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Review

Fruit Quality Characters of Myrtle (*Myrtus communis* L.) Selections: Review of a Domestication Process

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Abstract: Interest in myrtle (*Myrtus communis* L.) by food, cosmetics, and pharmaceutic industries generated the integration of biomasses harvested from wild populations as raw materials with yields of cultivated orchards. The domestication process is reviewed considering shoot, fruit, and leaf biometric characters of selections obtained in three steps of the program. The first step started in Sardinia (Italy) in 1995 by the analysis of wild germplasm variability. Seventy accessions were the object of the first studied population of mother plants. Agamic propagation tests, as well quality evaluations of fruit and leaves, were integrated into the first step. In the second step, a field of comparison of forty-two agamically propagated cultivars functional to biomass production and to food uses was planted and evaluated for phenotypic characters. In the third step, a new population of twenty selections was obtained by open cross-pollination of some of the cultivars and further phenotypic selection in seedling population. In this review, the three populations are compared for biometric shoot, leaves and fruit characters, in order to verify the pressure of domestication process on these traits. Wild populations showed high variability only partially used during the first step, while the hybridization may create new variability for use in the genetic improvement of myrtle.

Keywords: myrtle germplasm; phenotypic variability; wild populations; cultivar selections; hybrids

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1. Myrtle Characteristics and Uses

Myrtle (*Myrtus communis* L.) is an evergreen shrub of the Myrtaceae family widely spreading in the Mediterranean area in spontaneous bush-cover formations. Myrtle species comprise two subspecies, *communis* and *tarentina*. According to the color of ripe fruit, the two subspecies may be part of *melanocarpa* (bluish-black peel) and *leucocarpa* (yellowish peel) varieties. In Italy, wild myrtle grows in coastal areas and islands. In Sardinia Island, it is common below 800 m a.s.l. of altitude, mainly in neutral and sub-acidic soils [1]. Myrtle is a relatively rustic plant with an adaptability to difficult environmental conditions, but it is sensitive to cold winds [1]. Spring shoots growth occurs between April and September-October, with a period of vegetative rest in summer months due to loss of available water. The bloom, proceeding from the basal part of the new shoots, occurs from June until August. Further possible blooms on the apical part of the young shoots may occur during summer or autumn seasons [2]. Insects, birds, mammals, rains, and wind are the agents of seed dispersal [3]. The break color of fruit occurs between August and September, while ripening stages ranged from November until January-February. The myrtle fruit is a berry with different shapes (e.g., globular, ovoid, and pyriform) with one to eight seeds per locule [4].

The myrtle plant provides biomass as raw material for the pharmaceutical, cosmetic, ornamental, and food industries. Leaves and fruits are the most economically important plant parts. Leaves contain the essential oil glands and are used for fragrance extraction [5–7]. Berries, flowers, and seeds are also the raw materials to obtain essential oils and other extracts [6,8–10]. Several studies on the use of essential oils and extracts in post-harvesting products were carried out, showing a potential use of myrtle extracts to prevent the spread of fungal diseases in some postharvest fruit [11,12].

Myrtle is a multipurpose plant finding applications in several industries. It is appreciated and marketed as ornamental, as a garden plant, as cut fresh shoots, and as a potted plant, due to high vegetative vigor, the bright green color of the leaves, and the abundant white and pink flowers of the high summer flowering [2]. In the Sardinia region (Italy), berries and leaves are used for the production of the typical myrtle liqueur, obtained from hydro-alcoholic infusion of full ripe berries and leaves (red and white myrtle liqueur, respectively). Given the increased market of the liqueur, a production regulation of '*Mirto di Sardegna*' liqueur was promoted. The production specification contains the physical, chemical, and organoleptic characteristics of liqueur, as well as the best practices to respect the traditional process. According to the production rules, the liqueur '*Mirto di Sardegna*' must be produced exclusively from berries harvested in Sardinia and must not contain added flavor or coloring substances. In the last years, studies on berry and leaf hydroalcoholic extracts and liqueur qualitative composition were carried out, highlighting their antioxidant activity due to the phenolic compound content and composition [13–16]. Other findings have been obtained concerning the effect of the berry's cold storage on liqueur qualitative composition [17,18]. Moreover, recent studies suggested the potential use of myrtle plant and its derivates for nutraceutical and pharmaceutical applications due to biological, anti-inflammatory, and antiaging properties [19–22]. From these studies it has emerged that part of the biological properties of myrtle biomasses are due to phenolic compounds content. The first studies on the biosynthesis of these compounds in myrtle species were carried out on myrtle cultivars selected during the domestication process [23,24].

2. The Myrtle Industry and Problems of Sustainability

Myrtle berries used as raw material of the liqueur industry is still the main yield of harvests from spontaneous wild plants. In the last decades, a significant increase in myrtle biomass demand generated uncontrolled pressure over the wild plants of the species. A multitude of expert and inexpert people go across the countries and sometimes irrationally remove high quantities of berries and biomass without respect for some fundamental rules. Berry harvesters often forget the recommendation to harvest only berries without cutting shoot biomasses, thus exposing plants to a strong selective ecological pressure. These conditions could compromise the vegetative and productive plant development, the natural genetic evolution of the species by seed exclusion from the reproductive mission, and the ecological equilibrium among plants of different species. Moreover, myrtle is threatened by other recurring factors, such as fires, wood cutting, urbanization, and feeding of grazing animals [2].

In response to stress, plants can react by eliminating or delaying reproduction activity as a conservative survival strategy [25]. Anthropogenic pressure on the land may lead to fragmentation of the species with the formation of small, isolated populations that lost genetic variability, increasing their extinction probability [26]. The Mediterranean basin is characterized by high plant biodiversity distributed in limited geographical areas and, as reported by Le Roux et al. [27], the global plants' extinction rate is higher with respect to the Eurasian region. The main causes of species extinction in the Mediterranean area are the high impacts of invasive species, agriculture, and urbanization.

