PROJECT ON UNDERUTILIZED MEDITERRANEAN SPECIES

Taxonomy, distribution, conservation and uses of *Pistacia* genetic resources

Report of a workshop
29-30 June 1995
Palermo, Italy

S. Padulosi, T. Caruso and E. Barone, editors

International Plant Genetic Resources Institute
IPGRI

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The Underutilized Mediterranean Species (UMS) Project is an initiative supported by the Italian Government which seeks to improve the conservation and sustainable use of the valuable but neglected plant genetic resources present in the Mediterranean region. The project operates primarily through Networks for rocket, hulled wheats, oregano and pistachio species. Members of the UMS Networks carry out an agreed workplan with their own resources while IPGRI coordinates the networks and provides financial support for the organization of technical meetings. IPGRI also contributes to raising public awareness on the importance of better conservation and use of underutilized species.

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Preface

Pistachio is an indigenous Mediterranean nut tree with high market potentials. Eleven species of *Pistacia* are recorded from this region, including *P. vera*, the cultigen, which occurs wild in central and southwestern Asia. Wild species play an important role in the cultivation of pistachio varieties as they provide rootstock material resistant to pests, diseases and environmental stresses. Tolerance to drought and ability to thrive in poor soil conditions are among the characteristics that make this crop and its wild relatives particularly suitable for planting of marginal lands; in addition, they represent a source of income for local populations.

Pistacia species are under threat of genetic erosion. The destruction of natural habitats, and the change from traditional agricultural systems into modern cultivation practices which neglect the use of local varieties, have contributed to a reduction of the genetic diversity of both wild and cultivated pistachio types. In the United States of America, a country gaining a leading world role in nut production, extensive farms are being planted with just one pistachio variety, thus creating an unprecedented situation of genetic uniformity for this crop.

The valuable genetic resources of pistachio need to be safeguarded. Essential for carrying out this task is the gaining of a better knowledge on genetic diversity, ecogeographic distribution, uses and conservation status of the genus *Pistacia*.

In March 1994 IPGRI initiated a new project on Conservation and Use of Underutilized Mediterranean Species (UMS), and in the framework of this initiative a close collaboration between this Institute and the FAO's ESCORENA (European System of Cooperative Research Networks in Agriculture) Subnetwork on Pistachio has been established.

This book contains the papers that were presented during the International Workshop organized as part of the UMS initiative on pistachio in Palermo, on 29-30 June 1995. Major objectives of this Workshop were to review the taxonomy of *Pistacia* species in light of the latest findings in this area since M. Zohary's work in 1952, to survey their ecogeographic distribution and to gather better information on diversity, conservation and utilization of their genetic resources.

This successful scientific gathering is the result of a fruitful collaboration between IPGRI (the UMS project and the West Asia and North Africa regional office, WANA), FAO and the University of Palermo (Departments of Botanical Sciences and Fruit Tree Cultivation).

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IPGRI

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Taxonomy

The genus *Pistacia* L.

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Taxonomy

Pistacia L. (Anacardiaceae) is mainly a subtropical genus comprising some 10 species of dioecious trees and shrubs. All are characterized by pinnate leaves and by single-seeded drupes, and all are wind pollinated. Eight species are native to the Old World; two occur in the southern USA and Mexico. Geographically, the largest concentration of *Pistacia* species is found in West Asia (six species) and in the Mediterranean basin (four species).

The only full-scale taxonomic treatment of *Pistacia* is that of my late father, Michael Zohary (1952). In this monographic study the genus is subdivided into the following four sections and 10 species. The main diagnostic traits used to distinguish between the various species are leaf characters and fruit morphology.

I. Section Lentiscella Zohary

Partly evergreen trees. Leaves imparipinnate, with numerous pairs (6-18) of very oblique, acute leaflets. American species.

1. *Pistacia mexicana* HBK

Small trees with a single trunk. Leaves 7-15 cm long, with 8-18 pairs of oblong, mucronate, slightly falcate, 1.0-2.6 cm long leaflets. Fruits are sessile, globose, 4-6 mm in size, with relatively thin endocarp, red-blackish when ripe. Native to Mexico and Guatemala.

2. *Pistacia texana* Swingle

Small trees branching from the base. Leaves up to 10 cm long, with 4-7 (8) pairs of oblong, mucronate, membranaceous, 10-22 mm long leaflets. Fruits dark brown, lenticular, 5-6 mm broad, with relatively thin endocarp. Native to south USA and Mexico.

II. Section Lentiscus Zohary

Evergreen shrubs or trees, with winged leaf rachis and with persistent leaves.

3. *Pistacia lentiscus* L.

Evergreen shrubs (rarely small trees) with leathery leaves and conspicuously winged leaf rachis. The leaves bear 2-3 pairs of ovate to oblong or elliptical, obtuse, 1.5-3.0 cm long leaflets. The fruits are about 3-4 mm across, red when young and turn black at maturity. Chromosome number $2n=24$ (Zohary 1952). A circum-Mediterranean species, and a leading component of the thermophylous low-altitude (0-500 m a.s.l.) maquis vegetation in the Mediterranean basin, extending to Madeira island, and reappearing (as a distinct geographic race: var. *emarginata* Engl.) in East Africa (Somalia to Kenya and Uganda). In the past, *P. lentiscus* was appreciated for its mastic gum obtained by tapping its trunks. Superior clones that lent themselves

to vegetative propagation were selected and cultivated. This relic industry survives today on the island of Chios.

4. *Pistacia weinmannifolia* Poisson
Evergreen trees, 3-20 m high, with 8-20 cm long leaves, and winged or bicanaliculate rachis. Leaflets often alternate, usually 6-8 paired, 1-3 (4) cm long, ovate-oblong. Drupe scarlet, 4-5 mm long and 7-8 mm broad, with leathery endocarp. An East Asian species native to west China, east Tibet, Burma and Malaya.

III. Section Butmela Zohary
Deciduous trees with obtuse leaflets and winged leaf rachis. The drupes are with bony shells (endocarp).

5. *Pistacia atlantica* Desf. (including *P. mutica* Fischer & C.A. Meyer)
Relatively large Irano-Turanian tree, up to 20 m tall, with flattened and winged leaf rachis. Leaflets lanceolate or oblong to broadly oblong, obtuse, 2.5-7 cm long, 3-5 paired (Fig. 1). Drupes ovoid or ovoid-globular, 6-8 mm long, with bony shell (endocarp). Chromosome number 2*n*=28 (Zohary 1952). A variable xerophytic species, widely distributed over southwest Asia and the Maghreb countries of northwest Africa.

IV. Section Terebinthus Zohary
Deciduous trees, with unwinged leaf rachis, and with drupes containing bony shell (endocarp).

6. *Pistacia terebinthus* L.
A small, deciduous Mediterranean tree, 2-6 m tall. Leaves 10-20 cm long, with unwinged rachis, and usually with 4-6 pairs of ovate-oblong or oblong (rarely lanceolate), mucronate (rarely acuminate) 3-5 cm long leaflets. The terminal leaflet is well developed, and it is similar in size to the lateral ones. Fruit obovoid, 6-7 mm long, 5-6 mm broad, slightly oblique and tipped with the style, endocarp bony. Native to the central and western parts of the Mediterranean.

7. *Pistacia palaestina* Boiss.
A small deciduous Mediterranean tree, 2-6 mm tall. Leaves 10-25 cm long, with unwinged rachis, and usually with 4-6 pairs of ovate to oblong to lanceolate, acute to acuminate, 3-7 cm long leaflets. The terminal leaflet is much smaller than the lateral ones, or even reduced to a mucro (Fig. 2). Fruit ovoid to ovoid-globular, about 5 mm in diameter. Native to the eastern part of the Mediterranean.

8. *Pistacia khinjuk* Stocks
A small, deciduous, Irano-Turanian tree, 3-7 m high, with relatively long leaves, each bearing 1-3 (4) pairs of ovate-lanceolate to broadly ovate, 3-10 cm long leaflets. The terminal leaflet is usually larger than the lateral ones (Fig. 3). Fruits are almost globular, somewhat compressed, 4-6 mm in diameter. A southwest Asiatic xerophytic species, extending to Sinai and to the eastern part of the Egyptian desert.

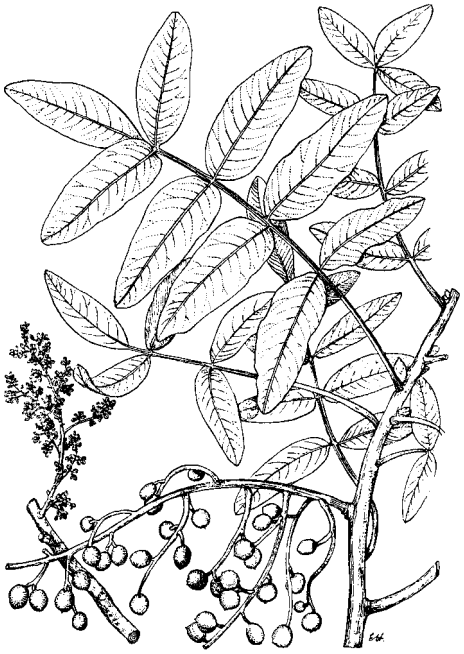

Fig. 1. *Pistacia atlantica* Desf.: fruiting branch (from Zohary 1972).

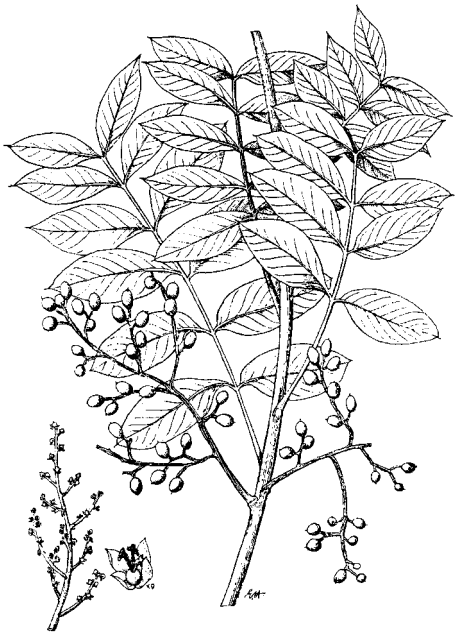

Fig. 2. *Pistacia palaestina* Boiss.: fruiting branch (from Zohary 1972).

Fig. 3. *Pistacia khinjuk* Stocks.: fruiting branch (from Zohary 1972).

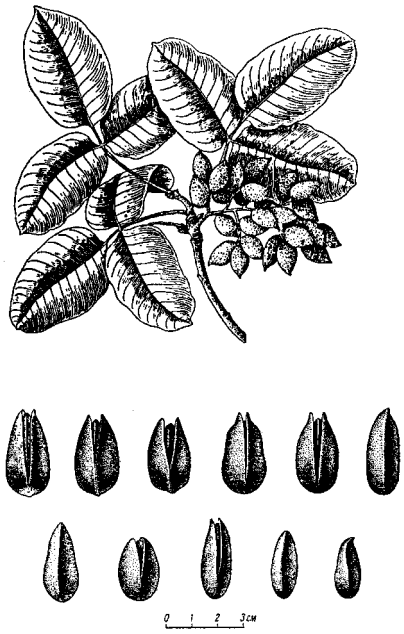

Fig. 4. *Pistacia vera* L.: fruiting branch of a wild form, and a sample of the variation in fruit morphology which occurs in Tadzhikistan (from Zapryagaeva 1964).

9. *Pistacia vera* L.

A xerophitic, deciduous tree, up to 8-10 m high, frequently with several main trunks and with dense spreading crowns and large, shining leaves; containing both wild forms and conspecific cultivars. The leaves usually have 3 (sometimes 5) large (up to 12 cm long), broad-elliptic to round-ovate, leathery leaflets (Fig. 4). The fruits are relatively big (1.0-3.5 cm long). They are smaller in wild forms and larger in the cultivated varieties. They are also very variable in shape, ranging from oblong-linear to broadly-ovate, with a relatively thick, bony shell that frequently splits longitudinally at maturity. Chromosome number is $2n$=30 (Zohary 1952), or $2n$=32 as reported by L.E. Jones and cited by Whitehouse (1957). Wild *P. vera* is native only to central Asia (Fig. 5). This area represents the place of origin of *P. vera* cultivation.

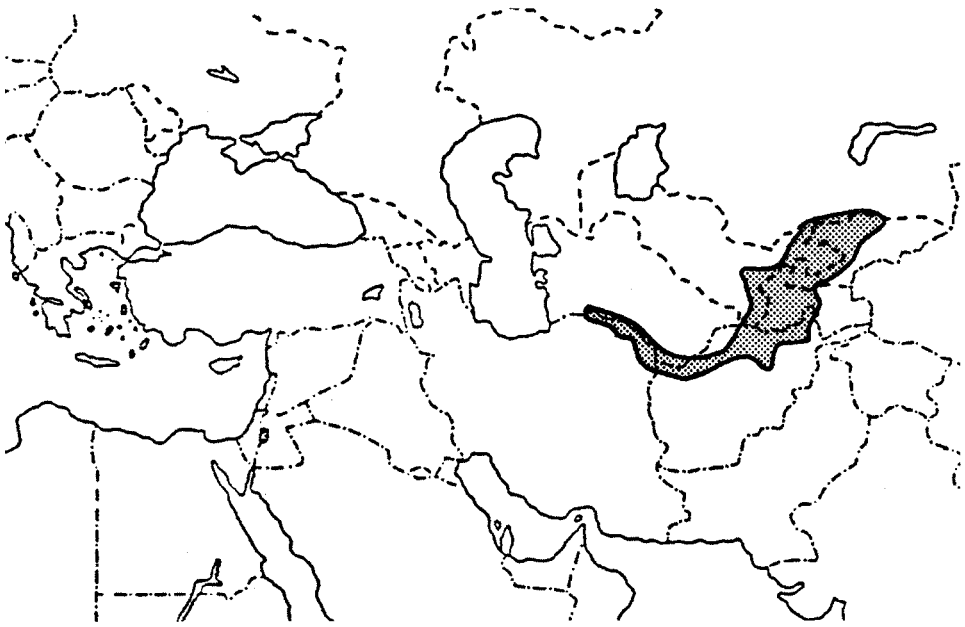

Fig. 5. Distribution of wild *Pistacia vera* L. Based mainly on Browicz (1988) and (for Iran) on Sheibani (1994).

10. *Pistacia chinensis* Bunge

A deciduous, mainly eastern Asiatic tree, up to 25 m tall with large (up to 25 cm long), pinnate (frequently paripinnate) leaves bearing 2-6 pairs of lanceolate, 4-8 cm long, leaflets. The terminal leaflet is much smaller than the lateral ones or even reduced to a mucro. The fruits are globular, apiculate, 5-6 mm in diameter, purplish red or scarlet turning purplish or blue at maturity, and with bony endocarp.

This polymorphic, widely distributed species is subdivided into several geographical races:

- subsp. *chinensis* is native to China, Taiwan and the Philippines
- subsp. *integerrima* (Stewart) Rech. f. is native to the western Himalayas
- var. *falcata* (Beccari) Zohary extends the distribution range of this species also into East Africa (Somalia, Eritrea and Ethiopia).

Pistacia. chinensis has been taken into cultivation as an ornamental tree. It is appreciated for its crimson leaf colour in the Fall.

An eleventh *Pistacia* taxon, namely *P. saportae* Burnat, considered in Zohary (1952) monograph as a true species belonging to Sect. Lentiscus, was later recognized (Zohary 1972) as an interspecific hybrid. It is now regarded as a product of spontaneous crossing between *P. lentiscus* and either *P. palaestina* or *P. terebinthus*. Rare individuals of what is now regarded as *P.* x *saportae* have been detected in the Mediterranean basin, in places where these *Pistacia* species grow side by side.

Hybridization between species

There is almost no cytogenetic or molecular genetic information available on the various *Pistacia* species, or on the genetic affinities between *P. vera* and the nine other species grouped in his genus. Even the chromosome number of most of the species is yet unknown. Chromosome counts are available (Zohary 1952) only from three species *(P. vera, P. atlantica* and *P. lentiscus*), but even these old counts need confirmation. Contrary to the situation in many leading fruit crops, crossing programmes between the cultivated pistachio and its various wild relatives have not been attempted yet. There is practically no experimental evidence on the crossability between the various members of *Pistacia*, and on the viability and fertility of experimentally produced interspecific F_1 hybrids.

In spite of the lack of experimental evidence, some clues on the crossing potentials between the various *Pistacia* species can be obtained by field examinations, i.e. by looking for spontaneous interspecific hybrids in areas in which two or more *Pistacia* species grow side by side, and by searching for introgressive hybridization variation patterns in such contact places. (For review of the phenomenon of introgressive hybridization in plants the reader may consult Anderson 1949, 1953 and Stebbins 1959).

The available information on spontaneous interspecific crosses can be summarized as follows.

Hybridization between wild species

Apparently even widely diverged species in the genus *Pistacia* such as *P. lentiscus* and *P. terebinthus* or *P. palaestina* do occasionally cross in nature. However their spontaneous interspecific F_1 hybrids (*P.* x *saportae*) are very rare. Significantly they are also largely sterile. However, in the eastern Upper Galilee, Israel, mixed stands of *P. lentiscus* and *P. palaestina* have been found by the present author, harbouring not only rare *saportae* individuals (intermediate in their morphology between the two parents), but also individuals displaying introgressive hybridization morphological patterns. This suggests that the sterility barriers between *P. lentiscus* and *P. palaestina* might not always be complete. Some geneflow may exist even between these two widely diverged and largely intersterile taxa.

Rare intermediate individuals as well as blurring in morphological differences were also encountered in the case of *P. atlantica* and *P. khinjuk* in north Iraq (Jeffrey 1980:497-498); again in places where these two species come into contact. However, Jeffrey does not report how fertile the presumed hybrids were.

Hybridization between cultivated *P. vera* and its wild relatives

The domestication of *P. vera* and the spread of pistachio cultivation far beyond the natural range of its wild progenitor brought the crop in contact with several southwest Asian and Mediterranean *Pistacia* species. In traditional areas of pistachio cultivation, contacts between the cultivated clones and the wild species *P. terebinthus, P. palaestina, P. khinjuk* and *P. atlantica* (which thrive at the edges of the plantations) are quite common. Moreover, many of these contacts have existed

for hundreds or even thousands of years. Examination of the wild populations in such places reveals the following picture:

- Introgressive hybridization variation patterns have been detected by the present author in *P. palaestina* populations growing at the edges of pistachio cultivation in southeast Turkey (Marash to Diyarbakir area).
- Similar signs of introgression (from the cultivated clones of *P. vera* into the local native species) were detected by the participants of the IPGRI *Pistacia* Workshop, upon examination of *P. vera* plantations in Bronte area, Sicily, Italy in 1995. Also here, several of the *P. terebinthus* individuals growing spontaneously at the edges of pistachio cultivation displayed some *P. vera* morphological traits. This is in contrast to what was observed in *P. terebinthus* individuals growing far away from the pistachio plantations, in which such traits are not present at all. This pattern of variation indicates that both *P. palaestina* and *P. terebinthus* are not fully intersterile with the crop.
- The information on genetic connections between cultivated *P. vera* and either *P. khinjuk* or *P. atlantica* is much sparser. I have not yet had a chance to study contacts between these species in the field. However, from talks with botanists who examined variation in the latter two species in Iran and east Turkey, I gather that similar introgression may also exist in these cases.
- The lack of strong crossability barriers between cultivated *P. vera* and the abovementioned wild species is also indicated by the pollination practices used in pistachio growing. Planters sometimes expose their (female) cultivars not to *vera* pollen, but to pollen produced by male individuals of *P. terebinthus*, *P. palaestina, P. atlantica* or *P. khinjuk* and obtain normal set of nuts under such circumstances (for review see Whitehouse 1957). According to this source, Raimondo Falci, in 1917, reported that in Sicily male individuals of *P. erebinthus* are often left in pistachio plantations to act as pollinators of the cultivars. In the Near East similar use of interspecific pollination is apparently also made with the other wild species. Whitehouse reports on good nuts set upon such interspecific pollinations in California. He also remarks that the nuts so obtained germinate and produce 'unpure' seedling populations.

Further information

The pistachio industry has special interest in wild forms of *P. vera* and also *P. atlantica, P. khinjuk, P. palaestina* and *P. terebinthus*. All these wild relatives are already very useful in pistachio cultivation because they provide vigorous and resistant stock material for cultivar grafting. All are also attractive for the future breeding work in this crop. Information on these five wild relatives, particularly on their distribution, variation and their ecological specificities, is presented here. For further details on the distribution of the southwest Asiatic species the reader is advised to consult Browicz (1988).

Wild *Pistacia vera*

This is the wild progenitor of the cultivated pistachio and the primary wild genepool of the crop. The distribution of wild *P. vera* is centered in Tadzhikistan, Kirgizia and north Afghanistan, and it extends westward to the north part of Khurassan district in Iran, and the Kopet mountain range of south Turkmenistan (Fig. 5). Geographically, wild *P. vera* represents the most northeastern wild *Pistacia* taxon in central Asia, and it is spatially almost fully separated from the two other wild pistachio species that occur in this general region, i.e. *P. atlantica* and *P. khinjuk*. These latter two grow more south, and overlap with wild *P. vera* only at

the fringe of their distribution range: in Khurassan district of Iran (Sheibani 1994, append. H), and probably also in north Afghanistan.

Over its range *P. vera* is frequently a dominant element in the native vegetation cover, thriving in dry environments (steppe-forests, steppes) and forming what the local botanists (Kamelin 1990) frequently describe as "*Pistacia* park forests". Such wild stands are apparently most common in Tadzhikistan (Zaprygaeva 1964; Browicz 1988). They thrive on both fine-grained soils and rocky slopes and are at their best at altitudes between 800 and 1500 m a.s.l. Some individuals descend to 450 m a.s.l. or climb up to 1800-2000 m a.s.l. According to Browicz (1988) natural stands of *P. vera* in Tadzhikistan occupy some 115 000 ha, and in the whole of Middle Asia this park forest formation extends over some 300 000 ha. Stands of wild *P. vera* in Iran occupy only some 20 000 ha (Sheibani 1994).

Across its distribution range *P. vera* has been an appreciated wild fruit tree, and its nuts have been extensively collected from the wild. This tradition survives today, and a considerable amount of nuts is still collected from the wild by local people. All over this area wild individuals are used also for *in situ* grafting with scions of cultivated clones or as stock material for grafting *vera* cultivars in plantations.

Pistacia atlantica

This tree (Fig. 1) is one of the most widely distributed wild species. It is spread—more or less continuously—over the whole area from northern and western Pakistan, to central and south Afghanistan, south and west Iran, the southeast Caucasus, north Iraq, south Turkey, Syria, Lebanon, Jordan to Israel (Fig. 6). Outside this rather continuous range, *P. atlantica* reappears in Cyrenaica, and it builds massive stands in the Maghreb countries (Tunisia, Algeria and Morocco) extending even to the Canary Islands. Isolated stands of *P. atlantica* also occur in north Turkey and in the southern Crimea. Over this vast range *P. atlantica* varies considerably, and is subdivided (Bowicz 1988) into the following ecogeographic races:

- subsp. *cabulica* (Stocks) Rech. f., grows in Pakistan, Afghanistan and southern Iran
- subsp. *mutica* (Fischer & C.A. Meyer) Rech. f. occurs in the Caucasus, Armenia Crimea, north Turkey and north Iran
- subsp. *kurdica* (Zohary) Rech. f., distributed in the Zagros range of western Iran, southeastern Turkey, Syria and Israel
- subsp. *atlantica* native to the Maghreb countries.

In numerous places in the Near East the nuts of *P. atlantica* are still extensively collected from the wild, and even sold in local markets. They are consumed fresh and (more rarely) used for extraction of oil.

