Chapter 2

Botanical Description

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1. Introduction

The olive (*Olea europaea* L.) is an emblematic species that represents one of the most important fruit trees in the Mediterranean basin (Loumou & Giourga, 2003). The Mediterranean form, *Olea europaea*, subspecies *europaea*, which includes wild (*Olea europaea* subsp. *europaea* var. *sylvestris*) and cultivated olives (*Olea europaea* subsp. *europaea* var. *europaea*), is a diploid species (2n = 2x = 46) (Kumar *et al.*, 2011).

The origin of the olive tree has been lost over time, coinciding and mingling with the expansion of Mediterranean civilizations which for centuries governed the destiny of mankind and left their imprint on Western culture. From the eastern of the Mediterranean basin, olive trees spread west throughout the Mediterranean area and into Greece, Italy, Spain, Portugal, and France. In 1560, the Spanish Conquistadors carried olive cuttings and seeds to Peru. From there or independently, olive trees were found in Mexico at Jesuit missions. The Franciscan padres carried olives and other fruits from San Blas, Mexico, into California. Sent by Jose de Galvez, Father Junipero Serra established the San Diego de Alcala Mission in 1769. Though oil production began there in the next decade, the first mention of oil was written in the records of the San Diego de Alcala Mission in 1803 as described by Father Lasuen (Winifred, 1967).

Currently, a renewed emphasis of the health benefits of monosaturated olive oil has lead to a resurgence of olive oil production. The olive tree has been widely used for shade around homes and as a street tree in cities. Its distribution is only limited by cold weather in winter, indeed temperatures below 10 °C are lethal (Denney *et al.*, 1993). Most olive-growing areas lie between latitudes 30° and 45° north and south of the equator, although in Australia some of the recently established commercial olive orchards are nearer to the equator than to the 30° latitude and are producing a good yield; this may be because of their altitude or for other geographic reasons.

Olive (*Olea europaea* L.) is the main cultivated species belonging to the monophyletic *Oleaceae* family that includes 30 genera and 600 species (Cronquist, 1981), within the clade of *Asterids*, in which the majority of nuclear and organellar genomic sequences are unknown. The *Olea* genus comprises 30 species and has spread to Europe, Asia, Oceania and Africa (Bracci *et al.*, 2011).

The olive is a member of the *Oleaceae*, the family that contains the genera *Fraxinus* (ash), *Forsythia* (golden bell), *Forestiera* (*F. neomexicana*, the California "wild-olive"), *Ligustrum* (privet), and *Syringa* (lilac) as well as *Olea* (olive). Its primary genetic resources are taxonomically classified in the *Olea europaea* complex in which six subspecies are recognized (Green, 2002) (scheme 1).

Kingdom: *Plantae*
Phylum: *Magnoliophyta*
Class: *Rosopsida*
Order: Lamiales

Family: *Oleaceae*
Sub-family: *Oleideae*

Genus: *Olea*
- **Sub-genera**: *Paniculatae*
  - *Tetrapilus*
  - *Olea*
    - Sections: *Ligustroides*
      - *Olea*
        - **Sub-species:** *cuspidata*
          - *laperrinei*
          - *maroccana*
          - *cerasiformis*
          - *guanchica*
          - *europaea*
          - varieties: *sylvestris* (wild olive)
          - *europaea* (cultivated olive)

Scheme 1. Taxonomic scheme of *Olea europaea* L.

The *Olea europaea* subsp. *europaea* include the wild form, also named *sylvestris*, and the cultivated form, called *Olea europaea* subsp. *europaea* var. *europaea*. The olive tree is self-incompatible. Out - crossing is mediated by the wind that transports pollen over long distances, with cytoplasmic male - sterile cultivars being pollinated efficiently by surrounding cultivars or even by sylvestris (Besnard *et al.*, 2000). It is assumed that cultivars originated from the wild Mediterranean olive and have been disseminated all around the Mediterranean countries following human displacement. It is also presumed that crosses between wild and cultivated forms could have led to new cultivars around Mediterranean countries (Besnard *et al*., 2001).

Nowadays, there are more than 2000 cultivars in the Mediterranean basin that displays huge diversity based on fruit morphology and pit size and morphology and several modern cultivars display small pits such as the *sylvestris*, making the distinction criteria doubtful (Bartolini *et al*., 1998; 2002; Ganino *et al*., 2006).

