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SUMMARY – Persimmon belongs to the genus *Diospyros* L. and it is scientifically known as *Diospyros kaki* L.f. (= *D. kaki* Thunb.). In relation to fruit astringency at harvest, cultivars are classified into: (i) Pollination Constant Non Astringent (PCNA); (ii) Pollination Variant Non Astringent (PVNA); (iii) Pollination Variant Astringent (PVA); and (iv) Pollination Constant Astringent (PCA). At present the PCNA group is the most interesting because its fruits are always edible at harvesting time. The introduction of persimmon in the Mediterranean countries is not dated, but in any case, local germplasm has developed in different countries of this area. The European germplasm collections hold 160 accessions distributed among Italy and Spain, and large repositories are located in Turkey and Israel. One of the problems for the persimmon industry is linked to genetic identity of cultivars: molecular markers were successfully applied in accession distinctness of local varieties in Italy and Spain. The varietal assortment in the Mediterranean area is very limited and production is based on 'Kaki Tipo' (PVNA), 'Rojo Brillante' (PCA) and 'Triumph' (PVA) in Italy, Spain and Israel respectively. Persimmon breeding is hindered by high ploidy, peculiar sex expression and narrow genetic variability of the PCNA group. Programs are carried out in Japan, China, Korea, countries of the former USSR and Brazil. In the Mediterranean area, breeding started in 1971 in Italy. A program on clonal selection is being carried out in Turkey, while in Israel breeding activities have been reduced and Spain is getting started on its own program.

Key words: *Diospyros kaki*, persimmon, cultivars, varietal assortment.

RESUME – *"Assortiment variétal du plaqueminier dans les pays de la région méditerranéenne, et amélioration génétique". Le plaqueminier appartient au genre* Diospyros *L. et il est connu scientifiquement comme* Diospyros kaki *L.f. (=* D. kaki *Thunb.). En ce qui concerne l'astringence du fruit à la récolte, les cultivars sont classés en : (i) Pollinisation Constante Non Astringent (PCNA) ; (ii) Pollinisation Variante Non Astringent (PVNA) ; (iii) Pollinisation Variante Astringent (PVA) ; et (iv) Pollinisation Constante Astringent (PCA). Actuellement le groupe PCNA est le plus intéressant car ses fruits sont toujours consommables au moment de la récolte. L'introduction du plaqueminier dans les pays méditerranéens n'est pas datée, cependant du germoplasme local s'est développé dans différents pays de cette région. Les collections de germoplasme européennes contiennent 160 accessions réparties en Italie et en Espagne, et de grands dépôts existent en Turquie et en Israël. L'un des problèmes de l'industrie du plaqueminier est liée à l'identité génétique des cultivars : des marqueurs moléculaires ont été appliqués avec succès pour la distinction des accessions des variétés locales en Italie et en Espagne. L'assortiment variétal de la région méditerranéenne est très limité et la production est basée sur 'Kaki Tipo' (PNVA), 'Rojo Brillante' (PCA) et 'Triumph' (PVA) en Italie, Espagne et Israël respectivement. L'amélioration génétique du plaqueminier est entravée par sa forte ploïdie, son expression sexuée particulière et l'étroite variabilité génétique du groupe PCNA. Des programmes sont menés au Japon, en Chine, Corée, dans les pays de l'ex-URSS et au Brésil. Dans la région méditerranéenne, l'amélioration génétique a commencé en 1971 en Italie. Un programme sur la sélection clonale est mené actuellement en Turquie, tandis qu'en Israël les actions d'amélioration ont été réduites, et l'Espagne est en train d'entamer son propre programme.*

Mots-clés : Diospyros kaki*, plaqueminier, cultivars, assortiment variétal.*

Origin and botanical classification

Persimmon belongs to the *Diospyros* L. gender, together with about 400 species developed mainly in the sub-tropical and tropical areas of Asia, Africa and Central and South America (Wagenitz, 1964; Cronquist, 1981; Ng, 1986). Persimmon, indicated also as Japanese persimmon, is native of temperate areas. The botanical name of persimmon is *Diospyros kaki*, but the paternity of the name is assigned to Linneo (L.), to his son (L.f.), and to Carl Peter Thunberg (Thunb.); hence to refer to persimmon, the two names commonly used are *D. kaki* L.f. and *D. kaki* Thunb.

D. kaki L.f. (= *D. kaki* Thunb.) is considered of Chinese origin. This theory is accredited by the native forms found in that country (Grubov, 1967), and by the existence of ancient documents from the 5th-6th centuries on persimmon cultivation in China (Kikuchi, 1948; Sugiura and Subhadrabandhu, 1996).

A part from *D. kaki* L.f., *D. lotus* L. and *D. virginiana* L., native to North America, are important in the persimmon industry (Table 1).

Table 1. Some useful *Diospyros* species for temperate areas with their distribution and chromosome number

Species	Distribution	Chromosome number	Utilisation
D. kaki L.f. (= *D. kaki* Thunb.)	China, Korea, Japan, and other countries of introduction	90, 135	Fruit production; rootstocks
D. lotus L.	Oriental, Central and Occidental Asia	30	The fruit is consumed fresh or dried; rootstock
D. virginiana L.	Oriental states of North America	60, 90	The fruit is edible, rootstock

The chromosome number of *D. kaki* L.f. is 2n = 90 (Zhuang *et al.*, 1990); it is 2n = 30 for *D. lotus* (Zhuang *et al.*, 1990), while *D. virginiana* seems to have two karyotypes with 2n = 60 and 90 (Baldwin and Culp, 1941). The base number of the *Diospyros* gender seems to be 15, hence *D. kaki* L.f. is hexaploid (2n = 6x = 90). Recently Zhuang *et al.* (1990) pointed out that within *D. kaki* L.f., the cultivars 'Hiratanenashi' and 'Tonewase' are nonaploid (2n = 9x = 135).

