarkan, Azougagh, Inconnu B, Tamkarkourth, Tazarzourth, and Tilizwith), and the truncate shape, which is the least common with three varieties (Achatoui, Avgaiti, and Tassahlit).

Table 4. Mean values of the UPOV fig characteristics for the harmonized examination of distinctness, homogeneity, and stability (DUS) of the fig cultivars under study.

UPOV Fig Characteristics	Leaf: Predominant Type		Only Varieties with Predominant Leaf Type: Entire: Leaf: Shape		Excluding Varieties with Leaf: Predominant Type: Entire: Leaf: Shape of Central Lobe		Excluding Varieties with Leaf: Predominant Type: Entire: Leaf: Ratio Length of Central Lobe/Length of Blade		Leaf: Shape of Leaf Base		Leaf Blade: Length		Lobed Leaf: Basal Lateral Lobes on Petiole Sinus		Lobed Leaf: Size of Basal Lateral Lobes on Petiole Sinus	
	17, (*), (+), QN,		18, (*), (+),PQ		19, (*), (+),PQ		20, (*), (+), QN,		21, (*), (+),PQ		22, (*), (+), QN,		23, (*), (+), QL		24, (*), QN,	
Accession Name	**Expression Level**	**Note**	**Expression Level**	**Note**	**Expression Level**	**Note**	**Expression Level**	**Note**	**Expression Level**	**Note**	**Expression Level**	**Note**	**Expression Level**	**Note**	**Expression Level**	**Note**
Avaaki	five-lobed	3	/	/	spatulate	4	medium	5	Moderately calcarate	4	medium	5	absent	1	/	/
Abairus	five-lobed	3	/	/	narrow rhombic	2	large	7	Moderately calcarate	4	long	7	absent	1	/	/
Achatoui	five-lobed	3	/	/	broad rhombic	3	medium	5	troncate	2	long	7	absent	1	/	/
Avarkan	seven-lobed	4	/	/	lyrate	6	large	7	strongly calcarate	5	long	7	present	9	large	7
Avarkan Lisse	three-lobed	2	/	/	broad rhombic	3	medium	5	cordate	3	long	7	absent	1	/	/
Avgaiti	three-lobed	2	/	/	narrow rhombic	2	medium	5	troncate	2	long	7	absent	1	/	/
Avouhvoul	five-lobed	3	/	/	linear	5	medium	5	cordate	3	long	7	absent	1	/	/
Azegzaw	five-lobed	3	/	/	narrow rhombic	2	medium	5	cordate	3	medium	5	absent	1	/	/
Azanjar	five-lobed	3	/	/	broad rhombic	3	small	3	moderately calcarate	4	long	7	absent	1	/	/
Azougagh	five-lobed	3	/	/	lyrate	6	medium	5	Strongly calcarate	5	long	7	absent	1	/	/
Baccor Blanc	three-lobed	2	/	/	narrow rhombic	2	medium	5	cordate	3	long	7	absent	1	/	/
BTA	five-lobed	3	/		spatulate	4	medium	5	cordate	3	long	7	absent	1	/	/
Chograni	five-lobed	3	/		spatulate	4	medium	5	cordate	3	long	7	absent	1	/	/
Hafer El Bghal	five-lobed	3	/		lyrate	6	medium	5	moderately calcarate	4	long	7	absent	1	/	/

Inconnu B	seven-lobed	4	/	lyrate	6	medium	5	strongly calcarate	5	long	7	present	9	medium	5
Inconnu M	five-lobed	3	/	narrow rhombic	2	medium	5	moderately calcarate	4	long	7	absent	1	/	/
Khanout	five-lobed	3	/	spatulate	4	medium	5	moderately calcarate	4	long	7	absent	1	/	/
Taamriwth	five-lobed	3	/	narrow rhombic	2	large	7	moderately calcarate	4	long	7	absent	1	/	/
Taamriwth ITAF	five-lobed	3	/	narrow rhombic	2	large	7	moderately calcarate	4	long	7	absent	1	/	/
Taghanimt	five-lobed	3	/	broad rhombic	3	small	3	cordate	3	medium	5	absent	1	/	/
Tahayount	five-lobed	3	/	spatulate	4	large	7	moderately calcarate	4	medium	5	absent	1	/	/
Tamkarkourth	seven-lobed	4	/	linear	5	large	7	strongly calcarate	5	long	7	present	9	medium	5
Tassahlit	five-lobed	3	/	spatulate	4	large	7	troncate	2	long	7	absent	1	/	/
Tazarzourth	seven-lobed	4	/	lyrate	6	large	7	strongly calcarate	5	medium	5	present	9	small	3
Tilizwith	seven-lobed	4	/	lyrate	6	large	7	strongly calcarate	5	medium	5	present	9	medium	5