Until recent years, cultivar identification was based only on morphological and agronomic traits. However, recognition of olive cultivars based on phenotypic characters appeared to be problematic, especially in the early stages of tree development. Traditionally diversity within and between olive tree cultivars was determined by assessing differences in the olive tree, namely leaf shape and color, and olive fruits morphology. These measures have the advantage of being readily available, do not require sophisticated equipment and are the most direct measure of phenotype, thus they are accessible for immediate use, an important attribute. However, these morphological and phenological markers have the disadvantage of the small number of polymorphism detected and of being environmentally dependent (Mohan *et al*., 1997; Tanksley & Orton, 1983). Besides that, some of the phenological characteristics are only accessible for a limited period (e.g., olive fruits) or when the olive tree achieves a mature stage, which may delay correct identification. Due to the high genetic diversity level observed in olive germoplasm and the presence of homonym and synonym cases, efficient and rapid discriminatory methods are urgently required.

2. Description of the *Olea europaea* sub-species

2.1. *Olea cuspidate*

Olea europaea subsp. cuspidata is a native from South Africa, from which it spread through the Middle East, Pakistan, India to China. Subtropical dry forests of *Olea europaea subsp. cuspidata* are found in the Himalayan subtropical broadleaf forests ecoregion.

In the nineteenth century it was introduced to the Australian territory for economic purposes (Spennemann & Allen, 2000; Bass *et al*, 2006). Since 1960, cuspidata naturalized populations have been found in the Hawaii Archipelago (Starr *et al*., 2003). The *Olea europaea* subsp. *cuspidata* includes much - branched evergreen trees, which vary their size between 2 to 15 m in height. The leaves have an opposite, decussate arrangement, and are entire. Their size is between 3 to 7 cm in length and 0.8 to 2.5 cm in width. The leave apex is acute with a small hook or point, and the base is attenuate to cuneate. Leaf margins are entire and recurved, the upper surface is grey-green and glossy, and the lower surface has a dense covering of silvery, golden or brown scales. Venation is obvious on the upper surface and obscure on the lower surface; the petiole is up to 10 mm long.

Fruit are borne in panicles or racemes 50 to 60 mm long. The calyx is four-lobed and is about 1 mm long. The corolla is greenish-white or cream; the tube is 1 to 2 mm long; lobes are about 3 mm long and reflexed at the anthesis. The two stamens are fused near the top of the corolla tube, with bilobed stigma.

The fruit is a drupe whose shape varies from globose to ellipsoid, it is 6 mm in diameter and 15 to 25 mm long. The drupe is fleshy, glaucous to a dull shine when ripe, and purple-black. The tree usually flowers in spring. The wood is much - prized and durable and it is used for fine furniture and turnery.

Figure 1. Phenotypic aspect of *Olea europaea* subsp. *cuspidata* trees

2.2. *Olea laperrinei*

The *Olea europaea* subsp. *laperrinei* is restricted to the massifs of central - southern Sahara and eastern Sahel (Wickens, 1976; Quézel, 1978; Maley, 1980; Médail *et al.*, 2001; Green, 2002). The *Olea europaea* subsp. *laperrinei* are present at high altitudes, from 1800 to 2800 m, on volcanic or eruptive rocks, generally in cliffs and canyon banks . This taxon is adapted to very dry conditions and in Hoggar, a highland region in southern Algeria, along the Tropic of Cancer, it persists in areas reaching a mean rainfall of about 20 – 100 mm *per* year (Quézel, 1965).

The *Olea europaea* subsp. *laperrinei* trees reach a height of 1.5 - 3 m and their trunk is mainly monocaulous. Leaves have a lanceolate - linear to linear aspect, 2.8 - 4 to 5 - 7 cm long and 0.3 – 0.5 to 1 - 1.5 cm wide. They are ashy-green above and whitish - silvery beneath in colour and their apex is clearly mucronate. The median vein is flat or canaliculated and the petiole is 0.2 - 0.4 cm in length. Flowers are 4 - 6mm in diameter, white, with bracteoles present and well developed. Fruit are borne in panicles. Their shape is ovoid - globose, they are 4 - 5 mm in diameter and 5 - 8 mm long. The pulp is purplish in colour (Medail *et al.*, 2001).

