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Morphological study of two *Prunus avium* varieties (wild and cultivated, Tunisian variety) in the Ain Draham region, Northwest Tunisia

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Abstract: This study provides valuable insights into the morphological variability of cherry species across different areas of implantation in Ain Draham, contributing to a better understanding of this important fruit crop. The study was conducted at four sites with high production potential, where leaf and fruit samples were taken from forty individuals of each variety. Sixteen morphological descriptors were retained. The cultivated cherry trees of Babouch 2 have a greater leaf development, measuring on average 10.79 cm long and 6.35 cm wide. The wild cherry species is characterized at the Babouch 1 and Souiniet 1 locations by its shorter and wider leaves, which measure 9.47 cm in length and 5.98 cm in width on average. In terms of fruit morphology, the Souiniet 2 site shows higher development. The wild species at Babouch 1 and Souiniet 1 has the biggest trunk circumference. The results show that the observed diversity in morphological descriptors is influenced by both variety and geographical origin. However, for some leaf-related characteristics, variability may be connected to the genome. Nonetheless, these discoveries must be verified through molecular analysis.

1. Introduction

The Mediterranean basin is one of the world's richest sources of plant diversity. It is home to about 25,000 flowering species, representing about 10% of the world's flora. The flora of the Mediterranean countries is characterized by a high number of endemic species (60%) (González-Tejero *et al.*, 2008; Médail *et al.*, 2019; Bedair *et al.*, 2023; Laita *et al.*, 2024). Vargas described thatthe Mediterranean floristic region is one of the richest hotspots of the with over 24,000 species distributed in the large territory (2,300,000 km^2) of the Mediterranean Basin. High numbers of genera (around 2000) and families (around 200) have been recorded, which gives this region the richest figures of the five Mediterranean floristic regions of the world (Vargas, 2020). One of the most recent species discovered in Tunisia is the wild cherry, also known as the sweet cherry (*Prunus avium*). This species is of great environmental value because it is used in forestry for its high-quality wood, in arboriculture for its fruits, in horticulture for its ability to regenerate ornamental Prunus varieties. Wild cherry (*Prunus avium*), a member of the Rosaceae family, has a rich cultural history and global presence

(Soundararajan *et al.*, 2019). This species is native to the Caspian Sea, the Black Sea, Europe, and North Africa (Magri *et al.*, 2023). Sweet cherry, a prominent fruit variety, is extensively cultivated around the world (Palasciano, 2022). These fruits are highly nutritious and offer considerable health benefits, containing a wide range of beneficial phytochemicals, such as anthocyanins, vitamins, and phenolics (Fonseca *et al.*, 2021). These qualities are highly valued by consumers (Clayton-Guo *et al.*, 2021).

The wild cherry is a highly valued forest species due to its marketable wood, which ranges from light brown to pinkish-yellow and is sometimes used as veneer. It is highly prized in the furniture industry, both for solid wood and veneers. This critical demand for cabinets overlooks other uses of wood, such as sculpture and tournage.The cherry tree, like all fruit trees, generates wood with excellent mechanical qualities (such as resistance to compression, tension, and bending). However, its shrinkage during the drying process is generally modest, though it can occasionally be excessive (Jdaidi & Hasnaoui, 2017; Jdaidi & Hasnaoui, 2018; Jdaidi *et al.*, 2023). In Tunisia, this species is of agronomic and ecological importance, but it faces various challenges from biotic (human, insect, and pathogen) and abiotic (climatic conditions) factors. These challenges can negatively impact its future evolution, ecological distribution, and product quality. In the northwest of Tunisia, sweet cherries are commonly grafted onto wild cherry trees. This variety of rootstock is particularly well-suited to sweet cherries (bigarreaux and guignes), providing them with significant vigor and longevity; however, it is important to note that its development is gradual.Nowadays, linguistic variety is a notable phenomenon in Tunisia. A planted cherry tree in the Ain Draham region shares the same varietal designation as our wild species. Thus, varietal identification is critical for the conservation, development, and characterization of this species.