Ecologically *P. atlantica* is a distinctively xerophytic plant. In southwest Asia it often grows as a dominant constituent of steppe-forests formations, and builds up savanna-like park forests, penetrating even to the drier semi-desert environments. In the Mediterranean basin, *P. atlantica* frequently borders the Mediterranean vegetation belt towards the desert. In this region it also thrives together with other xerophytic shrubs (such as *Amygdalus* and *Crataegus* species) in degraded oak, pine or juniper forests (particularly in dry and warm niches), and it occupies a wide variety of soils. Also the altitudinal range of *P. atlantica* is wide: in Turkey between 300 and 1800 m, in Iraq between 600 and 1800 m, in Iran between 900 and 3000 m, in Pakistan between 900 and 1400 m, in Afghanistan between 850 and 2500 m and in Israel between –50 and 1200 m a.s.l.

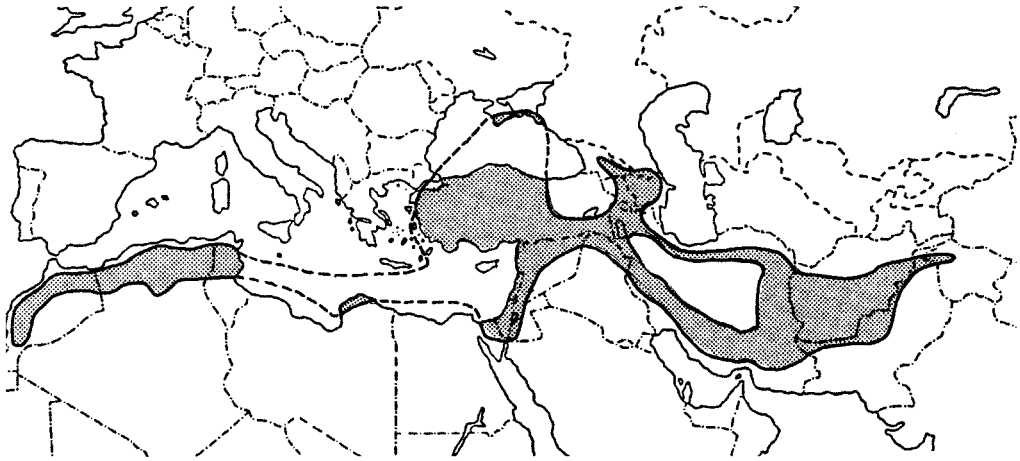

Fig. 6. Distribution of *Pistacia atlantica* Desf. (including *P. mutica* Fischer & C.A. Meyer). Based on Browicz (1988) for southwest Asia, and on A. Khaldi (pers. comm.) for the Maghreb countries.

Pistacia khinjuk

This wild pistachio (Fig. 3) is also an Irano-Turanian xerophytic species. Its main distribution range extends from southeast Turkey, to northern Syria, north Iraq, the mountains of west and south Iran, and from there through Pakistan, Baluchistan into eastern Afghanistan (Fig. 7). Towards the west, *P. khinjuk* penetrates into southern Jordan, Hijaz, south Sinai and the eastern desert of Egypt. The range of *P. khinjuk* coincides to a large extent with the area of *P. atlantica* in southwest Asia. However, in contrast with the latter, *P. khinjuk* is rarely a dominant element in the environments in which it occurs. Usually it is a rather rarer constituent. It thrives in dry steppe-forest or steppe formations together with numerous other xeric shrubs and small trees, mostly in stony places and in rocky mountain terrains. Its altitude preferences range between 400 and 2700 m in Iran, up to 2200 m in Afghanistan, up to 1800 m in Turkey, 2300 m in Saudi Arabia and 2450 m a.s.l. in Pakistan.

The fruits of *P. khinjuk* are collected and consumed locally. Furthermore, in eastern Turkey individuals with large fruits have been selected by the local farmers, and they are vegetatively propagated and maintained by grafting (N. Kaska, pers. comm.).

Pistacia terebinthus

This is a Mediterranean element native to the western and central parts of the Mediterranean basin. *P. terebinthus* is a characteristic constituent of the Mediterranean vegetation, frequently a co-dominant element in *Quercus coccifera* maquis formation or in similar, largely sclerophylous Mediterranean plant associations. In such environments it is more or less continuously spread from Morocco and Portugal in the west to the Aegean region in the east, mainly in the 0-1000 m a.s.l. altitudinal range. It attains much higher elevations in the southern parts of its distribution range (up to 2200 m in Morocco). Together with numerous other Mediterranean elements, *P. terebinthus* also extends to the coastal belt of the Black Sea, particularly to north Turkey.

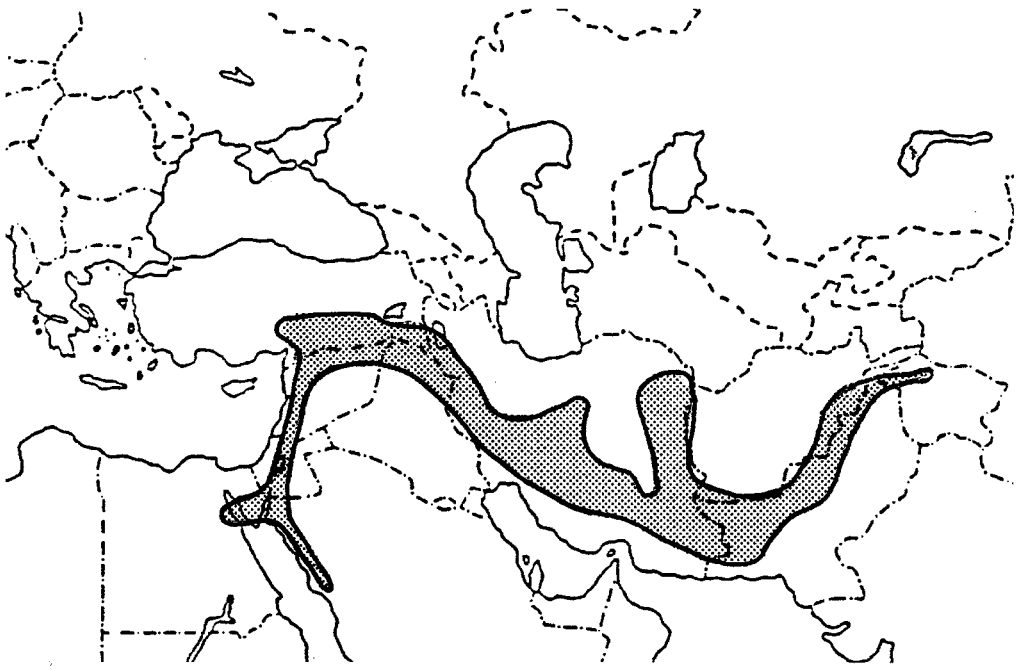

Fig. 7. Distribution of *Pistacia khinjuk* Stocks. Based mainly on Browicz (1988) and (for Iran) on Sheibani (1994).

Pistacia palaestina

An eastern Mediterranean element, closely related to *P. terebinthus*, replacing the latter in the eastern part of the Mediterranean basin (south Turkey, Syria, Lebanon, Israel and Jordan). Also *P. palaestina* is a characteristic constituent of the evergreen maquis vegetation, and a co-dominant element of the *Quercus calliprinos-Pistacia palaestina* association which is widespread in the Levant countries. It occupies a variety of soils (particularly limestone) and occurs in the 0-1200 m altitudinal range (up to 1500 m in Jordan).

P. palaestina is indeed similar to *P. terebinthus* both morphologically and ecologically. Leaf morphology is a main diagnostic character used to distinguish morphologically between these two taxa: in *P. terebinthus* the terminal leaflet is fully developed, in *P. palaestina* this leaflet is much reduced or even absent. Figure 8 shows the leaf silhouettes of *P. palestina* and other *Pistacia* species mentioned so far. In populations growing along the eastern coast of the Mediterranean sea this leaflet reduction is more or less consistent. However, in more westerly places (particularly southwest Turkey) *palaestina* and *terebinthus* plants frequently integrate, and populations commonly contain a whole range of individuals intermediate between typical *palaestina* and typical *terebinthus*. For these reasons some botanists no longer regard *P. palaestina* as a fully diverged species, and consider it only as an eastern subspecies of *P. terebinthus*.

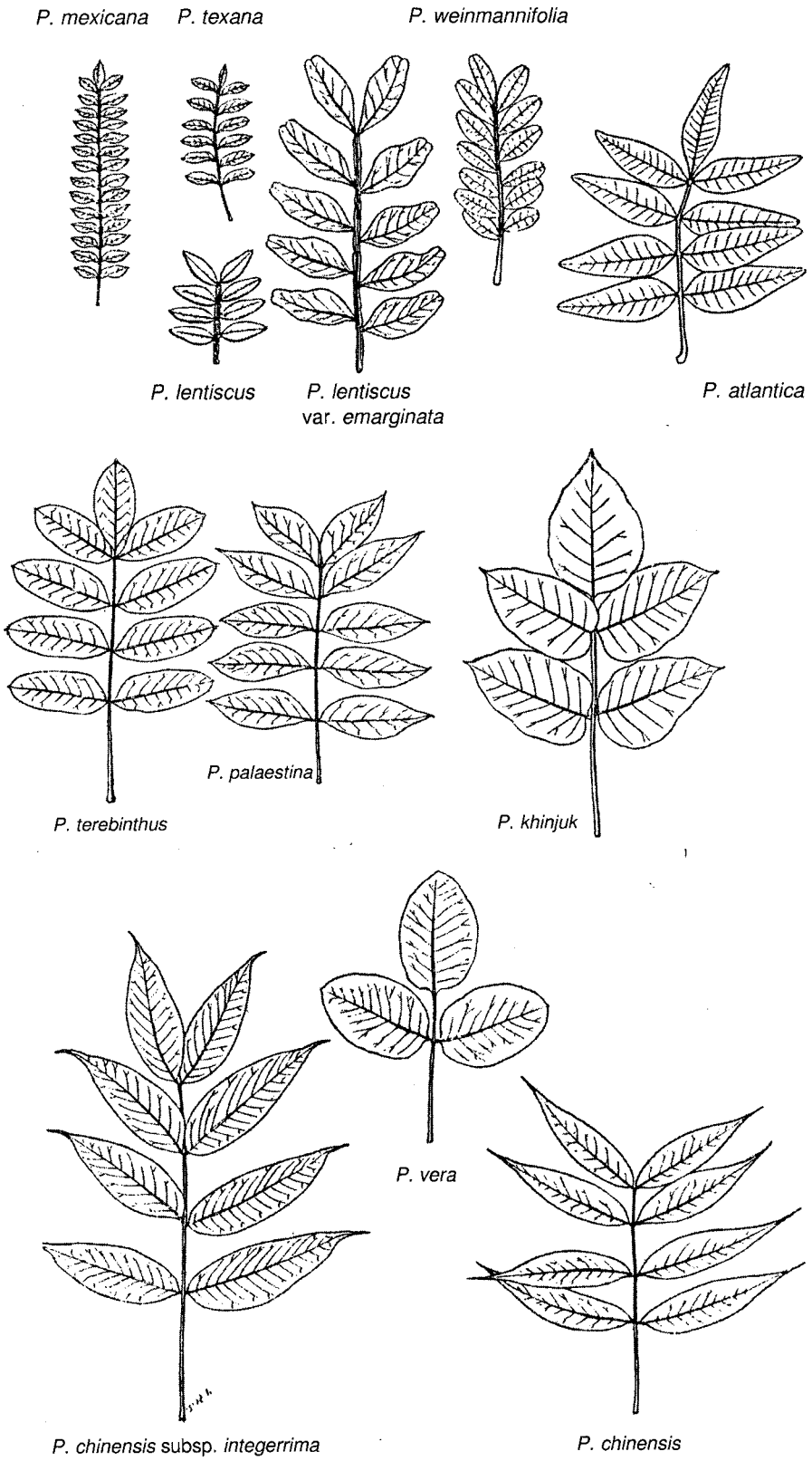

Fig. 8. Leaf morphology of the various species in the genus *Pistacia* L. (adapted from Zohary 1952).

Conclusion

The genus *Pistacia* has been subjected to a sound "classical" taxonomic treatment, and its generic infrastructure worked out. What we still totally lack in *Pistacia* is a modern cytogenetic and molecular genetic analysis. Such examinations in the pistachio crop and in its wild relatives (particularly *P. atlantica*, *P. khinjuk*, *P. terebinthus* and *P. palaestina*) are a prerequisite for determining the wild genetic resources available for breeding work in *P. vera.*

Only after examination of species crossability, and the viability and fertility of the various interspecific F_1 hybrids, would it be possible to define the primary and secondary wild genepools of this nut crop. Isozyme and DNA tests are also essential. They could provide critical information on the variation patterns in the various species, and make possible the assessment of genetic distances between taxa, thus reconfirming and complementing the classical taxonomic analysis.

References

Anderson, E. 1949. Introgressive Hybridization. John Wiley & Son, New York.

Anderson, E. 1953. Introgressive hybridization. Biol. Rev. 28:280-307.

Browicz, K. 1988. Chorology of Trees and Shrubs in South-west Asia and Adjacent Regions. Vol. 6. Polish Scientific Publications, Warsawa, Poznan.

Jefrey, C. 1980. Pistacia. Pp. 494-499 *in* Flora of Iraq, Vol. 4, part 1 (C.C. Townsend and E. Guest, eds.).

Kamelin, R.W., ed. 1990. Pistacia trees in Badkhyz [in Russian]. Komarov Botanical Institute, Leningrad.

Sheibani, A. 1994. Pistachio Production in Iran. Pistachio Research Institute, Ministry of Agriculture, Iran.

Stebbins, G.L. 1959. The role of hybridization in evolution. Proc. Am. Phil. Soc. 103:231-251.

Whitehouse, W.E. 1957. The pistachio nut - a new crop for the western United States. Econ. Bot. 11:281-321.

Zapryagaeva, V.I. 1964. Wild fruits of Tadzhikistan [Russian with English summary]. "Nauka", Moscow - Leningrad.

Zohary, M. 1952. A monographic study of the genus *Pistacia*. Palestine J. Bot.. Jerusalem series 5(4):187-228.

Zohary, M. 1972. Flora Palaestina Vol. 2. Israel Academy of Sciences and Humanities, Jerusalem.

Biosystematic research on the genus *Pistacia* in Jordan

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Abstract

Studies were undertaken on the morphology, anatomy and palynology of the genus *Pistacia* L. in Jordan. During an ecogeographic survey carried out in the country, four intrageneric taxa of *Pistacia* were recognized, namely *P. lentiscus* L., *P. terebinthus* L. subsp. *palaestina* (Boiss.) Engl., *P. atlantica* Desf. and *P. khinjuk* Stock., which was found as a non-fertile shrub. *Pistacia lentiscus* was collected and recorded for the first time from the Trans-Jordan region by the author. Although the palynological studies on these species revealed similar characters for all the species, these differed in leaf morphology and other anatomical features. These differences were compared with the data of other workers.

Introduction

Little work has been done on the taxonomic identification within the genus *Pistacia* in Jordan. Zohary (1952) made the first thorough study of this genus, recording the species *P. lentiscus* L., *P. atlantica* Desf. and *P. khinjuk* Stock. Kaspligil (1956b) reported the presence in Jordan of these species along with the cultigen *P. vera* L. The aim of the current study was to investigate the taxonomy, distribution, wood anatomy and palynology of the taxa recorded in Jordan.

Materials and methods

Morphology

The taxonomical revision was based on both fresh and dry material sampled in herbaria. Exsiccata were obtained from the following Institutes: British Museum (BM), Royal Botanical Gardens, Kew (K), the Herbarium of the Biology Department of the Jordan University, Amman and the Herbarium of the Forest Department of the Ministry of Agriculture in Amman. The specimens collected were kept at the Bachekoy Herbarium, Orman Faculty of the Istanbul University (ISTO), Istanbul, Turkey.

The herbarium material was studied using a binocular microscope. Floral parts were dissected and observed after being boiled in water or dehydrated by using 10% trisodium phosphate at 60°C for 6 hours.

Palynology

Material for pollen grain investigations was obtained only from herbarium specimens. The pollen was prepared for light microscopy observation using Erdtman acetolysis method (1969) (Fig. 1).

Leaf anatomy

The material used was obtained from either fresh or herbarium specimens. Leaf samples were collected from at least three different plants for each taxon. Sections were then prepared using the freezing microtome (Sartorium AG., Standard Microtome No. 27), stained with 1% safranin G in 50% ethanol, dehydrated and mounted in either Canada Balsam for permanent preparation, or fuchsin glycerin-gelatin for temporary preparations.

Epidermal peels were made by controlled maceration using Jeffray's solution, stained with safranin and mounted in Canada Balsam.

Wood anatomy

Wood samples were taken at 1.5 m from the ground on the main trunk of three healthy trees for each taxon from different sites in Jordan.

Material was boiled in water for 24 hours and 20-µm thick sections were cut with a sliding microtome. Sections were then washed by distilled water for 15 minutes, soaked in hypochloric acid to clear the tissues of resins and tannins, and rewashed in distilled water. The cleared sections were then passed through an alcohol series of 50, 75 to 95%, stained with safranin, dehydrated and mounted in either Canada Balsam or fuchsin glycerin-gelatin.

Fibres were prepared by following the Franklin maceration methods (Parvis *et al*. 1969). Isolated fibres were mounted in Canada Balsam or fuchsin glycerin-gelatin.

Results

Habit

Plants of *Pistacia* in Jordan are generally small trees with one or more stems.

Leaf

Leaf partitioning

The genus *Pistacia* is characterized by pinnate leaves. The number of leaflets ranges from 2 to 6 pairs. Leaf rachis and petiole are in some species expanded and flattened to form a green and wing-like expansion; this character is very important in the identification of species from prepared sections. Green wings are present in *P. lentiscus* and *P. atlantica* but in the latter species these are less developed than those of *P. lentiscus.* In *P. terebinthus* subsp. *palaestina*, the wing is absent and leaves show rounded rachis and petiole.

Petiole

A flattened wing-like petiole is found in *P. lentiscus* and *P. atlantica*; a brownish rounded petiole occurs in *P. terebinthus* subsp. *palaestina.*

Shape and apex of leaflets

Generally the leaflets in Jordanian *Pistacia* species range from lanceolate to ovate with an acute apex.

Texture

Leaflet texture is very important in identifying species. For example, *P. lentiscus* has thick, waxy leaflets in comparison with other species, whereas *P. terebinthus* subsp. *palaestina* leaflets are thin with clear veins.

Leaf indumentum

Mature leaves are always glabrate, with the exception of *P. atlantica*, in which leaflets are ciliate with unicellular hairs.

Inflorescence

The inflorescence in *Pistacia* is defined as a compound raceme. In *P. lentiscus*, the inflorescence is fascicle. The present study revealed that the inflorescences of *Pistacia* are completely compound racemes but males and females differ in size and density. In general, the female racemes are larger. The racemes usually appear on the previous years' shoots and before defoliation.

Flower

Floral characters could be used as diagnostic elements for taxa identification. These characters differ between species and sexes of flowers. The perigon of the male flower in Jordanian *Pistacia* contains 3 to 5 sepals with one green bract. The bract is hairy in all the taxa except *P. atlantica* where it is glabrate and rarely at the apex. The perianth of the female flower varies from species to species and sometimes within the same species. The perigon in *P. lentiscus* is formed by one green, lanceolate, acute, hairy bract and 3 to 5 sepals. Sepals are triangulate and reddish. In *P. terebinthus* subsp. *palaestina* the perigon is formed by one lanceolate, acute and hairy bract with 7 to 8 sepals arranged in two rows, of which the outer constitutes 2 to 3 sepals and the inner, 5 sepals. In *P. atlantica*, the perianths of the female flowers are highly variable. Three types of perianth were recorded during the present study. The first perianth contained a single bract with three sepals, the second one bract and 5 sepals, and the third was composed of two whorls, an outer with 3 to 5 lanceolate sepals with a hairy apex, and an inner with 3 to 5 sepals (Fig. 2).

The aim of the anatomical characterization study was to investigate the possible differences in the anatomy of leaf, bark and wood in *Pistacia* species from Jordan.

Leaf

Petiole

The cross-section of the petiole shows the outline surface as rounded or rounded straight adaxially in all Jordanian taxa. The transversal section reveals a uniseriate epidermis with rectangular cells. The epidermis is covered by a thick cuticular layer and calcium oxalate is present in the epidermal cells. Hypodermis is present in all the species investigated and is composed of 4 cell layers of collenchymatous tissue. The mesophyll layer is composed of a few paranchymatic cell layers. Calcium oxalate crystals are present in both layers in *P. terebinthus* subsp. *palaestina*, but absent in the other taxa. Prevascular sclerenchymatous tissues are present as an advanced sheath, mostly abaxially, surrounding the vascular bundle from the top to form a crescent shape. In *P. lentiscus*, the sclerenchymatous tissue extends to surround the wing traces. In *P. terebinthus* subsp. *palaestina* and *P. atlantica*, however, sclerenchymatous tissues form a continuous ring around the vascular bundles. Moreover, in *P. terebinthus* subsp. *palaestina*, the end of the sclerenchyma crescent merges into the phloem of the vascular bundle from both sides to surround the resin ducts. The number of vascular bundles ranges from 6 to 10. Gum ducts are present in the phloem of the vascular bundles and the cross-section shows that the petioles of *P. atlantica* and *P. terebinthus* subsp. *palaestina* have triangular shaped paranchymatic pith, whereas in *P. lentiscus* the parenchymatic pith is rounded and very narrow.

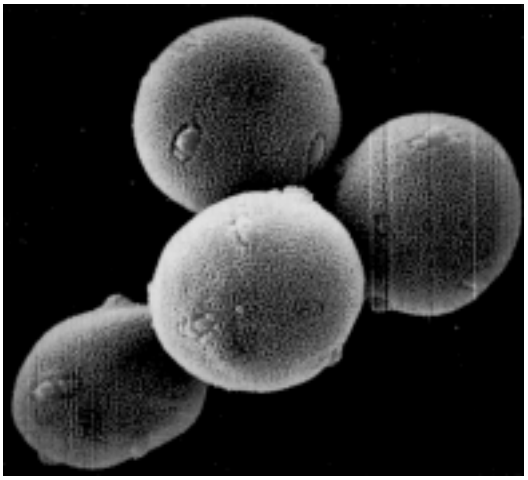

Fig. 1. Pollen grain of *Pistacia* species viewed under electron scanning microscope.

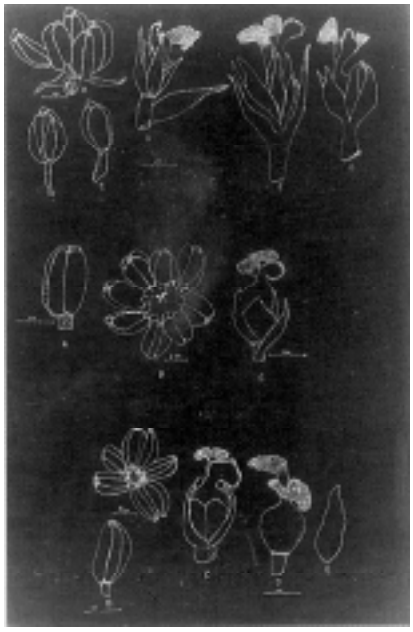

Fig. 2. Flower parts in *Pistacia* species.