2.3. *Olea maroccana*

The *Olea europaea* subsp. *maroccana* is located in the South - west of Morocco, in the western part of the High Atlas. Its area of distribution is mainly on the southern slope of the Ida – ou - Tanane massif and in the western Anti Atlas (Maire, 1933; Jahandiez & Maire, 1934). The existence and the taxonomic position of this tree have long remained uncertain, but the combination of several morphological traits is unique.

The *Olea europaea* subsp. *maroccana* tree is arborescent or shrubby in appearance, and evergreen. The trunk is 4 - 5 m high and generally pluricaulous. Branches and ramifications are erect, internodes of terminal ramifications are elongate, reaching 20 - 60 mm. The bark is smooth, grey-brown. Leaves are lanceolate or lanceolate-acute aspect; they are 3 - 4 to 7 - 8 cm long and 0.4 – 0.6 to 1.2 - 1.3 cm wide. They are slightly contracted into an acuminate reddish-brown apex and progressively contracted into a medium petiole 0.2 - 0.7 cm long. Lateral veins are not visible or scarcely visible, the median vein is partly canaliculate on the lower side. Leaf-blades have a revolute margin; glossy dark-green and very sparsely scattered with tectorous and star-like hairs above; whitish and densely covered by flattened tectorous hairs beneath.

Flowers are rather large, 4 – 6 mm in diameter, white - yellowish; inferior flowers are pedunculate and 2 - 4 mm long with 2 bracteoles ovoid - elongate of 1 - 2 mm, inserted either on the pedicel or beneath the calyx. The calyx is urceolate, erect, cylindrical - oval, 1 mm long. Fruit are borne in panicles or axillary and terminal racemes, elongate and flexuous; lateral ramets are 50 - 70 mm long, ramified; secondary ramets are 10 - 30 mm long; terminal ramets are reflected, and 60 - 120 mm long. Inflorescence bracts are lanceolate - obtuse, 3 - 4 mm long. The fruit is a globose - ovoid drupe; it is 5 - 7 mm in diameter and 9 -

11 mm long, obtuse at the apex, green then red - brown when unripe, becoming purplish - black. Drupe pulp is carmine and aqueous, sweet or slightly bitter taste (Medail *et al.*, 2001).

Figure 2. Morphological aspect of *Olea europaea* subsp. *maroccana* fruits

2.4. *Olea cerasiformis*

The *Olea europaea* subsp. *cerasiformis* tree is arborescent or shrubby, and evergreen. The trunk is 1 - 2.5 m high, generally pluricaulous, and is grey or whitish in colour. Leaves are oblanceolate to linear in shape, rarely suborbicular; they are 3 - 4 to 8 - 10 cm long and 0.4 – 0.6 to 1.0 - 1.4 cm wide. The leaf apex is acuminate and the colour is greyish-green above and paler beneath. They have a petiole 0.2 - 0.7 cm long. The main vein protrudes on the abassial surface.

Flowers are 4 mm in diameter, white; bracteoles are generally present and well developed. Fruit are borne in panicles. The fruit is an ellipsoid drupe; it is 9 - 12 mm in diameter and 12 - 22 mm long. Drupes are green then purplish - black; pulp with a bitter taste (Medail *et al.*, 2001).

2.5. *Olea guanchica*

Traditionally wild olive populations present in the Canary Islands are ascribed to the species *Olea europaea* subsp. *cerasiformis*. A recent genetic study concluded that populations of Madeira and the Canary Islands were genetically separate enough as to be separated into distinct subspecies, therefore the Canarian wild pass was renamed *Olea europaea* subsp. *guanchica*.

This subspecies is present throughout the islands forming part of transition forests or thermophiles. In Gran Canaria it is very abundant and it can be easily found around the north, forming clumps, but especially in the north-east. In the south of the island it is much more local and rare.

The *Olea europaea* subsp. *guanchica* is a small tree evergreen that can reach 6 m in height or more often it has a shrub appearance. Generally, the trunk is pluricaulous, grey or whitish. Leaves are bright green, oblanceolate to narrowly elliptic, 2 - 3 to 7 - 8 cm long and 0.4 – 0.6 to 1.1 - 2.1 cm wide. The apex is mucronate to cuspidate and the colour is greyish-brown above and paler beneath. Leaves have a petiole 0.2 - 0.5 cm long. The main vein partly protrudes on the abassial surface.