Hussain et al. gathered the phytochemistry, nutritional and pharmacological qualities. The studies onPrunus Avium L. (sweet cherry or wild cherry) indicated that the plant is a rich source of many phytochemicals,nutrients, phenolic compounds, sugars, anthocyanins, perillyl and phenolics. The presence of chemicalcompounds such as cyanidin 3-sophoroside, cyanidin 3-rutinoside, cyanidin 3-glucosylrutinoside, cyanidin 3-glucoside etc. renders the cherry fruit to demonstrate anti-cancer and anti-oxidation potential, antigenotoxic,anti-inflammatory, cytotoxic, antimicrobial, neuroprotective and diuretic activities(Hussain e*t al.*, 2018). Cherry consists ofcyanogenic glucoside (prunasin) which assists the body in tranquilizing cough and also effective for nervoustouchiness and nervous dyspepsia. For secure treatment of cough, pharmaceutical companies isolate prussicacid from the cherry bark as a dynamic component. Wild cherry is also helpful in treatment of arthritis due tothe presence of anthocyanins (Hanbali e*t al.*, 2013; Hussain e*t al.*, 2018; Agrawal e*t al.*, 2024). Phenolic compounds are well known as antioxidant, antibacterial, … activities (Elmsellem e*t al.*, 2019; Aourabi e*t al.*, 2021; Bouslamti e*t al.*, 2023; Cherriet e*t al.*, 2023; Nouioura e*t al.*, 2024)

The aim of this study is to study the phenotypic diversity of wild cherry (*Prunus avium*) in the northwestern area of Tunisia, which is characterized by a favorable climate for the cultivation of sweet cherry. This study focuses on the morphological characterization with 16 indicators (9 qualitative and 7 quantitative) in order to provide a morphological description of the types studied.

2. Material and Methods

2.1. Prospecting and characterization of sites

A comprehensive search was conducted in the primary areas of wild cherry and cultivated cherry occurrence in the Ain Draham region during 2021 and 2022 (Figure 1). The research identified four

sites, two for the wild population (Souiniet 1 and Babouch 1) and two for the cultivated population (Souiniet 2 and Babouch 2), based on the importance of their cultivation area and the species' distribution.The sites in question were located between 420 m (Babouch) and 720 m (Souiniet), with longitudes ranging from 36°77729 for Souiniet 1 to 36°85603 for Babouch and latitudes ranging from 80°68251 for Babouch to 8°78215 for Souiniet (Table 1). The region's topography is characterized by its uneven and mountainous terrain, with an average altitude ranging from 200 to 800 m. It is widely acknowledged to be one of the most complex topographies. The study area encompasses a humid bioclimate stage characterized by low temperatures. This is evidenced by the presence of substantial precipitation, which can attain up to 1550 mm in some regions. The region's average temperatures are indicative of a Mediterranean climate.