* Characteristics included in Test Guidelines, important for the international harmonization of variety descriptions and which will always be used in DUS testing and are included in the description by all EU members. QL: Qualitative character; QN: Quantitative character; PQ: Pseudoqualitative character; (+): Explanations relating to individual character. The characterization of the remaining parameters (Table 4 and Figure 4) revealed variability in the shape of the central lobe (code UPOV 19) and the shape of the leaf base (code UPOV 21). The center lobe comes in five different shapes: narrow rhombic (nine varieties: Abairus, Avgaiti, Azegzaw, Baccor Blanc, BTA, InconnuM, Taamriwth, Taamriwth ITAF, and Zarika), lyrate (6 varieties: Avarkan, Azougagh, Hafer El Bghel, InconnuB, Tazarzourth, and Tilizwith), spatulate (five varieties: Avaaki, Chograni, Khanout, Tahayount, and Tassahlit), broad rhombic (four varieties: Achatoui, Avarkan Lisse, Taghanimt, and Azanjar), and just two varieties whose shape is linear (Avouhvoul and Tamkarkourth). Regarding the shape of the leaf base, we observed four forms: The moderate calcarate shape was the most common with ten varieties (Avaaki, Abairus, Azanjar, BTA, Hafer El Bghel, Inconnu M, Khanout, Taamriwth, Taamriwth ITAF, and Tahayount), followed by cordate shape (Avarkan Lisse, Avouhvoul, Azagzaw, Baccor Blanc, Chograni, and Taghanimt), strong calcarate shape each with six varieties (Avarkan, Azougagh, Inconnu B, Tamkarkourth, Tazarzourth, and Tilizwith), and the truncate shape, which is the least common with three varieties (Achatoui, Avgaiti, and Tassahlit).

The leaf shape and other leaf characteristics are stable and associated with each variety independent of the growing area or the edaphoclimatic conditions that could only influence leaf size. In the same way, we did not find a significant difference in Taamriwth and Taamriwth ITAF, although it is the same variety grown at two different sites and without specific treatment. The first is cultivated at Beni Maouche at a high altitude (900 m) in a high-precipitation location, while the second is grown at ITAFV in Takarietz in a low-precipitation location at a low altitude (100 m).