Lamina

Cross-section of the leaflet lamina shows that the epidermis, covered with thick cuticule epidermis, on both the adaxial and abaxial sides, is usually straight-walled. In *P. lentiscus,* the striation is parallel and often radiating from the stomata. Stomata for all the taxa are found in the adaxial epidermis. Each stoma is like a wheat grain in appearance, but in *P. lentiscus* it is circular and somewhat sunken into the epidermis. There are from 80 to 240 stomata / mm^2 of epidermis. Stomata dimensions range from 13 to 38 µ x 14 to 36 µ.

Mesophyll

The abaxial palisade is one layer with large cells filled with chloroplasts. In *P. lentiscus,* the adaxial palisade has two layers, the first with long, large cells filled with chloroplasts, the second with shorter cells which rarely contain starch. In *P. terebinthus* subsp. *palaestina,* calcium oxalate crystals are present in this layer.

Spongy mesophyll is 2 to 3 cells thick. These are variable in shape and loose, with wide intercellular air spaces. The cross-section of the main vein in all the species shows that the hypodermal layer is composed of some cells which contain calcium oxalate crystals. The main vein has three vascular bundles whereas the lateral veins have one vascular bundle in each vein surrounded by sclerenchymatic sheath which always extends to the epidermis in all the taxa. In *P. terebinthus* subsp. *palaestina,* the calcium oxalate crystals are found in large quantities in the cells of the vascular tissue. The crystals are seen very clearly in surface section.

Wood

Vessels

The vessels of *P. terebinthus* subsp. *palaestina* have a regular distribution as isolated groups in early wood in cross-section. In late wood, the vessels are distributed in both vertical and horizontal directions, parallel to the rays in a cluster shape. The

wide vessels are found only in early wood. In *P. lentiscus*, the wide vessels are scattered in the growth ring, and in early wood, the vessels are distributed around the boundary of the growth ring. The vessel groups are unicellular or multicellular and are distributed in both vertical and horizontal directions for all species. The number of vessels ranges from 67 to 173 cells per mm^2. The number of vessels in each group ranges from 1 to 14 and from 1 to 17 cells in early and later wood, respectively. The vessels are moderately small or of medium size in early wood. The diameter ranges from 12.5 to 262.5 µ in the tangential diameter and from 12.5 to 175.5 µ in radial diameter. In late wood, vessels are very small. The length of the isolated, moderately short vessel cells ranges from 75 to 300 µ. Vessels of all species are ovate, rarely angulate or circular. In tangential section, the perforation plates are simple. The vessels contain a large amount of cells (especially in *P. atlantica*) and the vessels walls show spiral thickening.

Fibres

Wood fibres are almost similar in all taxa. Fibres are distributed among the vessel groups. They are pointed at their ends, rarely incised or forked. The fibres are very short and thin with lengths ranging from 315 to 915 µ, width from 19.9 to 36 µ, and cell wall thickness from 2.66 to 9.6 µ.

Rays

In cross- and tangential section, the rays are distributed regularly in all the taxa. Rays are of the heterocellular type. They range in number from 3 to 14/mm^2 in cross-section and from 25 to 88/mm^2 in tangential section. In radial section, calcium oxalate crystals are present in the boundary cells of the rays of *P. terebinthus* subsp. *palaestina*. In *P. lentiscus* and *P. atlantica*, the boundary cells of the wood rays are cubical and do not contain calcium oxalate crystals. Resin ducts are present in the centre of the rays but rarely at the ends. The length of the uniseriate rays ranges from 3 to 49 cells; the multiseriate types range from 3 to 87 cells. The multiseriate rays are usually 3 to 5 cells in width (Fig. 3).

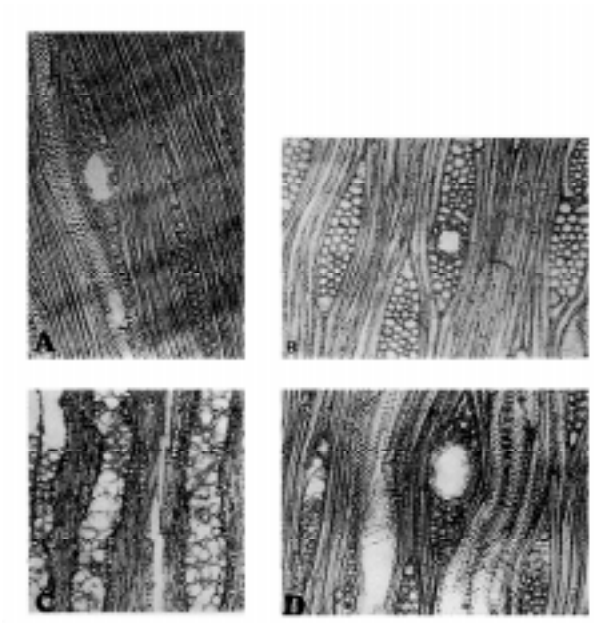

Fig. 3. Sections of resin ducts in *Pistacia* sp.

Discussion and conclusions

Pistacia lentiscus was collected from Trans-Jordan for the first time from the following localities near Irbid: Zobya, Ain Zobya, 1 km west of Ain Zobya on rocky slopes mixed with maquis elements and Jarash (550 m a.s.l.).

In Engler's reports (1936) *P. palaestina* was recognized as a subspecies of *P. terebinthus,* and terminal leaflets were identified as its most typical features. Yaltirik (1967b), in the Flora of Turkey, confirmed Engler's views, based on analyses of the same characters used by this author.

Upon the basis of the findings of this study on material from Jordan and the Middle East, the author has found that terminal leaflets of the lower branches and young shoots—appearing after cutting of the trees—are similar to the lateral ones. Whenever present, terminal leaflets were, except in a few cases, always smaller than the lateral ones. This fact supports Engler's view of considering *P. palaestina* a subspecies of *P. terebinthus*.

The present work showed that the lengths of the leaves of *P. atlantica* and *P. terebinthus* subsp. *palaestina* were almost identical, but in *P. lentiscus* the leaf is much shorter.

Zohary (1952) and Yaltirik (1967b) indicated that the male flower perianth of *Pistacia* species comprises 1 bract with two bracteoles arranged in 1 to 2 whorls and containing 3 to 7 sepals. Post (1932), Rehader *et al.* (1969) and Yaltirik (1967a) mentioned that the perianth of the female flower of *Pistacia* spp. contains one bract with 2 bracteoles and 3 to 5 sepals. During this investigation, the authors found that the perianth contains 1 bract with 3 to 5 sepals with the exception of *P. atlantica* Desf. in which the perianth is a bract with a 2-whorled perigon, each whorl containing 3 to 5 sepals.

The male flowers of *P. lentiscus* have 8 stamens but in the present study the stamen number was either 5 or 7. The stamens in *P. terebinthus* subsp. *palaestina* ranged from 5 to 7, but in *P. atlantica* they were 5. The anther in *P. atlantica* was always large with a short beak at the apex. This character is important in characterizing this taxon.

Horowotz *et al.* (1967) and Haddad (1969) considered *Pistacia* pollen grains to be poriporate or stephanoporate. Erdtman (1952) mentioned that *Pistacia* pollen grains are spheroidal or oblate and 25 to 40 µ in diameter. Pollen grains of Jordanian material are periporate, the shape *of P. lentiscus* pollen is subovate, *P. terebinthus* subsp. *palaestina* oblate, and *P. atlantica* spheroid. Pollen grain sizes range from 20 to 36 µ. The exine has a tectate infrastructure, with smooth reticulate ornamentations.

Zohary (1952) mentioned that *P. lentiscus* has palisade layers in both leaf faces; however, the author found that the *P. lentiscus* has two palisade layers only in the upper part of the leaf.

Fahn (1974) observed that the bundle sheath of the leaf veins contains crystals, a finding which is consistent with the present study.

In Jordanian *Pistacia* material, stomata are found on the lower epidermis. Fahn (1974) found that the number of stomata per square millimeter varies according to the species, in *P. palaestina* being 176 and in *P. lentiscus* 255. In the present work, the author has shown that this number in Jordan material ranged from 70 to 240.

Metcalf and Chalk (1957) found in *P. terebinthus* that transverse sections—through the distal end and abaxial continuous—are accompanied by 1 to 3 adaxial groups of vascular tissue of a dorsally flattened, slightly interrupted ring. Furthermore, they discovered that the petiolar vascular system has large resin canals in the phloem of all the species.

In the Jordanian *Pistacia,* a transverse section of the petiole revealed 6 to 13 vascular bundles arranged as a whole strand in triangular shape. In cross-section, the petioles in all the Jordanian species exhibit an epidermis covered by a thick cuticle, and immediately beneath, a hypodermis of parenchyma cells and a mesophyll layer. Supporting tissue surrounded the vascular bundle from the top end to make a crescent shape. In *P. terebinthus* subsp. *palaestina,* the phloem has more than one resin duct and sclerenchymatous tissue penetrates the phloem to surround the ducts. In *P. atlantica* there is scattered sclerenchyma supporting the tissue in the phloem. In *P. lentiscus* each vascular bundle is arranged under the sclerenchymatic ring with one vascular bundle located on each side of the wing and surrounded by supporting tissue attached to the main sclerenchymatous ring. The petiole has palisade parenchyma cells with wing sides which seemed to contain chloroplasts.

According to Fahn (1974), the vessels in *Pistacia* wood are arranged in irregular groups which consist of varying numbers of vessels in both radial and tangential direction. The present study supports this view, besides adding that in *P. lentiscus* advanced vessels occur as a group or as one single vessel.

The largest number of cells per vessel in the clusters are found in *P. atlantica.* According to Gergus (1945), the number of vessels per square millimeter ranges from 400 to 440 (in *P. terebinthus,* 26 to 280 cells). In the current work the number of cell vessels per square millimeter (1/2 mm^2 summer wood, 1/2 mm^2 spring wood) ranged from 67 to 506.

Gregus (1945), Huber (1954), Metcalf and Chalk (1957) and Fahn (1974) mentioned that the diameter of vessel cells in summer wood ranged from 10 to 25 µ, in spring wood, 15 to 50 µ. In the present study, spring wood vessels showed instead cell diameters ranging from 15 to 270 µ. In addition to this, the length of cell vessel ranged from 90 to 315 µ, with the longer cell being present in *P. lentiscus.*

This work showed that the perforation of *Pistacia* wood vessels is simple and the walls of vessel cells exhibit spiral thickening, as described by Gergus (1945), Metcalf and Chalk (1957) and Fahn (1974). The vessels filled with tyloses and calcium oxalate crystals are present in *P. atlantica* but the tyloses appeared in early stages and had occurred in all the vessels.

Gergus (1945) and Huber (1954) mentioned that the rays in *Pistacia* wood were heterogeneous and had resin ducts. The width of rays ranged from 1 to 6 cells and the length from 2 to 40 cells. Gergus mentioned that the *P. lentiscus* wood has compound rays and its length reached up to 100 cells. In the present work, the author found almost similar results to these.

According to Gergus (1945) the number of rays in *P. lentiscus* is 8 to 10 (35/mm^2) and in *P. terebinthus,* 14 to 18 (100-110/mm^2). In the present study, the number of rays ranged from 3 (25/mm^2) to 14 (87/mm^2).

Gergus (1945) concluded that all *Pistacia* species have fibres in their wood but they do not possess tracheid fibres. This study corroborates the previous findings. Gergus also found that the length of wood fibres ranged from 225 to 315 µ and the width from 10.9 to 36 µ. The fibre cell wall thickness ranged from 3.66 to 10.98 µ. In the light of these present data, the author agrees with the findings of Gergus.

References

Engler, A. 1883. Burseraceae et Anacardiaceae. In A. De Candolle et C. De Candolle Eds: *Monographiae phanerogamarum*, 4. 573 pp.

Engler, A. 1936. Syllabus der pflanzen familien. Berlin, Germany.

Erdtman, C. 1952. Pollen Morphology and Plant Taxonomy. USA.

Fahn, A. 1974. Plant Anatomy. 2nd Ed. Pergamon Press. Oxford, UK.

Gergus, P. 1945. The identification of Central European Dicotyledonous trees and shrub based on xylotomy. Budapest, Hungary.

Haddad, M. 1969. Quelques pollens de la Flora Libanaise, Pollen et Spores Vol. XI. No. 1

Horowitz, A. *et al.* 1967. The Arboreal Pollen Flora of Israel. Pollen et Spores Vol. IX. 18

Huber, B. 1954: Mikrophotographischer atlas Mediernaner. Holzer, Berlin

Kaspligil, B.1956a. Report to the Government the Hashemite Kingdom of Jordan on Ecology of the Vegetation in Relation to Forestry and Grazing. FAO, Rome.

Kaspligil, B. 1956b. Plants of Jordan with notes on Their Ecology and Economic Uses. Forestry Department. Amman, Jordan.

Metcalf, C.R. & Chalk, L. 1957. Anatomy of Dicotyledons Vol. 1: 452-262, Oxford, UK.

Parvis, M.J. et al. 1969. Laboratory techniques in Botany. London, UK.

Post, E. 1932. The Flora of Syria, Palestine and Sinai, Vol. 1: 285-287.American Press, Beirut, Lebanon.

Raeder, E.J. *et al.* 1969. Forest Trees in Iraq, pp. 119-124. Mosul University Press.

Yaltirik, F. 1967a. A new taxon for Flora of Turkey, *Pistacia eurycarpa*. 1st. Univ. Orman. Fakutesi Dergisi, Seri A. Cilt. 12: say 1: 148-155.

Yaltirik, F. 1967b. *Pistacia* L. In Davis Flora of Turkey vol. 2: 544-548, Edinburgh, UK.

Zohary, M. 1952. A monographic study of genus *Pistacia.* PalestineP J. Bot., Jerusalem series 5(4):187-228.

Diversity, Distribution and Conservation

Genetic diversity within *Pistacia vera* in Italy

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Introduction

Pistachio (*Pistacia vera* L.), is a dioecious and deciduous species that originated in West Asia and Asia Minor. It was introduced into Italy from Syria in 30 AD by the Romans at approximately the same time it was introduced in Spain (Minà Palumbo 1882). Its introduction into Sicily probably occurred some time later but it started to be grown on a large scale only during the Arab domination (827-1040 AD). Despite this ancient origin and the long period of cultivation only some ten female cultivars of Pistachio are now grown in Italy together with an even more restricted number of unnamed male selections (Table 1). In Sicily, where more than 95% of the 4200 ha of the Italian pistachio industry is located, at the present time Bianca is practically the only female pistachio cultivar grown commercially, mainly in the Bronte area (Catania, eastern Sicily) (Fig. 1). Thus, actually the other cultivars represent no more than 3% of the total (Barone *et al.* 1985). Most of these minor varieties are no longer grown on a commercial scale nor are available in nurseries, showing a trend towards continuous reduction, so that this genetic reserve is being rapidly eroded.

Table 1. Italian female pistachio cultivars and main area of cultivation in Sicily.

Cultivar	Location
Bianca (Napoletana)	East, south., central, west
Cappuccia	Southwest
Cerasola	East, south, central, west
Gialla	Southwest
Ghiandalora	Central
Insolia	Central
Pignatone	Central
Silvana	Central
Tardiva di Serradifalco	Central
Natalora	East ?
Agostina	East ?

The reasons for this paucity of cultivars are thought to be (Maggs 1973) the long juvenility of pistachios together with the long life-span of the trees and the hybridizations that very easily occur among *Pistacia* species (Whitehouse and Stone 1941); namely in Sicily with the spontaneous *P. terebinthus* (Minà Palumbo 1882). These characteristics, which limit seed propagation, were a major obstacle for the increase of genetic diversity. Furthermore, until recent times, the lack of awareness

concerning the importance of adequate pollination and the traditional use for this purpose of pollen sources other than *P. vera* (Bonifacio 1942) has strongly limited the identification, use and conservation of male varieties.

Nevertheless, considerable variation in male and female plant material can still be found in Sicily. Within the Sicilian pistachio germplasm, some desirable characteristics such as colour, flavour and nut quality are well known and make this germplasm worth describing, studying and preserving. Sicilian pistachios have long been famous and appreciated in the trade for the greenness of their kernels and the rich oily nut-like flavour (Woodroof 1967), in contrast to the Iranian type which has a light yellow kernel colour. Most of these characteristics have been maintained by other cultivars such as Bronte and Trabonella obtained from Sicilian pistachio seeds in the United States in the early 1900s (Joley 1969).

As part of a breeding research programme carried out since 1982, the University of Palermo established in 1984 a field germplasm collection including Bianca and Kerman, the latter being the most important cultivar in the USA, as standard cultivars, together with eight indigenous cultivars and eight unnamed male pistachio selections. Since the existence of possible cases of synonymy in such a collection could not be excluded (Dollo 1991), the varietal identification and characterization of these accessions was recognized as a problem of great concern.

Thus, evaluation of the main pomological traits and of the biometric characteristics of leaves, leaflets, inflorescence buds, inflorescences and nuts of these accessions was undertaken (Caruso *et al.* 1986, 1987, 1993; Barone *et al.* 1996).

In this paper we present an analysis of the results of these recent studies aimed at finding out the degree of variation existing within this source of germplasm. Data from previous works were, therefore, submitted to statistical analysis to determine the between-cultivar coefficient of variation (CV) for pomological and morphometric traits.

Male germplasm

A total of seven accessions of *P. vera* have been selected and studied, namely M1, M3, M4, M5, M7, M8 and M10. An eighth selection (M9) is a putative hybrid between *P. vera* and *P. terebinthus*, locally known as Santangilisi. The more striking differences can be observed between Santangilisi and the *P. vera* accessions, undoubtedly due to the hybridism of the former. Santangilisi differs from the other males in having a higher number of leaflets per leaf (7), a narrower basal leaflet (37.4 mm, i.e. –28.5% of the average), a longer leaf rachis (119.8 mm, i.e. +53.5%), a bigger size of the inflorescence buds (+50%) and, lastly, a generally later blooming period (average 5 days).

Among the *P. vera* accessions, excluding Santangilisi, M5 had the largest leaflets (leaf area = 44.3 cm^2, vs. an average of the remaining cvs. of 33.3 cm^2) and the smallest inflorescence buds (fresh weight = 0.1 g vs. an average of 0.2 g).

A considerable variation (CV approximately = 20%) can be observed mainly as far as leaf area (min. 28.3, max. 44.3 cm^2) and inflorescence bud fresh and dry weights are concerned (min. 117 and 69 mg, max. 242 and 125 mg, respectively) (Fig. 2). Negligible (CV <10%) was the variation in basal and central leaflet length (min. 62.5 and 68.3 mm, max. 75.2 and 82.4 mm, respectively), as well as in leaf rachis length (min. 67.9 mm, max. 91 mm).

Blooming period ranges from the last 10 days of April to the first 10 days of May, thus lasting a total of about 20 days.

Santangilisi and M5 continued to shed pollen until the latest blooming female, Tardiva di Serradifalco, reached full bloom.

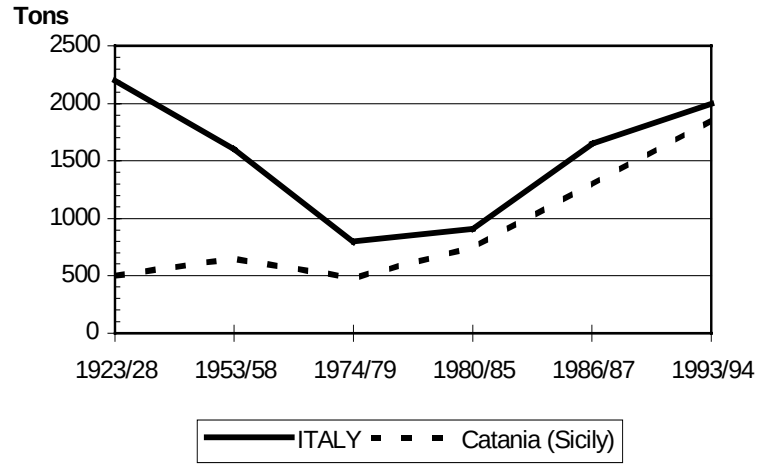

Fig. 1. Dynamics of pistachio production (in shell) in Italy.

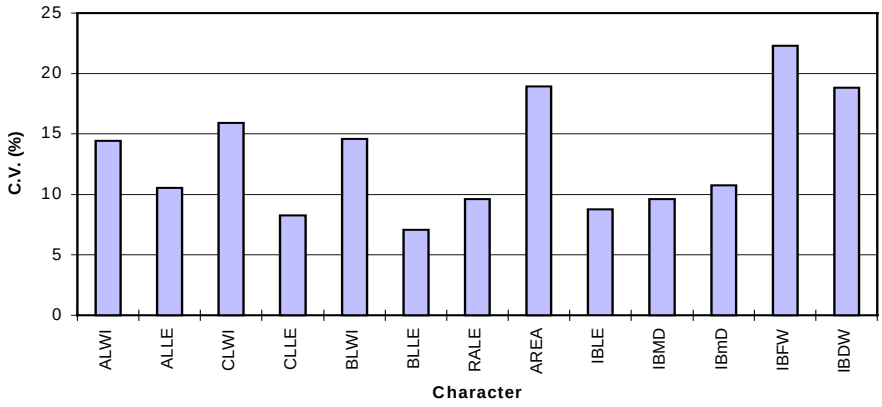

Fig. 2. Between-cultivar coefficient of variation (CV) for morphometric characters in the Italian male pistachio germplasm (see Table 2 for explanation of characters).

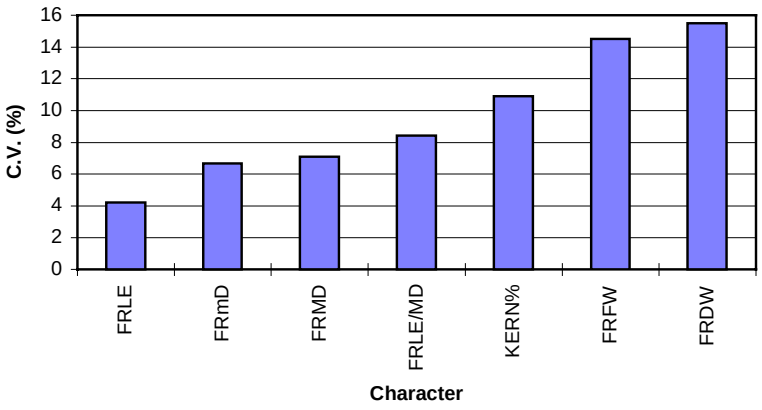

Fig. 3. Between-cultivar coefficients of variation (CV) for fruit morphometric characters of Italian female pistachio germplasm (see Table 2 for explanation of characters).

Table 2. Abbreviations used in Figures 2, 3, 5 and 6.

Abbreviation	Character	Male trees	Female trees
ALLE	Apical leaflet length	X	X
ALWI	Apical leaflet width	X	X
AREA	Leaf area	X	X
BLLE	Basal leaflet length	X	X
BLWI	Basal leaflet width	X	X
CLLE	Central leaflet length	X	X
CLWI	Central leaflet width	X	X
FRDW	Fruit dry weight		X
FRFW	Fruit fresh weight		X
FRLE	Fruit length		X
FRLE / MD	Fruit length / Fruit max. diameter		X
FRMD	Fruit max. Diameter		X
FRmD	Fruit min. Diameter		X
IBDW	Inflorescence bud dry weight	X	X
IBFW	Inflorescence bud fresh weight	X	X
IBLE	Inflorescence bud length	X	X
IBMD	Inflorescence bud max. diameter	X	X
IBmD	Inflorescence bud min. diameter	X	X
IRALE	Inflorescence rachis length		X
KERN%	Kernel %		X
NBR / INF	No. of branchelets per inflorescence		X
NFL / INF	No. of flowers per inflorescence		X
RALE	Leaf rachis length	X	X

Female germplasm

Nine female cultivars have been collected and studied: Bianca, Cappuccia, Cerasola, Gialla, Ghiandalora, Tardiva di Serradifalco Insolia, Pignatone and Silvana. All of them have nuts with an attractive green kernel and similar sizes and weights. However, kernel dry weight ranged from a minimum of 321 mg (Cerasola) to a maximum of 537 mg (Silvana) with a CV of 15.5% (Fig. 3). A similar CV (14.5%) was observed for kernel fresh weight and a lower (10.9%) for kernel percentage. Nut shape is elliptic: the ratio between nut length and nut width averages 1.86 with a minimum of 1.47 (Silvana) and a maximum of 2.03 (Ghiandalora) (Fig. 4). Nut length varied from a minimum of 19.8 (Silvana) to a maximum of 22.9 mm (Tardiva di Serradifalco) with a low CV (4.2%) Similar values of CV were detected for nut diameters.