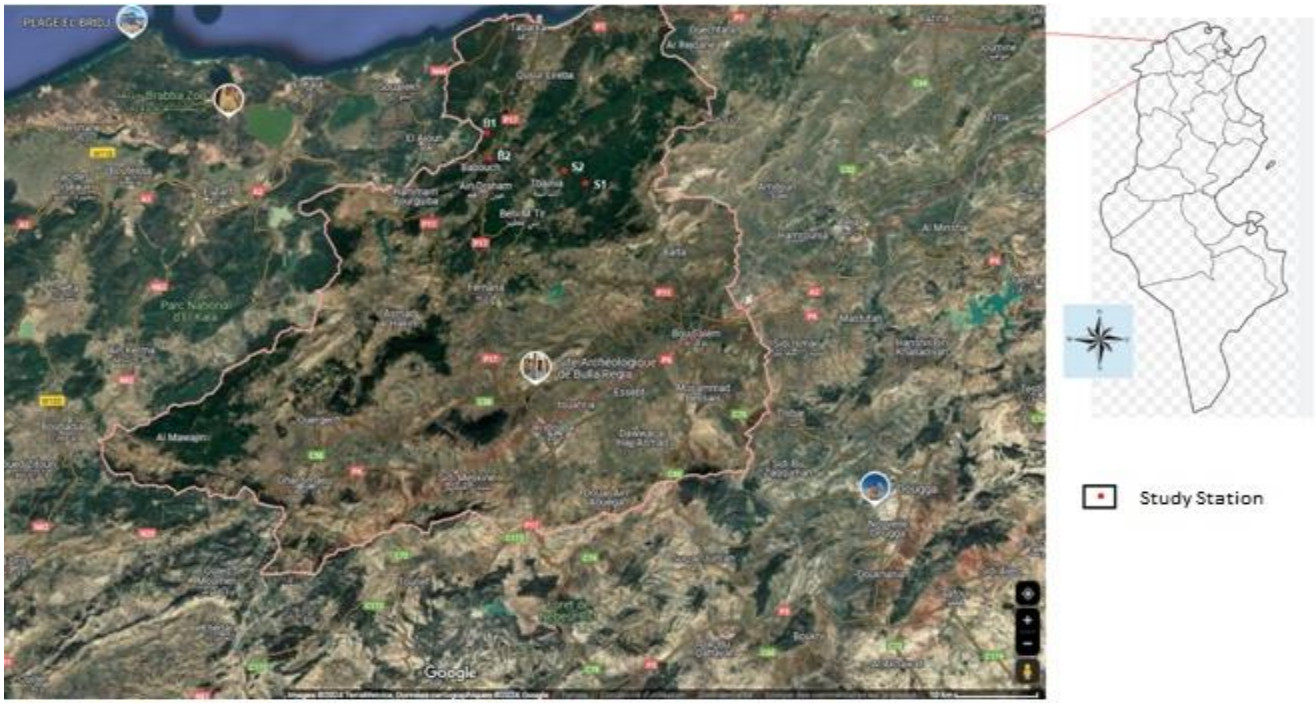

Figure 1: Geographic distribution of different wild and cultivated cherry sites

2.2. Plant Material

The investigation was conducted on adult trees of the wild cherry (*Prunus avium*) and cultivated cherry (Bouargoub) species, which are of similar maturity (Figure 2). The objective of this morphological characterization is to identify and compare the vegetative parts (leaves), reproductive parts (fruits), and total feet of the many cultivars evaluated, in order to emphasize their similarities and differences. The leaf and fruit samples were taken at random, with the sampling method taking into account factors such as sun exposure, orientation (north, south, east, and west), and the interior of the tree.

2.3. Morphological characterization

For each species, 40 trees were selected based on their vegetative progress and overall health. These were adult trees that had been producing for at least four years, had no graft compatibility issues, and showed no signs of infection or parasitic attacks. To characterize each clone, 400 leaves and 400 mature fruits were collected from 40 selected plants (10 leaves and 10 fruits per tree). Nine characteristics were reported qualitatively and classified as follows: leaf color, leaf dentition, leaf mosaic, leaf color, fruit form, flavor type, stone volume, tree habit, and tree height. Seven additional quantitative features

were assessed: trunk circumference, 10 fruit weight, peduncle length, fruit length, fruit width, leaf length, and leaf width.

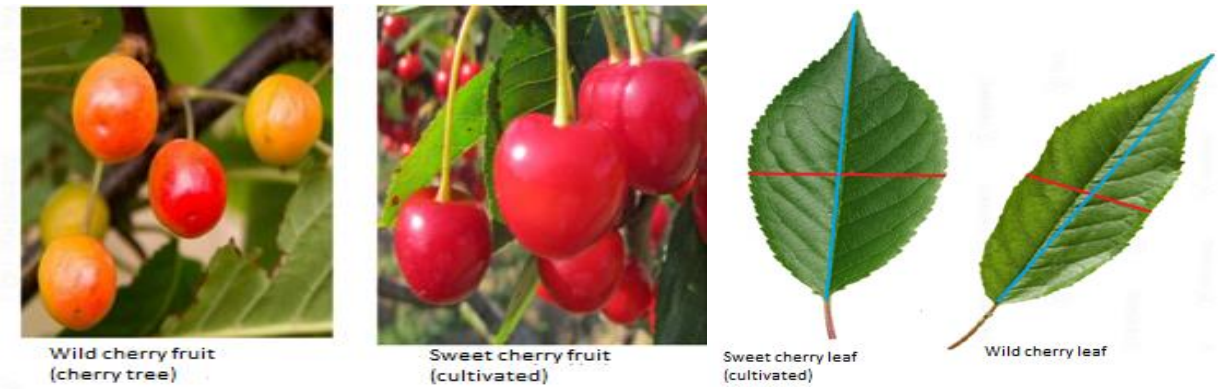

Figure 2: The measurement of leaves and fruits of wild cherry and sweet cherry (Photos from Jdaidi 2023)