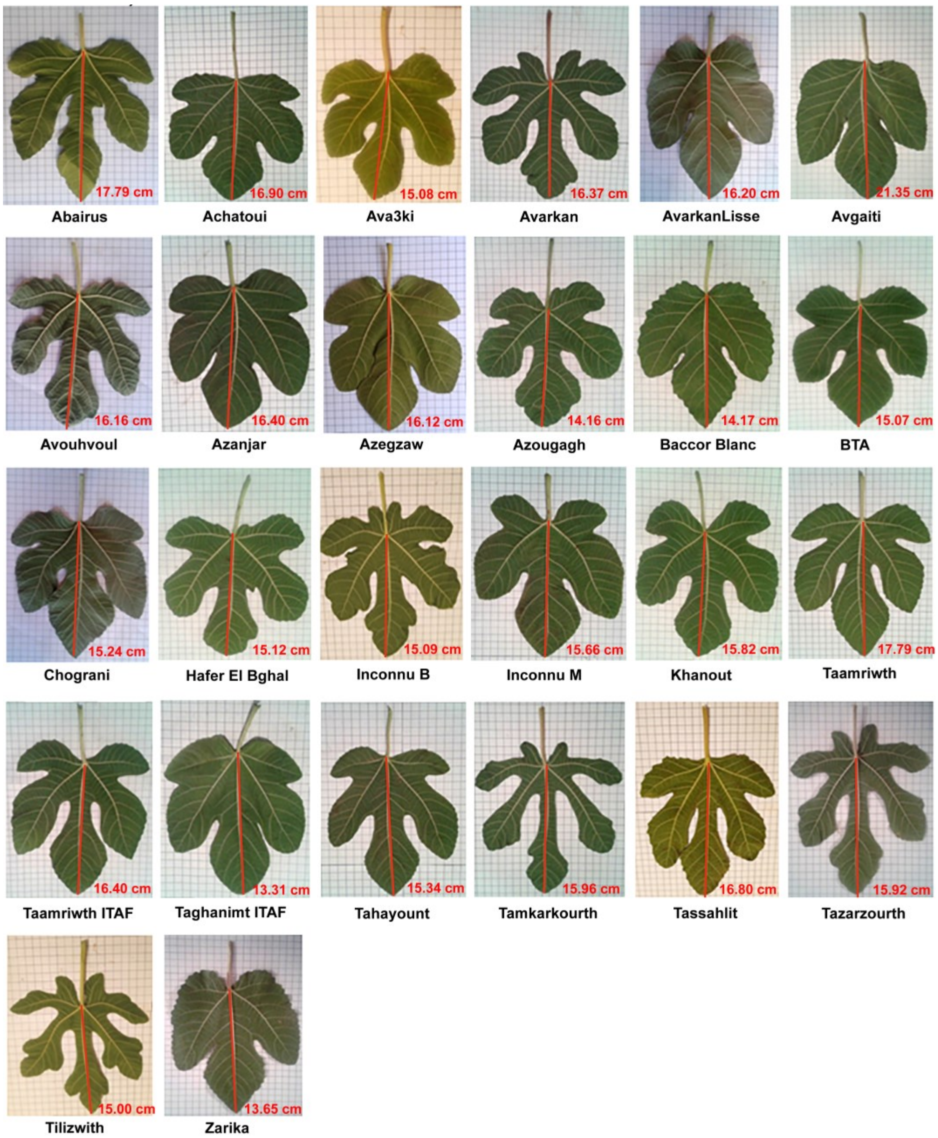

Figure 4. Typical leaves of each of the 26 fig tree accessions studied (*Ficus carica* L.).

3.2. The Principal Component Analysis (PCA)

In the principal component analysis (PCA) carried out by observing the relations and the angles, we observed that the first two components expressed 77% of the total variance. In the first component (Prin 1), the parameters that had the most weight were the relations Rel6, Rel7, Rel8, and Rel9, with all of them linked to the depth of the lateral sinuses and the number of leaf lobes. However, in the second component (Prin 2), the most important discriminant parameters were the relations Rel 1, Rel 10, and Rel 11.

In the PCA graphical representation (Figure 5) obtained from the first two components, we observed that according to Prin1, the Zarika, Baccor Blanc, Avarkan Lisse, and Avgaiti varieties were grouped together in the right part of the graph, showing leaves with two, scarce depth lateral sinuses and three lobes. Positioned at the far left of the graph is the variety Tilizwith and in a close position, the varieties Tamkarkourth, Avarkan, Tazarzourth, and Inconnu B with very divided leaves, deep lateral sinuses, and seven lobes. According to Prin 2, the variety Azougagh with wider angles was placed at the top of the chart. The Tassahlit variety, with the least-open angles, appears at the bottom of the graph.