On the basis of their morphological similarity and their geographical distribution, Ng (Ng, 1978) indicates that *D. roxburghii* (syn. *D. glandulosa*) could be the ancestor of *D. kaki* L.f. On the other hand, recent studies on the phylogenetic relationships among different *Diospyros* spp., based on studies of cDNA clearly show that *D. kaki* L.f. is not closely related to *D. glandulosa* and that it seems to have a common ancestor with *D. lotus* and with *D. virginiana* (Fig. 1) (Yonemori *et al.*, 1998).

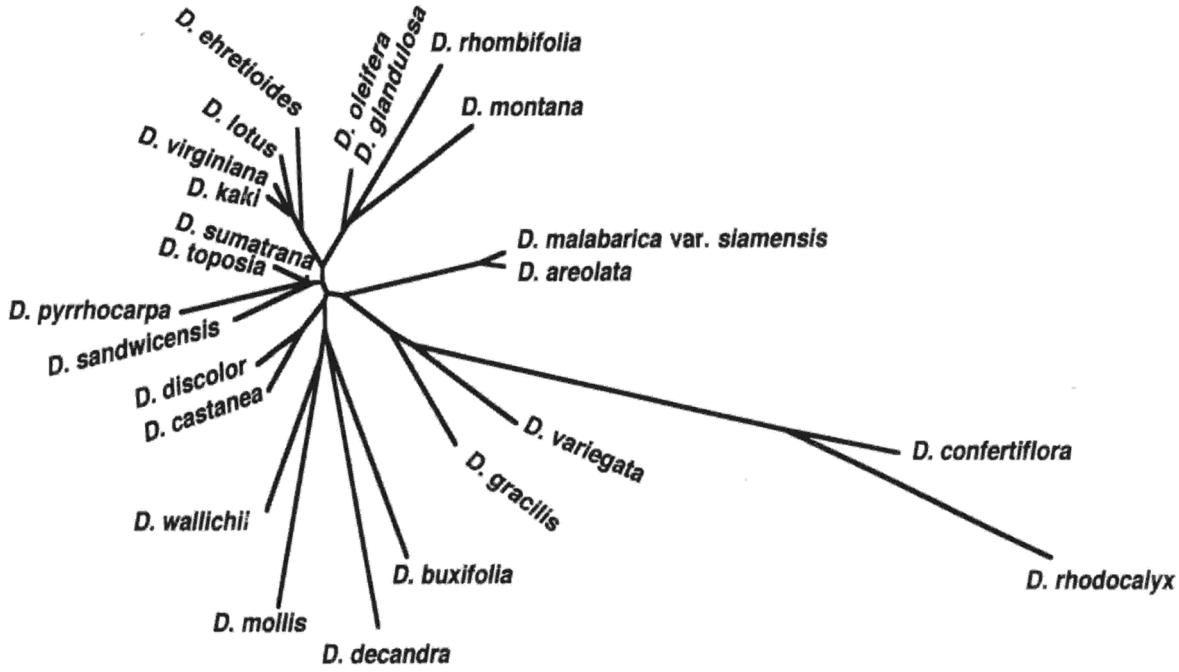

Fig. 1. Dendrogram built on the genetic distances for five temperate and 19 tropical *Diospyros* species (Yonemori *et al.*, 1998).

From the Chinese centre of origin, persimmon reached Korea, Japan and then other countries of the Far East. Even if the presence of persimmon in Ancient Rome is reported by Plinio, and it could have been present in Spain in the 16th century, its diffusion in the Mediterranean Basin has been relevant only in the last two centuries. Chinese and Japanese emigration to North America (namely California) and South America (namely Brazil) brought introduction of persimmon to the American continent. In recent years, persimmon has spread to most countries on all continents which have temperate fruit-culture.

Cultivar classification

Cultivar classification regards essentially sex expression and fruit astringency at harvest. Persimmon differentiates female (pistillate) flowers, from which normal fruits are obtained; male (staminate) flowers, effective only for pollination; and hermaphrodite flowers, from which small non commercial fruits are developed. For sex expression cultivars are classified into: (i) exclusively pistillate, with female flowers; (ii) monoic, with both female and male flowers; and (iii) polygamous-monoic, with female, male and hermaphrodite flowers. Exclusively pistillate cultivars are largely used in orchards, in some cases joined with monoic cultivars used as pollinators when they bring a large amount of male flowers. When parthenocarpic seedless fruits are desired, pollination is avoided and hence monoic cultivars and polygamous-monoic cultivars are not used.

Fruit astringency at harvest is the main trait for persimmon classification. The most common classifications distinguish persimmon cultivars into four groups (Bellini, 1982a; Sugiura, 1983):

(i) PCNA group – Pollination Constant Non Astringent: cultivars with non astringent fruits at harvest, regardless of the presence of seeds. The flesh is light coloured, rarely with very small brown spots. Fruits are edible at harvest (hard fruits) regardless fertilization ('Fuyu', 'Jiro', 'Hana Fuyu', 'O'Gosho', etc.).

(ii) PVNA group – Pollination Variant Non Astringent: cultivars with non astringent fruits when fertilized. The number of seeds (one to eight in persimmons) can be relevant for fruit astringency at harvest depending on the cultivar, but normally few seeds guarantee edibility of fruits. The flesh is brown and often rich in dark spots, with one or more seeds. Fruits are not edible at harvest if parthenocarpic, but they are consumed after natural softening or after artificial removal of astringency ('Kaki Tipo', 'Nishimura Wase', 'Zenjimaru', 'Shogatsu', etc.).

(iii) PCA group – Pollination Constant Astringent: cultivars with astringent fruits at harvest, regardless of the presence of seeds. The flesh is light coloured. Fruits are edible after natural softening or after artificial removal of astringency ('Hachiya', 'Atago', 'Yokono', etc.).