Among the characters of the leaf a higher CV was observed (Fig. 5) for basal leaflet length (12.5%) which varied from a minimum of 62.3 mm (Pignatone) to a maximum of 87.1 mm (Tardiva di Serradifalco) followed by basal leaflet width (11.5%) which varied from a minimum of 45.3 mm (Insolia) to a maximum of 64.1 mm (Cerasola). Apical leaflet length (CV 9.5%) ranged from a minimum of 80.7mm (Insolia) to a maximum of 108.7 mm (Tardiva di Serradifalco). An even higher CV (17.4%) was found when leaf area was calculated. It ranged from a minimum of 29.7 cm^2 (Pignatone) to a maximum of 48.8 cm^2 (Tardiva di Serradifalco). On the contrary, the less variable characters were the dimensions of central leaflet, with a CV of 5.6% and 6.8% for length and width, respectively. Leaf rachis length varied from 94.5 mm (Cerasola) to 75.7 mm (Ghiandalora) with a CV of 8.9%.

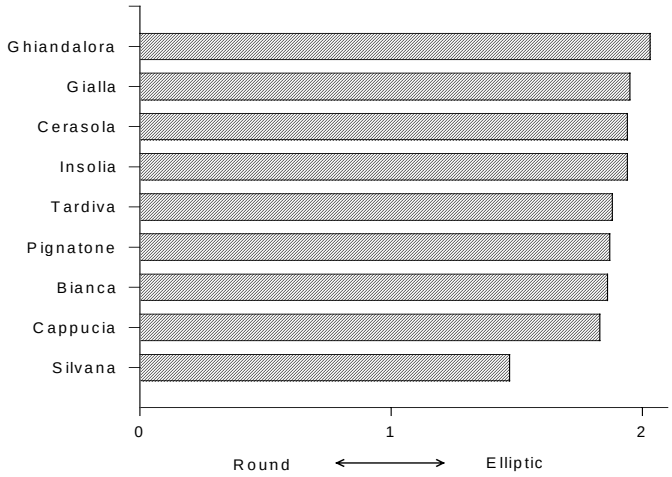

Fig. 4. Fruit shape of Italian female pistachio cultivars (nut length / fruit maximum width).

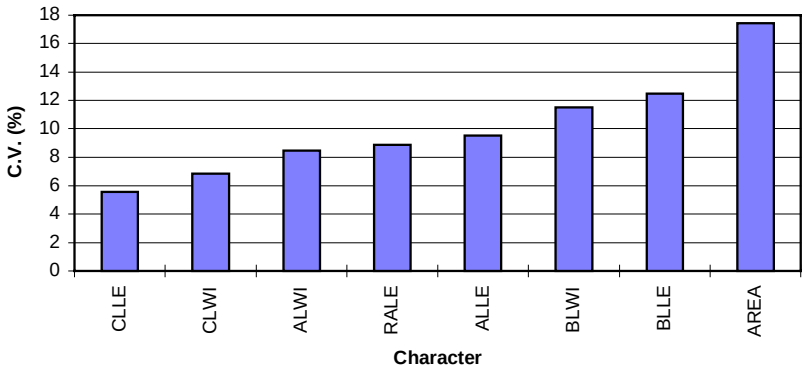

Fig. 5. Between-cultivar coefficients of variation (CV) for leaf morphometric characters of Italian female pistachio germplasm (see Table 2 for explanation of characters).

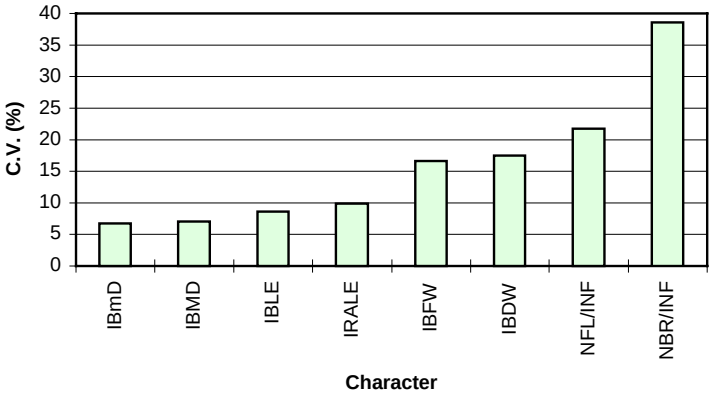

Fig. 6. Between-cultivar coefficients of variation (CV) for inflorescence morphometric characters of Italian female pistachio germplasm (see Table 2 for explanation of characters).

Dry weight was the most variable character for inflorescence bud (17.5%) (Fig. 6). Gialla and Insolia had the smallest inflorescence bud, Cappuccia and Silvana the biggest one, in terms of weight and dimension. Inflorescence rachis length (CV 9.9%) varied from 63 mm (Cappuccia) to 84 mm (Cerasola).

As expected, the higher the number of branchlets per inflorescence the higher the number of flowers per inflorescence, with a CV of 38.6 for the former and 21.8% for the latter. A minimum of 5 branchelets and 106 flowers per inflorescence (Cerasola) and a maximum of 17 and 229 (for Tardiva di Serradifalco and Insolia, respectively) were observed. Cerasola had the longest inflorescence, the poorest branching and the lowest number of flowers.

The total flowering period of all the Italian female germplasm may last up to approximately 20 days, from the early blooming Bianca (25 April) to the late Tardiva di Serradifalco (8 May) (Fig. 7).

Nut size of Sicilian pistachio cultivars is medium to small with approximately 1 g per kernel. Nut shape is elliptic, 21.5 mm in length and only 11.6 mm in width. Splitting, although variable from year to year, is generally low and, therefore, unsatisfactory for direct commercialization and consumption. Nevertheless, the deep green colour of kernels and its excellent quality are appreciated worldwide. Studies carried out at the University of Palermo to evaluate and characterize such germplasm showed that there is considerable variation in morphological and biochemical traits, especially in the characters of male pistachio germplasm (Barone *et al.* 1996). In this study 18 accessions, ten female (including Kerman) and eight unnamed male pistachio accessions, were examined for three enzyme systems and submitted to statistical multivariate procedures (canonical discriminant analysis) to identify such material and to detect the degree of similarity / dissimilarity within the Italian pistachio germplasm.

A more pronounced degree of polymorphism in the male genetic pool than in the female one was detected by the use of isozyme analysis. Hence, a relative degree of similarity, although none are identical, among the tested Sicilian pistillate cultivars is likely (Figs. 8, 9). This is undoubtedly due to a low pressure of selection exerted by growers on the male germplasm and, on the other hand, the lack of seed propagation in traditional cultivation practices. This would also confirm the statements of many authors that vegetative propagation has been practically the only propagation method used by the growers since ancient times (Minà Palumbo 1882; Bonifacio 1942).

Cerasola and M9 proved to be fairly distant from the other female and male selections, respectively. On the other hand, a lower phylogenetic distance could be supposed between Gialla and Silvana as well as among Insolia, Pignatone and Ghiandalora, which form a very compact varietal group.

Results from the canonical discriminant analysis (CDA) applied to the carpological and morphological measurements showed that fruit characteristics, and particularly fruit fresh and dry weight and fruit length, accounted for most of the discriminatory power for the female cultivars while the dimensions of the leaves, principally leaf rachis length and apical leaflet width, were the most effective discriminating characters for the males. These characters can be therefore advantageously used for taxonomic purposes more than others.

Together CDA and the rare enzyme patterns found for Cerasola and male selection No. 9 (M9) denoted the greater phylogenetic distance of these genotypes from the other accessions.

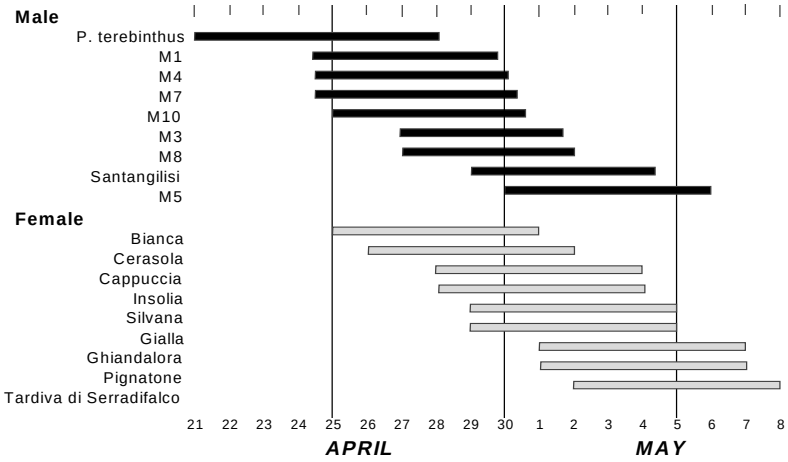

Fig. 7. Blooming period of Italian male and female pistachio accessions (Caruso *et al.* 1993).

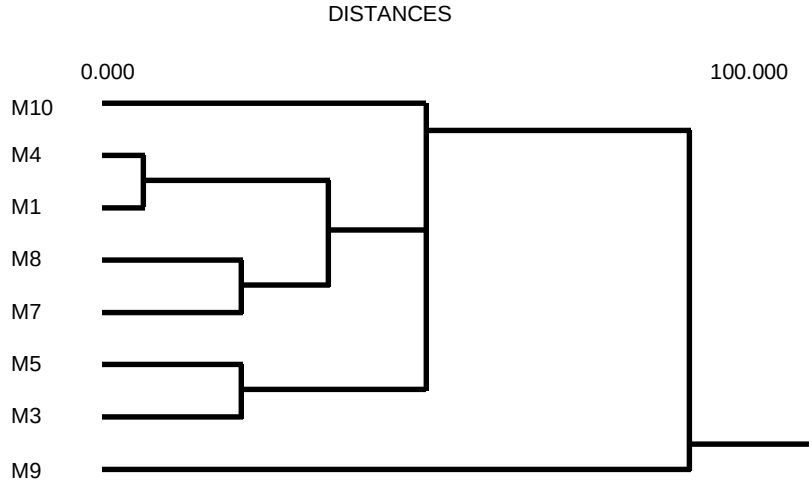

Fig. 8. Dendrogram of pistachio male accessions based on isozyme analyses (Barone *et al.* 1996).

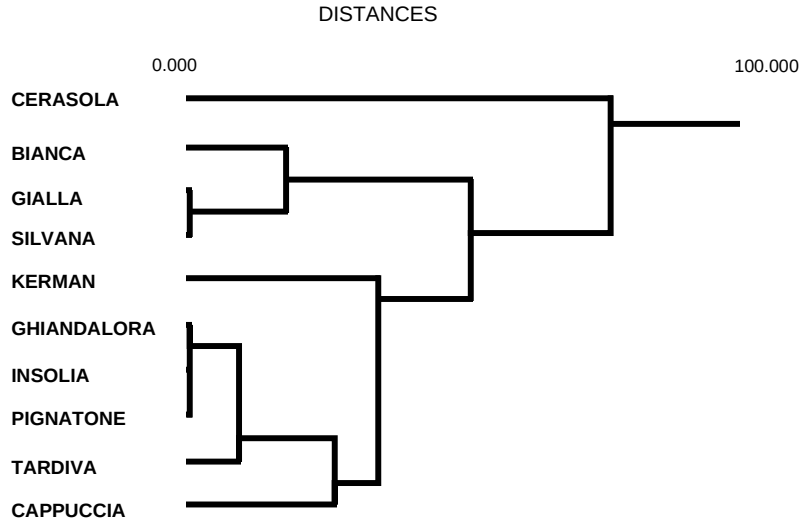

Fig. 9. Dendrogram of pistachio female cultivars based on isozyme analyses (Barone *et al.* 1996).

Cerasola is characterized by an extraordinary red colour of the hull similar to that of Red Aleppo or Kirmizi, while M9, locally known as Santangilisi, is a putative hybrid between *P. vera* and *P. terebinthus* (Bonifacio 1942). The existence of a rare isozyme pattern for Cerasola might suggest the existence of two main different genetic pools within the pistachio germplasm of Sicily. This hypothesis would be explained by a two-step introduction of genetic material coincident with the introduction from Syria of the reddish Cerasola by the Romans and the later introduction carried out by the Arabs (Fig. 10).

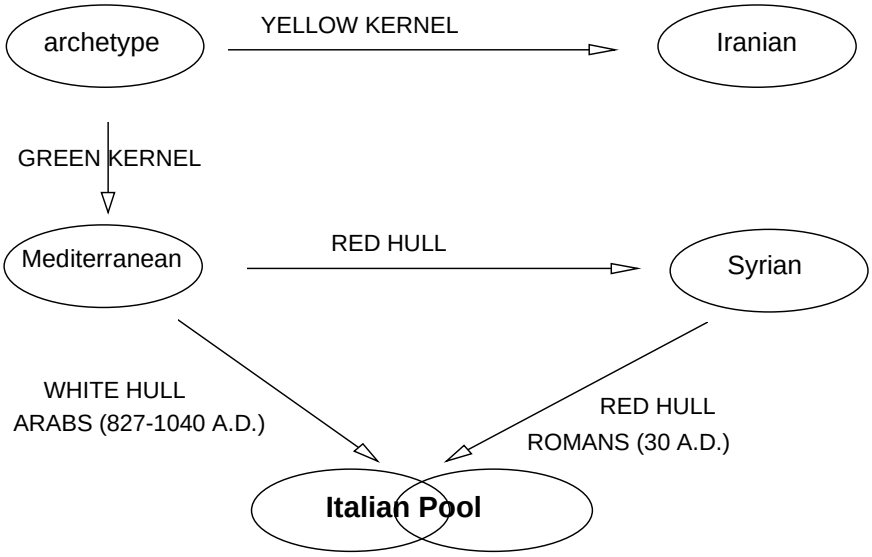

Fig. 10. A suggested hypothesis on the origin of the Italian pistachio genetic pool.

Concluding remarks

Pistacia vera genetic diversity is now very narrow in Italy. Nevertheless, considering Maggs' (1973) findings which indicate that all over the world a total of only about 100 cultivars have been described until recently, the Italian pistachio germplasm would represent about 10% of the whole world diversity of this crop.

Bianca or Napoletana is practically the only used cultivar while the others represent only 3% of the cultivated area, mostly in abandoned settlements. Some other relic varieties, such as Natalora, Rappa di sessa, Minnulina and Agostina reported in the literature, may have been lost already since they can no longer be found in the orchards.

The long life-span of the trees, propagation systems (especially the lack of seed propagation) and an intense pressure of selection exerted by the growers, have determined an extremely narrow germplasm pool. This has led ultimately to a rapid genetic erosion of the diversity within the crop. The much appreciated qualitative characteristics of the Italian pistachios—the rich oily nut-like flavour (Woodroof 1967) and the deep green colour of the kernels—are thus liable to be easily lost forever.

Nevertheless, a considerable variation can still be found, especially in pistachio male germplasm, which makes it worth describing and preserving also for future breeding purposes.

The strategies for conservation of the Italian *P. vera* resources should take into account the need for:

- new collections including all minor or neglected pistachio cultivars and ecotypes
- a special survey for the preservation of the male varieties
- evaluation tests
- definition of similarity and dissimilarity within the new collected accessions
- conservation via seed and graftwood storage.

References

Barone, E., T. Caruso e L. Di Marco. 1985. Il pistacchio in Sicilia: superfici coltivate e aspetti agronomici. L'Informatore Agrario 40:35-42.

Barone, E., L. Di Marco, F.P. Marra and M. Sidari. 1996. Isozymes and canonical discriminant analysis to identify pistachio (*P. vera* L.) germplasm. Hort. Sci. (in press).

Bonifacio, P. 1942. Il Pistacchio. Coltivazione, commercio, uso. REDA, Roma, Italy.

Caruso, T., L. Di Marco, D. Giovannini e A. Di Pisa. 1986. Caratteristiche carpologiche di 4 cultivar di pistacchio coltivate in Sicilia. Frutticoltura 9-10:63-66.

Caruso, T., L. Di Marco e A. Raimondo. 1987. Caratteristiche carpometriche di quattro cultivar di pistacchio (*Pistacia vera* L.) individuate in Sicilia. Agricoltura Ricerca 80:65-68.

Caruso, T., L. Di Marco, R. Lo Bianco and F. Sottile. 1993. The Pistachio germplasm of Sicily: pomological traits. Proceedings of the IX GREMPA Meeting - Pistachio. Bronte-Sciacca, 20-21 May. (in press).

Dollo, L. 1991. Aspetti della biologia fiorale di alcune specie del genere *Pistacia*, caratterizzazione genetica delle stesse e dei loro ibridi. PhD. Diss., Università di Catania, Italy.

Joley, L.E. 1969. Pistachio. Pp. 352-355 *in* Handbook of Northern American Nut Trees (R.A. Jaynes, ed.). The Northern Nut Growers Association.

Maggs, D.H. 1973. Genetic resources in pistachio. Plant Genet. Resour. Newsl. 29: 7-15.

Minà Palumbo, F. 1882. Monografia botanica ed agraria sulla coltivazione dei pistacchi in Sicilia. Lorsnaider Giovanni Tipografo, Palermo, Italy.

Whitehouse, W.E. and C.L. Stone. 1941. Some aspects of dichogamy and pollination in pistachio. Proc. Am. Soc. Hort. Sci. 39:95-100.

Woodroof, J.G. 1967. Pistachio nuts. Pp. 261-287 *in* Tree Nuts: Production, Processing, Products. AVI Publishing, Westport, Conn., USA.

Natural occurrence and distribution of *Pistacia* species in Italy

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Introduction

Current Floras (Fiori 1925; Tutin 1968; Pignatti 1982) report the presence of *Pistacia lentiscus* L., *P. terebinthus* L. and *P. vera* L. in Italy. Among these species, the first two are spontaneous, the third one is known as cultivated. Some interspecific hybrids, both between the natural species and between these and the cultivated one, are also known.

As pistachio is a traditional cultivation of local interest having development capacity, it appears useful to specify the distribution and ecology of the abovementioned taxa growing in Italy, not only for the floristic and vegetational aspects, but also for the relationships between the spontaneous component of the wild populations and the cultivated plants.

We have drawn an outline of the Italian distribution for each of the investigated species, illustrating the ecological and general synecologic roles, with special attention to Sicily, since the island is the only part of the Italian territory in which the presence of pistachio is still of some relevance.

Pistacia lentiscus L.

It is the most common species whose general distribution includes all the coastal regions of Mediterranean and Macaronesia. Its distribution is mostly coincident to that of the olive tree (Zohary 1952; Fenaroli 1964; Greuter *et al.* 1984; Tutin 1968). In Italy it occurs throughout the peninsula except for the regions not subject to the strict Mediterranean climate, such as the Appenninic part, the Po Valley and the northern areas (Fenaroli 1964). In particular, to the north of Campania and Apulia it occurs only in the coastal part and in the hills lying behind. The northeastern distribution limit lies in the Trieste area, the northwestern limit in Piedmont on the reliefs geographically belonging to the Ligurian Apennine.

In southern Italy, in Corse, Sardinia, Sicily, small islands and Malta (Haslam *et al.* 1977), lentisc is widespread. Historical data (Parlatore 1872) are confirmed by recent information on floristics and vegetation. Pignatti (1982) reports the species for all regions except the alpine ones. In Sicily it is distributed everywhere from the coast up to 700 m a.s.l. and in all the islands of the Sicilian archipelago (Gussone 1844; Lojacono-Pojero 1891). For the Etna Mount, Strobl (1880) reports it as very frequent at Belpasso and between Catania and Acicastello. Raimondo *et al.* (1990) substantially confirm this distribution.

Regarding the geographical distribution, the diffusion of the species depends somewhat upon the edaphic factor because it prefers soils poor in carbonates although it is not unknown on the siliceous substrata.

As regards the vegetation, it falls within evergreen maquis communities together with *Olea europaea* var. *sylvestris* Hoffmg. & Link., *Ceratonia siliqua* L., *Myrtus communis* L., *Phillyrea latifolia* L., *Arbutus unedo* L., etc. belonging to several phytosociological associations of *Oleo-Ceratonion* alliance within the *Pistacio-Rhamnetalia alaterni* order.

A typical example of phytocoenosis characterized by *P. lentiscus* and by *Genista ephedroides* DC., *Juniperus phoenicea* L., *Myrtus communis* L. and *Cistus monspeliensis* L. is that described from the island of S. Pietro (southwest Sardinia) and referred to

as the *Oleo-Lentiscetum* by De Marco and Mossa (1980). Along the Sicilian coasts, among several communities included within the *Pistacio-Chamaeropetum humilis* complex, *Chamaerops humilis* plays a significant role together with *P. lentiscus* (Raimondo *et al.* 1990).

As far as the infraspecific variability is concerned, Fiori (1925) reports for Italy three taxa of variety rank: *P. lentiscus* var. *lentiscus* whose area of distribution coincides with the species one, var. *latifolia* Coss. and var. *massiliensis* Mill. occurring in southeast Sicily. Other taxa, such as var. *angustifolia* DC. reported by Gussone (1844) for Gela (south Sicily) and *P. lentiscus* f. *Leptophylla,* are to be referred to as var. *massiliensis,* which grows also in southern France near Nice and in Tuscany.

Taxonomical relationships with the other species are indicated by the presence of hybrids derived by crossing between lentisc and terebinth named *P.* x *saportae* Burnat for France and Portugal whose distribution is scattered in the Italian peninsula and in Sardinia (Tutin 1968) and in different parts of the Mediterranean together with the parental species (Zohary 1972). In Sicily *P.* x *saportae* has not yet been reported.

Pistacia terebinthus L.

Its general area of distribution is similar to that of lentisc, but it is wider; in fact it also comprises central France and all of the Iberian Peninsula (Zohary 1952; Fenaroli and Gambi 1976). In Italy it is frequent in the central part and in the north in the Bergamo area and in Piedmont near Acqui, as well as in the Euganean Hills and in Friuli where it has been recently mapped by Poldini (1991).

In Sicily terebinth occurs in all the territory up to 800 m a.s.l. It is reported for Sicani Mountains (Marceno' *et al.* 1985) and for the areas of Palermo, Messina, Ragusa as well as on Madonie Mountains (Minà Palumbo 1882) and Etna (Gussone 1844; Strobl 1880) where it is very frequent because it is favoured by people. It is lacking in the minor islands. In Malta it occurs only as a cultivated plant (Haslam *et al.* 1977).

In the Italian area of distribution the species can be found up to 900 m a.s.l. without reaching the absolute height limit of 1200 m (Zohary 1952). It prefers limestone substrata in contrast with lentisc.

Pistacia terebinthus, although it is not rare, is less common than *P. lentiscus* and it is much less typical than lentisc both for the physiognomic and syntaxonomic aspects. Nevertheless, the communities in which its presence is more or less significant belong to associations included in the alliances *Quercion ilicis* (*Quercetalia ilicis*) and *Orno-Ostryon* (*Quercetalia pubescentis*).

As regards the interspecific taxa occurring in the Italian territory, *P. terebinthus* var. *angustifolia* Lec. & Lamte is known only from the Verona province (Fiori 1925). In Sicily there is a greater differentiation, mostly caused by the relationship with *P. vera* in the area of its cultivation.