With the aim to preserve wild myrtle populations and to select suitable genotypes for cultivation and industrial uses, the domestication process of myrtle species was started [28]. Moreover, the production and quality of berries is dependent on the variability of several factors, in particular environmental conditions and the altitude of the growing area of wild plants [29]. Indeed, the biomass destined for industrial transformation must have certain standards that spontaneous populations cannot provide with regular consistency.

In the literature, information about the domestication of many similar species is available, such as for bilberry and cranberries [30]. Domestication and selection processes affected morphological traits that can be used to distinguish wild populations from selected ones [31]. Zohary [32] classified plants selection during domestication into intentional and automatic selection. An economic purpose generates intentional or conscious selection, while automatic or unconscious selection occurs when the plants are moved from their natural habitat to an anthropic one.

The domestication program of myrtle followed some specific steps.

(a) Improve information about plant biology, particularly fruit development and ripening.
(b) Evaluate the performance of myrtle propagation by seed and cutting.
(c) Study spontaneous germplasm variability from morphological, phenological, and genetic points of view.
(d) Identify morphological characteristics useful for cultivation and other uses.
(e) Start the mass selection of valuable ecotypes for a first evaluation in situ and subsequent agamic propagation by softwood cutting of mother plants in the collection field of the University of Sassari, located at Fenosu (Central-Western Sardinia).

The aim of this review is to describe the process of myrtle transformation from wild species to aromatic crop through the steps of the domestication process, and the development of related genetic and metabolomic studies. The berry quality evaluation was a fundamental tool for cultivar selection [33]. Consequently, the determination of biometric characters allowed a comparison between wild and domesticated populations and further possibilities of the agricultural model used in domestication. The relevance of the biometric characters measured in the three populations studied in different steps of the research program is mainly linked to fruit and leaf performance during liqueur production. Fruit size, shape and seed/pulp ratio influence the infusion concentration and quality. In the same way, the leaf size is strongly related to the essential oil yield.

Three steps characterize the domestication process [2,4,34]: Mass selection in situ; the transfer, study, and selection of a candidate clone population in an experimental field; and the selection of a new group of hybrids obtained by open pollination of some of the previously selected clones (Table 1).

Table 1. Myrtle domestication workflow.

	Step 1—Mass Selection (1995–1997)	
Target	**Material**	**Method/Results**
In situ selection of candidate mother plants according to a pre-designed morphotype	Wild populations of all the Sardinia region	70 mother plants studied and agamically propagated Morphological and quality analysis according to a descriptor list
	Step 2—Cultivar Selection (1997–2001)	
Target	**Material**	**Method/Results**
Selections characterized by: - agamic propagation and nursery viability - agronomic performance - disease tolerance - fruit and leaf quality	40 cultivars obtained from the in situ selected wild mother plants and field tested	Observation in ex situ collection field and other experimental plots under the same ecological and management conditions Morphological and quality analysis
	Step 3—Open Pollination Cross and Hybrid Selection (2001–2006)	
Target	**Material**	**Method/Results**
Explore variability of new hybrids: - seedling comparison, agamic propagation, and nursery viability - agronomic performance - disease tolerance - fruit and leaf quality	Three selections used as mother plants for open cross 387 seedlings observed and 20 selections cloned	Open pollination and seed sowing Seedling observation Agamic propagation Morphological and quality analysis according to a descriptor list

3. Evaluation of Spontaneous Myrtle Germplasm and Mass Selection: The First Step

3.1. Guidelines for Wild Plant Selection and Primary Characterization

The study of spontaneous myrtle germplasm began about twenty-five years ago in Sardinia. From 1995 to 1997, 70 candidate mother plants selected and sampled from 36 localities of Sardinia formed the first studied population [4]. The localities were in a range of altitudes between 10 m a.s.l. (Porto Ferro and Pula localities) and 637 m a.s.l. (Laconi), with different geopedological substrates: Basaltic, granitic, alluvial, and sandstone soils. However, marked preference of myrtle for acid and sub-acid soils was found. A description of ecological characteristics and vegetation cover for each locality was part of the field relief. In some of these localities, myrtle was widely spread, while in others, it was sporadically present [1].

The choice of the mother plants was strongly influenced by some basic knowledge of wild myrtle populations characteristics [1]. Vigorous phenotypes were preferred because of the strong association between the vegetative development and fruit yield. Another component of the plant type candidate for selection was the flowering phenology. The flowering time was generally variable among and within the studied populations.

Water availability was the main factor that affected the natural re-flowering occurrence. Usually, under water stress, the less vigorous plant showed high scaling of ripening, because of the small fruit drop after fruit-set. Contrarily, vigorous plants supported by greater water availability during the summer months developed flowering mainly using the spring shoot flush, and fruit ripening is completed in Autumn without scaling. These observations were useful to define the preference for selections apparently characterized by only one flowering flush. Moreover, the cultivation guidelines were arranged including the need for irrigation support in the critical period during and immediately after fruit-set. In Sardinia, myrtle ripen from November to January, depending on the genotype and growing area. In order to avoid frugivorous (migratory birds) predation of berries in January, selected mother plants with early ripening times were preferred.

During fruit ripening, from October to February, biometric and morphological determinations on small shoots and fruits of 70 in situ selected "mother plants" were carried out. Thirty small branches per shrub, divided in three replications of ten branches, were the sample for the phenotypic analysis. According to the descriptor list preliminarily designed (Supplementary S2), the shoot length, the number of internodes per shoot, and the number of berries per shoot were determined. A sample of 50 fruit per every one of three replications was harvested to determine the peel color, fruit weight, volume, width, length, as well number and weight of seeds. Moreover, during the fruit ripening stage, using three replications of 20 leaves per selected plant, the mean length and width of leaf were observed.