(iv) PVA group – Pollination Variant Astringent: cultivars with astringent fruits regardless fertilization. When fertilized, flesh is not astringent only around the seeds, where brown spots are present. The number of seeds is not relevant for fruit astringency at harvest, since fruits with 8 seeds are still astringent ('Aizumishirazu', 'Koshu Hyakume', etc.). 'Hiratanenashi' and its mutants belong to this group, even if they normally do not bring seeds also when pollinated.

Taking into account the quality of tannin in the flesh and the capability of seeds of releasing volatile compounds during fruit development, two main groups can be defined (Sugiura, 1983; Sugiura and Tomana, 1983):

(i) Volatile Independent Group (VIG): group of cultivars in which the process of natural loss of astringency is not dependent on the formation and accumulation of volatile compounds in flesh. It comprises PCNA cultivars.

(ii) Volatile Dependent Group (VDG): group of cultivars in which the natural process of astringency loss is dependent on the formation and accumulation of volatile compounds in the fruit. It comprises non PCNA cultivars, hence:

- PVNA cultivars, bringing seeds with high capability of releasing volatile compounds.
- PVA cultivars, bringing seeds with low capability of releasing volatile compounds.
- PCA cultivars, bringing seeds with very low or no capability to release volatile compounds.

In Japan among the 300 persimmon cultivars, the distribution of pomological groups is: PCNA 11%, PCA 44%, PVNA 36% and PVA 9%. Taking into account fruit production in Japan, 50% belongs to PCNA, 5% to PVNA and the remaining 45% is distributed between PVA and PCA (Yonemori *et al.*, 1997). In the Mediterranean area the assortment is different, since PCNA cultivars are neglected and the production is based upon PVNA cultivars (more than 90% of Italian production), PCA cultivars (nearly all the Spanish production) and PVA (practically the whole production of Israel). Such situation can be explained by the lower climatic adaptability of PCNA cultivars, by the lower productivity both trough parthenocarpy and trough fertilization, by the grafting incompatibility with *D. lotus*, the rootstock for persimmon used in Italy and Spain, by their susceptibility to apex cracking and calyx separation. It is worth mentioning that such behaviour, typical of many PCNA cultivars, is genetically determined and it occurs also in Oriental countries.

Another important characteristic for the persimmon industry is the classification in relation to ripening time. Unfortunately the variability of this trait is very narrow: in the frame of the persimmon collection of the Department of Horticulture of the University of Florence, the arch of ripening time covered by the 85 collected accessions regards only 70 days (from the beginning of September with the cultivar 'Mikatani Gosho' till mid November with 'Shogatsu'), genotypes with intermediate or late ripening time being more frequent and both periods accounting together for more than 80% of the accessions. A similar situation can be found in other relevant persimmon collections in Italy and in Spain (Bellini and Giordani, 1999c), but also in the Japanese repositories (MAFF, 2001).

Hence it is relevant to notice that almost all Mediterranean production is based on three intermediate-late ripening cultivars ('Kaki Tipo' in Italy, 'Rojo Brillante' in Spain and 'Triumph' in Israel), causing perceivable problems in persimmon marketing, even with recourse to fruit conservation techniques and to the artificial removal of astringency. The distribution of the main cultivars used in Japan and in the Mediterranean countries is reported in Table 2.

Table 2. Classification of some persimmon cultivars based on the astringency of fruit and harvest time (the main cultivars used in the Mediterranean countries in italics) (adapted from: Yonemori *et al.*, 1997)

Harvest time†	Type			
	PCNA	PVNA	PVA	PCA
Early	Izu, Hana Fuyu	Mikatani-gosho, Nishimurawase, Akagaki	Sugitawase, Tonewase	Ichidagaki
Intermediate	Ichikikei-Jiro, Maekawa-Jiro, Matsumotowase-Fuyu, Tenjin-gosho	*Kaki Tipo*, Amahyakume, Mizushima	Hiratanenashi, Fuji, Hyakume	Hachiya, Saijyo, Yotsumizo
Late	Fuyu, Gosho, Jiro, Hana-gosho, Haze-gosho, Oku-gosho, Suruga	Shogatsu	Aizumishirazu, *Triumph*	*Rojo Brillante*, Atago, Hagakushi, Yamato, Yokono

†Early: till 20 of October; intermediate: from 20 of October till 20 of November; late: after 20 of November.

Evolution of persimmon cultivars

Cultivars of persimmon first developed in China, its country of origin, and where cultivation began in the 5th-6th centuries; at present in China more than 900 persimmon varieties have been counted, almost all of them belonging to the non PCNA groups, with the exception of 'Loutian Tianshi' (Wang, 1982). In Korea 186 cultivars have been collected, belonging mainly to PCA and PVA groups, and seldom to PCNA and PVNA (Kim *et al.*, 1988). In Japan persimmon evolved into many astringent varieties, but also into the outstanding group of PCNA non astringent cultivars. In ancient Japanese

writings of the 10th century descriptions of astringent varieties are reported, and written references of the 12th century regard 'Zenji-maru', a PVNA cultivar. The development of the PCNA group seems to be very recent, since 'Gosho', the first variety of this group, is dated in the 17th century and the variability within this group is very narrow, with only 17 ancestral cultivars being known all over Japan (Sugiura *et al.*, 1990).

The diffusion of persimmon from the countries of the Far East was slow and it seems to have occurred in different steps from ancient times. Records available do not allow reconstruction of the evolution of persimmon cultivation in the Mediterranean area. However, from the introduced genotypes, local varieties seem to have developed, both among random seedlings and bud mutations.

In Italy many presumed local varieties, belonging mostly to PVNA group, have been described by Bellini (1982b). Apart from 'Kaki Tipo', the most common cultivar in Italy and which is of uncertain origin, other Italian varieties are 'Rispoli', 'Mandarino', 'Moro', 'Vainiglia', 'Mercatelli', 'Brazzale', 'Lampadina', 'Cioccolatino' and 'Mancinelli', all of them recently inventoried and characterized in the frame of EC GENRES29 Project "Minor Fruit Tree Species Conservation in Europe" (Bellini and Giordani, 1999b).