3. Statistical analyses

Morphometric measurements of leaves and fruits were made with Image Mesurim software. Excel was used to code and organize the database, while XLSTAT 2020 was used for statistical analysis.
The descriptive analysis enabled us to synthesize the raw data and describe the unique characteristics of each variety. We calculated the mean, which is a measure of central tendency for quantitative traits. We then measured dispersion and position by calculating the standard deviation, which analyzes the distribution of information around the mean and helps establish data scope, as well as the minimum and maximum values. Finally, we determined the percentage of each modality's qualitative qualities. To analyze the data, we employed two primary methods: analysis of variance (ANOVA) and principal component analysis (PCA). These techniques allowed us to effectively separate the variables of the examined types. The following scale, developed by Ouédraogo (1995), was used to assess variability within and between populations:
CV = 0-10%: low variation;
CV = 10-15%: medium variation;
CV = 15-44%: fairly large variation;
CV > 44%: indicates a large variation.

3. Results and Discussions

3.1. Study of descriptive analysis

3.1.1. Analysis of qualitative variables

We analyzed the morphology of 80 trees from four locations in Aïn Draham, using 16 characters (9 qualitative and 7 quantitative). The varieties demonstrated polymorphism for tree-related traits. The cultivated cherry variety (sweet cherry or Bouargoub) is characterized by a broad shape and medium height (50%), while the wild variety is distinguished by a semi-broad shape and long height. In contrast, the wild variety exhibited a semi-broad shape and a long height. Regarding leaf-related traits, the cultivated variety (Bouargoub) exhibited toothed leaves, while the wild variety displayed finely toothed leaves. The majority of the leaves were dark green and free of mosaic for both varieties. Regarding fruit traits, the wild variety has yellow-brown fruits, round in shape, bitter in flavor, and with a small pit. In contrast, the fruit of the cultivated variety is bright red, kidney-shaped, and sweet in flavor, with a small pit (Table 1).

3.1.2. Quantitative Variables Analysis

The mean, minimum, maximum, and standard deviation for the quantitative features were calculated based on their morphological frequencies (Table 2). In wild species, there is minimal variance between morphological features. In contrast, most morphological measures, including leaf length and width, trunk circumference, and fruit weight, show average variable coefficients for farmed species (Table 2). Geographical considerations and the effects of agriculture on farmed species can link these variances. This discrepancy might be attributable to the similarities observed between the two groups.

The average length of the leaves of the wild cherry tree (wild cherry) collected is 6.14 cm. The highest values are observed for the cultivated species (Bouargoub) with an average of 7.95 cm. The variation between the two varieties is significant (CV: 22.76%). The width of the wild cherry leaves is an average of 3.54 cm. The cultivated species exhibited the widest leaves, with an average width of 3.73 cm. The inter-varietal variation is low (CV = 5.09%). The ten wild cherry fruits weigh an average of 31.48 g, with the highest average values recorded for the Bouargoub species (cultivated species) (43.14 g). The inter-varietal variation is significant, with a coefficient of variation equal to 27.02%. The Bouargoub species stands out with fruits measuring 1.98 cm in length. In comparison, the cherry species exhibit a smaller average size of 1.54 cm. The variation between varieties is also significant (CV = 22.22%).

Table 1: Results of descriptive qualitative statistics of the varieties analyzed

Variety	Character	Modality	Effective	Percentage (%)
Wild cherry or cherry tree (*Prunus avium*)	Leaf colors	Dark green	400	100
	Leaf teeth	Finely toothed	400	100
	Leaf mosaic	Absence of mosaic	400	100
	Fruit colors	Yellow tinged with brown	400	100
	Fruit shape	Round	400	100
	Flavor Type	Bitter	400	100
	Core volume	Little	400	100
	Tree port	Semi-expanded	40	100
	Tree height	High	40	100
Cultivated cherry or sweet cherry (Bouargoub) (*Prunus avium*)	Leaf colors	Dark green	400	100
	Leaf teeth	Toothed	400	100
	Leaf mosaic	Absence of mosaic	400	100
	Fruit colors	Bright red	400	100
	Fruit shape	Kidney-shaped	400	100
	Flavor Type	Sugar	400	100
	Core volume	Little	400	100
	Tree port	Open	40	100
	Tree height	High	10	25
		Intermediate	30	75