3.2. Morphological and Biometric Description of the Wild Mother Plant Population

The average values found for fruit weight (Figure 1a), volume (Figure 1b), length (Figure 1c), and width (Figure 1d) in the population were 0.35 g, 0.45 mL, 10.5 mm, and 8.9 mm, respectively. The number of seeds per fruit varied from 3 to 19 (Figure 2c), with seed weight per fruit highly variable between selections, from 0.01 to 0.22 g (Figure 2b). The number of fruits per shoot was highly variable among selection and comprised between 1.50 and 11 cm (Figure 2d). The pulp/seed ratio was between 0.8 and 13.8 (Figure 3b). Leaf length showed values between 1.5 and 4.5 cm (Figure 3c), and leaf width between 0.5 and 2.5 cm (Figure 3d). The leaf length/width average ratio, indicative for the determination of shape, was 2.4 (Figure 4a). The shoot length was 8.06 cm (Figure 4b). In a previously published elaboration of data recorded in this step of the program, authors found positive correlations between fruit weight, and fruit volume and seed weight per fruit (Table S1) and between shoot length and number of internodes, as well as a negative correlation between the number of internodes and leaf size, and a positive correlation between internode length and leaf size [4].

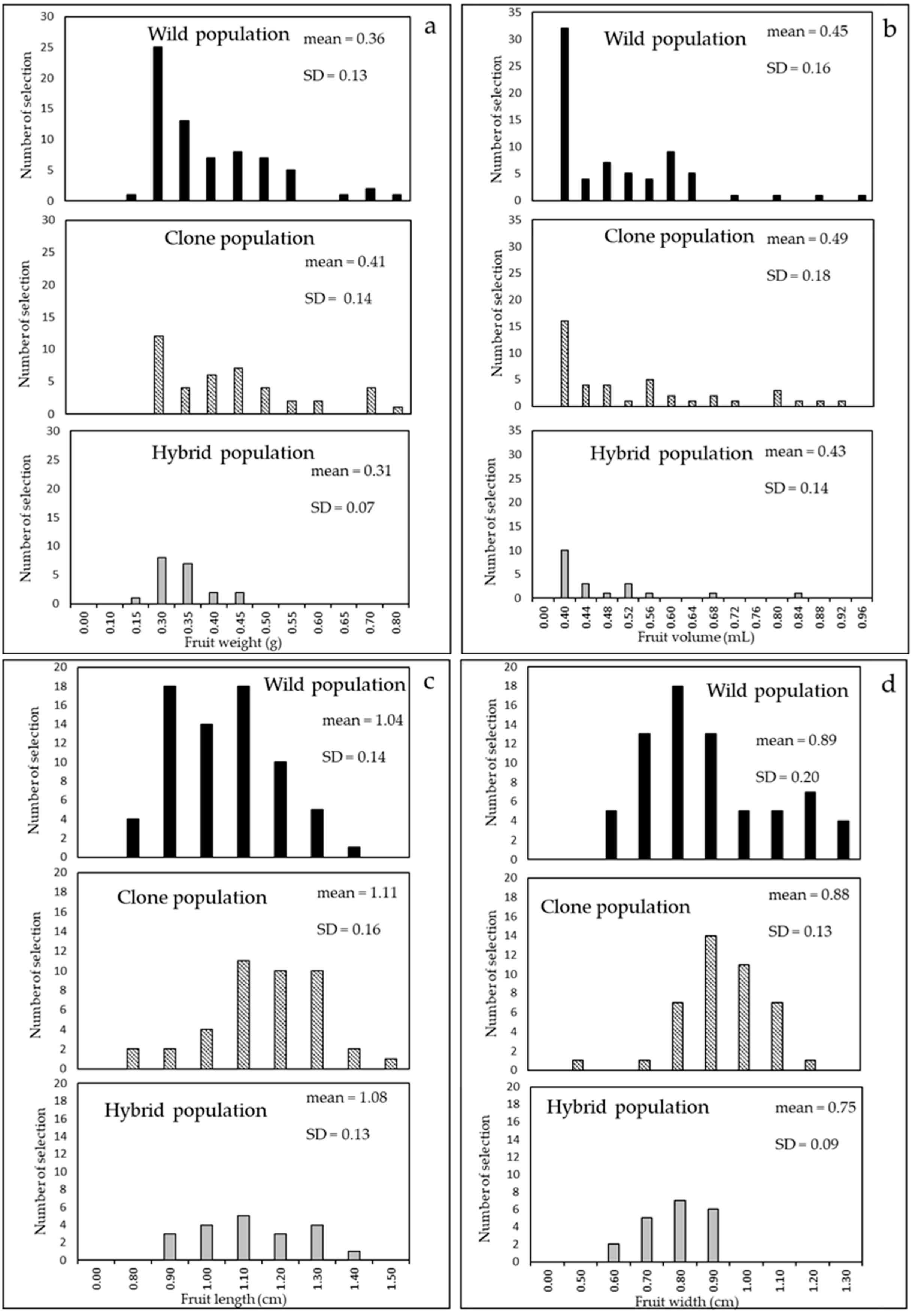

Figure 1. Distribution of fruit weight (**a**), fruit volume (**b**), fruit length (**c**), and fruit width (**d**) of myrtle selection.