In Spain local varieties belong essentially to the PCA group; among them 'Rojo Brillante' (possible mutation of 'Cristalino'), outstanding for its pomological traits, 'Tomatero', 'Xato del Bonrepós' (used mainly in the Valencia area) and then 'Aneva', 'Bétera', 'Buriana', 'Constanti', 'Enguera', 'Ferran', 'Garidells', 'La Selva', 'Picudo' and 'Reus' have already been characterized (Climent and Llácer, 2001; G. Llácer, pers. comm.).

There is no report on local varieties in France, where persimmon is not very common and where persimmon samples are conserved by botanical gardens.

In Greece persimmon cultivation is not intensive and propagation material is collected from astringent local varieties selected by farmers. At present, no description and inventory of local Greek accessions is reported (S. Lionakis, pers. comm.; C. Tsipouridis, pers. comm.). In Portugal local varieties exist, among which 'Coroa de Rei' is the most cultivated (de Sousa and Gomes-Pereira, 1995; L. Sabbo, pers. comm.). In Israel local varieties have not been inventoried (A. Blumenfeld, pers. comm.); in the mild areas of Turkey local varieties of persimmon are used for cultivation (O. Tuzcu, pers. comm.).

It can be argued that local genotypes do exist in Algeria, where the presence of persimmon cultivars since 1950 was reported (Baldini and Scaramuzzi, 1955). In Morocco the presence of persimmon seems to be limited to advanced and recently introduced cultivars such as 'Fuyu', 'Nishimura' and 'Maekawa Jiro' (Z. Messaoudi, pers. comm.).

The cultivation of scattered trees in other Mediterranean countries (former Yugoslavia and Cyprus) may have allowed the development of new local genotypes through gamy or bud mutation; related information is very limited (M. Cizmovic, pers. comm.; I. Pejic, pers. comm.).

Germplasm conservation

Initiatives to safeguard persimmon genetic resources in the Mediterranean area are limited and until now have not been integrated. The EC GENRES29 Project on the conservation of minor fruit tree species, carried out in the framework of CE 1467/94 Regulation, has contributed notably to germplasm conservation of persimmon in the European Mediterranean countries. The institutions involved in persimmon conservation and the number of collected accessions are reported in Table 3. More detailed information on the characterization and evaluation of accessions are available in the First European Catalogue and in the European Minor Fruit Tree Species Database (EMFTSDatabase) (Bellini and Giordani, 1999a).

In Turkey the main collection belongs to the Faculty of Agronomy of Cukurova at Adana where 69 accessions (ancestral imported varieties and local varieties) are collected; other collections are located in the most important areas of persimmon cultivation in Turkey (Tuzcu and Şeker, 1997). In Israel only high commercial value cultivars are collected (A. Blumenfeld, pers. comm.).

Table 3. Institutions involved in the Project GENRES 29 and number of collected accessions

Institution	Number of accessions
Dipartimento di Ortoflorofrutticoltura, Università di Firenze, Italy	85
Instituto de Recerca i Tecnologia Agroalimentaries-Mas Bobé and Instituto Valenciano de Investigaciones Agrarias-Valencia, Spain	35
Istituto Sperimentale per la Futticoltura, Sezione di Caserta, Italy	35
Dipartimento di Produzione Vegetale, Università della Tuscia, Viterbo, Italy	5

An in-depth analysis of the conservation of persimmon in Europe, which can be extended to all Mediterranean countries, has pointed out the necessity of surveying the areas expected to be rich in persimmon germplasm, identifying accessions both within and between collections also in relation to reference genotypes collected in Japan, introducing new genotypes to broaden genetic variability, and duplicating the genotypes at present conserved in a unique collection (Bellini and Giordani, 1999d).

Varietal identification in persimmon

The varietal identification of persimmon cultivars is one of the main problems in the development of the persimmon industry world-wide (Yonemori *et al.*, 1997). Cases of synonyms and homonyms within local varieties are quite common, and due to misleading transliterations from Japanese and to incorrect labelling in the past, the genotypes collected in Europe do not always correspond to those conserved in Japan. Recent studies (Bellini and Giordani, 2000) pointed out that among the 160 accessions conserved in Europe, the state of identification is weak, since only 37% of accessions are surely identified, while 55% are probably identified and 8% are totally uncertain.

Methods for cultivar identification and distinctness are based on morphological traits (Giordani, 1994), and on analysis of isozymes (Parfitt *et al.*, 1991) and of DNA (Luo *et al.*, 1995). Random Amplified Polymorphic DNA (RAPD) appears to be a very efficient marker for cultivar distinctness in persimmon, while no polymorphism was observed in plastidial and mitochondrial DNA with the RFLP technique (Nakamura and Kobayashi, 1994). Local Italian and Spanish varieties which were considered synonyms have recently been distinguished by RAPD markers (Fig. 2) (Bellini *et al.*, 2000; Badenes *et al.*, 2001).