The relationships with *P. lentiscus* were discussed in the previous paragraph.

Pistacia vera L.

In Italy, the presence of pistachio, a species native of central Asia (Zohary 1952), is relevant only in Sicily where it was probably introduced by the Arabs. The main nucleus is in the Bronte area (Etna Mount, east Sicily). Less important areas fall within the provinces of Agrigento (south Sicily) and Caltanissetta (central Sicily). These are the residuals of the cultivations which were widespread until the end of the last century. Here we consider only the taxonomic relationships between

pistachio and the other native taxa of the Sicilian flora, particularly with *P. terebinthus*, the species upon which it is grafted. For historical aspects and present situation of the cultivation we respectively refer to Minà Palumbo (1882) and to other pertinent papers. The coexistence of the two close species has generated several hybrids described as *P. hybrida* Gasp., *P. sicula* Tornab. and *P.* x *bocconii* Tornab. Notices on the more or less problematic occurrence of *P. vera* as a wild plant in the island (Pignatti 1982; Greuter *et al.* 1984) can be referred to these nothotaxa which are still to be studied from a taxonomic point of view even if in general there is agreement in considering the first two as *P. vera* x *P. terebinthus* and the latter as *P. terebinthus* x *P. vera.*

It is of some interest that in the diagnosis of *P.* x *bocconi* and *P.* x *sicula* some fossil specimens were analyzed (Tornabene 1860, 1882). They are probably to be referred to individual variations of the *P. terebinthus* Sicilian population.

Acknowledgements

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References

De Marco, G. e Mossa L. 1980. Analisi fitosociologica e cartografia della vegetazione (1: 25000) dell'Isola di S. Pietro (Sardegna sud-occidentale). C.N.R. Collana "Promozione della qualità dell'ambiente" AQ/1/80 pp. 34.

Fenaroli, L. 1964. Flora Mediterranea. 1. Martello Ed. Milano.

Fenaroli, L. e G. Gambi. 1976. Alberi. Dendroflora italica. Museo Tridentino di Scienze Naturali, Trento e Trieste.

Fiori, A. 1925. *Pistacia. In* Fiori A. Nuova Flora analitica d'Italia. 2: 116-117. Ricci, Firenze.

Greuter, W., H.M. Burdet and G. Long. 1984. Med. check-list, 1: 48-49.

Gussone, J. 1844. Florae Siculae Synopsis. 2, Neapoli.

Haslam, S.M, P.D. Sell and P.A. Wolseley. 1977. A flora of the Maltese islands. Malta Univ. Press, Malta.

Lojacono-Pojero, M. 1891. Flora Sicula 1 (1). Palermo, Italy.

Marceno', C., P. Colombo e R. Princiotta. 1985. Ricerche climatologiche e botaniche sui Monti sicani (Sicilia Centro Occidentale): La flora. Naturalista sicil. 8, ser. 4, (suppl.): 69-133.

Minà Palumbo, F. 1882. Monografia botanica ed agraria sulla coltivazione dei pistacchi in Sicilia. Palermo, Italy.

Parlatore, F. 1872. Flora Italiana. 5. Firenze, Italy.

Pignatti, S. 1982. Flora d'Italia, 2: 166. Edagricole, Bologna, Italy.

Poldini, L. 1991. Atlante corologico delle piante vaseolari nel Friuli-Venezia Giulia. Eds. Regione Autonoma Friuli-Venezia Giulia & Università degli Studi Trieste. Udine, Italy.

Raimondo, F.M., L. Gianguzzi, G. Venturella e M. Lo Valvo. 1990. Indagine preliminare sul patrimonio biologico-ambientale delle coste siciliane. Quad. Bot. Ambientale Appl. 1: 31-182.

Strobl, P.G. 1880. Flora des Etna. Ôsterr. Bot. Z., 3.

Tornabene, F. 1860. Flora fossile dell'Etna. Atti. Accad. Gioenia Sc. Nat., Catania, S.2, 16:1-147.

Tornabene, F. 1882. Flora Aetnea, 2. Catania.

Tutin, T.G. 1968. *Pistacia. In* T.G. Tutin *et al.* Flora Europaea 2: 237.

Zohary, M. 1952. A monographic study of the genus *Pistacia.* Palestine J. Bot., Jerusalem Series 5(4): 187-228.

Zohary, M. 1972. Flora Palaestina, 2. Israel Academy of Sciences and Humanities, Jerusalem, p. 299.

Pistacia terebinthus L. germplasm in Apulia region, southern Italy

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Introduction

Within *Pistacia* genus, *P. lentiscus* L. and *P. terebinthus* L. are the only two wild species occurring in peninsular southern Italy (Pignatti 1982; Fiori 1969). The former grows everywhere in the Mediterranean maquis while the latter, which has a marked lithophilous habit, colonizes preferably arid and rocky soils where it can overcome many other species in growing competition.

Terebinth is characterized by peculiar traits and is phenotypically very close to the cultigen *P. vera* (Zohary 1952). This paper reports on a survey conducted on terebinth germplasm in Apulia region, southern part of Italy, aiming at gathering material for a better understanding of the genetic diversity of those populations.

Germplasm material was collected from populations found in the following three regional subzones (Baldacci 1966; MAF 1976):

1. northern subzone: Gargano (GA), promontory with thermophilous forestry; max. altitude 1056 m a.s.l., mean annual rainfall 800 mm
2. central subzone: Murgia Barese (BA), plateau delimited by rocky cliffs; max. altitude 686 m a.s.l., mean annual rainfall 650 mm
3. southern subzone: Serra Salentina (SA), rocky reliefs; max. altitude 201 m a.s.l., mean annual rainfall 750 mm.

As a whole 26 specimens have been recorded: 8 from 200-400 m a.s.l. altitudinal range, in natural association with *Fraxinus ornus*, *Quercus robur*, *Quercus cerris*, *Acer* spp. from GA; 10 from ca. 200 m a.s.l., in plain Mediterranean maquis from BA; 8 from ca. 50 m a.s.l. in steepy and rocky sites along the Adriatic seacoast in SA zone.

Germplasm evaluation and methods

The following measurements were taken on five compound leaves and five infructescences removed from each of the 26 specimens.

Leaf

Length, width and length / width of the first three leaflets and the apical one; distance between the apical and the following leaflet (referred as 'apical stalk'); leaf rachis length; apical leaflet length / rachis length; apical stalk length / rachis length; leaflet couple number.

Fruit

Infructescence rachis length; lateral branch number; rachis length / no. of lateral branches; fruits number; fruits number / no. lateral branches; fruit length; fruit width; fruit length / fruit width.

In order to discern less discriminating variables, data were first submitted to a Stepwise Discriminant Procedure (STEPDISC, Backward Method) of SAS Package (SAS Institute, Cary, NC, USA). As a result of this analysis, none of the 25 variables was eliminated.

All data were then submitted to Principal Component Analysis (PCA) and subsequently, on the first three Principal Components (PC), the Cluster Analysis (Ward Method) was performed.

Results

Through the Principal Component Analysis, the three principal components PC1, PC2 and PC3 explained 67% of the total variability (Table 1). They separated quite well the different kinds of morphological parameters, and the most associated variables were:

- PC1 length of the apical leaflet, the apical stalk, the 3rd, the 2nd and the 1st leaflet; width of the apical, the 2nd and the 3rd leaflet
- PC2 length:width ratio of the 1st, the 2nd, the 3rd and the apical leaflet; width of the 1st leaflet
- PC3 leaf length rachis, apical leaflet length:leaf rachis ratio, fruit number per infructescence.

Four clusters were discriminated (Fig. 1, Table 2).

In Cluster 1, terebinth types (7 specimens) from Murgia Barese prevailed in combination with 4 specimens from Serra Salentina. These types showed average small-sized leaves (3.7 paired), mainly due to leaflet and rachis length. Apical leaflet was on average only 31.1 mm long, 16.1 mm large and had a short apical stalk.

Cluster 2 mostly included terebinths from Gargano (6 specimens) in addition to two others, very close to each other, collected in the central subzone. Plants in this cluster exhibited big sized leaflets (3.2 paired) with long rachis. Apical leaflet and apical stalk also were big.

Cluster 3 was composed by 4 specimens from Serra Salentina and just one from the central subzone. They had medium sized leaves (3.8 paired), somehow a bit more rounded than those of other groups, as suggested by length / width ratio of their leaflets. Length of apical leaflet and of apical stalk was medium too. This cluster was characterized by a very high number of fruits per infructescence, exceeding the other groups more than 2-fold.

Cluster 4 was formed by two specimens from the northern subzone (GA1 and GA3). They differed from those in Cluster 2 mainly for smaller leaves and markedly narrower leaflets (3.0 paired). The same differential characters were reflected by the apical leaflet. This cluster, moreover, had a length / width ratio of the 1st leaflet (2.8) different from all the other groups (1.7-1.9).

Discussion

The first three PCs were able to separate characters such as leaflet size (PC1), leaflet shape (PC2) and fruit traits (PC3). The dimension of the apical leaflet and the shape of the basal one (the 1st) proved to have a primary importance in the multivariate analysis, followed by infructescence and fruit traits.

On the whole, fillometric measurements pointed out the following facts:

- the 1st leaflet was the smallest among the laterals
- the 2nd and the 3rd leaflets had very similar size
- the apical leaflet was generally smaller than all the others; by comparing the four groups it represented quite well the mean leaf traits.

Table 1. Eigenvectors (W) and loadings (L) of the first 3 PC axes from PC analysis. Eigenvalues and their contribution to total variation are listed at the bottom of columns.

	PC1		PC2		PC3	
Variables	**W**	**L**	**W**	**L**	**W**	**L**
Rachis length	0.17	0.46	-0.16	-0.37	-0.38	-0.67
1st leafl. length	0.29	0.83	0.08	0.18	-0.19	-0.34
2nd leafl. length	0.30	0.86	0.11	0.25	-0.15	-0.26
3rd leafl. length	0.31	0.89	0.06	0.14	-0.10	-0.17
Apical leafl. length	0.32	0.91	0.08	0.18	0.15	0.27
1st leafl. width	0.24	0.68	-0.25	-0.57	-0.14	-0.24
2nd leafl. width	0.28	0.79	-0.23	-0.53	-0.07	-0.12
3rd leafl. width	0.27	0.78	-0.24	-0.56	0.01	0.01
Apical leafl. width	0.30	0.85	-0.10	-0.24	0.20	0.35
1st leafl. l:w	0.07	0.21	0.41	0.94	0.11	-0.08
2nd leafl. l:w	0.05	0.15	0.40	0.92	-0.07	-0.13
3rd leafl. l:w	0.02	0.05	0.40	0.92	-0.08	-0.14
Apical leafl. l:w	-0.01	-0.02	0.39	0.89	-0.09	-0.15
Leafl. couple number	-0.18	-0.52	-0.19	-0.43	-0.27	-0.48
Stalk length	0.31	0.91	0.01	0.02	0.07	0.13
Apical leafl. length: rachis length	0.19	0.55	0.16	0.37	0.37	0.66
Stalk length:rachis length	0.18	0.52	0.13	0.29	0.36	0.63
Infructescence rachis length	0.05	0.15	0.09	-0.20	0.03	0.04
Lateral branch number	-0.08	-0.24	-0.02	-0.06	0.26	0.46
Rachis length:lateral branch number	0.11	0.32	-0.04	-0.11	-0.16	-0.29
Fruit number	-0.02	-0.05	-0.13	-0.31	0.35	0.62
Fruit number:lateral branch number	0.01	0.03	-0.15	-0.35	0.32	0.56
Fruit length	-0.18	-0.53	0.01	0.01	0.01	0.01
Fruit width	-0.21	-0.60	-0.02	-0.04	0.07	0.12
Fruit l:w	0.05	0.16	0.07	0.16	-0.11	-0.20
Eigenvalue	8.31		5.32		3.11	
% of total variability	33.24		21.28		12.50	
Cumulative % of variability	33.24		54.52		67.02	

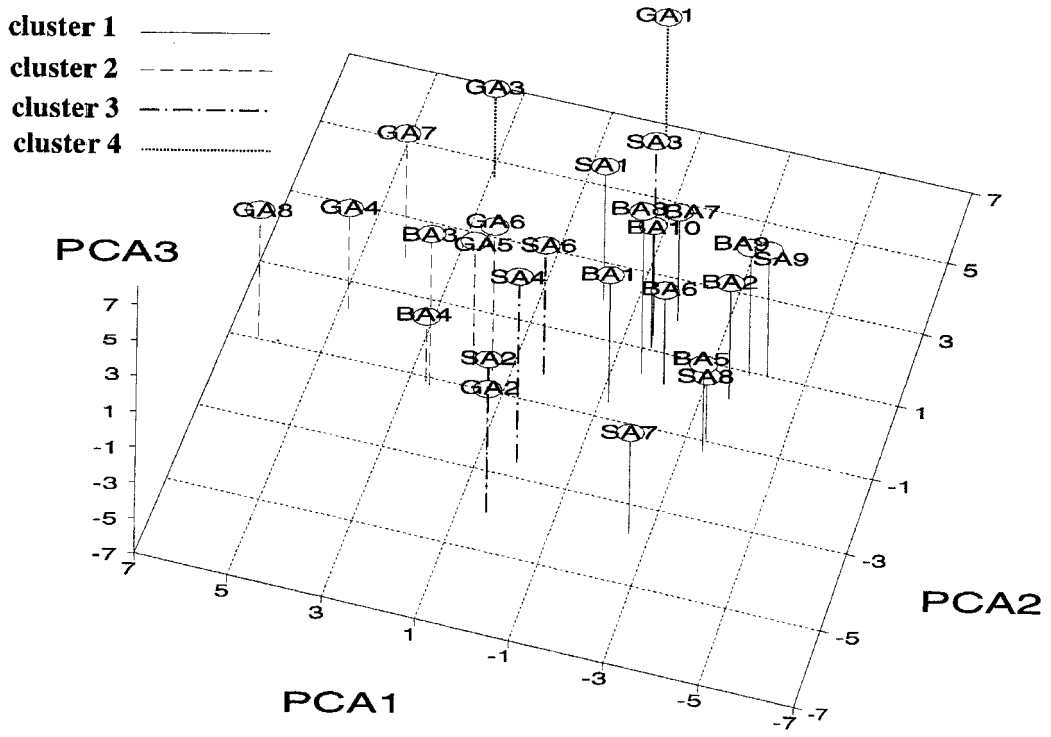

Fig. 1. Plot of the first three principal components for the 26 terebinth specimens.

Table 2. Main characters of clusters (average ± SD).

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Rachis length (mm)	93.0±16.80	120.4±26.03	108.7±24.39	113.1±30.30
1st leafl. length (mm)	37.9±7.59	51.4±11.24	37.8±7.59	48.6±7.88
2nd leafl. length (mm)	45.7±6.06	61.4±10.63	47.5±7.35	61.5±10.82
3rd leafl. length (mm)	47.6±5.96	62.9±10.14	51.3±5.83	59.6±8.93
Apical leafl. length (mm)	31.2±6.10	47.4±11.26	36.7±7.66	42.1±5.92
1st leafl. width (mm)	19.6±3.69	27.0±5.18	23.0±4.78	17.1±2.98
2nd leafl. width (mm)	20.7±2.51	29.2±5.14	24.9±4.64	20.1±3.28
3rd leafl. width (mm)	20.4±2.29	28.2±4.73	25.8±4.12	18.8±4.16
Apical leafl. width (mm)	16.1±3.21	25.8±7.32	21.9±4.55	16.5±2.64
1st leafl. l:w	1.9±0.24	1.9±0.27	1.7±0.36	2.8±0.14
2nd leafl. l:w	2.2±0.28	2.1±0.28	2.0±0.40	3.1±0.21
3rd leafl. l:w	2.3±0.33	2.2±0.26	2.0±0.32	3.3±0.70
Apical leafl. l:w	1.9±0.20	1.9±0.29	1.7±0.34	2.6±0.14
Stalk length (mm)	11.0±3.28	16.4±4.24	13.1±3.70	14.9±1.91
Fruit number	102.4±57.50	110.1±30.60	258±104.40	99.0±15.90

Moreover, three terebinth specimens from Serra Salentina, included in Cluster 1 and referred to as SA7, SA8 and SA9, showed a very small apical leaflet having maximum length and width of 20 mm and 15 mm, respectively. As the same character was found in other specimens (e.g. BA2, BA5, BA9 in the same cluster), although just in a few leaves but not on the entire tree, these accessions were probably not discriminated as an individual group.

Conclusion

In the light of these findings we can say that Apulian terebinth germplasm, investigated throughout its morphological features, seemed to show a phenotypic variability related with regional geographic subzones.

Among the assessed parameters, fillometric characters were more important than those related to infructescence and fruit traits in discriminating clusters.

Basically, terebinth trees from forests exhibited a higher vigour in their leaves. Specimens from the Mediterranean maquis in the middle of the region had small leaves. Among specimens from the south, the warmest area, some specimens showed a very small apical leaflet as a distinctive character, while others revealed a great fruiting capacity, though all seemed to have leaf size intermediate between the first two clusters.

Based on these results, the cluster mean values could be used as reference material to evaluate morphological characters of leaves in botanical descriptions of *P. terebinthus.* Moreover, this study has also suggested that germplasm-evaluating parameters such as those used in this investigation could be useful for characterizing other *Pistacia* species from other ecogeographical zones and eventually contributing to their better botanical identification.

References

Baldacci, O. 1966. Puglia. Unione Tipografica Editrice Torinese, Torino, Italy.

Fiori, A. 1969. Nuova Flora analitica d'Italia. Edagricole, Bologna, Italy.

MAF. 1976. Carta della montagna. 16 Puglia. Arti Grafiche Editoriali AGE,Urbino, Italy.

Pignatti, S. 1982. Flora d'Italia. Edagricole, Bologna, Italy.

Zohary, M. 1952. A monographic study of the genus *Pistacia.* Palestine J. Bot., Jerusalem Series 5(4):187-228.

Conservation strategies of *Pistacia* genetic resources in Greece

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Introduction

In Greece, four *Pistacia* species are recorded as occurring naturally, two other species being cultivated in orchards. Some additional species variation and a number of spontaneous or cultivated hybrids also exist.

Greece's location in the southeast of Europe, its vicinity to Asia Minor, its numerous islands dispersed in the Mediterranean Sea, its climatic and relief situation might explain the richness in the naturally occurring *Pistacia* species recorded here.

A systematic survey of this genetic variation has not yet been carried out in the country.

Species of the genus *Pistacia* indigenous to Greece

P. lentiscus L.

This species occurs throughout the country, from sea level to an elevation of about 600 m a.s.l. A variant of *P. lentiscus* named Chia or Mastichophora exists in the island of Chios. Another variant, named *P. lentiscus* var. *Latifolia*, is present in the island of Coss. According to Zohary (1952) this taxon is similar to the one present in Chios (Chia). Specimens of this taxon have been collected in the past by several authors in other localities: Mount Athos (by Ballolas), Salamis and Pore island (by Paulsen in 1908), Chios (by Orphanidis in 1956), Sporades (by Pallis in 1936) and in Crete (by Gandoger).

Pistacia terebinthus L.

This species occurs spontaneously throughout the country from sea level to about 750 m a.s.l. Botanists have recorded its distribution in Cephalonia, Chios and Crete.

Pistacia atlantica Desf. var. *latifolia* (syn. *P. mutica*)

This species grows in the Attica region and in the islands of Rhodos and Chios (among its synonyms is the name *P. chia* Desf.). Specimens have been gathered in the past in Athens (by Koroncas), in Chios (by Olivier in 1822) and in Rhodos (in 1923 by Fiori).

Pistacia palaestina Boiss.

This taxon is speculated to occur in mainland Greece and in the islands of Chios, Rhodos and Coss. The author tends to support the hypothesis of its occurrence mainly in the Peloponnesus and in the Attica Regions.

Tsikoudia

In the islands of Chios and Crete the author has found the presence of a taxon, locally called Tsikoudia, which according to the leaf morphology seems to be either a hybrid between *P. palaestina* x *P. terebinthus*, or just a variant of *P. palaestina*.

Use of *Pistacia* species in Greece

Pistacia lentiscus

This species is being cultivated in the island of Chios for extraction of the resin. The area planted with this tree is rather relevant.

Tsikoudia

Tsikoudia (Fig. 1) is being used as a source of rootstock for the cultivation of *P. vera.* In Greece this is the only source of rootstock material actually being used in orchards.

Pistacia vera

Female varieties: Today the only female variety grown in Greece is Aegina. In the past other selections have been used, such as Nichato, Foundoucato and Kinezaki.

Male varieties:

Selection C. this is the latest flowering selection material and also the most widespread type planted in orchards (about 80%)

Selection B. an earlier selection used in orchards along with the previous one (about 20%)

Selection A. this selection (Fig. 2) is probably not a true *P. vera* variety. It is likely to be a hybrid of *P. terebinthus* x *P. vera.* It is the earliest flowering selection. It is used in a small percentage in some orchards located in the south as well as in the islands of Aegina and Thira.

Fig. 1. Tsikoudia's leaflets and fruits.

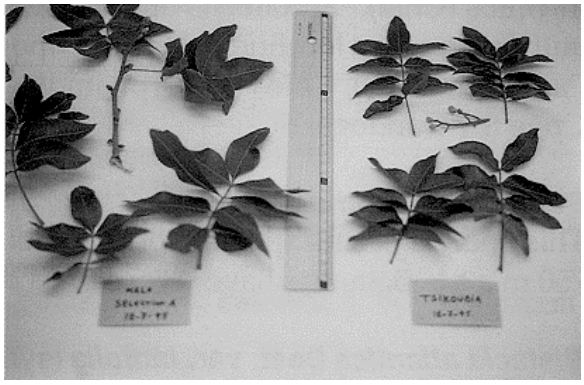

Fig. 2. Comparison of Tsikoudia and male Selection A leaflets.

Some elements regarding pistachio industry in Greece

Data referring to variety Aegina show that in the last 5 years in Greece the pistachio production has been, on average, close to 4600 tonnes.

Table 1 shows the figures referring to the production of pistachio nuts in the years 1986 to 1993 in Greece, accompanied by additional information on the extent of pistachio cultivation, yield, import, export and retailer's price in the same period.

Table 1. Information on production and marketing of pistachio nuts in Greece in the period 1986-93 (source: Hellenic Ministry of Agriculture).

Year	Area (ha)	Production (t)	Yield (kg/ha)	Imports (t)	Exports (t)	Retailer's price (drachmes/kg)
1986	3800	2300	605	0	200	515.9
1987	3900	4000	1026	500	0	589.6
1988	3500	2300	657	0	0	605.9
1989	3900	4900	1256	50	110	641.9
1990	4000	2600	650	700	50	891
1991	3700	5000	1351	1700	160	1026
1992	–	4400	–	1200	–	1003
1993	–	6300*	–	–	–	1000*

* approximate value.

The Prefectures of Ftiotida, Attika and Aegina grow more than 80% of the entire Greek pistachio production. In the last few years, an increase in production has occurred as a result of a parallel increase in the cultivated area devoted to this crop.

Aegina variety is known for the good quality of its nuts. These are green in colour and have a very good taste, although the weight (1 g)of the nuts (Fig. 3) is not very high. Figure 4 shows this variety.

In 1995 the price paid to the growers for pistachio nuts was around US$4/kg (for nuts in which the incidence of split shells (Fig. 5) was not less than 85-90%).