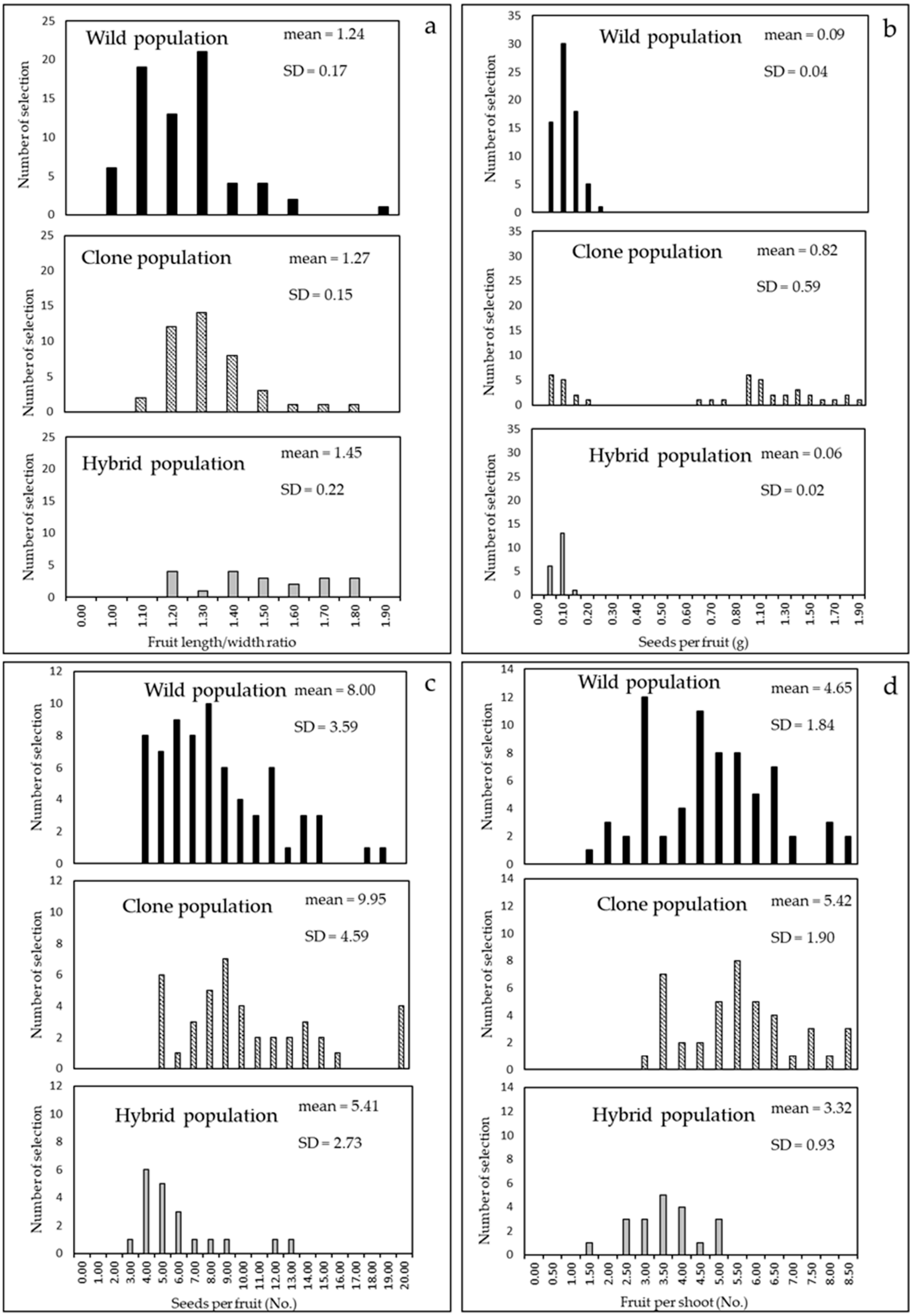

Figure 2. Distribution of fruit length/width ratio (**a**), weight of seeds per fruit (**b**), number of seeds per fruit (**c**), and fruit per shoot (**d**) of myrtle selections.