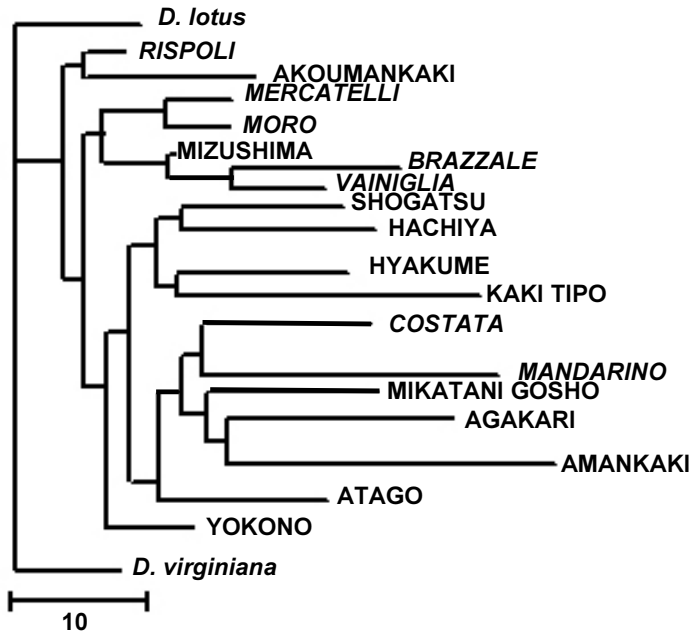

Fig. 2. Dendrogram obtained from the molecular (RAPD) distance matrix (the presumed Italian accessions in bold italics) (Bellini *et al.*, 2000).

Varietal assortment of persimmon in the Mediterranean area

Varietal assortment in the Mediterranean countries is extremely reduced, being formed by less than 20 cultivars among those recently imported ('Fuyu', 'O'Gosho', 'Jiro', 'Hana Fuyu', 'Hachiya', etc.) and those belonging to local germplasm (namely Italian, Spanish and Turkish), while the production is based essentially on three cultivars: 'Kaki Tipo', 'Rojo Brillante' and 'Triumph'.

Llácer and Badenes (2001) developed the aspects of production and marketing in many countries of the Mediterranean areas also in relation to the used cultivars. Here we describe in detail the main cultivars which Mediterranean persimmon growing is based on; some cultivars which are seldom used for cultivation and those which appear to be interesting for diversification of production. Notes on recently released cultivars which have not yet been tested in one or more Mediterranean countries are also reported.

Persimmon is not listed among the species included in the comparative evaluation in national programs, such as the Project of the Italian Ministry of Agriculture "Fruit growing – List of varietal orientation" and up to now no financial support exists for such objective.

The descriptions reported here are obtained from years of conservation and data analysis on the varietal performance in Tuscany and in the Emilia Romagna region for most of the cultivars (Bellini, 1979a, 1982b; Bellini *et al*., 1988); for some varieties ('Rojo Brillante' in detail) the information gathered from different sources, quoted in each description, has been reviewed.

Description of the main cultivars used in the Mediterranean areas

Persimmon production in Italy (50-60,000 t), Spain (33,000 t) and Israel (10-13,000 t) are essentially based on 'Kaki Tipo', 'Rojo Brillante' and 'Triumph' respectively.

In Italy persimmon production is decreasing, hence interest in 'Kaki Tipo' (PVNA), the cultivar generally used for the production of seedless fruits to be eaten after softening, which assured alone more than 90% of Italian production, is presently reduced. The supremacy in the European markets of 'Kaki Tipo', considered outstanding for its productivity and fruit quality, has been undermined by the appearance of 'Rojo Brillante'. The superiority of this new PCA cultivar, individuated within the Spanish germplasm, is due to its excellent taste and its attractiveness associated to a constant and very high productivity. The Italian varietal assortment is completed by 'Mercatelli', 'Moro', 'Vainiglia' (very similar between them) and, in the Campania Region, by 'Cioccolatino' and 'Melella'.

In Spain, 'Rojo Brillante' has supplanted the other local varieties in the area of Valencia, where 'Triumph' and other local cultivars were cultivated. 'Triumph' is present also in Andalucia, and in Catalunya the main cultivar is 'Gordo'. In any case, the common trait of Spanish persimmon production is the rapidly increasing diffusion of 'Rojo Brillante'.

In Israel, 'Triumph', which covers accounts for 95% of the surface area of persimmon orchards, is the main cultivar because of its suitability to artificial removal of astringency and to export; nevertheless the lack of alternative cultivars is felt also in Israel.

The descriptive sheets of these three cultivars are reported below:

(i) 'Kaki Tipo' (PVNA)

- Origin: uncertain, possibly Japanese, from unknown pedigree.
- Tree: high grafting compatibility on *Diospyros lotus*; medium-high vigour; brings only pistillate flowers, high flowering entity and intermediate flowering time; high fruit set and medium-low fruit drop; high productivity.
- Fruit: large size (180-250 g); round shape both in longitudinal and cross sections; pale orange-yellow skin colour; orange flesh colour; very good taste.
- Harvest and ripening: harvest time is intermediate; it overlaps consuming time when fruits bringing at least 4-5 seeds; seedless fruits must be eaten after softening or after artificial removal of astringency.

- Notes: it is the most cultivated variety in Italy; valuable because of high and constant productivity of large and very good tasting fruits. In Italy a certain number of "Kaki Tipo-like" cultivars were used in the past (such as 'Kirakaki', 'Kuro Kuma', 'Akoumankaki'). Exported fruit are always seedless, hence astringent at harvest. Astringency removal causes a rapid loss of flesh firmness and a short fruit conservation, which must be marketed soon. Suitability to drying is medium. Overall evaluation: good to very good. References: Testoni *et al*. (1981) and Bellini (1982a,b).

(ii) 'Rojo Brillante' (PCA)

- Origin: possible bud mutation of 'Cristalino', selected among local varieties in Valencia (Spain).
- Tree: high grafting compatibility on *D. lotus* and *D. virginiana*; high vigour; brings only pistillate flowers; high flowering entity and intermediate flowering time; high fruit set and medium low fruit drop; high parthenocarpic productivity.
- Fruit: very large size (250-300 g); conical elongated shape in longitudinal section and round in cross section; very attractive bright red skin colour; yellow-orange flesh at harvest time and reddish-orange at physiological ripening; very good taste.
- Harvest and ripening: late harvest time.
- Notes: it is the most cultivated variety in Spain; valuable because of the high and constant productivity of very large fruits, with very attractive colour and very good taste. Fruits are seedless and astringent at harvest. Astringency removal causes a rather rapid loss of the flesh firmness. Overall evaluation: very good. References: Bellini and Giordani (1999c) and Romero *et al*. (2001).