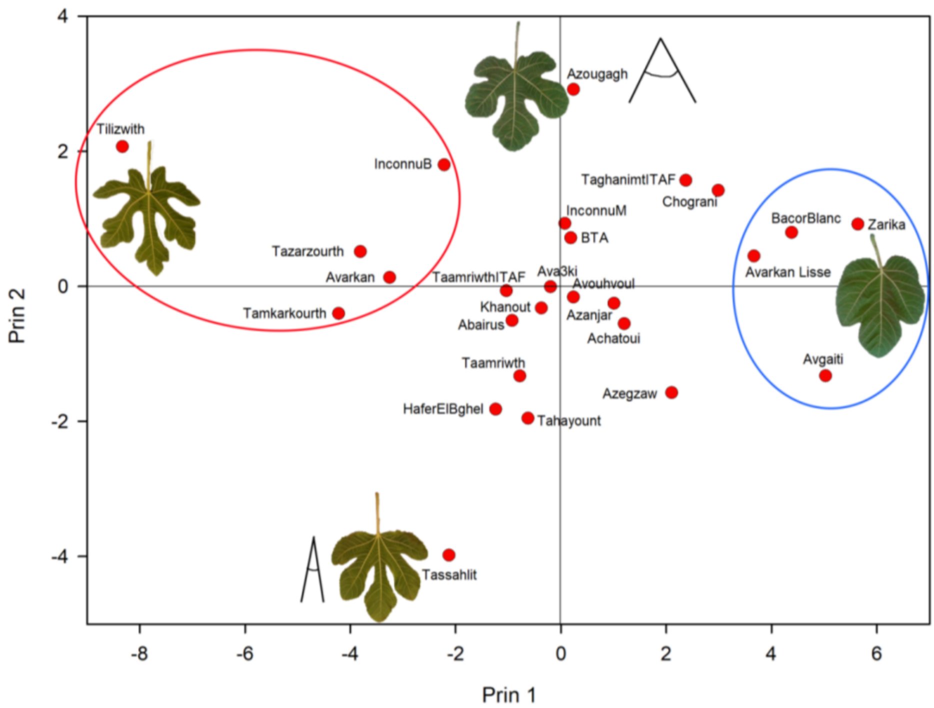

Figure 5. Graphic representation of the results of the Principal Component Analysis (PCA), considering the relationships among the different lengths measured in each of the 11 leaves per variety. Blue circle: varieties with entire leaves; Red circle: very divided leaves.

As expected, the varieties were not separated according to their origin or their place of cultivation, but by the morphology of their leaves. For example, leaves of different origins can be found very close in the graphic because of their similar morphology (BTA and Azanjar or Tamkarkourth and Tazarzourth). For the same reason, two specimens of the same variety, but from different places, are very close in the graphic representation of the PCA (Figure 5), as is the case with the specimen of Taamriwth of ITAFV in Takarietz and Taamriwth of Beni Maouche (Plot 1).

The results observed in Figures 4 and 5 confirm the differentiation made on the basis of the UPOV parameters, with most of the studied varieties presenting five lobes. None was found with entire leaves (without sinus or lobes), and only four of the twenty-six varieties studied (Baccor Blanc, Avgaiti, Avarkan Lisse, and Zarika), presented leaves with three lobes. Within the latter group, three of them (Baccor Blanc, Avgaiti, and Zarika) came from the ITAFV collection in Takarietz and the fourth from the Timezrit plot of land.

4. Discussion

A morphological analysis can provide information on the variability in fig trees, using morphological parameters related to the leaves, to appreciate the genetic variability among and within cultivars [23,24]. According to Aljane et al. [25], the important parameters for comparing varieties are the number of lobes, leaf length and leaf width, surface area, and petiole length. The characterization of varieties and even clones of several woody species used in agriculture focuses not only on the fruits but also on the morphology and morphometry of the leaves. This is the case, for example, in grapevine varieties, for which both the UPOV and OIV descriptor codes are used [14,15], as well as the morphometric method for the reconstruction of the average vine leaf [18]. The same procedure can be applied to the UPOV code for olive [26], apple [27], and many other fruit trees. Considering our results, the number of lobes is one of the most important characteristics of fig leaf description. Several authors [28] agree that these parameters are very relevant for the differentiation of foliar-toothed plants, including the fig tree, with these characteristics being hardly influenced by the environment, with high heritability and high genetic correlation [29]. Varying between three and five in this case, Gozlekci [30] assumes the number of lobes to be just between three and five, while other authors, such as Rodrigues et al. [28], add a third level for leaves showing seven lobes, and Abdelsalam et al. [31] increase the scale from one to ten lobes.