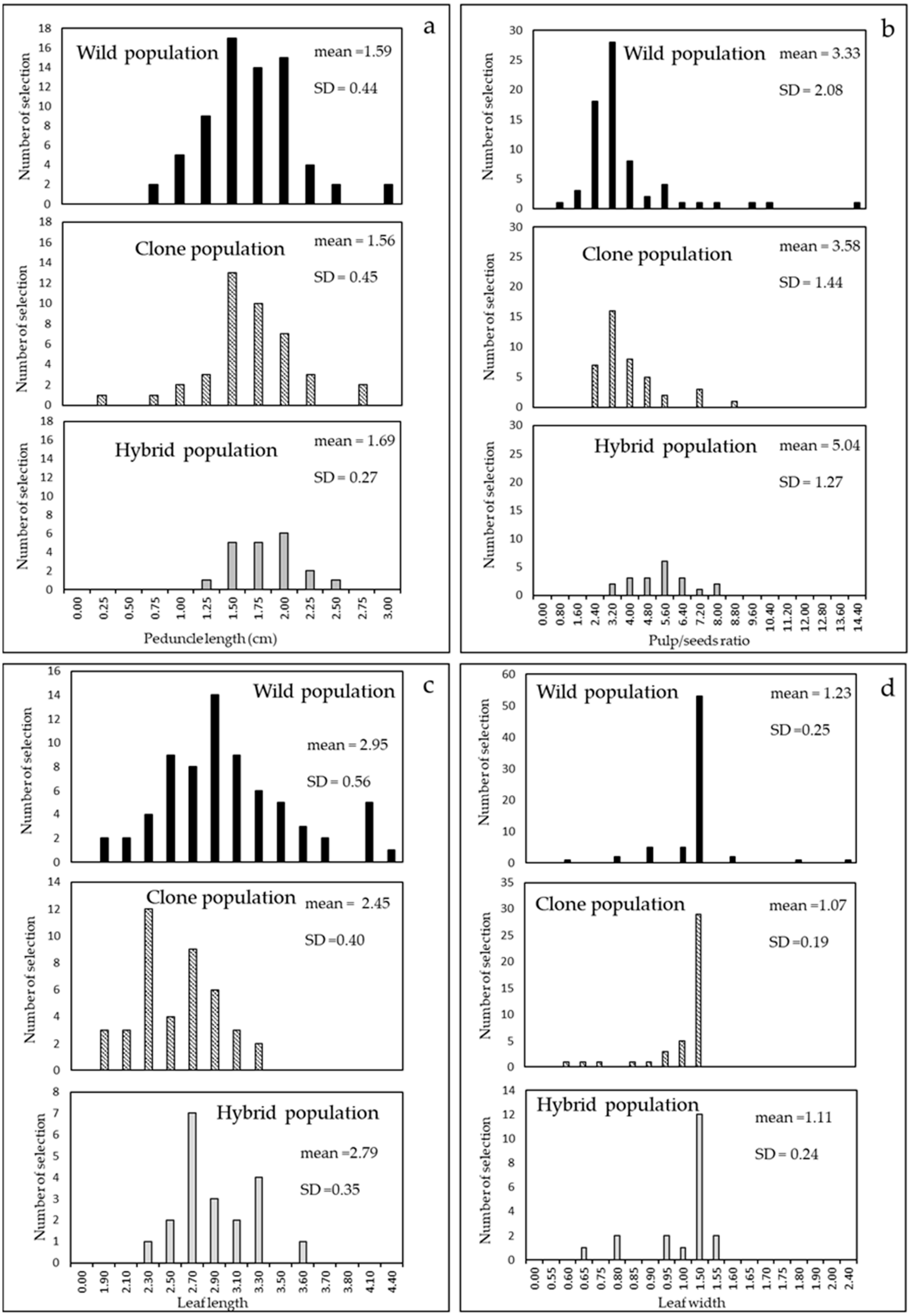

Figure 3. Distribution of peduncle length (**a**), pulp/seeds ratio (**b**), leaf length (**c**), and leaf width (**d**) of myrtle selections.

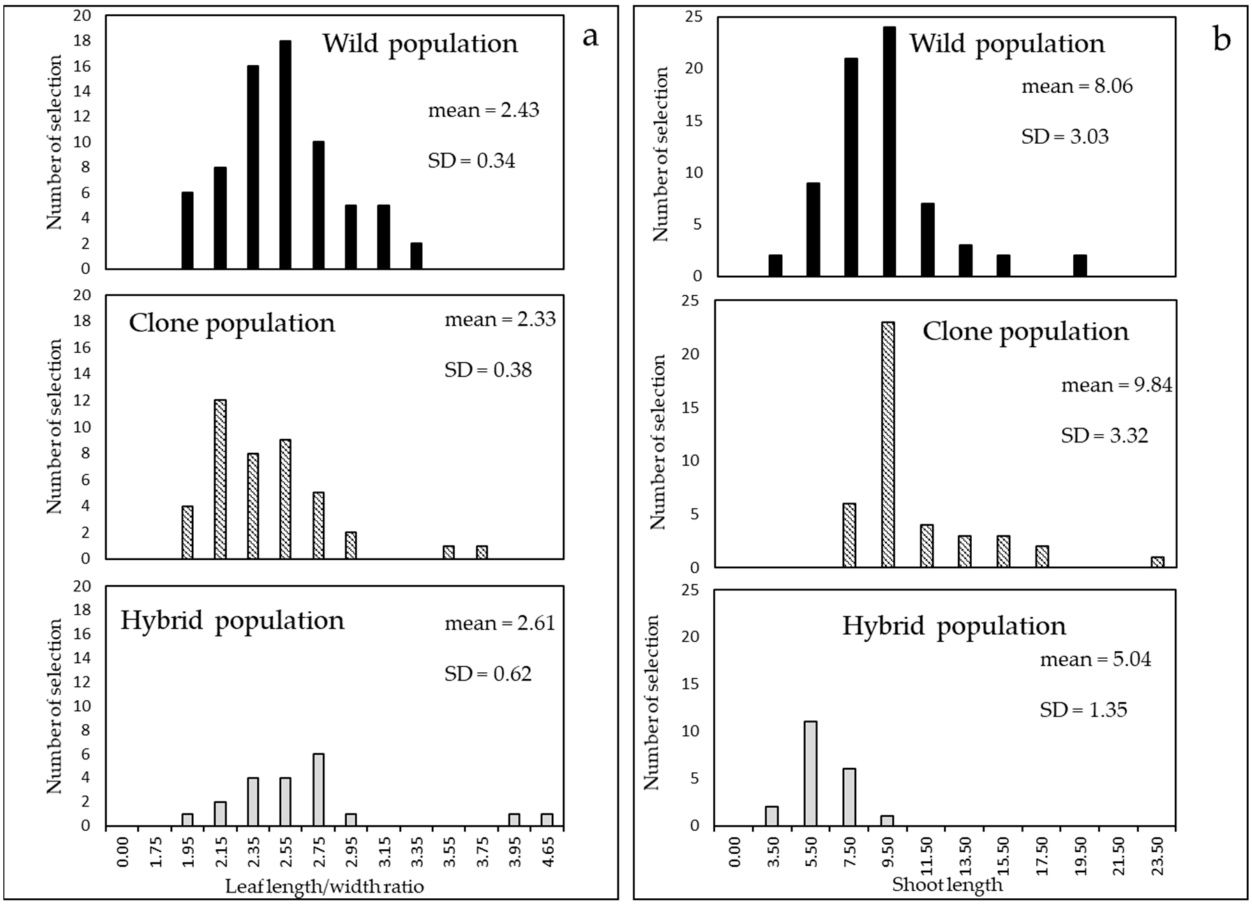

Figure 4. Distribution of leaf length/width ratio (**a**) and shoot length (**b**) of myrtle selections.

As previously reported, the myrtle plant is also appreciated as ornamental and, during mass selection, some interesting mother plants were evaluated. Characters useful for this purpose were a high number of flowers per cm of shoot, stalk length, and diameter of the corolla. Moreover, some selections are interesting for the supernumerary production of petals. Usually myrtle flowers have five petals, but they can reach an average of nine in some selections. Moreover, some fruit forms, such as pedunculated and swirled, or colorations (white and pink) are requested for ornamental use [2].