(iii) 'Triumph' (PVA)

- Origin: unknown genealogy, possible old Japanese cultivar.
- Tree: high vigour; brings only pistillate flowers, medium flowering entity and intermediate flowering time; medium fruit set, medium fruit drop; medium productivity.
- Fruit: medium-large size (150-220 g); squared shape in longitudinal section and round in cross section; deep yellow-orange skin colour; yellow flesh colour; medium-good taste.
- Harvest and ripening: late harvest time; astringent at harvest, needs softening or artificial astringency removal for consumption.
- Notes: in Israel productivity is not always constant, but it is suitable for removal of astringency by carbon dioxide since fruit maintains firmness for quite a long time. Environmental adaptability is limited; in New Zealand it is susceptible to cracking and fruit quality is not very good. Overall evaluation: low to good. References: Gross *et al*. (1984), Blumenfeld (1986) and Bellini *et al*. (1988).

Description of the sporadically cultivated varieties in the Mediterranean area

The introduction of about 80 cultivars considered interesting for the Mediterranean area mainly by research institutions from Italy, Israel, Spain and Turkey from Oriental (namely from Japan), American (California and Brazil), and from Oceanic countries (New Zealand) (Bellini, 1982b; Bellini and Giordani, 1999c; A. Blumenfeld, pers. comm.; O. Tuzcu, pers. comm.) has allowed enterprising fruit-growers to use "new" genotypes in order to broaden the range of offered persimmons. Up to now, none of the cultivars introduced in the last decades has asserted on those traditionally employed, but their use is limited to small surfaces due to productive problems sometimes, but very often because lack of marketing.

A specific case is that of the PCNA cultivars, such as 'Fuyu', 'O'Gosho', 'Jiro', 'Hana Fuyu', 'Tenjin Gosho', 'Suruga', 'Izu' and others derived from bud mutation from the some of the former ones. Less productive than 'Kaki Tipo' and 'Rojo Brillante', with lower taste quality if not cultivated in suitable areas, they hardly reach the high productivity and quality of the former local varieties. Furthermore, consumers do not recognize fruits of PCNA cultivars as a different product in comparison to the traditionally eaten product. The advantage of PCNA cultivars, with edible hard fruits at harvest, is linked to the reduced costs of the post-harvest step, since artificial removal of astringency is not necessary and hence it is less susceptible to injuries due to handling and transport than softened fruits. The increase of their cultivation world-wide, in relation to non-PCNA cultivars, indirectly confirms their productive, qualitative and commercial validity.

Among non-PCNA cultivars (like 'Hachiya', 'Yokono', 'Hiratanenashi' and 'Tone Wase' which showed very good productive performances in some Mediterranean countries), none has been adopted for large production in this area.

As regards pollinators, useful for obtaining fertilized fruits and namely for the production of non astringent fruits of PVNA cultivars and for increasing productivity in some PCNA cultivars (e.g. 'Hana Fuyu'), different cultivars, such as 'Mercatelli' and 'Cioccolatino', are available within Italian germplasm, while 'Zenjimaru', introduced from Japan, is present in repositories.

A quite complete list of cultivars collected in Europe, together with their description, can be consulted on Internet (Bellini and Giordani, 1999a); a detailed description of the sporadically cultivated varieties in the Mediterranean area is reported here:

(i) 'Hachiya' (PCA)

- Origin: probably Japanese, from unknown genealogy.
- Tree: high grafting compatibility on *Diospyros lotus*; brings only pistillate flowers; high flowering entity and medium-late flowering time; medium-high fruit set, medium-low fruit drop; medium-high productivity.
- Fruit: large size (180-250 g); conical shape in longitudinal section and round in cross section; orange skin colour; yellow-orange flesh colour; very good taste.
- Harvest and ripening: intermediate harvest time, fruits are edible after loss of astringency.
- Notes: cultivar diffused in California. Fruits are very valuable for organoleptic characteristics, and they are very suitable for conservation and quite suitable for drying. Overall evaluation: from good to very good. References: Bellini (1979b, 1982b), Bellini *et al*. (1988) and de Sousa and Gomes-Pereira (1995).

(ii) 'Fuyu' (PCNA)

- Origin: Japan, from a chance seedling. The identity of the genotype collected in Italy is uncertain.
- Tree: very low grafting compatibility on *Diospyros lotus*; medium vigour; brings only pistillate flowers; high flowering entity and intermediate flowering time, high fruit set, medium-low fruit drop; medium-high productivity.
- Fruit: large size (180-250 g); flat-round shape in longitudinal section and round or round-squared shape in cross section; orange to red-orange skin colour; orange-yellow flesh colour; good taste.
- Harvest and ripening: late harvest time.
- Notes: it is the most important cultivar in Japan; parthenocarpic productivity is low, while pollination notably increases fruit set. Uniform fruits, with firm flesh, juicy and sweet (14-16° Brix). Market value is high; it is very suitable for conservation. Fruits are sometimes susceptible to calyx separation. Fruits are suitable for drying. Overall evaluation: very good. In Italy the Californian monoic clone 'Cal-Fuyu', to be better identified, is sometimes used on *Diospyros lotus*. References: Bellini (1982b) and Bellini *et al*. (1988).

(iii) Jiro (PCNA)

- Origin: Japan, unknown genealogy.
- Tree: very low grafting compatibility on *Diospyros lotus*; medium vigour; brings only female flowers, intermediate flowering time with medium flowering entity; high fruit set, and medium fruit drop; high productivity.
- Fruit: large size (180-250 g); flat shape in longitudinal section and squared in cross-section; deep orange skin; orange flesh; very good taste.
- Harvest and ripening: medium-late harvest time.
- Notes: medium resistance to currant clear wing. Pollinators are required in order to guarantee high productivity. Fruits are not suitable for drying. Overall evaluation: good. In Italy the mutation 'Jiro C. 24276', imported from California in 1974, is sometimes cultivated after grafting on *Diospyros lotus*. 'Maekawa Jiro' and 'Ichikikei Jiro', with earlier ripening time and less susceptible to apex cracking, are cultivated in Japan. References: Bellini (1982a,b) and Bellini *et al*. (1988).