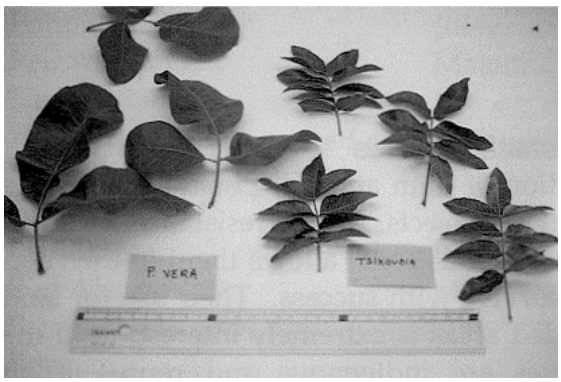

Fig. 3. Fresh fruits of cv. Aegina.

Fig. 4. Comparison of Tsikoudia and *P. vera* (female variety Aegina) leaflets.

Cultivation methods in Greek orchards

The ratio of male/female trees used in Greece is 1 to 8. The ratio, referring to the type of clones used, is 80% for the clone C and 20% for the clone B.

The trees are usually planted in plots spaced 7 m x 7 m, where they are trained in a vase shape with three to four branches. The training system seems to be suitable for the growth habit of the pistachio plant (Fig. 6).

The most common soil conditions in pistachio cultivations in the country are: 20-52% clay, 45-50% sandy, 20-45% calcium carbonate and pH 7.2-8.1.

Most pistachio cultivations (70%) have irrigation systems, usually of the drip irrigation type. Fertilization is also practised according to the need of the plants (in relation to plant age, soil conditions, production, etc.).

There have been cases of pollination problems in the past due to high humidity in the month of April, when the highest incidence of anthesis occur in this species.

The nuts are harvested from the end of August to the end of September. After harvest, they are washed and hulled through a single process. This is followed by drying, roasting and salting operations. At the end of these processes the nuts are ready for being commercialized.

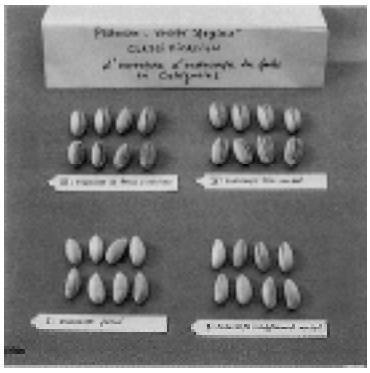

Fig. 5. Classification of dry fruits in four categories according to the splitting of their endocarp.

Fig. 6. Photo of a 12 year old tree of cv. Aegina on its over-production year.

Other uses of *Pistacia* species

Apart from nut production and the extraction of gum and oil, *Pistacia* species are very suitable candidates for soil conservation projects. Their resistance to harsh conditions (i.e. extremely dry and highly calcareous soils) allows them to thrive in areas where few other tree species would survive with success. Their use for land reclamation and for afforestation of degraded areas is extremely interesting in the Mediterranean region, where these species are indigenous and represent an important component of the local maquis.

Germplasm conservation strategies in Greece

A major constraint for carrying out proper conservation of *Pistacia* germplasm in Greece is the lack of adequate financial support. Despite this obstacle, however, a number of research institutions, including universities, have tried to contribute in some way to the preservation of this valuable indigenous germplasm. A summary of steps taken in this regard is listed below:

- establishment of a small germplasm collection at the Faculty of Agriculture, University of Athens. This is the oldest *Pistacia* collection in the country
- establishment of two small collections, one located at the ARS in Rhodos and the other at the Pomology Institute, Naoussa
- establishment of two germplasm collections meant for carrying out the evaluation of *P. vera* material as well as wild species used as rootstock. The collections, created at the ARS of Vardates, are also the most recent. The first material to constitute this collection was introduced in 1990 (some 20 varieties, 5 males and 15 females) and grafted on Tsikoudia rootstocks (Table 2). Subsequently an additional 14 accessions (11 females and 3 males) were introduced and grafted on *P. integerrima* rootstocks (Table 2). On the margins of this collection field three female selections (clones) of Aegina have been planted, along with other several female varieties of *P. vera* and eight young trees of *P. integerrima.* This collection was established thanks to financial support received from the European Union, through a number of research projects.

Table 2. ARS germplasm collection: male and female varieties.

Female		Male
1990 acquisitions grafted on *T. terebinthus* var. Tsikoudia		
Aegina	Sefedex	B- Selection
Ajamy	Capuccia	C- Selection
Cerasola	Bianca	Peters
Keeman	Bronte	Chico
Momtaz	Ohadi	Macho-502
Pontikis	Joley	
Red Aleppo	Mateur	
Sfax		
1994 acquisitions grafted on *P. integerrima*		
Aegina	Joley	Peters
Larnaka	Cerasola	Macho-502
Bianca Regina	Bianca	C- Selection
Red Aleppo	Mateur	
Bronte	Sfax	
Kerman		

Conclusions

In consideration of the danger of genetic erosion being faced by *Pistacia* species in Greece, the author wishes to stress that there is an urgent need for strengthening conservation activities on these species in the country.

The safeguarding of the genetic diversity of wild and cultivated material of pistachio represents an important action relevant not only for the scientific community, but also for the economy of Greece as well as other nations. Through a well-planned conservation strategy we will ensure for future generations the availability of precious material, like the Aegina variety, which has made such a significant contribution so far to the agricultural economy of this country.

Reference

Zohary, M. 1952. A monographic study of the genus *Pistacia*. Palestine J. Bot., Jerusalem Series 5(4):187-228.

Natural occurrence, conservation and uses of *Pistacia* species in Spain

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Abstract

There are three *Pistacia* species native to Spain—*P. atlantica* Desf., *P. lentiscus* L. and *P. terebinthus* L.—and the hybrid *P.* x *saportae* Burnat (*P. lentiscus* x *P. terebinthus*), which occurs where the latter two species grow close together. Two species, *P. lentiscus* and *P. terebinthus* are widely distributed in most parts of Spain and only *P. atlantica* seems to be partially endangered due to its very limited distribution in the Canary Islands. The main *Pistacia* genebank of Spain and one of the largest of the Mediterranean Region is at IRTA Mas Bové in Reus (Tarragona). This genebank holds some 75 *P. vera* L. cultivars and a number of accessions of different origin for each of the 5 following species*: P. atlantica, P. integerrima* Stewart, *P. khinjuk* Stocks, *P. palaestina* Boiss. and *P. terebinthus*. There are around 600 ha of commercial pistachio growing in Spain and good prospects for its development.

Introduction

The genus *Pistacia* belongs to the heterogeneous family Anacardiaceae and includes at least 11 tree and shrub species thoroughly described by Zohary (1952). Some species play an important role in the vegetation of the Mediterranean and Asian Regions. There are also two species of American origin included in the genus. Most species can be used as rootstocks for top-working with the cultivated pistachio (*P. vera*). This tree produces large and dehiscent nuts and is the only commercially grown species of the genus.

This genus comprises dioecious trees or shrubs which are resinous and mostly hardy. Leaves are deciduous or persistent, paripinnate or imparipinnate. Flowers are minute and unisexual, appearing in axillary panicles. Pollination is anemophilous. Most *Pistacia* species intercross freely, forming interspecific hybrids, since there are no evident physiological or genetic barriers. The fruit is a drupe.

The pistachio tree was first introduced in Spain from Asia by the Romans. The crop was developed during the Middle Ages and later disappeared for unknown reasons. This crop was reintroduced in the early 1980s and some 600 ha of young orchards are currently planted, in both dry and drip-irrigated conditions, mainly in Catalonia, Andalusia, Extremadura, Castile-La Mancha and Aragon regions.

In the Iberian Peninsula and the Balearic and Canary Islands, the three *Pistacia* native species reported are: *P. atlantica* Desf., *P. terebinthus* L. and *P. lentiscus* L. Also the spontaneous hybrid *P.* x *saportae* Burnat *(P. lentiscus* x *P. terebinthus*) appears in some places. The three species are sclerophyllous, showing xeromorphic characteristics such as the ability to endure severe water stress. *Pistacia atlantica* and *P. terebinthus* are deciduous species, *P. lentiscus* is evergreen and *P.* x *saportae* is semideciduous.

Geographic distribution

The geographic distribution of the three *Pistacia* species native of Spain is given in Table 1. The interspecific hybrid *P.* x *saportae (P. lentiscus* x *P. terebinthus*) occurs only in places where both species thrive together.

Table 1. Geographic distribution of the three *Pistacia* species native to Spain.

Species	Iberian Peninsula	Balearic Islands	Canary Islands
P. atlantica			x
P. lentiscus	x	x	x
P. terebinthus	x	x	

Pistacia atlantica appears in isolated groups of trees only in the Canary Islands, mainly in the western islands of Tenerife, Gomera and La Palma, but also in the eastern Fuerteventura. It ranges from sea level up to 600 m a.s.l., usually in northern exposures. It is more often found in ravines and near settlements. It was more common some years ago (Ceballos and Ortuño 1976).

Pistacia lentiscus appears as wild bushes mainly on the Mediterranean shores and in the southern areas of the Iberian Peninsula from sea level up to 1000 m a.s.l. It is widespread in Andalusia and Extremadura and rare in Castile-León, Navarra, Euskadi and Galicia. In the Balearic Islands it is common in most major islands in which evergreen bushes are frequently dominated by this species. In the Canary Islands it has been reported in Gran Canaria, Tenerife, Lanzarote and Fuerteventura. It is not hardy and is absent in Continental places with severe frost. It shows no soil preference and thrives well in dry and poor soils (Ceballos and Ruiz de la Torre 1979; López 1982).

Pistacia terebinthus appears in isolated areas, forming patches in most of the Iberian Peninsula, mainly in the southern part but reaching the Pyrenees and Galicia in the north. However in some hilly areas of Avila, Sierra Morena range and Sierra Mágina (Jaén) there are dense patches (Mesa and Delgado 1995). It also occurs in the island of Majorca and has not been described in the Canary Islands. It thrives from sea level up to 1500 m. It appears more often on calcareous and rocky soils (Ceballos and Ruiz de la Torre 1979; López 1982).

Conservation and uses

The Spanish *Pistacia* germplasm bank is held at IRTA Mas Bové in Reus (Tarragona), in the northeast of Spain, and occupies more than 1 ha. The first accession was introduced in 1976. Currently the genebank holds germplasm material belonging to six species: *P. atlantica*, *P. integerrima* Stewart, *P. khinjuk* Stocks, *P. palaestina* Boiss., *P. terebinthus* and *P. vera*. The *P. vera* collection comprises 46 female and 29 male cultivars from the most important producing countries and represents a good sample of the existing genetic variability within the cultivated pistachio, as probably less than 100 cultivars have been described worldwide (Maggs 1973).

There are also over 2000 *P. vera* seedlings from the breeding programme under evaluation (Vargas *et al.* 1993). The five wild species tree groups of the same taxon are planted together in isolated plots to prevent hybridization. The material has been documented and part of it has been isoenzymatically characterized (Rovira *et al.* 1994; Vargas *et al.* 1994). IRTA's wild and cultivated *Pistacia* genebank (Table 2) is probably the largest in the Mediterranean Region and it has been used to provide

P. vera cultivars and wild species to a large number of institutions of several countries (graftwood or seed material). There are also two smaller pistachio living collections in Spain, namely the SIA's in Zaragoza and the CMA's in Ciudad Real.

Table 2. *Pistacia* species held at IRTA Mas Bové genebank.

Species	No. of trees	Origin
P. atlantica *	65	USA and Syria
P. integerrima *	35	USA
P. khinjuk	33	Turkey
P. palaestina *	32	Greece, Syria and USA
P. terebinthus	54	Greece and Spain
P. vera cultivars	75	13 different countries
P. vera seedlings	> 2,000	IRTA breeding programme

* Some are hybrids

The three *Pistacia* native species play an important role in the vegetation of extensive areas of Spain.

Pistacia atlantica appears only and scarcely represented in the vegetation of the Canary Islands. There are still some isolated trees located in dry and low lands, mainly in northern exposures of the islands of Tenerife and Gomera (Ceballos and Ortuño 1976) and they also thrive in some desert places like Bentacuría in the island of Fuerteventura. The seeds mature in June (E. González, pers. comm.). The overexploitation of its wood and resin have put this taxon under threat of disappearance.

Pistacia lentiscus occurs together with some other important evergreen sclerophyllous species of the Mediterranean vegetation like carob (*Ceratonia siliqua* L.), olive (*Olea europaea* var. *sylvestris* Brot.) and holly oak (*Quercus coccifera* L.) mainly in the coastal maquis. It is well represented in wide areas and shows no conservation drawbacks.

Pistacia terebinthus usually thrives as an isolated tree although it also forms patches in some hilly areas in Sierra Mágina (Jaén) where about 1000 ha are covered with this bushy tree (Mesa and Delgado 1995). It is not an endangered species in Spain.

In Spain, there are wide zones suitable for pistachio production and large vineyard areas which have to be reconverted. There was small demand for pistachio nuts and also little interest in the potential of this underutilized crop until the early 1980s. Today Spain is a big importer—over 12 000 t of in-shell nuts per year—and thus there are good market possibilities due to high consumer appeal. In addition, there is sufficient production information, technology and easy adaptability of harvesters from other nut crops and olive which make pistachio expansion in Spain feasible. Propagation technology has been successfully applied and suitable nursery trees are now available.

The potential use of some of the *Pistacia* species native to Spain, particularly *P. atlantica*, in the afforestation of wide arid areas seems promising as they show outstanding features like high vigour, upright habit and healthiness in our collection (450 mm of annual rainfall). There are also foreign species like *P. palaestina* and *P. integerrima* and some interspecific hybrids which also show good promise. The trees of *P. khinjuk* are still too young to make any remark.

In some Mediterranean countries the increasing need, due to land aridization, to protect soil against erosion makes such drought-resistant plants most useful. Thus collection and selection of our native *Pistacia* genetic resources is necessary for their use both as rootstock and for planting to prevent soil erosion. At the same time it is also important to maintain and preserve the genetic variation existing in the wild species.

In Spain, some native *Pistacia* species have only recently been introduced in xerogardening and as ornamental trees. The use of leaves, bark, wood, resin, mastic and turpentine in medicine, carpentry, the varnish industry or as fuel had some importance a few years ago.

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References

Ceballos L. y F. Ortuño. 1976. Estudio sobre la vegetación y flora forestal de las Canarias Occidentales. Excmo. Cabildo Insular, Santa Cruz de Tenerife p 354.

Ceballos, L. y J. Ruiz de la Torre. 1979. Arboles y arbustos de la España Peninsular: 344-347.

López, G. 1982. Guía de INCAFO de los árboles y arbustos de la Península Ibérica: 712-717.

Maggs, D.H. 1973. Genetic resources in pistachio. FAO Plant Genet. Resour. Newsl. 29:7-15.

Mesa, S. y A.B. Delgado. 1995. Los cornicabrales y la cultura pastoril. *Quercus* 112: 8-10.

Rovira, M., I. Batlle, M. Romero and F.J. Vargas. 1994. Isoenzymic identification of *Pistacia* species. I International Symposium on Pistachio Nut. ISHS-FAO, Adana (Turkey). Acta Horticulturae (in press).

Vargas, F.J., M. Romero, M. Rovira and I. Batlle. 1993. Pistachio cultivar improvement at IRTA-Mas Bové. IX GREMPA Meeting Pistachio, May 1993. Sciacca (Agrigento), Italy (in press).

Vargas, F.J., M. Romero, J. Plana, M. Rovira and I. Batlle. 1994. Characterization and behaviour of pistachio cultivars in Catalonia (Spain). I International Symposium on Pistachio Nut. ISHS-FAO, Adana (Turkey). Acta Hort. (in press).

Zohary, M. 1952. A monographic study of the genus *Pistacia*. Palestine J. Bot., Jerusalem PSeries 5(4): 187-228.

Genetic diversity and germplasm conservation of *Pistacia* species in Turkey

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Introduction

Anatolia is a major centre of diversity for the genus *Pistacia*. Its species are naturally distributed throghout the country, with the exception of very cold and humid areas. *Pistacia* is present in the form of bushes or trees in different plant sizes that differ due to genetic factors, soil types and the climatic conditions that characterize the region. In the Mediterranean and Aegean region, *P. atlantica* trees reach gigantic dimensions. In the transitional zone between the Mediterranean and central Anatolia where the rainfall is less, a gradual reduction in height of these trees is observed. In fact, *P. terebinthus*, which grows in the form of relatively big bushes in the Mediterranean region, has reduced its plant size in southeast Anatolia. Because of its wide adaptability to a variety of soils and climate, *P. terebinthus* thrives well from the coastal zone at sea level to up 2000 m a.s.l. into the mainland, this taxon being the most widespread among all *Pistacia* species (Kaska and Bilgen 1992).

In addition to the abovementioned species, there are also some less distributed taxa such as *P. mutica, P. lentiscus* and *P. palaestina*. *Pistacia* species in their natural habitat show hybrid constitution due to the free pollination which clearly enhances the genetic diversity of the genus in the country.

Pistacia richness in Anatolia

Several *Pistacia* species occur in various parts of Anatolia. From the viewpoint of species richness, southeast Anatolia ranks first in Turkey and is followed by the Mediterranean and the Aegean regions. In these two areas the number of trees is not particularly high, but the degree of species richness is relevant. Woods made of *Pistacia* stands are on the other hand present in the transitional zone between the Mediterranean and central Anatolia where suitable valleys represent an ideal habitat for these species. A similar situation can be observed in southeast Anatolia, where rainfall is higher and the more favourable environmental conditions have determined the establishment of a much higher number of trees than in any other place in the country (Kaska 1990). Severe anthropogenic pressures (fires, unsustainable exploitation of the timber for fuel and unregulated forest clearance for cropping purposes) are reported to occur more and more in this area, thus posing a serious risk to the conservation of the genetic diversity of *Pistacia* forests in this part of Turkey.

These facts indicate that the level of genetic erosion on *Pistacia* is becoming increasingly higher, and it would not be too alarmist to state that these species may soon be close to extinction if no adequate steps are taken for halting their unsustainable exploitation, along with measures for ensuring their proper conservation. It would not help to say that the threat to these species is not so high because they are not timber trees; in fact if this were the case, we would not have had any of them today in our forests at all!

In the area of research investigation, it is important to focus on the identification of hybrid forms within the genus, as the potential application in horticultural practices of these taxa is relevant. Direct utilization of wild species like *P. atlantica* and *P. khinjuk* is also very important for the management of pistachio orchards.

It is in the light of these facts, the presence of genetic erosion and the need for a wider source of *Pistacia* germplasm for the improvement of the cultigen, that germplasm surveys and conservation activities on these species are highly recommended.

Southeast Anatolia

In the southernmost province of Anatolia, *P. khinjuk* grows in the form of big trees that may exceed 20 m in height and 2 m in trunk diameter. In this region, some magnificent trees of *P. khinjuk* with an estimated age of 400-500 years have been recorded to be still thriving today. That these trees have survived anthropogenic pressure for so long is largely due to the respect of the locals who regard them as holy plants. These trees grow in Siirt locality at altitudes of about 900 m a.s.l. They are found mainly in valleys and on slopes of hills. All of them have originated from seedlings, and therefore their genetic structure differs from one plant to another.

In the areas surrounding where these old trees are found, there are also some relatively younger specimens, which belong to two categories of khinjuk, i.e. large-fruited and small-fruited types (Kafkas 1995). Large khinjuks have a high oil content, and they are thus popularly called 'fatty' khinjuks. Their shells are softer than those harvested from smaller types. The yield of large khinjuk trees is high and since the price of the nuts is also higher than the price of smaller khinjuks' nuts, farmers top-work smaller khinjuk trees with fatty khinjuks.

In 1980, in the framework of a famous project carried out in this area, thousands of *P. khinjuk* trees were top-worked with cultivated pistachio varieties. This project has now been halted, and the objective pursued by the farmers is rather the opposite: since farmers are very happy with the yield and price of the large khinjuks plants, they re-topwork pistachio trees back to fatty khinjuks.

The value of its oil is also high; this is used to make soap, whose price is higher than that made with olive oil. Furthermore, green kernels of *P. khinjuk* are used in the confectionary industry for flavouring ice-creams and pastries. A big specimen of a fatty khinjuk tree has an average yield of 150 kg, but when top-worked with a Siirt cultivar this can produce up to about 200 kg of pistachio nuts.

Pistacia species, trees or shrubs, do not form dense populations in Mardin and Diyarbakir Provinces, except for Sanliurfa locality where *P. terebinthus* is very common (particularly in the hills of Tek-tek). Two other areas where bushes of this taxon are also common are Kahramanmaras and Adiyaman Provinces. Most of these trees have been, however, top-budded with Uzun and Kirmizi pistachio varieties.

Gaziantep and Saliurfa are the main pistachio cultivation areas in Turkey. Seedlings of *P. vera*, *P. khinjuk* and *P. terebinthus* can be found occasionally in these zones along with the cultivated trees.

Mediterranean region

Apart from the southeast Anatolia region which is the traditional pistachio production area of the country, wild pistachio trees are found abundantly throughout the Mediterranean region. In Turkey this region consists of two major zones, one running along the coastal strip and the other in the mountainous zone of the Thaurus Chain, both lying parallel to the sea (Çaglar and Kaska 1994).

One may come across large *P. atlantica* specimens along the coast, but small trees of *P. terebinthus* growing as bushes are actually those plants that are most commonly found in this region.

In Icel Province, *P. terebinthus* is the most widespread species. Its presence here is estimated to be about 12 million plants, of which 60% are located in forest, and the remainder scattered in other places. In this regard it must be added that the frequency of occurrence of *P. terebinthus* trees differs a lot from one zone to another; while growing abundantly in some lands, it is quite scarce in others. The irregular trend in the distribution of this taxon might be explained by the cutting of the forest for timber and in the clearing made by farmers for the reclamation of new lands for agricultural purposes. These acts have led to the establishment of trees mainly along roadsides or field boundaries. For the same reason it is also understandable why they are also present as dense populations, particularly in slopes and mountainous sites (Çaglar and Kaska 1994).

Wild pistachio taxa are mainly used as rootstock material for *P. vera*. An important economic exploitation of these trees is being practised in Icel Province. For the last two decades *P. terebinthus* trees have been appreciated as rootstock material by upland farmers, who, individually or with support from local Agricultural Services, have been top-budding them in large number. It is estimated that 600 000 plants have been top-budded so far, while some 200 000 buddings are being performed each year. The pistachio nuts produced in upland areas are particularly appreciated by the processing industry because of their greenish kernels.

It is well understood that chilling requirements of *P. vera* limit the cultivation of this crop in the region. Pistachio female cultivars in Turkey need 600-900 chilling hours below 7°C (Küden *et al.* 1994). This means that *P. terebinthus* trees in the coastal strip zone or on the slopes facing south in lower altitudes under mild winter temperature do not attract the interest of farmers for top-budding operations, unless "rest-breaking" measures are taken to compensate for the lack of chilling hours. As an example of the unsuitability of this climate for growing pistachio, it has been observed that female *P. vera* trees here often produce incompletely developed leaflets, including one-leaflet leaves (a rather uncommon phenomenon in the genus). It is interesting to add that these symptoms of leaf morphology alteration are not found at higher altitudes, where the mentioned cold requirements for the plant can be met. We estimate that the critical altitude that marks the boundary of the pistachio cultivations should not be lower than 200 m a.s.l. The same value marks the limit of cultivation for *Citrus* species which, on the contrary, are damaged by low temperatures if they are grown at higher altitudes.

Sloping sites facing north and open to the wind can be considered suitable for the cultivation of pistachio.

Senir, Nur and Imambekirli localities of the Icel Province, located between 300 and 600 m a.s.l., have become important centres for pistachio production. Roughly 400 t of pistachio nuts are being produced in this relatively small area, even though the top-budded trees used here are irregularly spaced. Open spaces among trees are usually filled with container-grown pistachio seedlings which are chip-budded *in situ*.