Within the observed characters useful to discriminate the best selections for berry production, the following have been identified: High yield of fruit per shoot, fruit weight over 0.5 g, high pulp/seed ratio, and peduncle with a length over 2 cm to facilitate the harvest. Correlations found between branch length, number of internodes, and leaf size were useful for the selection of clones for biomass production [4]. Leaves of the 70 selections showed high variability in both biometric characters and morphology characteristic. The twig length varied from 2 to 31 cm, and the number of internodes per branch from 2 to 35. The yield in essential oil varied from 0.2 and 1.4%.

4. Cultivar Selection and Field Evaluation: The Second Step

4.1. Mother Plant Agamic Propagation, Nursery Management and Field Data Record

From the preliminary study of the myrtle spontaneous germplasm of Sardinia, a first selection of candidate cultivars potentially interesting for the cultivation and industrial use of the plant was obtained [2]. From the 70 selections studied in the previous step, after the softwood cutting propagation tests and nursery management, 42 cultivars were selected with a number of cloned plants sufficient to constitute a catalogue field and some further test fields distributed in Sardinia. Softwood cuttings were treated with 1.0% of indolbutyric acid and placed in a rooting perlite bed for 3–4 weeks. After rooting, cuttings were placed in pots, and after one year of nursery growth, planted in a field. The catalogue field was planted in 1998 in the experimental station of the University of Sassari located in Fenosu (Central Western Sardinia 39°54′12″ N, 8°37′19″ E). A sub-plot of fifteen plants represented every selection.

The comparison of selections in the same environment and under the same field management allowed a better evaluation of genotype influence on plant characteristics. Consequently, in the years after planting, all the new cultivar populations were submitted to phenotypic observation according to the yet tested descriptor list (Supplementary S2). The descriptor list, optimized in this step of the program, contains the following sections: General data of the access, descriptors of the site of origin or sampling site, descriptors for seed sample, descriptors of the repository, morphological descriptors of the plant, qualitative aspects of plant organs and derived products, sensitivity to biotic and abiotic stresses, and molecular type determinations. Every two weeks, descriptions on phenological stages were observed. The biometric analyses (e.g., fruit color and shape, and seed number per fruit) reported for the previous stage selection were newly carried out on fruiting branches during the ripening stage. On berries and leaves, qualitative determinations, such as fresh weight, dry weight, acid content, reducing sugars, total sugars, and essential oil yield, were carried out.

4.2. Cultivar Biometric Characters and Other Agronomic Evaluation

The fruit of forty-two cultivars showed an average value of the mean weight of 0.41 g (Figure 1a), volume of 0.49 mL (Figure 1b), length of 1.11 cm (Figure 1c), and width of 0.88 cm (Figure 1d). The seed number in the fruit was between 4.13 and 21.37 (Figure 2c), while their weight per fruit ranged from 0.05 to 1.74 g (Figure 2b). The number of fruits contained per shoot (Figure 2d) was from 2.57 to 12.37. The pulp/seed ratio (Figure 3b) was variable among selected cultivars ranging from 2.13 to 8.56. Leaf size showed a value of length between 1.23 and 3.30 cm (Figure 3c) and width between 0.57 and 1.43 cm (Figure 3d). The leaf length/width ratio average (Figure 4a) was 2.33, while the average shoot length (Figure 4b) was 9.84 cm.

Among the forty-two selected cultivars, some bearing pigmented and unpigmented fruits were included. In general, it was observed that unpigmented cultivars, showing high vegetative vigor and good tolerance to phytoplasmas, were suitable for ornamental use. Moreover, some cultivars, as 'Angela' and 'Luisa', showed a high re-flowering aptitude, valuable character for ornamental use [2].

Furthermore, agronomic information on myrtle cultivar was provided. The vegetative vigor of described cultivars was generally medium or low, except for some selections like 'Ika' cultivar due to vigor and leaf size, which can be suitable for green biomass, white myrtle liqueur, and essential oil productions.

The productivity was high or medium for all cultivars, ranging from 1 to 2 kg per plant. Selections with unpigmented fruit normally give the highest yields (over 4 kg/plant) [35].

5. The New Group of Hybrid Selections

5.1. Open Pollination Cross, Seedling Sowing, Field Comparison, Phenotypic Selection, and Softwood Cutting Propagation

The third step of the domestication process involved the selection of new, more productive genotypes, with the absence of re-flowering and vigorous, suitable for fruit and biomass production. This new selection began in 2001, starting with the cross-pollination of plants of the cultivars 'Grazia' and 'Erika' growing in the comparison field described in the second step [34]. Seeds taken from mature fruit were washed and immediately sowed in small pots containing a mixture of peat and perlite. Seed germination in myrtle is always easy and any dormancy was observed in the case of the tested genotypes. A population of 387 hybrid seedlings were selected and transplanted in single pots of about 1 L volume. After one year of nursery growth, seedlings were planted in a new field of comparison in the experimental station of Fenosu. Seedlings grew for three years, and in the 2005, 20 plants previously observed for vigor and early fruit production were selected following the same methodology applied in the first step: Mother plant primary description; softwood cutting propagation, nursery growth, and finally, planting of a new field of comparison containing 20 plants for each new cultivar [34].

Five years after planting, a description of selected ecotypes was provided by means of biweekly observations on phenological stage evolution and morphological trait measurement, as reported in Section 4 for the first group of selections. Morphological traits comprised fruit weight (Figure 1a), volume (Figure 1b), length (Figure 1c), width (Figure 1d), length/width ratio (Figure 2a), weight and number of seeds per fruit (Figure 2b,c), length of peduncles and shoots (Figure 3a), and length (Figure 3c), width (Figure 3d), shape, and color of leaves, and length of shoots (Figure 4b).