(iv) 'O'Gosho' (PCNA)

- Origin: Japan, unknown genealogy.

- Tree: medium-high grafting compatibility on *Diospyros lotus*; medium vigour; brings only female flowers, intermediate flowering time, with medium-high entity; medium-low fruit set; medium productivity.
- Fruit: large size (180-250 g); round-flat in longitudinal section and squared in cross-section; deep orange skin colour; orange flesh colour; good taste.
- Harvest and ripening: harvest time is medium-late.
- Notes: in Japan fruits are susceptible to apex cracking; high resistance to currant clear-wing. In Italy productivity is high and fruit size is medium, with apex cracking; fruits are not suitable for conservation but good for drying. Overall evaluation: good. References: Bellini *et al*. (1988).

(v) 'Hana Fuyu' (PCNA)

- Origin: Korea or China, from unknown genealogy; synonyms: 'Yotsundani', 'Jumbo' and possibly 'Mikado'.
- Tree: medium-high grafting compatibility on *Diospyros lotus*; medium-high tree vigour; brings only female flowers; intermediate flowering time, with high flowering entity; medium fruit set and medium-low fruit drop; productivity medium-high.
- Fruit: large size (180-250 g); round and slightly flat shape in longitudinal section, squared-furrowed in cross section; orange-yellow skin colour; pale orange-yellow colour, smooth texture; very good taste.
- Harvest and ripening: early harvest time.
- Notes: not well known cultivar, with pomological traits not inferior to 'Fuyu'. It requires pollinators to reach a high productivity. In Italy large fruits in young trees are susceptible to apex cracking and to calyx separation. Fruits are suitable for conservation. In 1993 a monoic clone was individuated in Italy. Overall evaluation: good to very good. References: Bellini (1982b), Bellini *et al*. (1988) and M. Yamada (pers. comm.).

Persimmon breeding

Persimmon breeding is mainly hindered by its high ploidy and by its complex sex expression. Furthermore, research on heredity in persimmon is limited. The most interesting studies regard flesh astringency at harvest (PCNA/not PCNA, being PCNA recessive) (Ikeda *et al.*, 1985; Yamada, 1993); sex expression (Oohata *et al*., 1964), ripening time, fruit weight and soluble solid content, calyx separation and apex cracking (Ikeda *et al.*, 1975; Yamada *et al.*, 1988, 1994, 1995, 1997).

Persimmon breeding in Japan

The main objective in Japanese breeding programs is the development of new PCNA cultivars with specific characteristics, such as early ripening time, high and constant parthenocarpic productivity, low susceptibility to apex cracking and to calyx separation (Yonemori and Sugiura, 2000). At present the most active breeding centre is the Fruit Tree Research Station (FTRS) at Akitsu (Hiroshima Prefecture). 'Suruga' (late ripening but slightly juicy) and 'Izu' (early ripening but poorly productive) are two PCNA cultivars released in 1959 and 1970 respectively. More recently, two new PCNA cultivars were obtained by cross-breeding: 'Shinshuu' – medium-early ripening, high sugar content, susceptible to skin damage and 'Youhou' – intermediate ripening, high parthenocarpic productivity (Yamane *et al.*, 1991a,b). 'Taishuu' (with large and high quality fruits) and 'Yubeni' (late ripening, with attractive skin colour) were released in 1994 and 1997 respectively (Yamane *et al*., 1995, 1998), while 'Soshu' (juicy with medium size fruits, early ripening time and low susceptibility to apex cracking) was released in 2001 (Yamada and Sato, this volume). 'Tanrei' and 'Kinshuu', both for ornamental use, were obtained by the same institution (Yamane *et al.*, 1998).

In the last two decades many cultivars have been obtained by selecting bud mutants (Table 4), valuable for early ripening time and for large fruit size in relation to their ancestors.

Biotechnology has been applied in Japan as a tool for breeding persimmon. Persimmon ploidy has been modified by protoplast fusion and reduced pollen fertilization and transgenic plants *in vitro* resistant to insects have been obtained (Yonemori and Sugiura, 2000). Kanzaki *et al.* (2001) have individuated a molecular marker obtained by AFLP (Amplified Fragment Length Polymorphism) technique effective in the early identification of PCNA seedlings.

Table 4. Cultivars of persimmon registered in Japan since 1980

Name	Type	Year	Genetic origin	Ripening time and other characteristics
Uenishiwase	PCNA	1986	Bud mutation of Matsumotowase-Fuyu	10-14 days before Matsumotowase-Fuyu
Sunami	PCNA	1988	Bud mutation of Fuyu	End of October; large fruits
Aisyuhou	PCNA	1994	Bud mutation of Maekawa-Jiro	Early November; large fruits
Tanbawase-Fuyu	PCNA	1995	Bud mutation of Fuyu	Early October
Kyi-joh	PCNA	1996	Bud mutation of Matsumotowase-Fuyu	Early November
Tonewase	PVA	1980	Bud mutation of Hiratanenashi	10-15 days before Hiratanenashi
Ohtanenashi	PVA	1985	Bud mutation of Hiratanenashi	Together with Hiratanenashi, large fruits
Kohshimaru	PVA	1991	Bud mutation of Hiratanenashi	Mid October

Persimmon breeding in China, Korea, Brazil and former Soviet Union

Selection among ancestral genotypes is carried out in China (Wang *et al*., 1997) and Korea, where 74 valuable cultivars have been individuated and where a cross-breeding program has been developed in order to obtain new PCNA cultivars (Yonemori *et al*., 2000). In Brazil at the Istituto Agronomico di Campinhas (S. Paolo) Ojima *et al.* (1985) have released 'Pomelo', 'Rubi' (PCA) and 'Kaoru' (PVA), all of them with early ripening time, high productivity and good tree hardiness; Rigitano *et al.* (1984) have obtained 'Fuyu Hana' a PCNA cultivar selected in the progeny of 'Fuyu' × 'Hana-gosho' with high quality fruits; it is very productive and monoic. In the former Soviet Union the main objective is to obtain frost resistant cultivars; a large number of seedlings, among them 'Seedling 10' (open pollination of 'Jiro'), are under evaluation (M.D. Omarov, pers. comm.; A.M. Sapiev, pers. comm.).