The exploitation of wild pistachios does play an important role for the poor farmers of the mountainous region, increasing their revenues thanks to the earnings from the selling of the nuts. This has created an artificial competition between pistachio growers and the traditional type of livelihood based on incomes from goat-breeding activities.

Because of the increasing interest in pistachio cultivation in this zone, some research investigations have been carried out through a joint initiative of the Horticultural Research Institute and the Horticultural department of the Agricultural Faculty of Çukurova University aiming at improving the cultivation techniques adopted here. So far, these studies have been successfull in changing the early summer 1-month traditional pistachio top-budding period in favour of chip-budding methods lasting up to 6 months. Also, the use of supplemental pollen collected from *P. terebinthus* trees has improved fruit set and filled-nut percentages in the orchards. Siirt cultivar, the best Turkish pistachio cultivar, was also found to be the most suitable type for this region. Further research including drip irrigation is needed for promoting rapid growth of the pistachio trees.

Mediterranean–central Anatolia transitional zone

In the transitional zone between the Mediterranean and central Anatolia, wild pistachios are concentrated in Karaman, Ermenek and Mut areas. In these zones, the most common species is *P. terebinthus*, followed by *P. atlantica.* Here and there, *P. khinjuk*, *P. mutica* and some hybrid trees can be found occasionally. Twenty to 30 years ago, farmers used to harvest the nuts of *P. atlantica* and extract the oil.

In Karaman, at 1020 m a.s.l., *P. terebinthus* becomes more common than *P. atlantica*, which grows up to 500 m a.s.l. as sporadic, old and big plants. The nuts of *P. therebinthus* are consumed fresh because of their softness and easy harvest. The top-working operations are neglected.

Ermenek, situated at 1200 m a.s.l., is particularly rich in *P. atlantica* trees, which form woods here. Top-working of these trees has been unsuccessful owing to a wrong selection of male trees. On the other hand, the inadequate satisfaction of heat requirements received by the trees in this zone leads to shriveling of the nuts.

Aegean region

In this region, the most common taxon is *P. atlantica.* It can be found especially in Manisa, Yunt mountain area (around 200 m a.s.l.), and to lesser extents in Aydin and Mugla where 400-500 year old *P. atlantica* trees are found. Young trees are top-worked through a local budding method which is quite successful (90% bud take) but rather difficult.

Despite the medium size of the nuts, the economical return to farmers is rather good. A major problem is the incidence of empty nuts, caused by insufficient pollination. This has been overcome recently by artificial pollination. Very big trees of *P. atlantica* are still recorded in this area, although forest fires occurring regularly in summer pose a serious threat to their survival.

In Aydin locality, *P. atlantica* trees can be seen bordering orchards or in cemeteries. Very few of these specimens have been top-worked, whereas in Mugla and Balikesir localities, in addition to the top-working of this species and *P. terebinthus* bushes, some nurseries are being maintained.

Along the coastal line of Izmir, local stands of *P. lentiscus* are being exploited for the extraction of gum, and preserved at the same time as ornamental trees. In this province, *P. terebinthus* and *P. atlantica* are present in large numbers. Some of these trees have been top-worked but the success rate of these operations is low.

Marmara region

The indigenous populations of *P. atlantica* have been top-worked for many years, though with scant success. On the European side of Istanbul there is a forest of *P.*

atlantica. Until today this area has been properly preserved. No study has been conducted on the trees growing here.

Transitional zone between central Anatolia and Black Sea regions

In this zone, the Amasya Province is important for the presence of a good number of wild *P. atlantica* trees. These trees seem not to be affected by the rather low temperatures occurring here. There have been attempts to top-work these trees but the results seem to be not satisfactory (Odabas *et al.* 1990).

Conclusions

Anatolia, together with Iran, is the richest source of *Pistacia* genetic diversity in the world. In Turkey, it is estimated that the number of wild *Pistacia* trees is around 66 million. A few million of these trees have been top-worked in different parts of the country, but the majority are still standing untouched.

A number of studies (based mainly on leaf morphology) have been made in the past to ascertain their taxonomic position and investigate their differentiation; however, these old descriptions no longer agree with present findings and pose serious problems of interpretation. Therefore, detailed work, supported by modern and more reliable methods of investigation, on this interesting source of genetic variation is very much needed. It is recommended that such work should not neglect hybrid forms, scarcely studied in the past.

Because of fires, cutting for wood, road and building constructions, these very valuable trees are in danger of disappearing forever. Top priority should be given to surveying these populations, identifying the taxa and establishing safe field germplasm collections for conserving this diversity.

Pistacia do not represent only the rootstock material for cultivated pistachio, they can be employed in fact as excellent material for afforestation programmes in areas affected by drought problems or characterized by high salinity, where very few other Mediterranean species can compete in terms of resistance.

We would like to end this exposition by stressing once more the need for a common action among all Mediterranean countries for the proper survey, identification, selection, collecting and most of all preservation of these important and valuable species.

References

Çaglar, S. and N. Kaska. 1994. Top-budding of *Pistacia terebinthus* L. rootstocks in the Mediterranean region of Turkey. I Intern. Symposium on Pistachio Nut, Adana, Turkey (in press)

Kafkas, S. 1995. Possibilities of using *P. atlantica* Desf. and *P. khinjuk* stock types as rootstocks. MSc Thesis, Faculty of Agriculture, University of Çukurova, Adana, Turkey

Kaska, N. 1990. Pistachio research and development in the Near East, North Africa and Southern Europe. Nut Production and Industry in Europe, Near East and North Africa. REUR Technical Series 13. FAO 133-160, FAO, Rome, Italy

Kaska, N. and A.M. Bilgen. 1992. Top-working of wild pistachios in Turkey. Pp. 317-325 *in* 7e Colloque du GREMPA (Groupe de recherche et d'Etude Mediterranee Pour le Pistachier et l'Amandier) (C. Grassely, ed.). Report Eur, 11557.

Küden, A.B., N. Kaska, E. Tanriver, B.E. Ak and H. Tekin. 1994. Determining the chilling requirements and growing degree hours of some pistachio nut cultivars and regions. Firts Intern. Symposium on Pistachio Nut, Adana, Turkey (in press)

Odabas, F., S. Kurnaz, N. Kopuzoglu, F. Soyugur and M. Kocabas. 1990. Growing possibilities of pistachio in Amasya [in Turkish with English summary]. Türkiye 1. Antepfstigi Simpozyumu, Gaziantep:248-255.

Distribution, use and conservation of pistachio in Iran

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Introduction

The name of *Pistacia* derives from the Persian name 'pisteh' or 'pesteh'. Existing documents show that pistachio (*Pistacia vera* L.) has been cultivated since 3000-4000 years ago in Iran and was introduced into Mediterranean Europe at approximately the beginning of the Christian Era (Crane 1978). Pistachio cultivation plays an important role in the agricultural economy of arid and semi-arid countries such as Iran, a country which leads the world in the production of these nuts. Other major producers are Turkey, USA, Syria, Greece, Italy and more recently Australia.

Three out of 11 species occur naturally in Iran: *P. vera, P. mutica* and *P. khinjuk.*

This paper provides a brief botanical introduction to each of these species along with a description of their habitat, distribution, utilization and conservation in Iran.

Distribution

Pistacia vera

The pistachio tree (*P. vera*) originates from central Asia between the borders of Afghanistan, the former USSR and northeast Iran (Fig. 1). In northeast Iran it occupies an area of some 20 000 ha, including the Sarakhs pistachio forest, Khajeh Kalat and Shoricheh, which are its main growing regions. In Iran, pistachio trees grow within a range of 700-3000 m a.s.l. The tree can tolerate temperatures between –20 and +45^{0}C. In summer, the relative humidity (RH) level is more suitable for fruit production of this plant when it is lower than 35%.

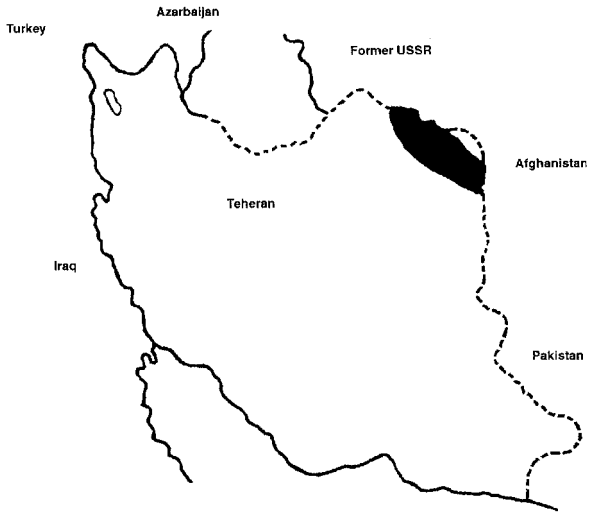

Fig. 1. *Pistacia vera* distribution: northeast Iran (Khorasan, Afghanistan, Turkmenistan).

The plant is dioecious and the male flower appears as a spike or cluster. Each flower lacks petals but is surrounded by five sepals having five short anthers (Tabatabaee 1966). Usually female flowers appear several days after the male ones, and the ovary bears 4-5 greenish stigmas, which are pink just before and brown after fertilization.

The fruits grow rapidly and are mature after a period of about 140-150 days from fertilization.

Fruit shape is often described as almond or hazel nut-like, owing to the shapes of the nuts of the different varieties. The husk is green when immature and cream, red, violet, or dark green according to the cultivar upon ripening (Sheibani 1987). The fruit kernels are dicotyledonous, coloured light brown or pale green.

The tree has a pinnately compound leaf. The main roots grow vertically through the soil to 2-6 m or more in depth, which allows the plant to absorb water deep in the soil during periods of drought, thus favouring its surviving in extremely dry conditions. The soil of pistachio-growing areas in Iran is of two main types: Aridisols and Entisols. The water permeability of the soil is high and the level of underground water is very low. Lands are flat to moderately sloped.

Pistacia mutica

This is a wild species indigenous to Iran, growing along with almond, oak, and other forest trees common to most Alpine regions (Zohary 1952; Tabatabaee 1966). It occupies an area of some 2.5-3.0 million hectares in many parts of Iran. It has been selected as a stock resistant to root-knot nematodes (Sheibani 1987). Its leaves are divided into 5-7 leaflets. Flowers bloom earlier than those of *P. vera*, the female ones beginning to produce fruits in 17 to 18-year-old trees (Sheibani 1987). According to Zohary (1952), Rechinger (1969) and Sabeti (1976) *P. mutica* corresponds to *P. atlantica* or is a subspecies of this taxon, which is distributed in the Mediterranean regions, Middle East and central Asia. In Iran three subspecies are recognized for this taxon. They occur in forests of semi-desert areas, in localities such as Fars, Kerman, Baluchestan, Khorasan, the foothills of Alborz mountains extending to Alemoth, Azarbaeejan, Kordestan, Kermanshah, and Lurestan regions, at altitudes between 600 and 3000 m a.s.l. (Fig. 2a, 2b, 2c).

Pistacia khinjuk

This is another species indigenous to Iran, growing along with *P. mutica* in Alpine areas, foothills, lower altitudes and warmer areas as well (Fig. 2d). It may form forests or grow in solitary stands. Fruits are egg-shaped, smaller than those of *P. mutica*. Leaves have 1-3 heart-shaped leaflets. According to Tabatabaee (1966), three subspecies or varieties are recognized in this species:

(i) var. *heterophylla* Bornm. distributed in Joypar mountains, Kerman Province and having 3 leaflets
(ii) var. *populifolia* Boiss. growing in Alpine Joypar areas and having leaves with 1-5 leaflets
(iii) var. *oblonga* Bornm. which grows in Kordestan area in northwest Iran; this variety has 5-7 leaflets.

Cultivation and utilization

Kerman province, especially the Rafsanian Region, in southeast Iran, is the main pistachio production area, and also the largest in the world with more than 210 000 ha devoted to the cultivation of this crop. Pistachio cultivation is supposed to have started in Kerman when pistachio seeds or seedlings were brought from Khorasan province during the period of the Safavi Kingdom (17th-18th centuries). However, it was only about 50 years ago that pistachio cultivation started playing an important role in the agricultural economy of Iran. Since then, the importance of this nut has grown steadily, while at the same time groves and orchards in Iran increased in number and areas.

The importance of Kerman in pistachio cultivation is also due to the fact that here is concentrated the largest number of varieties of this crop bearing typical characteristics, if compared with other areas of Iran or any other country in the world. Furthermore, it has to be stressed that the possibility of having these varieties recognizable through a number of characters relevant for their research, breeding and utilization has a strong positive impact on their economic value.

Fig. 2. Distribution of: **a.** *P. atlantica* (syn. of *P. mutica*, subsp. *cabulica*): Kohkilioviyeh, Kerman and Beluchestan; **b.** *P. atlantica* subsp. *kurdica*: many parts of Iran (from Turkish border) and Iraq, to Beluchestan and Iran-Pakistan border; **c.** *P. atlantica* Desf. subsp. *mutica*: borders of Azarbajan and Iran, Turkey, Iraq, Kurdestan, Kermanshah, Lurestan, Arak, Fars, Khorasan, Kerman, Yazd, south foothills of Alborz (Karaj, Alemut and Rudbar) and in Baluchestan, border of Pakistan; **d.** *P. khinjuk*: Kordestan, Kermanshah, Lorestan, Khuzestan, Fars, Kerman, Jiroft, Baluchestan and Sistan, Khorasan and near Yazd.

Cultivars of *Pistacia vera*

The pistachio industry in various countries is based on a limited number of cultivars, each with specific characters. Iran is the country with the largest number of varieties in the world. Standard characteristics for pistachio nuts which are considered most important in Iran are: percentage of shell splitting, fruit shape (Fig. 3), size of nut, kernel free from insects and aflatoxins from fungal attacks.

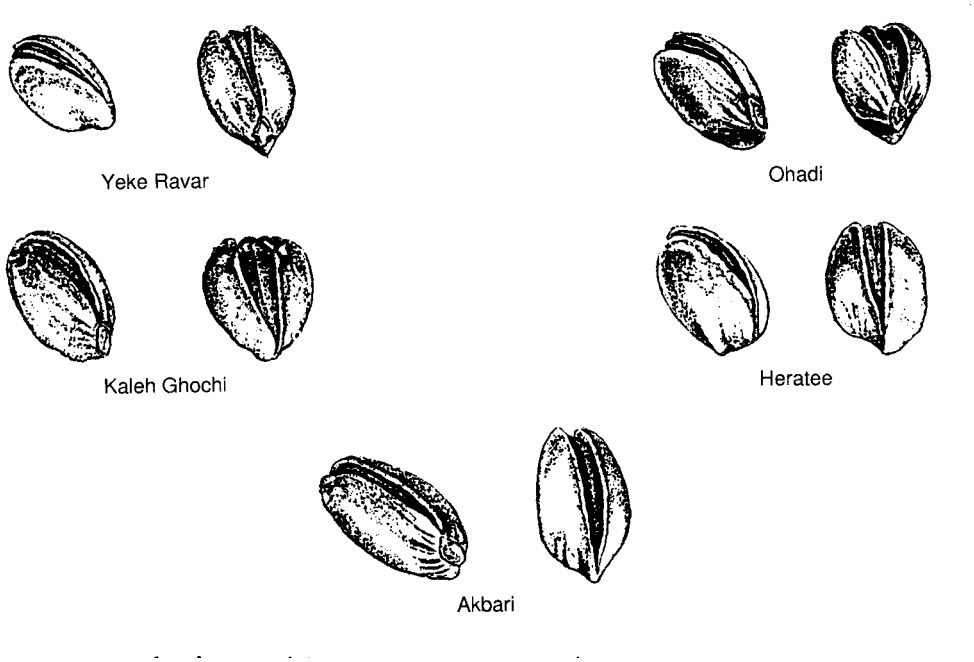

Fig. 3. Kernels of some pistachio varieties from Iran.

The described pistachio cultivars in Iran are indeed very numerous, with characteristics determined for more than 60 named varieties. The most important varieties, which have been described at the Pistachio Experimental Station of Rafsanjan, are as follows (Sheibani 1987):

- Ghazvin (also known as "almond type rootstock"). This cultivar is the most widely used rootstock, onto which more than 95% of all commercially grown cultivars are grafted in Kerman. It originated in the Ghazvin area in north-central Iran, where its full name is Ghazvin Kaleh Pazi.
- Ohady. This is an important cultivar suitable for cultivation in most parts of Rafsanjan. It was first selected by a local grower (Mr Mehdi Ohady) in Rafsanjan during the years 1941-51, through the selection of desired traits. Its cultivation has been increasing during the past 40 years and it now occupies probably more than 60-70% of cultivated pistachio orchards in Rafsanjan.
- Kaleh Ghochi. This cultivar is widespread in Rafsanjan and Kerman province. It is a high-yielding and large-fruited variety, and these characters have determined its wide popularity. It has a more obvious tree-shaped growth compared with Ohady, stronger branches, and yields fruit after the third year from grafting. Early blossom production (earlier than Ohady) makes it sometimes exposed to spring frost damage.

Pistachio nuts are rich in mineral contents, particularly for Fe and Zn, although with considerable variation from one cultivar to another (Table 1).

Table 1. Mineral contents in kernels of some pistachio varieties in Iran.

	N	P	K	Ca	Mn	Na	Fe	Mg	Zn	Cu
Cultivar	(%)						(mg/kg)			
Ghazvini	4.20	0.60	0.96	0.16	7.03	0.01	27.37	0.27	14.34	5.94
Ohady	4.27	0.41	1.10	0.13	8.82	0.01	35.64	0.17	14.09	6.76
Kaleh Ghochi	4.07	0.43	1.28	0.14	6.20	0.01	29.75	0.16	16.54	6.44
Sefeed Pesteh Nugh	3.6	0.43	1.18	0.19	0.19	0.01	29.00	10.26	14.95	7.83
Ahmad-Aghai	0.01	0.52	1.08	0.16	0.17	0.01	29.01	9.32	14.62	7.08
No. 48	2.63	0.37	1.19	0.12	7.52	0.01	25.88	0.12	14.23	4.67
Momtaz	3.55	0.51	1.09	0.22	11.02	0.01	33.39	0.21	23.08	7.58
Hassani	4.10	0.59	1.27	0.17	4.94	0.01	24.85	0.16	13.56	6.91
Amiri	3.73	0.68	1.14	0.14	6.20	0.01	30.55	0.18	18.25	7.43
Jandaghi	5.00	0.56	1.12	0.15	6.41	0.02	25.02	0.13	16.75	7.78
Vahedi	4.10	0.56	1.61	0.16	5.35	0.01	34.37	0.23	18.16	12.89
Ghafori	4.37	0.65	1.09	0.16	9.32	0.01	31.67	0.19	20.56	9.33
Rezai	3.33	0.36	1.07	0.16	7.03	0.01	29.50	0.16	14.21	7.01
Jabbari	3.50	0.38	1.01	0.18	6.28	0.01	25.54	0.16	11.96	7.10
Gholam-Rezai	3.70	0.16	1.02	0.16	8.21	–	22.67	0.16	10.42	5.87
Harati	4.12	0.48	1.46	0.20	7.03	0.01	30.74	0.19	21.48	12.38
Shasti	4.83	0.49	1.16	0.16	7.01	0.02	31.36	0.18	18.22	10.21
Seif-addini	4.47	0.40	1.00	0.20	8.83	0.01	36.60	0.21	19.67	10.94
Khandani	3.07	0.48	1.21	0.14	5.92	0.01	23.91	0.16	9.18	4.48
Sefid pesteh	3.60	0.43	1.18	0.19	10.26	0.01	29.04	0.19	14.95	7.84
Sirizi	3.92	0.45	1.11	0.20	6.23	0.02	27.67	0.18	12.40	7.83
Italian	4.60	0.47	1.04	0.18	8.06	0.01	28.49	0.17	14.60	6.22
Nish Kalaghi	3.17	0.46	1.27	0.11	9.78	0.01	25.26	0.16	16.84	8.74
Lahijani	2.60	0.20	0.96	0.26	6.18	0.02	22.46	0.12	12.03	7.08
Ebrahim Abadi	3.73	0.48	1.16	0.12	5.76	0.02	23.52	0.15	14.96	5.58
Cherok Khordeh	2.77	0.28	1.21	0.16	5.34	0.02	22.95	0.15	16.63	8.44
Saeed-Abadi	2.53	0.34	1.35	0.11	4.74	0.03	18.75	0.12	10.68	4.83
Javad-Aghai	3.43	0.43	0.99	0.17	8.03	0.01	22.46	0.15	16.42	7.12
Ameri	3.17	0.43	1.31	0.12	6.07	0.01	22.74	0.13	14.97	7.75
Badami-Kadg	3.30	0.34	1.30	0.14	6.11	0.01	23.23	0.14	16.37	7.97
Hassan Zadeh	3.47	0.45	1.26	0.16	5.89	0.01	21.62	0.14	19.57	10.49
Sabz-Pesteh Noghi	3.30	0.34	1.12	0.15	6.37	0.02	22.73	0.14	13.70	8.24
Karim-Abadi	3.03	0.33	1.17	0.13	6.02	0.02	22.23	0.14	14.53	6.17
Lok-Sirizi	2.73	0.30	1.30	0.15	5.52	0.02	22.08	0.15	14.06	7.43
Fandoghi Ghafori	2.73	0.35	1.25	0.14	6.43	0.01	23.97	0.14	16.54	6.87
Poostkhormaee	2.57	0.38	1.23	0.14	5.09	0.02	23.42	0.41	10.67	3.54
Mohseni	2.87	0.28	1.25	0.15	7.14	0.02	24.27	0.13	13.74	5.53

Germplasm conservation

In order to safeguard the genetic diversity of this important crop, a number of steps have been taken by the Pistachio Research Institute of Rafsanjan, main Institution, dealing with the conservation of *Pistacia* species in the country:

1963. Surveying, collecting and planting of 30 local cultivars of pistachio in the genebank of a local Experimental Station.

1982. Establishment of a new Institute devoted to the conservation and research on pistachio, namely the Pistachio Research Institute of Rafsanjan (PRI). Here the abovementioned varieties together with other cultivated material sampled from Damghan, Ghazvin, Yazd and Kerman were replanted. As a whole, some 62 varieties of pistachio are being conserved at this centre.

Since its establishment, PRI has been carrying out extensive characterization and evaluation trials on the material grown there.

Collecting and rescue of PRI wild pistachio species including *P. mutica*, *P. muticayvera* (Baneh Baghee), *P. khinjuk*, *P. saraghs* (*P. vera*), *P. atlantica* and *P. integerrima.*

1994. Since this date, seed collecting expeditions have been mounted for unknown pistachio varieties throughout the country, including Khorasan, Damghan, Ghazvin, Baluchestan, Yazd and Kerman Provinces. These seeds have been then placed in a cold room for storage.

Regarding male varieties, the PRI is involved in the determination of unknown varieties, their study and their conservation in the genebank. More than 110 male varieties obtained from sister lines of known cultivars are being actually preserved at PRI.

References

Crane, J.C. 1978. Pistachio tree nuts. Avipublishing Co. Westport, USA.

Rechinger, K.W. 1969. Flora des Iranshen Hochlandes und umrahmen den cebirce. Akademisch Druck-U-verlagsanstait, Graz, Austria.

Sabeti, H. 1976. Forests, trees and shrubs of Iran. Agricultural Reserach Organization Pub. Tehran, Iran.

Sheibani, A. 1987. Characteristics of Iranian pistachio varieties. Iranian Pomology Seminar. Seed and Plant improvement Institute. Rafsanjan, Iran.

Sheibani, A. 1994. Pistachio production in Iran. Pistachio Research Institute, Rafsanjan, Iran.