Flowers are 4 - 5 mm in diameter, white; bracteoles not well individualized or missing. Fruit are borne in panicles. The fruit is an ovoid - globose drupe; it is 9 - 12 mm in diameter and 12 - 22 mm in length; their colour is green then purplish - black; pulp with a bitter taste (Medail *et al.*, 2001).

Figure 3. Morphological aspect of *Olea europaea* subsp. *guanchica* leaves and trunk

2.5.1. *Olea europaea subsp. europaea var. sylvestris (wild olive)*

Olea europaea subsp. europaea var. *sylvestris* is a typical tree of the Mediterranean regions and it contributed to the Mediterranean forest. In fact, it is considered by many authors as a forest tree. With the olive being the most longeve plant crop species, numerous ultra-millennial still living *sylvestris* trees are present over all the European Mediterranean countries (Baldoni *et al.*, 2006).

However, forest fires and extensive urbanization that characterize the Mediterranean coast have endangered the *sylvestris* variety determining a decline of this genetic resource.

Olea europaea subsp. europaea var. *sylvestris* has not been recorded and evaluated and thus it is not used as a genetic resource although it spread to areas without olives and it seems well adapted to hard environments such as drought, cold, salt, poor soils, etc.

The *Olea europaea* subsp. *europaea* var. *sylvestris* tree is arborescent or shrubby. The plant is long-lived, despite the difficulty in determining the real age, in many cases it can exceed 1000 years old. The trunk is often twisted and cable, and it can reach a considerable size, up to 15 m in the monumental specimens (Baldoni *et al.*, 2000). The branches are numerous, they have thorns in young plants, and can have erect, intermediate or pendulous aspect. The bark is gray – ash - colored, more or less smooth in young trees, becoming rough in the adult ones. The leaves are opposite, leathery, with smooth margin. The lamina is elliptic - lanceolate in shape, the adaxial surphace is green and glabrous, the abaxial one has small silver shield-shaped scales. Flowers are white, pedunculated, very numerous and grouped in axillary racemes (inflorescence). The calix normally has four leaves ovoid, while the corolla, white, is formed by four petals of 2 - 4 mm. There are two stamens per flower, the stigma is bifid and the ovary has four niches. The fruit is an ovoid-globose drupe; it is 5 - 7 mm in diameter and 10 - 15 mm in length. Pulp is initially green then black - brown at maturity. The endocarp is hard and woody with a single seed, rarely two (Camarda *et al.*, 1983).

Figure 4. *Olea europaea* subsp. *europaea* var. *sylvestris* trees: one of the oldest *sylvestris* genotypes located in Sardinia

Figure 5. *Olea europaea* subsp. *europaea* var. *sylvestris*: higher magnification of the trunk of the plant represented in fig. 4

Figure 6. *Olea europaea* subsp. *europaea* var. *sylvestris* fruits

2.5.2. Olea europaea subsp. europaea var. europaea (cultivated olive)

Commercial olive fruits are products of *Olea europaea* subsp. *europaea* var. *europaea*, and only this sub-species of the *Olea* genus produces edible fruits.

The cultivated olive tree can reach heights ranging from just a few meters to 20 m. The wood resists decay, and when the top of the tree is killed by mechanical damage or environmental extremes, new growth arises from the root system. Whether propagated by seed or cuttings, the root system is generally is shallow, spreading to 0.9 - 1.2 m even in deep soils. The above - ground portion of the olive tree is recognizable by the dense assembly of limbs, short internodes, and compact nature of the foliage. Light does not readily penetrate to the interior of an olive tree unless the tree is well managed and pruned to open light channels toward the foliage. If unpruned, olives develop multiple branches with cascading limbs. The branches are able to carry large populations of fruit on terminal twigs, which are pendulous and flexible - swaying.

Figure 7. *Olea europaea* subsp. *europaea* var. *europaea*: morphological aspect of a cultivated olive tree (A), leaves (B); inflorescence (C); fruits (D); endocarp (E)

Olive leaves are thick, leathery, and oppositely arranged. Each leaf grows over a 2-year period. Leaves have stomata on their abassial surfaces only. Stomata are nestled in peltate trichomes that restrict water loss and make the olive relatively resistant to drought. Some multicellular hairs are present on leaf surfaces. Olive leaves usually abscise in the spring when they are 2 or 3 years old; however, as with other evergreens, leaves older than 3 years are often present.