Persimmon breeding in the Mediterranean area

Most breeding work in the Mediterranean area is carried out in Italy. The Italian breeding program started in 1971 and is at present developed by the Dipartimento di Ortoflorofrutticoltura of the University of Florence (Bellini *et al*., 1988, 1992, 1993).

The main objectives are: PCNA type, low tree vigour, monoic trees, early ripening time, high productivity also trough parthenocarpy, resistance to chill injuries, compatibility on both *D. kaki* L.f. and *D. lotus* L., tree hardiness. New cultivars should bring large size, round or slightly flat shaped fruits, orange-red skin colour, hard orange flesh without black spots, suitability to conservation and to industrial transformation (drying), low susceptibility to apex cracking and calyx separation.

The principal results achieved are reported in Table 5. 'DOFI-86.II.034' (a PCNA selection obtained by crossing 'Hana Fuyu' × 'Cal Fuyu') is valuable for its fruit size and shape, with medium-early ripening time (beginning of October in Tuscan Maremma).

Research on *in vitro* regeneration from callus of the main Japanese, Italian and Spanish cultivars is being carried out by the Dipartimento di Ortoflorofrutticoltura of Florence and preliminary results have been obtained in gene transfer by means of the biolistic technique on 'Jiro' and 'Kaki Tipo' (Benelli *et al*., 1999).

A program of selection among local varieties is in force in Turkey (O. Tuzcu, pers. comm.), and in Spain (Valencia) a cross-breeding program has been recently set up (G. Llácer, pers. comm.). In Israel the breeding program is at present not active (A. Blumenfeld, pers. comm.).

Conclusions

The assortment of persimmon varieties in Mediterranean countries is very limited and very few cultivars are widely used, when compared to the number of varieties evaluated in the past. The renewal of the assortment, with the exception of the case of 'Rojo Brillante' in Spain, however linked to a unique cultivar, is practically null in the Mediterranean countries dealing with persimmon cultivation.

Table 5. Cross-breeding programs carried out in Florence

Year	Female plant	Pollinator	No. of seedlings	Selected seedlings
1971	Kaki Tipo, Lycopersicon, Farmacista Honorati, Amankaki	Mercatelli	1139	58 (PCA, PVA, PVNA)
1981 1985 1986 1988	O'Gosho, Hana Fuyu Jiro, Kaki Tipo, Amankaki, Atago, Yokono, Aizumishirazu	Cal Fuyu Mercatelli	629 526 805 400	78 (mainly PCNA)
1990	Ichkikei-Jiro, Izu, F_1 (PCNA × non PCNA), Jiro, Fuyu, Koda-gosho	Cal Fuyu, F_1 (PCNA × non PCNA)	500	Under evaluation. Mainly non PCNA
1991	Mikatani-gosho, Izu, Agakaki, Jiro, Suruga, Takura	Cal Fuyu, F_1 (PCNA × non PCNA)	300	Under evaluation. Mainly non PCNA
1992	Atago, Tenjin-gosho, Jiro, Selezioni non PCNA (PCNA × non PCNA)	F_1 (PCNA × non PCNA) Self-pollinated	100	Under evaluation
1993	Hana Fuyu (monoic)	Self-pollinated	250	Under evaluation

In Italy, where in the last decades cultivars differing from 'Kaki Tipo' have been evaluated, the innovative value of the "new" PCNA and non-PCNA typologies has been neglected. Such a lack of response to renewal can be associated to the difficulties in finding the propagation material (both cultivars and compatible rootstocks) and to managing the novelties in relation to the productive certainty of 'Kaki Tipo', together with the problems linked to marketing a different product. The expanding persimmon cultivation in Spain is relying on 'Rojo Brillante', a cultivar with exceptional characteristics both of quality and productivity, but the signals of congestion are at the door. Hence, the new Spanish persimmon industry is not developing by diversifying production and up to now it appears impossible to find cultivars as valuable as 'Rojo Brillante'.

The situation in Israel is analogous, since 'Triumph' cannot be replaced or flanked by other cultivars, given the productive and market context of that country.

On the other hand the variety diversification in Far East countries and in other non European countries is similar to the Mediterranean one in relation to quantity, since the ratio between number of used cultivars and production is very low. Nevertheless, the composition of the assortment is different: a very high proportion of product relies on PCNA cultivars in Japan and cultivation of PCNA cultivars is noticeably increasing world-wide. The utilization of PCNA cultivars can represent a way out of the present situation in Italy, Spain and Israel, all of them with a consolidated persimmon industry, and a valuable option for developing an elastic assortment in those Mediterranean countries still in the first steps towards industrial production of persimmons.

The rigidity of the varietal assortment does not motivate breeding and the release of new cultivars, thus emphasizing the steadiness of the assortment. In such a context, it is difficult to settle down breeding programs for improving persimmon cultivars valuable for the Mediterranean area.

Furthermore, persimmon breeding is complex and results are not always as valuable as expected, namely when working on the PCNA group. The recently released cultivars, obtained mainly by Japanese breeders, should be evaluated in the Mediterranean areas involved with persimmon production. This could be a first step in order to enlarge its varietal assortment.

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