5.2. New Cultivars Originated by Hybridation: Phenotypic Characters and Biometric Data

Unpigmented 'Grazia' cultivar generated V1, V2, V3, V4, V5, V6, V7 V8, V9, V10, V11, V12, V15, V17, V19, and V20 clones. 'Erika' cultivar was the mother of V18 clone, while V13, V14, and V16 clones derived from 'RUM 11' (a candidate selection subsequently discarded) [34]. For a total of 20 clones selected in this step, only V3 and V8 clones have unpigmented berries. The new selections suitable for berries production were V1, V2, V4, V5, V6, V7, V8, V9, V12, V16, and V19. The V1, V5, V9, V11, and V14 are vigorous selections that adapt to biomass production. With regard to phenological stages, V5 showed an early ripening stage between November and December, while V18 was the selection with ripening in January. A slight re-flowering aptitude was observed for V7 and V13 clones. Regarding phytosanitary status, in general, all clones showed no symptoms of phytoplasmas.

Morphological determinations on fruits showed an average weight of fruit between 0.44 g for V15 and 0.14 g for V13 (Figure 1a). The fruit length/width ratio (Figure 2a) among hybrids was variable, with an average value of 1.45, while the average weight of seeds per fruit ranged from 0.11 g for V18 to 0.043 g for V6, V11, and V13. V7 (Figure 2b). Most clones, such as V1, V2, V3, V4, V16, V17, and V18, showed elliptical shape, V5 showed elongated pyriform fruits, while V13 simply showed a pyriform shape. The number of seeds per fruit was between 2.33 and 12.50, with an average weight of 0.06 g (Figure 2c). Regarding leaves, the most frequent shape was elliptical for V1, V2, V3, V4, V6, V7, V9, V10, V12, V15, V17, V19, and V20. Indeed, in the other selections, the leaves were acute and elongated.

6. Comparison of the Populations Studied in the Three Steps

When analyzing the average fruit weight character (Figure 1a), it was observed that for all three populations, the higher number of individuals was in the range of 0.3–0.4 g. The wild selections and cultivars showed a similar frequency distribution reaching a maximum of 0.8 g, while the hybridization resulted in cultivars with a maximum weight of 0.45 g. Moreover, for fruit volume, the highest number of selections of the three populations was recorded in the same range of variability (0.4 mL). However, hybrids showed less variability for this character, as compared to cultivars and wild ecotypes (Figure 1b).

The frequency distribution of the three populations for the fruit length showed a similar trend, with a high number of selections having a length of 1.10 cm and a lower number with 1.40 cm (Figure 1c). The hybridization caused an alteration in the distribution of fruit width (Figure 1d) reducing the variability. The hybrids reached a maximum fruit width of 0.90 cm, while cultivars reached 1.30 cm. The cultivar population reflects the trend of the wild population, with the difference that there are no hybrids with a fruit width of 1.30 cm. On the contrary, hybridization has led to an increase in variability for the fruit length/width ratio (average 1.45), as compared to the wild population (average 1.24) (Figure 2a).

The number of seeds per fruit was higher in the wild and selected cultivars than in the hybrids. Most of the wild selections had a number of seeds per fruit of 8, cultivars were around 9, while in the hybrids, the highest frequency was recorded in the range of 4, and any individual was in the range from 14 to 20 (Figure 2c). As regards the weight of seeds per fruit (Figure 2b), it is important to note that the selection of cultivars led to a wide variability for this characteristic (average 0.82 g), with selections that reach about two grams. Hybrids reflect the same trend of the wild population, although with a maximum value of 0.15 g compared to the wild average 0.25 g. Considering the pulp/seed ratio, the hybridization brought an increase in this character (average 5.04), ranging from 3.20 to 8, with most at 5.60, while in the cultivars, the highest frequency was 3.20. The ratio pulp/seeds, as well as the number and weight of seeds, are useful parameters to evaluate the use of the fruit for industrial processing or fresh product.

For the number of fruits per shoot (Figure 2c), the second stage of domestication allowed the selection of cultivars with a range of values from 3 to 8.5, while the hybridization reduced the variability of the character with a maximum of 5 fruits per shoot. The trend of the frequency of distribution for the peduncle length was similar in the three populations, with the difference that there were no hybrids with a length less than 1.5 cm (Figure 3a).

For leaf length, some wild genotypes had values greater than 4 cm, whereas with selection and hybridization, variability decreases with a maximum range between 3.3 cm for cultivars and 3.6 cm for hybrids (Figure 3c). In all populations, the greatest number of individuals showed a leaf length/width ratio around 1.5 (Figure 3d). From Figure 4a, it can be seen that hybridization has produced an increase in variability for the leaf length/leaf width ratio value. In fact, there are hybrids with ratios of 3.95 and 4.65 that were not present in the other two populations. In contrast, hybridization created a reduction in shoot length variability, with an average value of 5.04 cm, as compared to the other two populations, where some selections showed a length of 19.5 cm or over 23 cm (Figure 4b).

7. General Evaluations and Future Perspectives of the Domestication Program

Plant uses are of fundamental importance for the survival and development of human population all over the world. The number of species submitted to domestication is inversely proportional to the technological level of agriculture. Indeed, agriculture of the Anthropocene era is based on a strong reduction of biodiversity of the cultivated species and global food supply today is mainly assured by five to ten plant species [36]. The over-exploitation of wild species is very common in the case of aromatic and medicinal plants [37]. Consequently, within-species biodiversity erosion and the risk of extinction are well evidenced. The historical case of the "*silphium*" plant extinction in the classical age is paradigmatic of a possible loss of not completely studied and domesticated resources [38,39]. Myrtle is just one among many possible cases of useful natural resources that support the development of a valuable industry that overcame the red line of the sustainability of use [2]. The lack of cultivation became particularly dangerous when the wild genetic resources were systematically destroyed like in the case of rosemary, oregano, the carry plant, and many other examples [40,41].