Flower buds are borne in the axil of each leaf. Usually the bud is formed on the current season's growth and begins visible growth the next season. Buds may remain dormant for more than a year and then begin growth, forming viable inflorescences with flowers a season later than expected. When each leaf axil maintains a developing inflorescence, there are hundreds of flowers per twig. Each inflorescence contains 15 - 30 flowers, depending on the cultivar.

Olives are polygamo - monoecious. The flowers are born axially along the shoot, arranged in panicles. Perfect flowers, those with both pistillate and staminate parts, normally consist of a small calyx, 4 petals, 2 stamens with a filament supporting a large pollen-bearing anther, and a plum green pistil with a short thick style and a large stigma. Perfect flowers are borne apically in an inflorescence, and within the typical triple-flower inflorescence the middle flower is generally perfect. Imperfect flowers are staminate, with the pistil either lacking or rudimentary. The flowers are borne on the inflorescence and are small, yellow-white, and inconspicuous.

The perfect flower is evidenced by its large pistil, which nearly fills the space within the floral tube. The pistil is green when immature and deep green when open at full bloom. Staminate flower pistils are tiny, barely rising above the floral tube base. The style is small and brown, greenish white, or white, and the stigma is large and plumose in a functioning pistil.

Floral initiation occurs by November (Pinney & Polito 1990), after which, the flower parts form in March. The inductive phase of flowering in the olive may occur as early as July (about 6 weeks after full bloom), but initiation is not easily seen until 8 months later in February. Complex microscopic and histochemical techniques reveal evidence of floral initiation by November, but the process of developing all the flower parts starts in March. Some olive cultivars, such as those grown in Crete, southern Greece, Egypt, Israel, and Tunisia, bloom and fruit heavily with very little winter chilling; whereas those originating in Italy, Spain, and California require substantial chilling for good fruiting.

At full bloom, flowers are delicately poised for pollination, when some 500,000 flowers are present in a mature tree; a commercial crop of 7 metric tons/ha or more can be achieved when 1 or 2% of these flowers remain as developing fruit. By 14 days after full bloom, most of the flowers destined to abscise have done so. By that time, about 494,000 flowers have abscised from a tree that started with 500,000 flowers (Rosati *et al.*, 2010).

Cultivars vary, but most abscission occurs soon after full bloom and final fruit set nearly always occurs within 6 weeks of full bloom. Further fruit abscission can result from pest infestation and environmental extremes. When trees have an inflorescence at nearly every leaf axil a commercial crop occurs with 1 to 2% fruit set; with a small population of inflorescence, a commercial crop may require 10% fruit set.

Shot berries (parthenocarpic fruits) occur randomly and for reasons which have not been clearly understood. When shot berries occur, they may be seen in clusters on each inflorescence. Here, the inter-fruit competition for raw materials differs from that of normal olive fruits. Shot berries mature much earlier than normal fruit and may be more prevalent when conditions favor a second large crop in succession.

The olive fruit is a drupe, botanically similar to almond, apricot, cherry, nectarine, peach, and plum fruits. The olive fruit consists of a carpel, and the wall of the ovary has both fleshy and dry portions. The endocarp (pit) enlarges to full size and hardens by 6 weeks after full bloom. At that time, the endosperm begins to solidify and embryo development takes place, leading to embryo maturity by September. The mesocarp (flesh) and exocarp (skin) continue their gradual growth. The fruits begin changing from the green color to yellow-white (straw) and accumulate anthocyanin from the distal or base end. Fruit shape and size and pit size and surface morphology vary greatly among cultivars (see the elaiographic cards attached to chapter “Description of varieties”)

The mature seed is covered with a thin coat that covers the starch-filled endosperm. The latter surrounds the tapering, flat leaf like cotyledons, short radicle (root), and plumule (stem). Seed size and absolute shape vary greatly with cultivar.

The seed undergoes most of its development starting in July and ending in about September. The fruit is horticulturally mature in October or November (in Italy) and if harvested and stratified at that time, it will achieve the maximum of germination. However, seeds are physiologically mature in January or February when its germination is greatly reduced (Lagarda *et al.*, 1983a).

Olea europaea L. subsp. e*uropaea* var. *europaea* is a species of great economic importance in the whole Mediterranean basin.