At least in this study, area fig varieties with leaves presenting three lobes are much less frequent (15%) than those with five lobes. This proportion is similar to that observed by Lopez et al. [32] for 13 uniferous varieties (produce a single crop of figs in a year) of Spanish fig trees described by these authors, where only 2 of them (15%) showed three-lobed leaves. However, among the 34 biferous varieties (those that produce two crops in a year, a crop of brebas and another of figs) described in the same work, a higher percentage of leaves with 3 lobes was observed (16 of the 34 studied, which represents 47%). On the opposite side, 5 varieties stood out among the 26 studied in the present work (Tamkarkourth, Tazarzourth, Avarkan, Inconnu B, and Tilizwith), showing 7 lobes, representing 19%. Compared to the varieties described by Lopez et al. [32], we found in their work a slightly higher percentage of 7-lobed leaves within the varieties biferous (8 of the 34 described, which represents 23%) and closer to the uniferous (3 of the 13 varieties described, representing 20%). As mentioned above, the option of considering leaves with seven lobes is not included in the UPOV descriptor code (Code 17: leaf: predominant type), which only covers three levels of expression ("entire", "three-lobed", and "five-lobed"). We added this option and assigned it a new expression level ("seven-lobed", note 4).

Although some authors, such as Chitwood et al. [33], suggest that leaf shape in individuals, populations, and species varies with evolutionary processes and environmental factors or that the spatial distribution and functional significance of leaf lamina shape in Amazonian forest trees and the nutrient content of the soil influence leaf size and shape much more than precipitation [34], several studies carried out by different authors focused on some species for agricultural use, such as grapevine [17,18,20–35] or olive [22], demonstrate that the shape and other leaf characteristics are stable and associated to each variety independent of the growing area or the edaphoclimatic conditions that could only influence leaf size.

The molecular study using SSR markers of the same fig tree varieties from the ITAF Takarietz station (Hafer El Bghal, Baccor Blanc, Achatoui, Azanjar, Avouhvoul, Taghanimt, Taamriwth, Azougagh, Azegzaw, Abairus, and BTA) and cultivars from the Skikda station and some cultivars from an orchard in Tizi Ouzou showed a medium variability among cultivars. [13]. However, the cases of homonymy observed were among cultivars from different stations and not within the collection.

The morphometric method proposed in this work showed to be a useful complement to the UPOV code, because it allowed us not only to describe and clearly differentiate some varieties from others, but also to prove it through a mathematical and objective process, and compare them, to determine the varieties that are closer or do not present an apparent relationship, depending on the foliar morphology.

As we mentioned in previous paragraphs and stated for other botanical species (*Vitis vinifera* L..., *Olea europaea* L, etc.), the morphology of fig leaves is a very important botanical parameter that allows an easy differentiation among varieties. In fact, UPOV uses several parameters related to leaf morphology for the official identification of fig tree varieties.

Leaf shape is an easy parameter to observe both in the field and in the laboratory, for experts or nonexperts. It would also be easy to use modern technologies (image analysis, ICTs, etc.) to develop programs that allow the leaves of an unknown variety of fig tree to be automatically compared and identified with all those already described. To do this, it will be necessary to first create a bank of leaf images or a database, which collects all the existing diversity. In this way, it will be possible to increase the possibilities of discovering new varieties that have not yet been described and to recover those that are on the edge of extinction.

This fact will clearly be a great help for the conservation of the agricultural plant heritage subject to progressive and strong genetic erosion as is the case of many fruit trees, including fig trees grown in this and other study areas.

5. Conclusions

This work allowed us to get to know a part of the existing biodiversity in Algeria, within the species *Ficus carica* L. This knowledge is the first step to be able to conserve this agricultural heritage.

The results of this study indicate the possibility of going more deeply into the characterization of fig varieties (*Ficus carica* L.) complementing the use of the UPOV code for this species with the leaf morphometric method proposed in this study. This method allows us not only to identify leaves of the different Algerian varieties, but also to compare them and determine their level of similarity in a mathematical and objective way.

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