Plant domestication still remains as a tool to increase a multipurpose and sustainable agriculture, and many scientists work all over the world to study the available diversity of wild species with a clear orientation towards domestication [42]. The domesticated cultivars obtained by natural and human selection, as well as the environmental influences, lead to changes in morphological, phenotypic, and vegetative traits [43–45]. This review aimed to describe the work that has been done so far on myrtle domestication, as well as to evaluate the influence of the process on some fruit and leaf characters. The comparison of three populations (wild in situ selected, cultivated ex situ growing, and hybrids derived from free pollination) allows evaluating the influence that each single step had on the phenotypic variability. The study of these characters is useful to define the effective variability of the species transferred to cultivars, as well as the potential of classical hybridization to enhance the natural variability from a breeding perspective [46–50].

Table 2 resumes the main phenotypic characteristics that are the object of comparison with the corresponding indications on the technological value for both cultivation and postharvest processing. Considering the mean size of fruit, the linkage between this character with an easy hand-harvest according to fruit volume and mechanical-harvest according to fruit weight is clear. Indeed, researchers from countries like Turkey, where myrtle is a fresh fruit revenue source, performed detailed research on the physical properties of myrtle berries [51,52]. The processing of myrtle fruit as a dried spice, mainly marketed in Central Italy and Middle East, also requires berries of good size for aesthetic and market reasons. Moreover, all ornamental uses of myrtle plants benefit from well-visible fruit [53]. Fruit peduncle length is substantially linked to easy fruit detachment both by hand and by machine [54].

Table 2. Technological relevance of the observed biometric characters for the different uses of the myrtle biomasses.

Character Observed	Influence on Myrtle Industry Applications
Fruit weight, volume, length, and width Fruit length/width Fruit peduncle length	Quality and concentration of phenols and of essential oils compounds in infusions Fresh/dry consumption Ornamental use Essential oils yield Manual and mechanical harvesting
Seeds number per fruit Seed weight per fruit Pulp/seeds ratio	Fresh consumption Quality and concentration of tannins in infusions
Shoot length	Yield abundance and reflowering occurrence
Leaf length and leaf width Leaf length/width ratio	Essential oils and other extracts yield Green biomass production Quality and concentration of white myrtle liqueur Ornamental value

However, the main use of myrtle berries is the industry that processes the biomass by means of water extraction to produce a syrup for the aromatization of soft drinks or by a hydro-alcoholic solution for liqueurs production [55]. The leakage of phenolic compounds with (anthocyanins) and without coloring properties is mainly due the fruit epidermis and hypodermis tissues. This is also the location of the essential oil glands. In the case of both phenol and essential oils extraction, it is evident that the best yields are from small fruit, which are strongly preferred for industry uses, including pharmaceuticals [56]. The fruit shape showed the same importance to optimize the extraction yield of aromatic and coloring substances. Indeed, the spherical shape showed the smallest surface for the same weight and minor extraction yield with respect to elongated or pyriform fruit. This is because cultivars with berries of elongated and pyriform shape generated more aromatic and intensely colored liqueurs [2,4].

Seed percentage of total fruit weight and pulp/seeds ratio are characters that negatively influence the use of myrtle for consumption as fresh fruit. However, also in the case of the extraction processing, excessive seed percentage is negative because of the high content of tannins in seeds with respect to fruit pulp. Indeed, in the last stages of fruit ripening, fruit tannins sharply decrease, making pulp sweet and less astringent [57]. On the contrary, seeds maintain a high content of tannins even after ripening and may leak these compounds into the infusions [58,59]. Positive evaluation of this character is possible in the case of cultivation purposes oriented to the pharmaceutical industry because tannins (particularly ellagitannins) are the compounds of greatest interest [8].

Leaf shape and size influence the quality of the green biomass harvests from myrtle cultivations. Yields of leaf essential oil depend on genotype but the final quantity of the green biomass harvested is the other key to good economic results [5]. Furthermore, leaves also contain a strong quantity of phenolic substances and have wide possibilities of uses for many purposes [51,60–62]. Large and long-living leaves have a good ornamental effect, but the market also requires genotypes showing very small leaves as ornamentals and cut branches [53].

8. Conclusions

Myrtle domestication contributed to the safeguard of genetic resources of the species [2]. Most of the raw myrtle materials for industries still come from the harvest of spontaneous plants, causing erosion of the natural biodiversity of the species.

Research programs supporting cultivar selection provided better knowledge of myrtle biology and ecological requirements. Consequently, the quality standard of plant biomasses to objectively optimize different industrial uses were also defined and measured. Myrtle berries and leaves of cultivated selections showed higher market value, because of the predictable chemical composition, homogenous ripening stage, and absence of consequences of tissue stress (excessive dehydration, high level of tannins, and low content of anthocyanins). These characteristics strongly contribute to enhancing the quality of raw materials, particularly when the final destination of the industry process is the production of essential oil, nutraceutical food additives, or medicinal extracts like that increasingly obtained from the myrtle plant [19–22].

The analysis of data observed in the different steps of the myrtle domestication process allows some final considerations. Wild populations showed a rich variability only partially used in the mass selection of the first step. This is justified by a good level of preliminary knowledge on the species biology and ecology. The association between vegetative vigor and fruit yield was well considered in the choice of mother plants, and the consequent pressure of selection influenced the variability of the cultivars selected in the second stage with a further slight reduction. Hybridization seems to be the tool to open the breeding work to new variability in order to improve yield and adaptability to crop management.

Today, many basic studies on wild myrtle populations in different countries are being carried out with different approaches, like in Tunisia, Algeria, Turkey, and Iran [51,61,62]. Myrtle cultivation is a reasonable goal and the time seems right for international cooperation for the evaluation of this plant resource. Further objectives are breeding for plant shape, tolerance to phytoplasmas, low re-flowering, and super-production of a single useful compound, particularly for the pharmaceutical industry where most of the international interests are actually oriented.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su13168785/s1, Supplementary Table S1. Correlation among biometric measures of myrtle fruit and leaf as observed in the wild population of domestication step 1 (data extract by Mulas and Cani, 1999). Supplementary S2: Summary of myrtle germplasm descriptor list.

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