The cultivated cherry tree's fruits measure an average of 1.59 cm in width. The wild cherry tree has the highest recorded value (1.10 cm). A substantial variation is observed between the wild and cultivated varieties (CV = 30.81%). The measurements taken on the peduncle lengths of the wild cherry fruits

show that they are, on average, 4.96 cm long. The cultivated varieties exhibited the highest lengths, with an average of 5.37 cm. The inter-varietal variation is low (CV = 7.63%). The trunk circumference of wild trees averages 78 centimeters. In contrast, cultivated trees exhibit lower mean trunk circumference values of 45.09 cm. The coefficient of variation for these measurements is 42.19%, indicating significant variation between the varieties. These findings align with those reported by Mezour (2023), who found that the leaves of the wild species range from 3.59 to 12.44 cm in length and from 2.31 to 6.49 cm in width. The same author's description of the wild cherry species indicates that the fruit length ranges from 1.17 to 1.63 cm, the width varies from 0.914 to 12.44 cm, and the peduncle length is between 3.65 and 6.31 cm. These measurements confirm the results of this study. Our wild species exhibits a strong morphological similarity with the wild and cultivated species in Algeria (Elhar).

Table 2 : Results of quantitative descriptive statistics

Variety	Character	Number	Minimum	Maximum	Mean	Standard deviation	CV (%)
Wild cherry	Sheet length	400	3.54	9.47	6.14	0.33	5.37
	Sheet width	400	1.72	5.98	3.54	0.12	3.38
	Fruit width	400	0.90	1.52	1.10	0.06	5.45
	Fruit length	400	1.09	2.05	1.54	0.10	6.49
	Peduncle length	400	2.91	6.78	4.96	0.45	9.07
	Trunk tour	40	25.00	95.00	78.00	1.98	2.53
	Weight of 10 fruits	400	28.00	35.00	31.48	1.36	4.32
Cultivated cherry	Sheet length	400	4.33	10.79	7.95	0.96	12.07
	Sheet width	400	1.95	6.35	3.73	0.31	8.31
	Fruit width	400	1.25	2.15	1.59	0.19	11.94
	Fruit length	400	1.33	2.23	1.98	0.22	11.11
	Peduncle length	400	3.09	7.12	5.17	0.32	6.18
	Trunk tour	40	15.00	63.00	45.09	4.56	10.11
	Weight of 10 fruits	400	32.09	48.19	43.14	4.45	10.31

Regarding the quantitative morphological indicators of our cultivated variety, our observations align strongly with several cultivated species in Algeria, such as Habarbi, Lapin, Burlat, Van, and Summit. (Mezour, 2023). Morphologically, our cultivated species Bouargoub resembles several cultivated species in Lebanon, such as Abiad, Banni, and Nouwari. (Chehade *et al.*, 2005). These characterization results, based on qualitative and quantitative markers, revealed significant polymorphism within the same variety and between varieties. This phenomenon can be explained not just by the environment but also by diversity adaptability (both genetic and environmental effects). However, certain commonalities between the variations have been found. The same variety exists under numerous names, which can be explained by regional and national linguistic differences. Badenes (1991) states that the description of morphological traits is the most widely acknowledged legal process for patenting and registering variations. These nominations can be validated with molecular tools. Research investigations similar to the present study have been undertaken using morphological criteria, as

reported by Hamed *et al.* (2021) in Algeria for the Bigarreau noir variety, which exhibits considerable parallels as well as some divergences. Rodrigues *et al.* (2008) investigated Portuguese varieties, whereas Ganopoulos *et al.* (2015) examined several countries. These studies also indicated the presence of morphological diversity between the distinct kinds. The factors contributing to this diversity include the age of the trees selected, their geographical location, and the duration of the sampling period.

3.2. Correlation between morphological descriptors

The principal component analysis (PCA) of the studied variables represents 99.87% of the information used for statistical processing (Figure 3). The variables are correctly illustrated, with the exception of the peduncle length, which is not properly represented on both axes. This PCA enabled the creation of Figure 2, which demonstrates that the length, width, and weight of the fruits, as well as the length of the peduncle, define axis F1. Regarding axis F2, the length and width of the leaves, as well as the trunk circumference, are the most determining factors.