In fact, the genetic patrimony of the Mediterranean basin olive trees is very rich and is characterised by an abundance of varieties. Based on estimates by the FAO Plant Production and Protection Division Olive Germplasm (FAO, 2010), the world's olive germplasm contains more than 2.629 different varieties, with many local varieties and ecotypes contributing to this richness. It is likely that the number of cultivars is underestimated because of inadequate information about minor local cultivars that are widespread in different olive-growing areas.

Current scientific knowledge offers the possibility of introducing new assessment systems, based not only on the varietal character phenology, usually adopted, but also on genetic traits.

For seed production, the fruits should be harvested when ripe, but before they turn black. This period extends from late September to mid-November, depending on the cultivar (Largarda *et al.*, 1983a,b). Pits are removed from the flesh of the fruit with macerators. Pits can be stored in a dry place for years or planted directly, but germination is slow and uneven. Pre-germination treatments are designed to overcome both seed coat (mechanical) and embryo dormancy. Mechanical or chemical scarification is used to treat mechanical dormancy. During the scarification phase, the endocarp can be cracked mechanically or clipped at the radicle end, with care taken not to damage the embryo. Clipping just the cotyledonary end of the endocarp does not improve germination. Good germination results can be obtained using a seed cracking device before subsequent handling procedures (Martin *et al.*, 1986). Pits may be soaked in concentrated sulfuric acid to soften the endocarp. Soaking time depends on the thickness of the endocarp; typical soaking times for Manzanillo are between 24 and 30 hours. The acid bath is followed by 1 to 2 hours of rinsing in water (Crisosto & Sutter, 1985).

The pits can be planted directly after the endocarp treatments at a depth about 2 to 3 times their diameter. Seeds planted outdoors in December do not germinate until the following spring. Pits can also be planted in pots or seedbeds in a greenhouse maintained at a range of temperature between 21 - 24 °C. Germination takes up to 3 months (Hartmann, 1949).

Germination is quicker and more uniform when treatments to overcome internal dormancy are carried out in addition to scarification. The most successful of these treatments on a commercial scale is stratification. Pits are scarified as described above and then soaked in water at room temperature for 24 hours. The pits are mixed with moist sand or vermiculite and then placed in the dark in a controlled environment. The temperature is kept at 15 °C for 30 days. Stratification is thought to reduce abscisic acid, an inhibitor of germination, within the embryo or seed-coat. After stratification, pits can be planted outdoors if the weather is suitable; severe weather can cause losses. Pits can be planted in a greenhouse at 21 to 27 °C. Bottom heat is necessary. Germination should occur within 1 month. Transplanting seedlings from the greenhouse to the nursery should include steps to harden the seedlings, such as partial shade provided by a lath house. Adequate irrigation and fertilization are recommended to ensure continued rapid growth.

Virtually all olive trees are produced from rooted cuttings. Seed handling difficulties, low germination percentage, and slow initial seedling growth rate make seedling production impractical.

3. Conclusion

Olea europaea L. represents one of the most important trees in the Mediterranean basin and the oldest cultivated plant. Among cultivated plants, the olive is the sixth most important oil crop in the world, presently spreading from the Mediterranean region of origin to new production areas, due to the beneficial nutritional properties of olive oil and to its high economic value.

The Mediterranean basin is the traditional area of olive cultivation and has 95% of the olive orchards of the world. From the Mediterranean basin, olive cultivation is presently expanding into areas of Australia, South and North America (Argentina, Chile, United States), South Africa and even in exotic place, like Hawaii. Given its wide range of distribution, it is becoming increasingly urgent to identify plants into different ranges of distribution in the world to avoid cases of homonymy, synonymy and mislabeling so that a reliable classification of all varieties can be achieved without unnecessary confusion.

In this context, along with morphological characteristics the acquisition of additional information on biochemical markers is essential. This aspect represents a fundamental and indispensable step to preserve the main olive varieties and also to safeguard minor genotypes, in order to avoid a loss of genetic diversity.

Recent research has focused on using morphological markers associated with molecular ones to characterize and identify olive varieties (Ercisli *et al*., 2009; Muzzalupo *et al*., 2009). The identification of varieties by using molecular markers is a crucial aim of modern horticulture, because such a technique would greatly facilitate breeding programmes and germplasm collection management.

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