Tabatabee, M. 1966. Pistachio and its Importance in Iran. Forest Service, Ministry of Agriculture, Tehran, Iran.

Zohary, M. 1952. A monographic study of the genus *Pistacia*. Palestine J. Bot., Jerusalem Series 5(4): 187-228.

Atlas pistachio (*Pistacia atlantica* Desf.) in North Africa: taxonomy, geographical distribution, utilization and conservation

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Introduction

Pistacia atlantica ('le pistachier de l'Atlas') is an autoctonous species of the flora of North Africa. Its geographical distribution, though dependent upon various factors, is mainly affected by those linked to the life conditions of people and animals. The degradation faced by this species is alarming and the number of specimens to be found in each site is reducing with time at an alarming rate.

Studies have been conducted at a national level in Algeria, Libya, Morocco and Tunisia to evaluate the actual situation of distribution of this species, the constraints faced for its conservation and utilization and survey on research activities being carried out on it. The investigations were carried out in the period 1991-92 in the framework of the Green Belt Project of North African Countries, an initiative based in Tunis and involving six North African countries. A synthesis of such reports has been prepared and a research project on the conservation and multiplication of plant genetic resources was carried out by the Institut National de Recherches Forestières of Ariana, Tunis in the period 1992-93.

Such a project has yielded very positive results, and the purpose of this paper is to provide a general overview of its achievements.

This presentation will be preceded by a brief introduction on the taxonomy, distribution, conservation and utilization of *P. atlantica* across North Africa.

Taxonomy

Pistacia atlantica Desf. belongs to the Anacardiaceae Family, Order of Dicotiledon. *Pistacia* species found in North Africa are *P. atlantica* Desf., *P. lentiscus* L., *P. terebinthus* L. and *P. vera* L.

Botanical description

The plant

Pistacia atlantica is a tree with a dense canopy, whose height can range from 5 to 20 m, depending on the ecogeographical conditions. The trunk diameter sometimes exceeds 1 m, the bark presents longitudinal splits, leaves are caducous, sessile and imparipinnate with 7 to 11 lanceolate leaflets similar to those of *P. lentiscus*. The most common leaves are those bearing 9 leaflets. Leaflets are entire, and measure 2-6 cm in length and 0.5-1.5 cm in width. Their colour varies from dark green on the superior surface to light green on the inferior surface.

The flower

Pistacia atlantica is a dioecious species. Male flowers are grouped in inflorescences in the form of thyrsi, joined at the bases and carrying at their extremities yellow pollen sacs. Female flowers are grouped in short panicles (colour ranging from yellow to green) which carry ovaries bearing a single ovule.

The fruit

Fruits of *P. atlantica* have a small size (never longer than 0.5 cm), are oval, green in colour soon after they are formed and turning into bleu foncé or black depending

on the individuals (in one single site we have found both types). Each fruit contains a single seed. Seed maturity coincides with the end of summer (i.e. August-September).

Geographical distribution

Pistacia atlantica is distributed in North African countries mainly in those areas characterized by arid or semi-arid climatic conditions.

The species is actually reduced to small populations (sometimes consisting of a single individual), localized mainly in depressions (along watercourses), hedges or areas frequented by marabouses (big birds of *Leptoptilus* genus). It is here that the oldest specimens are in fact found.

This species grows adequately within the isohyets of 200 and 400 mm, although it can be found in smaller numbers outside this range. Plants grow at altitudes ranging from 100 m a.s.l. (locality of Kalaa, Tunisia) to very high elevations (e.g. 3000 m a.s.l. in eastern Algeria).

For soil requirements, the species grows well in clay or silty soils, although it can thrive as well on calcareous rocks where roots insinuate and develop inside cracks.

Algeria

The largest distribution of *P. atlantica* is in the Daias region (Saharan Atlas). In the Oranais (west), close to Maghnia and Telmcen region, *P. atlantica* is found in populations made of isolated stands on slight slopes. It is found also in remnants of the *Oleum-Pistacetum* association where pistachio and olive trees are the main arborescent component.

In this region, *P. atlantica* is associated also with *Rhus pentaphylla* Desf., *Ziziphus lotus* (L.) Lam., *Withania frutescens* Pauq., *Lavatera maritima* Gouan. *Helianthemum pilosum* (L.) Pers. subsp. *pergamaceum* and *Stipa tenacissima* L.

On the Mediterranean coast and on the north versant of Djebel Filaoussene (about 20 km from the sea), *P. atlantica* can be found as isolated trees within a relict forest of Zeen oak (*Quercus mirbeckii*) at an altitude of 1050 m a.s.l.

East of Maghnia and towards Telmcen, *P. atlantica* only grows in the form of stunted shrubs.

Between Sidi bel Abbes and Maascar, the presence of the plant is rather scarce, never forming dense populations. It is often found within the thuya area (*Tetraclinis articulata* Vahl Link), though it does not closely associate with this species.

In the west Algerian region (centre-north) and in the area of the Tell Oranais and Tell Algerois, the Atlas pistachio is found within clusters of jujube trees, along road margins and field hedges.

It has been recorded (Monjauze 1968) as seedlings on the hedges of *Agave americana* plants, close to Cheliff banks. The main stations in this region are:

- at Dahar, in association with suber oaks (*Quercus suber*), east of Ténès, in the Guergor, in the mountainous area of Bissa and Djebel Sidi Barnous.
- close to Zaccar region (in the north versant) near Ain Nsour locality, its presence has been recorded within a thick population of holm oak (*Quercus ilex* L.).
- in the Saharian Atlas and Daïas region (west and centre-south). Here the plant is found particularly in the Ksour Mountains. It appears in forest galleries within steppes of *Arthrophytum scoparium*, *Anabasis aretioïdes* and *Launea arborescens*.

It is associated with *Stipa tenacissima* on the southeast versant and at higher altitudes with *Juniperus phoenicea* and with holm oak.

In the region of Djebel Amour and Oulad Nail (close to Laghouat), relict trees of *P. atlantica* are also found. Within Daïas region, south of the Saharan Atlas, the plant has largely disappeared. Here it has reduced from a vast area where it was once diffused, to a limited presence only on valley bottoms. It is in this region that we have not been able to find the plant in many sites where it was once very common. This is a clear indication that severe genetic erosion has taken place for this species. Here *P. atlantica* is associated with *Periploca loevigata, Rhus tripartitum* and *Capparis spinosa.*

Further south, in the Hoggar, trees of *P. atlantica* are becoming rarer and there are reasons to believe that the species is under threat of disappearance from this area.

In the eastern part of Algeria, the species is found in the Aurès mountains, where it is present as a large but dispersed number of trees dispersed. The area of distribution of this species continues to extend south of Batna and towards the east, to the central-west of Tunisia.

Morocco

The area of distribution of *P. atlantica* in this country extends to the Canary Islands. In Morocco, the species can be found within arid, semi-arid and subhumid environments.

In arid environments, the Atlas pistachio is found along the coast, south of Essaouria in association with argan trees, becoming less common in contact with the region of Hamadas. In the zone where it is closely associated with argan trees, its presence is limited to the fitocenosis with *Z. lotus, P. laevigata* and *R. tripartitum*.

In the plains of Haouz and Tadla, in the northwest of the Atlas mountains, the tree is an integral part of the vegetation, confirming what has been reported previously by Emberger (1939) and Moujauze (1968). Here the forest is dominated by *Z. lotus, Whitania frutescens* and *Acacia gummifera* growing on its warmest slopes.

Other species associated with *P. atlantica* in this area are *Ephedra altissima, Asparagus stipularis, Lavandula multifida* and *Ballota hispanica; P. atlantica* is, however, not common in this zone.

On the Algerian border, close to the region of Oujda, some relict stands exist in association or in superposition with steppes dominated by *S. tenacissima*.

Within the semi-arid zone, the tree is present in isolated stands in the area of Gharb. Here the species becomes less represented when moving from semi-arid to temperate zones, where it is associated with *J. phoenicia* plants.

In the subhumid area, the pistachio shows in holm oak forests, where other species such as *P. lentiscus, Olea europea, Plyllirea media, Ceratonia siliqua* and *Arbutus unedo* are also common.

Libya

In this country the species can be found growing along the reliefs located in the northern regions. It is distributed over an area within Yefreu (west), Tarhouna (northeast), Beni Oulid (southeast) and Mezdah (south). It is represented by only a few isolated stands within the depressions of Djebel Neffous.

In this country the species faces an advanced state of degradation and a serious threat of erosion.

Tunisia

Today the pistachio of the Atlas is a rare species in the country. It is found here in the semi-arid, arid and Saharan climatic areas.

Its distribution in the south of the country corresponds to the isohyet of 150 mm, further south growing in pasture areas. Its northern presence is confined to Ghardimaou area, a site characterized by an isohyet of 480 mm (a subhumid zone with mild winter). The bioclimatic range extends from hyperarid to subhumid. Pistachio trees are exceptionally found in the inferior arid zone, in the bottom of valleys and on the borders of temporary swamps.

In the northwest it can be found close to GharDimaou and Feija, where it grows in an *Oleo-Lentisc* vegetation.

In the centre, close to Kairoun, Faidh, Sidi Saad and Sidi Ali ben Nasrallah, the Atlas pistachio can be found within the plant associations dominated by *J. phoenicea*. Its presence is likely to occur also associated with Aleppo pine trees in the superior arid zone, where *Genista microcephala* is a common species as well.

Pistacia atlantica in central Tunisia belongs to, on one side, the *Ziziphus lotus-Artemisia campestris* association, and on the other side to the rocky species association of *Ferula tunetana* and *Ephedra major*. These two associations are considered as two regressive series of the *Juniperous phoenicea* forest.

Le Houreou (1969) has placed the species within the forest dominated by Aleppo pines in the high plains, associations dominated by *J. phoenicea* and *Rosmarinus* sp. and *Berber thuyas* in the littorals and sublittoral zones.

In east Tunisia the species is found close to Sousse (Kaala locality and its surroundings).

In the south is recorded close to Maknassy, Bouzayane and Bou hedma (where it is associated with *Olea europaea*), and to *Euphorbia bivonae* on the north versant of Djebel Bouhema at a point where towards the south versant there is a forest of *Acacia raddiana* (syn. *Acacia tortilis*).

Still further south, its presence has been recorded close to Dhiba area.

Conservation

The pistachio of the Atlas is among those species most in danger of genetic erosion.

In North Africa, its area of distribution is very large; however its presence has become rarer due mainly to anthropogenic pressure. Pasture and firewood collecting are among the most destructive factors; herds of animals and timber cuts continuously reduce the size of existing populations and particularly of those isolated old trees growing in depressions and talwegs.

The natural regeneration of these trees has become very rare. Eventually those seeds that have not been eaten by animals might find a protected niche to germinate in areas covered by *A. americana*, *Opuntia ficus-indica* or in bushes of *Z. lotus*. Environments frequented by marabouses also provide good sites for the conservation of old specimens.

It has to be mentioned that efforts are being made by North African countries for safeguarding the species. Unfortunately these are of a limited nature and with no continuity.

In addition to the abovementioned problems of overexploitation, there are also others of a technical nature which represent an obstacle for carrying out re-afforestation programmes.

In regard to these problems we could mention the lack of knowledge on how to carry out successfully the multiplication of both seeds and vegetative parts and the

insufficient knowledge that we have on suitable conditions required for the development in nature or in nurseries of seeds of *P. atlantica.*

Although research investigations have been pursued on this subject in various countries of this region we would like to limit ourselves only to those carried out by the Institut National de Recherches Forestières of Ariana, Tunis.

Research at this Institute has been done on the sexual reproduction of *P. atlantica,* and in particular has been studying:

- the effects that chemicals have on the germination of its seeds
- the variability of the germination ability in relation to the characteristics of the tree donor of the seeds
- the effect of harvest time on the seed germination ability.

The following table summarizes the results obtained in these investigations.

	Seed germination (%)
Treatment	
Sulfuric acid	93
Chloridic acid	79
Scarification	68
Acetic acid	67
Boiling water	0
Harvest period	
End of July / early August	28*
First week of September	34*
Last week of September	39*
Parental effect	69-77 (on 5 trees of the same site)

* average of all treatments.

These studies will be continued in 1996 aiming at studying which are the conditions required for enabling plantlets obtained in nurseries to grow in natural environments.

Utilization

Pistacia atlantica can be well considered a multipurpose species. It can be used in fact as:

- rootstock for *P. vera:* thanks to its wide adaptation to harsh edaphic conditions, *P. atlantica* is an excellent rootstock species for the cultigen.
- source of edible fruits: in some regions (Gallel, Kharrouba and Maknassy in Tunisia) fruits of pistachio of the Atlas are appreciated as edible food and gathered by the local populations. There are reports that its seeds are being used for the extraction of a much-appreciated oil.
- source of forage: seeds and leaves are eaten by goats, sheeps and cattle. The young plant shoots and the seeds are the parts most sought by animals, and this fact explains the reason why the natural regeneration of the species is almost absent. As mentioned earlier, only those seeds and plantlets that grow in less accessible places (protected by spiny or thorny plants), have

some chances to develop into adult individuals. Regarding the potential of the plant as source of forage, studies conducted in Tunisia and Morocco (El Hamrouni and Sardon 1974) indicate that the plant is able to produce some 0.35 feed units / kg.

- source of shade: animals find in *P. atlantica* a good refuge from heat and solar irradiation. The tree is often the only plant in the area, thus the role that it plays in protecting animals from the sun should not be underestimated.
- source of energy: the utilization of the species as source of wood for cooking and heating in those areas where living conditions are particularly poor is a serious menace to its genetic diversity.

References

El Hamrouni, A. et Sardon. 1974. Valeur alimentaire de certaines plantes spontanées ou introduites en Tunisie. Tunis note de Recherche no. 2. INRF, Tunisia.

Emberger, L. 1939. Aperçu général sur la végétation du Maroc. Mem. H.s. Soc. Sci. Nat. Maroc. Haus Huber, Berne.

Le Houreou, H.N. 1969. Végétation de la Tunisie Steppique. Ann. De l'INRAT, Tunisie. Vol. 42, fasc. 5.

Montjauze, A. 1968. Répartition et écologie de *Pistacia atlantica* Desf. En Algérie. Bull. De la S.H.N. Université d'Alger.

International Cooperation

International activities on pistachio nut: GREMPA and ISHS Working Groups

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The activities of GREMPA

The GREMPA (Groupe de Recherche et d'Étude Mediterranéen pour le Pistachier et l'Amandier) was founded in 1974 with the objective to work specifically on pistachio and almond nuts. This Working Group was initiated by CIHEAM (Centre International de Hautes Etudes Agronomique Méditerrannéennes) and today is carried out under the auspices of the Organisation for Economic Cooperation and Development (OCDE) and the European Union (EU). The founding members of this Working Group are:

Spain	A. Felipe*, E. Priero, F. Vargas*, R. Vidal Barraquer, M. Vidal Hospital
France	R. Bernhard, H. Gall, Ch. Grasselly, M. Lansac*, J. Southy
Italy	A. Dionigi, F. Monastra*
Tunisia	P. Crossa Raynaud, A. Jouani El Garbi*

* scientists actually undertaking active research.

Scientists from the whole Mediterranean are associated with GREMPA. Current activities concentrate on the following subjects:

1. varieties testing
2. selection of parental material bearing most outstanding characteristics
3. setting up of standardized procedure for the evaluation of some important physiological and morphological traits (blooming, ripening, shell hardness, etc.) and preparation of pomological fiches
4. cooperative research on rootstocks
5. establishment and preservation of botanical collections for taxa belonging to the *Amygdalus* genus.

Since 1980, GREMPA WG on pistachio and almond has been receiving financial support through the EU AGRIMED programme. Nine meetings have been organized by GREMPA so far:

1974 Saragoza, Spain, 19-20 February; Organization of the WG; 14 participants from 4 countries.

1975 Montpellier, France, 8-11 September; 23 participants from 11 countries; 17 papers delivered. CIHEAM-GREMPA proceedings available.

1977 Valenzano, Bari, Italy, 3-7 October; 59 participants from 11 countries; 38 papers delivered. GREMPA proceedings available

1980 Izmir, Turkey, 16-18 June; 26 participants from 8 countries; 27 papers delivered. Proceedings Options Mediteranéénnes series Etudes 1981-1.

1983 Sfax, Tunisia, 2-4 May; 19 participants from 5 countries; 27 papers delivered. Proceedings Options Mediteranéénnes series Etudes 1984-1.

1985 Thessaloniki, Greece, 10-12 June; 41 participants from 14 countries; 21 papers delivered. Proceedings Options Mediteranéénnes series Etudes 1985-1. During this meeting it was decided that in subsequent GREMPA meetings almond and pistachio would be dealt with by the same WG. This was thought to be a sensible decision since the scientists working for almond were in fact the same ones working on pistachio.

1987 Reus, Spain, 17-19 June; 41 participants from 14 countries; 27 papers delivered for almond and 9 for pistachio. Proceedings CEE EUR 11557.

1990 Nimes, France, 26-27 June; 49 participants from 10 countries; 38 papers delivered on almond and 12 for pistachio. Proceedings CEE-EUR.

1993 Agrigento, Sicily, Italy, 16-21 May; 75 participants from 9 countries. This meeting was held in parallel with the First International Almond Congress. 47 papers delivered for almond and 33 for pistachio.

ISHS Working Group on nut crops

The International Society for Horticultural Science (ISHS) Working Group was established in 1989 in Budapest, Hungary, during the First International Walnut Symposium in the framework of the ISHS Fruit Section. The election of the Chairperson and the establishment of Subgroups took place, however, during the 23rd International Horticultural Congress in 1990 in Florence, Italy. Following is the list of Chairpersons for each Subgroup along with their contact address:

Chairperson	Gale Mc Granaham, Pomology Department, University of California, Davis, CA 95616, USA
Vice-chairperson	Francesco Monastra, Istituto Sperimentale per la Frutticoltura, Via di Fioranello, 52, 00134, Rome, Italy
Almond Subgroup	Francesco Monastra, Istituto Sperimentale per la Frutticoltura, Via di Fioranello, 52, 00134, Rome, Italy
Chestnut Subgroup	George Salesses, INRA, Station de Rec. Arb. Fruitieres, BP 81, Villenave d'Ornon, 33883, France
Hazelnut Subgroup	Shawn A. Mehlenbacher, Department of Horticulture, Faculty of Agriculture, Oregon State University, Corvallis, OR 97331, USA
Pecan Subgroup	Bruce Wood, USDA-ARS, Fruit and Tree Nuts Res. Lab., Byron, GA 31008, USA
Pinenut Subgroup	Jose Gomes Pereira, INIA, Estacao Nac. de Fruticultura de Vieira, Natividade, Alcobaca, 2460, Portugal
Pistachio Subgroup	Nurettin Kaska, Hort. Dept., Faculty of Agriculture, Çucurova University, Adana, Turkey
Walnut Subgroup	Eric Germain, INRA, Stat. rec. Arb Fruitieres, BP 81, Villenave d'Ornon, 33883, France

Activities of the ISHS Nut Crops Working Groups:

- serve as a meeting point for the international research community working on nut crops
- facilitate and/or organize workshops, conferences and symposia on behalf of the ISHS community
- facilitate the activities of international research programmes on nut crops
- coordinate research activities in this field
- disseminate information on nut crops to institutions working in this field and remain aware of the activities being conducted by the Working Group.

Among the past achievements are five symposia:

1992 Hazelnut. III International Congress on Hazelnut, Alba, Italy, 14-18 September, Convener Prof. P. Romisondo

1993 Almond and Pistachio. I International Congress on Almond and IX GREMPA Meeting on almond and pistachio, Agrigento, Sicily, Italy, 10-15 May, Conveners Prof. G. Barbera and Prof. T. Caruso.

1993 Chestnut. I International Congress on Chestnut, Spoleto, Italy. 20-22 October, Convener Prof. E. Antognozzi.

1994 I International Symposium on Pistachio Nut, Adana, Turkey, 20-24 September, Convener Prof. N. Kaska.

1995 III International Congress on Walnut, Alcobaca, Portugal, 12-16 June, Convener Dr Gomes Pereira.

The Agenda for the future activities of the ISHS WG on nuts includes the organization of the following symposia:

1996 IV International Congress on Hazelnut, Ordu, Turkey, 30 July 30-2 August 1996, Convener Prof. Koskal

1996 X GREMPA Meeting, Meknes, Morocco, 14-17 October 1996, Convener Dr M. Laghezali.

1997 II International Congress on Almond and Pistachio, Davis, California, USA, September 1997, Convener Dr L. Ferguson.

1997 II International Congress on Chestnut, Bordeaux, France, 1997, Convener Dr G. Salesses.

1999 IV International Congress on Walnut, Bordeaux, France, 1999, Convener Dr E. Germain.

2001 III International Congress on Almond and Pistachio, Greece, 2001, Convener Dr D. Rouskas.

The Work Plan of the UMS Initiative on Pistachio

During the Palermo Workshop, a separate session was held for discussion on the future activities that will be carried out in the framework of IPGRI's Underutilized Mediterranean Species (UMS)[1] initiatives on *Pistacia.*

Participants unanimously agreed that descriptors lists would represent a major contribution towards the strengthening of conservation and utilization of *Pistacia* species and that the scientific community working on *Pistacia* should, as soon as possible, come up with a standardized descriptors list (some descriptors lists already exist in Turkey, Italy, Spain and Iran).

After discussing how to proceed with the production of this important input it was agreed on the following:

1. Two descriptors lists need to be made: one for the wild species, including spontaneous *Pistacia vera*; the second for *P. vera* cultivars
2. Two committees will work on the production of these two descriptors lists
3. Two focal points will coordinate the work of the two committees
4. Five species will be included in the descriptors lists for the wild *Pistacia* are: *P. vera* (wild), *P. terebinthus*, *P. khinjuk*, *P. palestina*, *P. atlantica* (all Mediterranean deciduous species). Other species might be added into an updated version of the descriptors lists at a later stage. *Pistacia vera* cultivars include those plants that have been vegetatively propagated and cultivated by farmers, whereas spontaneous *P. vera* are plants that arose from seeds and have not yet been vegetatively propagated.
5. The focal point will liaise directly with the committee members to produce the descriptors. He will send a first draft to each member and seek their comments. The deadline for the production of the first draft of the descriptors lists is mid-September for the wild species and mid-October for the cultived.
6. Focal point for the production of wild species descriptors list is Prof. N. Kaska of Çucurova University, Turkey
7. Focal point for the production of pistachio cultivar descriptors lists is Dr E. Barone of the University of Palermo, Italy
8. Organs that will be considered at this stage for the production of both descriptors are:
   1. plant habit
   2. fruit
   3. leaf and leaflets

   additional characters, i.e. flower, bud and wood, will be addressed at a later stage (spring 1996). Characters should be measured separately on both male and female plants
9. Illustrations of the plants under investigation would be very welcome.

[1] The UMS activities on *Pistacia* are being carried out in close collaboration between IPGRI and the FAO's ESCORENA (European System of Cooperative Research Networks in Agriculture) Subnetwork on Pistachio.

Names of attending persons who expressed interest in this initiative and committed themselves to working together for the production of these descriptors are given below. They are listed under the Committee they wished to participate most actively in.

Descriptors list Committees	
Wild species	**Cultivars**
1. Batlle	1. **Barone (focal point)**
2. Caruso	2. Batlle
3. De Palma	3. Jaradat
4. **Kaska (focal point)**	4. Kaska
5. Khaldi	5. Mlika
6. Martelli	6. Monastra
7. Novello	7. Rouskas
8. El-Oqlah	8. Sheibani
9. Sheibani	9. Vargas
10. Vargas	10. Zohary (to give input when draft is ready)
11. Zohary	

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