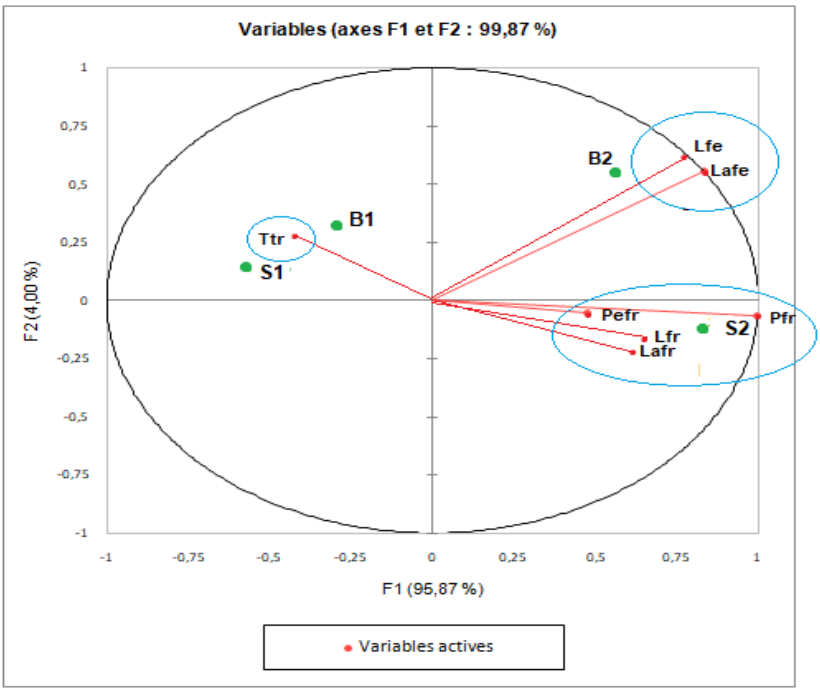

Figure 3: Distribution of morphological variables and sites by principal component analysis: Pfr: weight of 10 fruits; Ttr : trunk circumference; Lfr: Length of fruit; Lafr: Width of fruit; Lfe: Length of leaf; Lafe: Width of leaf; S1: Souiniet 1; S2: Souiniet 2; B1: Babouch 1; B2: Babouch 2

We define three categories of features, indicating that the parameters within each group are positively correlated. The first group comprises tree-related features such as leaf length and width. The second group covers fruit-related features. (Fruit weight, length, and width). It should be emphasized that these two groupings do not have any pictorial correlation. Furthermore, there is a modest negative association between the third group's characteristics (trunk circumference) and those of the second group. The results indicate that the cherry trees cultivated at Babouch 2 exhibit more pronounced leaf development. The leaves of the Babouch 2 population are notably long and wide, a distinction from the leaves of the Souiniet 2 population. In contrast, the wild populations of Babouch 1 and Souiniet 1 exhibit less developed leaves.

The cultivated population of Souiniet 2 demonstrates the most advanced fruit characteristics in terms of length, width, and weight, along with the length of the peduncle. Additionally, the wild species at the two sites have a larger trunk circumference.

Conclusion

The project involves conducting a descriptive morphological study of two varieties of wild and cultivated cherry (*Prunus avium*) across four stations in the Ain Draham region, located in the northwestern part of Tunisia. This morphological characterisation encompasses the most distinctive quantitative and qualitative descriptors associated with the tree, leaves, and fruits, encompassing a total of 16 morphological markers (nine qualitative characteristics and seven quantitative characteristics).

The study revealed that the leaves of the two cherry tree varieties are dark green, finely serrated, and free of mosaic. The two varieties are distinguished by their qualitative parameters, notably the color, shape, type of flavor, and the volume of the fruit's pit. The tree's growth habit is semi-erect for the wild variety and open for the cultivated variety. The cultivated variety Babouch 2 stands out for its distinctive leaf development, featuring long and wide leaves. In contrast, the wild varieties of Souiniet 1 and Babouch 1 exhibit less developed leaves. In terms of fruit morphology, Souiniet 1 displays the most notable characteristics in terms of length, width, and peduncle length. This observed variability in morphological traits can be attributed to the influence of environmental factors, such as agricultural practices, as well as to the adaptation of the varieties to their environment, which encompasses both genetic and environmental components.

This information is derived from thousands of measurements on the fruits and leaves of the cherry species (wild and cultivated), and it can support programs for improvement, cherry production, and the protection of wild forest fruit trees in the Ain Draham region.

Disclosure statement: *Conflict of Interest:* The authors declare that there are no conflicts of interest.
Compliance with Ethical Standards: This article does not contain any studies involving human or animal subjects.

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